POWER ACROSS EAST AFRICA: TRENDS, CHALLENGE AND PATHWAYS TO UNIVERSAL ELECTRICITY ACCESS

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TETOUGUENI CYRILLE, MBA

Table of Contents

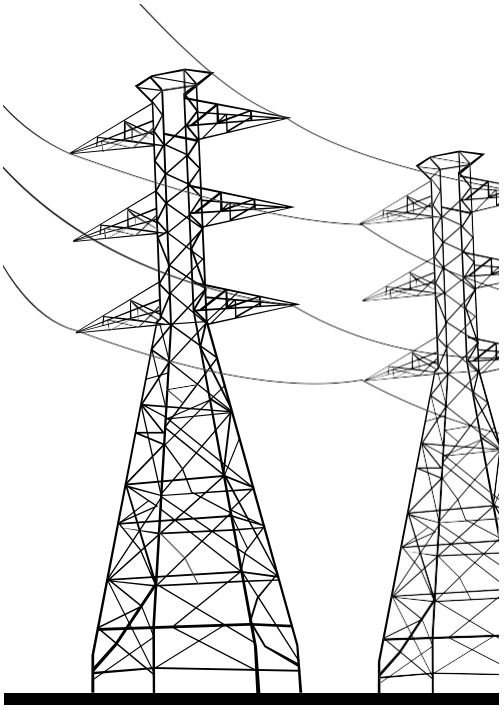
Introduction

Access to electricity is one of the pillars of global socio-economic development, poverty reduction and human well-being. Its transformative potential ranges from boosting production capacity and telecommunications to stimulating business growth and improving household livelihoods through better lighting and refrigeration.
However, despite recognition of its socio-economic importance, challenges persist, particularly in sub-Saharan Africa (SSA), where up to 70% of the world's population lives without electricity.

In East Africa, where the struggle for reliable and affordable electricity persists, a ground-breaking report highlights the complexities of the region's energy landscape. Produced as part of a pioneering initiative focusing on the East African region, this publication marks the start of a series aimed at dissecting access to electricity across Africa, region by region.

The report provides a meticulous analysis of the most recent data on access to electricity in the East African countries considered (EA-19), revealing the underlying causes of access difficulties. From the high connection costs that hamper rural electrification to the persistent problems of reliability and accessibility of services in urban and peri-urban areas, the report navigates through the complexities that stand in the way of progress.

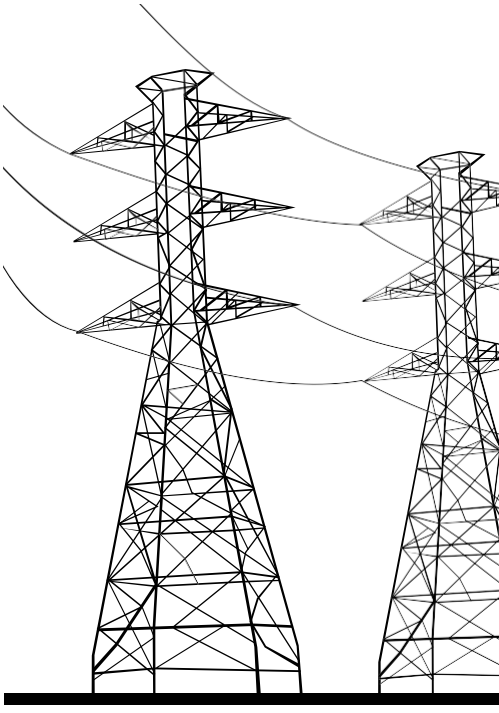
It also looks at the policy initiatives and reforms adopted by different governments to improve access to electricity. By examining the strategies and interventions in place, the report provides a comprehensive overview of efforts to overcome barriers to electricity access in East Africa.



Introduction

In addition, the report summarizes its findings in the form of concise country snapshots or overviews, offering a succinct description of the current state of electricity access in each EA-19 country. This collection of country profiles is a valuable resource, providing stakeholders with actionable information to inform decision-making and drive progress.

In essence, this report serves as a beacon of knowledge, illuminating the path towards universal access to electricity in East Africa. As the region faces the electrification imperative for economic growth, human development and sustainability, the information presented here paves the way for informed strategies and collaborative efforts to unleash the transformative power of electricity for all.



Foreword

Electricity is not just a commodity; it is the cornerstone of progress, a beacon that lights the way to socio-economic development and human fulfilment. In the diverse tapestry of East Africa, where cultures intersect and landscapes are fascinating, the quest for reliable and affordable electricity is a testament to the region's drive for progress.

In this report, we take a journey through the complex web of challenges and opportunities that shape the East African electricity landscape. From the majestic peaks of Ethiopia to the coastal lure of Tanzania, each nation in this dynamic region makes its own unique contribution to the wider story of energy access and resilience. Diving into the depths of East Africa's electricity sectors, we are confronted with a mosaic of generation sources, regulatory frameworks and socio-economic dynamics. From hydroelectric cascades to burgeoning wind farms, the range of energy sources reflects East Africa's wealth of natural resources and human ingenuity.

Yet amidst this diversity lies a common aspiration: to harness the transformative power of electricity to improve lives and livelihoods. Whether powering medical facilities in remote villages or businesses in bustling urban centres, electricity is the lifeblood of progress, flowing through the veins of development.

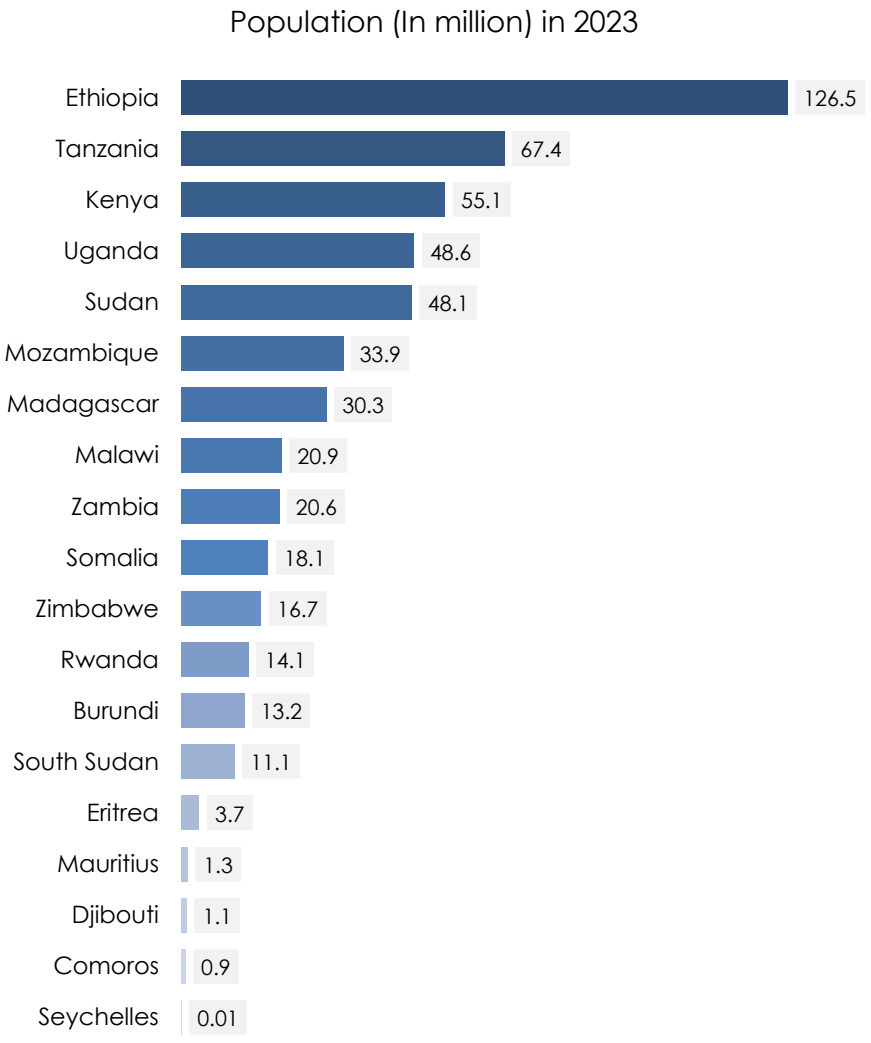
However, the road to universal access to energy is strewn with pitfalls. Inadequate infrastructure, regulatory constraints and disparities in electrification rates underline the urgent need for concerted action. Yet in the midst of these challenges lies an opportunity for collective effort, as nations unite in regional cooperation initiatives to chart a course towards a brighter, electrified future.

Over the pages of this report, we invite you to discover the untold stories of resilience and innovation that are shaping East Africa's electricity landscape. Together, let's light the way to a future where electricity knows no borders and where every corner of the region holds the promise of progress.

OVERVIEW

The East Africa Region, situated in the eastern part of the African continent, stands out as a dynamic and culturally diverse area, renowned for its distinct landscapes, cultures, histories, and political perspectives.

According to various sources, the region comprises up to 21 countries [1]. For the purpose of this report, East Africa (EA-19) is defined as encompassing 19 countries: Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Somalia, South Sudan, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe.

