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Case of Kenya, Ethiopia and Burundi

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DEDICATION

I dedicate this humble work to the loving memory of my late father, Saliou NDIAYE, and my dear older brother, Alpha NDIAYE, who have left us but continue to inspire me every day. Their guidance, strength, and love remain with me and motivate me to pursue my dreams.

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ABSTRACT

Energy access remains one of the most pressing development challenges in East Africa, where large sections of the population continue to live without reliable electricity. At the same time, the region possesses abundant renewable resources, making the transition to sustainable energy not only an environmental priority but also a critical driver of economic growth. Against this backdrop, this thesis investigates the role of sustainable energy in fostering economic development in East Africa, with particular attention to the contrasting experiences of Kenya, Ethiopia and Burundi.The main objective of the study was to assess whether renewable energy can meet the region's projected electricity demand while supporting inclusive growth and reducing carbon emissions. To achieve this, the research combined scenario-based modelling of electricity demand and renewable supply with a statistical analysis of the relationship between energy consumption and economic growth. A policy priority index was created to check how well countries national strategies are working to attract investment for energy transition. The results show a strong link between electricity uses per capita and income per capita, meaning that economic growth and energy use go hand in hand. In Kenya, a mix of geothermal, solar, wind and hydropower investments show that good planning helps increase energy access and supports growth. Ethiopia relies heavily on its huge hydropower resources which highlights the need for big projects but also the risk of depending too much on one energy type.Burundi continues to struggle because of weak policies and low investment, which creates big gaps between supply and demand. The study shows that East Africa has enough renewable energy to cover future needs, but this will only be possible if countries invest more and put strong policies in place. The results also suggest that the region can keep growing its economy without increasing carbon emissions, as long as renewable energy remains a top priority. In short, this thesis demonstrates that renewable energy is not only good for the environment but also essential for building strong and fair economic growth in East Africa. To achieve this, countries will need good policies, solid investments plan, and strong cooperation between countries will be crucial to making renewable energy the foundation of the region's future economy.

Key words: Sustainable Energy, Economic Growth, East Africa, Environmental Impact

RESUME

L’accès universel à l’énergie constitue l’un des enjeux de développement les plus cruciaux pour l’Afrique de l’Est, où une partie importante de la population demeure privée d’électricité fiable et abordable. Cette situation freine la croissance économique, limite les opportunités d’industrialisation et aggrave les inégalités sociales. Pourtant, la région dispose d’abondantes ressources renouvelables tel que le solaire, l’éolien, l’hydroélectricité et la géothermie qui offrent un potentiel considérable pour combler le déficit énergétique et favoriser une transition vers un modèle plus durable. Cette étude aborde le rôle stratégique des énergies renouvelables dans le développement économique inclusif et résilient en Afrique de l’Est, à travers une comparaison entre trois pays aux trajectoires contrastées : le Kenya, l’Éthiopie et le Burundi. La démarche méthodologique repose sur la collecte de données socio-économiques et énergétiques, la modélisation de scénarios de croissance du PIB et de la demande en électricité entre 2025 et 2050, ainsi que sur une analyse statistique de la relation entre consommation énergétique et performance économique.Les résultats révèlent une forte corrélation positive entre la consommation d’électricité par habitant et le PIB par habitant, soulignant l’importance de l’énergie comme moteur du développement. Le Kenya illustre le succès d’une diversification énergétique intégrant la géothermie, l’hydroélectricité, l’éolien et le solaire, permettant d’améliorer l’accès à l’électricité tout en réduisant la dépendance aux combustibles fossiles. L’Éthiopie, dotée d’un immense potentiel hydroélectrique, démontre l’importance des grands projets d’infrastructure mais souligne également en lumière les risques liés à une dépendance excessive à une seule source d’énergie. Le Burundi, en revanche, reste confronté à de sérieux défis: faiblesse institutionnelle, cadre politique peu adapté et insuffisance d’investissements, ce qui crée un décalage important entre l’offre et la demande énergétique.L’analyse par scénarios montre que l’Afrique de l’Est dispose de ressources renouvelables suffisantes pour répondre à la demande future, mais à la condition d’un accroissement significatif des investissements et de la mise en place de politiques publiques cohérentes. Par ailleurs, les résultats indiquent que la région peut poursuivre sa croissance économique tout en maintenant des niveaux relativement bas d’émissions de carbone si les énergies renouvelables restent au centre des stratégies de développement. En conclusion, ce mémoire met en évidence que l’énergie durable n’est pas seulement une nécessité environnementale, mais également une voie stratégique pour favoriser une croissance inclusive, réduire la pauvreté énergétique et renforcer la résilience économique en Afrique de l'Est

Mots-clés : Énergie durable, Croissance économique, Afrique de l'Est, Impact environnemental

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LIST OF ACRONYMS

AfDB : African Development Bank

CAPEX : Capital Expenditure

CF : Capacity Factor

CO_2 : Carbon dioxide

DESA : Department of Economic and Social Affairs (United Nations DESA)

EAC : East African Community

EF : Emission Factor

EAPP : East Africa Power Pool

GDP : Gross Domestic Product

GWh : Gigawatt-hour

IEA : International Energy Agency

IPCC : Intergovernmental Panel on Climate Change

IRENA : International Renewable Energy Agency

IMF : International Monetary Fund

kWh : kilowatt-hour

MW : Megawatt

NDC : Nationally Determined Contributions

OECD : Organisation for Economic Co-operation and Development

PV : Photovoltaic

RE : Renewable Energy

RES4Africa : Renewable Energy Solutions for Africa

SDGs : Sustainable Development Goals

USD : United States Dollar

GENERAL INTRODUCTION

East Africa faces an urgent need for sustainable energy driven by rapid population growth, expanding urban areas, and industrial development. While demand for clean, affordable, and reliable energy increases, many countries in the region remain highly dependent on traditional fuels such as firewood, charcoal, and fossil fuels. These energy sources contribute to environmental degradation, hinder economic advancement, and elevate carbon emissions (Bishoge et al., 2020).

To tackle this, East Africa countries are putting more money into sustainable energy sources such as solar, wind,water power, and geothermal . These green energy options can help meet the growing demand for electricity in a way that benefits both people and the environment. East African countries are putting more money into clean energy sources like solar, wind, water power, and geothermal. These green energy options can help meet the growing demand for electricity in a way that benefits both people and the environment. Groups like the International Renewable Energy Agency (IRENA) and the African Development Bank say that using more clean energy can grow the economy, create new jobs, and help reduce poverty by bringing electricity to more people (IRENA et AfDB, 2022; African Development Bank, 2023). Successful projects such as Kenya's Lake Turkana Wind Farm and Uganda's Bujagali Hydropower Plant show how local clean energy can help communities and support economic development (Simberg-Koulumies, 2024; Nduwayesu et al., 2023).

This study will look at how renewable energy can help East Africa grow its economy, reduce pollution, and improve people's quality of life. It will explore the impact of renewable energy on GDP. It will also identify obstacles and solutions for developing clean energy. The goal is to provide helpful information for policymakers, investors, and others who want to support green and inclusive growth in the region.

Problem Statement

East Africa faces big challenges in building a strong and sustainable economy. One of the main problems is that many people still don't have access to modern, clean energy. Instead, they often use polluting sources like firewood and diesel, which harm the environment and release a lot of carbon emissions (Maklewa et al., 2023). Although the region has abundant renewable resources, they are underused. As a result, many countries are behind on climate goals and miss out on clean energy benefits.

Access to energy is very important for growing the economy. Studies show that when countries invest in renewable energy like solar and wind, they often see the economy grow faster, more jobs are created, and electricity becomes more reliable (Mmbaga et al., 2023). East African countries have great potential for renewable energy but face many obstacles. These include weak infrastructure, fundings shortages, and complicated rules. Millions, especially in rural areas, still do not have electricity or clean cooking options, which keeps poverty high and slows development.

The energy policies in the region are very different one country to another. Solving. Countries like Ethiopia and Kenya have made good progress with supportive laws and incentives, while others like Burundi lag behind due to unclear rules and low investment (Mabea, 2020). This makes regional cooperation difficult. Comparing policies can identify best practices and areas needing improvement.

Research Gaps and Questions

Although numerous global studies explore the economic and environmental benefits of sustainable energy, there is still little research that look closely at East Africa. In particular, limited research on how renewables influence not only the environment but also the economy growth and quality of life in the region. Moreover, few studies compare energy policies across East African countries.

This study will address these gaps by answering:

- To what extent can renewable energy resources cover current and future energy demand?
- How much can carbon emissions be reduced in East Africa by increasing renewable energy use?
- What impact does renewable energy have on GDP and the economy?
- How do national energy policies influence investment requirements and the successful growth of renewable energy in East African countries?

Research hypothesis

Based on previous studies showing that renewable energy reduces CO_2 emissions and promotes economic growth (Elom et al., 2024; Motadi et Masiya, 2024), this study hypothesizes that:

- Sustainable energy resources can meet much of the energy demand, but key gaps persist

- Increasing the use of renewable energy in East Africa will significantly reduce CO_2 emissions
- Expanding renewable energy deployment will positively impact economic growth, particularly GDP
- Strong and well-designed energy policies reduce investment barriers and significantly enhance the development and success of renewable energy in East Africa

Research objectives

The main objective of the study is to assess whether renewable energy can meet the region's projected electricity demand while supporting inclusive growth and reducing carbon emissions.

This research intends to:

- Evaluate renewable energy potential and identify the gap between supply and demand in the study countries: Kenya, Ethiopia and Burundi

- Calculate the potential reduction in CO2 emissions by using more renewable energy

- Uunderstand renewable energy's impact on economic growth, particularly GDP.

- Assess the impact of energy policies on investment needs and the growth of renewable energy in East Africa

To achieve these objectives, the thesis is organized into three main chapters. The general Introduction presents the general background, research problem, objectives, hypotheses, and scope of the study. Chapter 1 reviews the relevant literature on renewable energy, economic growth, and energy policy in East Africa. Chapter 2 provides the methodology, data sources, and analytical framework applied to evaluate energy demand, supply potential, CO_2 emissions, and policy priorities. Chapter 3 presents the results and discusses them in light of previous studies, with a focus on Kenya, Ethiopia, and Burundi. Finally, the general conclusion and perspectives, summarizing the main findings, highlighting the study's limitations, and suggesting future research and policy directions.

CHAPTER 1: LITERATURE REVIEW

Introduction

The purpose of this literature review is to provide a comprehensive overview of current academic knowledge on the relationship between sustainable energy and economic growth in East Africa. This section sets the stage for understanding how investments in renewable energy such as solar, wind, hydro, and geothermal can influence economic performance, social development, and environmental sustainability in the region.

Currently, much of the energy comes from biomass and fossil fuels, which can constrain economic development and create environmental challenges (OECD and African Union Commission, 2023). Supporting this, a study by Yang et al. (2022) found that renewable energy consumption positively influences economic growth in East African countries connected to the Eastern Africa Power Pool, highlighting the potential benefits of transitioning to renewable energy sources. Reliable energy is important for economic growth and better living standards in Eastern Africa. To achieve this, it’s necessary to improve energy infrastructure, use energy more efficiently, and consider cleaner and more sustainable energy sources (Mbaga et Kulindwa, 2024).

1.1 Conceptual framework

1.1.1 Defining sustainable energy

Sustainable energy refers to energy systems and sources that meet present needs without compromising the ability of future generations to meet their own needs. In academic literature, sustainable energy is most often associated with renewable resources such as solar, wind, hydropower, and geothermal, which are naturally replenished and have low environmental impact (Grigoroudis et al., 2019; Niang et al., 2024). Unlike fossil fuels, these sources do not deplete over time and emit little or no greenhouse gases during operation, making them essential for both environmental protection and long-term economic stability (Farghali et al., 2023).

It's important to understand the difference between "renewable" and "sustainable" energy. While all sustainable energy comes from renewable sources, not all renewable energy is always sustainable. For example, some bioenergy projects cause problems like deforestation or compete with food production, which raises concerns about long-term impact (Grigoroulis et al.,2019)**.**

Table 1:Main types of sustainable and renewable energy sources and theirs keys characteristics

Energy sources	Renewable	Sustainable	Key characteristics
Solar	*Yes*	*Yes*	Abundant, low emissions, scalable
Wind	*Yes*	*Yes*	clean, variable, suitable for many areas
Hydro	*Yes*	*Yes*	Reliable, site-dependent, large/small
Geothermal	*Yes*	*Yes*	Constant, location-specific, low carbon

Source : Adapted from Grigoroudis *et al (2023)*

1.1.2 Economic growth in East Africa

Economic growth is commonly defined as the increase in the production of goods and services in an economy over time, typically measured by growth in Gross Domestic Product (GDP) (Cervelló-Royo et al., 2025). In East Africa, economic growth is also linked to improvements in employment, industrial output, and reductions in poverty (Mmbaga et al., 2023). Access to reliable and affordable energy is a foundational driver of economic growth because it enables industrialization, supports the development of new sectors, and improves productivity across agriculture, manufacturing, and services (Jinapor et al., 2025, Alex-Oke et al,2025).

Figure 1 illustrates the economic trends of East Africa countries between 2011 and 2022.Overall, most economies grew steadily during this time, with some fluctuations.

