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Energy Outcomes in Africa: Is Digital Infrastructure Relevant?

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Abstract

This chapter examines the role of digital infrastructure in improving energy outcomes in Africa. Although the continent has vast energy potential, access, reliability, and efficiency remain limited. Progress is being made, with a shift toward cleaner fuels and reduced dependence on fossil fuel imports. Carbon emissions are mainly concentrated in the power sector, especially in Southern Africa. A scatter diagram shows a positive correlation between digital infrastructure and energy outcomes, particularly with electricity access. Case studies across Africa highlight how digital tools enhance energy access and efficiency. However, challenges such as infrastructure deficits, limited technical and institutional capacity, regulatory misalignment, and affordability and financing barriers continue to restrict the full benefits of digital integration in the energy sector.

1 Introduction

Africa's energy sector presents a paradox of abundance and scarcity. The continent is endowed with vast energy resources, including substantial reserves of oil, natural gas, coal, and some of the world's richest potential for renewable energy particularly solar, wind, hydro, and geothermal power. Sub-Saharan Africa (SSA) alone has undiscovered but technically recoverable resources estimated at 115.34 billion barrels of oil and 21.05 trillion cubic meters of gas (Kambanda, 2020). Major natural gas discoveries in Mozambique, Tanzania, Egypt, Mauritania, Senegal, and South Africa accounted for over 40% of global finds between 2011 and 2018, significantly boosting Africa's energy prospects (International Energy Agency (IEA), 2019). In fact, Africa is home to 60% of the best solar resources globally (IEA, 2022). Yet despite this natural wealth, energy consumption and poverty remain a pervasive challenge. As of 2024, Africa accounts for approximately 4% of global primary energy consumption (Africa Energy Commission (AFREC), 2024). In 2022, 970 million Africans lack access to clean cooking (IEA, 2022).The rural-urban divide is particularly stark, with rural communities often left behind due to high infrastructure costs and limited grid expansion (Acheampong et al., 2022).

In addition to low energy consumption and limited access, the continent is highly vulnerable to climate change, largely driven by energy-related emissions such as carbon dioxide (CO_2), despite contributing the least to global emissions. Africa faces severe climate impacts, including reduced water availability, more frequent droughts, desertification, food insecurity, and growing conflict risks linked to resource scarcity and displacement. For example, over 23.5 million people in Ethiopia, Kenya, and Somalia were enduring high levels of acute food insecurity due to the prolonged drought (OCHA, 2023). Practical examples from countries such as China and the USA show how digital infrastructure has been applied to improve energy outcomes. China, for instance, has leveraged digital tools to expand energy access, optimize consumption, and reduce CO_2 emissions (Ren et al., 2025; Sun, 2023; Xu et al., 2025). The question ss, can digital infrastructure also be relevant to Africa's energy outcomes?

Africa's digital revolution is advancing rapidly but unevenly. The continent is making a lot of effort to increase digital infrastructure. Since 2020, the African Union has collaborated with public and private institutions to support its ambition of connecting the continent through universal internet access. Mobile phone use exceeds 80% in many areas, and mobile internet is growing due to cheaper devices and innovative models. Between 2016 and 2021, the number of internet users in SSA grew by 115%, 160 million African gaining broadband access between 2019 and 2022, and 191 million becoming new users of digital payments from 2014 to 2022 (World Bank, 2024). Digital infrastructure however includes the core technologies and systems that support digital communication, data processing, and information storage (Ren et al., 2025). Building on the significant progress across the continent in strengthening digital infrastructure, this chapter explores how its expansion can improve energy outcomes in Africa.

This inquiry lies at the intersection of two major shifts: the drive for universal energy access and the continent's digital transformation. It goes beyond technical considerations to examine the social, political, and economic dimensions, including who gains from digital innovation, who is excluded, and what institutional and regulatory measures are needed to maximize its impact. The chapter seeks to offer a more integrated and forward-thinking view of development in Africa, positioning digital infrastructure as essential to achieving energy equity and sustainability.

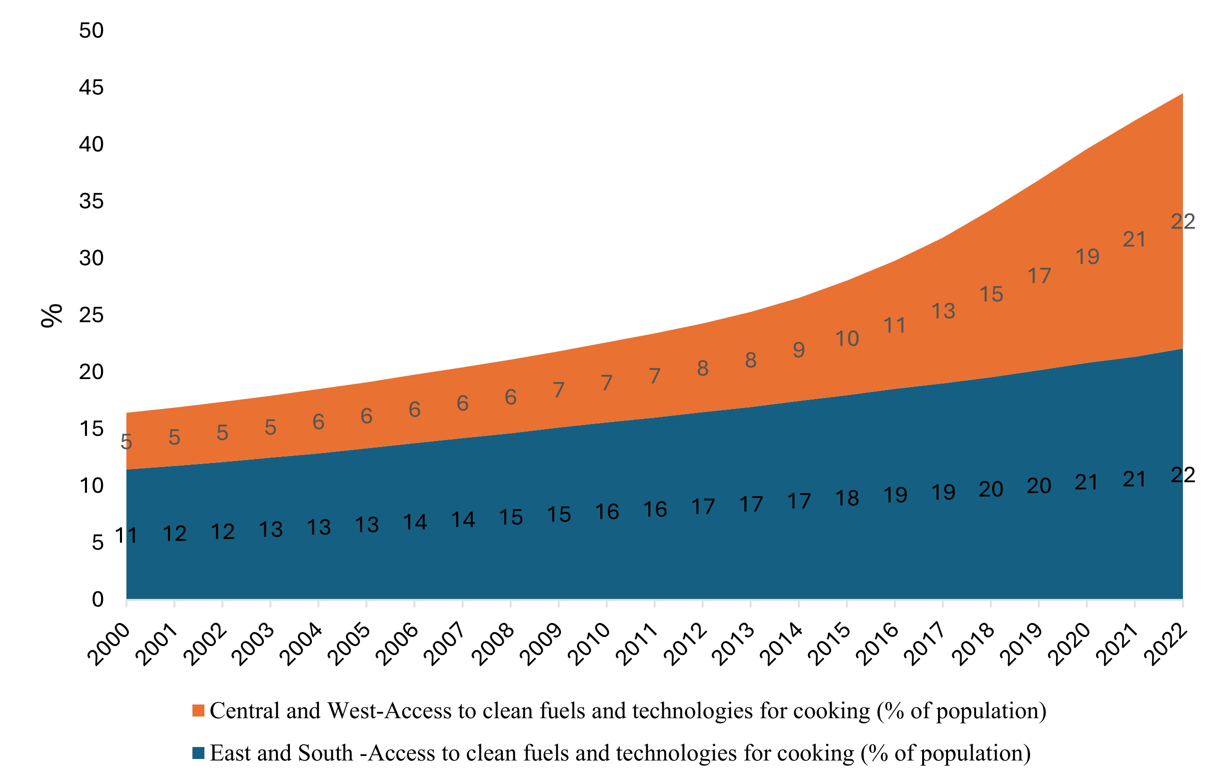
The remainder of the chapter is organized as follows: Section 13.2 examines the state of energy in Africa, while Section 13.3 explores the continent's digital infrastructure. Section 13.4 presents the descriptive results, and Section 13.6 highlights selected case studies. Finally, Section 13.7 concludes the chapter by summarizing the key findings and outlining practical implications.