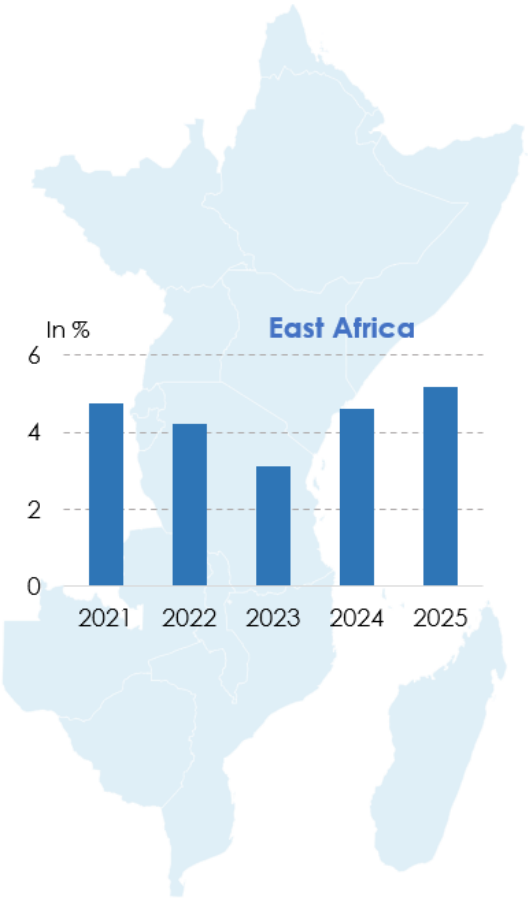


As of 2023, the population of East Africa was estimated at 515,095,836 inhabitants, reflecting a growth of over 30% in the past decade. Ethiopia, Tanzania, and Kenya are the most populous countries in the region, whereas Seychelles, the least populous, had only 10,766 inhabitants in 2023.

East Africa is renowned for its diverse geography, encompassing the Great Rift Valley with its mountains, lakes, and fertile lands, as well as savannahs, deserts, and coastal areas. The region's climate varies from tropical along the coast to temperate in the highlands. Notably, East Africa boasts rich biodiversity, with iconic sites such as the Serengeti Plains in Tanzania, famous for the annual wildebeest migration, and the Maasai Mara Reserve in Kenya. The region supports a wide array of wildlife and plant species, thriving within its numerous national parks and reserves.

From an economic standpoint, East Africa has become the continent's most rapidly advancing region in recent years. It is home to several of the fastest-growing economies, including Ethiopia, Djibouti, Kenya, Rwanda, Tanzania, and Uganda. According to data from the International Monetary Fund, the GDP of the 19 countries in the region has surpassed several trillion dollars, with Ethiopia and Kenya leading the way, collectively accounting for nearly half of the region's GDP.

In 2022, the mean of the real GDP growth of these 19 countries experienced a dropping from 4.77% to 4.22, though still surpassing Africa's average of 3.8% from AfDB analysis but falling short of Central Africa's 5.0% growth [2].



Fastest Growing Region Despite Recent Slowdown

East Africa has emerged as Africa's most rapidly advancing economic region, with real GDP growth of 4.22% in 2022—still outpacing the continental average of 3.8%.

Economic Concentration in Two Giants

Ethiopia and Kenya dominate the regional economy, collectively accounting for nearly half of East Africa's total GDP (which has surpassed several trillion dollars)

Services Sector as the Primary Growth Engine

The services sector has become the cornerstone of East Africa's economic expansion, contributing nearly 50% of the region's GDP growth in 2022.

Various factors contributed to this slowdown including global economic trends, rising consumer prices, adverse weather conditions, and increasing public debt. With 8.9% GDP growth recorded in 2022, Seychelles exhibited the highest GDP growth, driven by its thriving tourism, fisheries, and financial sectors.

In 2020, Tanzania became the latest country in East Africa to graduate from low-income to middle-income status, joining three of its neighbors—Kenya, Comoros, and Djibouti—in the World Bank’s lower middle-income category. Seychelles and Mauritius are classified as a high-income country, while the remaining countries in the region are classified as low-income.

The services sector emerged as a key driver of East Africa's GDP growth, accounting for nearly half of the region's economic expansion in 2022. The region's attractiveness to tourists, fueled by its natural and cultural assets, has spurred demand for services like hospitality and transportation, especially with urbanization and the rise of a middle class.

	Country	GDP [Billions $] in 2022	GDP trend 2018 - 2022	Real GDP growth [%] in 2022
	Burundi	3.918		1.8
	Comoros	1.237		2.6
	Djibouti	3.662		3.2
	Eritrea	NAN	NAN	NAN
	Ethiopia	120.369		6.4
	Kenya	113.701		4.8
	Madagascar	15.149		4
	Malawi	12.537		0.8
	Mauritius	12.898		8.7
	Mozambique	19.157		4.2
	Rwanda	13.309		8.2
	Seychelles	1.977		8.9
	Somalia	10.42		2.4
	South Sudan, Republic of	8.535		0.5
	Sudan	33.752		-2.5
	Tanzania	77.065		4.7
	Uganda	48.244		6.4
	Zambia	29.742		4.7
	Zimbabwe	31.49		6.2

Electricity Landscape

Electricity is a pivotal component of development within a nation, and in the East African region, it serves as a cornerstone for socio-economic progress across multiple countries. Its provision transcends mere convenience; rather, it stands as a fundamental catalyst for advancement, facilitating progress in various sectors crucial for elevating living standards, driving economic growth, and fostering sustainable development.

Access to reliable and affordable electricity is indispensable for key sectors such as healthcare, education, agriculture, industry, and communication in East Africa. It underpins the delivery of medical services, powers educational tools, amplifies agricultural productivity, propels industrialization, and promotes connectivity and digital inclusion. Ultimately, electricity emerges as a transformative agent, empowering individuals, igniting entrepreneurial endeavors, and propelling sustainable development throughout the region.

2.1 Introduction to the Power Sector in East Africa

The East African region stands as a mosaic of nations, each distinguished by its own economic trajectory, geographical characteristics, and energy reservoirs. Countries such as Ethiopia, Kenya, Tanzania, Uganda, Rwanda, Burundi, and South Sudan collectively constitute the East African region, with each contributing to the regional energy framework amidst a tapestry

of challenges and prospects.

In navigating the electricity landscape, these nations exhibit a diverse mix of generation sources, encompassing hydroelectric, thermal, solar, wind, and geothermal power. While certain countries benefit from ample renewable energy reservoirs, others heavily rely on thermal generation or external imports to fulfill electricity demand. Encountering hurdles such as insufficient infrastructure, limited rural electrification, and regulatory complexities, East Africa confronts formidable impediments in its quest for universal energy access and the maintenance of dependable, cost-effective electricity provision.

2.1.1 Electricity Generation

Electricity generation in East Africa is sustained by a diverse spectrum of resources, delicately balancing renewable and non-renewable reservoirs to meet the region's burgeoning energy demands. Hydropower, drawn from abundant water resources, stands as a cornerstone of electricity production, notably dominating the energy landscape in countries like Ethiopia, where it constitutes over 95% of the generation portfolio.

Thermal power plants, propelled by coal, oil, or natural gas, play a pivotal role in furnishing reliable baseload electricity and serve as a dependable fallback during periods of renewable energy scarcity. Renewable energy sources, progressively assuming greater significance, offer promising avenues for sustainable power generation. Solar, wind, and geothermal resources emerge as particularly promising alternatives.

Solar energy, tapped through both utility-scale projects and off-grid solutions, benefits immensely from East Africa's ample sunlight. Concurrently, wind power initiatives diversify energy sourcing, especially in coastal and highland regions. Geothermal energy, exploiting the geological bounty of the East African Rift System, significantly contributes to electricity generation, with Kenya's pioneering geothermal power plants exemplifying the region's prowess in this domain.

Furthermore, biomass and waste-to-energy technologies complement electricity generation efforts, particularly catering to the energy needs of rural communities. This multifaceted approach to electricity generation underscores East Africa's commitment to fostering energy resilience and sustainability while striving to meet the evolving needs of its populace.

East Africa has witnessed a remarkable surge in electricity generation over the past two decades. According to an analysis conducted by the International Renewable Energy Agency (IRENA), the countries under consideration in this report collectively generated 114.2 terawatt-hours (TWh) of electricity (Figure 1), more than double the output recorded two decades ago.

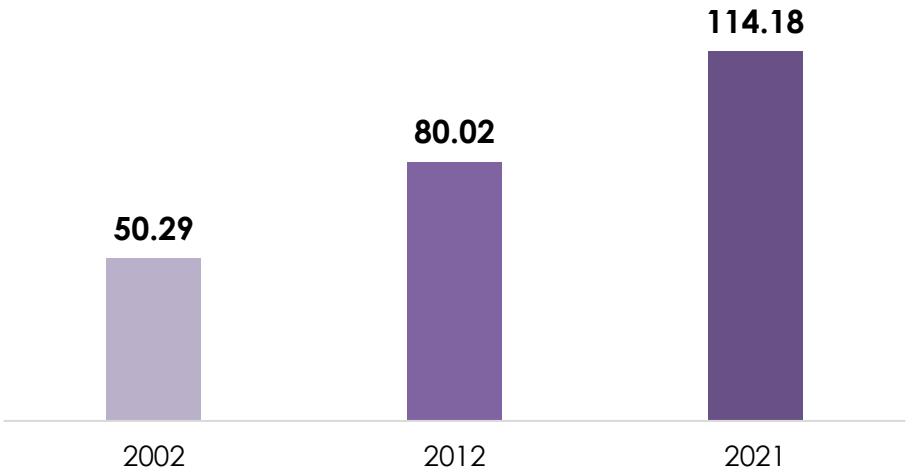


Figure 1: Electricity Generation in TWh

In a detailed examination, it becomes evident that East Africa possesses abundant resources capable of harnessing a substantial amount of renewable energy, be it wind, hydro, or solar. Particularly noteworthy is the significant geothermal potential concentrated in the Rift Valley, coupled with record levels of solar irradiation conducive to photovoltaic development, and consistent winds favorable for wind energy production.