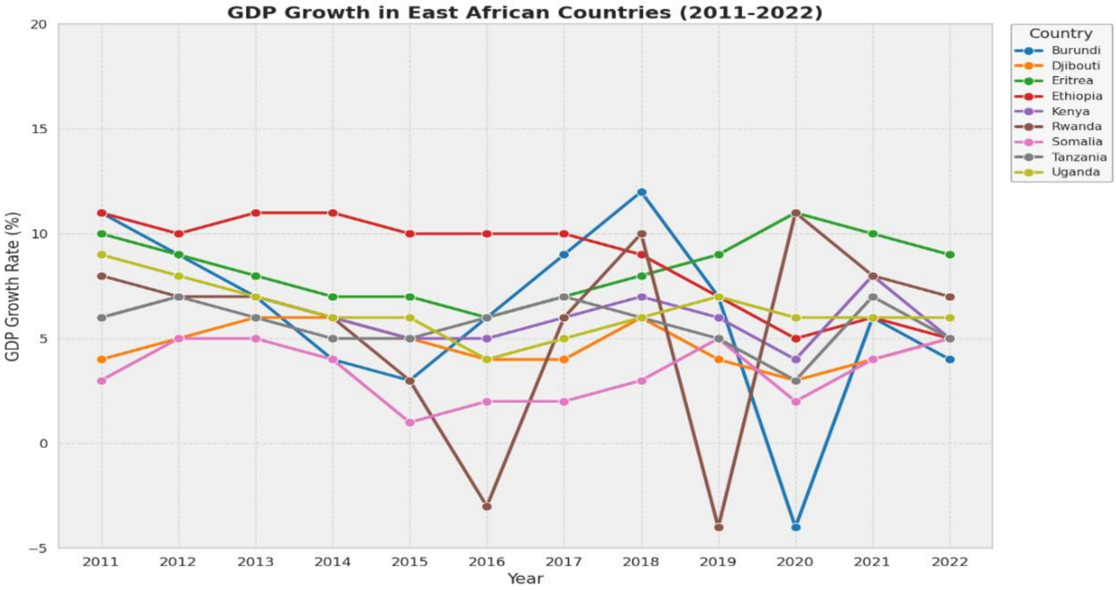

Figure 1: GDP growth in East African countries (%), 2011-2022. Adapted from RES4Africa

1.2 Overview in the energy sector in East Africa

The energy sector in East Africa is characterized by a mix of traditional and modern energy sources, with a significant portion of the population still relying on biomass, such as firewood and charcoal, for their daily energy (RES4Africa Foundation, 2023). Access to modern energy remains uneven, with urban areas generally having better access to electricity compared to rural regions (Michel et Vessat, 2023, Wassie et al.,2023). Figure 2 shows that East Africa's power capacity almost doubled between 2011 and 2021, reaching 16.3 GW with renewable energy, grew from 64% to 69%.

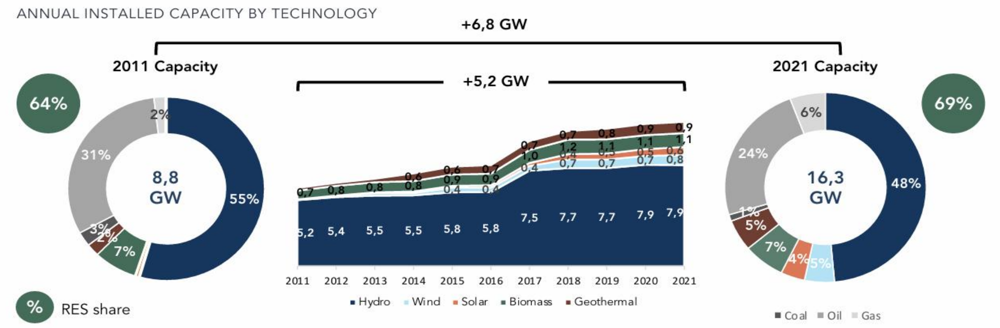

Figure 2 : Annual installed capacity by technology in East Africa (2011–2021) adapted from RES4Africa Foundation, 2023

Over the past ten years, more people in East Africa have gained access to electricity. However, there are still big differences between countries and between cities and rural areas. For example, while about 70% of people in Kenya have electricity, in Tanzania the number is closer to 40%. In rural communities, many people still don't have reliable access to power compared to those living in towns and cities (Sarkodie et Adams, 2023). Limited grid infrastructure, high connection costs, and affordability issues continue to hinder progress toward universal access (IEA, 2022).

1.3 Theoritical perspectives

To understand how sustainable energy affects economic growth in East Africa, it is helpful to look at some key theories from the academic literature.

1.3.1 The energy-led growth hypothesis

The theory posits that improved access to energy facilitates accelerated economic growth. Having reliable electricity helps factories and businesses work more efficiently. allows shops to open longer, and makes it easier for students to study at night. Studies show that in many african countries when people use more energy, the economy also grows (Mbaga et al., 2024; Kebede et Mitsufuji, 2017). However, unreliable or costly electricity can hinder economic growth and limit opportunities for individuals businesses struggle to expand, health services suffer, and households lose out on better livelihoods (World Bank, 2025).

1.3.2 The environmental Kuznets curve (EKC) hypothesis

The environmental Kuznets curve is a theory that explains how the environment changes as countries get richer. At first, when countries start to grow, pollution usually increases because people use more fuel and natural resources. But after reaching a certain income level, pollution begins to decrease, as countries invest in cleaner energy, better technology, and stronger environmental rules. This idea is often uses to study whether economic growth can also lead to better environmental protection (Muratoğlu et al., 2024).

1.3.3 Sustainable development and energy

The sustainable development approach goes further. It says that energy should not only help the economy, but also protect the environment and support social well-being. This means using more renewable sources like solar, wind, and hydropower, which do not create as much pollution or greenhouse gases (Yuni et al., 2023). In East Africa, using clean energy can help reduce poverty, improve health, and protect nature for future generations (World Bank, 2023). As shown in Figure 3, improved energy access is widely recognized as a driver of economic growth and a key enabler of progress toward the Sustainable Development Goals (Leal Filho et al., 2025; Parab et al., 2024).

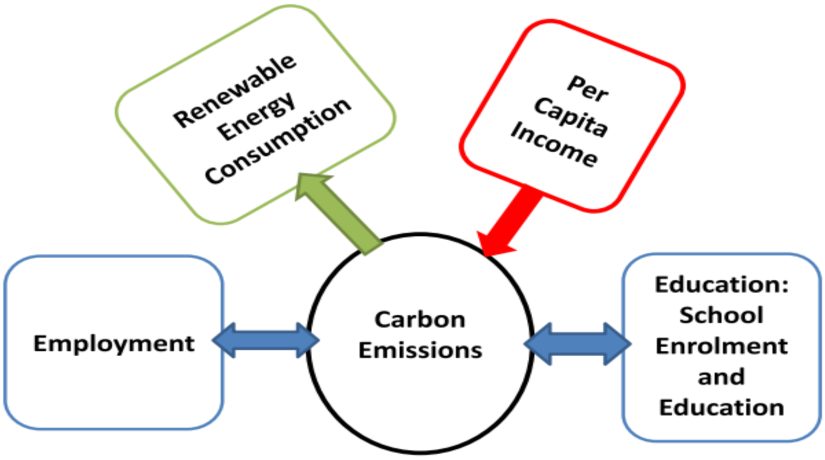

Figure 3 : Conceptual framework linking renewable energy consumption, per capita income, education, employment, and carbon emissions. Adapted from Elom et al. (2024)

1.4 Research gaps and futures directions

Even though East Africa has made progress with renewable energy, there are still some important areas where more research and action are needed.

1.4.1 Not enough long -term and regional studies

Most existing studies on energy in East Africa focus on a single country or cover only a limited period, which limits our understanding of broader regional trends and long-term developments. This narrow scope makes it difficult to identify effective strategies for sustainable energy development across multiple countries. Scholars emphasize the need for comprehensive, long-term, and regional analyses that capture patterns, drivers, and disparities in energy adoption and policy implementation (Rady et al., 2025; Tachega et al., 2025). Such studies can provide policymakers with more robust evidence to design coordinated strategies, improve regional cooperation, and promote sustainable economic growth throughout East Africa.

1.4.2 Policy implementaions

Many countries have good policies on paper, but there are not enough studies looking at how well these policies are actually working in practice. More research is needed to check if the policies are really helping people get access to clean energy and if they are being followed as planned (RES4Africa Foundation, 2023).

1.4.3 New technologies and innovation

There is also a need for more research on new clean energy tools like batteries, smart grids, and digital payment systems for solar energy in places without power lines. Finding out what supports or slows down the use of these tools will help countries switch to clean energy faster (Kinnaly et al.,2023; Anku,2025)

Partial conclusion

This chapter has examined renewable energy development in East Africa and its economic and social implications. The review began by outlining the current energy landscape and theoretical frameworks linking energy access with economic growth.

Investments in solar, wind, and hydropower are contributing to economic growth, job creation, and improved living standards. In 2024, the renewable energy market in East Africa was valued at around USD 4.1 billion, driven by rising electricity demand, supportive policies, and falling costs

Overall, East Africa has made good progress, but more work is needed to make sure everyone can get clean, cheap, and reliable energy. This will help the region grow in a way that lasts over time while maximizing its contribution to sustainable economic growth.

CHAPTER 2: MATERIALS AND METHODS

Introduction

This research uses a structured and step-by-step methodology to assess the role of renewable energy in economic growth and CO_2 emissions reduction in three East African countries: Kenya, Ethiopia, and Burundi. The study combines real-world data with forecasting techniques to estimate future electricity demand, energy supply, and environmental and economic outcomes under different renewable energy scenarios.

2.1 Study area

This study looks at East Africa and focuses on three countries: Ethiopia, Kenya, and Burundi. These countries were chosen because they are at different stages of developing their energy sectors and have different types of energy policies. This makes them good examples to compare and learn from in the region.

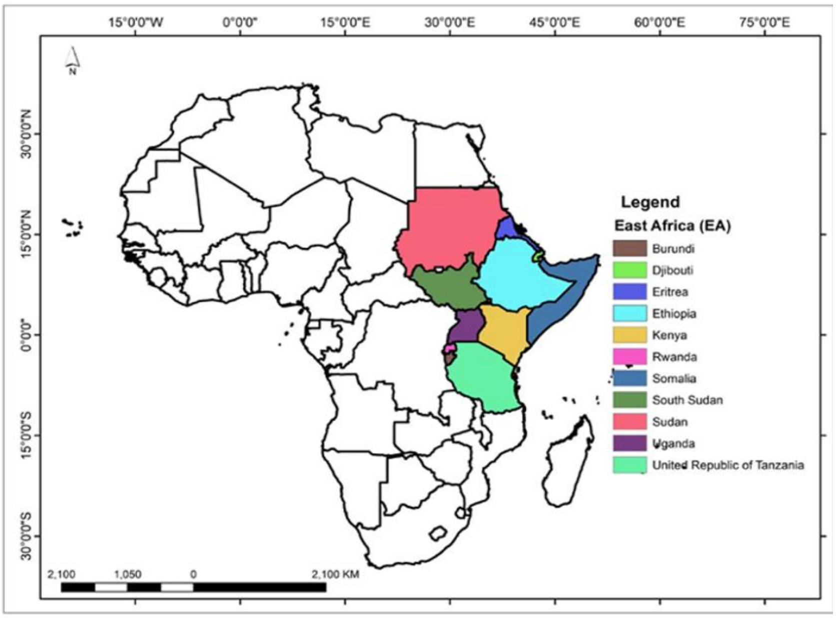

Figure 4 : Study area map showing the East African countries included Focus country in this research, namely Burundi, Ethiopia, Kenya

Source: Mellaku, M. T., Wassie, Y. T., Seljom, P., & Adaramola, M. S., 2023, Decentralized renewable energy technology alternatives to bridge manufacturing sector energy supply-demand gap in East Africa: A systematic review of potentials, challenges, and opportunities.

KENYA

Kenya is one of the leading countries in Africa when it comes to renewable energy. The country has made big investments in geothermal, wind, and solar power, especially using off-grid solar to reach more people in remote areas. Nearly 85–90% of Kenya's electricity now comes from renewable sources, with geothermal energy making up the largest share. Kenya also has strong policies supporting clean energy and, as a result, over 75% of its people now have access to electricity, which is one of the highest rates in East Africa (World Bank, 2023). This makes Kenya a good example of what can be achieved as energy access and renewable investment keep growing.

ETHIOPIA

Ethiopia has focused on building large hydropower plants, such as the Grand Ethiopian Renaissance Dam. The government plays a big role in planning and expanding energy infrastructure. Because of these efforts, Ethiopia's electricity grid is getting bigger, but many rural areas still have limited access. About half of Ethiopians currently have electricity at home (IEA, 2023). Hydropower is important for the country's energy, but problems like uneven access and climate risks, which can impact water levels, remain challenges (Eberhard et al., 2008).

BURUNDI

Burundi faces the most difficulties among these three countries. Less than 15% of the has access to electricity, and most people rely on traditional fuels like firewood and charcoal (AfDB, 2022). The country has not yet made large investments in new renewable projects, and government policies to support clean energy are still being developed. Burundi's renewable energy potential especially for hydro and solar power is mostly untapped, making progress slower compared to its neighbors.

To provide a clear overview of the study context, Table 2 summarizes the key characteristics of the three countries under investigation. It highlights their population size, main renewable energy potentials, as well as the advantages, disadvantages of each national energy system.

Table 2:Comparative overview of key characteristics of the study countries

Country	Population (2023, millions)	Main Energy Potential	Advantages	Disadvantages
Kenya	54	Géothermal, Wind, Solar, hydro	Diversified energy mix; relatively advanced policy framework; strong experience in geothermal projects	Dependence on external financing; rural–urban disparities in access; vulnerability of hydropower to droughts
Ethiopia	123	Hydropower (very high), solar, wind, geothermal	Abundant hydro resources (GERD and other dams); ambitious government strategy; potential for regional exports	Heavy reliance on hydropower → climate vulnerability; limited electricity access; financing challenges
Burundi	13	Small-scale hydropower, Solar	Moderate solar potential; some local hydro projects	Very low access rate (<15%); weak infrastructure; limited policy framework; high reliance orn biomass

2.2 Data collection

This study relies on secondary data collected from well-established international and national sources, ensuring the reliability and robustness of the analysis. The selected data aligns closely with the study's objectives, which include forecasting electricity demand, analyzing renewable energy supply, and estimating economic and environmental impacts within Kenya, Ethiopia, and Burundi. To comprehensively support the analysis, several key data types were gathered from leading international organizations, governmental agencies, and relevant scholarly literature. These data sources encompass a broad range of indicators vital for achieving the study's goals, including energy production statistics, consumption patterns, economic metrics, and environmental data. Table 3 below provides a detailed summary of the data types used, their specific purposes in the study, and the principal sources from which this information was derived, demonstrating the depth and breadth of the secondary data foundation for this research.

