Dynamic Role of Renewable Eenrgy to Strengthen Energy Security and Energy Poverty Reduction: Mediating Role of Low Carbon Finance

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Abstract

This paper provides an empirical analysis of deploying renewables in Africa's five most populous countries for 2001-2019. It analyzed these factors to see how they impact deploying renewables by employing panel data using the pooled ordinary least squared(OLS) at frim level analysis to increase energy security and to reduce energy poverty. After the analysis, we proved that access to clean fuels and technologies for cooking needs the study countries to deploy renewables as most Africans cook with polluting fuels having detrimental health implications. The analyses further revealed that these countries generate a chunk of their electricity from fossil fuel sources, making it imperative to jettison fossil fuels and embrace renewables cheaper and environmentally friendly. The analysis also showed that the Quality of regulation in a country is vitally important to scaling up renewables in the study countries since the right policy tools underpin the transition. Furthermore, the lack of Electrification is important to developing renewal energy sources in the study countries. Sub-Saharan Africa has about nearly 600 million people not having access to electricity. Thus deploying renewables will bridge the access gap. Cleaner energies will be the panacea to the study countries' energy insecurity situation and bridge the access gap. The study countries have the technical and theoretical potential for all the renewable energies needed to ensure sustainable consumption. What is needed is to institute cornerstone financial policy de-risking instruments to crowd in private capital since the renewables sector is perceived as a high-risk area.

KeyWords: Renewables, Africa, Energy security, Pooled effect analysis,Energy Access, Energy Supply

1. Introduction

Renewables allow African countries to transition to cleaner consumption. The costs of renewables have been falling since 2009, making them cost-competitive to fossil fuels source. Yet Africa installs about 2% of the global capacity of Renewable energy capacity(RE) in about a decade. Despite the abundant theoretical and economic potential of renewables in the continent. Thus, this study seeks to delve into the determinants of scaling up RE resources in Africa's five most populous countries, estimating energy access, regulatory Quality in a country, effective compliance in a country, Carbon dioxide emissions levels, Access to clean fuels and technologies for cooking, energy imports, electricity generation from fossil fuels sources,GDP growth and Renewable energy consumption (% of total final energy consumption) as the dependent Variable. Cleaner production (C.P.) aims to boost production efficiency and eliminate or reduce waste from being produced rather than the firefighting approach or treat the waste when they occur. C.P. gained traction towards the end of the 1990s, where good environmental results and economic gains were attained through innovative industrial projects. Before then, national Cleaner production centers (NCPLCs) were set up by UNIDO and the UNEP in 1994 to boost cleaner productions in emerging and transitioning economics. Creating awareness and making governments and businesses implement policies and adopt technologies to reduce waste and pollutions(Sakr & Abo Sena, 2017). Climate change has become more pronounced and urgent in our dispensation. Governments institute green industries by formulating economic policy instruments to scale up these industries to reduce waste and environmental pollution. For instance, in South Africa, one of the focus areas of the NCPC-SA is renewables and Nuclear energy, which are carbon-free energy sources and cleaner. South Africa plans to enhance existing industries' production capacities, create green jobs in the economy by 2020, and fight climate change(NCPCs, 2013).All these lofy goals can be attained through the right investmet. Eighteen Sub Saharan Africa countries (SSA) have attracted about $18 Million in RES investment in 2018(Bloomberg NEF, 2020).

Besides, over 2.8 billion people worldwide still cook with solid Biomass, and nearly 800 million people don’t have access to electricity(*Cooking with Electricity*, 2020.).This means around a billion people have access to electricity and still cook with Biomass (*Cooking with Electricity*, 2020). It is is even more important for developing countries, where they rely more on fossil fuels to generate electricity. Africa generates more than 81% of its electricity from thermal sources, emitting carbon dioxide, and costly, that is not sustainable(Alemzero et al., 2020). As the world strives to contain the rise of global temperature beyond the1.5 degree Celsius levels, renewables sources are seen as the mainstays to achieving this aim and at the same time attaining energy security. Renewable energy is directly linked to energy security. Thus, renewables sources supply energy clean to the population, reduce or eliminate Carbon dioxide emissions levels and ensure energy security. Energy security has been defined as , power should be available at all prices, and there is no danger of its supply (Narula, 2019) and (Alemzero et al., 2020). Energy security became a global concern during the 1970 oil crisis that saw oil prices sky rocked and made nations started looking for alternative cheaper sources of energy to meet their energy needs. This brought about the formation of oil exporting countries (OPEC) as a cartel to promote oil producing countries' economic interest. Energy secuirty has even gained traction recently, given the Paris Agreement's importance to limit global emissions levels by 1.5 degrees Celsius. The concern now is not oil price volatility but how to scale up renewable technologies such as Wind, Solar, Biofuels, Geothermal, hydropower, etc., to sustainably meet the Paris Accord. Even though African countries have not been insulated from defined energy crises since the 1970s, the only way for African countries to secure their energy future is to embrace renewables energy production, which is economically compelling for them to integrate into their grids. Thus, this study seeks to see how the five countries selected from the various sub-regions can secure their energy futures by consuming renewables generating technologies. These countries are Nigeria from West Africa, South Africa from Southern Africa, Egypt from Northern, Ethiopia from East Africa, and DR.