2 The State of Energy in Africa

2.1 Access and Affordability

Electricity access remains one of Africa's most urgent development challenges. As of 2023, 565 million people in SSA still lacked access to electricity, representing 85 percent of the global population without power (World Bank, 2025). In 2023, 35 million people in the region gained access to electricity; however, population growth meant the number of people without electricity declined by only 5 million, dropping from 570 million in 2022 to 565 million in 2023 (World Bank, 2025). Urban access is relatively high, with connection rates around 80 percent, while rural access remains below 30 percent in many countries (World Bank, 2025). In countries like Malawi, Burkina Faso, and Niger, fewer than 25 percent of rural households are connected to the grid (Lee et al., 2022). Grid reliability is also a concern, with only 43 percent of Africans reporting that their electricity works most or all of the time (Lee et al., 2022). World Bank data shows that access to clean fuels and technologies remains limited overall (see Figure 13.1).

Figure 1: Access to Clean Fuels and Technologies in Africa, 2000 to 2022, by subregion

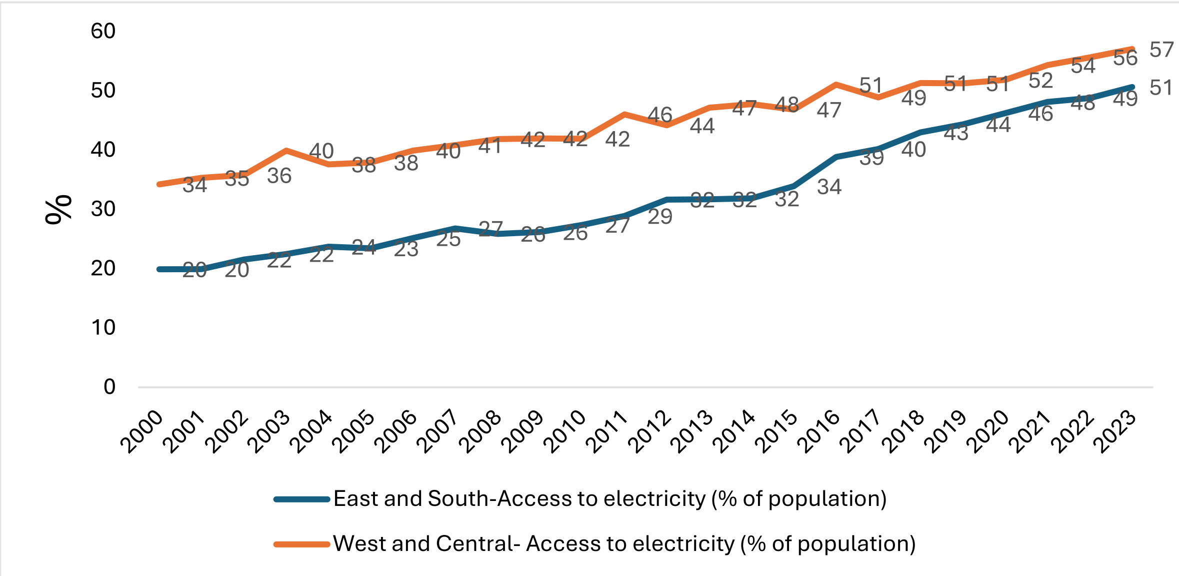


Source: Authors Construct based on World Bank data

Although Eastern and Southern Africa have generally had higher access levels, Western and Central Africa have made significant progress, particularly since 2015. In 2000, access in Western and Central Africa was just 5 percent, rising to 10 percent by 2015 and reaching 22 percent in 2022, matching the level of Eastern and Southern Africa (see Figure 13.1).

Unlike access to clean fuels and technologies, Africa has made notable efforts to improve electricity access, as shown in Figure 13.2, although progress remains below the global average of 93%. Western and Central Africa are currently outperforming Eastern and Southern Africa. In 2000, electricity access in Western and Central Africa stood at 34 percent, compared to 20 percent in Eastern and Southern Africa. By 2022, access in Western and Central Africa had risen to 57 percent, while Eastern and Southern Africa had reached 51 percent (see Figure 13.2).

Figure 2: Access to Electricity in Africa, 2000 to 2022, by subregion



Source: Authors Construct based on World Bank' WDI data

Affordability further complicates access. An empirical study by Hirmer et al. (2025) reveal that under the current tariffs, around 659 million people, representing 51 percent of the population, are unable to afford Tier 4 electricity (i.e., 102 kWh per month for a household) across the region. This number increases to 1.11 billion people, or 86 percent, when considering full access to Tier 5 electricity (i.e., 250 kWh per month for a household). In many cases, even when electricity is available, households and small businesses struggle to afford connection fees or regular usage costs. Tariff systems often do not reflect income levels, and existing subsidies rarely benefit those most in need. Many are left relying on costly and polluting alternatives such as diesel generators and kerosene, increasing both financial burdens and health risks. For instance, in 39 SSA countries, the cost of connecting to the electricity grid can exceed US$400, a figure that surpasses the average monthly income of many rural households (World Bank, 2025).

Most African countries rely heavily on imported refined fuels for transport, which makes them vulnerable to global price shocks. Although many nations export crude oil, they often lack sufficient refining capacity and therefore depend on imports of refined products such as petrol, diesel, and kerosene. These products are typically sourced from regions like Europe, India, and the Middle East. In 2019, Russian fuel accounted for 2.9 percent of Africa's total fuel imports, with much higher shares in countries like Burkina Faso and Senegal, where it approached 20 percent. By 2023, total refined fuel imports across Africa had reached nearly 2.5 million barrels per day. Countries such as Nigeria, Morocco, South Africa, Kenya, and Ghana were among the top importers.

To reduce this dependency, many African countries are now exploring alternative strategies for fueling vehicles and expanding domestic refining capacity. In Nigeria, for example, around 90 percent of refined fuel was previously imported. However, the recent commissioning of the

Dangote Refinery, with a capacity of 650,000 barrels per day, is expected to significantly reduce import reliance and help stabilize prices. The disruption caused by the Ukraine-Russia conflict has further accelerated efforts across the continent to identify more secure and diversified sources of fuel. Specifically, most of African countries are shifting to usage of gas, efficient vehicles and electric cars (see Table 13.1).

Table 1: Countries with Alternate Transport Fuels

Country	Alternative Fuel	Key Initiative
Egypt	Compressed Natural Gas (CNG)	Over 400,000 vehicles converted to CNG; 1,000+ fueling stations planned
Nigeria	CNG, Electric Vehicles (EVs)	National Gas Expansion Program; 1M vehicles targeted for CNG conversion by 2025
Morocco	CNG, Evs	10,000 taxis to be converted to CNG; strong EV incentives and solar charging hubs
South Africa	CNG, Evs	150+ CNG buses in Johannesburg; growing EV market with local assembly
Kenya	CNG, Evs	CNG pilot for public service vehicles; e-mobility startups scaling electric boda bodas
Tanzania	CNG	First integrated CNG filling and conversion center launched in 2024
Rwanda	Evs	Government-backed electric motorcycle and bus programs; solar charging stations
Mozambique	Biofuels	Exploring cassava-based ethanol for blending with petrol
Ghana	Ethanol, Evs	Ethanol blending policy under review; EV tax incentives introduced
Equatorial Guinea	CNG	Partnered with Egypt's TAQA Arabia to deploy CNG vehicles and infrastructure

Source: Ekanem (2024), Volpi (2024) and Energy Capital & Power (2023)

2.2 Reliability and Quality

Beyond access, the quality and reliability of electricity in Africa are major concerns. Frequent power outages, voltage fluctuations, and grid instability are common across many African countries, even in urban centers with high connection rates. Businesses and households often suffer from unpredictable service disruptions, which negatively impact productivity, education, healthcare delivery, and overall quality of life. Energy sector challenges and power shortages are estimated to reduce Africa's GDP by 2 to 4 percent each year, hindering economic growth, job creation, and investment (AfDB, 2018). Businesses in countries such as Tanzania and Ghana lose around 15 percent of their sales value due to power outages (AfDB, 2018).. In South Africa, persistent limitations in electricity generation capacity and frequent load-shedding have significantly constrained economic growth in recent years (AfDB, 2018).