Table 3:The summary of main data types collected, their descriptions, and sources

Data type	Descriptions	Time range	Data Sources
Population	Annual population projections for each country from 2025 to 2050. Used to estimate future energy demand and GDP per capita.	2025-2050	World Bank (2023), United Nations DESA (2022)
GDP and Economic Indicators	Gross Domestic Product (current USD) and growth trends	2023	World Bank Open Data (2023), IMF Data (2023)
Electricity Access & Consumption	National electrification rates (% of population); per capita electricity consumption (kWh).	2023	IEA Statistics (2023), World Bank Energy Indicators
Renewable Energy Supply and Potential	Installed capacity by energy type (solar, wind, hydro, geothermal); estimated technical and economically usable potential.	2023 baseline	IRENA country profiles, national energy reports, AfDB (2023)

CO_2 Emissions and Energy Mix	National-level CO_2 emissions from electricity generation; emission factors by fuel type (coal, diesel,	2000-2023	IEA, Climate Watch, Our World in Data (2022)

2.3 Forecasting models and calculations

2.3.1 Population and GDP forecasting

- **Population projections**

A projection of the populations of Kenya, Burundi, and Ethiopia from 2024 to 2050 was done using data collected directly from the World Bank, a highly trusted international source. The World Bank's population estimates and projections are based on a wide range of inputs, including census data, official national statistics, demographic surveys, and data from organizations like the United Nations Population Division. These projections follow established demographic methods that consider fertility, mortality, and migration trends, and are aligned with the United Nations World Population Prospects medium scenario to ensure consistency and accuracy (World Bank, 2024).

- **GDP projections**

Before projecting future GDP, a development of three different economic scenarios for each country was made, based on the most recent forecasts and standard long-term modeling practices. For each decade from 2025 to 2050, these scenarios: Low, Baseline and High (Table 4) reflect different possible growth paths depending on factors like government policies, investment, global trends, and risks such as debt or climate shocks. For example, in Kenya, the baseline scenario uses the average growth rate expected by most experts, the low scenario reflects potential challenges and slowdowns, and the high scenario assumes strong reforms and favorable external conditions. The same approach is used for Burundi and Ethiopia, with each country's scenarios tailored to its own forecast range, economic outlook, and likely changes over time. This step-by-step scenario development helps us estimate a range of possible futures before calculating the specific GDP projections for each country.

Table 4:Projected Annual GDP Growth Rate Scenario (%),2025-2050

Country	Scenario	2025-2030	2030-2040	2050
Kenya	Low	4.0%	3.0%	2.0%
	Baseline	5.1%	4.2%	3.2%
	High	6.0%	5.5%	5 %
Burundi	Low	3.0%	2.0%	1.5%
	Baseline	5.3%	4.2%	3.2%
	High	6.5%	6.0%	5.0%
Ethiopia	Low	5.5%	4.5%	3.5%
	Baseline	6.4%	5.7%	4.7%
	High	7.7%	7.0%	6.3%

Note: Sources include IRENA, IMF, World Bank, African Development Bank, and national economic reports. Baseline, low, and high reflect different assumptions as outlined in the scenario development section.

We forecast then the future GDP of Kenya, Burundi, and Ethiopia from 2025 to 2050. This is done using the compound growth formula (Eq1), which assumes that GDP increases at a constant annual rate over time. The projection is expressed as:

$$\mathbf{GDP_t = GDP_{2025} \times (1 + g)^{(t - 2025)}} \quad \text{(Eq1)}$$

where $\mathbf{GDP_t}$ is the projected GDP in year t, $\mathbf{GDP_{2025}}$ is the base year GDP (2025), and **g** is the annual GDP growth rate that we develop earlier. This formulation is widely used in long-term economic and energy modeling studies (Ouedraogo, 2017).

- **Annual GDP per capita calculation**

After calculating the total GDP for each country under the different scenarios, we work out the GDP per person called GDP per capita. To do this, we simply divide the total GDP by the total population for each year (Eq2). This tells us, on average, how much income every person in the country would have if the GDP were shared equally. By using our projected GDP and population numbers for each scenario, we can see how people's average living standards might change in the future, in both good and bad economic conditions.

$$\textbf{GDP per capita}_t = \textbf{GDP}_t \div \textbf{Pop}_t \quad \textbf{(Eq2)}$$

where **GDP per capita**$_t$ is the projected GDP per capita in year t, **Pop**$_t$ is the population size in year t. This formulation is widely used in long-term economic and energy modeling studies to evaluate growth and welfare dynamics (World Bank, 2022; Ouedraogo, 2017).

2.3.2 Electricity consumption forecasting Using GDP per capita regression

To estimate future electricity consumption per capita for Kenya, Ethiopia, and Burundi, this study adopts a global linear regression model based on the relationship between electricity consumption per capita and GDP per capita. This method is widely used in energy economics because electricity demand tends to increase alongside income levels.

- **Data and country selection**

Data from 25 countries with different levels of development, covering the years 2010 to 2023, are used for this regression model. The sample includes developed countries such as Japan, South Korea; emerging economies like China, Brazil, and South Africa; and low-income countries including Kenya, Ethiopia, and Burundi (the study countries). This wide range of countries makes the results more accurate and useful for the whole world.

- **Regression equation:**

$$\textbf{EPCt} = \boldsymbol{\alpha} \times \textbf{GDP per capita}_t \quad \text{(Eq3)}$$

where **EPCt** denotes the projected electricity consumption per person in year t, **GDP per capita**$_t$ is the gross domestic product per person in year t and **α** is a proportionality parameter that reflects the elasticity of electricity demand with respect to income that we get from the regression model. This relationship (Eq3) has been widely used in empirical energy economy modeling frameworks to estimate future electricity needs based on income growth (Li, Bae and Rishi, 2022).

- **Adjustment for Country Specific-Error**

To improve accuracy, the model includes an error adjustment based on observed 2023 data:

$$\mathbf{EPCt} = \boldsymbol{\alpha} \times \textbf{GDP per capita}_t + \boldsymbol{\varepsilon} \qquad \text{(Eq4)}$$

ε is the **initial error** and it is calculated by comparing the regression estimate with the actual observed electricity use in 2023.This correction (Eq4) aligns projections with each country's starting point.

- **Application**

After the global regression model is set up, it is applied to Kenya, Ethiopia, and Burundi to forecast electricity consumption per person from 2025 to 2050 under three scenarios: Low, Baseline, and High. For each scenario, the forecast helps estimate how much electricity an average person is expected to use each year in the future.

The next step is to calculate the total electricity demand for each country and scenario. Electricity demand at year t is defined as the product of population and electricity consumption per capita (Eq5) a commonly used identity in energy demand modeling (Bhattacharyya, 2011)

$$D(t) = \mathbf{Pop}_t \times \mathbf{EPCt} \qquad \text{(Eq5)}$$

where D(t) is the electricity demand at year t, $\mathbf{Pop}_t$ is the population at year t, and **EPCt** is the electricity consumption per capita at year t,

This method provides an overall estimate of how much electricity each country will need in total under different future conditions. The calculations use population forecasts and scenario-based electricity consumption values, making it possible to plan for energy investments and infrastructure needs that match expected growth and living standards.

2.4 Energy supply assessment

In this section, we explain how we assess the energy supply situation for the selected countries (Kenya, Ethiopia, and Burundi). This analysis helps to understand how much sustainable energy is available, how much is currently used. This step is crucial for evaluating the gap between energy needs and available resources.

2.4.1 Usable sustainable energy potential

We first identify the total technical potential of renewable energy (RE) sources, including solar**,** hydropower**,** wind and geothermal. The technical potential refers to the maximum amount of energy that could be produced using current technology, considering geographical and resource limitations.

This helps figure out the largest amount of sustainable energy each country can produce. Later, this will be compared with how much energy they will need.

2.4.2 Estimation of annual energy output from renewable resources

This part of the study explains how to calculate the amount of electricity that can be generated in one year from available renewable energy sources. The calculation is based on the installed capacity of each energy source, the capacity factor, and the total number of hours in a year. The method follows a simple formula: the annual energy produced equals the installed capacity multiplied by the capacity factor and then multiplied by 8760, which is the number of hours in a year (Eq6).

$$\mathbf{Eyear = P \times CF \times 8760} \qquad \text{(Eq6)}$$

where P is the installed capacity, CF is the capacity factor, and 8760 is the total number of hours in a year (Boyle, 2012).

Capacity factor shows how well a renewable energy source works. It tells us how much of the time in a year the power plant runs at its full strength. This number changes depending on the energy type and the country's natural conditions. In this study, we use common capacity factor values: 0.20 for solar, 0.25 for wind, 0.40 for hydropower, and 0.70 for geothermal, since geothermal plants usually run steadily all year. These values are collected directly from the International Renewable Energy Agency (IRENA,2023).

2.4.3 Supply/ Demand gaps

After estimating electricity demand and the technical potential of sustainable energy supply in the previous subsections, this part focuses on their comparison. The annual projected demand values by scenario are set against the aggregated supply potential to determine whether future needs can be fully met. The difference between the two curves (demand vs. supply) is analyzed to identify potential surpluses or deficits in specific years.

This gap analysis helps us find out what infrastructure is missing, how much investment is needed, and what policies should be made. These steps are important to make sure there is whether enough energy to help the economy grow.

2.5 Energy policy and investment needs for renewable energy expansion

To assess the impact of national energy policies on investment needs and the growth of renewable energy in East Africa, this part of the study builds directly on the renewable energy potential and exploitable capacity estimates established in earlier sections. The analysis began by taking the projected capacity requirements for each country under the three GDP growth scenarios: low, medium, and high growth developed in the previous step.

Next, the study turns this exploitable capacity into investment numbers. It does this by using data on how much money it costs to build different renewable energy technologies, such as how many dollars are needed per megawatt (MW) of the different technologies (Solar, Wind, Hydro, Geothermal).

For that, we use capital expenditure (CAPEX), which means the upfront money needed to build renewable energy projects. CAPEX is shown as the cost to install one megawatt (MW) of power. For example, according to the IRENA Renewable Cost database (2024) and the International Energy Agency (IEA,2024), building 1 MW of solar power typically costs about $691,000, wind power about $1,041,000 per MW, hydropower around $2.5 million per MW, and geothermal roughly $4 million per MW. By multiplying these costs by the total exploitable energy capacity, the study finds out the total money needed to build the renewable energy facilities. This shows how much investment is required to meet future clean energy goals.

After estimating the investment needed for renewable energy development, we looked at each country's energy policies and strategic plans to see if they align with the investment needs. To do that, an index from 1 to 5 was given to each country based on how strong and clear their policies are. This index considered things like what the policies cover, how fast they are expected to be put into action, the incentives they offer, and the rules they set. This way, we can see how well the goals of the country line up with the investment required to reach them.

By combining quantitative investment forecasts with this structured policy scoring approach, it provides a clear picture of how effectively current energy policies are supporting the scaling up of renewable energy. It also highlights where additional policy measures, funding mechanisms, or regional cooperation efforts may be necessary to meet both national and regional sustainable energy goals.

2.6 CO2 emissions estimation

In this section, we estimate how much carbon dioxide (CO_2) emissions can be reduced by shifting from fossil fuels to renewable energy. This calculation is important to understand the environmental benefits of increasing the share of clean energy in Kenya, Ethiopia, and Burundi.

2.6.1 Calculation method

The amount of CO_2 avoided is calculated using the following standard formula:

$$\Delta CO2 = E \times (EFf - Efr) \quad \text{(Eq7)}$$

Where:

- **E** = Electricity generated or consumed (in kilowatt-hours, kWh).
- **EFf** = Emission factor of fossil fuel (kg CO_2 per kWh), meaning how much CO_2 is emitted when producing electricity from fossil fuels.
- **Efr** = Life-cycle emission factor of sustainable energy (kg CO_2 per kWh),

The reduction in CO_2 emissions from using renewable energy is calculated by multiplying the amount of electricity generated by the difference in pollution between fossil fuels and renewables. This method (Eq7) is commonly used to measure how much greenhouse gas emissions are avoided by switching to cleaner energy (IPCC, 2019).

2.6.2 Data source

Emission factors for both fossil fuel and renewable electricity production are derived from the International Energy Agency, IPCC reports, and World Bank data (IEA, 2023; IPCC, 2021; World Bank, 2022). On average, generating electricity from fossil fuels emits about 0.7 kg of CO_2 per kilowatt-hour, whereas renewables release significantly less, with typical values near 0.05 kg CO_2 per kilowatt-hour (IEA, 2023). These emission factors are applied alongside projected electricity demand to calculate total emissions in the different scenario, ensuring the analysis globally consistent and in line with established international sources (IEA, 2023; IPCC, 2021; World Bank, 2022).

2.6.3 Application in the study

We apply this formula to the projected electricity demand for (2025,2035, 2040,2045,2050) and under the three scenarios (Low, Baseline, High).

The goal is to show how much CO_2 each country can avoid by increasing renewable energy adoption.

2.7 Tools and software used

We used both Excel and Python. Excel was used to organize and clean the data, calculate basic numbers like population and GDP growth, and create simple charts. Python was used for making high-quality graphs, running detailed analysis to understand relationships like between GDP and electricity use, and automating repetitive calculations for many years and countries.