Congo from Central Africa. African countries are still in the lock-in state of diversifying their energy mix, consuming an overwhelming 81% of their energy from fossil fuel sources(Alemzero et al., 2020).

Moroso, Africa is a continent on the move with rapid population growth, urbanizing at 4% a year(RES4,2020) and a growing gross domestic product growth of averagely 3% till 2030(Alemzero et al., 2020). Efforts have been made across the continent to boot renewables production with the formation of the African renewable energy initiative(AREI) in 2015, which seeks to achieve new and additional renewable capacity by 2020 and 300GW by 2030 Alemzero et al., 2020). Furthermore, the Clean Energy Corridor (ACEC) formation is supported by the A.U.'s Agenda 63 program to scale up renewable capacity in the continent(IRENA, 2019). The pooled ordinary least squared clustered method(OLS) was used in analysing the data from a panel of 5 countries from 2001-2019.This paper contributes to the policy debate on renewables deployment in Africa. Firstly, it gives insights on the important factors to deploying renewbles in Africa. Second, it has introduced new varibles on the deteminants such as quality of the regulatory enviroment and the effectiveness of compliance to estimate, using the pooled ordinary least squared method.Most papers on this topic on Africa don't consider these factors.Finally, it adds to a growing knowldge of literature on this field.

The rest of the paper is organized as follows; Chapter two does a deep analysis of the study's relevant literature. Chapter three is the methodology, while Chapter four covers the results and discussion, and chapter five wraps up with the conclusion.

2. Literature Review

2.1 Macroeconomic Indicators

Table 1 shows the macroeconomic indicators of the study countries. The Gini coefficient explains the income distribution of a population. How uneven income in a population is distributed.

Economic growth continues to be robust among these countries, which make up the chunk of the population in the African countries. The Democratic Republic of Congo has the second-highest population growth rate among the study countries and certainly one of the highest on the continent. The country has more than 84 million people, with a 72 872 billion gross domestic product and a per capita income of $ 867.The average real GDP growth rate is 5.9 percent from 2010-2020, on a steady growth path. However, the pandemic has likely distorted this steady growth pathway. The country's real GDP growth was projected to grow by 3.9% downward in 2020 and 3.4% in 2021(AfDB, 2020). But for the pandemic, these projections would be revised downwards since the demand has slowed from China for its mineral resources. Copper and cobalt have all seen a significant drop in prices. DRC's economy relies heavily on these raw materials. The extractive sector forms the nucleus of the economy of the country.

The GDP growth is expected to be reduced by 6.2 and 8.1 points, giving rise to a budget and current account widening deficit coupled with inflation doubling against what was initially projected(AfDB, 2020). The real GDP growth rate is forecasted to contract by 2.3% in 2020, as the pandemic continues to the first half of 2020 and will worsen by 4.2% by the worst-case scenario if the pandemic continues to December(AfDB, 2020). The country's economy lacks diversity and relies mostly on the primary sector, dominated by mining. The Gini coefficient for DRC is 42.1%, which is very high for the country. This explains the uneven distribution of income in the country. The wealth in the country is not equally distributed among the population. That is almost half of the people of varying income distribution in the country. The higher the Gini coefficient, the inconsistent the income distribution.

Ethiopia is one of the countries in East Africa with the fastest economic growth rate. Ethiopia has the highest population growth rate of 8.2% of about 108 million people, with GDP per capita of half of more than a thousand dollars, $550. Ethiopia has a GDP of 220 billion dollars. Ethiopia's average real GDP growth rate since 2010 is 9.7 percent; this is quite a robust growth pathway the country is heading. Ethiopia even projects to grow its GDP by 11% over the decade(Selvakkumaran & Silveira, 2018). The country relies mostly on agricultural products; it gives the country about 65% of its foreign exchange, and tourism makes up 9% of its GDP(AfDB, 2020). The country's real GDP rate is forecasted to decline from before the COVID-19 figure of 7.2% to 3.6% Covid-19 level, and the worst-case scenario of 2.6% to December(AfDB, 2020). The country has a Gini Coefficient ratio of 39.1%, indicating the country has uneven income distribution of about 40%. The wealth of the country is skewedly distributed.

