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Energising Africa: Current Landscape and Path to Renewable Energy

Abraham Lartey[1]

Abstract: Climate change poses a significant threat to global economic stability, driven by greenhouse gas emissions from human activities. The transition to renewable energy is vital for mitigating climate risks and meeting emission reduction targets. Many countries in Africa, rich in renewable energy resources such as solar, wind, and hydropower, remain heavily dependent on fossil fuels, exposing them to economic instability from energy price fluctuations. State utilities often face financial challenges due to high costs, low tariffs, inefficient payment systems, high system losses, and outdated infrastructure. These structural challenges hinder industrial development and economic diversification, essential for sustainable growth. For Africa, the energy transition offers a chance to develop energy systems that support sustainable structural transformation. This paper examines Africa's energy landscape, focusing on the potential of renewable energy to address challenges and promote industrialisation. It underscores the critical need for affordable sustainable energy to boost economic transformation, enhance productivity, and foster green industries including green hydrogen. It also highlights the need for context-specific strategies to overcome barriers to renewable energy adoption and harness the full potential of green industries in fostering economic diversification and structural transformation across the continent.

Keywords: Energy transition, renewable energy, green industrialisation, Africa, green hydrogen

JEL Codes: Q42, O13, O55, Q01, Q28

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1. Introduction

Climate change poses a significant threat to the economic stability and social resilience of countries worldwide. Over the past fifty years, global temperatures have risen dramatically, accompanied by an increase in the frequency and severity of extreme weather events. This trend is primarily attributed to the accumulation of greenhouse gases (GHGs) in the atmosphere, largely due to human activities such as fossil fuel combustion, deforestation, and industrial processes (IPCC, 2021). Transitioning to renewable energy technologies, including wind and solar, is crucial for achieving the substantial emission reductions necessary to limit global temperature rise to well below 2°C above pre-industrial levels (Gielen et al., 2015; IRENA and IEA, 2017). As fossil fuel combustion accounts for most anthropogenic GHG emissions, moving away from these energy sources is imperative (Edenhofer et al., 2011; Gielen et al., 2015).

Africa is endowed with vast renewable energy resources, including bioenergy, geothermal, hydropower, ocean energy, solar, and wind, which are over 1,000 times greater than the projected electricity demand for 2040 (IRENA and AfDB, 2022). This diversity positions the continent to benefit significantly from the global energy transition, potentially transforming its energy landscape and promoting sustainable development. However, many African countries currently rely heavily on fossil fuels like coal, oil, and natural gas for electricity generation. This dependency makes energy-importing nations vulnerable to price fluctuations and external economic shocks, leading to economic instability that impacts household energy bills and industrial production costs.

A substantial portion of Africa's population lacks access to electricity, and those with access often face unreliable and unaffordable supply. Frequent power outages disrupt daily life and economic activities, particularly affecting businesses that cite unreliable electricity as a major constraint on their performance and growth. This instability limits productivity increases operational costs and deters both local and foreign investment. Additionally, fossil fuel subsidies in some countries divert public funds away from essential services such as healthcare, education, and infrastructure, failing to benefit the most vulnerable populations while disproportionately aiding wealthier households and businesses. State utilities often struggle financially, unable to cover operational costs due to high expenses, low tariffs, inefficient payment collection, system losses, and outdated infrastructure (World Bank, 2024).

These structural challenges in the energy sector impede the continent's overall development. Energy insecurity hinders industrial development, preventing nations from advancing their manufacturing sectors and enhancing economic resilience. Reliable and affordable electricity is critical for developing the industries necessary for economic diversification. Renewable energy can address these challenges and facilitate structural economic transformation in Africa. By leveraging the continent's abundant renewable resources, such as solar and wind, African countries can cultivate green industries that reduce dependence on fossil fuels. Developing renewable energy sectors can diversify the economic base, create new markets, and unlock opportunities in other sectors. However, despite the availability of renewable energy resources and their potential benefits, the adoption and diffusion of renewable energy technologies in Africa have been slow, with investments and installed capacity concentrated primarily in a few countries like South Africa.

This overview paper delves into the current energy landscape in Africa, focusing on electricity access, generation mix, the potential for renewable energy and green hydrogen, while also assessing the readiness of various countries to embrace this transition. By exploring these key issues, the paper aims to provide insights that can inform strategic decisions to facilitate Africa's transition towards a more sustainable energy future.

2. Context

Industrialisation is vital for Africa's development, given its youthful labour force, rich natural resources, and expanding internal markets (AfDB, 2021). These factors position Africa as a potential global industrial powerhouse. Central to this vision is industrial development, which is key to fostering inclusive growth and creating quality jobs, as emphasized in the "AU Agenda 2063."[2] Several regional economic bodies have also outlined bold industrialisation strategies. For instance, the Southern Africa Development Community aims to boost its manufacturing sector, targeting a 30% share of manufacturing value added in GDP by 2030 and 40% by 2050.[3] Furthermore, it seeks to increase the proportion of medium- and high-technology industries within total MVA from the current 15% to 30% by 2030 and 50% by 2050.

Transforming an economy from primarily agrarian to one dominated by manufacturing and industrial activity is challenging, particularly in the context of climate change. Sustainable and reliable energy is essential to power this transformation. Africa will need to harness efficient renewable energy sources to increase productivity, scale up industrial operations, and drive technological innovation, while also ensuring the environmental sustainability of its industrial growth.

However, most existing studies on energy transition in Africa tend to focus primarily on household energy access, with limited attention given to how the energy transition can drive sustainable industrialisation and broader structural transformation (see for example, Nerini et al., 2016). Additionally, the diversity in energy systems, resource availability, levels of industrialisation, and development goals across African countries highlights the need for context-specific, policy-oriented research (Mulugetta et al., 2022). This means that different countries will require tailored approaches to promoting sustainable industrialisation and structural transformation, considering their unique circumstances and priorities.

3. Current Energy Landscape

3.1 Electrification Rates

In 2022, approximately 685 million people worldwide did not have access to electricity, highlighting a significant global energy challenge. A striking 83% of this population, or roughly 568 million people, reside in Sub-Saharan Africa (SSA) reflecting a disparity in energy access between SSA and other parts of the world (

Figure 1). The access deficit in the region is largely driven by Nigeria (86 million), the Democratic Republic of Congo (78 million), and Ethiopia (55 million), due to their large populations.

[2] https://au.int/en/agenda2063/overview
[3] https://sadc-eu.sardc.net/resources/RISDP/SADC-Industrialisation-Strategy-and-Roadmap-2015-2063.pdf

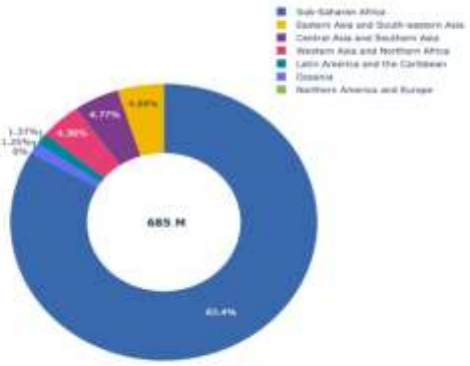

Figure 1. Share of population without access to electricity by regions, 2022
Source: Authors' Elaboration based on IEA, IRENA, UNSD, World Bank, and WHO (2024)

Electricity access varies substantially across different countries within Africa (Figure 2). In Northern Africa, countries like Morocco, Tunisia, Egypt, and Algeria have made substantial progress, successfully providing electricity to the vast majority of their populations. Similarly, in South Africa and Ghana, more than 80% of the population has access to electricity. However, in countries such as Chad, South Sudan and Central African Republic, less than 20% of the population has access to electricity.

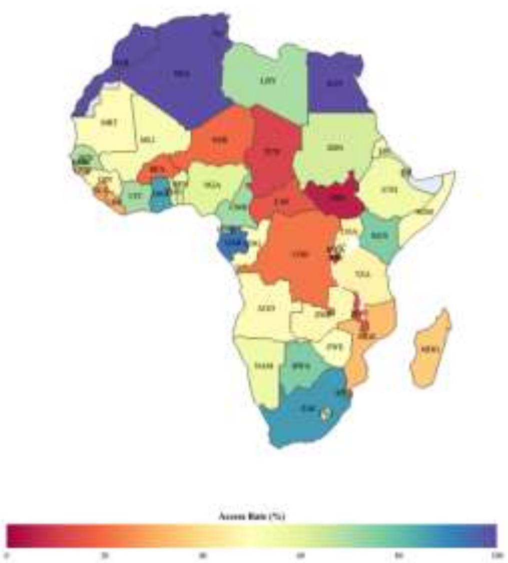

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Figure 2. Electrification rates across countries in Africa, 2022.
Source: Authors' Elaboration based on IEA, IRENA, UNSD, World Bank, and WHO (2024)

The region is also characterised by a pronounced urban-rural divide in electrification rates, which remains a significant challenge in most countries (Figure 3). This disparity highlights the uneven distribution of infrastructure and resources, with urban areas generally enjoying far greater access to electricity compared to their rural counterparts. For instance, in Nigeria, the contrast is stark: approximately three times as many urban residents have access to electricity compared to those living in rural areas. This disparity not only reflects the challenges of extending the grid to more remote regions but also underscores the broader inequalities in infrastructure development between urban and rural areas.

Similarly, in the Democratic Republic of Congo, the situation is even more extreme. While about 45% of the urban population has access to electricity, a mere 1% of the rural population is electrified. This vast gap reveals the profound challenges in reaching rural communities, where logistical, financial, and infrastructural barriers can severely hinder efforts to provide reliable electricity.

These examples underscore the pressing need for targeted interventions to bridge the electrification gap between urban and rural areas, ensuring that all populations can benefit from the critical services that electricity provides.

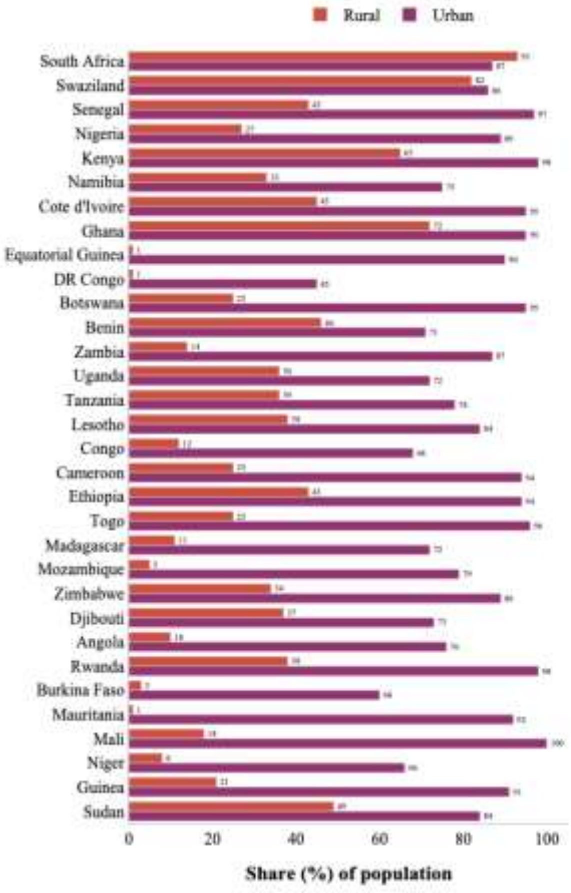


Figure 3. Access to Electricity by Rural and Urban Areas, 2022

Source: Authors' Elaboration based on IEA, IRENA, UNSD, World Bank, and WHO (2024)
Note: Countries are ranked based on 2022 Africa industrialisation Index (AfDB, 2022)

3.2 Energy Supply Mix

The energy supply mix across countries in the region is heavily skewed towards fossil fuels, with a significant portion of the region's energy comes from oil, which accounts for 23% of the total energy supply in 2021, followed by natural gas (17%), and coal (12%) (IEA, 2024). By the end of 2021, Africa had discovered approximately 626 trillion cubic feet of proven natural gas reserves (EIA, 2024)[4]. Most of these reserves are concentrated in a few key countries, including Nigeria, Algeria, Mozambique, Egypt, and Libya, which together hold the bulk of the continent's natural gas wealth (Figure 4). Oil remains a primary energy source due to its widespread use in transportation, industry, and electricity generation, while natural gas is often used for electricity generation and industrial processes.

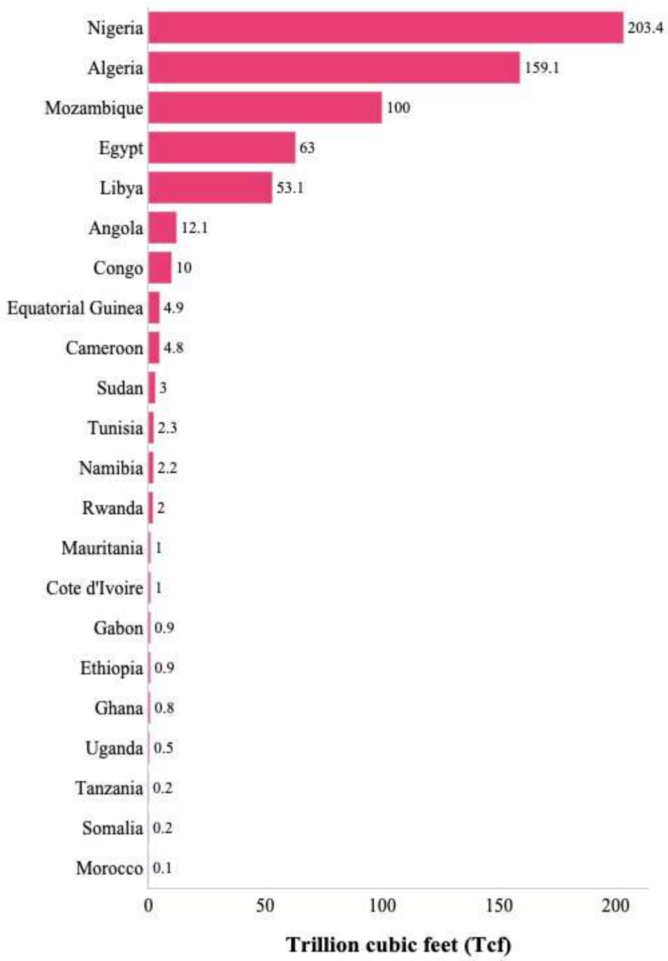


Figure 4. Natural Gas Reserves by country, 2021
Source: Authors' Elaboration based on EIA (2023)

[4] https://www.eia.gov/international/data/world

Nevertheless, there is substantial variation in the energy mix across different countries in the region. For example, coal is a major component of electricity generation in South Africa, Morocco, and Botswana (Figure 5). In South Africa, coal is particularly dominant, as the country relies extensively on its local coal resources to supply the majority of its electricity grid. Similarly, Botswana's energy sector is heavily dependent on coal, driven by the country's abundant coal reserves. In Morocco, while coal is also a significant part of the energy mix, the country relies predominantly on imported coal to meet its energy needs.

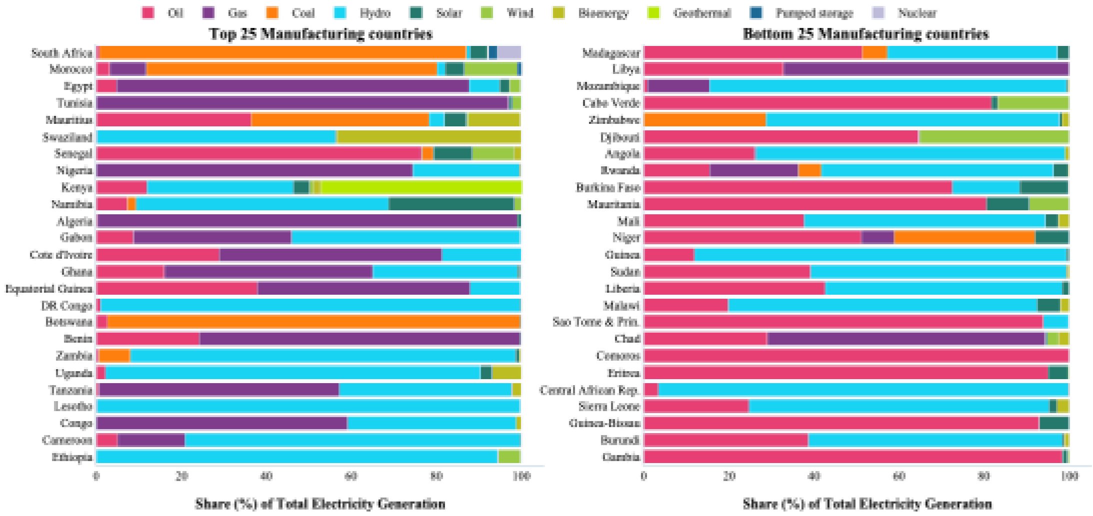


Figure 5. Electricity Generation Mix, 2021
Source: Authors' Elaboration based on IRENA (2024)
Note: Countries are ranked based on 2022 Africa industrialization Index (AfDB, 2022)

Natural gas plays a crucial role in electricity generation, contributing substantially to the electricity generation mix in countries such as Egypt, Tunisia, Nigeria, Algeria, Benin, Tanzania, Congo, Tanzania and Chad. The reliance on natural gas in most of these countries is driven by the availability of domestic gas resources, which provide a more cost-effective and stable supply of energy compared to imported fuels. Nigeria, which holds the largest proven natural gas reserves on the continent (Figure 4), has leveraged its vast resources to integrate natural gas extensively into its electricity sector. In addition to meeting domestic energy demands, Nigeria also plays a crucial role in regional energy dynamics. Through the West Africa Gas Pipeline (WAGP)[5], Nigeria exports natural gas to neighbouring countries, including Benin, and Togo, where it is used to fuel power plants and meet their electricity generation needs.

In Egypt and Algeria, both of which are significant producers of natural gas, domestic resources are similarly crucial for electricity generation. These countries have developed extensive infrastructure to harness and utilise their gas reserves, enabling them to produce a substantial portion of their electricity from this resource. Tunisia, though smaller in terms of gas reserves, relies heavily on natural gas for power generation, benefiting from its

[5] https://www.wagpco.com

geographical proximity to Algeria and its domestic production. In Tanzania, the development of the Songo Songo gas field[6] and its associated infrastructure has been central to the country's thermal power generation (IGU and Hawilti (2023). This project has provided a reliable source of natural gas, forming the backbone of Tanzania's efforts to expand and stabilize its electricity supply.

Hydropower also serves as the cornerstone of electricity supply for many countries across the African continent, a testament to the region's rich water resources and the economic advantages of hydropower generation. The continent's abundant rivers, lakes, and rainfall make it well-suited for harnessing hydropower, which offers a cost-effective and sustainable solution for meeting energy demands. Hydropower is the dominant source of electricity, contributing over 80% of their electricity supply in countries such as Ethiopia, Democratic Republic of Congo and Zambia (Figure 5). For instance, in Ethiopia, the Grand Ethiopian Renaissance Dam and other hydropower projects play a pivotal role in generating electricity and supporting the country's rapid development. Similarly, in the Democratic Republic of Congo, the Inga Dam complex is a major hydropower facility that significantly contributes to the nation's electricity supply, reflecting the country's vast potential for hydropower generation.

Hydropower, is however, highly vulnerable to climate change due to its dependence on rainfall and temperature variations. Changes in streamflow, seasonal flows, and increased evaporation can significantly impact energy output (IPCC, 2014). As reliance on hydropower increases, so does exposure to climate hazards. Managing these risks requires addressing vulnerability, which involves sensitivity to climate impacts and the adaptive capacity of energy systems and stakeholders (IEA, 2020). Africa, possessing only 9% of global renewable freshwater resources, faces severe water shortages that exacerbate competition for water among energy, residential, and agricultural needs, especially in countries like Mozambique, Zimbabwe, and Ghana (UNESCO, 2019). There is thus the need to build a more resilient and sustainable energy infrastructure that can drive structural transformation.

Another notable characteristic of the electricity mix in several countries across the continent is the substantial reliance on oil, particularly in countries such as Senegal, Gambia, Comoros, Eritrea, Cape Verde, and Guinea-Bissau. In Senegal, for example, oil-fired power plants are a major component of the country's energy infrastructure, helping to meet growing electricity demands. In many of these countries, imported oil plays a dominant role in power generation, driven by the limited availability of domestic energy resources and the need to ensure a consistent and reliable power supply. The dependence on imported oil not only impacts the cost of electricity but also makes these countries vulnerable to global oil price volatility and supply disruptions.

The integration of renewable energy sources (excluding hydro) into the electricity generation mix is notably concentrated in a select number of countries such as Kenya, Djibouti, and Morocco. In Kenya, renewable energy has become a central component of the country's electricity strategy. The country has made substantial progress in harnessing geothermal energy, taking advantage of its location along the East African Rift.

[6] https://www.panafricanenergy.com/overview/our-operations/

3.3 Electricity Consumption by Sectors

Each country shows substantial variation in the distribution of electricity use across sectors over time (Figure *6*). In South Africa, industry consumption decreased slightly from 59.4% to 52.5%, while the residential sector's share nearly doubled from 12.9% to 24.2%, highlighting an increased focus on residential access. Morocco experienced a slight reduction in the industry share, staying at around 37%, while the residential sector saw a modest increase, and the share in services dropped slightly from 18% to 17%.

Nigeria and Tanzania show different dynamics. In Nigeria, most of the electricity consumption was consistently in the residential sector, rising from 58% in 2010 to 59% in 2021, with no notable presence in other sectors such as agriculture and transport. Tanzania also shows an increase in residential use from 43% to 44%, while the services sector increased significantly from 24% to 31%. Across all four countries, agriculture and transport generally remain minor consumers of electricity, indicating limited direct electricity consumption in these sectors over the years. Overall, the trends point towards an increasing focus on residential electricity consumption across these countries, suggesting efforts to expand electricity access for households.