Many utilities face operational inefficiencies, aging infrastructure, and high transmission and distribution losses—sometimes exceeding 20% of generated electricity. As a result, electricity supply cannot consistently meet growing demand. In response, millions of people and businesses rely on costly backup systems, particularly diesel generators, which contribute to pollution, noise, and rising fuel import bills. This unreliability hampers industrialization and discourages private investment in energy-intensive sectors. It also limits the potential of digital technologies and modern services, which depend on stable power to function effectively.

2.3 Energy related Carbon Emission in Africa

Carbon emissions are a direct consequence of energy consumption, with increased energy use leading to the release of greenhouse gases (GHGs) into the atmosphere. Among the various GHGs, CO_2 is considered the most significant due to its long-lasting impact and major contribution to global warming. As a result, this chapter focuses specifically on CO_2 and its implications. In Africa, the most contributor of CO_2 is energy consumption. Data shows that energy-using sectors in Africa are major contributors to CO_2 emissions. As illustrated in Table 13.2, the power sector emits more CO_2 than both the transport and industrial combustion sectors. However, this trend varies by subregion. For example, in Eastern and Southern Africa, most emissions from the power sector are largely due to South Africa. In contrast, in Western and Central Africa, the transport sector contributes more to emissions, mainly due to public transportation.

Surprisingly, CO_2 emissions from the power sector in Eastern and Southern Africa are higher than the total emissions from all sectors within the same subregion, as well as those in Western and Central Africa. For instance, even in 2023 when emissions had declined, the power sector in the subregion emitted 227 million tonnes of CO_2 equivalent. This figure is significantly higher than the 122 million tonnes from the transport sector and 75 million tonnes from the industrial sector within the same subregion. It also exceeds the combined emissions from all sectors in Western and Central Africa, which totaled 169 million tonnes of CO_2 equivalent (see Table 13.2). This highlights the importance of accelerating the transition to clean energy in the power sector within that subregion.

Table 2: Energy-related Carbon Emission in Africa, 2000 to 2023, by subregion

	Africa Eastern and Southern			Africa, Western and Central		
Year	Power Industry (Energy) (Mt CO2e)	Transport (Energy) (Mt CO2e)	Industrial Combustion (Energy) (Mt CO2e)	Power Industry (Energy) (Mt CO2e)	Transport (Energy) (Mt CO2e)	Industrial Combustion (Energy) (Mt CO2e)
2000	204	56	53	13	35	8
2001	192	59	49	13	40	7
2002	196	61	53	15	42	7
2003	215	64	55	14	44	12
2004	231	69	62	15	46	13
2005	228	71	67	17	45	12
2006	230	75	65	19	42	12
2007	237	81	60	19	41	14
2008	265	83	59	18	47	15
2009	247	83	77	19	48	13
2010	262	87	69	23	55	13
2011	256	94	64	23	59	19
2012	258	98	65	26	65	20
2013	266	109	69	28	76	22
2014	281	110	74	31	81	24
2015	264	114	71	33	80	24
2016	268	115	72	35	88	23
2017	260	119	68	36	88	22

2018	269	121	78	38	95	23
2019	288	123	76	38	101	24
2020	245	108	69	40	94	24
2021	246	121	74	42	101	26
2022	237	120	74	42	105	26
2023	227	122	75	41	103	25

Source: Authors Construct based on World Bank data

2.4 Policy and Investment Trends

Over the past decade, African governments, development partners, and private actors have intensified efforts to address energy challenges through policy reform and capital mobilization. At the global level, Sustainable Development Goal 7 (SDG 7) aims to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030. This has helped guide both international cooperation and national strategies. Regional institutions like the African Development Bank (AfDB) have launched major initiatives, such as the New Deal on Energy for Africa, which targets universal access by 2025 through investments in grid expansion, off-grid solutions, and enabling policy environments (see Box 13.1). (AfDB, 2018)

Box 1 New Deal on Energy for Africa Policy Aims to Enhance Energy Sector

The New Deal on Energy for Africa is a comprehensive, partnership-driven initiative led by the African Development Bank with the goal of achieving universal energy access across Africa by 2025. It seeks to unify various ongoing efforts and foster collaboration through the Transformative Partnership on Energy for Africa, a platform that promotes public-private partnerships and innovative financing models. The initiative rests on five core principles: raising aspirations to address Africa's energy challenges, creating a unified partnership platform, mobilising domestic and international capital, strengthening policy and governance, and increasing the Bank's investment in energy and climate finance. It targets key outcomes such as adding 160 GW of on-grid generation, increasing grid connections by 160% to reach 130 million people, expanding off-grid access to 75 million people, and providing clean cooking energy for 130 million households. The initiative also supports major policy reforms and utility overhauls to enhance the sector's transparency and bankability. It aims to raise US$30–55 billion annually in energy investments, up from US$22.5 billion in 2015. Between 2016 and 2020, the Bank committed to invest US$12 billion and leverage an additional US$50 billion, while tripling climate finance to US$5 billion annually. The rollout of the New Deal involved a series of high-level strategic actions from 2015 to 2017, including the establishment of a new Power, Energy, Climate Change and Green Growth Complex, the launch of a US$500 million Energy Inclusion Facility, and the recruitment of leadership for specialised directorates to oversee power systems, renewables, finance, policy, partnerships, and climate initiatives. These efforts are designed to transform Africa's energy landscape, support sustainable development, and align with global climate goals.

Source: African Development Bank (AfDB, 2018)

Similarly, the Power Africa initiative, led by the United States, has attracted substantial public and private investment to advance large-scale power generation, transmission infrastructure, and off-grid energy solutions. This policy initiative also reinforces several key programs of the African Development Bank, such as the Sustainable Energy Fund for Africa (SEFA), the African Legal Support Facility (ALSF), and the Partial Risk Guarantee (PRG) mechanisms (see Box 13.2).

Several countries have adopted national electrification strategies, independent power producers (IPP) frameworks, and renewable energy targets. For example, Kenya's National Electrification Strategy combines grid extension, mini-grids, and solar systems to achieve universal access by 2030, raising electricity access from 32% in 2013 to 75% by 2022 (Waweru, 2025). Rwanda has a transparent and competitive IPP process, guided by its Public-Private Partnership (PPP) Law (2016) and managed by the Rwanda Development Board (RDB) and REG subsidiaries[1].