Partial Conclusion

This chapter explained the study’s method for analyzing how renewable energy can help East Africa’s economy grow. It combined population and economics forecasts with electricity demand estimates, renewable energy supply checks, emissions assessment , and policy reviews to create clear future scenarios. Using both Excel and Python made thee work transparent and accurate. Overall, this method gives a strong base for the results and discussions in the next chapter.

CHAPTER 3 : RESULTS AND DISCUSSION

Introduction

This chapter shows the main results of the study. It focuses on what was found when looking at energy trends for Kenya, Ethiopia, and Burundi from 2025 to 2050.It starts by looking for the gaps between sustainable energy potential and their utilization ,showing how electricity demand will change over time. It then explains how much renewable energy potential each country has compared to their needs. After that, it looks at how using more renewable energy can help reduce CO_2 emissions and improve economic growth. Finally, it shows how policy priorities can iinfluence the investment requirements to scale up sustainable energy potential in Kenya, Ethiopia and Burundi under the three scenarios.

3.1 Gaps between potential and utilization

The assessment of renewable energy potential compared to actual utilization reveals one of the central paradoxes of East Africa's energy landscape**:** vast resources remain untapped**.** As shown in Figure 5, Kenya, Ethiopia, and Burundi all possess abundant technical potential in solar, wind, hydro, and geothermal energy, but their actual exploitation remains a fraction of what is available.

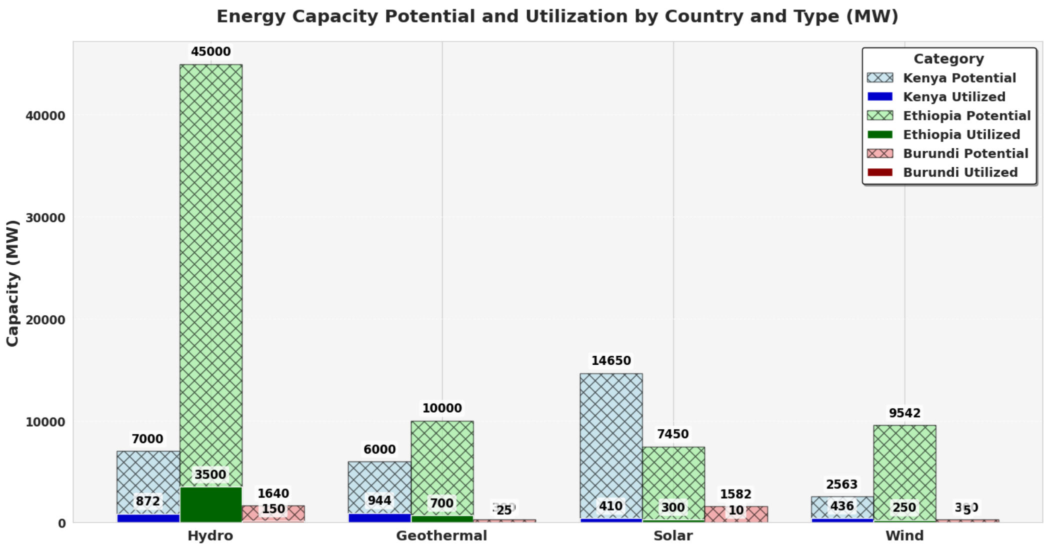

Figure 5:Gap between the usable renewable energy potential and the current level of utilization for Kenya, Ethiopia, and Burundi in 2023

These findings are consistent with the broader literature. For instance, Wassie et al. (2023) emphasize that East Africa's technical renewable potential far exceeds projected demand, with Kenya alone theoretically capable of meeting its 2030 energy needs many times over. The International Renewable Energy Agency (IRENA, 2023) similarly highlights that Ethiopia's hydropower endowment, if fully developed, would not only secure national supply but also position the country as a regional electricity exporter. In Burundi, the African Development Bank (2022) has repeatedly stressed that underinvestment and institutional fragility explain why available solar and hydro resources remain underdeveloped.

While this analysis captures the broad inconsistency between resource endowment and utilization, several caveats must be noted. First, potential figures are highly theoretical**,** often based on geographical or climatic modeling without fully accounting for environmental, social, or economic constraints (e.g., land use conflicts, costs of grid integration). Second, the comparison is static and does not consider pipeline projects such as Kenya's planned geothermal fields, Ethiopia's GERD expansion, or Burundi's Jiji–Mulembwe hydropower project. Finally, this analysis treats potential resources as equally accessible, but in reality, capacity factors, seasonal variability, and technological limitations mean that not all potential can be economically realized.

3.2 Population and GDP per capita growth trends

Population projections are particularly important, as they indicate how many people will require access to electricity, while GDP per capita trends shed light on how rising incomes and economic development will influence energy consumption patterns. Figure 6 specifically focuses on population growth across the three countries.

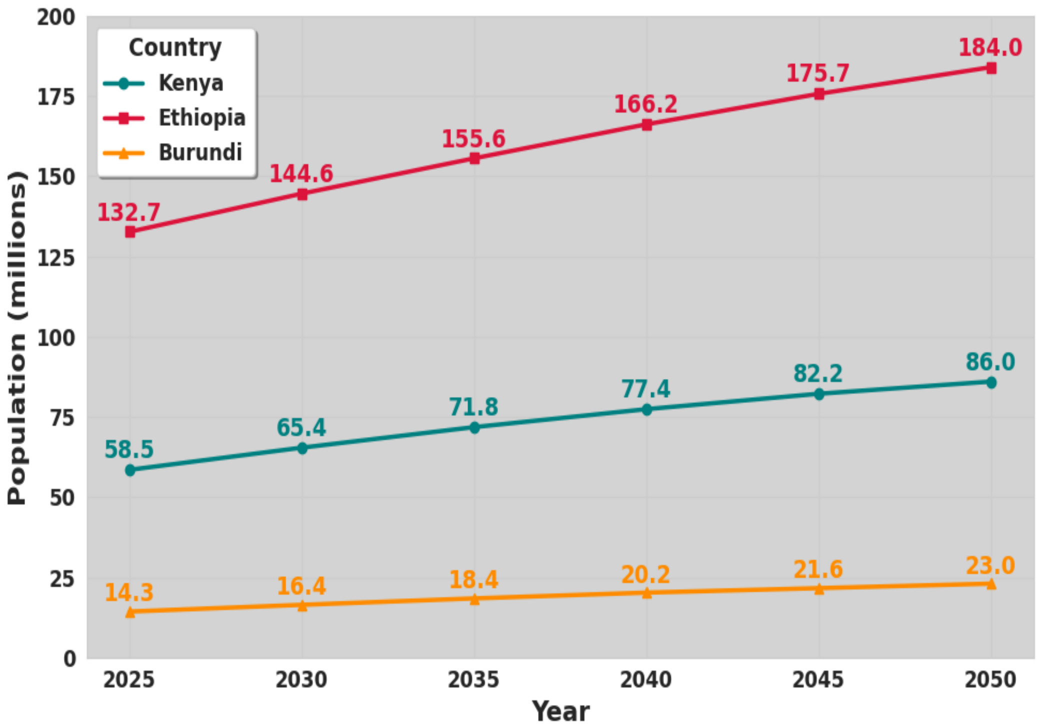

Figure 6: Projected population from 2025 to 2050 of Kenya Ethiopia and Burundi

Ethiopia, which already has the largest population, is expected to see a significant increase, rising from around 132 million people in 2025 to about 184 million by 2050. Kenya's population also follows a steady upward trajectory, growing from 58 million to nearly 86 million over the same period. Burundi, though starting from a smaller base, experiences notable growth as well, expanding from about 14 million to approximately 23 million people by 2050. Altogether, these demographic shifts demonstrate the magnitude of future electricity needs in the region and the importance of planning energy infrastructure accordingly.

Figures 7 clearly illustrate that per capita are expected to rise steadily between 2025 and 2050 in Kenya, Ethiopia, and Burundi. The GDP per capita expands more rapidly under the High scenario compared to the Low and Medium growth paths, underlining the strong link between economic momentum and improvements in living standards. Kenya shows the largest improvement, where people's average income could grow from around 2,100 USD in 2025 to over 8,000 USD by 2050 in the High scenario. Ethiopia also demonstrates strong economic growth, particularly in the High scenario, which could not only speed up poverty reduction and industrialization but also enhance regional economic influence. Burundi also might experience an important increase over time while lower compared to Kenya and Ethiopia.

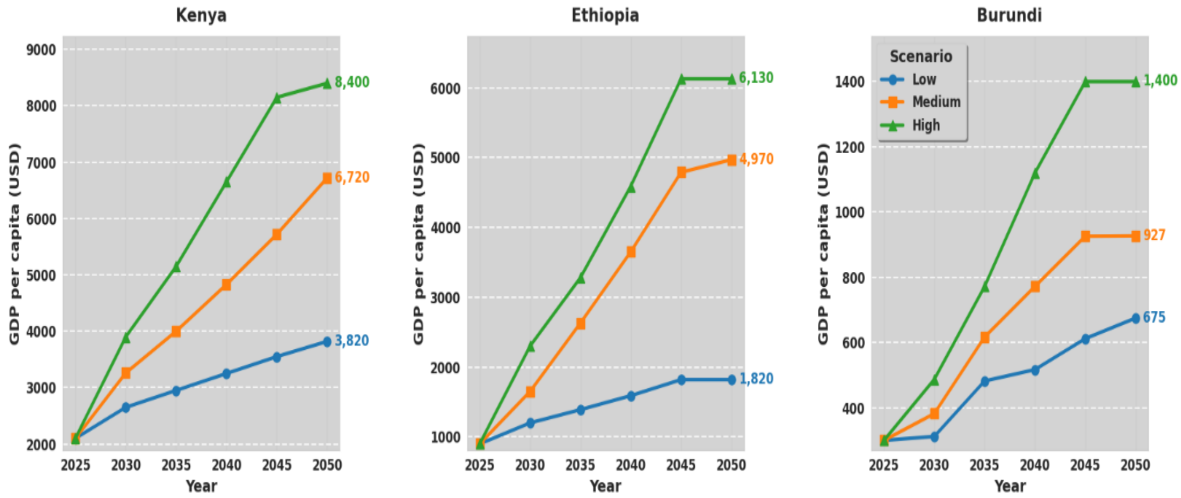

Figure 7:: Projected GDP per capita under each scenario in Kenya, Ethiopia and Burundi from 2025 to2050

This combination of rising population and income levels means energy demand will increase quickly, especially in Kenya and Ethiopia. It also shows how important it is for Burundi to catch up in both economic growth and energy access to meet the needs of its growing population.

These findings are consistent with recent studies showing that rising GDP per capita in East Africa is closely linked to higher energy demand. In Kenya, steady growth in income levels has supported rapid electrification and a projected annual demand increase of about 5.7% in the near future (IEA, 2024). Ethiopia has also experienced improvements in GDP per capita, which is driving higher electricity use as more households and industries gain access (World Bank, 2025a). On the other hand, Burundi's very low GDP per capita and limited progress in income growth have slowed energy access, leaving less than 12% of its population connected to electricity despite some increase in generation capacity (World Bank, 2024;). This shows how differences in economic growth strongly shape the pace of energy demand and access across the region.

3.3 Regression between GDP and electricity use

To better understand how electricity use relates to economic performance, this study carried out a regression analysis linking electricity consumption per capita with GDP per capita for a set of countries, including Kenya, Ethiopia, and Burundi. The results, presented in **Figure 8,** reveal a strong positive association: countries with higher electricity consumption per person also tend to have higher income levels. The statistical fit is very strong ($R^2 = 0.877$), meaning that almost 88% of the variation in GDP per capita within the sample can be explained by differences in electricity consumption.

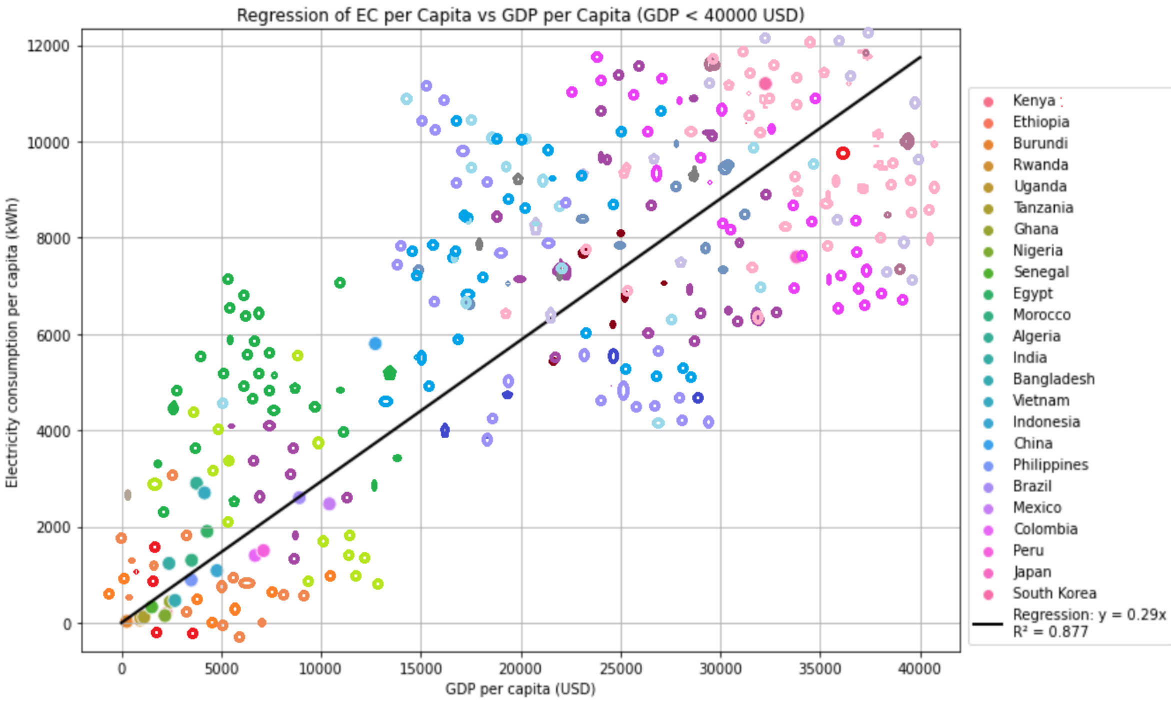

Figure 8: Regression between GDP per capita and electricity consumption per capita (2010–2023), showing a strong positive correlation ($R^2 = 0.877$)

This trend make sense because electricity is essential for economic and social progress. As households and firms gain reliable access, they are able to modernize production, expand services, and improve education and health outcomes all of which support higher income levels. Figure 8 shows this clearly: Countries like Kenya, Ethiopia, and Burundi are positioned in the lower-left of the chart, where both electricity uses and incomes are relatively low. On the other hand, middle income countries like Brazil and Mexico appear in the middle of the chart and developed economies such as South Korea and Japan are in the upper-right of the chart, with both high electricity consumption and high GDP per capita.