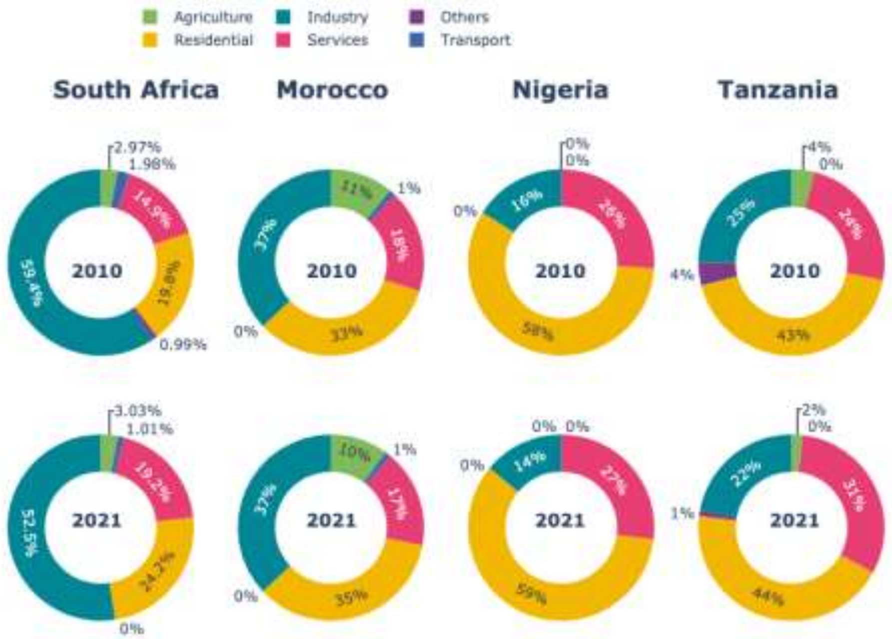


Figure 6 Electricity Consumption by Sectors
Source: IEA (2024a)

Africa currently contributes less than 3% of global energy-related carbon dioxide emissions, making it the region with the lowest emissions per capita globally (IEA, 2022). However, there are notable variations among countries within the continent. South Africa stands out as the largest GHG emitter in Africa (Figure 7), primarily due to its heavy reliance on coal for energy production and its significant industrial base. Over the past three decades, the energy sector has been responsible for at least 80% of South Africa's GHG emissions each year (Figure 8), reflecting the carbon-intensive nature of its coal-powered electricity generation.

While most African countries maintain relatively low emissions, these disparities underline the continent's diverse energy landscapes, shaped by varying energy sources, economic activities, and industrialisation levels. With Africa's rapidly growing population and economies, GHG emissions are expected to rise in the future, making the shift to cleaner energy sources essential for sustainable development and mitigating climate impacts.

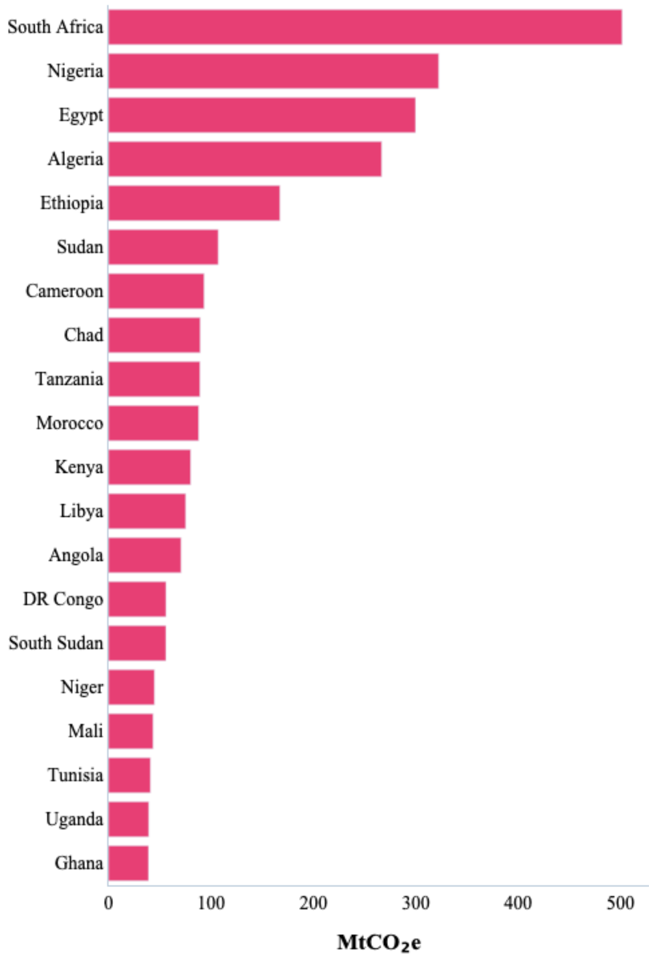


Figure 7 Top 20 GHG Emitters in Africa
Source: Author's Construct based on WRI (2024)

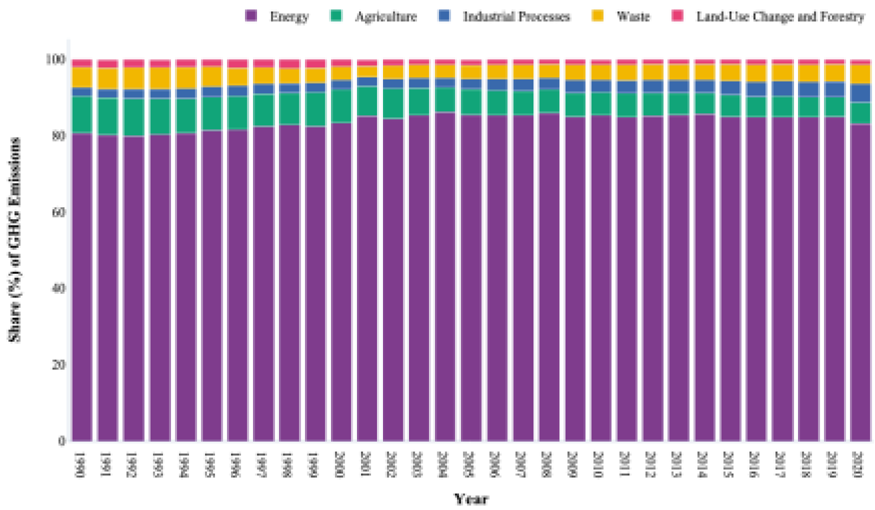


Figure 8 South Africa's Historical GHG Emissions
Source: Author's Construct based on WRI (2024)

3.4 Structure of Power Markets in Africa

Since the early 1990s, market-oriented reforms and restructuring initiatives that began in developed countries during the 1980s have been adopted by developing nations, including those in Africa (Wamukonya, 2003). These reforms generally follow a standard framework and include several key components: 1) unbundling the electricity sector by separating generation, transmission, and distribution within state utilities to enhance efficiency and transparency; 2) opening the power generation market to independent power producers (IPPs), fostering greater competition and supply diversity; 3) establishing independent regulatory bodies to oversee the sector, ensuring fair practices and protecting consumers; and 4) introducing competitive wholesale and, where possible, retail markets to offer consumers better pricing and service options (Joskow, 2008; Bacon, 2018; Dertinger and Hirth, 2020; Lee and Usman, 2018).

Although countries vary in their approach and progress with these reforms, the current state of power sector reform remains incomplete and, in some cases, disappointing (Eberhard and Godinho, 2017). The current structure of power markets in Africa can generally be categorised into three main groups (Figure 9). The first, and by far the most common, consists of state-owned, vertically integrated utilities with no private sector participation (PSP). In these systems, a single state entity controls the entire value chain of the electricity industry, including generation, transmission, and distribution. Countries such as the Democratic Republic of Congo and Chad exemplify this structure, where the government maintains full ownership and operational control of the power utilities.

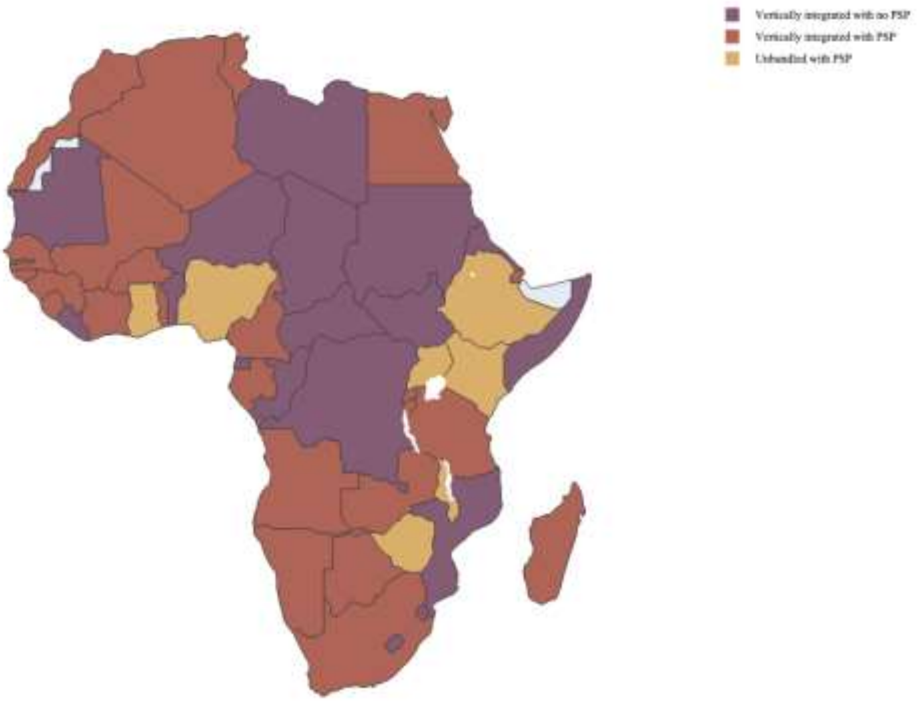


Figure 9. Current Structure of Power Markets in Africa
Source: Authors' Own Construct based on Odetayo and Walsh (2021); Eberhard et al., (2017)

The second group also involves state-owned, vertically integrated utilities; however, these countries have introduced some level of PSP. This participation is most commonly seen in the generation side in the form of Independent Power Producers (IPPs), which generate electricity and sell it to the state utility (Figure 10). In addition to IPPs, private sector involvement may take the form of concession agreements, where private companies are granted the right to operate and maintain certain parts of the power sector under government oversight. Furthermore, some countries allow small, privately owned electricity companies to serve specific industrial customers directly, particularly in sectors like mining. This hybrid model is designed to attract private investment, increase generation capacity, and diversify energy sources, all while maintaining state control over the broader system. A few notable exceptions in these group include Zambia, which allows PSP in generation, transmission and distribution, while in countries such as Cameroon, Ivory Coast, Gabon ad Mali, these vertically integrated utilities are privately owned.

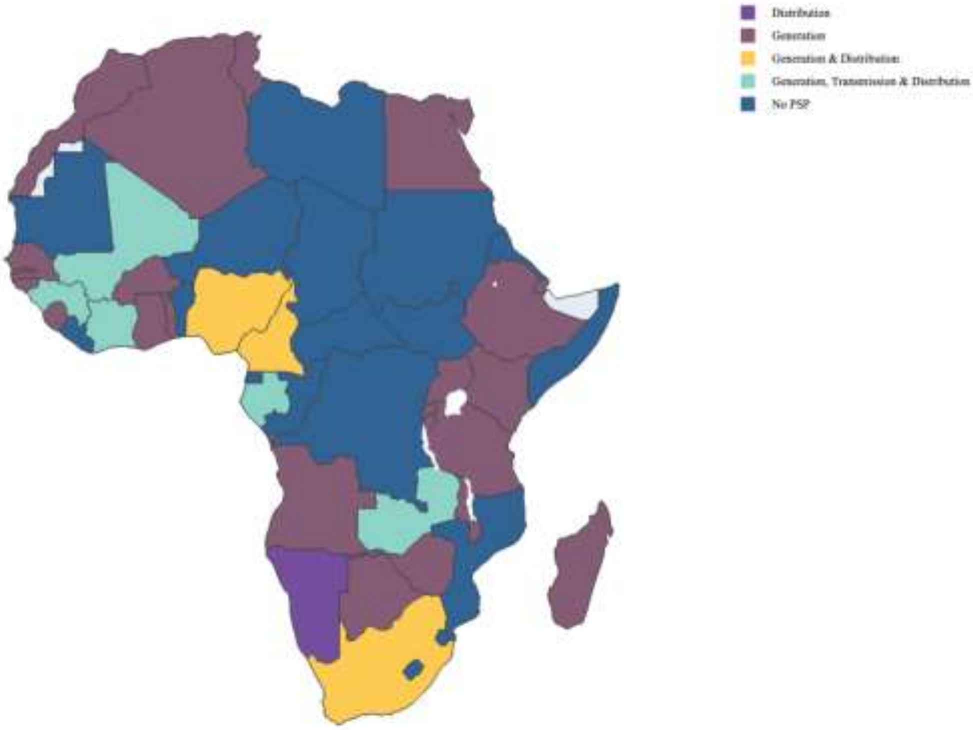


Figure 10. Private Sector Participation in the Power Sector in Africa
Source: Authors' Own Construct based on Odetayo and Walsh (2021); Eberhard et al., (2017)

In the third group, the power markets have undergone more substantial restructuring, with vertically integrated utilities either fully or partially unbundled. This means that the generation, transmission, and distribution segments have been separated into distinct entities, which can be state-owned or privately managed. Countries such as Ethiopia and Lesotho have vertically unbundled their utilities into separate state-controlled utilities and do not allow for PSP. Other countries allow for varying degrees of PSP across different segments of the electricity value chain. In Ghana, PSP is limited to the generation sector, as is the case in Zimbabwe and Angola. Kenya allows private sector involvement in both generation and transmission, while Nigeria and Uganda have opened both the generation and distribution sectors to PSP. This varying degree of PSP reflects the unique approaches taken by these countries to attract investment, improve efficiency, and address the challenges in their power sectors.

Despite the varying degrees of restructuring and market reforms across the three groups, the majority of utilities—whether fully integrated or unbundled—remain under state control, with IPPs remaining on the periphery (Malgas and Eberhard, 2011; Eberhard and Godinho, 2017). Privatisation, particularly in the form of private concessions, is still relatively rare and has been implemented in only a limited number of countries. In addition, the single buyer model, where a state utility purchases electricity from generators at regulated prices and then sells it to consumers is predominant in most countries.

3.5 Power Market Regulation

Most African countries have established regulatory authorities to manage their power markets, indicating a commitment to structured energy management. However, the quality of these bodies varies substantially across countries. Uganda is notable for its high regulatory quality, having successfully implemented essential components of a strong policy, legal, and institutional framework. While several leading manufacturing nations possess substantial regulatory frameworks, others fall into medium or low categories. South Africa, for instance, demonstrates a medium level of regulatory development, with basic elements of a supportive framework in place, although its legal and institutional structures and regulatory capacity are limited.

South Africa has a medium level of regulatory development as basic elements of a supportive regulatory framework are established with limited legal and institutional structures and capacity of the regulator. Countries like Nigeria, Tanzania, Kenya, and Namibia exhibit considerable regulatory progress, having introduced supportive measures (Figure 11) to foster growth and investment in the energy sector. However, many of these frameworks have inherent weaknesses that hinder the regulators' overall capacity and effectiveness (AfDB, 2023).

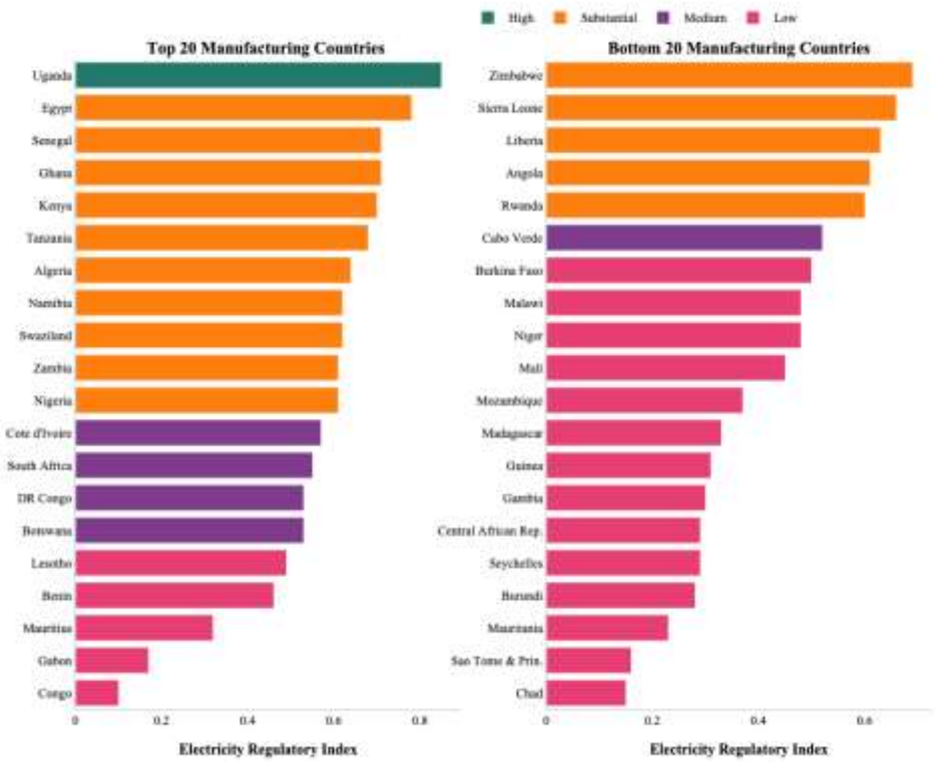


Figure 11 Electricity Regulatory Quality of Selected Countries
Source: Authors' Construct based on AfDB (2023)
Notes: The Electricity Regulatory Index (ERI), developed by AfDB, measures the level of development of electricity sector regulatory frameworks in African countries and the capacity of regulatory authorities to effectively carry out their relevant functions and duties, and thus give an indication of the quality of the regulatory framework. The ERI scores were calculated

based
on responses to comprehensive surveys distributed to electricity sectorregulatory institutions and utilities.

Regulatory autonomy is essential for effective energy regulation in Africa. However, many countries face interference in decision-making roles, such as tariff approvals and licensing (Figure *12*). This lack of independence from government and stakeholder influence leads to inadequate oversight and accountability, undermining the performance and reliability of energy markets. Such dependence hinders necessary reforms and investments in sustainable energy initiatives. Strengthening the independence of regulatory bodies is crucial for enhancing their ability to enforce regulations, promote transparency, and ensure efficient energy market operations, ultimately supporting a sustainable energy future for the continent.

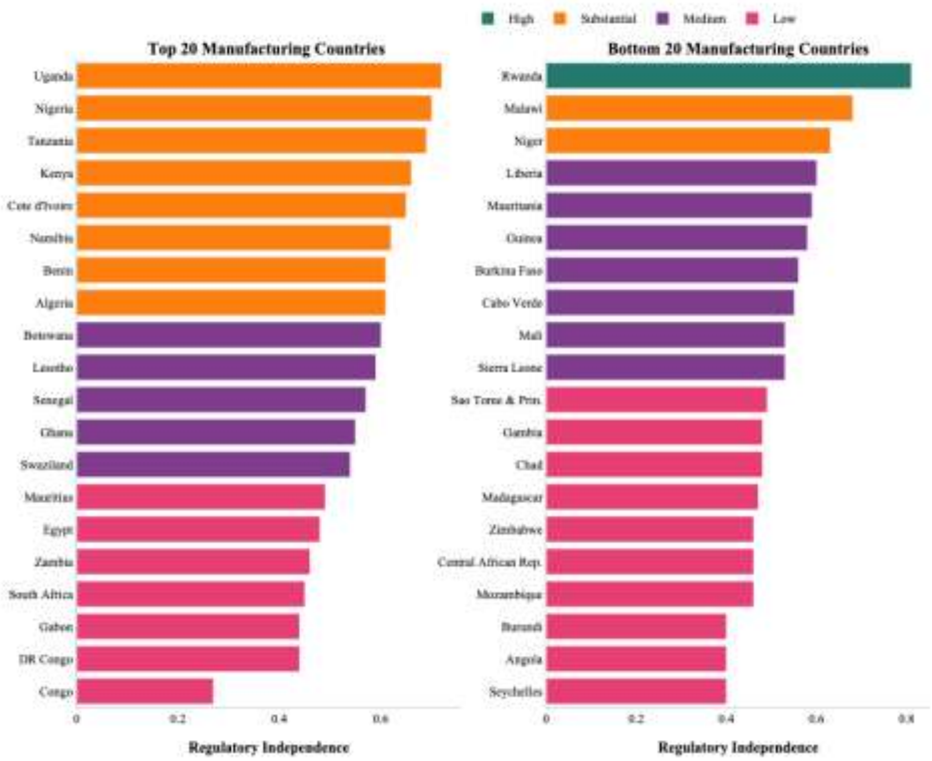


Figure 12 Independence of Electricity Regulation
Source: Authors' Construct based on AfDB (2023)
Notes: Regulatory independence evaluates the financial and decision-making autonomy of regulators, free from government and stakeholder influence. It is measured through four sub-indicators: (a) independence from government and the legislature, (b) independence from stakeholders and market participants, (c) decision-making independence, and (d) financial and budgetary independence.

3.6 Regional Power Markets

Regional power pools are integrated power transmission grids and electricity markets among African countries within regional economic communities, aimed at achieving economies of scale in electricity generation and transmission. For a power pool to function effectively, three conditions must be met: interconnection among member countries, alignment of legal and regulatory frameworks, and a multi-country organization to oversee system planning and cross-border market operations (Odetayo and Walsh, 2021).