Although supportive policies are in place, energy investment in Africa remains relatively low, amounting to just 1.2 percent of the region's GDP. Clean energy investment, while showing growth, represents only 2 percent of the global total according to the IEA (IEA, 2024). In 2018, Africa received about US$100 billion in energy sector funding, which made up just 5.5 percent of global investment. Of this, approximately US$70 billion was allocated to fossil fuels, US$13 billion to renewable energy, and another US$13 billion to electricity networks (IEA, 2019). Chinese investment has been instrumental in advancing energy infrastructure across the continent, but a steep decline in such funding between 2015 and 2021 significantly contributed to the overall drop in energy investment (IEA, 2025). As a result, public and development finance institution (DFI) support also fell from US$28 billion in 2015 to US$20 billion in 2024. Despite these setbacks, clean energy investment has started to recover since 2021, with around 40 percent now directed toward low-emission electricity projects (IEA, 2025).

Box 13.2: Power Africa Policy Supports Sustainable Energy

Power Africa is a five-year initiative launched in 2013 by U.S. President Barack Obama to support economic growth and development by expanding access to reliable, affordable, and sustainable electricity across Africa. The initiative operates as a multi-stakeholder partnership involving the U.S. government, six African countries, Tanzania, Kenya, Ethiopia, Ghana, Nigeria, and Liberia, and both African and American private sectors. The African Development Bank (AfDB) is a central partner, expected to commit up to US$3 billion over five years, leveraging at least four times more investment through loans, policy reforms, guarantees, and advisory services. USAID, in collaboration with the AfDB, has helped identify priority energy transactions in the six focus countries. The main source of AfDB's funding is the African Development Fund, which has already provided US$1.4 billion of US$1.6 billion invested in these countries' energy sectors over five years. The initiative also supports key AfDB programs, including the Sustainable Energy Fund for Africa (SEFA), the African Legal Support Facility (ALSF), and Partial Risk Guarantee (PRG) mechanisms. Additionally, Power Africa collaborates with the AfDB to mobilize private capital, including sovereign wealth and pension funds, through instruments like the Africa50Fund, designed to increase the number of bankable infrastructure projects and attract further investment.

Source: https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/power-africa-initiative Accessed June 25, 2025

[1] https://www.reg.rw/what-we-do/investments/ipps/process-to-become-an-ipp/ Accessed June 25, 2025

3 Digital Infrastructure in Africa

Digital infrastructure is the foundational technologies and systems that support digital services and connectivity (UNECA, 2023). Digital infrastructure can be classified as internet, data-related, digital payment systems, digital platforms and delivery-related (logistics) infrastructure (see Table 13.3).

Table 3: Components of Digital Infrastructure

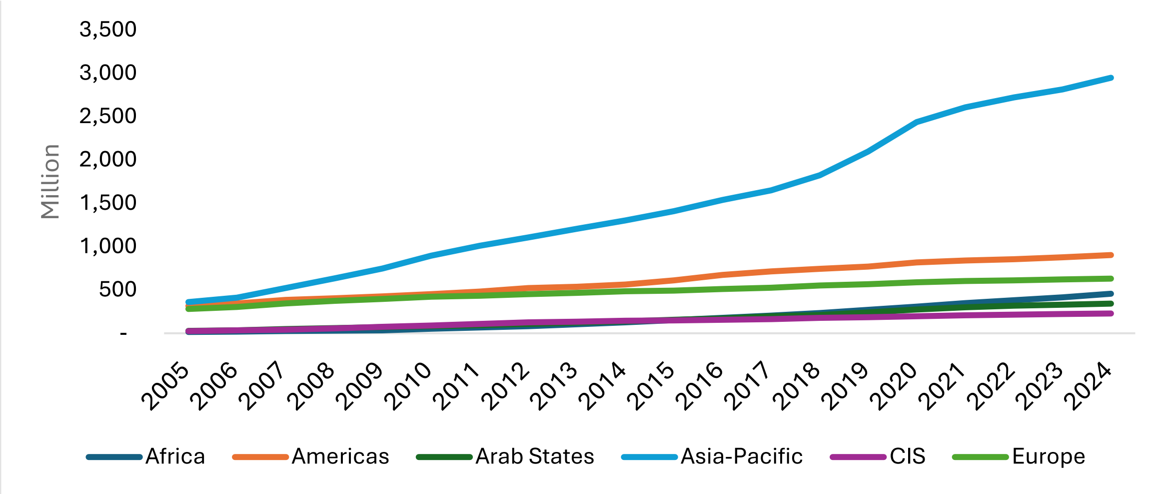
Infrastructure	Uses	Tools
Internet	physical and digital systems that enable internet connectivity, data transmission, and online communication.	cables, servers, networks, and data center
Data related	Systems, servers, storage facilities, networks, and tools that collect, process, manage, store, and analyze large volumes of digital information.	
Digital payment systems	Technologies, networks, and institutions that support electronic financial transactions such as mobile money, online banking, point of sale, and card payments.	Instant payment systems like Mobile money interoperability, USSD, mobile applications
Digital platforms	Systems that enable online services, e commerce, digital communication, and data exchange.	Social media, search engines, websites, emails
Delivery-related	Systems that support the efficient movement and distribution of goods and services	Postal networks including

Source: Authors' Construct based on UNECA (2023)

3.1 Internet Infrastructure

Internet connectivity is essential for digital trade, enabling the online exchange of goods and services across borders. Africa has historically lagged in internet use due to limited infrastructure and high service costs. However, the continent is now experiencing the fastest growth in internet adoption, with user numbers increasing nearly fourfold between 2013 and 2024 (see Figure 13.3). Despite this progress, significant disparities remain. Internet usage varies widely by country, from below 10 percent in Burundi, Congo, Somalia, and South Sudan to over 80 percent in Morocco and Seychelles (UNECA, 2023). Gender and geographic divides also persist, with more men (46 percent) than women (34 percent) using the internet in 2022, and usage in urban areas nearly three times higher than in rural ones. Broadband internet in Africa is expanding but remains the lowest globally (UNECA, 2023). Fixed broadband penetration stayed below 1 percent between 2013 and 2022, while mobile broadband rose from 11 to 42 percent. The lower cost of upgrading mobile networks and competitive service provision have driven this trend. However, broadband access varies significantly across countries, income levels, and urban-rural areas. In 2021, over half of African countries had fixed broadband penetration below 1 percent, with Seychelles and Mauritius as outliers due to strong investment and governance (UNECA, 2023). Mobile broadband is more widespread but still under 10 percent in several fragile states. Fibre optic infrastructure is expanding, especially in coastal and urban areas, but rural connectivity remains limited. Internet quality is shaped by factors like international bandwidth and technology type.

Figure 3: Global Access to Internet, 2005 to 2024, by region



Source: Source: Authors' Construct based on ITU data

Though mobile internet coverage is improving, 5G remains limited. Device affordability and digital skills are key barriers to broader access and next-generation network adoption (UNECA, 2023).

3.2 Data related Infrastructure

Internet Exchange Points (IXPs) are physical locations where network operators, internet service providers, content providers, and governments connect to exchange internet traffic through a shared switching system. This process, known as peering, keeps local data traffic within countries or regions, reducing reliance on costly international links. Africa has 83 IXPs across 45 countries, though many are underutilized due to regulatory and competitive barriers (UNECA, 2023). The African Union has promoted IXPs to strengthen local internet infrastructure. Data centres, which store and process digital information, are vital to supporting digital services. Africa hosts just 2 percent of global colocation data centres, mostly in South Africa, raising concerns about digital sovereignty and high data transfer costs. Building new data centres is expensive, but investment is growing. Cloud computing allows users to access services remotely without owning infrastructure. However, Africa's cloud ecosystem is dominated by a few large foreign providers, creating risks around pricing, access, and regulatory oversight.