Several countries in the region rely on hydroelectric dams for their electricity generation. This is notably the case for Ethiopia, where over 90% of the generated electricity is derived from various hydroelectric dams constructed within the country. Similar scenarios are observed in countries such as Mozambique, Zambia, Sudan, Zimbabwe, and Tanzania, where more than half of their energy originates from hydroelectric power.

However, it is noteworthy to highlight Kenya's leadership in geothermal energy generation. In 2021, the country produced 5,183 gigawatt-hours (GWh) of electricity through various geothermal power plants (Figure 2). These observations lead to the conclusion that in countries like Ethiopia, Kenya, Zambia, Mozambique, Zimbabwe, and Tanzania, green energy constitutes a significant portion of the overall power generation.

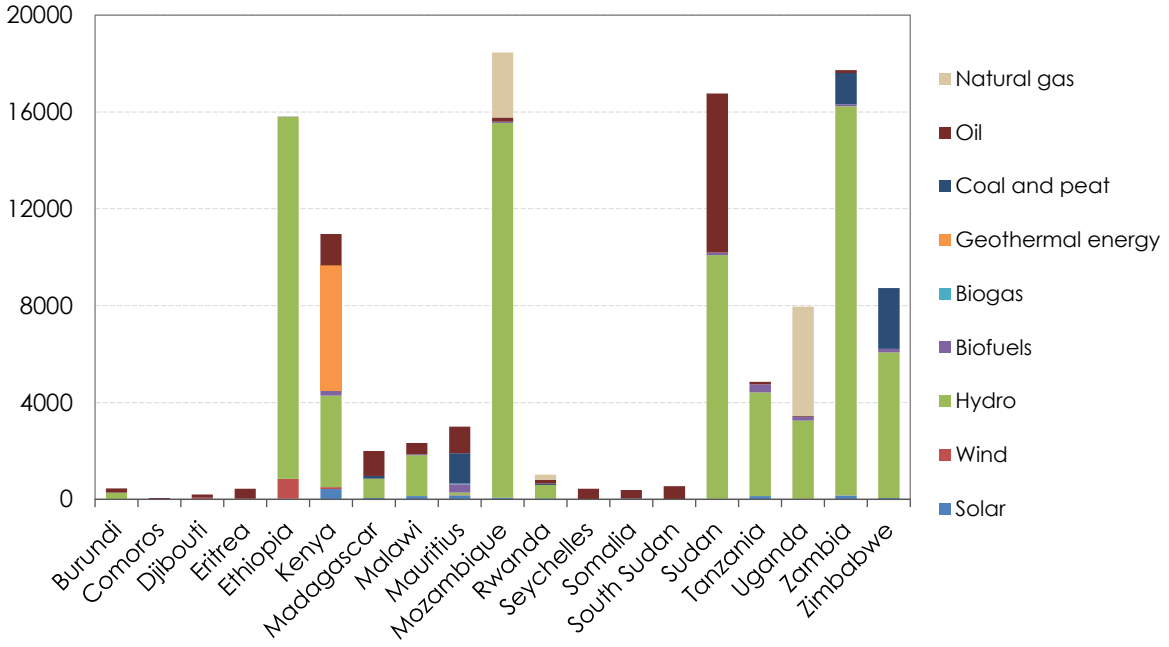


Figure 2: Generation in 2021 by sources in GWh

Finally, while most of the countries examined here generate their electricity through green sources, it is pertinent to note the significant contribution of fossil fuels (derived from gas or oil) in countries such as Uganda and Sudan (Figure 2).

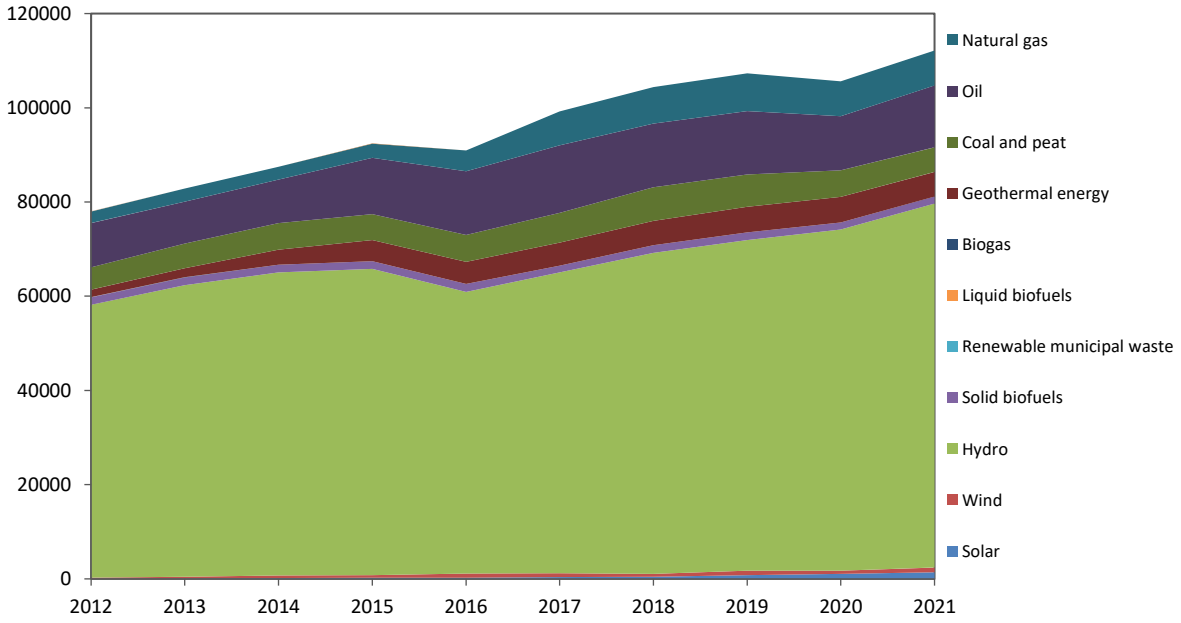


Figure 3: Electricity generation in GWh over time (period 2012 – 2021)

In a broader perspective, it is evident that the cumulative energy generated in the region has often been dominated by hydroelectric sources. Moreover, there has been a noticeable increase in the proportion of hydroelectricity in recent years, primarily attributed to the construction, renovation, or expansion of several dams across multiple countries (Figure 3). Indeed, in the year 2021 alone, over 69% of the electricity produced in these countries originated from hydroelectric power. Furthermore, 76% of this electricity production stemmed from green sources, as depicted in the accompanying pie chart (Figure 4).

With projects like the Grand Ethiopian Renaissance Dam underway, Ethiopia is poised to maintain its leadership in the production of increasingly sustainable energy.

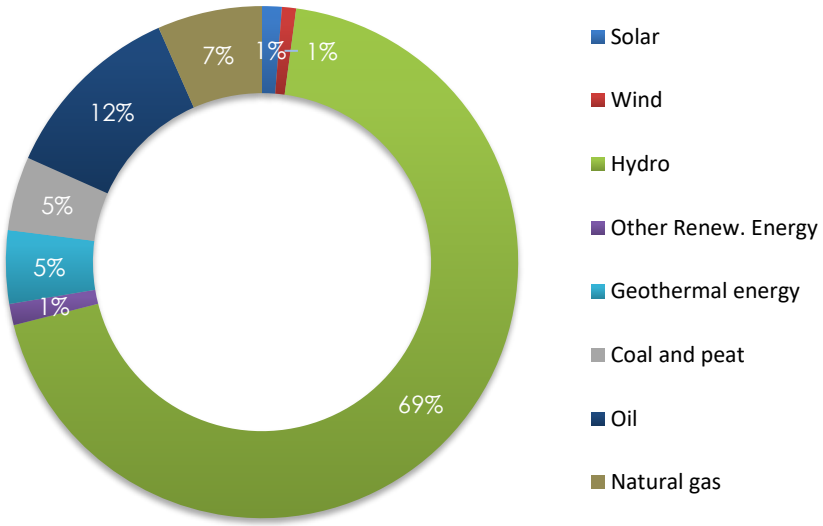


Figure 4: Electricity generation by source in 2021 (GW)

2.1.2 Installed electricity capacity

In 2022, the total installed electricity capacity in the 19 countries reached 29.25 GW, representing an increase of more than 150% since 2002 and approximately 60% since 2012 (Figure 5). However, despite this significant growth over the past two decades, the installed capacity remains a relatively small proportion (12%) of the 245 GW representing the total installed electricity capacity in Africa, according to the Annual Development Effectiveness Review 2023 by the African Development Bank (AfDB) [3].