Africa currently has five regional power pools: the West African Power Pool (WAPP), North Africa Power Pool (NAPP), Central African Power Pool (PEAC), Eastern Africa Power Pool (EAPP), and Southern African Power Pool (SAPP). These pools are linked to various Regional Economic Communities, including Economic Community of West Africa States (ECOWAS), Arab Maghreb Union (AMU), Economic Community of Central African States (ECCAS), Common Market for East and Southern Africa (COMESA), Southern Africa Development Community (SADC). A notable feature of these communities is the overlapping memberships, where countries often belong to multiple RECs, referred to as the "spaghetti bowl." Consequently, most countries are members of at least one regional power pool (Figure 13).

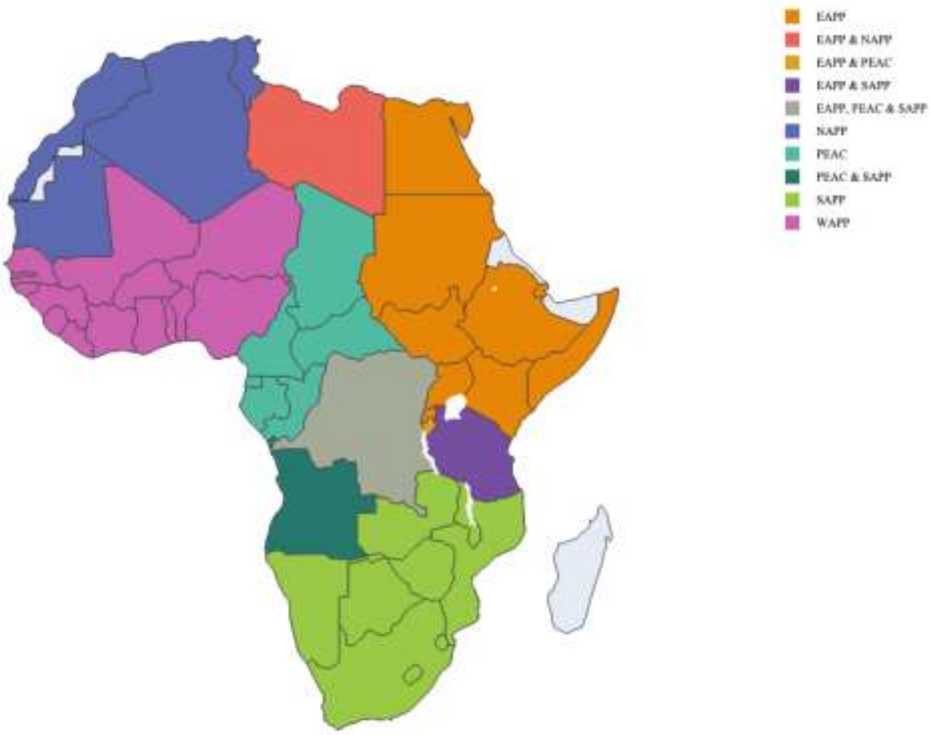


Figure 13. Regional Power Pools in Africa
Source: Authors' elaboration based on Odetayo and Walsh (2021)

Regional power generation, interconnection, and trade can significantly enhance the diffusion of clean energy in Africa. Countries with surplus renewable energy can trade with those lagging in development, fostering collaboration and resource optimisation. However, a major challenge faced by these power pools is the heterogeneity among member countries. Many countries are at varying stages of market reforms (Figure 9), private sector involvement (Figure 10), quality of regulation (Figure 11), and the financial stability of state utilities (Figure 15). This disparity can hinder effective cooperation and integration within power pools, making it essential to address these differences to fully realise the potential of regional energy collaboration and accelerate the transition to clean energy.

3.7 Electricity Prices

In many African countries, the cost of electricity is exceedingly high (Figure 14), primarily because of high cost generating electricity.[7] Factors contributing to these high production costs include aging infrastructure, and reliance on fossil fuels, which can fluctuate in price. This situation often compels governments to subsidize electricity consumption to alleviate some financial strain on consumers and businesses. However, high electricity tariffs present significant challenges to Africa's industrialisation efforts as they impose a heavy burden on firms that require affordable power to enhance productivity and create jobs. As a result, the lack of access to affordable cost-reflective priced electricity stands as a critical barrier to economic development across the continent, hindering growth and limiting opportunities for innovation and investment.

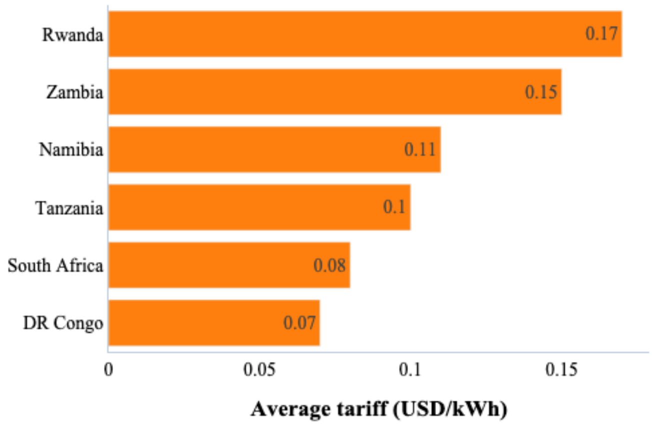


Figure 14 Average Electricity Tariff across Selected Countries
Source: Authors' elaboration based on World Bank (2024)
Note: Data are for latest year available

3.8 Financial and Technical Performance of Utilities

One of the major challenges facing the power sector is the financial performance of state-owned utilities, which often struggle to cover their operational expenses and service their debt obligations. This issue is pervasive across many countries, with most utilities failing to achieve financial sustainability (Figure 15). Only a few utilities, such as Zambia Electricity Company (ZESCO), have managed to achieve a level of financial viability where they can recover both their operational and debt service costs.

[7] The electricity tariff varies between households and firms, so the average may hide this variation.

The financial difficulties of these utilities are attributed to several factors (World Bank, 2024). This includes high operation costs, non-cost recovery reflective tariffs, inefficient payment collection systems, high system losses, obsolete infrastructure, among other factors. In many of these countries, high operational costs and low tariffs contribute to this. The financial unviability of utilities results in underinvestment in critical maintenance, upgrades, and system expansion, and increased dependence on government subsidies. Additionally, they frequently face challenges such as inadequate revenue collection due to inefficient collection systems, high levels of non-technical losses (e.g., electricity theft), and political interference, which can distort pricing and investment decisions. This results in high level of transmission and distribution losses which is more than 10% is most countries (Figure 16).

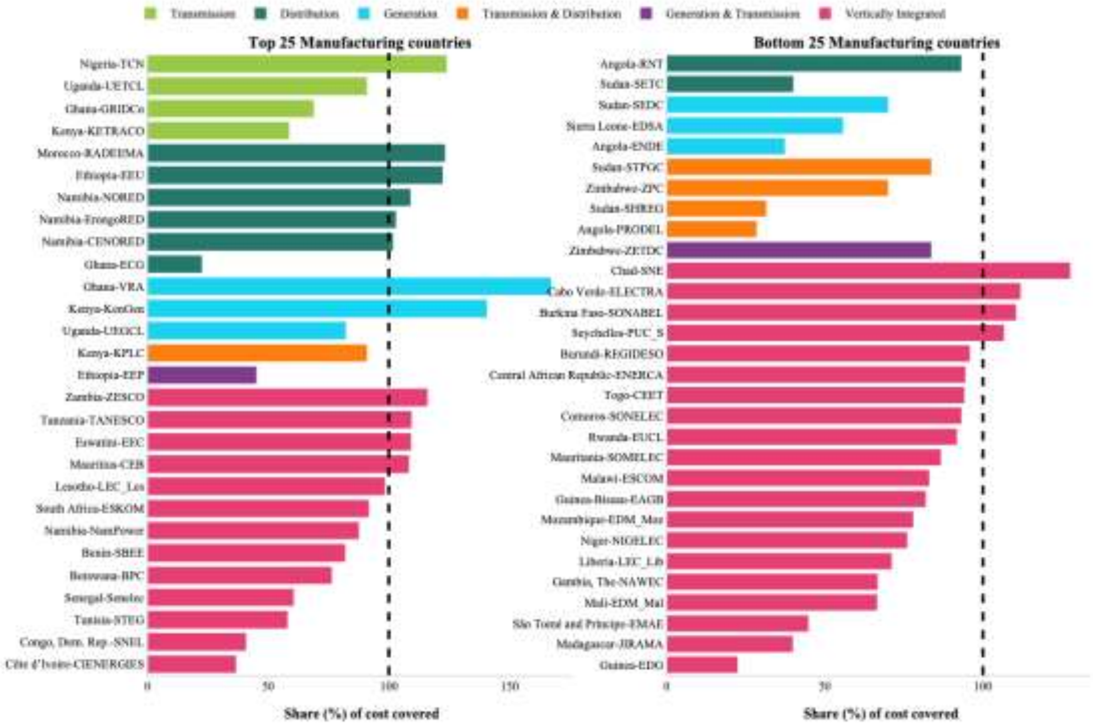


Figure 15. Operational and debt service recovery
Source: Authors' elaboration based on World Bank (2024)
Note: Data are for latest year available

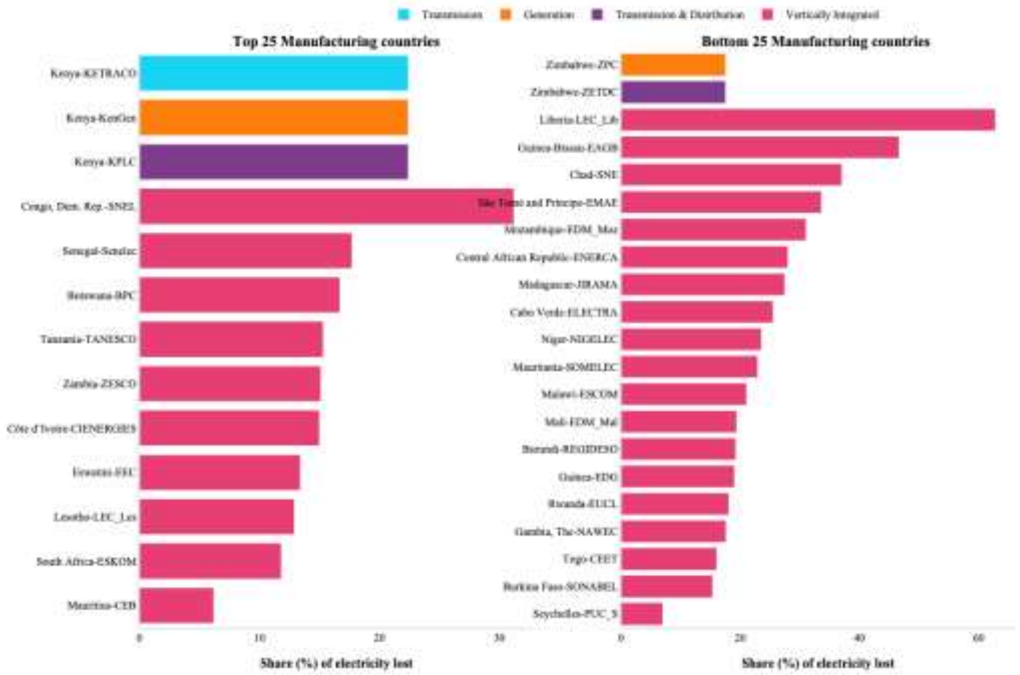


Figure 16. System Losses across selected utilities
Source: Authors' elaboration based on World Bank (2024)
Note: Data are for latest year available

In addition, these structural factors tend to reinforce exacerbate one another, creating a self-perpetuating cycle of underperformance and insufficient investment in grid infrastructure (Figure 17). When utilities are unable to recover sufficient costs, they lack the necessary funds to invest in both the development of new infrastructure and the maintenance of existing systems. This financial shortfall prevents essential upgrades and repairs, leading to increased system inefficiencies and elevated losses. As the infrastructure deteriorates, the frequency and duration of power outages rise, further degrading the reliability of the service provided, which constrains the performance of most firms (Figure 18). Some firms have to rely on backup generators which increases their production costs.

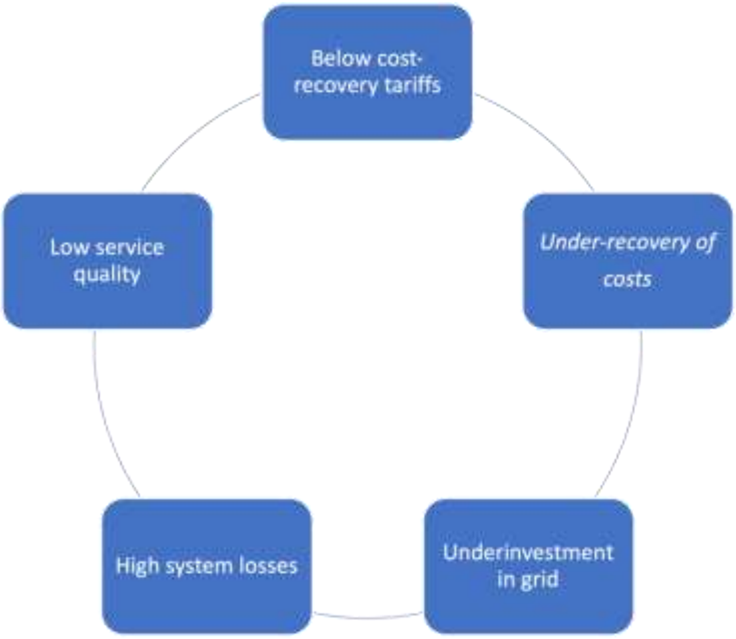


Figure 17. The vicious cycle of underperformance and insufficient investment in grid infrastructure
Source: Authors' own construct

The worsening service quality often prompts regulators and policymakers to become more hesitant to approve necessary tariff adjustments. This reluctance stems from concerns about public reaction and the perceived impact of higher rates on consumers. Consequently, utilities find themselves in a deepening financial strain, as they are deprived of the revenue needed to address these very issues. The cycle continues as the decline in service quality and the increased system losses contribute to a further erosion of financial stability. For instance, in Tanzania, the management and maintenance of energy generation and transmission infrastructure is inefficient, leading to bottlenecks that affect energy reliability, increase power losses, and necessitate government subsidies (Andreoni et al. 2022).

This situation not only impedes the ability of utilities to undertake critical infrastructure projects but also diminishes their capacity to make necessary improvements, perpetuating the cycle of underperformance and inadequate investment. Additionally, the revenue-related risks, specifically those linked to relying on financially unstable state utilities, serve as deterrent for investors. These off-taker risks make it challenging for countries to secure private capital at reasonable rates. As a result, the ability to attract investment for grid modernization and infrastructure upgrades is severely hampered (World Bank, 2024).

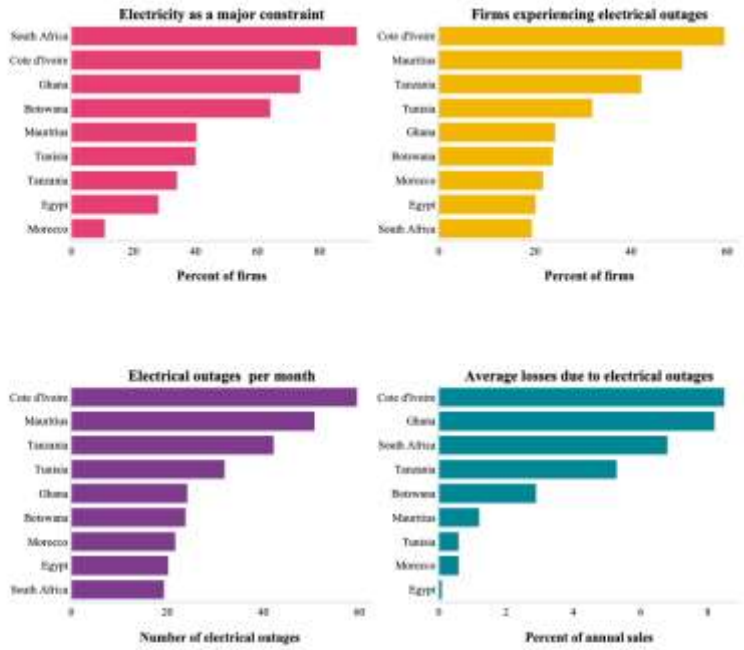


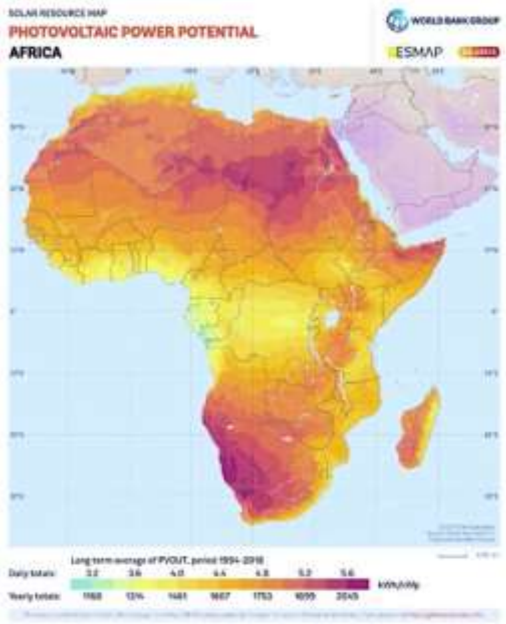
Figure 18. Electricity Constraints in Selected Countries
Source: Authors' Elaboration based on World Bank (2024)
Note: Data are for either 2020 or 2023

4. Renewable Energy Development

4.1 Diffusion of Renewable Energy

Africa is richly endowed with a wide range of renewable energy resources, including solar, wind, hydro, and geothermal, positioning the continent to become a global leader in clean energy development. Among these, solar energy stands out as Africa's most abundant resource. The continent holds an impressive 60% of the world's prime solar energy potential (IEA, 2022), offering unparalleled opportunities for large-scale solar power generation. According to IRENA and AfDB (2022), Africa's technical potential for solar power is estimated at a staggering 7,900 GW, based on a conservative assumption of utilising just 1% of its land area for solar installations. This highlights the continent's vast capacity to harness solar energy and underscores its potential to play a transformative role in the global shift towards renewable energy sources.

Figure 20 illustrates the long-term average practical solar photovoltaic (PV) potential, representing the power output a typical PV system can achieve. This potential is measured in kilowatt-hours per installed kilowatt peak (kWh/kWp), commonly called PVOUT. It offers a comprehensive simulation of how effectively the available solar energy can be converted into electricity, taking into account various environmental and technical factors that influence system performance including air temperature, terrain horizon, and albedo, as well as module tilt, configuration, shading, soiling, and other factors affecting the system performance (ESMAP, 2020). PVOUT thus reflects the amount of power generated per unit of installed PV capacity over the long term, offering insight into the practical solar power potential that can be achieved across different regions. Notably, the data reveals that this practical solar PV potential extends across all areas of the continent. With an average PV power potential of 4.51 kWh/kWp per day, Africa surpasses the global average of 4.19 kWh/kWp per day, highlighting the continent's significant advantage in solar PV power generation.



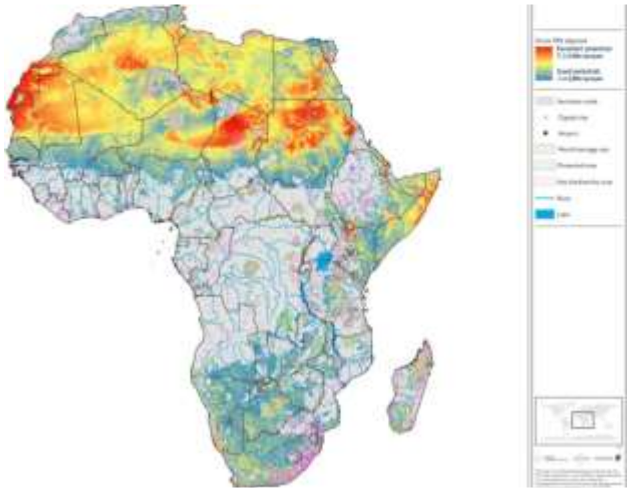


Figure 19. Wind Power Potential
Source: IFC (2020)

Figure 20. Long term average of Solar PV Power Potential.
Source: ESMAP (2020)

The technical potential for wind power generation across Africa is substantial, with estimates placing it at an impressive 461 GW, based on a 1% land-utilization factor (IRENA and AfDB, 2022). This reflects the vast opportunities for wind energy development, particularly in regions with favourable wind conditions. According to IFC (2020), the total wind power potential on the continent is even more staggering, estimated at 180,000 TWh per year. This figure is approximately 250 times greater than the current energy demand across Africa, underscoring the immense untapped capacity that could meet not only local but also regional and global energy needs. However, unlike solar energy, which is abundant and relatively uniform across the continent, wind power potential is more unevenly distributed and concentrated in a few countries including Algeria, Mauritania, Egypt, Namibia, Ethiopia, and South Africa. This geographical disparity means that while some African countries have exceptional wind resources, others are less suited for large-scale wind energy production.

Despite the continent's vast and diverse renewable energy resources, the adoption and integration of these sources into the electricity generation mix have been relatively slow. The distribution of renewable energy technologies—excluding hydroelectric power—is notably uneven across Africa, with their deployment being concentrated in only a few countries (Figure 5). Currently, the majority of Africa's installed capacity for modern renewable energy technologies is concentrated in South Africa, Morocco, Kenya, and Egypt (Figure 21). These countries have made significant strides in developing and deploying renewable energy infrastructure, yet their combined efforts highlight a broader trend of uneven progress across the continent.