3.3 Digital payment systems

Online payments are central to digital trade, yet adoption rates vary globally due to differences in financial inclusion and payment infrastructure. In Africa, limited access to bank accounts restricts the use of credit or debit cards, making cash and mobile money the preferred methods. Mobile money has significantly boosted financial inclusion, allowing users without traditional bank accounts to transact digitally. East and West Africa lead in mobile money usage, with services like M-PESA and mobile money growth in countries such as Kenya, Ghana and Nigeria, supported by enabling regulations (Iddrisu et al., 2025). Africa also hosts a growing fintech ecosystem, providing cross-border payment options and innovation, though regulatory gaps present risks related to consumer protection, data privacy and cybersecurity (UNECA, 2023). The rise of digital currencies and central bank digital currencies further expand digital payment options. Instant payment systems (IPSs), which allow real-time, low-cost transactions, are also gaining traction across Africa, with 26 systems operating domestically and regionally. Interoperability, regulatory clarity, affordability for non-smartphone users and inclusive governance are key to IPS success. Strengthening cybersecurity, market integration and multistakeholder collaboration are critical to ensuring these systems support financial inclusion and digital trade across the continent.

3.4 Digital platforms

Digital platforms are vital to Africa's digital infrastructure, enabling access to online goods and services and generating data that enhances business competitiveness. This data helps firms understand consumer behavior and innovate accordingly. The analysis focuses on three types of platforms: online marketplaces, e-government services, and trade facilitation portals. Online marketplaces exist in every African country, but their distribution and type vary. Algeria, Egypt, Morocco, South Africa, and Tunisia dominate traffic. Two-thirds are classified sites where transactions happen offline due to a lack of integrated payment systems. Most marketplaces serve domestic users only, limiting cross-border digital trade. Only 13% are locally owned, with most operated by third parties (UNECA, 2023). Regional efforts, such as the COMESA Digital Free Trade Area and AfCFTA's African Trade Exchange, aim to scale platforms regionally. E-government platforms enhance service delivery and transparency. South Africa, Mauritius, and Seychelles lead in e-government development. However, weak telecommunication infrastructure limits progress. Rwanda and Kenya offer comprehensive online services, but usage remains low due to digital skill gaps and device access. Trade facilitation portals improve transparency by detailing import and export procedures. Several African countries and regional bodies have launched portals to streamline trade processes and promote intra-African commerce under frameworks like the AfCFTA and African Union initiatives.

3.5 Delivery-related infrastructure

Reliable logistics infrastructure is essential for digital trade, particularly for delivering goods ordered online within and across countries. The World Bank's Logistics Performance Index (LPI) evaluates logistics capabilities through six indicators: customs efficiency, infrastructure quality, shipment ease, logistics services, tracking, and timeliness. Only Côte d'Ivoire, Rwanda, and South Africa score above the global average (UNECA, 2023), highlighting customs and infrastructure as key obstacles in Africa's logistics landscape. To address these, initiatives like the Boosting Intra-African Trade Action Plan and national single window systems aim to streamline export processes. Postal networks also play a crucial role due to their extensive rural and urban reach, yet Africa lags in postal reliability, reach, and relevance. This weakens their viability for cross-border deliveries. While larger businesses create private delivery systems, smaller firms rely on courier services and motorcycles. Poor addressing remains a major issue, prompting use of collection points. Countries like Egypt and Nigeria have introduced innovations to improve services. Egypt Post enables payment-on-delivery for small businesses, while Nigeria's postal service uses what3words to navigate inconsistent addresses, boosting efficiency. E-logistics platforms are also expanding, driven by improving digital infrastructure

4 Digital Infrastructure and Energy Outcomes

We used scatter diagrams to depict how digital infrastructure influence energy access and energy related carbon emissions. Macro data for all the 54 African countries was used for the period 2005 to 2022. Table 13.4 presents the data, its measurement and sources.

Table 4 Summary of Variables

Variables	Measurement	Source
Electricity access	Access to electricity (% population)	WDI
Clean energy access	Access to clean fuels and technologies for cooking (% population)	WDI
Carbon emission from power	CO_2 emissions from Industrial Combustion (Energy) (Mt CO2e)	WDI
Carbon emission from transport	Carbon dioxide (CO_2) emissions from Transport (Energy) (Mt CO2e)	WDI
Carbon emission from industry	CO_2 emissions from Power Industry (Energy) (Mt CO2e)	WDI
Digital infrastructure	ICT index	AIKPP

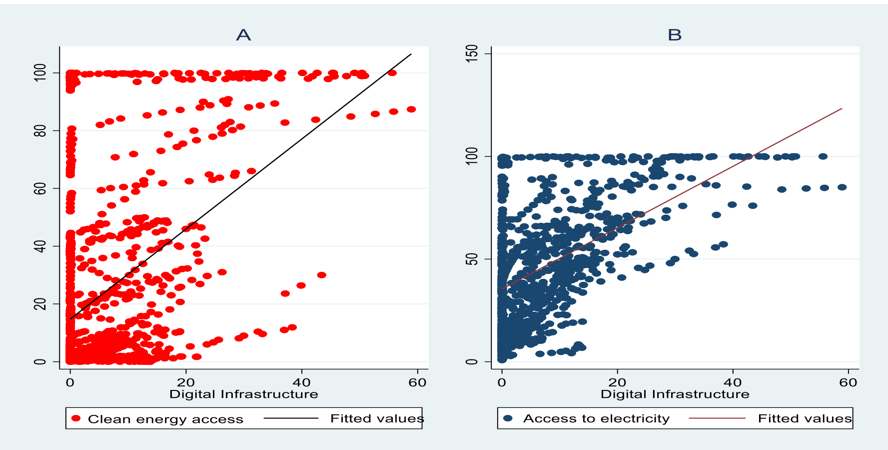
Note: WDI is World Development Indicators of the World Bank whereas Africa Infrastructure Knowledge Program Portal of the African Development Bank

4.1 Digital Infrastructure and Energy Access

This section discusses the link between digital infrastructure and energy access in Africa. Figure 13.4 is the scatter plots exploring the relationship between Digital Infrastructure and two energy access indicators in African countries.

The results in Figure 13.4 reveal that there is a positive correlation between digital infrastructure and access to clean cooking technologies, although the relationship is weaker and more dispersed compared to the electricity plot. At low levels of digital infrastructure, most countries also exhibit low access to clean cooking solutions. However, there is significant variation, with some countries achieving high levels of clean energy access despite limited digital infrastructure. This suggests that other factors such as donor funding, public health initiatives, or supportive local policies may play a more influential role. While investments in digital infrastructure can contribute to improvements in clean cooking access, they do not appear to be the primary driver.