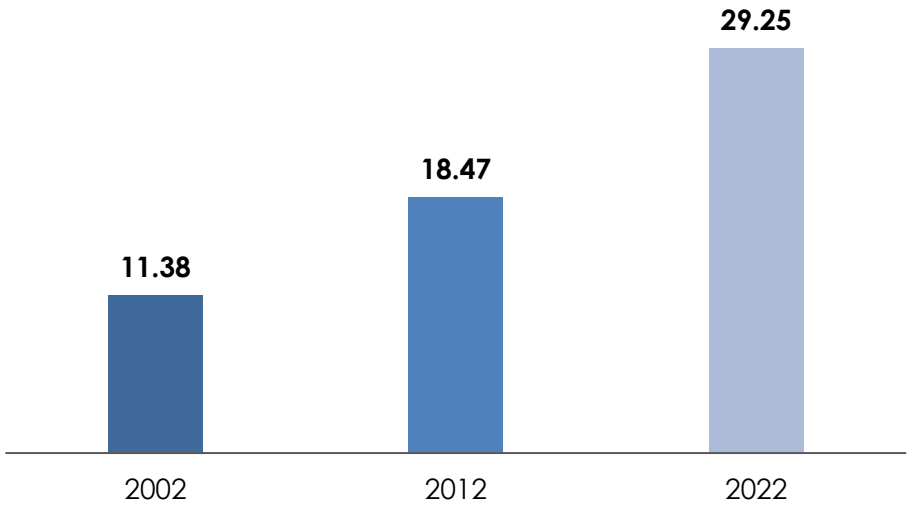


Figure 5: Installed Electricity capacity in GW

However, the favorable hydroelectric resources have led the majority of countries in this region to anchor their electricity production strategies around hydroelectric power plants. In 2022, according to IRENA data, approximately 55% of the total installed electricity capacity came from hydroelectric plants.

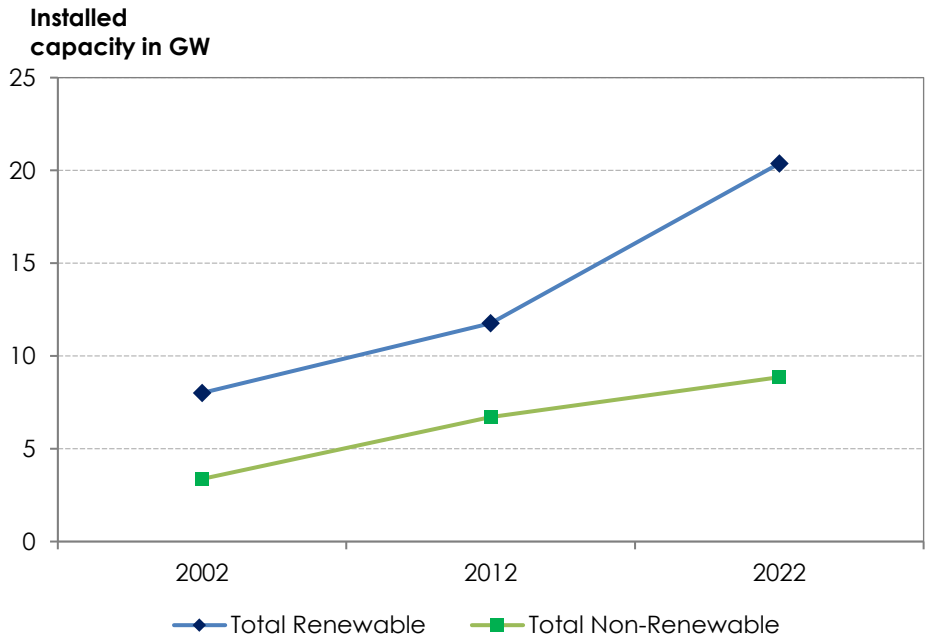


Figure 6: Total renewable vs non-renewable installed capacity

The region's renewable installed electricity capacity was 20.38 gigawatts (GW), accounting for nearly 69% of the total installed capacity. A country-level analysis reveals that six countries—Ethiopia, Uganda, Zambia, Malawi, Mozambique, and Kenya—have renewable energy shares exceeding 80%, with Ethiopia, Uganda, and Zambia surpassing 90%.

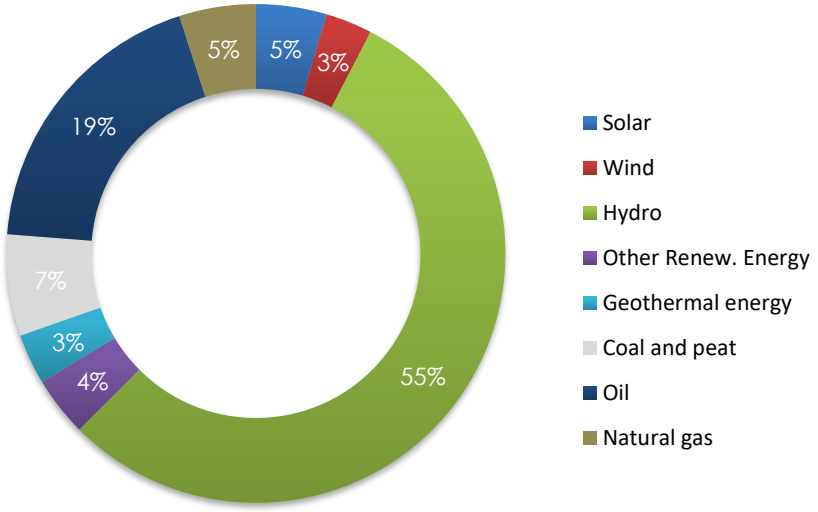


Figure 7: Electricity capacity by source in 2022

This favorable indicator for sustainable infrastructure was primarily driven by the expansion of hydropower in the early 2000s, later complemented by geothermal, bioenergy, wind, and solar power. Among non-renewable energy sources, oil and coal occupy the largest shares. Of the 8.86 GW of installed non-renewable capacity in 2022, 1.92 GW came from coal-fired plants, 5.50 GW from oil, and 1.45 GW from natural gas.

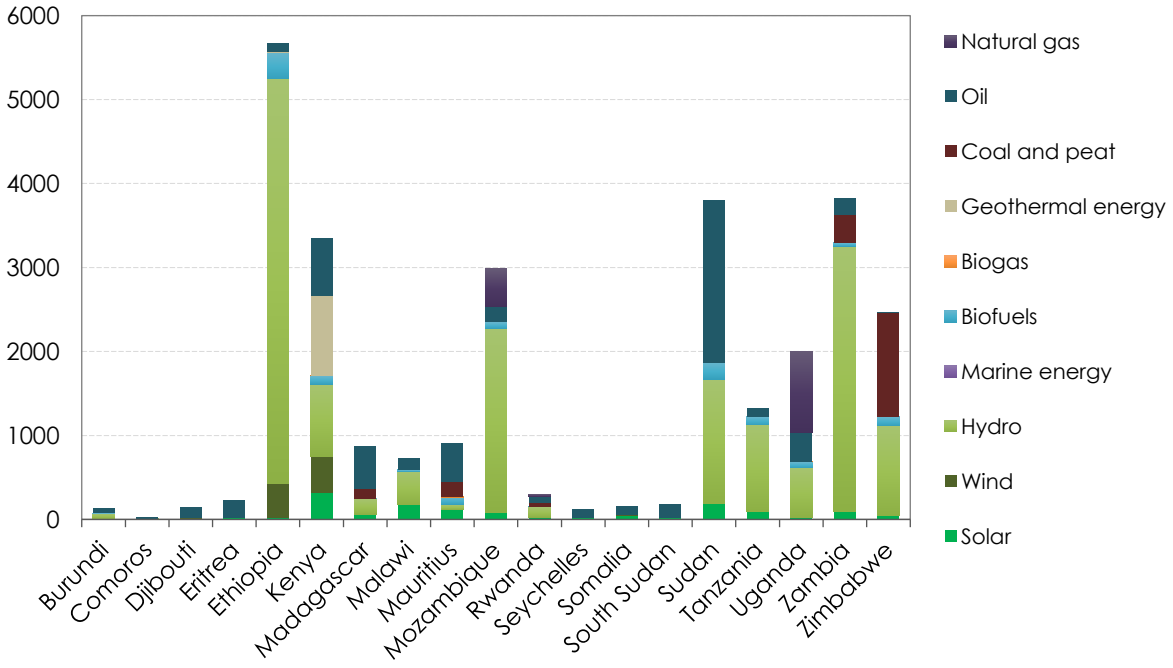


Figure 8: Installed capacity in MW by sources

The energy mix in the East African region has consistently been characterized by a strong reliance on renewable sources. The presence of major rivers, such as the Nile and the Zambezi, has notably facilitated the construction of hydroelectric dams in several countries. When analyzing the evolution of the region's energy mix over the past decade, it is evident that the total installed capacity from hydroelectricity increased by 50% between 2012 and 2022, with a compound annual growth rate (CAGR) of approximately 4%.

Additionally, there has been an impressive surge in solar and wind power within the energy mix, which have grown by over 3200% and 800% respectively over ten years, with CAGRs of 64% and 70%. While these indicators highlight the region's commitment to producing low-carbon electricity, it is important to note that the region is still far from realizing its full solar and wind energy potential.