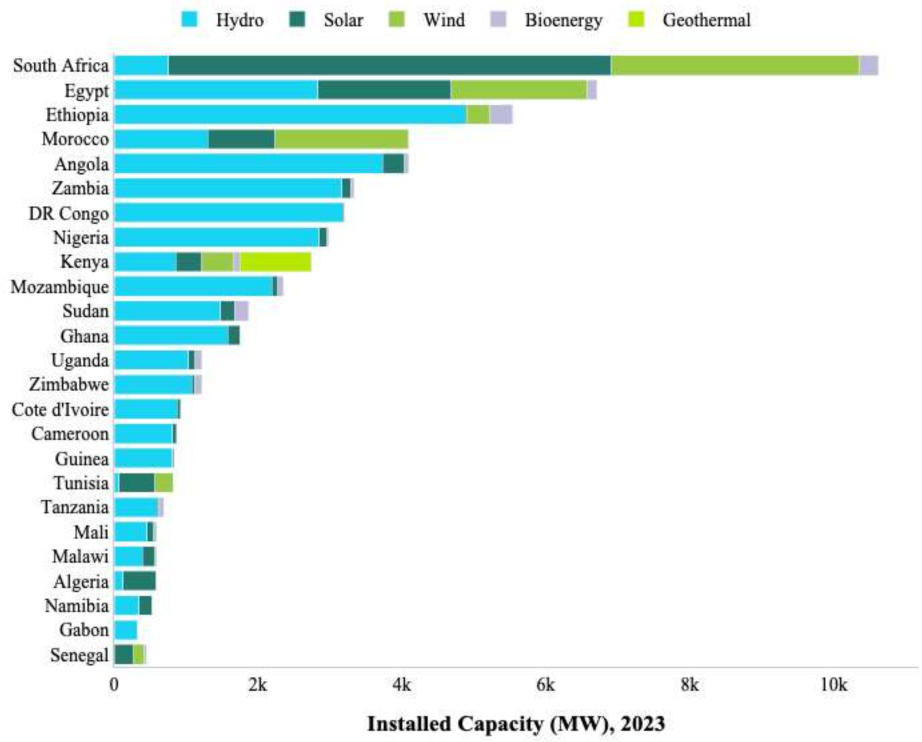


Figure 21 Renewable Energy Installed Capacity by Technology, 2023
Source: Authors' Elaboration based on IRENA (2024)
Note: Countries are ranked based on 2023 total renewable installed capacity (MW)

For instance, in South Africa, renewable energy development has gained substantial momentum, driven by government policies and a commitment to diversifying the country's energy sources. South Africa has invested heavily in wind and solar power, establishing itself as a leader in renewable energy within the region. The country's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has been instrumental in this growth, attracting significant investment and facilitating the development of numerous renewable energy projects. Kenya's renewable energy landscape is similarly notable, with the country focusing on both geothermal and wind energy. Kenya is also recognised for its substantial geothermal resources, which have been harnessed to provide a significant portion of the country's electricity (Figure 21).

While these countries are making impressive progress, the overall rate of renewable energy integration across Africa remains slow. Many other African nations are still in the early stages of exploring or developing their renewable energy resources. Factors such as insufficient investment, policy and regulatory challenges, and limited infrastructure have contributed to the slower pace of renewable energy adoption in these countries.

4.2 Investment in Renewable Energy

One of the primary obstacles hindering the widespread adoption of renewable energy is the insufficient flow of investment into the sector. Global clean energy investments are projected to reach approximately USD 320 billion in 2024, marking a significant increase of over 50% from 2020 levels (IEA, 2024). This surge in investment reflects a growing commitment to transitioning towards sustainable energy sources, driven by the urgent need to address climate change and reduce greenhouse gas emissions. Despite this overall increase in clean energy investment, emerging markets and developing economies (EMDEs) outside of China receive only about 15% of global clean energy spending. Within this group, Africa's share is particularly small. In 2024, the continent's clean energy investments are expected to account for a mere 2% of the global total (Figure 22). This stark disparity highlights the challenges faced by African countries in scaling up their renewable energy infrastructure despite their significant renewable resource potential.

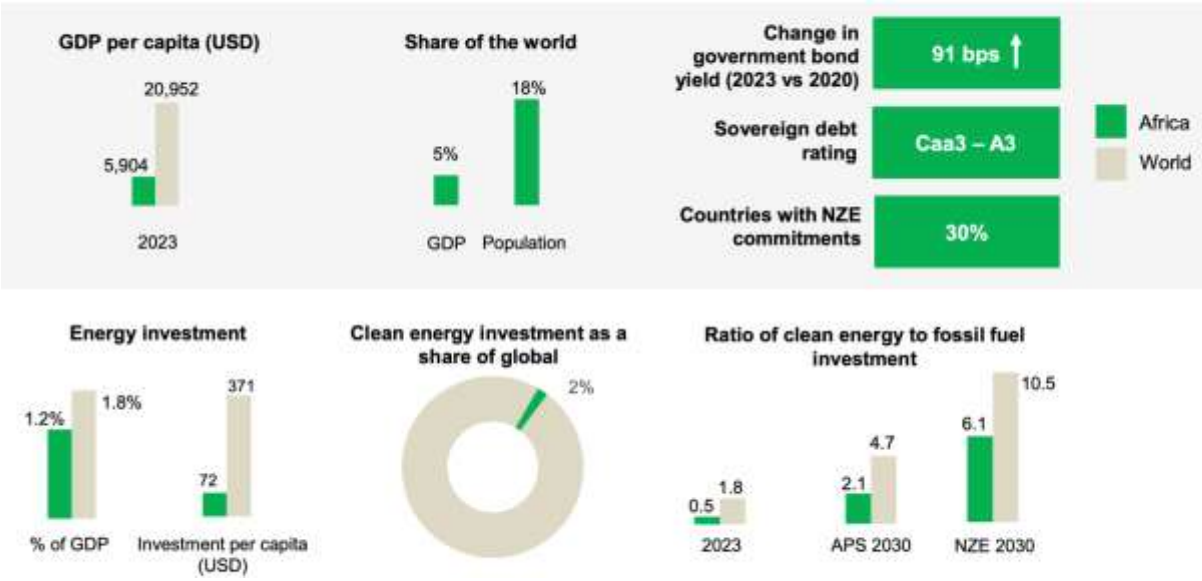


Figure 22. Africa's share of clean energy investments
Source: IEA (2024b)

In addition, the limited public investment flows in renewable energy technologies (excluding hydro) the region are concentrated in a few countries including South Africa and Morocco (Figure *23*). This imbalance and unequal distribution of investment flows across the continent is further aggravated by a complex array of interrelated challenges that many African countries face. These include the lingering impacts of the COVID-19 pandemic, which severely disrupted economies and healthcare systems, as well as the energy and food crises triggered by Russia's invasion of Ukraine. These crises have intensified pre-existing vulnerabilities in supply chains and further strained national budgets and limits fiscal space.

In parallel, borrowing costs in many countries have soared to unsustainable levels, as rising global interest rates make it more expensive to access finance. As a result, debt servicing obligations in numerous nations now exceed clean energy investment by a factor of two (IEA, 2023), hindering progress towards essential energy transitions and sustainable development. As a consequence, fiscal sustainability indicators have deteriorated in many countries within the region (IMF, 2023), with countries like Ghana and Zambia defaulting on their debt obligations. Compounding these issues are the escalating risks posed by climate change, which threaten both short- and long-term development goals, placing additional pressure on already fragile ecosystems and economies. These creates a formidable challenge, highlighting the urgent need for coordinated international efforts and innovative financial mechanisms to address the investment deficits.

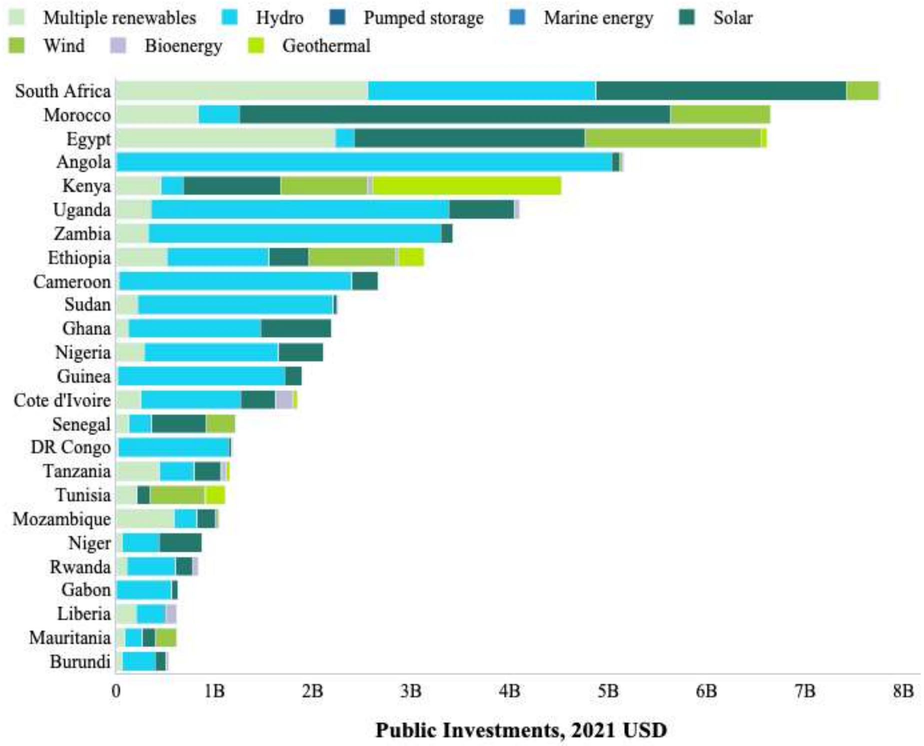


Figure 23. Public Investment flows by technology, 2000-2022
Source: Authors' Elaboration based on IRENA (2024)
Note: This includes investments funded by governments, state-owned financial institutions, state- owned enterprises, development finance institutions (national, bilateral and multilateral), export credit agencies and climate funds.

Several factors influence the investment climate for clean energy in developing countries, particularly in Africa (IEA, 2021). Renewable energy has seen remarkable cost reductions over the past decade, with solar PV costs dropping by nearly 90% and wind energy costs falling by 60% to 70% (IRENA, 2023). These declines have been observed across capital expenditures (CAPEX), operating expenditures (OPEX), and financing costs (Melekh et al., 2024). Despite these advances, one of the most significant challenges to accelerating the adoption of renewable energy in Africa is the substantial upfront capital required for such projects. A key barrier to investment in the continent's clean energy sector is the high cost of capital, which can vary greatly due to local interest rates and broader financial conditions. According to the IEA (2021), the cost of capital for energy projects in African countries is typically two to three times higher than in advanced economies and China. This elevated cost poses a significant obstacle to attracting the necessary investment. Higher capital costs either inflate the total cost of renewable energy projects, making them less economically viable or deter potential investors entirely, given the perceived financial risks.

These risks are multifaceted IEA (2021), and include revenue risks, such as low demand for energy, payment delays from power purchasers, contract renegotiations, and concerns about the financial stability of energy off-takers. Political risks, like instability or sudden changes in government policy, can introduce additional uncertainty, further raising project costs. Furthermore, inadequate local administrative capacity can lead to delays in project implementation due to challenges with licensing and permits, land acquisition issues, and strict local content or minimum localization requirements for project approvals. These hurdles often slow down the pace of renewable energy projects, adding layers of complexity and cost. Currency exchange and convertibility risks also affect the financial viability of renewable energy projects, particularly in countries with volatile or weakening currencies. Currency fluctuations can increase the financial burden on projects reliant on foreign financing, as costs may rise unexpectedly when converted back into local currencies.

As a result, even with the dramatic cost reductions in renewable technologies, the financial challenges of accessing affordable capital continue to slow down the growth of the sector in Africa. Addressing these financial barriers is crucial for unlocking investment opportunities and accelerating the development of clean energy infrastructure in Africa.

Foreign direct investment (FDI) in renewable energy in Africa displays distinct patterns when compared to public renewable investment. While public investments tend to focus heavily on hydroelectric power, particularly across various African nations, foreign investments are increasingly directed toward the development of solar and wind energy (Figure 24).These forms of renewable energy are receiving greater attention from international investors, who see significant potential in harnessing the continent's abundant solar and wind resources. However, it's noteworthy that this influx of renewable energy investment is also not evenly distributed across the continent; rather, it is predominantly concentrated in a few key countries. South Africa, Egypt, Nigeria, and Morocco emerge as the primary recipients of this FDI, benefiting from supportive policies. Interestingly, Nigeria ranks third in terms of renewable energy FDI inflows, signalling the potential of the oil rich country as an emerging player in the renewable energy sector.

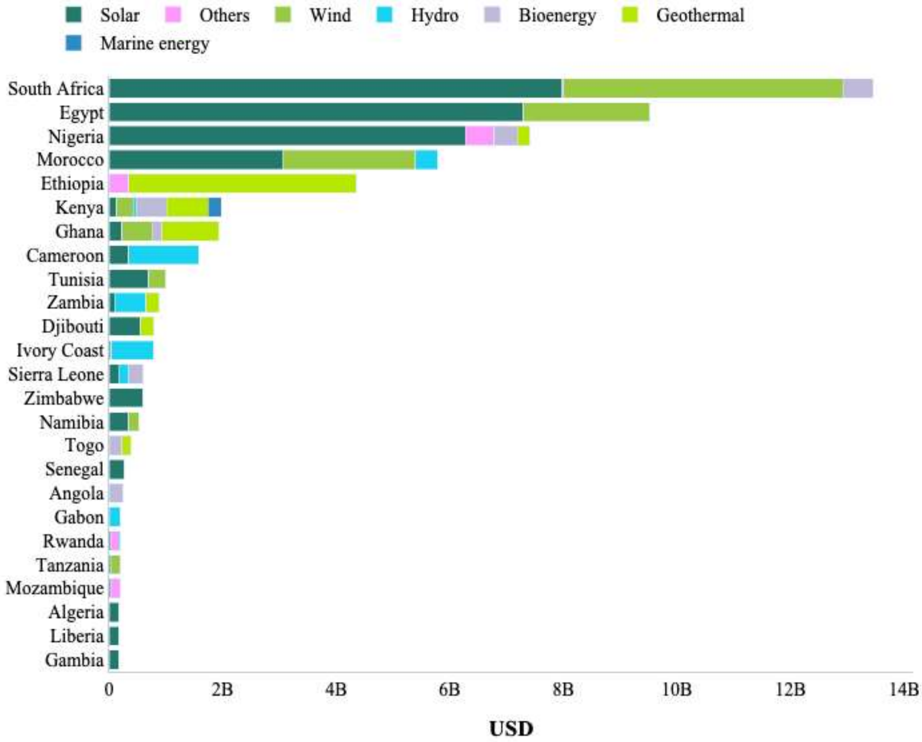


Figure 24 Renewable Energy Foreign Direct Investments, 2004-2018
Source: Authors' Elaboration based on FT fDi Markets database

Several countries are pivotal in driving these investments across the continent (Figure *25*). In South Africa, foreign investment primarily comes from Ireland, France, Italy, Saudi Arabia, and the United States, showcasing a diverse array of international partners committed to advancing renewable energy initiatives. Conversely, in Egypt, Bahrain stands out as the largest source of FDI, highlighting the significance of regional partnerships in fostering investment. Meanwhile, Morocco has seen substantial Chinese investment, reflecting China's expanding influence in Africa's renewable energy sector. For Nigeria, the main sources of renewable energy FDI are Canada and the United States, demonstrating North American interest in expanding clean energy infrastructure in this country.

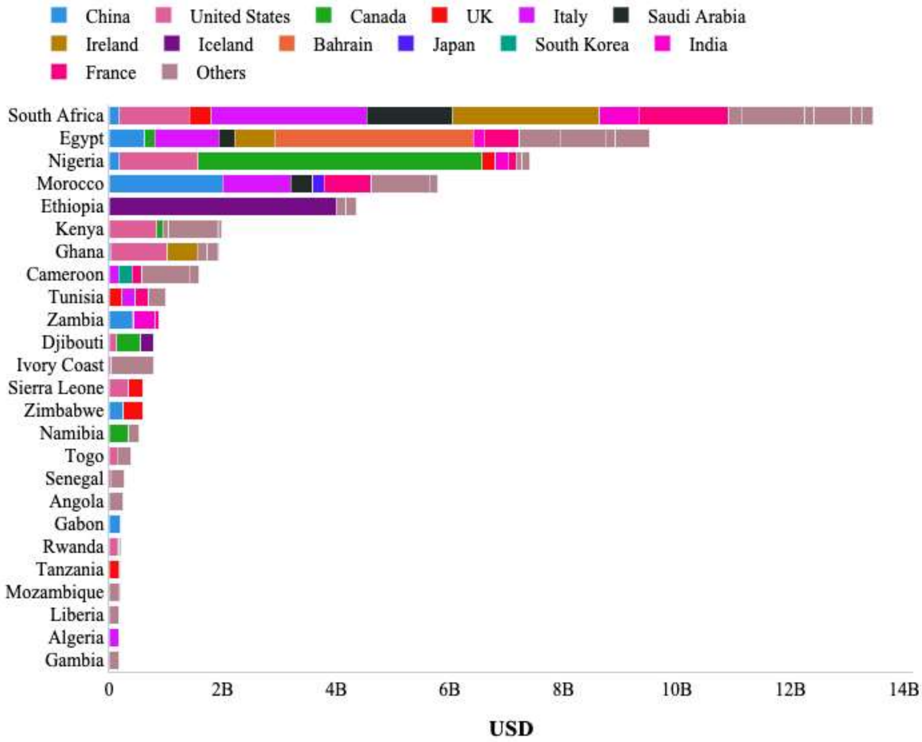


Figure 25 Source of Renewable Energy Foreign Direct Investments, 2004-2018
Source: Authors' Elaboration based on FT fDi Markets database

4.3 Imports of Renewable Energy Technologies

China is the global leader in solar panel production, playing a key role in advancing renewable energy. Since 2011, it has invested over USD 50 billion in photovoltaic (PV) supply capacity, creating more than 300,000 jobs. China's dominance spans over 80% of all manufacturing stages of solar panels—polysilicon, ingots, wafers, cells, and modules—far exceeding its share of global demand (IEA, 2022). The country is also home to the world's top 10 suppliers of solar PV manufacturing equipment. China's large-scale production has significantly reduced costs globally, accelerating clean energy transitions (IEA, 2022).

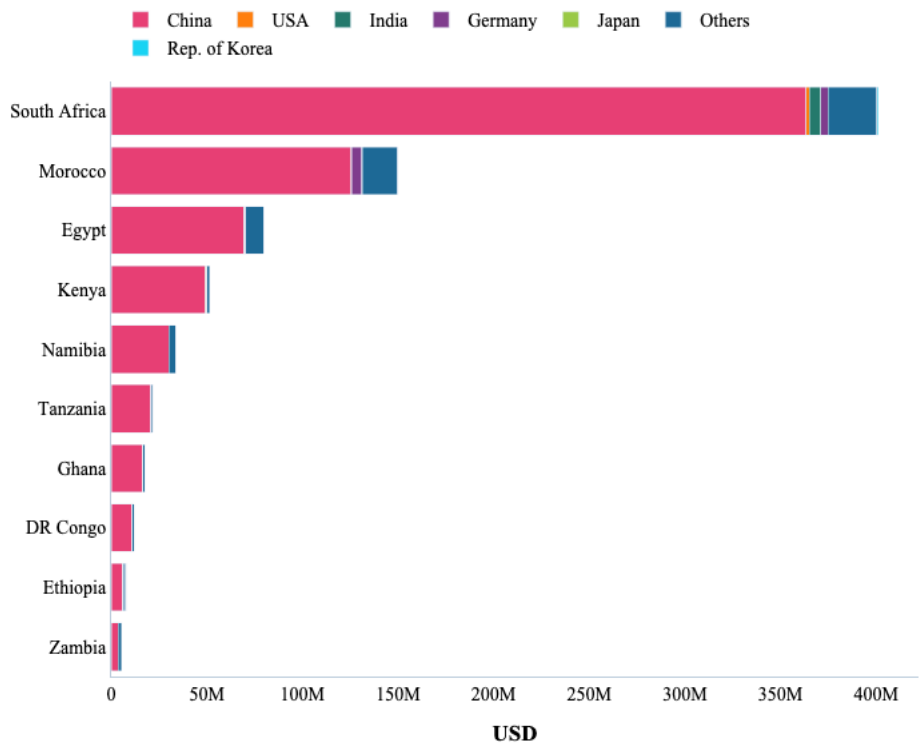


Figure 26 Import of Solar Panels by Country and Origin, 2022
Source: Authors' Elaboration based on CEPII-BACI International Trade Database

South Africa stands out as the largest importer of solar panels from China, taking advantage of China's manufacturing capabilities to boost its renewable energy initiatives (Figure 26). Following South Africa, other African nations like Morocco, Egypt, and Namibia have also emerged as significant importers, reflecting a growing commitment to harnessing solar energy.

In contrast, the landscape for wind turbines is more varied. Morocco leads the continent as the largest importer of wind turbines, primarily sourcing them from Germany, a country renowned for its advanced engineering and renewable energy technologies (Figure 27). However, in in Egypt and Ethiopia, China holds a dominant position in the wind turbine market. China's competitive pricing and growing technological expertise allow it to maintain a strong presence in these countries, supporting their renewable energy goals.