Figure 4: Digital infrastructure and energy access in Africa, 2005 to 2022



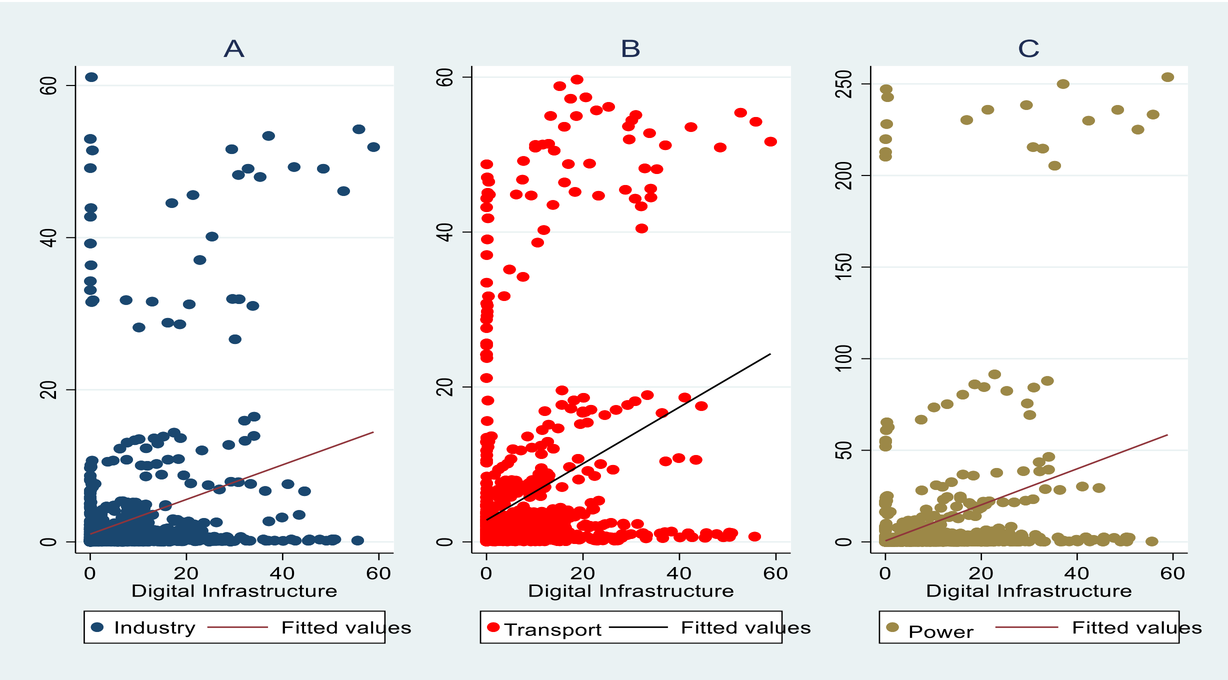
Source: Authors' Construct

There is a clearer and stronger positive relationship between digital infrastructure and access to electricity. As digital infrastructure improves, electricity access tends to increase consistently across countries. Very few countries with high digital infrastructure scores have low levels of electricity access, indicating a reliable association between the two. This pattern may reflect complementary investments, as countries that expand digital systems such as internet connectivity, mobile networks, and data centers often simultaneously invest in strengthening their electric power grids, particularly in urban areas. This confirms to some empirical studies who identified that digital infrastructure has a positive relationship with access to electricity (Horvey et al., 2024; Sohail et al., 2025).

4.2 Digital Infrastructure and Carbon Emission

The three scatter plots illustrate how digital infrastructure (independent variable on the x-axis) relates to sectoral carbon emissions from energy use in Africa, specifically in industry (A), transport (B), and power (C) sectors. Each plot shows the fitted regression line to help assess the strength and direction of the relationships.

Figure 5: Digital infrastructure and Carbon Emission in Africa, 2005 to 2022



Source: Authors' Construct

The relationship between digital infrastructure and industrial emissions in Africa appears weak and scattered. Most countries show low levels of both digital infrastructure and industrial combustion emissions, with only a few exceptions. Although the fitted line suggests a slight upward trend, the wide spread of data points indicates that digital infrastructure currently has little impact on industrial emissions. This likely reflects the relatively small and underdeveloped industrial base in many African countries. While digital infrastructure may help drive industrial growth in the future, it does not yet appear to significantly influence energy use or carbon emissions in the industrial sector.

A moderate positive relationship is observed between digital infrastructure and carbon emissions from the transport sector (see Figure 13.6B). As digital infrastructure improves, transport-related emissions tend to increase, though with noticeable dispersion. The fitted line is steeper here than in the other plots, indicating a stronger association. This could suggest that digital development enables greater mobility and logistics, which in turn increases fuel consumption in road, rail, and air transport. It may also reflect urbanization and the expansion of digital services like ride-hailing and e-commerce logistics, which increase transport activity.

There is a clear positive correlation between digital infrastructure and emissions from the power sector. As digital infrastructure improves, emissions from electricity generation rise significantly. This relationship is likely due to the higher energy demands associated with digital systems, such as data centers, mobile towers, and increased device usage, which place pressure on electricity grids that are often powered by fossil fuels. In many African countries, the lack of clean energy infrastructure and limited capacity to manage carbon emissions may exacerbate this trend. As a result, the rise in emissions is particularly evident in countries with the highest digital infrastructure scores.

5 Case Studies of Digital Infrastructure and Energy Outcomes in Africa

Case study 1- Smart Metering and Mobile Payments Enhance Energy Outcomes in Kenya

Kenya's national utility, Kenya Power, integrated mobile payment platforms like M-Pesa with digital metering systems, especially smart prepaid meters, to improve electricity services. This shift enabled real-time consumption data transmission, remote disconnection/reconnection, and token top-up via mobile, drastically reducing non-payment, electricity theft, and meter-reading costs. As of 2021–2025, Kenya Power has progressively rolled out these smart meters, targeting SME and domestic prepaid users, with over 7.4 million meters being upgraded by mid-2024

Energy outcomes achieved include:

- **Reduced non-payment and energy theft**: Kenya Power estimates losing about KSh17 billion annually (US$170 million) to theft and billing errors; smart meters cut these losses by enabling rapid tampering detection and remote control
- **Improved revenue collection and billing accuracy**: Smart meters with two-way communication and real-time monitoring reduced manual readings, disputes, and revenue leakage, boosting billing quality and utility income
- **Better demand forecasting & grid management**: Continuous usage data supports enhanced forecasting, outage detection, and load balancing, leading to greater grid reliability.
- **Increased customer access & convenience**: PAYG prepaid systems via M-Pesa, along with mobile self-service platforms (*977# and MyPower), expanded electricity access and user autonomy—especially in rural and peri-urban regions—while reducing in-person visits by 75%
- **Fibre-backed grid digitization**: Kenya Power leveraged fibre-optic infrastructure alongside the power network to support smart grid systems, remote management, and partnerships with telcos, deepening reach and improving energy-digital synergies

Source: Mbugua (2016)

Case Study 2-Uganda Used Digital Payment to Enhance Access to Energy

In Uganda, SolarNow has enabled rural households, primarily low-income farmers, to access clean energy by combining high-quality solar systems with an innovative asset financing model. Customers can acquire solar home systems and appliances such as TVs, fridges, fans, and radios by making a small upfront deposit (as low as 15 percent) and paying the remainder in instalments over up to two years. While mobile money is available, many customers prefer bank payments for official receipts.

SolarNow's model is personalized to the income patterns of rural households. Payment plans are adjusted based on agricultural seasons, livestock ownership, and personal circumstances. For instance, cotton farmers may pay for larger instalments after harvest, while dairy farmers pay steadily throughout the year. Customers are also allowed to reschedule payments in case of emergencies such as illness or crop failure.