Many countries have recently invested in major infrastructure projects, such as the construction of the Grand Ethiopian Renaissance Dam, the Lake Turkana Wind Power project, and the Bujagali Hydropower Station. These projects will further strengthen their position in promoting a green and sustainable energy mix.

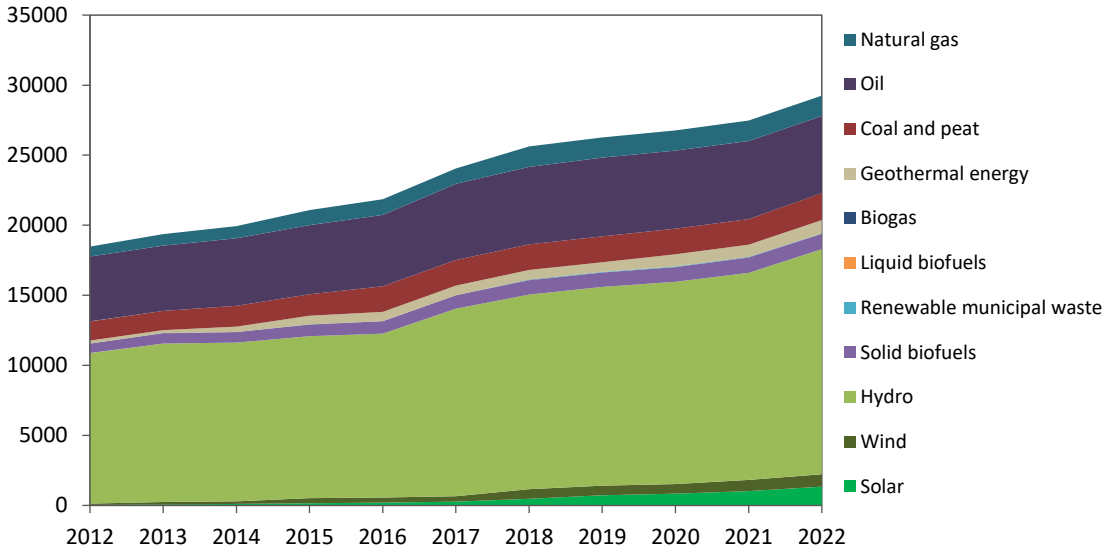
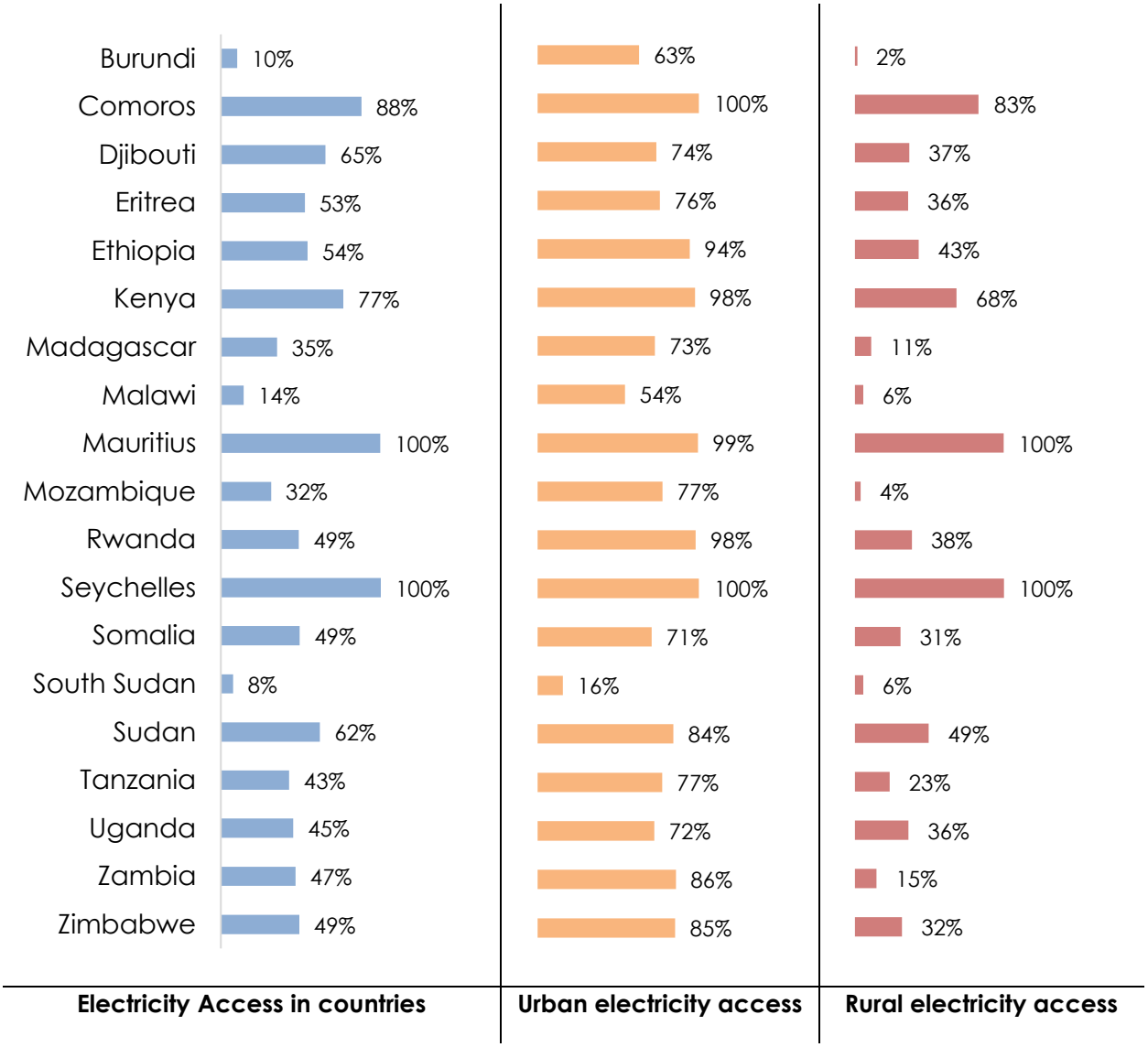


Figure 9 : Installed capacity in GW by sources [period 2012 – 2022]

2.2 Electricity Access and Electrification Rates

The East African region, home to five of the ten most populous African nations, demonstrates a predictably high demand for electricity. However, access to electricity remains a significant challenge for several countries in the region. World Bank data from 2021 indicates that over 261 million people, constituting 52% of the combined population of the 19 countries studied, still lack access to electricity [4].



Despite these challenges, it is important to acknowledge the significant strides made in improving electricity access across the region. Between 2005 and 2021, several countries, including Madagascar, Malawi, Sudan, and Zambia, successfully doubled their electricity access rates. Others, such as Burundi, Ethiopia, Kenya, Mozambique, Uganda, and Tanzania, achieved even greater progress, more than tripling their rates.

Rwanda stands out as a remarkable example, having increased its electricity access rate tenfold over the past 15 years, from 4.8% in 2005 to 48.7% in 2021. These substantial improvements are largely attributed to the prioritization of agendas focused on achieving universal electrification in the short to medium term. In contrast, Seychelles and Mauritius, which already boasted access rates exceeding 95% in 2005, have experienced minimal variation over the same period (Figure 10).

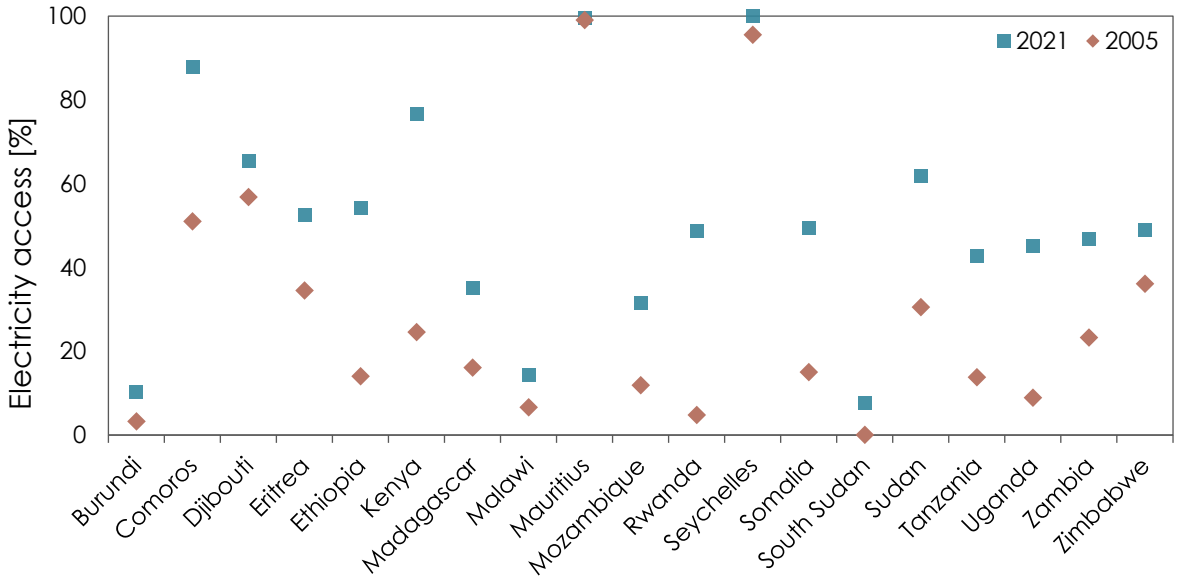


Figure 10: Electricity access variation between 2005 and 2021

Nweke-Eze's analysis highlighted a correlation between GDP per capita (PPP international dollars) and electricity access (% of population) in both West Africa [5]. A similar pattern appears in East Africa. Countries with higher GDP per capita, such as Mauritius, Seychelles, and Kenya, generally exhibit higher electrification rates. Conversely, countries with lower GDP per capita, such as Burundi and South Sudan, often have the lowest electricity access rates (Figure 11). This trend underscores the interconnectedness of economic development and energy access in the region.