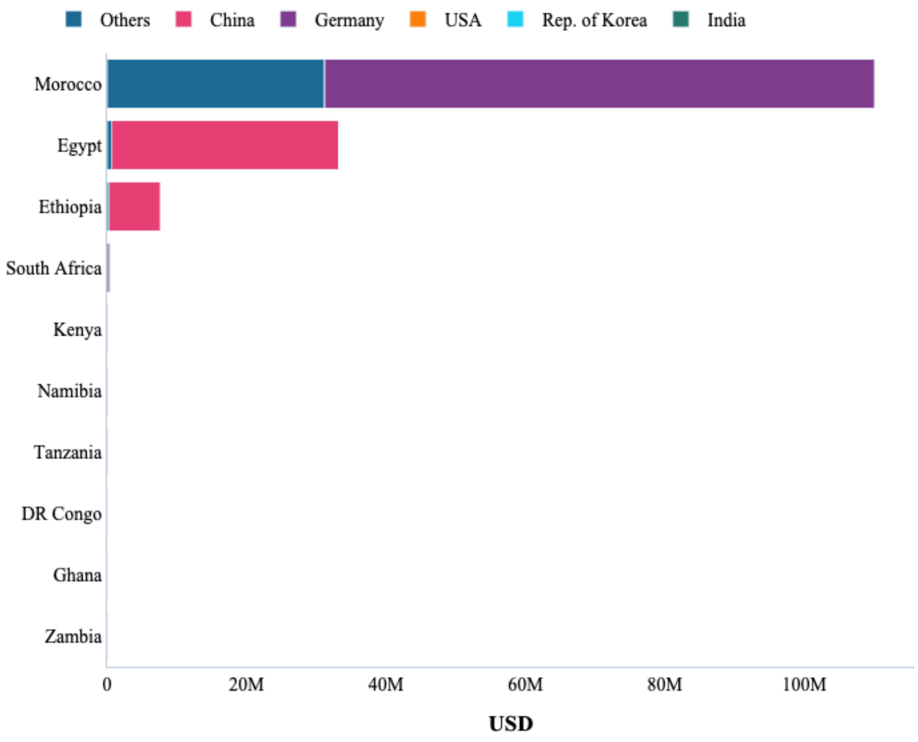


Figure 27 Import of Wind Turbines by Country and Origin, 2022
Source: Authors' Elaboration based on CEPII-BACI International Trade Database

4.4 Renewable Energy Procurement Policies

Countries in Africa are increasingly adopting policies to boost investments in renewable energy technologies. Up until the late 2000s, renewable energy technologies have been procured by direct negotiations (Figure 28). In this process, developers of power projects engage directly with government entities or state utility companies to negotiate the terms of their projects, including power purchase agreements (PPAs). While DNs offer flexibility to tailor agreements for specific projects, they often lack competition and transparency. This non-transparency can lead to higher tariffs and create opportunities for corruption, undermining the legitimacy of contracts and potentially deterring further investment (Eberhard and Gratwick, 2011; PPP Knowledge Lab, 2021).

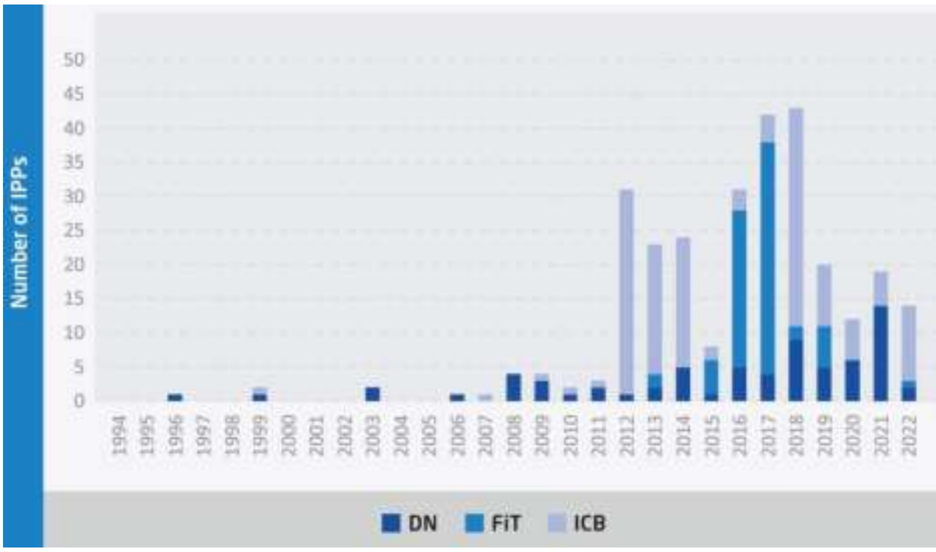


Figure 28. Trend in Renewable Energy Independent Power Procurement
Source: Kruger and Alao (2024)
Notes: DN-Direct negotiation; FiT: Feed-in- Tariff, ICB: International Competitive Bidding

Since 2010, at least 25 African nations have introduced renewable energy auctions (Figure 29), while Feed-in Tariffs (FiTs) have been used in 14 countries (IRENA, 2024). FiTs offer guaranteed prices for fixed periods for electricity produced from renewable sources, while auctions involve inviting bids from developers to supply renewable energy at the lowest possible cost, promoting transparency and cost-efficiency. Under FiT programs, potential developers typically do not compete on price; instead, they focus on policy-driven criteria such as project speed, quality, and socio-economic benefits (IFC, 2020; USAID, 2019; Kruger et al., 2018). Despite the broad implementation of FiTs, investments have been limited to just a few countries, namely Egypt, Uganda, Namibia, and Kenya (Kruger and Alao, 2024). This indicates that while FiTs are popular, their effectiveness in attracting widespread investment across the continent remains constraint.

Auctions entail soliciting bids from developers to provide renewable energy at the lowest possible cost, fostering transparency and cost-effectiveness. Beyond pricing, competition may also encompass factors such as local content, economic development, and the quality of technology, among other considerations. The shift to auctions on the continent (Figure 29) mirrors the global trend, where auctions have recently taken the lead as the primary tool in the renewable energy policy arsenal, surpassing FiTs, which were once the main policy instrument (Grashof, 2021). By 2020, approximately 116 countries had embraced auctions worldwide (REN21, 2021). Several factors are driving the increasing preference for auctions as the primary policy choice. Key among these is the broader market transformation influenced by the decline in renewable energy costs, which has rendered FiTs more costly for the government. For developing countries, limited fiscal resources, underdeveloped electricity grids, the World Bank's support for market-oriented approaches, and the underperformance of FiTs in some countries have all contributed to the shift towards auctions (Grashof, 2021).

Figure 29. Countries using renewable energy auctions in Africa
Source: Kruger and Alao 2024)

While auction models are becoming the predominant model for procuring renewable energy technologies, there are differences in their design, implementation and performance across countries (Table 1). South Africa operates four key auction schemes for utility-scale renewable energy generation. The Renewable Energy Independent Power Producer Procurement Programme (REPPPP), initiated in response to electricity supply constraints, facilitates private investment in grid-connected projects. The Small Projects Independent Power Producer Procurement Programme (SP-I4P), introduced in 2013, aims to procure 200 MW from small projects, encouraging participation from local players. The Risk Mitigation Independent Power Programme (RMI4P), launched in 2020, targets 2,000 MW of dispatchable power to address short-term supply gaps, while the Battery Energy Storage Independent Power Producer Procurement Programme (BESI4P) focuses on integrating battery storage to enhance grid stability (Kruger and Alao, 2024).

The auctions programs feature single-round bidding processes without pre-qualifications, expediting procurement. Project developers must secure sites independently, distinguishing South Africa from other Sub-Saharan countries that typically involve the government in site selection.

Rigorous qualifications ensure that only capable bidders proceed, and socio-economic development requirements foster job creation and local industrialization. Bids are evaluated primarily on price, with recent rounds prioritizing tariffs. Preferred bidders enter 20-year PPAs with Eskom, supported by government guarantees to mitigate risks from Eskom's financial instability.

South Africa’s renewable energy auction scheme stands out for its large scale and comprehensive design, aligning well with the country’s economic and electricity objectives. Its emphasis on socio-economic development and environmental sustainability has driven the adoption of renewable energy auctions (IRENA, 2018). Consequently, project realization rates in the REIPPP rounds are among the highest globally (Kitzing et al., 2022), due to the program's well-structured approach to financing and due diligence (Kruger and Alao, 2024).

In contrast, other African countries like Ethiopia have struggled, with at most one round of procured projects successfully reaching financial closure. This highlights the need for country-specific auction designs. Simply implementing auction policies does not guarantee optimal results, as varying policy frameworks produce different outcomes across countries. Success depends on tailored designs that account for local conditions and challenges.

Table 1. Overview of Auctions models in selected countries

	South Africa	Mauritius	Botswana	Ethiopia	Morocco
Year of Introduction	2011	2011	2015	2016	2010
Auction Demand	18,894 MW (11 rounds)	244 MW (6 rounds)	Over 400 MW (6 rounds)	1,100 MW (3 rounds)	3,180 MW (7 rounds)
Technology	Solar PV, Wind, CSP, Biomass, Biogas, Landfill Gas, Small Hydro, and Battery Storage	Solar PV, Wind, and Battery Storage	Solar PV, and CSP	Solar PV	Solar PV, Wind, and CSP
Procurer	Independent	Utility	Utility	Independent/Utility	Independent
Bidding stages	One	Two	Two	Two	Two
Site selection	Developer	Developer	Government	Government	government
Local content	40% min.	None	40% min.	15% min.	Up to 40%
Evaluation	Earlier – 70:30 (Price: ED), Recently – 90:10 (Price: ED)	Earlier – 70:30 (Price: Technical), Recently – 100% price	N/A	70:30 (Price: Technical)	N/A
PPA	20 years, 25 years for battery storage	Earlier – 20 years, recently – 25 years	25 years	20 years	20 years for Wind and 25 years for Solar
Risk covers/ Guarantees	Sovereign guarantee	None	None	Sovereign & payment guarantees, & political risk cover	Payment guarantee, currency risk cover
Lowest price (US$c/kWh)	2.3	9.9	N/A	2.5	2.5
Currency	ZAR (indexed to US$)	MUR, USD, EUR	Pula (partially indexed to US$)	US$ (but payment in ETB)	MAD (indexed to EUR and/or US$)
Commercial operation	7,064 MW	75 MW	No	No	690 MW

Source: Kruger and Alao (2024)

4.5 Electricity Transmission and Distribution Grids

The global shift towards clean energy is accelerating the transformation of energy systems, placing electricity at the centre of modern economies. As countries strive to achieve net-zero emissions, this transition requires a fundamental upgrade of power infrastructure. Bigger, more resilient, and smarter grids are essential to support the increasing demand for electricity, especially as more sectors electrify and renewable energy sources expand (IEA, 2023).

However, across the continent, existing grids are outdated, largely due to decades of underinvestment. The continent faces significant challenges in expanding its transmission and distribution networks, which are critical to achieving both energy access and sustainability goals. Africa has some of the shortest grid lengths globally, and much of its infrastructure is aging, with many lines and substations over a decade old (Figure 30). This underdeveloped grid limits the ability to integrate new renewable energy sources like wind and solar, which require flexible, modern networks to operate effectively. Without substantial investment in modernizing and expanding grid infrastructure, the continent's clean energy transition could be slowed, hindering progress towards both economic development and climate goals.

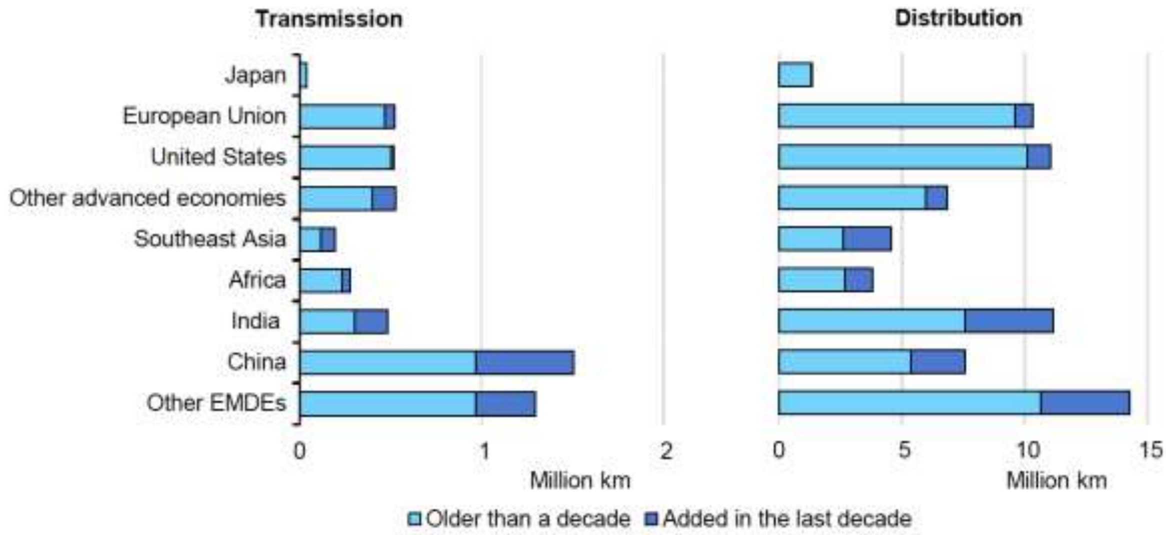


Figure 30. Electricity transmission and distribution lengths by age and country/region, 2021

Source: IEA (2023)

Another significant issue is the spatial distribution of power grids, which can hinder the efficient development of renewable energy sources. In South Africa, for example, the existing grid infrastructure is often located near coal resources and far from areas with the highest potential for renewable energy generation, such as regions rich in solar and wind resources. This geographic mismatch creates logistical and financial challenges in transmitting clean energy from remote areas to urban centres and industries that need it most. Expanding or modifying the grid to connect these renewable-rich areas is crucial for enhancing the country's energy transition and sustainability efforts.

5. Country Readiness for Renewable Energy

While the continent has abundant renewable energy potential, several key factors (Figure 31) are essential for its development:

a. Policy Environment: A supportive policy environment is vital for renewable energy growth. Governments must establish clear goals and provide incentives such as subsidies and tax breaks to encourage investment. Without favourable policies, investors may be deterred by uncertainty or high initial costs.

b. Regulatory Framework: A well-structured regulatory framework facilitates the smooth implementation of renewable energy projects, covering areas like grid access and licensing. Outdated or complex regulations can hinder project approvals and discourage investment. Effective regulations promote fair competition and protect both producers and consumers.
c. Finance: Substantial upfront investments are often needed for renewable energy projects. Access to affordable financing, is crucial for attracting private capital.
d. Infrastructure: Renewable energy requires modern infrastructure for generation, storage, and distribution. Upgrading grid systems, building transmission lines, and implementing energy storage solutions are essential to accommodate fluctuating energy sources and integrate them into existing systems.
e. Skills: A skilled workforce is necessary for developing and maintaining renewable energy technologies. Investments in education and training programs can create a talent pool capable of driving innovation and sustaining projects. A shortage of skilled workers can slow technology adoption.

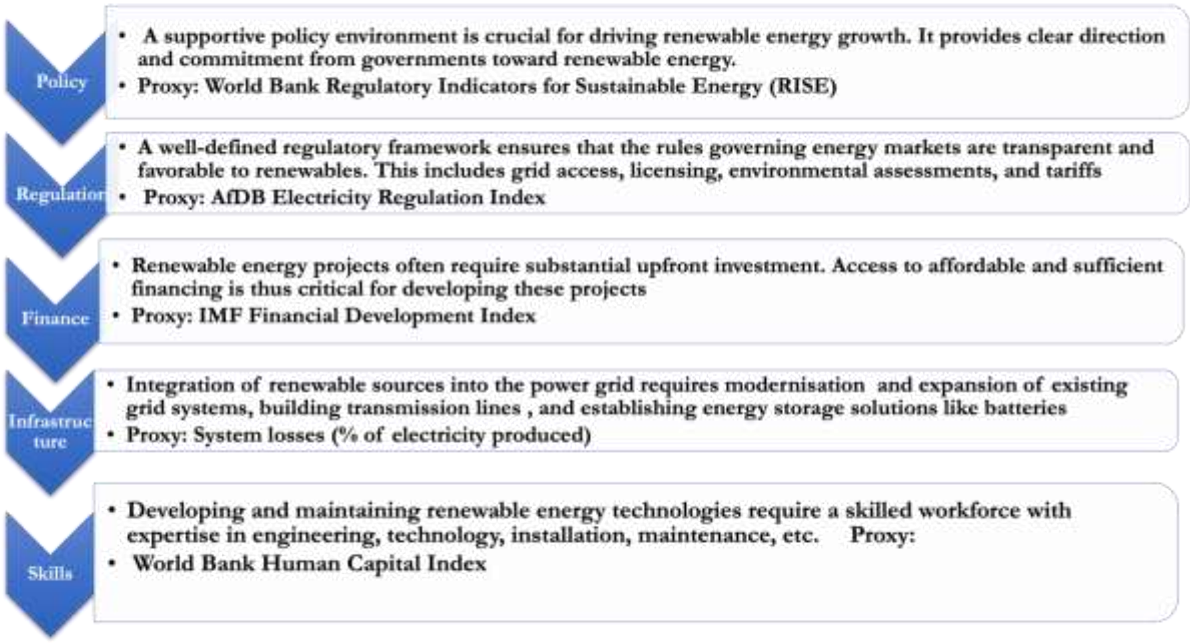


Figure 31. Key Enablers of Renewable Development

Source: Authors' Construct based on IRENA (2024).

These elements collectively create a supportive environment for renewable energy development, helping nations transition to cleaner energy sources. In the following section, we evaluate the readiness of countries based on these five factors.[8]

[8] A detailed description of the data used in this evaluation can be found in the Appendix.

5.1 Policy Environment

Countries with significant solar energy potential, such as Egypt, Morocco, and South Africa, have developed advanced policy frameworks to harness their RE resources effectively (Figure 32). These countries have undertaken considerable efforts to create policies that tap into their abundant RE potential and foster an environment conducive to the growth and expansion of the RE sector. A key component of these efforts has been the design and implementation of relevant legal frameworks that establish a solid foundation for RE development. For example, until the late 2000s, Morocco relied almost entirely on imported fossil fuels to meet its energy needs, making it vulnerable to fluctuating international energy prices (Clean Technica, 2016; Luigi et al., 2016). The introduction of the National Energy Strategy (NES), the Solar Plan (MSP), and the Integrated Wind Energy Programme (IWEP) between 2009 and 2010 catalysed the country's renewable energy development (Mansita Njie, 2019; Roberto & Karen, 2019). In addition, in 2022, Morocco took a significant step by revising its renewable energy laws to simplify and accelerate the approval process for RE projects, making the sector more appealing to investors. Additionally, these legal reforms are intended to ensure the financial viability of public entities within the electricity sector, while balancing investor interests with public sector sustainability.[9]

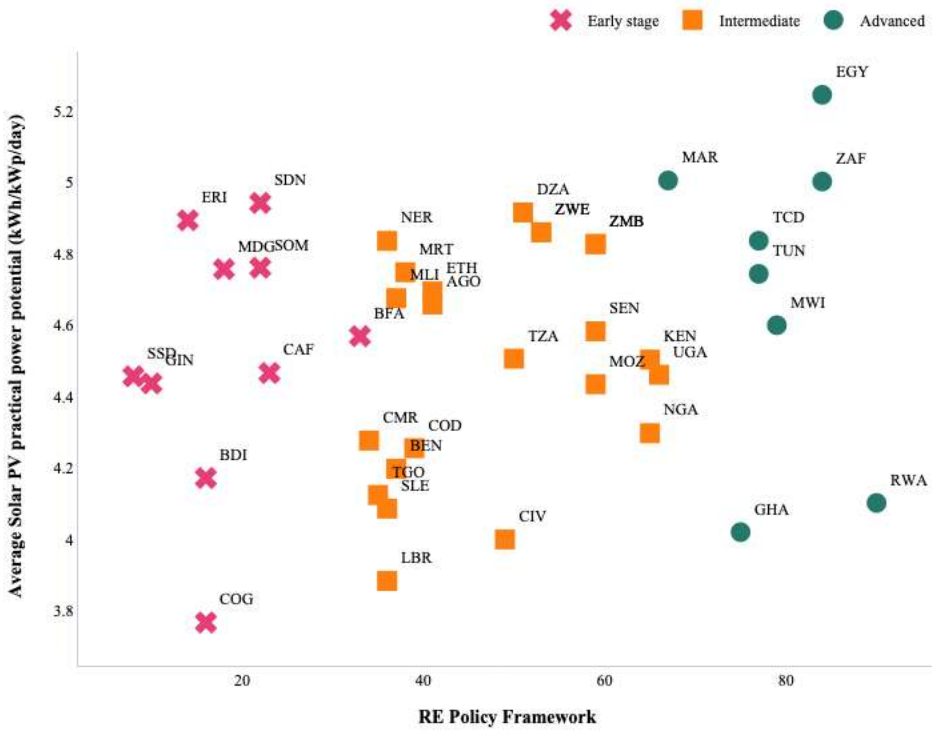


Figure 32. Solar PV Potential and Renewable Energy Policy Framework
Source: Authors' Construct based on ESMAP (2020;2024)

To stimulate demand and foster the growth of a robust renewable energy market, some of these countries have implemented measures designed to create a favourable environment for renewable energy solutions. One such measure is the establishment of competitive bidding procurement processes. A notable example is South Africa's REIPPPP, launched in 2011 as

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[9] https://www.whitecase.com/insight-alert/morocco-new-legal-framework-independent-power-producers

part of the government's commitment to achieving the objectives outlined in the Integrated Resource Plan (IRP 2010-2030). The REIPPPP is a competitive procurement program for renewable energy that has successfully attracted significant private sector expertise and investment into grid-connected renewable energy projects in South Africa at competitive prices (Eberhard et al., 2014). Key best practice features of the REIPPPP include effective and efficient institutional coordination; coherence and consistency in the chosen support scheme; flexibility to adapt to significant market changes or unforeseen consequences; emphasis on the price mechanism; assurance of return on investment; coordination among all stakeholder groups; development goals for rural and vulnerable populations; and regulatory principles of transparency, clarity, and predictability (Bjork et al., 2014; Montmasson-Clair and Ryan, 2014 ; Kruger and Eberhard, 2018). This makes South Africa’s model one model one of the best globally, with a higher realisation rate compared to European countries. Additionally, when considering larger project unit sizes, its performance in terms of price outcomes and realization periods is on par with that of European nations (Kitzing et al., 2022).

Several countries, such as Eritrea, Sudan, and Somalia have significant solar energy potential but lack robust policy frameworks to harness this potential effectively. This implies that despite favourable natural conditions, the lack of supportive policies is likely to hinder large-scale solar energy development in these regions. Addressing this gap could unlock significant opportunities for renewable energy development.