These findings are consistent with earlier research. Mmaga et al. (2023), Wolde-Rufael (2006) and Shahbaz et al. (2022), among others, have shown that electricity consumption and economic growth are strongly linked in Africa and other developing regions, though the direction of causality can vary. The World Bank (2022) also stresses that lack of reliable electricity is one of the main barriers to growth in low-income countries, particularly in sub-Saharan Africa.

At the same time, we should be careful when looking at these results. A simple regression shows a link, not proof that one thing causes the other. Higher incomes can lead to more electricity use, just because of electricity can support higher income allow countries and not only that electricity drives higher incomes. Other factors like good governance, trade, the type of industries a country has, and the level of education also play a big role in growth but are not included here here. On top of that, national averages can hide big differences. For example, electricity may help industry more than on agriculture, or benefit cities more than rural areas.

Even with these limits, the regression clearly shows that access to electricity is closely linked to development which is the central insights of this study. For Kenya, Ethiopia, and Burundi, as for the whole region of East Africa expending reliable electricity supply is therefore not only about energy, it is key for economic growth. Policies that combine electrification with industrial upgrading, education, and investment in human capital are likely to produce the strongest growth outcomes.

3.4 Electricity demand forecasting results

Father more, Electricity demand in Kenya, Ethiopia, and Burundi is expected to rise quickly between 2025 and 2050.Figure 9 shows that all three countries will use more electricity over time, but the speed and scale is very different. Kenya is likely to stay ahead with the highest level of demand, thanks to its stronger economy and more advanced industries. Ethiopia also shows fast growth, driven by its ambitious development plans and growing population. Burundi’s demand rises more slowly, but the increase is still important compared to its very low starting point. These trends show both the chances and the challenges in making sure energy growth supports economic progress in a fair and sustainable way.

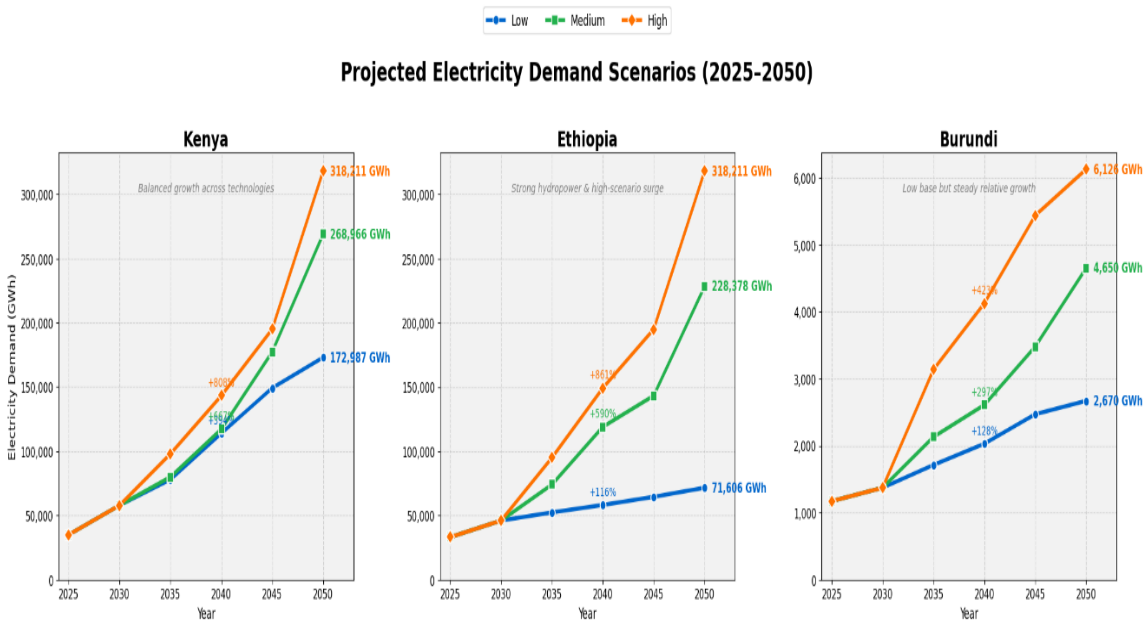

Figure 9: Projected Electricity Demand under each scenario from 2025 to2050

In Kenya, demand rises sharply in every scenario, with total consumption projected to exceed 300 TWh by 2050 in the high-growth case. This reflects both population growth and continued industrialization, supported by government strategies that aim to expand manufacturing and electrify transport. Ethiopia's demand increases even more dramatically, potentially reaching 350 TWh by 2050 under the high scenario, driven by its large population and fast economic growth. Burundi's increase is smaller in absolute terms but still significant: from a very low base today, demand could grow almost ten time by 2050.

These projections match what other major reports are saying about the region. Both the International Energy Agency (IEA, 2023) and Enerdata (2023) agree that African power demand is set to rise quickly as incomes increases and more people get access to power. Kenya's national energy plan expects to triple electricity capacity by 2030, which supports the growth seen in this study. Ethiopia's energy needs are also expected to grow faster than most neighboring, thanks to its strong reform plan (RES4Africa ,2023). which predict that the country's electricity needs will grow faster than most of its neighbors due to its ambitious economic reforms. For Burundi, the World Bank (2022) says there is good potential for demand to grow if access improves, but warns that weak institutions and limited funding could slow things down.

A key insight here is that electricity demand will grow much faster than population alone**,** highlighting the importance of economic growth, industrialization, and electrification policies. The results confirm what other studies have also shown: without major investment in generation and grid infrastructure, East African countries risk falling short of future demand.

The demand projects in this study relies on the relationships between electricity consumption, GDP, and population, offering a reasonable projection of future trends. However, this approach has limitations. It assumes that historical patterns will continue, despite potential changes from new technologies or efficiency improvements could alter ho electricity usage. It also doesn’t consider unexpected events like political instability, droughts, or global crises that might slow growth. Lastly, the forecasts presume continuous power availability , but in reality, shortages and blackouts could hold back actual demand.

3.5 Renewable energy supply potential and gap analysis

3.5.1 Renewable electricity supply potential (2024)

In 2024, Kenya, Ethiopia, and Burundi each displayed different levels of renewable energy potential, reflecting differences in their natural resources and geographic conditions. The total electricity that could be produced from available solar, wind, hydro, and geothermal sources was estimated using the most recent national datasets together with realistic capacity factors for each technology. The assessment makes it clear that Ethiopia stands out with the highest renewable energy potential, largely due to its abundant hydro resources and emerging opportunities in wind and geothermal energy. Kenya ranks second, benefiting especially from significant geothermal capacity along the Rift Valley and strong solar prospects. Burundi, on the other hand, has comparatively limited resources, giving it the smallest renewable energy potential among the three, though small-scale hydro and solar could still play an important role in meeting its domestic needs. These findings, summarized in Table 5, emphasize both the opportunities for large-scale development and the importance of tailored energy strategies for each country.

Table 5 : Estimation of the maximum renewable electricity generation in GWh for each country and each energy type in 2024.

Country	Solar (GWh)	Hydro (GWh)	Wind (GWh)	Geothermal (GWh)	Total Renewable (GWh)
Kenya	26,280	21,936	3,679	74,460	126,355
Ethiopia	26,280	157,680	4,137	49,056	237,153
Burundi	158	4,466	N/A	N/A	4,624

3.5.2 Gap between supply and demand (2025–2050)

When future electricity demand is compared with the projected supply from renewable energy, a clear picture emerges: the region's renewable resources, although abundant, are not being developed quickly enough to keep pace with demand. As illustrated in **Figures 10–12**, all three countries face a widening gap between what they could potentially generate and what their economies and populations are likely to require.

In Kenya, Figure 10 shows that energy need increases widely in all scenarios, thanks to the country's development and expending cities. Under the Low demand scenario, Kenya's full renewable energy potential is sufficient to meet much of the electricity demand, helping the country maintain a clean energy trajectory. However, under the Baseline and High demand scenarios, starting around the mid-2030s, renewable energy generation begins to struggle to keep pace with rising demand. The percentage of electricity demand covered by renewable sources falls below 100%, signaling emerging gaps in electricity supply capacity. This shortfall indicates that Kenya must plan proactively to expand renewable capacity or integrate additional energy sources, such as enhanced grid infrastructure, energy storage solutions, or complementary fossil fuels with low emissions, to avoid future power shortages. Given Kenya's goal to generate nearly 100% of its electricity from clean sources by 2030, addressing these potential supply gaps is critical, especially if demand grows at a faster rate than expected due to industrial expansion, urbanization, and increased household electricity use. Strategic investments and policy support will be essential to sustain the growth in electricity availability without compromising environmental commitments and economic development goals.

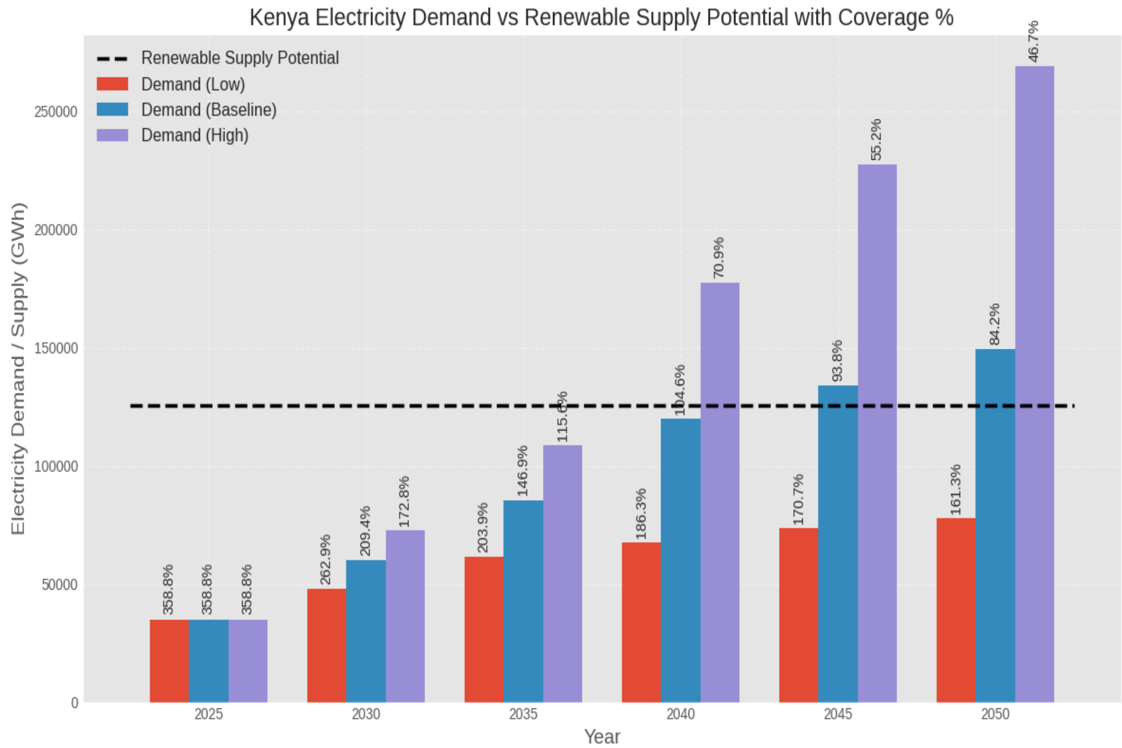

Figure 10 : Investment projections for renewable energy technologies in Kenya under different scenarios, compared with the Policy Priority Index scores

Ethiopia shows a similar but even more urgent pattern (Figure 11). Electricity demand rises very steeply, particularly under the Baseline and High scenarios, reflecting the country's rapidly growing population and fast-paced economic development. As a result, the full renewable potential is able to cover a smaller share of the demand much earlier, with noticeable supply gaps emerging well before 2040. The coverage percentage declines quickly thereafter, underscoring the mounting pressure on the country's energy system and the limitations of relying solely on existing renewable capacity. This trend highlights the critical need for Ethiopia not only to invest in additional large-scale energy infrastructure but also to diversify its energy mix by integrating complementary sources such as natural gas, regional power trade, or advanced storage solutions. Proactive investment and early planning will therefore be essential to avoid electricity shortages, ensure system resilience, and sustain the country's economic momentum.