Egypt is a more developed country relative to other countries in the study. It has a population of almost 100 million people, growing at 1.9 % with a GDP of more than $1 billion people as of 2018. Its GDP per capita is $ 13,051 as of 2018. The country has an average annual GDP per capita of 3.9 percent since 2010. Egypt's Gini coefficient is 31.9%, the lowest among the countries. That explains the country's wealth is, to some extent, distributed equally to the rest of the study countries. Egypt's economy depends solely on natural resources such as oil and gas, and so the pandemic worsens its foreign exchange earnings position, with a current account balance of a negative 6.1%. Besides, Egypt undertook significant structural reforms in 2017-18. This resulted in substantial improvement in the ease of doing business in the country and a robust regulatory and legal framework. The energy sector equally became very sustainable and competitive, with an enhanced governance system. The public power sector saw power supply outstripping demand, creating a surplus(Bank African Development, 2019). These achievements could be reversed due to the pandemic; real GDP is forecasted to fall 2.2% in 2020, 5.6% in 2019, and return to the growth path in 2021(Bank African Development, 2019).

If the pandemic persisted to December, the economy would reduce by 0.8%, meaning Egypt will be the only country attaining a positive growth pattern in North Africa (African Development Bank, 2019. The increase in the Pandemic spendings will further exacerbate the country's fiscal deficit to 8.5% in 2020 in the face of lower revenues, culminating in public debt reaching 85%(Bank African Development, 2019). Egypt's government took measures to alleviate the pandemic's adverse effects on the economy and people by putting together a stimulus package worth % 6.34billion dollars, which is 1.6% of Egypt's GDP. The country reduced gas prices for industry and a stimulus package of 63 million dollars (Bank African Development, 2019).

Nigeria has the third-highest GDP growth rate among the study countries of 2.6%, with almost 200 hundred million people. The government has a GDP per capita of $5,969, with a total GDP of $ 1 169 billion. Its average GDP per capita for a decade starting from 2010 is 3.6%. This explains a significant economic growth trajectory for Nigeria for the period. Most surprisingly, its Gini Coefficient 43.0% is the second worse one among the study countries surveyed in 2009. This explains that 43.0% of the country's population experiences an uneven income distribution. That is quite remarkable for Africa's biggest economy. It further emphasizes the point that the nation's wealth is in the hands of a few people.

Nigeria is bearing the pandemic's brunt with weak economic performance as oil price volatility hit the nation due to the pandemic. Oil prices fell to almost pre- COVID levels of 60% per barrel at the start of the year to 30% in March. The country relies mostly on oil and gas revenue. Nigeria's real GDP is forecasted to reduce around 4.4% and 7.2% due to the pandemic persisting and its severity(AfDB, 2020). This will undo the significant gains choked during the consistent three years of economic growth since 2016.

Oil and gas make up 90% of Nigerian's foreign exchange earnings and more than 50% of the government's fiscal revenue(Hepburn et al., 2020)(AfDB, 2020). The government's revenue is forecasted to fall by 90% in 2020 due to lower oil demand coupled with increased spending increasing the budget deficit to about 6.7% and 7.8% in a worst-case scenario(AfDB, 2020). All this will increase the current account deficit to 5% in the country's worst-case scenarios, provided the pandemic goes beyond 2020. (AfDB, 2020)(Hepburn et al., 2020)

In the light of these economic woes, the country has come out with a stimulus package to lessen the pandemic's burden. It has set up a naira 500 billion credit facilities ($1.4billion) to aid the health sector, give tax relief to the populace, and encourage companies to continue to employ even amid the pandemic. (AfDB, 2020). The government has increased the number of conditional cash transfers to the households to 3.6 million and reduced the interest rate from 9% to 5%(AfDB, 2020). All these aimed at cushioning the impact of the pandemic.

South Africa is Sub Saharan Africa's second-largest economy, with a population growth of 1.2% and nearly 60 million people. Its GDP per capita is $7,525 and GDP of789billion dollars. South Africa's average annual GDP growth since 2010 is 1.9%, showing the country has been on a slower growth pathway. Its Gini coefficient is the highest among the countries in the study. This shows the stark reality of the uneven distribution of wealth in South Africa. Despite its GDP per capita, the income distribution is highly irregular. This does not promote social inclusion.

Furthermore, table,1 shows that South Africa's economic performance has been very sluggish due to inefficient structural reforms in the energy sector and labor rigidity. This has had dire consequences on the economy. The economy has been growing on average of 1.1 % for the last five years(AfDB, 2020). The country is faced with hydra-headed problems of a high unemployment rate of 30% coupled with economic contraction in the second half of 2019 as well as the COVID-19 and its resultant effects, electricity supply bottlenecks, and financially distressed state-owned companies, making the growth in 2020 almost nonexistent (AfDB, 2020). The economy grew by 0.2% in 2019, the least in a decade; the GDP will contract 6.3%in 2020 and 7.5% in the worst-case scenario. According to the South African revenue service, the country's fiscal situation has been made worse by the loss of ZAR285 billion or $15billion, exacerbated by the pandemic(AfDB, 2020), (Table.1). The COVID-19 could cause a 12% fiscal deficit and 3.9% current account deficit of GDP AfDB, 2020). The government with its development partners, set up a fund to lessen the effects of the pandemic on the populace.