Energy policymaking is closely linked to a country's political economy, featuring strong path dependencies and entrenched incumbent interests. Established companies and industries that benefit from current energy systems pose significant challenges. They possess considerable financial resources, political influence, and market dominance, which they use to resist changes that threaten their position. These entities lobby for favourable regulations, fund supportive research, and run public relations campaigns to shape public perception. For example, Tanzania's state-owned utility, TANESCO, has not always prioritized cost efficiency in its purchasing decisions during the period 2008–2017 (Andreoni et al. 2021). Instead, it disproportionately subsidised more expensive power generation plants. Evidence suggests political motives may influence these decisions, including opportunities for rent capture (e.g., running diesel plants in remote areas) and power purchase agreements with guaranteed capacity charges (Andreoni et al. 2021).

5.2 Regulatory Framework

Egypt shows strong solar PV potential alongside medium/high renewable energy regulation indices (Figure 33). Egypt stands out due to its advanced regulatory environment. Private renewable electricity producers in Egypt benefit from guaranteed access to the national transmission and distribution grids, operating under clear, transparent, and non-discriminatory regulations. This clear regulatory framework promotes investor confidence and helps integrate renewable energy into the grid.

South Africa and Zimbabwe benefit from supportive regulatory environments that promote large-scale solar projects. South Africa’s grid code includes priority dispatch for renewables, curtailment compensation, and coverage for imbalance risks.[10] In 2020, however, Eskom curtailed wind power due to reduced demand during COVID-19 lockdowns. In 2021, South Africa exempted projects up to 100 MW from the lengthy generation license process, waiving the threshold entirely by late 2023. This led to a surge in registrations, with over 2,400 MW of projects registered in early 2023. However, projects still require grid connection permits to ensure compliance (Kuhudzai, 2021).

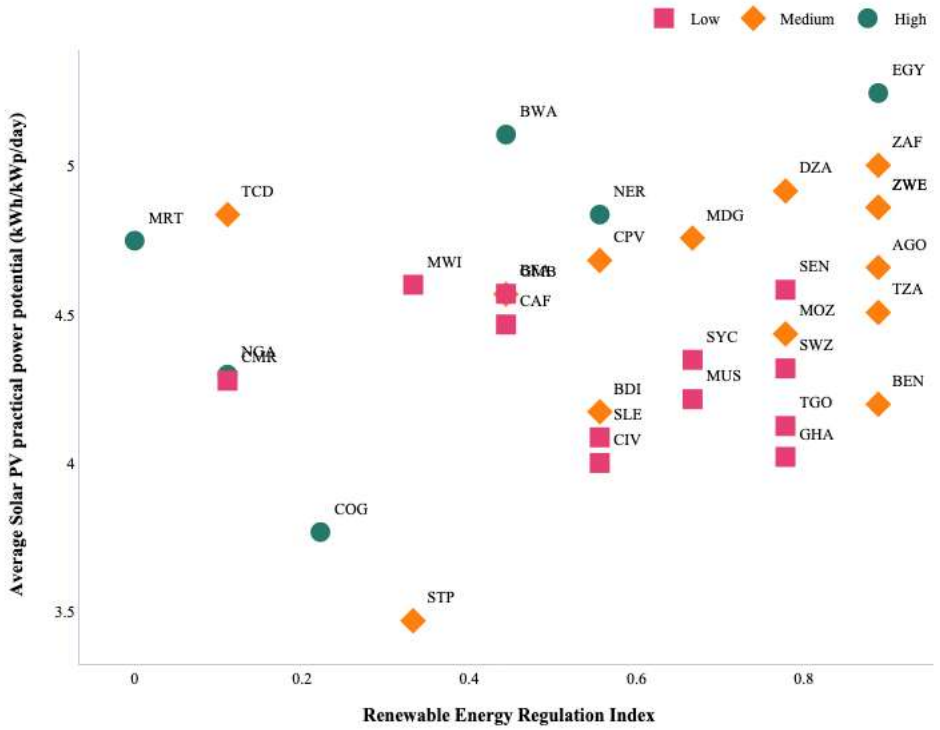

Figure 33 Solar PV Potential and Renewable Energy Regulation

Source: Authors' Construct based on ESMAP (2020) and AfDB (2023)

Countries with high solar potential, such as Mauritania, Niger, Botswana, and Madagascar, have favourable conditions for renewable energy but face moderate regulatory frameworks. These frameworks create uncertainties around grid access, interconnection, and project financial viability, hindering private sector involvement. Meanwhile, countries like Chad, Mali, Cameroon, and the Central African Republic struggle with weak regulatory systems. This leads to unclear policies on grid access, pricing, and investor protections, further deterring investment and making it difficult to turn their significant solar potential into actionable projects. Stronger regulations are essential for progress in these countries.

[10] https://www.eskom.co.za/distribution/wp-content/uploads/2022/03/RSA-Distribution-Governance-Code-Ver-6.2.pdf

5.3 Finance

While many African countries exhibit strong renewable energy potential, countries have underdeveloped financial sectors, leading to high capital costs for energy projects, and hinder their ability to attract affordable investment, slowing the development of renewable energy projects.

South Africa's financial sector is the most developed and stands out for having a medium-cost capital environment compared to other African countries (Figure 34), promoting large-scale renewable projects. Despite this, the cost of capital in developing countries like South Africa remains two to three times higher than in advanced economies, impacting investment. For example, the 10-year government bond yield was about 11% in South Africa in 2023 compared to about 2% in the Eurozone (IEA, 2024).

Egypt benefits from strong financial sector development, but like many other countries, faces challenges with high capital costs. The country's relatively developed financial sector enables better access to investment, though affordability remains a concern. Countries with high renewable energy potential but low financial development like Mauritania, Niger, and Chad face significant financing barriers due to underdeveloped financial sectors, making it difficult to attract affordable investment.

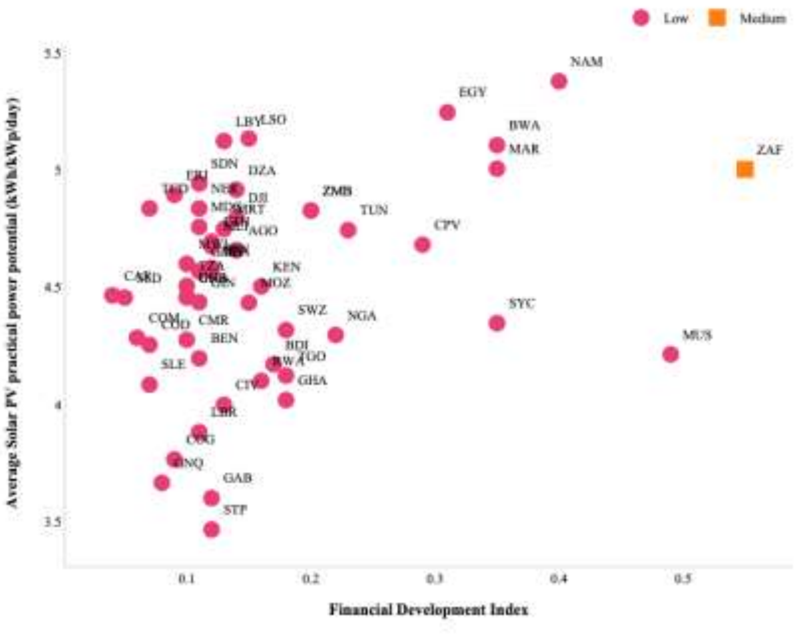

Figure 34 Solar PV Potential and Financial Development
Source: Authors' Construct based on ESMAP (2020) and Svirydzenka (2016)

Creditworthiness of the off taker in PPAs, typically the state utility in most countries on the continent, is a crucial factor in financing renewable energy projects. A financially healthy off-taker can provide necessary guarantees regarding payment delays and termination clauses, which are vital for securing funding from financial institutions and energy producers (RES4MED and Africa, 2018). However, many of these utilities are financially unviable (Figure

15). In addition, current fiscal constraints and economic challenges across numerous countries significantly hinder governments' ability to secure affordable financing for renewable initiatives (IEA, 2024). Rising debt repayments exacerbate the difficulty in accessing funds for capital-intensive clean energy projects. Furthermore, low sovereign debt ratings restrict foreign investment, with only Botswana and Mauritius achieving investment-grade status in 2023 (IEA, 2024). This underscores the urgent need for innovative financing mechanisms to attract investment and facilitate the transition to sustainable energy solutions across the continent.

5.4 Grid Infrastructure

Most African countries are grappling with outdated grid infrastructure, resulting in significant system losses, as illustrated in Figure 35. Countries rich in renewable energy potential, such as Namibia, are particularly affected, experiencing system losses approaching 40%. This inefficiency hinders their ability to effectively integrate and utilize renewable energy sources. The outdated infrastructure not only prevents the optimal use of available resources but also limits the overall advancement of renewable energy initiatives, underscoring the urgent need for investments in modernising the grid to enhance energy reliability and the integration of renewable energy across the continent.

Grid investment is projected to reach USD 400 billion by 2024, driven primarily by Europe, the U.S., China, and parts of Latin America (IEA, 2024). Battery storage investment hit USD 40 billion in 2023 and is expected to grow further in 2024 (IEA, 2024). However, both sectors see most of their investment concentrated in advanced economies and China, leaving other regions particularly those in Africa lagging. The surge in grid and battery funding highlights the increasing focus on energy infrastructure, but its uneven distribution underscores the challenges for less developed countries to keep pace with the global energy transition.

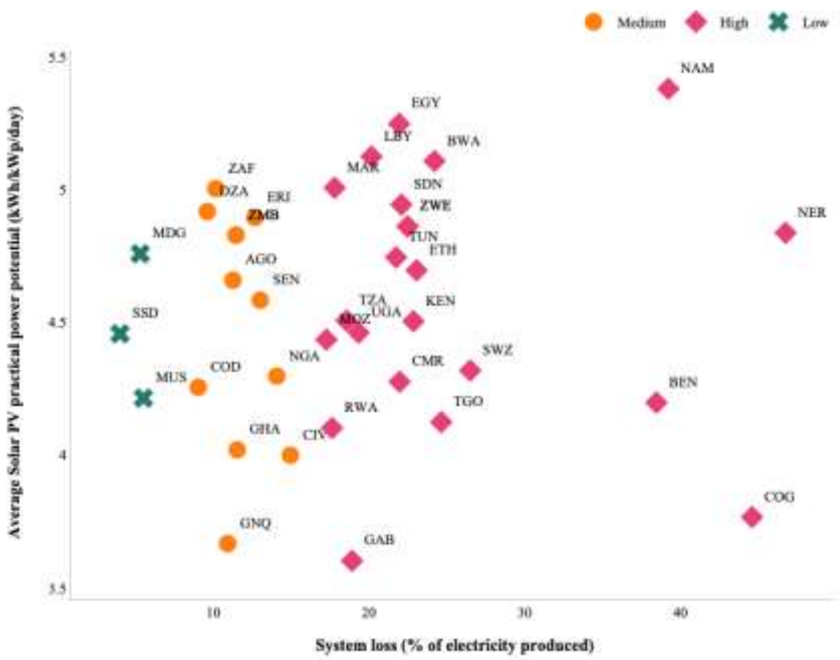

Figure 35. Solar PV Potential and Grid Performance

Source: Authors’ Construct based on ESMAP (2020) and IEA (2024a)

5.5 Skills and human capital

Countries like Namibia, South Africa, and Egypt exhibit high renewable energy potential but low human capital (Figure 36). This disparity suggests a critical challenge: while these countries possess abundant natural resources for solar energy, their human capital development does not match this potential.

Human capital plays a pivotal role in the renewable energy sector, as a robust workforce of engineers, technicians, and specialists is essential for the effective design, construction, and maintenance of solar energy infrastructure. In countries with underdeveloped human capital, there is often a limited pool of skilled workers, which hinders their ability to effectively harness renewable energy resources. This gap between the available talent and the sector's needs may stymie efforts to expand renewable energy production and related industries such as green hydrogen value chain development.

As a result of this mismatch, countries may increasingly rely on foreign expertise and investment to develop their renewable energy sectors. This dependence can create additional challenges, including higher costs, potential delays in project implementation, and a lack of knowledge transfer to local workers. To bridge this gap, it is crucial for these countries to invest in education and training programs focused on renewable energy technologies, thereby cultivating a skilled workforce that can meet both current and future demands.

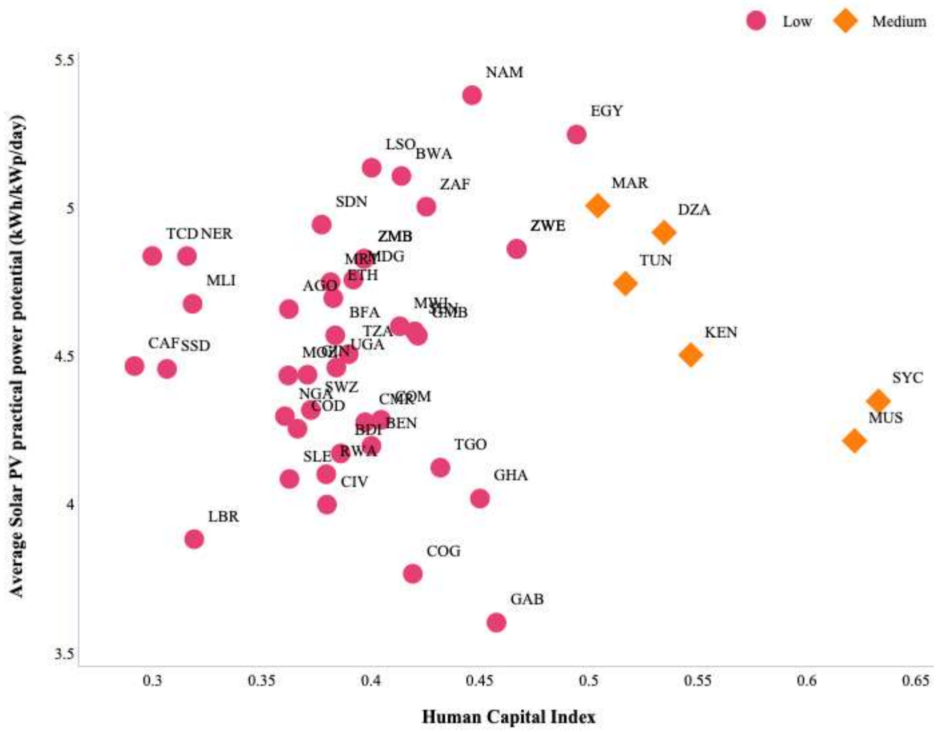

Figure 36 Solar PV Potential and Human Capital
Source: Authors’ Construct based on ESMAP (2020) and Kraay (2019).

6. Green Hydrogen Development

The transition to clean energy will create green windows of opportunity, enabling developing countries, particularly those in Africa, to catch up and even take the lead in green sectors and related value chains (Lema and Rabellotti, 2023).

One such opportunity lies in the production of green hydrogen, which is regarded as the fuel of the future due to its clean, storable, and portable nature. With its high energy density, green hydrogen is ideal for powering energy-intensive industrial processes such as steel, cement, and fertilizer production. It is also well-suited for other difficult-to-decarbonize sectors like aviation and shipping.

Green hydrogen production in countries abundant in renewable resources has the potential to open new avenues for green industrial development, enhance local value creation, and generate employment opportunities (Stamm et al., 2023). The renewable energy transition thus offers a unique opportunity for African countries to leapfrog and leverage their green competitive advantage. Africa's abundant solar and wind resources offer substantial potential for green hydrogen production at low cost at less than USD 2 per kilogramme (Figure 37)—equivalent to global total energy supply today (IEA, 2022).

Harnessing Africa's immense solar potential to produce around 50 million metric tons (Mt) of green hydrogen annually will significantly decarbonize the continent's heavy industries, including steel, fertilizers, mining, and transportation (EIB et al., 2022). This transition will enhance Africa's global competitiveness and lead to reduction of greenhouse gas emissions, thereby fostering accelerated and sustainable growth throughout the continent and beyond.

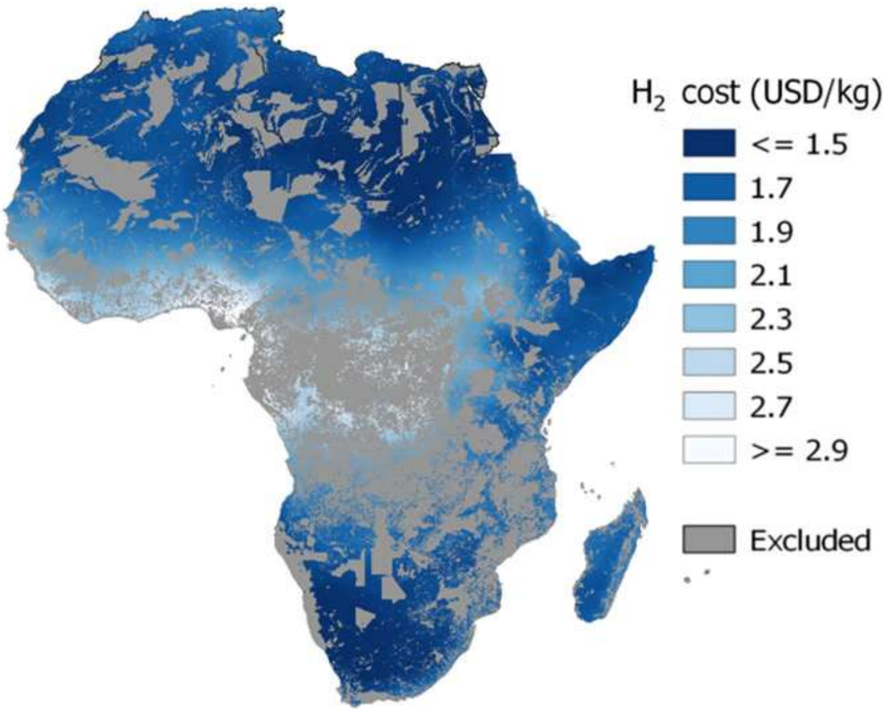

Figure 37 Hydrogen cost production potential in Africa in 2030 within 200 km of a serviceable coast
Source: IEA (2022)

Since 2021, approximately 60 renewable hydrogen projects have been announced across 16 countries, with the majority concentrated in Morocco and Egypt (Figure 38). These projects aim to leverage renewable energy sources, such as solar and wind, to produce green hydrogen, ammonia, and ethanol, offering sustainable alternatives to traditional fossil fuels. Morocco and Egypt, due to their abundant natural resources and favorable geographical conditions, have become key players in the large-scale development of these projects. The focus is on creating significant, commercially viable ventures that can meet both domestic energy needs and international demand for cleaner energy solutions.

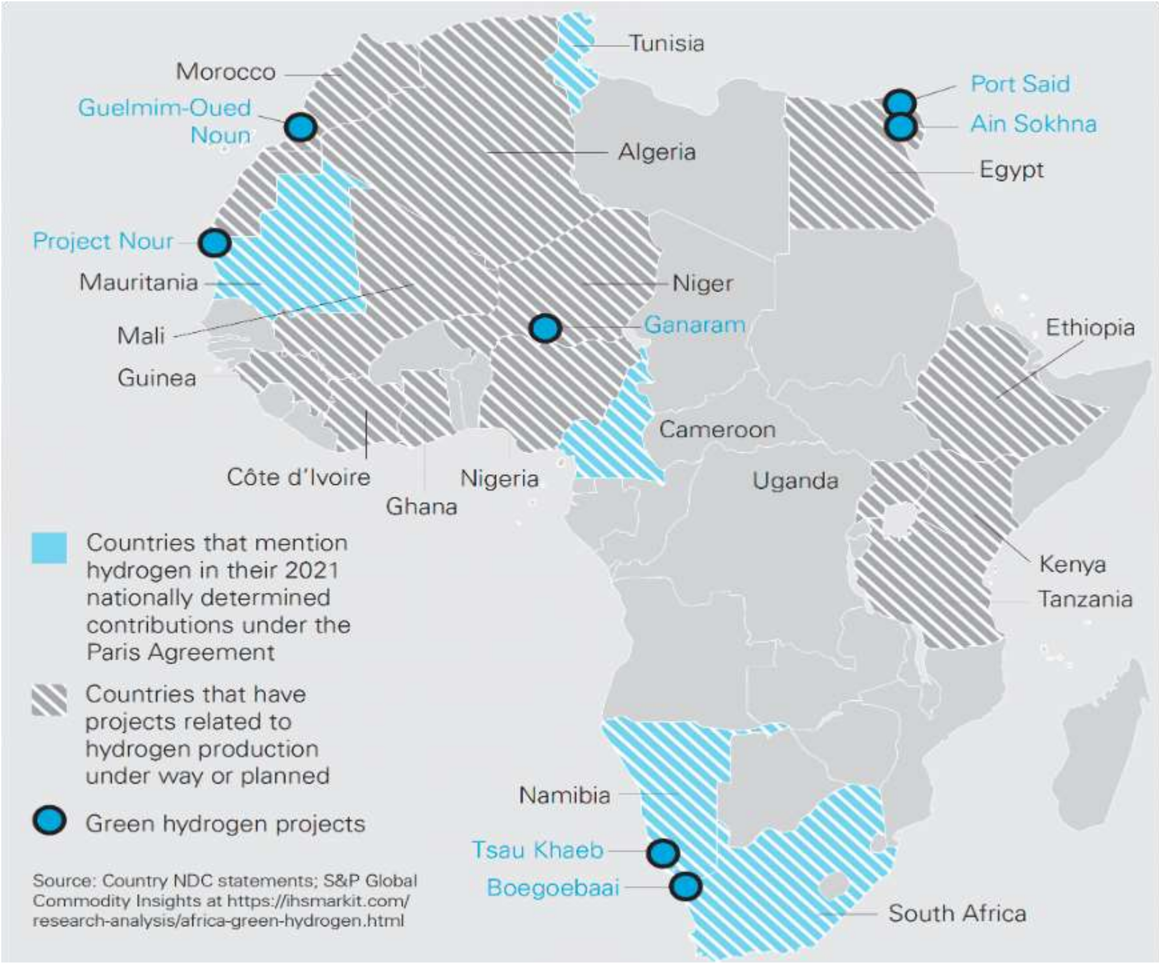

Figure 38. Selected Hydrogen Projects in Africa
Source: White & Case (2022)

Table 2. Overview of selected green hydrogen projects in Africa

Country	Project Name	Classification	Year of Announcement	Year Expected online	H2 Produced (kt/year)	Electrolyser Capacity	Final Product
South Africa	Boegoebaai Project (Multi-phase)	Production project	2021	unknown	400	>2 GW	Hydrogen
South Africa	Sasolburg Electrolyzer Revival Pilot Project	Pilot Project	2022	2024		0-100 MW	Hydrogen
South Africa	Nelson Mandela Bay	Production Project	2021	2026		100 -	Ammonia

	Ammonia Project (Multi-phase)					500 MW	
Namibia	Hyphen Multi-phase Project	Production Project	2021	2027	150	500 MW -2 GW	Ammonia
Namibia	Renewstable Swakopmund Project	Production Project	2021	2026		0-100 MW	Hydrogen
Namibia	Daures Green Hydrogen Village, Multi-phase	Production Project		2027		0-100 MW	Ammonia
Egypt	Fortescue Future Industries -Egypt Project	Production Project	2022	2030	1380	>2 GW	Hydrogen
Egypt	Ocior Project (Multi-phase)	Production Project	2023	2027	100	500 MW -2 GW	Ammonia
Egypt	Scatec-Ani Sokhna Project (Multi-phase)	Production Project	2022	2025	1000	>2 GW	Methanol
Morocco	Amun Project (Multi-phase)	Production Project	2022	2028	100	>2 GW	Hydrogen
Morocco	H2Pro-Gaia Project (Multi-phase)	Production Project	2022	unknown	1500	>2 GW	Hydrogen
Morrocco	White Dunes Project	Production Project	2023	2028	1200	>2 GW	Hydrogen

Source: Authors' Construct based on Energy for Growth Hub (2024) and IEA (2024c)

Despite the ambitious nature of the announced green hydrogen projects in Africa, many remain in the initial stages of development (Figure 39). Only a few projects have reached the critical point of making financial investment decisions. The high capital costs associated with renewable energy infrastructure, particularly the expansion of electrolysis technology, pose significant challenges. Furthermore, these projects face risks stemming from political instability and uncertainties in regulatory frameworks. Bureaucratic hurdles, such as obtaining necessary licenses and securing land, also contribute to delays and increase costs, ultimately undermining the overall competitiveness of green hydrogen initiatives. In many developing countries, these challenges are particularly pronounced, making it difficult for projects to move forward in a timely manner. As a result, demand-side stakeholders tend to adopt a cautious "wait and see" approach, leading to a lack of offtake agreements (UNIDO et al., 2023).