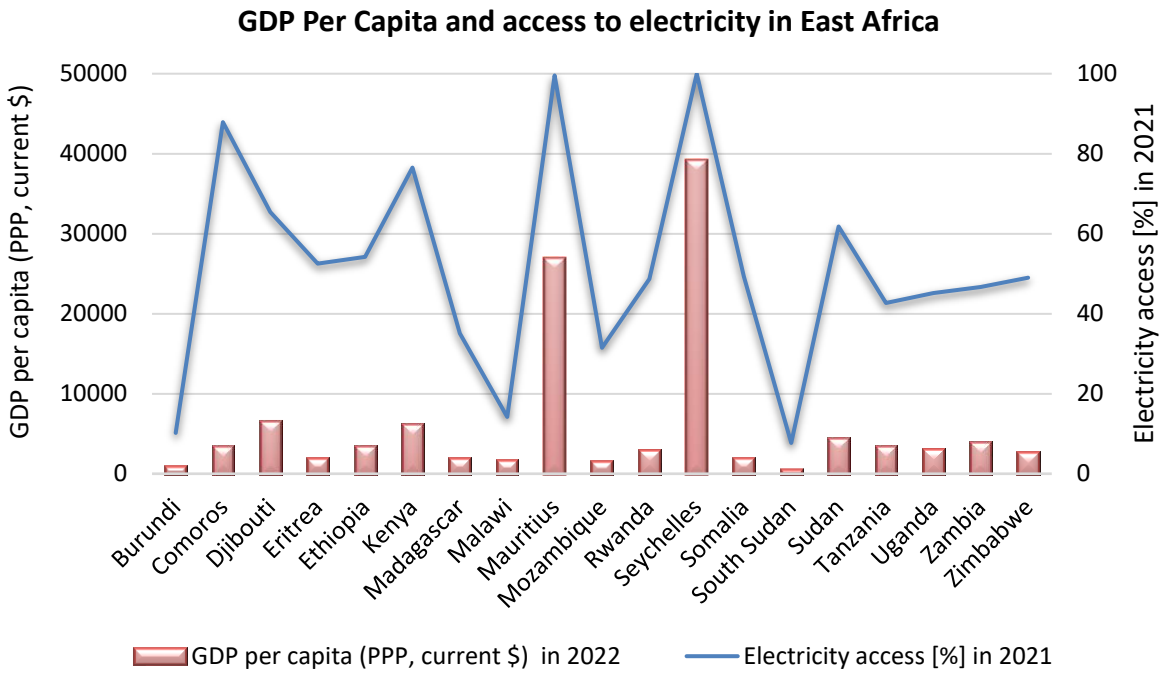


Figure 11 : GDP per capita and access to electricity

Despite significant progress in electricity access over the past 15 years, approximately 50% of the population in the 19 studied East African countries still lacks electricity. Additionally, several countries in the region exhibit low electricity generation per capita. Data from IRENA reveals that 16 countries have per capita generation below the African average of 613.5 kWh, significantly lagging behind global and European figures.

2.2.1 Identification of barriers to electricity access

Multiple factors contribute to this low per capita generation in East Africa. While countries like Mauritius, Zambia, Seychelles, and Kenya boast high per capita generation and rank among the top five in electricity access, many others face insufficient installed energy capacity to meet the population's needs, despite the region's abundant renewable energy potential.

The World Bank identifies lack of generation capacity as a major impediment to electrification in Sub-Saharan Africa. Insufficient generation capacity leads to frequent power outages, which in turn influence household decisions to connect to the grid. Research indicates that a reliable power supply is a key factor in increasing grid connections. Countries experiencing frequent blackouts typically have weak infrastructure and limited capacity

for new connections. Moreover, households are reluctant to connect to an unreliable grid that cannot meet their electricity needs.

This complex interplay of factors underscores the challenges in achieving universal electricity access in East Africa. Addressing these challenges requires a multifaceted approach that encompasses expanding generation capacity, strengthening infrastructure, and ensuring the reliability of electricity supply.

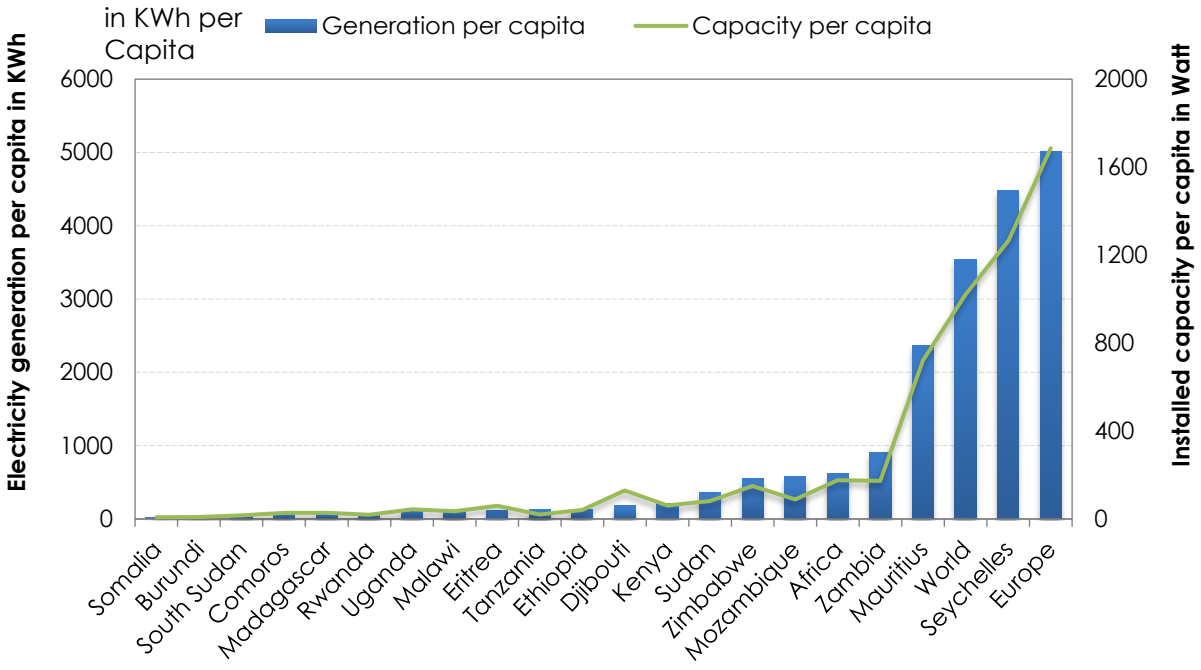


Figure 12: Installed electricity capacity and generation per capita

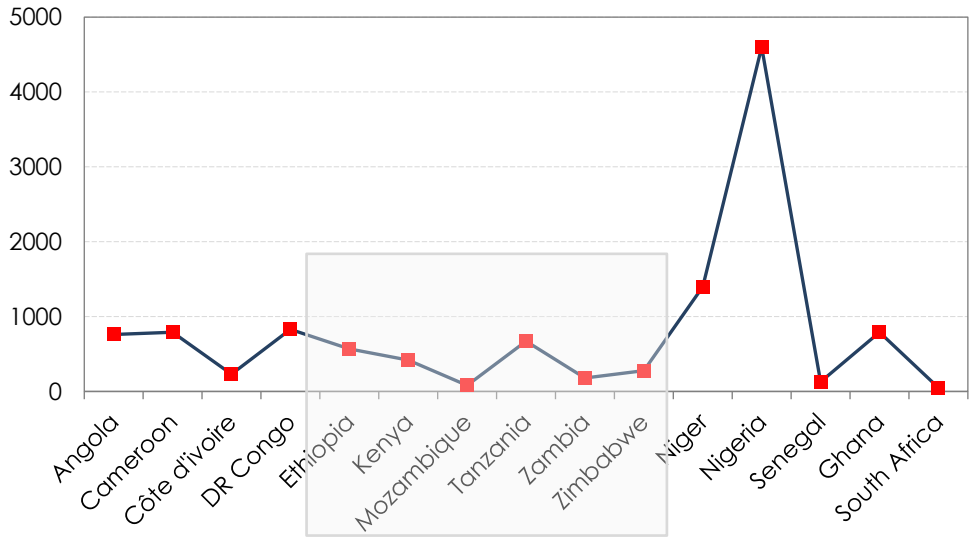


Figure 13: Average duration of electricity outages per year in Africa in 2018 in hours [6]

The literature often attributes the unreliability of power supply and frequent outages to insufficient and aging power infrastructure. Electricity, after generation, must traverse complex networks comprising transformers, overhead cables, and extensive equipment before reaching the consumer. Inevitably, a percentage of power is lost during this transmission process. This loss is exacerbated when the infrastructure is faulty, outdated, or improperly configured.