Beyond lighting, these systems have transformed homes into modern living spaces. Many clients have progressively upgraded their systems from basic lighting to powering televisions and refrigerators without needing to replace their original units. This modular approach, paired with a two-year warranty, builds trust and reduces default rates.

Energy Outcomes Achieved

- Expanded access to clean and reliable energy for over 9,500 rural households

- Reduced reliance on kerosene and firewood, improving health and indoor air quality
- Improved quality of life, with clients gaining access to modern appliances and services
- Enabled energy scalability as households gradually increase capacity as their finances improve
- Supported energy affordability and financial inclusion, with minimal defaults and very few repossessions
- Enhanced energy reliability and user trust, reversing skepticism caused by previous low-quality solar systems.

Source: Mulupi (2015)

Case Study 3- Accra Metropolitan Assembly Used IoT to Power Street Light in Ghana

The Accra Metropolitan Assembly implemented smart street lighting using IoT-enabled systems equipped with sensors and remote controls. These systems adjust lighting based on ambient conditions and real-time usage patterns. The project was part of a broader initiative to install over 14,000 energy-efficient LED streetlights across more than 500 km of roads in Accra and other districts.

Energy Outcomes:

- Reduced energy consumption through optimized lighting schedules
- Up to 40% energy savings reported across municipalities
- Lower municipal energy bills and improved operational efficiency

Source: Opoku (2020)

Case Study 4- Devergy Used Digital Infrastructure to Provide Energy Access to Rural Tanzania

Devergy, with support from GSMA, USAID, and DFID, has implemented smart solar mini-grids in various regions of Tanzania including Mbeya, Morogoro, and Dar es Salaam. These mini-grids are powered by solar photovoltaic systems with battery storage and are equipped with digital meters that integrate with mobile money platforms such as M-Pesa and Tigo Pesa. Designed to serve between 60 and 400 households per village, the systems provide 24-volt DC electricity for essential uses such as lighting, phone charging, powering appliances, and supporting small businesses. Households prepay for energy in flexible bundles (daily, weekly, or monthly) through mobile money, and the smart meters are remotely activated upon payment. The system continuously collects real-time data on electricity usage and network performance, which is transmitted to cloud-based servers, allowing for efficient remote monitoring and management.

Energy Outcomes:

- Provided reliable access to electricity in underserved rural areas where national grid coverage was approximately 7%, replacing kerosene and enabling the use of essential appliances such as refrigerators and power tools.
- Electrified more than 1,266 households across 20 villages, achieving approximately 99% system uptime.
- Facilitated broader financial inclusion through mobile-money platforms, with 17% of users opening new accounts specifically for energy payments and increased usage among existing users.
- Reduced household spending on lighting and phone charging by an estimated 20%, allowing families to reallocate funds to other essential needs.

- Supported local economic development by enabling income-generating activities such as mobile phone charging and appliance sharing, while also creating employment opportunities for community agents responsible for sales, installations, and maintenance services.

Source: Karim (2018)

Case Study 5- Grid Modernization for Renewable Integration in Seychelles

In 2014, the Seychelles Public Utilities Corporation (PUC) and the Seychelles Energy Commission (SEC), with technical support from Energynautics and funding from the World Bank through the Small Islands Developing States (SIDS DOCK) initiative, launched a digital grid modernization initiative to support renewable energy integration. Central to this effort was the deployment of Phasor Measurement Units (PMUs) on key 11 kV feeders to capture high resolution, synchronized voltage and current data. This data was transmitted via mobile networks to Energynautics' servers for real-time monitoring and analysis. In parallel, a comprehensive grid code was developed to guide the integration of renewable energy into the national grid. The project assessed the grid's capacity to absorb solar photovoltaic (PV) generation, established technical standards for interconnection, and defined protocols to ensure grid stability, laying the foundation for more sustainable and reliable energy infrastructure in Seychelles.

Energy Outcomes:

- Clarified the technical capacity of the grid to reliably integrate up to 8% intermittent renewables, paving the way for scaling solar power deployment
- Enhanced grid stability and visibility, enabling better balancing of diesel generation with solar output and smoother integration of PV systems.
- Informed the establishment of regulations like grid codes, feed-in protocols, and demand-side management measures to support renewables expansion

Source:(Bhagwat & Hadush, n.d.)

6 Digital Infrastructure to Enhance Energy Outcomes: Challenges

Table 5 shows the challenges and possible strategies.

Table 5: Challenges Affecting the Impact of Digital Infrastructure on Energy E

	Challenge	Possible Way forward
Infrastructure Gaps	Gaps such as internet blackspots, unreliable electricity, and lack of local data centers, limit the effectiveness of digital energy solutions, hinder renewable integration, increase emissions through diesel reliance, and raise energy use from data transmission. These challenges reduce energy efficiency and slow digital-driven energy transitions	Countries can bridge infrastructure gaps by expanding broadband, deploying decentralized renewables, and building clean-powered local data centers, supported by public-private partnerships and policies that drive sustainable digital energy integration.
Skills and Capacity	Developing digital energy systems requires skilled workers.	Investments in training, education, and partnerships can build local capacity to operate, maintain, and innovate energy-efficient digital infrastructure effectively.
Regulatory Misalignment	Regulatory misalignment slows digital energy innovation, discourages investment, and creates data risks	Updating, harmonizing, and coordinating policies across energy, digital, and data sectors can enable faster deployment of innovations, attract investment, enhance interoperability, and ensure secure, efficient digital energy systems.
Affordability and Financing	Affordability and limited financing restrict access to digital energy technologies, especially in low-income areas. High upfront costs deter investment in smart grids, IoT, and data centers. For example, many African utilities struggle to finance smart meter rollouts without external support.	To address affordability and financing barriers, governments can offer targeted subsidies, risk guarantees, and blended finance schemes. Partnering with development banks and private investors can unlock capital for digital energy projects in underserved regions.

Source: Nwaiwu (2021), Sohail et al., 2025 and Horvey et al. (2024)

7 Conclusions

Digital infrastructure is increasingly gaining global attention as countries invest in it to drive economic and social development. African nations are no exception, with growing efforts to expand digital systems across various sectors. This chapter explores how digital infrastructure can support improved energy outcomes in Africa. Despite the continent's significant energy potential, current energy indicators including access, reliability, and efficiency remain relatively low. However, many countries are making progress in expanding energy access, with gradual transitions toward alternative and cleaner fuels aimed at reducing reliance on imported fossil fuels. While carbon emissions remain concentrated in the power sector, particularly in Southern Africa, there is a noticeable policy shift toward sustainable energy solutions supported by development partners. A descriptive analysis using a scatter diagram reveals a positive correlation between digital infrastructure and energy outcomes. Notably, the relationship is stronger with electricity access than with access to clean fuels and technologies for cooking. Case studies from across the continent further demonstrate that digital infrastructure plays a vital role in enhancing energy access and efficiency. However, several challenges hinder its full potential, including infrastructure gaps, limited technical skills and institutional capacity, regulatory misalignment, and issues related to affordability and financing.