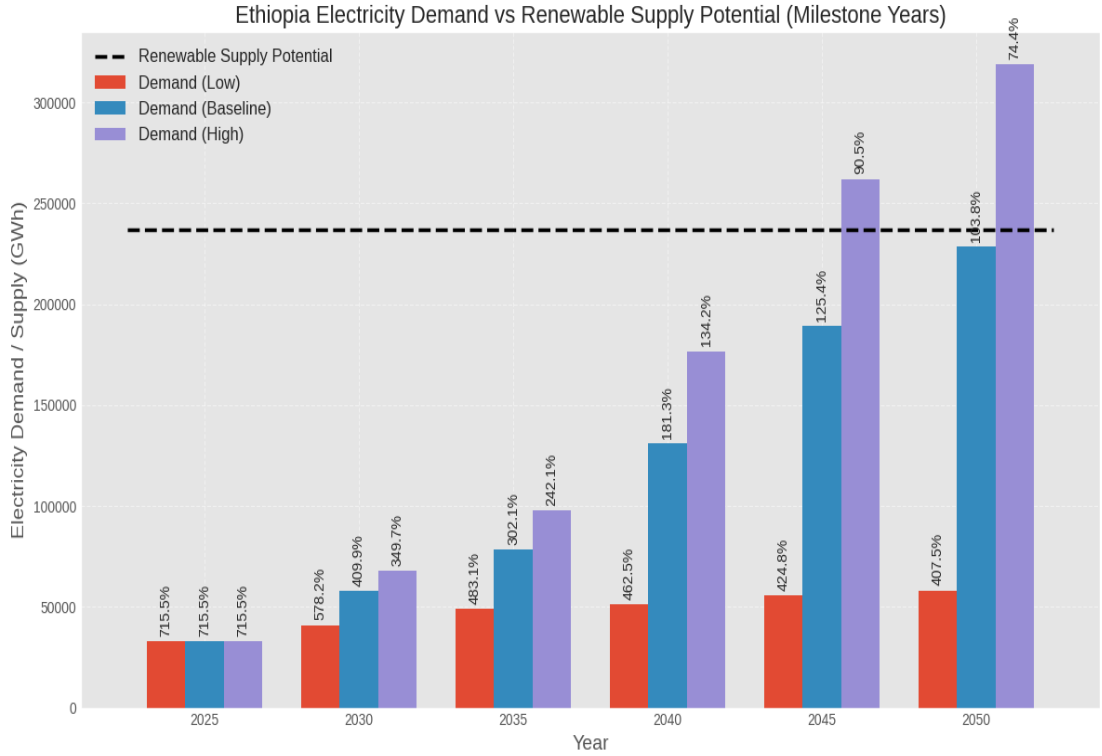

Figure 11:Ethiopia electricity demand (Low, Baseline, High scenarios) vs exploitable renewable potential (2025–2050), with percentage coverage labeled for each scenario and year

Burundi's situation is different from Ethiopia and Kenya because it has smaller electricity demand and a less developed economic activity. Figure 12 shows that in the low and baseline scenario can meet or even exceed demand up to 2050. This means Burundi could stay mostly self-sufficient if growth is moderate. However, in the High scenario, demand eventually exceeds renewable supply, especially in later years, creating a risk of power shortages. This shows that while the current renewable potential is enough for moderate growth, Burundi will need to expand capacity, improve transmission, and diversify energy technologies to keep up with faster demand increases and ensure reliable electricity.

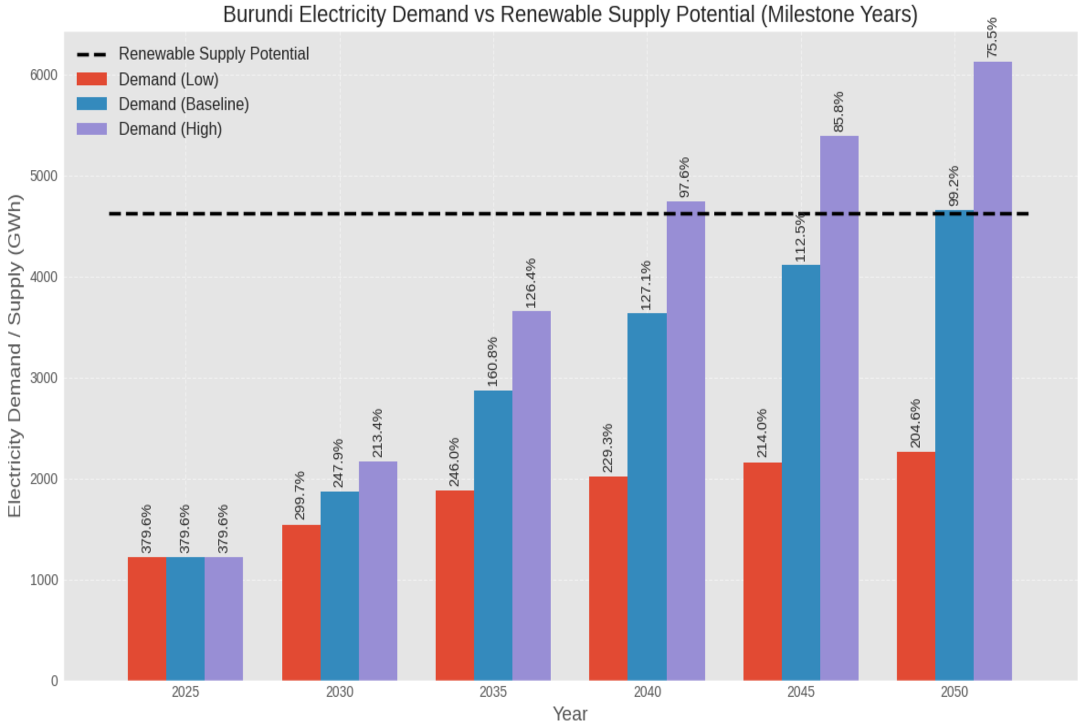

Figure 12:Burundi electricity demand (Low, Baseline, High scenarios) vs exploitable renewable potential (2025–2050), with percentage coverage labeled for each scenario and year

3.5.3 Discussions and implications

These differences show why energy planning must consider different demand scenarios. When demand first exceeds renewable capacity, it signals the needs for new investments in clean energy, grid upgrades, or alternative power sources. Years when coverage goes above 100% indicate potential surpluses that could be used for exports or expending electricity use in other area.

From a policy perspective, these findings help governments balance managing demand with increasing renewable capacity. They demonstrate the importance of efficiency, new technologies, and regional energy trade, as well as the need for flexible systems that can handle uncertainties and ensure reliable electricity as countries grow.

Overall, this detailed comparison of electricity demand against full renewable potential offers practical guidance for future energy planning. It points out when and where energy shortfalls or surpluses may happen, helps time investments properly, and supports making robust policies for sustainable electricity access and climate goals in East Africa.

These findings are consistent with earlier research. The International Renewable Energy Agency (IRENA, 2023) and Ndayishimiye et al. (2025) stresses that, across Africa, meeting future demand will require not only expanding renewable capacity but also strengthening transmission networks and investing in storage. Similarly, Cai et al. (2024) and the IEA (2022) notes that demand growth across sub-Saharan Africa is likely to exceed supply unless countries accelerate project implementation and regional power trading. In other words, the gap we observe here is not unique to these three countries but reflects a broader challenge for the whole region.

The results indicate that maintaining a “business as usual” will not be enough to meet the rising electricity demand in East Africa. If investments stay at current levels, East Africa will struggle to meet growing electricity demand. Bridging this gap will require faster renewable energy development, regional cooperation through power pools, and additional measures like energy efficiency and storage technologies to ensure reliable supply and sustainable growth.

3.6 Environmental Impact: CO_2 emissions reduction potential

Electricity generation using fossil fuels produces a large amount of carbon dioxide (CO_2), which harms the environment and contributes to climate change. This section shows how much CO_2 emissions can be avoided if countries meet their growing electricity demand using renewable energy instead of fossil fuels. The focus is on showing the differences between the Low, Baseline, and High scenarios, and highlighting which countries can save the most emissions between 2025 and 2050.

3.6.1 Emissions avoided by country and scenario

The results show that Kenya and Ethiopia have the highest potential to avoid CO_2 emissions thanks to their growing electricity demand and renewable energy capacity.

In Kenya, Figure 13 shows that avoided emissions increase a lot over time, thanks to both higher electricity demand and a bigger share of renewables in the energy mix. By 2050, the country could cut about 27 million tonnes of CO_2 in the Low scenario and up to 188 million tonnes in the High scenario. This big difference shows how much emission cuts depend on strong investment in clean energy and reducing fossil fuel use. It also highlights Kenya’s potential to support global climate goals, improve energy security, and lower the risks of depending on fuel imports. In addition, large emission reductions could attract climate finance, carbon markets, and clean investments, helping the country grow sustainably and build long-term resilience.

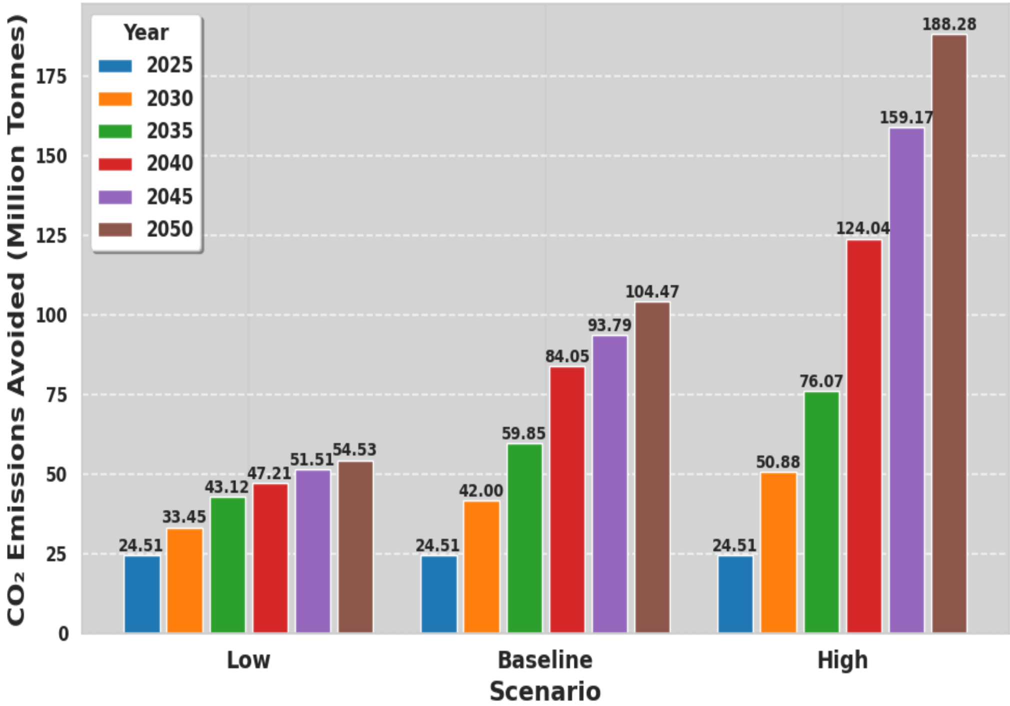

Figure 13: CO2 emissions avoided in Kenya by year under each Scenario

In Ethiopia (Figure 14), the potential emissions savings are even more substantial, reflecting the country's rapid population growth, accelerating industrialization, and abundant renewable resources. In some cases, the avoided emissions could reach over 150 million tonnes by 2050 in the High scenario, making Ethiopia one of the region's leading contributors to climate mitigation through clean energy expansion. This large potential arises from both the sheer scale of future electricity demand and the opportunity to meet much of that demand with low-carbon sources such as hydro, wind, and geothermal power. Achieving these emission reductions could position Ethiopia as a key player in regional energy trade by enabling the export clean electricity to neighbouring countries. It could also attract climate finance and new technologies, while improving electricity access at home, supporting industry, and promoting long-term sustainable development.

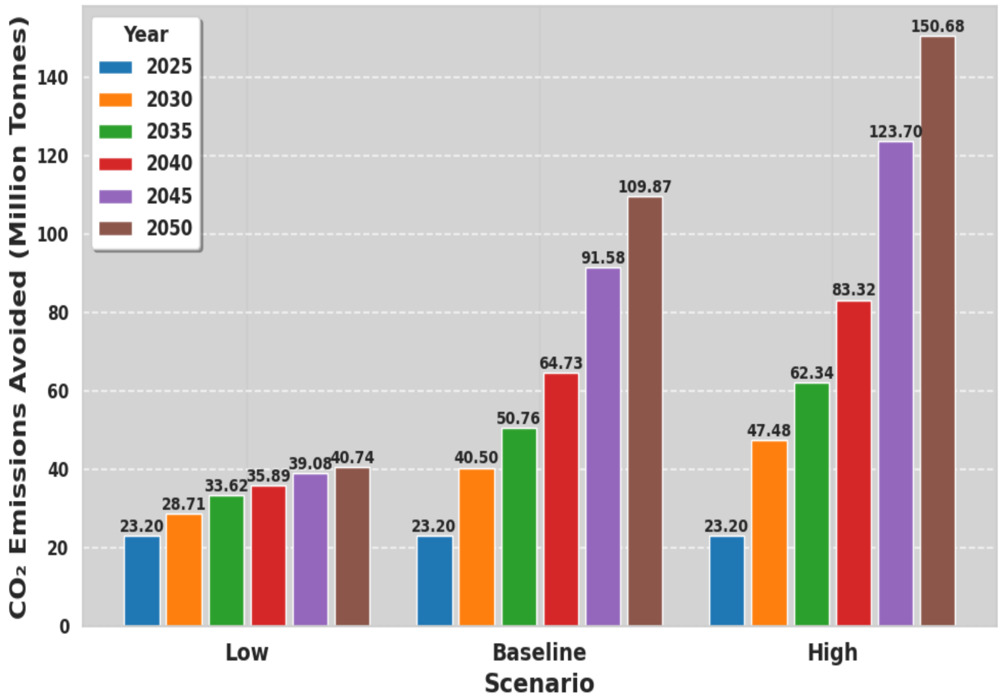

Figure 14:CO2 emissions avoided in Ethiopia by year under each scenario

In Burundi, as shown in Figure 15, the overall electricity demand is much lower compared to Ethiopia and Kenya, yet the country still demonstrates meaningful progress in reducing emissions through renewable energy deployment. Even under the High scenario, Burundi could avoid more than 4 million tonnes of CO_2 by 2050, which, while smaller in absolute terms, represents a significant achievement relative to the country's size and current energy system. These avoided emissions highlight the importance of scaling up small-scale hydro, solar, and off-grid renewable projects, which play a central role in meeting local electricity needs sustainably. Moreover, by pursuing clean energy pathways early on, Burundi has the opportunity to "leapfrog" reliance on fossil fuels, avoiding the lock-in of carbon-intensive technologies that other nations have faced. Beyond environmental benefits, the steady gains in avoided emissions can also help attract international climate finance, enhance rural energy access, and strengthen resilience against global fuel price shocks, thereby supporting both sustainable development and climate commitments.