Notably, the majority of transmission losses occur due to the resistance of wires in high-voltage transmission lines over long distances, although this is relatively minimal due to high voltage minimizing current and subsequent losses. However, a significant portion of losses occur during distribution, as electricity navigates local power lines and transformers, encountering increased resistance, transformer inefficiencies, and other localized factors that contribute to overall distribution losses.

Frost & Sullivan's analysis emphasizes that Sub-Saharan Africa faces considerably higher transmission losses compared to many other regions [7]. World Bank data [8] reveals that numerous countries in the region exhibit power transmission and distribution losses exceeding 15%, surpassing the generally accepted global average of 7-10%.

Further analysis of specific countries, including Ethiopia, Kenya, Tanzania, Zambia, and Zimbabwe, indicates a positive correlation between electric power outages and power transmission and distribution losses. This suggests that the higher the losses incurred during transmission and distribution, the more likely these countries are to experience disruptions in electricity supply.

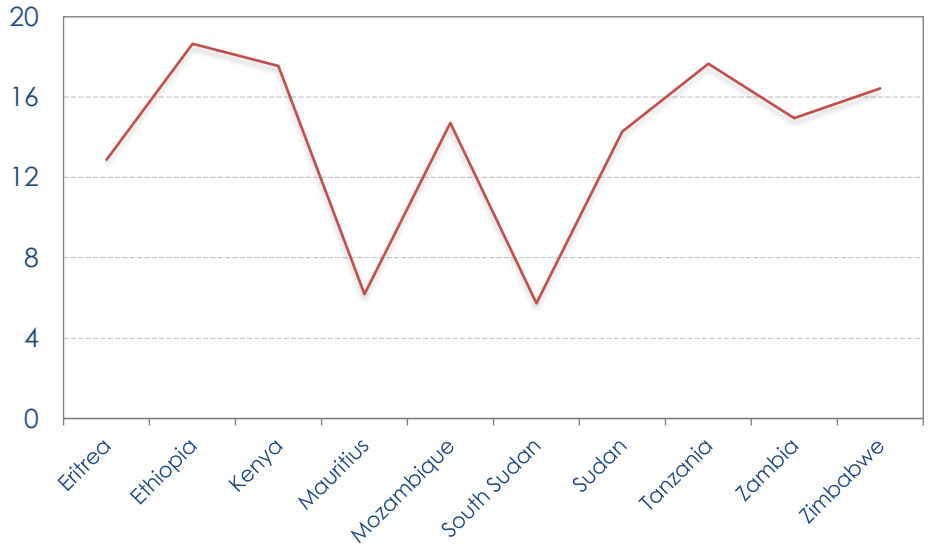


Figure 14: Electric power transmission and distribution losses (% of output)

A second crucial demand-side variable is the cost of electricity. Cross-referencing data from ClimateScope and the World Bank on electricity access rates and kilowatt-hour (kWh) prices in African countries reveals a significant inverse correlation: where electricity bills consume a larger share of household income, indicating high electricity prices, access to electricity is notably low.

For instance, electricity tariffs in South Sudan are among the highest on the continent, exceeding three times the Sub-Saharan Africa (SSA) median tariff. Concurrently, South Sudan's electrification rate in 2021 was a mere 8%. This pattern is mirrored in countries like Uganda, Mozambique, Madagascar, and Burundi, where electricity prices surpass the African mean and median, and electrification rates remain below 45%.

This analysis underscores the critical role of affordability in expanding electricity access. High electricity prices present a significant barrier to access, particularly for low-income households.

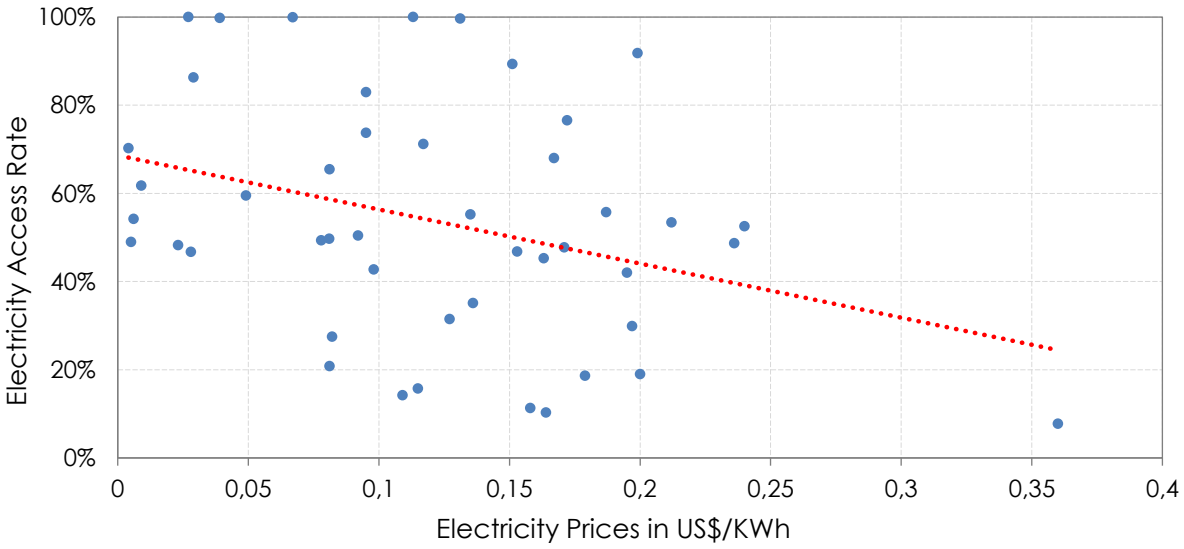


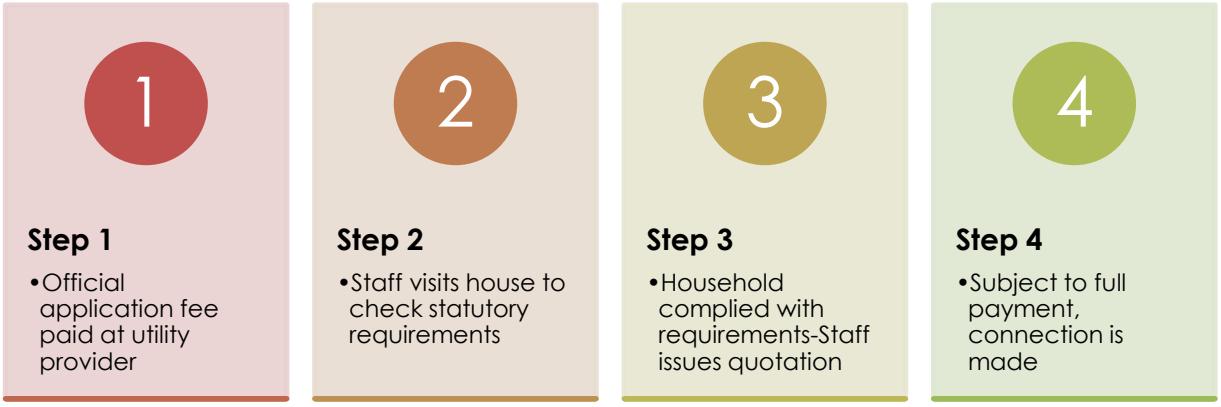
Figure 15: Electrification rate in Africa as a function of connection prices

2.2.1.1 Financial constraints

An additional challenge highlighted in the literature is the cost of connecting to the grid. In Tanzania, for instance, the average connection cost for a house within 30 meters of the power line was approximately $300 in 2011 [9]. This cost escalated to $870 for houses requiring one additional pole and surpassed $1200 for those needing two [10]. Beyond the connection fee, households must also factor in the expense of wiring their premises, which can match or exceed the initial connection cost [9, 11].

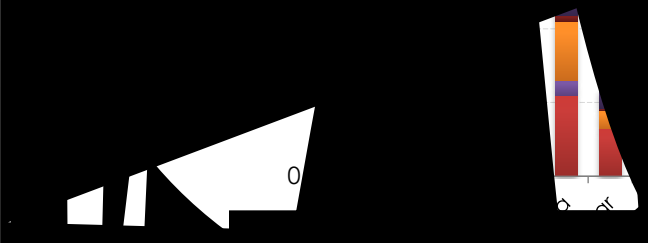
In Ethiopia, financial constraints were cited as the primary obstacle to grid connection by 41% of unconnected households [12]. As Kristine Bos notes in "Benefits and challenges of expanding grid electricity in Africa: A review of rigorous evidence on household impacts in developing countries," the upfront connection expense is likely a more significant barrier than monthly consumption costs. This is because grid electricity tends to replace costlier fuels like batteries, generators, and kerosene [9, 10]. A study in three major Tanzanian cities found that electricity had the lowest effective customer cost per kWh compared to firewood, charcoal, kerosene, and liquid petroleum gas [13]. Chaplin in 2012 even estimated that if rural and peri-urban Tanzanian households switched from kerosene to grid electricity, the savings a few years later could offset the connection costs.