The following are policy recommendations based on our findings; First, African governments and energy stakeholders should prioritize investments in digital technologies such as smart meters, IoT-enabled mini-grids, mobile payment platforms, and remote monitoring tools. These technologies can increase electricity access, especially in rural and off-grid areas, and improve the reliability and efficiency of existing energy systems. Second, addressing skills and institutional capacity gaps is essential. Training programs and partnerships with technical institutions can help build a local workforce capable of designing, maintaining, and scaling digital energy systems. Third, bobile money and digital platforms have proven effective in enabling access to decentralized energy systems (e.g., Pay-As-You-Go solar). Expanding these platforms can empower consumers while improving utility revenue collection and reducing losses. Fourth, policymakers need to harmonize energy and digital infrastructure policies to accelerate the deployment of integrated solutions. Regulatory frameworks should support innovation in areas such as decentralized energy, digital billing systems, and demand-side management tools.

References

Acheampong, A. O., Shahbaz, M., Dzator, J., & Jiao, Z. (2022). Effects of income inequality and governance on energy poverty alleviation: Implications for sustainable development policy. *Utilities Policy*, *78*, 101403. https://doi.org/10.1016/j.jup.2022.101403

AfDB. (2018). *The New Deal on Energy for Africa: A transformative partnership to light up and power Africa by 2025*. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Brochure_New_Deal_2-En.pdf

AFREC. (2024). *Key Africa Energy Statistics 2024*. https://au-afrec.org/sites/default/files/2025-02/Digital KEY AFRICA ENERGY STATISTICS EN A5 .pdf

Bhagwat, S. R., & Hadush, S. Y. (n.d.). *Energising islands in the age of transition*. Medium. Retrieved June 30, 2025, from https://medium.com/florence-school-of-regulation/energising-islands-in-the-age-of-transition-c9d508f4c95b

Ekanem, S. (2024, November 7). *6 countries championing CNG transition in Africa*. Business Insider Africa. https://africa.businessinsider.com/local/markets/6-countries-championing-cng-transition-in-africa/c9jz2tp

Energy Capital & Power. (2023, April 1). *3 African countries advancing gas-for-transport*. FurtherAfrica. https://furtherafrica.com/2023/05/12/3-african-countries-advancing-gas-for-transport/

Hirmer, S., Kou, Y., Yang, P., Leonard, A., & Egli, F. (2025). *Assessing Grid Affordability for Universal Electricity Access in Sub-Saharan Africa*. https://doi.org/10.21203/rs.3.rs-6427206/v1

Horvey, S. S., Odei-Mensah, J., Moloi, T., & Bokpin, G. A. (2024). Digital economy, financial development and energy transition in Africa: Exploring for synergies and nonlinearities. *Applied Energy*, *376*, 124297. https://doi.org/10.1016/j.apenergy.2024.124297

Iddrisu, K., Yakubu, I. N., & Asongu, S. A. (2025). FinTech Innovations for Sustainable Banking. In *Strategic Approaches to Banking Business and Sustainable Development Goals. Sustainable Development Goals Series* (pp. 63–86). Springer. https://doi.org/10.1007/978-3-031-80744-2_4

IEA. (2019). Africa Energy Outlook 2019 – Analysis Scenarios. In *World Energy Outlook Special Report (2019) 288*.

IEA. (2024). *World Energy Investment 2024*. https://www.iea.org/reports/world-energy-investment-2024

IEA. (2025). *World Energy Investment 2025*. https://www.iea.org/reports/world-energy-investment-2025

International Energy Agency. (2022). *World Energy Outlook 2022, IEA, Paris*.

Kambanda, C. (2020). *Atlas of Energy Resources of Africa*. https://au.int/sites/default/files/documents/36067-doc-ica_-africa_energy_atlas_stc.pdf

Karim, S. F. (2018, August 7). *Devergy: Leveraging a mobile services bonus to encourage the use of mobile money wallets for smart solar mini-grids in Mbeya, Tanzania*. GSMA. https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-for-development/country/tanzania/devergy-leveraging-a-mobile-services-bonus-to-encourage-the-use-of-mobile-money-wallets-for-smart-solar-mini-grids-in-mbeya-tanzania/?utm_source=chatgpt.com

Lee, H. E., Kim, W. Y., Kang, H., & Han, K. (2022). *Still lacking reliable electricity from the grid,* *many Africans turn to other sources* . https://www.afrobarometer.org/wp-content/uploads/2022/04/ad514-pap10-still_lacking_reliable_electricity_from_the_grid-many_africans_turn_to_alternative_sources-afrobarometer-10april22.pdf

Mbugua, W. (2016, April 21). *Powering the nation through innovation*. The East African Business Times Magazine. https://www.eabusinesstimes.com/powering-the-nation-through-innovation/?utm_source=chatgpt.com

Mulupi, D. (2015, November 26). *An asset financing model for rural households in Uganda*. Maritz Publishing. https://www.howwemadeitinafrica.com/an-asset-financing-model-for-rural-households-in-uganda/52719/?utm_source=chatgpt.com

Nwaiwu, F. (2021). Digitalisation and sustainable energy transitions in Africa: assessing the impact of policy and regulatory environments on the energy sector in Nigeria and South Africa. *Energy, Sustainability and Society*, *11*(1), 48. https://doi.org/10.1186/s13705-021-00325-1

OCHA. (2023). *Horn of Africa Drought Regional Humanitarian Overview & Call to Action*.

Opoku, A. O. (2020, September 23). *Installation of smart streetlights to be completed by March 2021 – MiDA*. Citi Newsroom. https://citinewsroom.com/2020/09/installation-of-smart-streetlights-to-be-completed-by-march-2021-mida/

Ren, H., Zhou, J., Yu, Y., & Ye, M. (2025). Carbon emission reduction effects of digital infrastructure construction development: the broadband China strategy as a quasi-natural experiment. *Frontiers in Environmental Science*, *13*. https://doi.org/10.3389/fenvs.2025.1510118

Sohail, M. T., Ullah, S., Ozturk, I., & Sohail, S. (2025). Energy justice, digital infrastructure, and sustainable development: A global analysis. *Energy*, *319*, 134999. https://doi.org/10.1016/j.energy.2025.134999

Sun, X. (2023). The impact of digital infrastructure on energy-environmental efficiency: empirical evidence from China. *Frontiers in Energy Research*, *11*. https://doi.org/10.3389/fenrg.2023.1277333

UNECA. (2023). *Digital Infrastructure in Africa*. https://repository.uneca.org/handle/10855/50027

Volpi, C. (2024, June 10). *Transforming Africa's Transport: The Rise of CNG*. Africa24.It/En.

Waweru, M. (2025, June 23). *Kenya's electrification success provides a blueprint for Africa's energy transformation; BCG report*. Africa Business Communities . https://africabusinesscommunities.com/sustainable-energy/kenyas-electrification-success-provides-a-blueprint-for-africas-energy-transformation-bcg-report/

World Bank. (2024, January 8). *Digital Transformation Drives Development in Africa*. World Bank. https://www.worldbank.org/en/results/2024/01/18/digital-transformation-drives-development-in-afe-afw-africa#:~:text=Over 160 million Africans gained,payment between 2014 and 2021

World Bank. (2025). *Tracking SDG 7 – The Energy Progress Report 2025*. https://www.worldbank.org/en/topic/energy/publication/tracking-sdg-7-the-energy-progress-report-2025

Xu, X., Meng, Q., & Huang, J. (2025). Identifying the Impact of New Digital Infrastructure on Urban Energy Consumption: Evidence from the Broadband China Strategy. *Energies*, *18*(5), 1072. https://doi.org/10.3390/en18051072