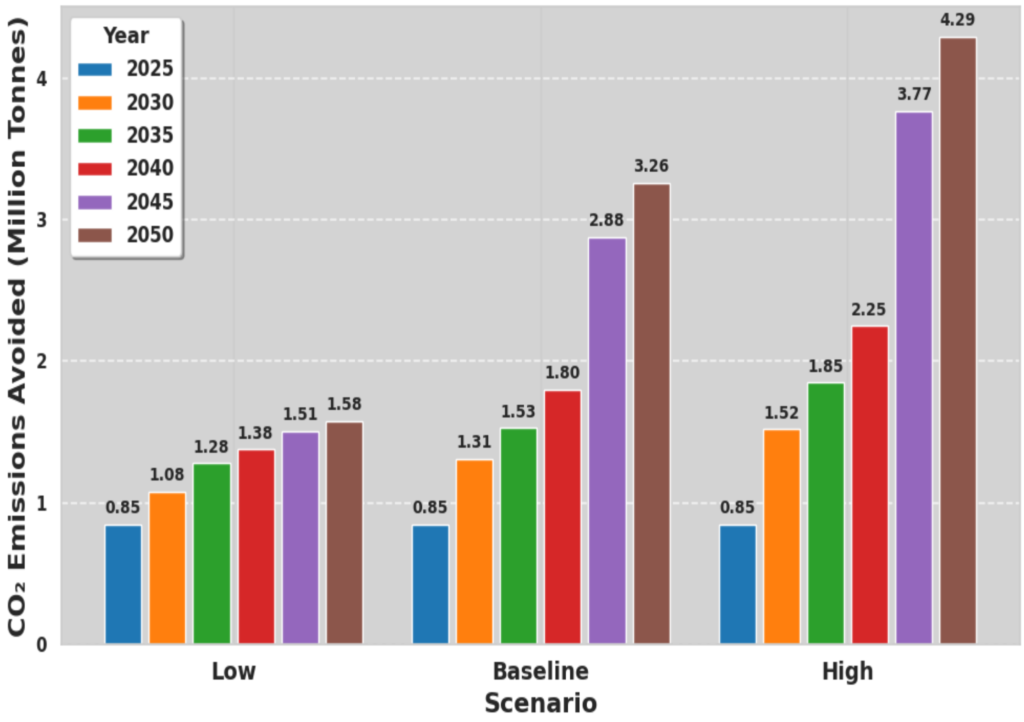

Figure 15: CO2 emissions avoided in Burundi by year under each scenario

3.6.2 Discussions and implications

These results fit well with what other studies have found. The IEA (2023) and Jean d'Amour and Boudjella (2016) notes that East Africa's electricity sector could become almost carbon-neutral by mid-century if planned renewable projects are realized. Similarly, the World Bank (2022) stresses that countries like Kenya and Ethiopia are in a strong position to cut emissions without compromising economic growth because their energy systems are already largely renewable. Research by Oteng et al. (2024) and the Global Carbon Project (2023) also points out that while Africa's share of global emissions is small, its choices today will determine whether future growth is low-carbon or carbon-intensive.

The broader message here is clear: expanding renewables is not just about meeting demand it is also about avoiding a rise in emissions as these economies grow. By 2050, the difference between a renewable-based pathway and a fossil-fuel-based pathway could mean tens of millions of tonnes of CO_2 saved.

These estimates give a useful idea but should be seen as rough approximations, not exact numbers. They assume the carbon intensity of fossil fuels stays unchanged , even though new technologies or fuel switching could change emissions. They also only look at electricity generation and ignore other major sources like transport, industry. So, the results show the overall trend rather than precise amounts.

3.7 Investment needs and policy influence on renewable energy expansion

3.7.1 Investment requirement Estimation by Scenario

The investment needs for renewable energy deployment vary significantly across countries, technologies, and economic growth scenarios.

In Kenya, Figure 16 shows a more varied investment picture compared to other East African country. Geothermal energy stands out as the largest investment, thanks to the country's rich Rift Valley resources and strong national policies that support its development. In the Low scenario, investment requirements already grow markedly, rising from 3.18 billion USD in 2025 to around 14.0 billion USD by 2050, with hydropower, wind, and solar PV playing smaller but steady roles in complementing base-load supply. The Medium-growth scenario accelerates this trend further, pushing geothermal investment to about 23.65 billion USD by 2050, while hydropower also grows substantially to 7.28 billion USD, indicating Kenya's ability to expand its renewable portfolio more evenly across multiple sources. The High-growth scenario is the most ambitious, requiring nearly 30.0 billion USD for geothermal development alone by mid-century, alongside significant scaling of wind, solar, and hydro assets. This trajectory highlights how Kenya's supportive policy framework and early investments in geothermal capacity enable it to lead in scaling high-potential technologies, while also maintaining a relatively balanced energy mix. At the same time, the widening gap between the Low and High scenarios underscores the scale of the emerging financing challenge, suggesting that mobilizing both domestic resources and international investment will be critical to achieving the country's ambitious clean energy plans.

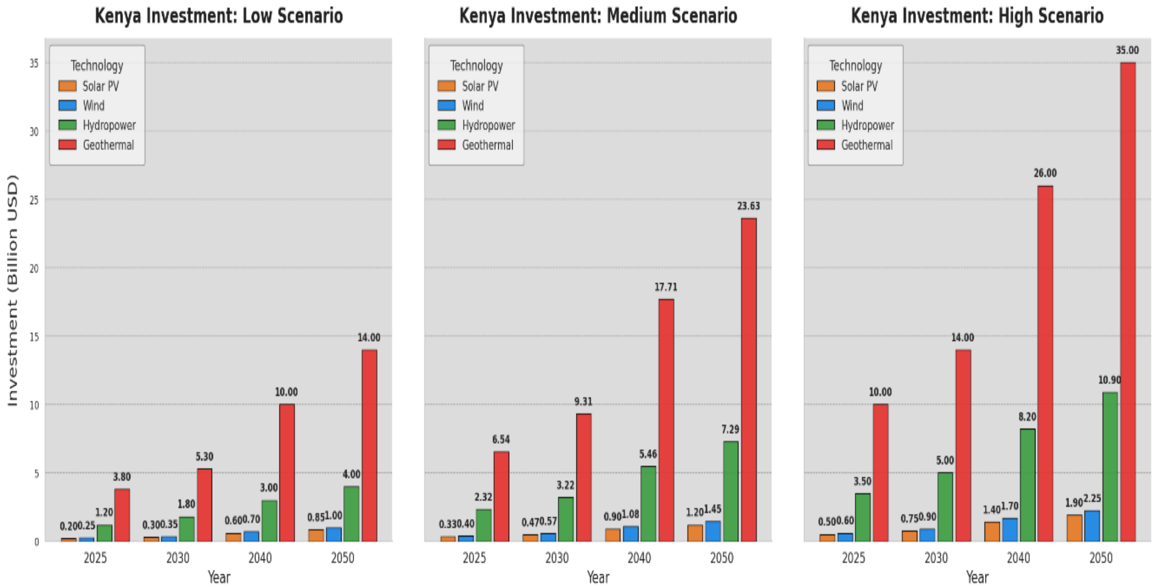

Figure 16 : Kenya investment required by sustainable energy technologies from 2025 to 2050 under Low, Medium, and High Scenarios. Investments (in billion USD)

In Ethiopia**,** the investment profile is heavily dominated by hydropower**,** which aligns with the country's vast untapped river systems and its proven track record of pursuing large-scale dam projects. In the Low scenario, required investment already risen steeply, starting at around 3.3 billion USD in 2025 and climbing to nearly 29.7 billion USD by 2050. The Medium scenario more than doubles this requirement, reaching about 58.4 billion USD for hydropower alone by 2050, while also introducing a significant role for geothermal energy**,** with projected investment needs of 15.5 billion USD**.** The High-growth scenario is even more ambitious, pushing hydropower financing requirements to nearly 70.0 billion USD and geothermal to around 19.0 billion USD by mid-century. Figure 17 highlights Ethiopia's continued reliance on large-scale hydropower projects as the backbone of its electricity mix. However, it also emphasizes the strategic importance of geothermal investments for diversifying supply, providing baseload stability, and managing seasonal hydrological risks linked to climate variability.

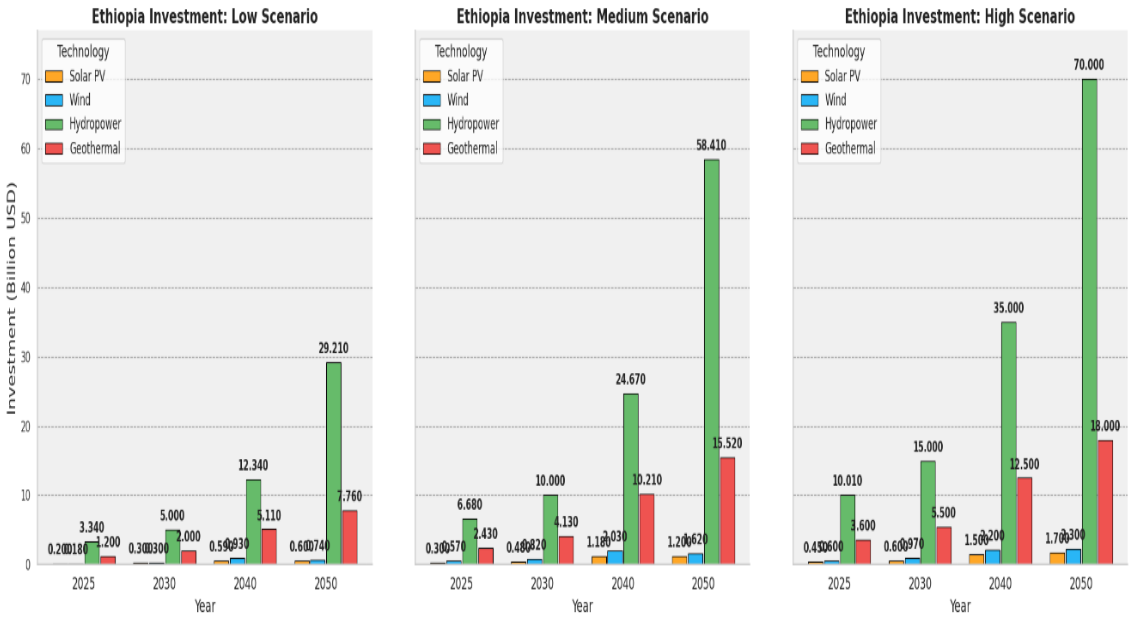

Figure 17:Ethiopia investment required by sustainable energy technologies from 2025 to 2050 under Low, Medium, and High Scenarios. investments (in billion USD)

In Burundi (Figure 18), most renewable energy investments will focus on hydropower in all future scenarios. The study shows that under low economic growth, investment in hydropower would grow from about $0.22 billion in 2025 to $0.83 billion by 2050, with very little spent on solar and almost none on wind or geothermal energy. In medium growth scenarios, hydropower investments increase to $1.65 billion, and in high growth, they reach $2.2 billion, still mainly for hydropower. This means Burundi should focus on expanding hydropower sustainably while also encouraging solar and wind development to make the energy supply more reliable.

The disparities between Low, Medium, and High Scenarios are less important than Ethiopia's but still demonstrators a triple increase in hydropower investments by 2050 from low to high scenarios. Given Burundi's scale and economic context, these investment volumes point out the critical role of external financing and innovative off-grid solutions in achieving electrification goals.