In addition to the cost of connecting to the electricity grid, the requirements and connection process are not always designed to mitigate the constraints faced by low-income households. Moussa Blimpo and Malcolm Cosgrove-Davies, in their publication "Electricity Access in Sub-Saharan Africa," outline the standard steps required to obtain a connection [14]. These steps are relatively similar across countries like Ethiopia, Rwanda, and Zimbabwe. The first step for a potential household is to visit the local distribution company office to request a connection. Sometimes, an application fee is required, which varies from country to country but is often minimal, ranging from US$1.75 (in Ethiopia).



Upon receipt of the application fee, the utility provider schedules an appointment with the household to assess statutory requirements, such as infrastructure and wiring. If the household meets all requirements, they receive a cost quotation, and upon full payment, the grid connection is established. If not, the household can make necessary changes and schedule a follow-up inspection.

Compliance frequently causes delays in electricity provision, as households may need to invest significantly in housing upgrades or rewiring to meet the



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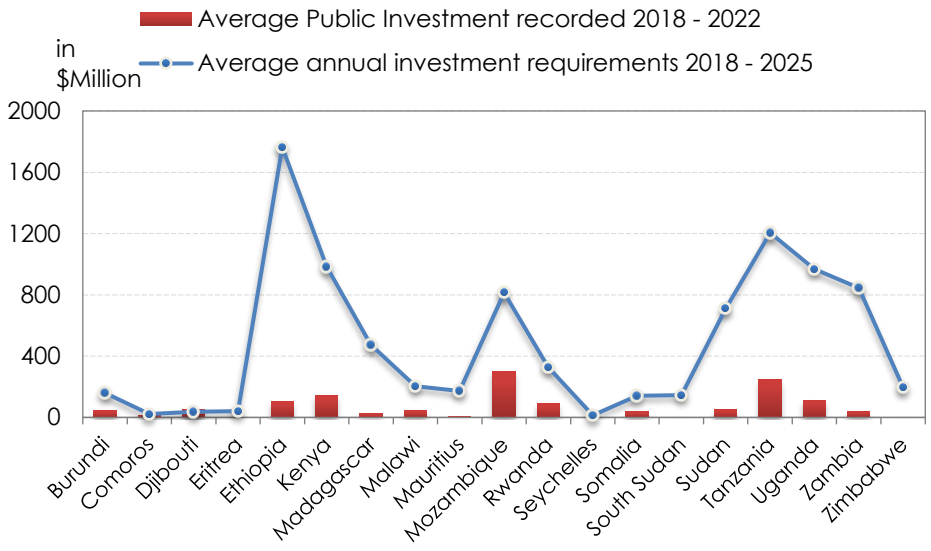

Figure 17: Average investment requirements vs Average Public Investment

However, there is a considerable gap for several countries between the investment needed and the observed public investments in the 19 countries studied. The reasons for this can be multiple and varied. Some countries made significant efforts in the years leading up to 2018, such as Zimbabwe, Tanzania, and Kenya, which had cumulative public investments of over US$1 billion in the 2015-2017 period. Thus, to meet this investment need, the governments of these countries will need to raise the necessary funds from the private sector.

2.3 Key Solution Areas Identified

East Africa's electricity sector is typified by abundant renewable resources but also by low access rates, high connection costs and fragile infrastructure. In 2021 hydro-power still provided about 69 % of electricity generated in the region and East Africa generated only 114 TWh of electricity – a figure that, while double that of two decades ago, remains insufficient for a population that has grown to more than 515 million.

Many countries rely heavily on large dams, leaving them vulnerable to droughts, and almost 70 % of the population remains without reliable electricity. Closing the access gap will require a coordinated set of policy reforms, financing measures, technological solutions and regional cooperation. The following solution axes translate evidence from the recent literature into actionable recommendations for East Africa.

2.3.1 Utility Reform, Governance and Tariff Policy

Many East African utilities are vertically integrated, financially weak and unable to finance expansion. As of 2019 only 10 of 42 surveyed African utilities had unbundled structures [16]. Utility reform is therefore essential.

- **Unbundle and corporatize utilities:** Separate generation, transmission and distribution to introduce competition and transparency. Establish independent transmission system operators and allow private participation in generation and mini-grids. Uganda's GET FiT program illustrates how corporatized utilities combined with risk-mitigation instruments can unlock private investment [17].

- **Strengthen regulatory bodies:** Empower independent regulators to set cost-reflective tariffs, ensure service quality and arbitrate disputes. Regulators should implement **lifeline tariffs** and targeted subsidies for poor households to balance financial sustainability with affordability [18].

- **Improve utility financial health:** Introduce corporate turnaround programs to reduce technical and commercial losses (through smart meters and revenue collection), renegotiate expensive power-purchase agreements, and adopt digital management systems. Stable utility finances are prerequisite for attracting private capital [17].

- **Tariff reform with protection for the poor:** Many countries keep tariffs artificially low, undermining utilities. Tariff reform should gradually move towards cost-reflective pricing while maintaining lifeline rates, connection subsidies and voucher schemes for low-income households [18]. Such targeted subsidies help households afford basic consumption while keeping utilities solvent.

2.3.2 Off-Grid and Decentralized Solutions

Connecting dispersed rural populations requires flexible decentralized solutions. In many parts of East Africa, the least-cost option is off-grid solar or mini-grids [18].

- **Mini-grids:** Create clear regulatory frameworks for tariff setting, licensing and eventual grid interconnection. Provide viability-gap grants and results-based subsidies to developers. Ensure interoperability so that mini-grids can connect to the main grid when it arrives.

- **Pay-as-you-go (PAYG) solar:** Encourage PAYG solar-home-system providers by removing import duties and value-added taxes on small solar products, enforcing quality standards and supporting mobile-money integration. DFIs should provide guarantee schemes or credit lines to local banks to lend to PAYG companies, helping them expand [19].

- **Productive-use appliances:** Subsidize solar irrigation pumps, refrigerators and grain mills to increase productive consumption, raise incomes and improve mini-grid viability. Pay-as-you-go financing can also be applied to productive-use equipment.

2.3.3 Regional Integration and Power Trading

A regional approach can cut costs, improve reliability and accelerate access. The East African Community (EAC) promotes power-sector cooperation and established the East African Power Master Plan and an Interconnection Code. The East Africa Power Pool (EAPP) is now preparing to launch a centralized **Day Ahead Market (DAM)** in 2025; the market will allow members to buy and sell electricity at financially binding day-ahead prices and harness the region's renewable resources [20]. Key actions include:

- **Complete cross-border interconnections:** Expedite construction of high-voltage lines such as the Ethiopia–Kenya HVDC and Kenya–Tanzania interconnector (already used in trial wheeling) [21]. Build interconnectors linking Uganda–Rwanda–Burundi, Kenya–Uganda,

Tanzania–Zambia, and Ethiopia–Sudan. Cross-border electrification programs should supply border communities from the nearest grid.

- **Operationalize the Day-Ahead Market:** Finalize market rules, trading platforms and settlement procedures. Align national regulations, wheeling charges and grid codes to enable efficient regional trading [20]. A well-designed power market will incentivize investments in flexible generation and storage.

- **Regional generation projects:** Jointly develop projects with regional benefits (e.g., geothermal fields on the border of Ethiopia and Djibouti, large solar parks in Sudan or Somalia). Pooling investment reduces country-specific risk and allows economies of scale.

- **Coordinated planning for hydropower:** Develop water-sharing agreements and climate-resilient operating rules for shared river basins, ensuring that large dams do not create downstream conflicts. Diversify away from hydro to reduce vulnerability to drought.

2.3.4 Mobilizing Finance and De-risking Investment

According to the IEA, closing the energy access gap in sub-Saharan African countries will require an estimated annual investment of $28 billion up to 2030 [22]. Mobilizing such sums demands innovative financing instruments and de-risking measures:

- **Structured procurement mechanisms:** Use competitive auctions and standardized power-purchase agreements (PPAs) for solar, wind and geothermal projects, ensuring transparency and cost discipline [16]. Auctions in Ethiopia and Kenya have attracted record-low solar tariffs.

- **Risk-mitigation instruments:** Development finance institutions (DFIs) and donors should provide partial risk guarantees, insurance against currency fluctuations and political risk, and viability-gap funding. Uganda's GET FiT program combines these instruments to attract private developers [17].

- **Blended finance and results-based financing:** Combine concessional loans, grants and private capital to reduce project costs.

Results-based financing programs, such as the Beyond the Grid Fund for Africa (BGFA), provide grants and incentives to companies that deliver verified off-grid connections; by 2024 BGFA supported over 610 000 subscriptions and provided electricity to 3.15 million people.

- **Local capital market development:** Establish renewable-energy credit lines for local banks and microfinance institutions, backed by guarantee schemes so that banks can lend to solar-home-system and mini-grid companies [19].

- **Green bonds and climate finance:** Encourage utilities and governments to issue green bonds for renewable-energy and grid projects. Accessing global climate funds (Green Climate Fund, Global Environment Facility) and leveraging carbon credits can also mobilize finance.

- **Mission 300 and ASCENT:** Participate in multi-donor initiatives. The World Bank and African Development Bank's Mission 300 aims to connect 300 million Africans by 2030; their Accelerating Sustainable and Clean Energy Access Transformation (ASCENT) program intends to provide electricity to 100 million people in 20 countries through grid and distributed renewable systems. These programs bring sizeable concessional finance and help align national reforms with investment.

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