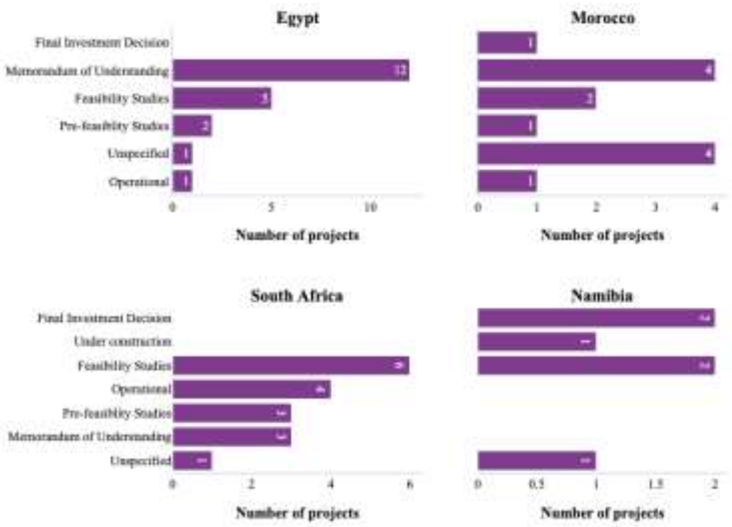

Figure 39. Status of announced green hydrogen projects

Source: Authors’ Construct based on Energy for Growth Hub (2024) and IEA (2024c)

Most green hydrogen projects in Africa focus on exporting to Europe and Japan (Figure 40), potentially boosting foreign exchange earnings and trade balances. However, international transport of green hydrogen faces technological and regulatory uncertainties, complicating cost-effective compliance with standards (UNIDO et al., 2023). The future of global green hydrogen trade is uncertain, with guaranteed short-term opportunities like the EU Hydrogen Bank offering no long-term (Medinilla & Dekeyser 2024). Therefore, it is essential to redirect focus towards domestic economic opportunities, including upstream and downstream activities, to create sustainable employment, add long-term value, and enhance international competitiveness (UNIDO et al., 2023).

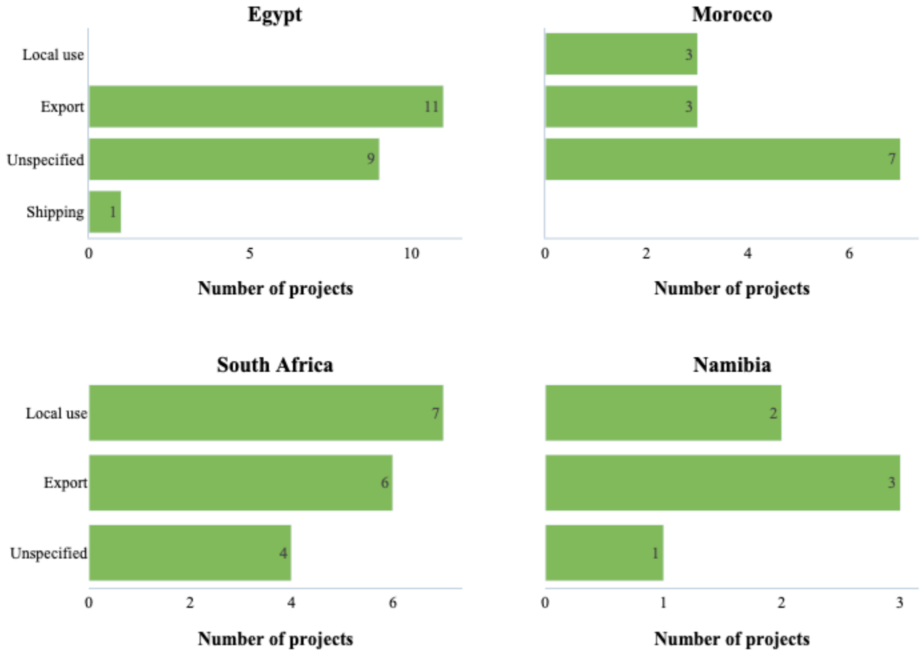

Figure 40 Proposed end uses of green hydrogen projects

Source: Authors' Construct based on Energy for Growth Hub (2024) and IEA (2024c)

Several policy measures are currently being implemented or are anticipated to be enacted in the near future to foster the development of green hydrogen, as outlined in the respective green hydrogen strategies of various countries (Table 3). Specifically, South Africa and Namibia are actively pursuing a range of initiatives aimed at advancing their green hydrogen sectors. These initiatives are outlined in their respective strategy documents that specify the roles of public bodies and establish clear timelines for implementation.

In South Africa's strategy for commercializing green hydrogen, the focus for the skills development in the short term (2023-2027) is on building the essential skills and capabilities needed across the value chain. The roadmap aims to utilize existing technical and vocational institutions, Sector Education and Training Authorities (SETAs), and universities to develop the skills required by this sector. The Department of Higher Education and Training will implement the skills development action plan in collaboration with the Department of Science and Innovation. The country recently published a study outlining the current skills demand–supply dynamics in the South African labour market with respect to the hydrogen economy

By 2030, South Africa plans to establish a regulatory framework and standards for green hydrogen, covering production, storage, refuelling, and transportation. Additionally, it aims to introduce regulatory incentives, such as reduced import duties and tax breaks, and to develop a system for green hydrogen guarantees of origin to secure product premiums. After 2030, as the industry matures, these incentives will gradually decrease while carbon penalties will increase, directing resources toward green initiatives and projects.[11]

Namibia aims to address skill gaps by identifying the necessary resources and competencies, outlining strategies to bridge these gaps, and creating targeted programs. The country is focused on enhancing the skills of its passive labour force through vocational training for unemployed individuals and recent graduates, in collaboration with the Namibian Training Authority. This initiative is expected to significantly fulfil the demand for lower-skilled positions, such as technician roles, by 2025.

Table 3. Policy tools of selected countries

Mentioned policy	South Africa	Namibia	Morocco
Infrastructure creation	Green	Green	Yellow
Production support mechanisms			
Demand Side Support	Green	Green	Yellow
Regulations, standards and certification	Green	Green	Yellow
Land permits	Green	Red	Red
Skills	Green	Green	Red
Local Content manufacturing	Green	Red	Green
Knowledge creation	Green	Red	Green
Finance and Investment			
Grants	Green		Yellow
Mobilisation of finance	Green	Green	Red
Taxation	Green	Red	Yellow
Financial incentives	Green	Green	Green

Source: Country Green Hydrogen Strategies, IRENA (2024)
Note: - Red- not mentioned, yellow- mentioned, green-mentioned with timeline and governance

There is also variation in the prioritization of end-use sectors among different countries (Table 4). All three selected countries place a strong emphasis on developing green hydrogen for export purposes. Namibia plans to export hydrogen products—such as ammonia, methanol, synthetic kerosene, and hot-briquetted iron—to markets in Europe, China, Japan, South Korea, and beyond. The current domestic utilisation of hydrogen and its derivatives in Namibia is constrained by a limited industrial base. Nevertheless, the country plans to utilise its first green hydrogen and ammonia production plant (Daures green hydrogen village[12]) as a demonstration hub for hydrogen applications in the Erongo region, with a focus on producing green ammonia for heavy-duty transport applications, including trucks, locomotives, mining equipment, and ships.

In addition to exports, Morocco and South Africa place a strong emphasis on utilising green hydrogen to decarbonize their industrial sectors. In Morocco, the focus is particularly on the chemical industry, the transportation sector—which encompasses long-haul trucks, trains, and buses—and power generation. The chemical industry, a vital component of Morocco's economy, stands to gain significantly from the adoption of green hydrogen as a cleaner alternative to conventional fossil fuels. This shift is crucial for transforming the country's

[11] https://lmi-research.org.za/publication/identification-of-skills-needed-for-the-hydrogen-economy/
[12] https://energycapitalpower.com/daures-green-hydrogen-village-namibia/

transportation infrastructure, as green hydrogen holds the potential to significantly lower carbon emissions in heavy-duty transport, including long-distance trucking and public transportation systems. Additionally, Morocco is prioritizing the integration of green hydrogen into power generation, aiming to diversify its energy mix and enhance the share of renewable sources in its overall energy supply, thus supporting its ambitious climate objectives.

For South Africa, green hydrogen is positioned as a cornerstone of the country's decarbonization strategy, especially for its energy-intensive industries, which are some of the largest carbon emitters (DST, 2021). The country's extensive mining and manufacturing sectors, which are vital to the national economy, are central to these decarbonisation efforts. The country sees green hydrogen as essential for reducing emissions from the production of iron and steel, refining metals, and other industrial processes that rely heavily on fossil fuels. Moreover, there is growing interest in using green hydrogen to decarbonise South Africa's energy system, which has historically depended on coal. The country also plans to integrate green hydrogen into its transportation sector, particularly for large-scale applications like freight trucks, buses, and shipping.

Table 4. Prioritisation of End use Sectors

Categories	Morocco	Namibia	South Africa
Production segment (upstream)			
Green	[dark green]	[dark green]	[dark green]
Blue			[dark green]
Transportation segment (midstream)			
Hydrogen pipelines	[yellow]		
Distribution by road/railway			[dark green]
Shipping		[dark green]	[dark green]
Storage options	[yellow]		[yellow]
Off-taking (downstream)			
Chemical industry	[dark green]	[dark green]	[dark green]
Steelmaking		[dark green]	[dark green]
Cement			[dark green]
High temperature heating	[yellow]		
Other industry		[dark green]	[dark green]
Long haul aviation	[yellow]		[dark green]
Long haul shipping	[yellow]		[dark green]
Long Haul trucks	[dark green]		[dark green]
Train	[dark green]		[dark green]
Bus	[dark green]		[dark green]
Other mobility	[yellow]		
Power generation (fuel cell / turbines)	[dark green]		[dark green]
Residential	[yellow]		
Export	[dark green]	[dark green]	[dark green]

Source: IRENA (2024)
Note: green: high priority, yellow: low priority

7. Future outlook of Energy Sector

All 54 African countries have committed to the Paris Agreement, submitting ambitious climate action plans known as Intended Nationally Determined Contributions (INDCs). Most have ratified these as Nationally Determined Contributions (NDCs). South Africa, for example, aims to reduce greenhouse gas emissions by 31%, targeting emissions between 398-510 MtCO2e by 2025, and further reducing to 350-420 MtCO2e by 2030. [13]

Kenya aims to achieve 100% of its electricity generation from clean energy sources by 2030 (Figure 41), a bold commitment that underscores its dedication to sustainable development. Similarly, Tanzania targets generating approximately 62% of its electricity from renewable sources by the same year, while Nigeria has set a goal of reaching 31%. These ambitious plans indicate a significant transformation in the energy sector across the African continent. As countries strive to enhance their energy independence and reduce carbon emissions, investments in solar, wind, hydro, and geothermal energy will be crucial. If successful, these targets will not only reduce dependency on fossil fuels but also enhance energy security and foster sustainable economic development.

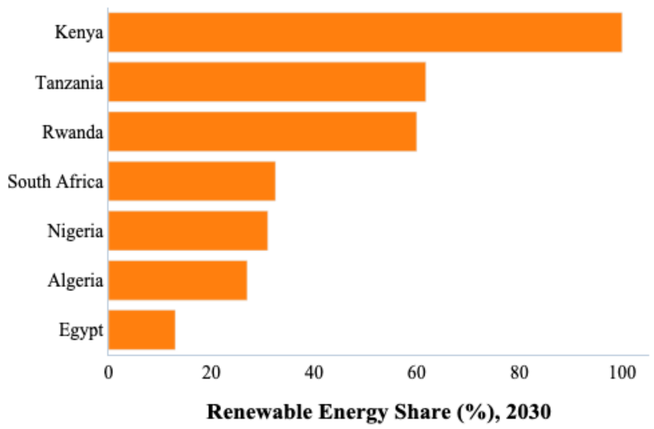

Figure 41 Countries' targets for electricity generation from renewable energy by 2030. Source: EMBER (2024).

Africa's population is expected to grow by 350 million by 2030, reaching 1.7 billion—more than the current population of the United States. Nearly half of the global population increase from 2020 to 2030 will occur in Africa, with eight of the fifteen fastest-growing countries located on the continent. Population growth and economic expansion are key drivers of rising energy demand (IEA, 2022). The rapid demographic shift will continue to increase the need for energy services across Africa in the coming decades (IEA, 2022).

[13] https://ndcpartnership.org/knowledge-portal/good-practice-database/making-renewable-energy-affordable-south-african-renewables-initiative#:~:text=South%20Africa%20has%20a%20goal,require%20an%20estimated%20%2435.6%20billion.

According to the IEA's sustainable Africa Scenario (SAS)[14], ongoing urbanisation and industrialisation will play a crucial role in driving up energy demand across the continent (Figure 42). As more people migrate to urban areas, the demand for infrastructure, housing, and services will surge, leading to increased consumption of industrial products. Specifically, industrial product consumption is projected to rise by at least one-third between 2020 and 2030. This significant increase will be driven by a surge in construction activities and a growing industrial sector, particularly in key materials such as steel and cement. As urban centres expand and economies develop, the need for these foundational materials will be paramount for supporting new buildings, roads, and other infrastructure projects. Moreover, the rising population and enhanced economic activity will necessitate a transition to more sustainable energy sources to meet this growing demand while addressing the environmental challenges that accompany rapid industrial growth in Africa.

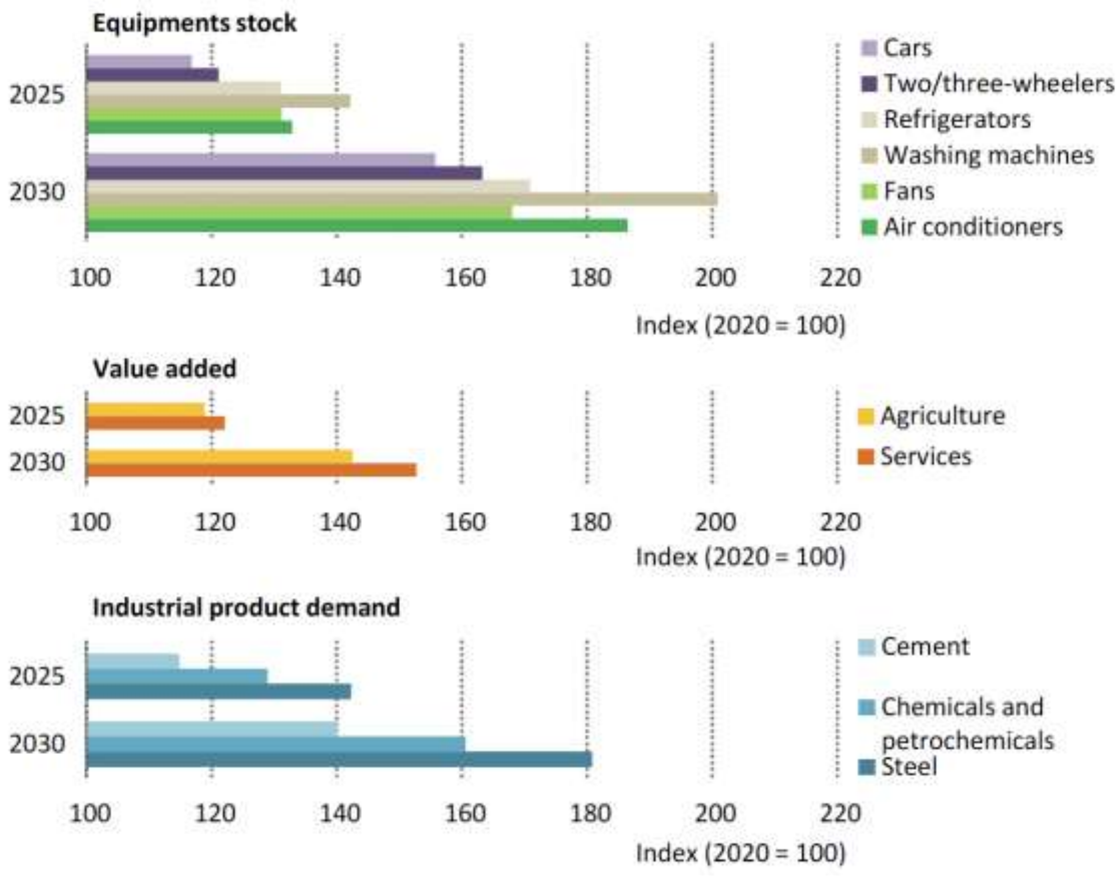

Figure 42 Growth in selected energy-related economic activities in Africa in the SAS, 2020-2030
Source: IEA (2022)

[14]The sustainable Africa Scenario sets out a pathway that achieves all of Africa's energy-related development goals, including universal access to modern energy services by 2030 and all of the Nationally Determined Contributions (NDCs) and announced net zero emissions pledges on time and in full.

In the context of the electricity generation mix, the share of fossil fuels in Africa is not expected to decline significantly during the 2020–2030 period, according to the IEA's SAS (Figure 43). This will be counterbalanced by increasing contributions from hydropower, wind, and solar PV. The transition to renewable energy is primarily driven by a consistent decrease in relative costs, along with supportive policies aimed at promoting low-carbon energy solutions. This shift provides a unique opportunity to harness Africa's vast domestic renewable energy potential. By 2030, the combined share of solar PV and wind is projected to reach 27% of total power generation, representing an eightfold increase compared to 2020 levels. This substantial rise in renewable energy generation will necessitate adaptations in power system operations to ensure a stable balance between supply and demand, underscoring the importance of modernisation the grid and investing in energy storage solutions.