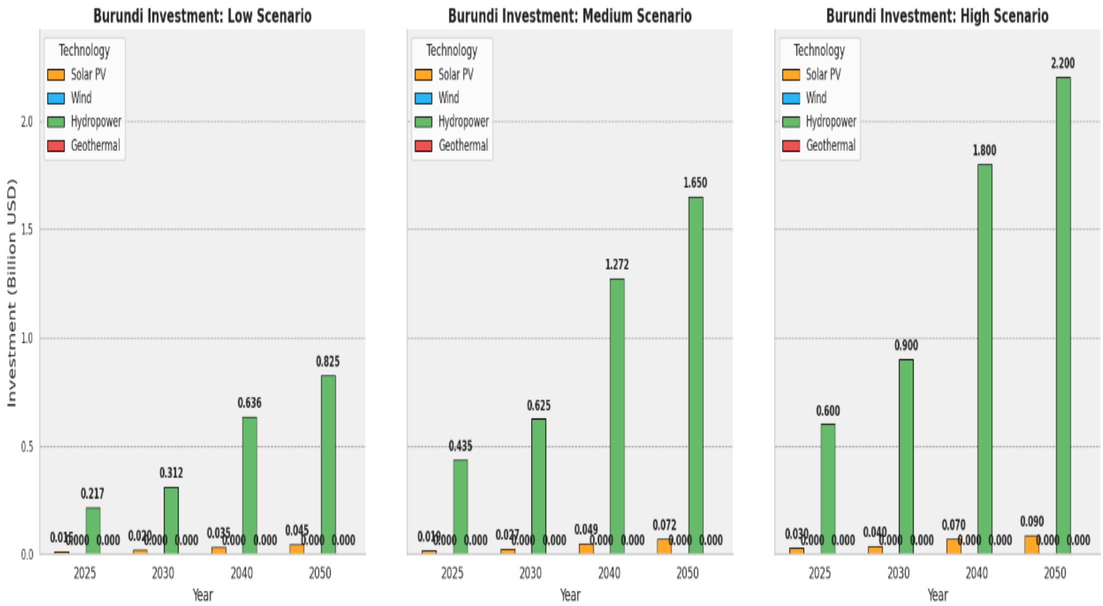

Figure 18 : Burundi investment required by sustainable energy technologies from 2025 to 2050 under Low, Medium, and High Scenarios. investments (in billion USD)

3.7.2 Discussion and implications

These results align with earlier research. The International Renewable Energy Agency (IRENA, 2023) estimates that sub-Saharan Africa will need over USD 2 trillion by 2050 to meet energy transition targets, with East Africa representing a major share due to its growing population and demand. The African Development Bank (2022) also stresses that mobilizing private investment will be critical, since public funds alone cannot close the gap. In Kenya, studies (e.g., Mellaku et al., 2025) highlight those favorable policies and public–private partnerships have already attracted significant geothermal investment, but more work is needed to replicate this success in wind and solar. Ethiopia's heavy reliance on concessional loans for hydropower has been flagged as a risk by RES4Africa (2023), suggesting that a broader investment mix is needed. For Burundi, donor financing remains the main driver, but weak institutions and political instability limit absorption capacity, a point repeatedly emphasized in World Bank (2022) reports.

While this analysis highlights broad investment needs, the estimates are not based on a detailed cost–benefit model. Instead, they are derived from projections of demand and indicative costs of renewable technologies. This means the figures should be seen as orders of magnitude rather than precise forecasts**.** In addition, the study does not fully account for the complexity of financing such as interest rates, debt sustainability, or risks of cost overruns. Finally, the political and institutional context, which often determines whether investments succeed or fail, is only discussed qualitatively here.

3.7.3 Alignment between policy priorities and investment projections

A key question in assessing the future of renewable energy in East Africa is whether the stated policy ambitions of each country are realistically matched by the scale of investment projected in this study. By comparing the Policy Priority Index (Table 6) with the investment outlook across technologies (Figure 19), it becomes possible to see how far intentions and resource requirements are aligned.

Table 6 shows the policy priority index and provides qualitative descriptions of the renewable energy policy environments in Kenya, Ethiopia and Burundi. This table serves as a useful reference for understanding the policy context basis the investment projections of the baseline scenario shown in Figure 19.

Table 6:Policy priority index scores and qualitative assessment of renewable energy policy frameworks in Burundi, Kenya, and Ethiopia

Country	Policy Priority Index (1–5)	Qualitative Description of Renewable Energy Policy Landscape
Burundi	2	Limited electrification plan; weak regulatory capacity; insufficient financing mechanisms; reliance on donor-driven initiatives.
Kenya	4	Strong policy frameworks (Energy Act 2019); robust investment in renewable projects (geothermal, wind, solar); clear NDC targets.
Ethiopia	5	Ambitious national electrification program; high policy coherence; diversified targets (hydropower, wind, solar); strong state support.

These differences are illustrated in Figure 19, which presents the renewable energy investment projections by country, scenario, and technology, alongside the policy priority scores. This figure visually contextualizes the scale and composition of investment needs while highlighting the variation in policy ambitions across the three countries.

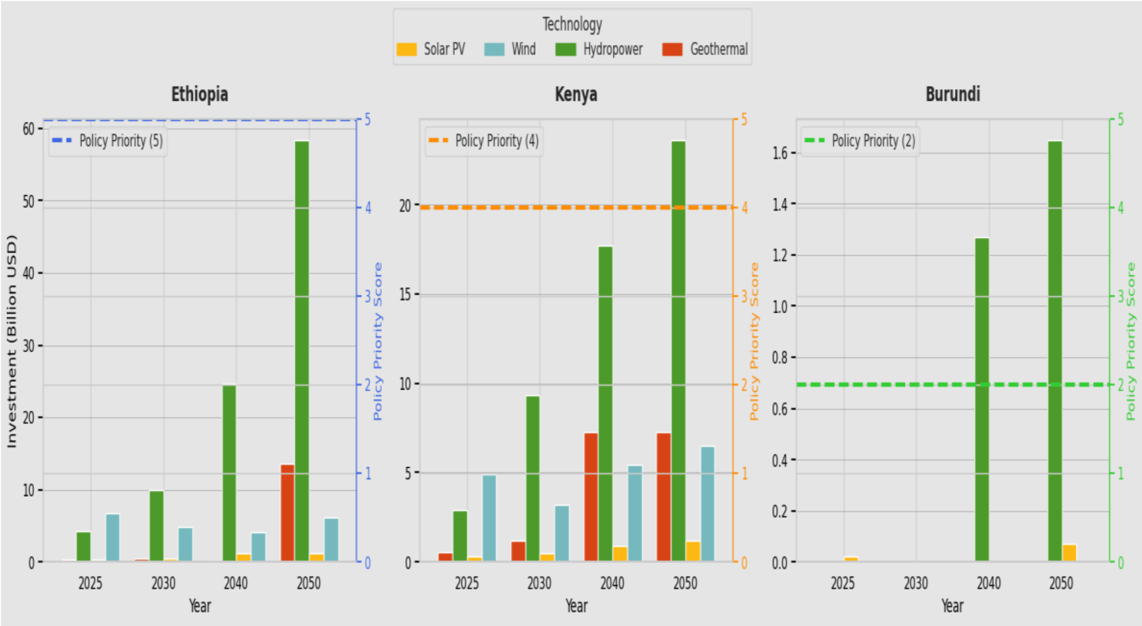

Figure 19:Investment projections for renewable energy technologies in Kenya, Ethiopia, and Burundi under the baseline scenario, compared with the Policy Priority Index scores

The results reveal a broad but uneven pattern of alignment**. Ethiopia,** which recorded the highest policy score, also shows the largest projected investment needs, dominated by hydropower expansion. This reflects the government's long-standing strategy of large dam construction and regional power exports. The finding is consistent with earlier analyses by Tadesse and Rashid (2024) and RES4Africa Foundation (2023), which emphasize Ethiopia's strong policy commitment but also caution that over-reliance on hydropower exposes the sector to climate risks such as drought.

Kenya also demonstrates good consistency between policy priorities and projected investments. Its diversified investment outlook spanning geothermal, wind, solar, and hydropower reflects a deliberate strategy to balance resources. This aligns with IRENA (2023) and IEA (2022) assessments, which highlight Kenya's success in creating a favorable regulatory framework that has already attracted significant private investment, especially in geothermal. Previous studies also note that diversification improves resilience, this is supported by Mellaku et al. (2025), who underline that Kenya's balanced approach reduces exposure to single-technology risks.

On the other hands, Burundi has a lower policy score and only modest investment plans, mostly focused on small hydropower. This shows limited ambition rather than strong alignment with energy goals. Similar points are made by Nkurunziza and Murekezi (2023) and the Oxford Institute for Energy Studies (2022), which note that weak governance, low institutional capacity, and financial constraints make it hard for Burundi to attract major energy investments

Overall, the comparison shows that countries with stronger and more credible policies tend to have higher and more varied investment plans. However, having good policies on paper does not always mean projects are delivered. For example, RES4Africa (2023) and AfDB (2022) note that Ethiopia's big hydropower projects often face cost overruns and delays, while the World Bank (2022) points out that countries with weaker capacity, like Burundi, struggle with implementation. Even in Kenya, where policies are strong, financing problems and land issues can slow project progress.

The results reinforce the conclusion of previous work like Kolawole (2024) that credible policies are a necessary but not sufficient condition for investment mobilization. To turn ambition into results, countries need to enhance governance, reduce investment risks with guarantees or blended finance, and set up clear project pipelines that attract private investors. Regional cooperation, especially through the EAPP, can also make projects more attractive by creating larger, integrated energy markets.

While useful for broad assessment, the Policy Priority Index is a simplified measure that cannot fully capture the complexity or credibility of national policies. Investment projections also assume smooth policy implementation and do not fully reflect financing constraints, debt sustainability, or social and environmental barriers. As highlighted by earlier studies (IRENA, 2023; World Bank, 2022), these factors often prove decisive in determining whether policy ambition leads to real investment.

Partial Conclusion

This chapter shows that Kenya and Ethiopia are moving faster in renewable energy development than Burundi, mainly because they have stronger policies and more diverse investment plans. Electricity demand is expected to rise in all three countries, but only Kenya and Ethiopia seem ready to meet it, while Burundi risks falling behind. The regression analysis confirms a strong link between electricity use and economic growth, although the relationship is complex. Comparing policy priorities and investment plans also shows that higher ambition usually comes with larger investment needs, but good implementation is not guaranteed.

Overall, the findings reinforce previous research highlighting both opportunities and risks in East Africa’s energy transition. At the same time, limitations such as using secondary data, simplified measures, and linear projections mean these results should be interpreted as indicative rather than definitive. In summary, expanding sustainable energy offers a clear path to economic growth and lower emissions, but achieving success will require strong policies framework, diversified investments sources , and better implementation capacity.

GENERAL CONCLUSION AND PERSPECTIVES

This thesis set out to investigate the role of sustainable energy in fostering economic growth in East Africa, with a particular focus on Kenya, Ethiopia, and Burundi. The research was motivated by the pressing need to understand how renewable energy development can both respond to the region's rising electricity demand and contribute to broader development objectives such as poverty reduction, industrialization, and climate change mitigation. By combining statistical analysis, scenario-based forecasting, and a comparative study of country experiences, the work sought to determine whether renewable resources are sufficient to meet future needs, what level of investment would be required, and how policy frameworks influence the feasibility of such a transition.

The analysis reveals clear differences in the current energy and economic situations of the three countries. Kenya, with its mix of renewable energy sources and strong policies, shows how robust planning and investment can lead to better electricity access and steady economic growth. Ethiopia, despite facing uneven access, benefits from its vast hydropower resources and clear policies enabling large-scale projects to move ahead. Burundi, on the other hand, struggles with low access, limited infrastructure, and weaker policies, which hold back both investment and growth. These results underscore a strong positive correlation between energy availability and economic performance, as the regression analysis shows a strong positive connection between electricity consumption per capita and GDP per capita highlighting that improving electricity access and usage effectiveness is closely linked to stronger economic outcomes in these countries.

When projecting future demand under various growth scenarios, the analysis indicates that indigenous renewable resources are in principle sufficient to meet rising needs, but only if investment is scaled up significantly. In Kenya and Ethiopia, renewables can cover most of the demand increase under low and medium growth scenarios while in the high scenario shortfall might occurs. In Burundi, however, large supply–demand gaps remain, pointing to the urgent need for accelerated capacity additions and deeper reforms. Importantly, the emissions analysis confirmed that East Africa remains a low-carbon region in absolute terms. Even under higher demand projections, the expansion of renewables would keep per-capita emissions modest, reinforcing the idea that the region can industrialize without repeating the carbon-intensive pathways of other parts of the world.

The investment analysis gives more insight into energy needs. Higher growth requires much more capital two to three times more than lower-growth scenarios. Ethiopia, with its big hydropower projects, needs the most investment overall, while Kenya spreads its needs more evenly across geothermal, wind, solar, and hydro. Burundi needs less total investment, but the real challenge is attracting any significant funding without stronger governance and rules. A key part of this study was creating a policy priority index, which proved useful. Countries that scored higher, like Ethiopia and Kenya, were better able to attract investment and carry out projects, while lower-scoring countries such as Burundi struggled to get enough funding.

Overall, these findings have important for both theory and practice. They emphasize that energy is fundamental to economic growth in East Africa, and that renewable energy is not just good for the environment, it is also vital for the economy growth. Planning energy access together with economic development is essential, and large projects need to be coordinated with institutional reforms and financing plans. Clear and consistent policies are also crucial to attract private and concessional funding. Finally, regional cooperation is important: cross-border projects, like the Ethiopia–Kenya electricity link, can lower costs, improve reliability, and help integrate renewable energy across countries.

The study is not without limitations. Data inconsistencies, particularly in the case of Burundi, constrained the precision of projections. The methodological choice of Excel-based scenario modeling enhanced transparency but could not fully capture the complexities of system operation, including hourly variability, grid stability, or the financial structuring of projects. These limitations suggest that future work should employ richer system models that integrate intermittency, storage, and transmission dynamics, as well as micro-level studies on the socio-economic impacts of decentralized energy solutions. Moreover, more research is needed on financial pathways that can crowd in private capital at the scale required by the projections developed in this thesis.

Looking ahead, the future of sustainable energy in East Africa is both challenging and promising. The region has abundant renewable resources that could support low-carbon, inclusive development, but achieving this requires several key actions:

- Strengthening governance and building credible policies to attract private and concessional investment.

- Diversifying energy sources, especially in Ethiopia and Burundi, to reduce climate and resource risks.
- Using innovative finance, such as blended funds and risk guarantees, to fill the investment gap.
- Expanding regional integration, turning national projects into regional assets and improving resilience.
- Improving research and monitoring, including models that track real-time trends and social aspects of energy access.

Overall, East Africa has the potential for economy growth while keeping a low-carbon development pathway by fully harnessing its renewable resources. Success will depend not only on resources availability, but also on strong policies, coordinated planning, and credible investment frameworks. Countries that align their ambitions with clear institutional and financial measures are best positioning to close energy access gaps and support inclusive economic growth. Ultimately, pursuing sustainable energy in East Africa is not only an environmental choice but also a strategic economic one. By putting renewable energy at the center of development plans, the region can achieve energy security, expand access, create jobs, cut emissions, and build a more resilient and prosperous future.

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