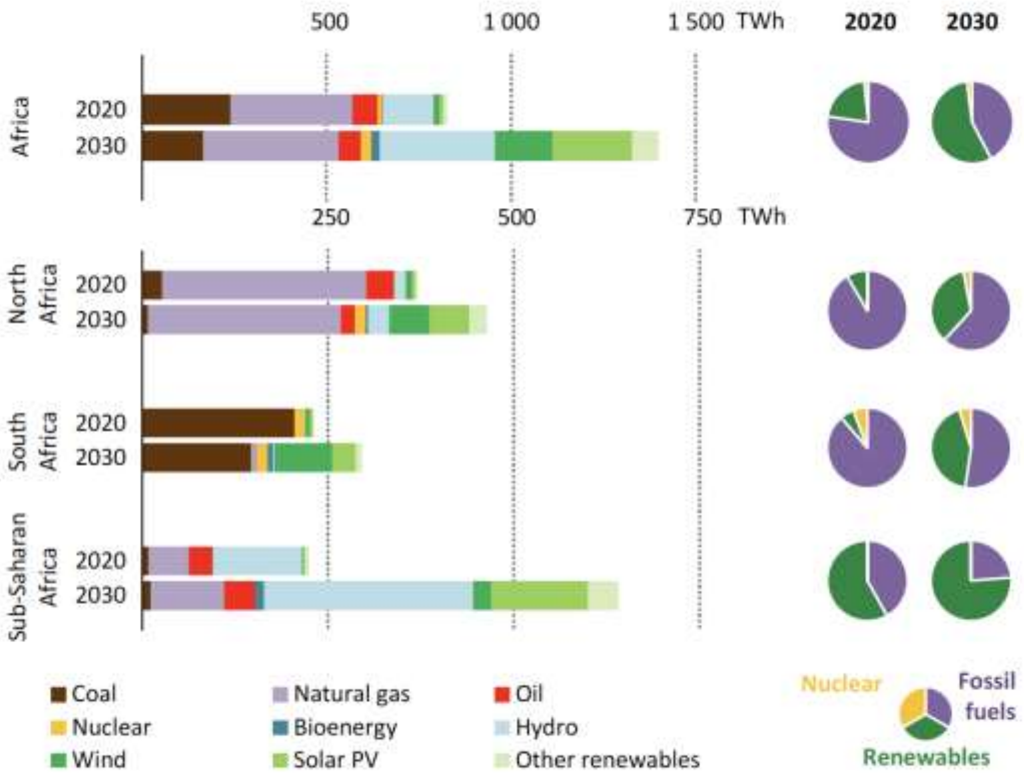

Figure 43 Electricity generation by source in the SAS, 2020 and 2030
Source: IEA (2022)

In the SAS, IEA (2022) expects coal to play a dominant role in electricity generation in South despite the increase in renewables in 2030. This is line with NBI (2021), which forecasts coal as one of the major sources of electricity generation. By accelerating the transition to renewable energy and phasing out coal sooner, NBI (2021) estimates that cumulative emissions could be reduced by about 1 gigaton of CO2 equivalent (Gt CO2e) under a low emissions pathway compared to an Integrated Resource Plan (IRP)[15] constrained pathway

[15] The Integrated Resource Plan (IRP) estimates South Africa's future electricity demand and outlines how to meet this demand, including associated costs.

(Figure *44*). This is mainly due to coal plants being turned down by 2042 and the dominance of renewables.

This proactive investment strategy in low emissions not only contributes to a flatter capital expenditure (CAPEX) profile for new energy projects but also has the potential to generate approximately 1 million net job-years within the first 15 years, exceeding the IRP constrained pathway by roughly 200,000 jobs NBI (2021) However, it is important to note that the low emissions pathway may incur additional costs ranging from 2 to 9 cents per kilowatt-hour (c/kWh) in the short term, specifically from 2025 to 2040 (NBI 2021). This trade-off between investment and cost highlights the need for strategic planning in achieving long-term sustainability goals.

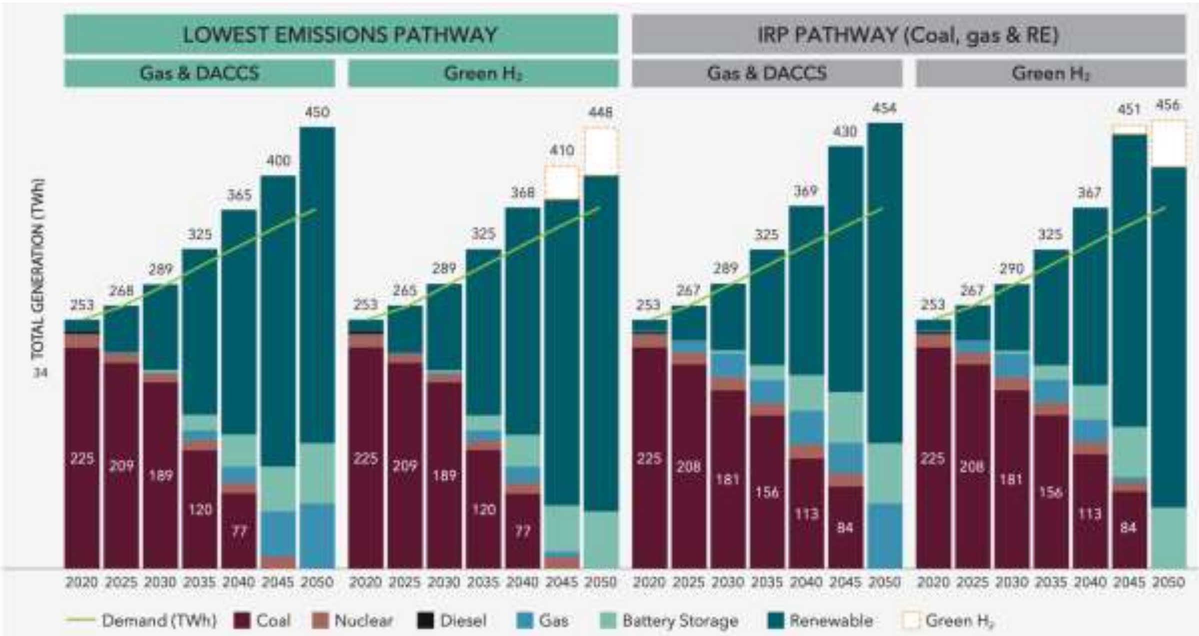

Figure 44 South Africa's Power Sector Decarbonisation Pathways
Source: NBI (2021)

Future outlook of green hydrogen development

South Africa

South Africa recently launched the Hydrogen Society Roadmap[16], which outlines ambitious goals and prioritises key sectors within the hydrogen economy, aligning with the country's IRP. This comprehensive roadmap establishes both short-term and long-term targets for hydrogen deployment (Figure 45). In the short term, the roadmap envisions the small-scale deployment of electrolysers and the piloting of a 1 MW green hydrogen facility. By 2030, South Africa aims to expand its electrolyser capacity to an ambitious target of 10 GW, producing at least 500 kilotons of hydrogen. Looking ahead to 2040, the roadmap anticipates further growth in electrolyser capacity, projecting an increase to 15 GW.

On the demand side, the roadmap focuses on the small-scale deployment of green hydrogen in the transport sector, targeting vehicles such as buses, trucks, and forklifts. By 2030, it is

[16] https://www.dst.gov.za/images/South_African_Hydrogen_Society_RoadmapV1.pdf

expected that a growing number of buses and trucks will be powered by hydrogen, contributing to the decarbonization of the transportation sector. In the long term, the roadmap envisions broader sector coupling, where green hydrogen will be fully integrated not only in transportation but also in power generation and industrial applications. This comprehensive approach aims to maximize the potential of green hydrogen across multiple sectors, supporting South Africa's transition to a low-carbon economy.

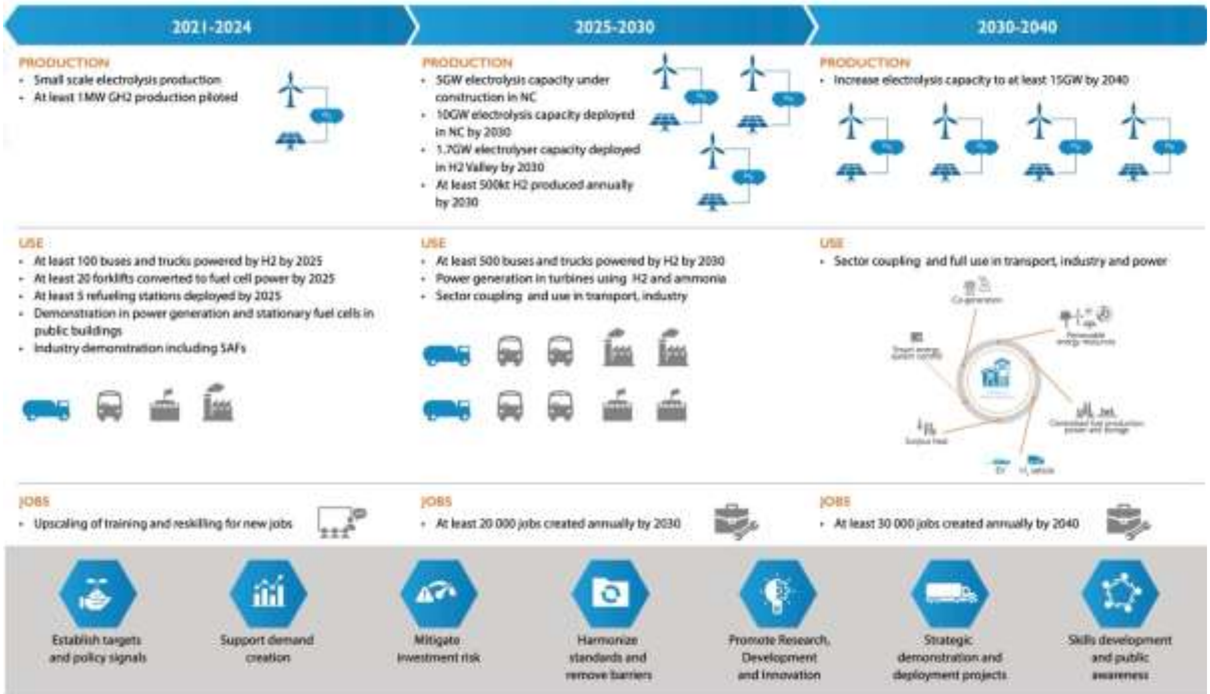

Figure 45:Roadmap for Green Hydrogen Development in South Africa
Source: DST (2021)

Morocco

Morocco's green hydrogen strategy projects demand for the green hydrogen industry and its derivatives to reach between 13.9 TWh and 30.1 TWh by 2030, escalating to 67.9 TWh to 132.8 TWh by 2040, and further to 153.9 TWh to 307.1 TWh by 2050. In the short term (2020-2030), the strategy prioritizes using green hydrogen as a raw material in industry, particularly for green ammonia production in the fertilizer sector, while also exporting hydrogen derivatives to countries focused on decarbonization. By 2030, demand is expected to largely stem from industrial uses and exports, with lower contributions from the transport sector, particularly in freight and public transport.

In the medium term (2030-2040), Morocco anticipates advancements driven by reduced production costs and stricter environmental regulations, leading to a significant expansion in green hydrogen, green ammonia, and synthetic fuels. Hydrogen is also expected to serve as an electricity storage vector and see increased use in fuel cell vehicles.

In the long term (2040-2050), demand will likely rise in transportation as synthetic fuels gain competitiveness, leading to a diverse distribution of hydrogen usage across industry, transport, and exports by 2050.

8. Conclusion

Countries in Africa stands at a pivotal crossroads in their energy journey, marked by both immense challenges and opportunities. The continent's reliance on both domestic and imported fossil fuels for electricity generation exposes it to economic vulnerabilities and exacerbates the impacts of climate change. Despite being endowed with vast renewable energy resources that surpass projected demands for 2040, the transition to sustainable energy has been sluggish, hindered by financial constraints, regulatory inefficiencies, and insufficient infrastructure. To capitalize on its renewable energy potential, Africa must prioritise comprehensive policy reforms and substantial investments in infrastructure, human capital, and financing mechanisms. Governments, investors, and development partners must collaborate to create enabling environments that attract investment in renewable energy technologies, such as solar and wind. Furthermore, addressing the inefficiencies in state utilities will free up essential public funds for critical development needs.

By embracing renewable energy, African countries can significantly enhance their energy security, reduce greenhouse gas emissions, and promote economic diversification and structural transformation. Coordinated efforts will allow Africa to harness its abundant renewable resources, driving sustainable development and fostering a resilient, prosperous future. However, the transition to cleaner energy sources requires deliberate action, as it will not occur automatically. Addressing the identified challenges and seizing the opportunities outlined in this paper is essential to facilitate this transformation and ensure that Africa can fully benefit from its renewable energy potential in the coming years.

9. References

IEA (2020). Climate Impacts on African Hydropower. International Energy Agency. https://iea.blob.core.windows.net/assets/4878b887-dbc3-470a-bf74-df0304d537e1/ClimateimpactsonAfricanhydropower_CORR.pd

AfDB (2022). Africa Industrialization Index 2022. Africa Development Bank. https://www.afdb.org/en/documents/africa-industrialization-index-2022

AfDB (2023). Electricity regulatory index for Africa 2022. Africa Development Bank. https://africa-energy-portal.org/reports/electricity-regulatory-index-africa-2022-eri

Andreoni, A., Tasciotti, L., & Tayari, E. (2021). Feasible pathways for energy transition in Tanzania: shifting unproductive subsidies towards targeted green rents. https://eprints.soas.ac.uk/38575/1/ACE-WorkingPaper039-Tz-energy-transition-Proof02.pdf

DST (2021). Hydrogen Society Roadmap for South Africa. Department of Science and Innovation. South Africa. https://www.dsti.gov.za/images/South_African_Hydrogen_Society_RoadmapV1.pdf

Eberhard, A., & Catrina Godinho, C. (2017). A review and exploration of the status, context and political economy of power sector reforms in sub-Saharan Africa, south Asia and Latin America.

Eberhard, A., & Gratwick, K. N. (2011). IPPs in Sub-Saharan Africa: determinants of success. Energy policy, 39(9), 5541-5549.

Eberhard, A., Kolker, J., & Leigland, J. (2014). South Africa's renewable energy IPP procurement Program: Success factors and lessons. World Bank Group, Washington, DC.

EMBER (2024). Global renewable power sector targets 2030. https://ember-climate.org/data-catalogue/global-renewable-targets-2030-power/

ESMAP (2020). Global photovoltaic power potential by country. Energy Sector Management Assistance Program, World Bank.

ESMAP (2024). Regulatory Indicators for Sustainable Energy. Energy Sector Management Assistance Program, World Bank. https://rise.esmap.org

European Investment Bank, International Solar Alliance and the African Union (2022). Africa's Extraordinary Green Hydrogen Potential. https://www.eib.org/attachments/press/africa-green-hydrogen-flyer.pdf

IEA (2020). Climate Impacts on African Hydropower. International Energy Agency. https://iea.blob.core.windows.net/assets/4878b887-dbc3-470a-bf74-df0304d537e1/ClimateimpactsonAfricanhydropower_CORR.pdf

IEA (2021). Financing Clean Energy Transitions in Emerging and Developing Economies. https://www.iea.org/reports/financing-clean-energy-transitions-in-emerging-and-developing-economies

IEA (2022). Africa Economic Outlook 2022. International Energy Agency. https://www.iea.org/reports/africa-energy-outlook-2022

IEA (2023). Electricity Grids and Secure Energy Transitions. Enhancing the foundations of resilient, sustainable and affordable power systems. International Energy Agency. https://iea.blob.core.windows.net/assets/ea2ff609-8180-4312-8de9-494bcf21696d/ElectricityGridsandSecureEnergyTransitions.pdf

IEA (2024a) World Energy Balance. International Energy Agency. https://www.iea.org/data-and-statistics/data-product/world-energy-balances

IEA (2024b). World Energy Investment 2024. International Energy Agency. https://iea.blob.core.windows.net/assets/60fcd1dd-d112-469b-87de-20d39227df3d/WorldEnergyInvestment2024.pdf

IEA (2024c). Hydrogen Production and Infrastructure Projects Database. International Energy Agency. https://www.iea.org/data-and-statistics/data-product/hydrogen-production-and-infrastructure-projects-database

IFC (2020). Nubian Suns (Egypt): Scale at Speed. https://www.ifc.org/wps/wcm/connect/

IGU and Hawilti (2023). Gas for Africa. Assessing the Potential for Energising Africa. International Gas Union. https://www.igu.org/resources/gas-for-africa-report-2023/

IMF (2023). Navigating fiscal challenges in Sub-Saharan Africa: resilient strategies and credible anchors in turbulent waters. International Monetary Fund, Washington, DC.

IPCC (2014) AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar5/wg2/

IRENA (2024). Key Enablers of Renewable Energy. https://www.irena.org/News/articles/2024/Aug/Key-Enablers-to-Triple-Renewables-by-2030-International-Collaboration#:~:text=The%20International%20Renewable%20Energy%20Agency,least%20benefits%20from%20the%20transition.

IRENA and AfDB (2022), Renewable Energy Market Analysis: Africa and Its Regions, International Renewable Energy Agency and African Development Bank, Abu Dhabi and Abidjan.

Kitzing, L., Siddique, M. B., Nygaard, I., & Kruger, W. (2022). Worth the wait: How South Africa's renewable energy auctions perform compared to Europe's leading countries. Energy Policy, 166, 112999.

Kraay, A. (2019). The World Bank human capital index: a guide. The World Bank Research Observer, 34(1), 1-33.

Kruger, W., & Eberhard, A. (2018). Renewable energy auctions in sub-saharan Africa: Comparing the South African, Ugandan, and Zambian programs. Wiley Interdisciplinary Reviews: Energy and Environment, 7(4), e295.

Kruger, W., & Eberhard, A. (2018). Renewable energy auctions in sub-Saharan Africa: Comparing the South African, Ugandan, and Zambian Programs. Wiley Interdisciplinary Reviews: Energy and Environment, February, 1–13. https://doi.org/10.1002/wene.295

Kuhudzai, R. J. (2021). South African Companies Now Allowed To Generate Up To 100 MW Without Applying For Generation License! CleanTechnica, https://cleantechnica.com/2021/06/10/south-african-companies-now-allowed-to-generate-up-to-100-mw-without-applying-for-generation-license/

Medinilla, A & Dekeyser, K (2024). Green hydrogen: The future of African industrialisation? https://ecdpm.org/work/Green-hydrogen-the-future-of-African-industrialisation

Montmasson-Clair, G., & Ryan, G. (2014). Lessons from South Africa's renewable energy regulatory and procurement experience. Journal of Economic and Financial Sciences, 7(si-1), 507-526.

Mulugetta, Y., Sokona, Y., Trotter, P. A., Fankhauser, S., Omukuti, J., Somavilla Croxatto, L., ... & Yussuff, A. (2022). Africa needs context-relevant evidence to shape its clean energy future. Nature Energy, 7(11), 1015-1022.

NBI (2021). Decarbonising South Africa’s Power Sector. National Business Initiative. https://www.nbi.org.za/wp-content/uploads/2021/08/NBI-Transition-Chapter-Decarbonising-SA-power-11-Aug-2021.pdf

Nerini, F. F., Andreoni, A., Bauner, D., & Howells, M. (2016). Powering production. The case of the sisal fibre production in the Tanga region, Tanzania. Energy Policy, 98, 544-556.

Odetayo, B., & Walsh, M. (2021). A policy perspective for an integrated regional power pool within the Africa Continental Free Trade Area. Energy Policy, 156, 112436.

PPP Knowledge Lab. (2021). Benefits and Pitfalls of Unsolicited Proposals. https://ppp.worldbank.org/public-private-partnership/applicable-all-sectors/benefits-and-pitfalls-unsolicited-proposals

RES4MED & Africa (2018). Egypt case study: Risk Analysis and mitigation measures in the existing policy and regulatory framework. Renewable Energy Solutions for the Mediterranean & Africa RES4MED&Africa. https://res4africa.org/wp-content/uploads/2023/04/Project-Finance-Egypt_FINAL_WEB_VERSION-2.pdf

Svirydzenka, K. (2016). Introducing a new broad-based index of financial development. International Monetary Fund.

UNESCO (2019). Water as Cross-Cutting Factor in the SDGs Under Review at the High-Level Policy Forum for Sustainable Development 2019 in Africa, https://archive.uneca.org/sites/default/files/uploaded-documents/ARFSD/2019/water_as_cross-cutting_factor_in_the_sdgs_under_review_at_the_high-level_panel_forum_for_sustainable_development_hlpf_2019_in_africa_final.pdf

UNIDO, IRENA and IDOS (2023). Green hydrogen for sustainable industrial development. A policy toolkit for developing countries. Green hydrogen for Sustainable Industrial Development A Policy Toolkit for Developing Countries.pdf (unido.org)

USAID. (2019). Understanding Power Project Procurement (Vol. 3). https://cldp.doc.gov/sites/default/files/UnderstandingPowerProjectProcurement_0.pdf

White & Case (2022) Is "low-carbon" hydrogen a useful option for Africa's energy needs? https://www.whitecase.com/insight-our-thinking/low-carbon-hydrogen-useful-option-africas-energy-needs

WRI (2024). Climate Watch Historical GHG Emissions. World Resource Institute, Washington DC.https://www.climatewatchdata.org/data-explorer/historical-emissions?historical-emissions-data-sources=climate-watch&historical-emissions-gases=all-ghg&historical-emissions-regions=All%20Selected&historical-emissions-sectors=total-including-lucf%2Ctotal-including-lucf&page=1

Appendix

Table A. 1 Top Ten Countries with Highest Average Solar PV Practical Potential

Country	Locations
Namibia	Nkurenkuru, Ongwediva, Oshakati, Ondangwa, Tsumeb
Egypt	Aswan, Luxor, Siwa Oasis
Lesotho	Maseru, Quthing, Mohale's Hoek, Mokhotlong, Leribe
Libya	Fezzan, Al Bayda, Derna
Botswana	Gaborone, Francistown, Maun, Kasane, Selibe Phikwe
Morocco	Ouarzazate, Tarfaya, Errachidia, Marrakech,Agadir
South Africa	Northern Cape, Northwest, and Limpopo provinces
Sudan	Northern State (Al-Shamaliyah), Kassala State, River Nile State, Blue Nile State, Darfur Region
Algeria	Sahara Desert, Tamanrasset, Ouargla, Adrar, Biskra
Eritrea	Asmara, Mendefera, Keren, Barentu, Assab

Table A. 2 Renewable Energy Readiness: Variable Description and Source

Variable	Description	Source
Solar PV Potential	The long-term average practical solar PV potential, representing the power output a typical PV system can achieve.	ESMAP (2020)
Renewable Energy Policy Framework	Countries score on the renewable energy component of Regulatory Indicators for Sustainable Energy	ESMAP (2024)
Regulatory Framework	Countries score on the renewable energy regulation component of the electricity regulation index.	AfDB (2023)
Financial Development Index	How developed financial institutions and markets are regarding their depth, access and efficiency. The index ranges from zero to 1, with a value of 1 indicating that a country is financially developed	Svirydzenka (2016)
Grid Reliability	Electricity lost via transmission and distribution as a percentage of electricity produced.	IEA (2024a)
Human Capital Index	The contribution of health and education to the productivity of the next generation of workers, and ranges from zero to 1.	Kray (2019)

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