Table 1. Macroeconomic indicators

	Population growth rate (%)	GDP per capita ($)	Total Population(Millions)	GDP (billion 2018 USD)	Average GDP growth rate 2010-2020	Gini Coefficient	
Country						Survey year	Value
DRC	3.3	867	84,005	72,872	5.9	2012	42.1
Ethiopia	8.2	550	108	220	9.7	2015	39.1
Egypt	1.9	13,051	99,376	1,296,973	3.9	2015	31.8
Nigeria	2.6	5,969	196	1 169	3.6	2009	43
South Africa	1.2	7,525	57	789	1.9	2014	63

Source: African Economic Outlook Supplement, 2020

3.2 Electricity Access

Table 2 gives energy access of the countries. Energy access continues to be a thorny development issue on the African continent. About 565 million people have no access to electricity in Africa, about 50% of Africa's population(SEforALL, 2020). In the absence of electricity, African countries cannot eliminate poverty, access essential health services, and create an energy economy. Table 2 shows that the DRC has an access rate as low as 19.0%, and half of the urban population has access to electricity. However, only a minute 1% of rural areas have electricity access. On the other hand, renewable energy consumption, a percentage of total energy consumption, is relatively high, at 95.8%. DRC plans to double down on renewables' share on final energy consumption to nearly 100% in 2030(Selvakkumaran & Silveira, 2018). On the contrary, renewables' per capita consumption is deficient (Selvakkumaran & Silveira, 2018). The figure is coming from hydro sources. DRC aims to have a 75% electricity access rate by 2030, resulting in 80% electrification in urban areas and 70% in rural areas, as against 100% envisaged by the SDGs(Selvakkumaran & Silveira, 2018). DRC has many hydro resources potential; especially, If the grand Inga dam is constructed, it could meet DRC's 100% electricity demand(Selvakkumaran & Silveira, 2018). The country's Hydro resources are estimated at 100GW; out of this number, only 2.4GW was tapped into (Selvakkumaran & Silveira, 2018). Furthermore, access to clean fuels and technologies for cooking is as low as 4.02%. About 68 million people still lack access to energy in DRC, of the about 84 million people. This will retard socio-economic development and exacerbate inequality in the country.

Ethiopia is another country that is less electrified among the study countries. Its urban electricity access rate is nearly 100%, while the rural access rate is 32%. The share of renewable energy in final consumption is 92.2%. Ethiopia plans to take this to almost 100% by 2030(Selvakkumaran & Silveira, 2018). Ethiopia's access to clean fuels and cooking technologies is the lowest among the study countries, with a value of 3.51%. The inadequate access to clean technologies explains the country uses more polluting sources for cooking. Air pollution is the most casual risk factor of untimely deaths in Ethiopia(Beyene et al., 2018). Furthermore, in Ethiopia, about 65000 premature deaths occurred due to household pollution from cooking with solid fuels and 3.1 million disability-adjusted life- years per year (Selvakkumaran & Silveira, 2018).

Similarly, about 95% of Ethiopian households cook using polluting fuels and technologies, especially firewood, and the number is almost a hundred in the countryside(Beyene et al., 2018). The situation is even worse for rural areas since they are less electrified, but the problem is better in urban centers, with a high value of 38% biomass and 30% firewood(Beyene et al., 2018). Urban centers households use about one-fourth of clean fuels and technologies, 23% use electricity for cooking, and 1% with liquefied petroleum gas(LPG)(Beyene et a,2018.) Ethiopia has about 60 million people without access to electricity and aims to achieve 75% electrification rate in 2030 through their Intended Nationally Determined Contributions(INDC) (Selvakkumaran & Silveira, 2018)(SEforALL Sustainable Energy for All, 2020).

Egypt is the only country that has achieved a 100% electrification rate among the study countries. According to (Godinho & Eberhard, 2019), Egypt has nearly attained universal access in 2007 and got all hooked on the national grid. Egypt's government set up the Rural Electrification Authority (REA) in 1971 to ensure ubiquitous excess to grid electricity(Godinho & Eberhard, 2019). Once the government's rural electrification program was achieved, the government disbanded the REA. The country has universal access for urban and rural areas and has gained 97.6% access to clean fuels and cooking technologies. On the other hand, the renewable energy consumption of total final consumption is 5.7%, which is relatively less low.

Supporting research done by(US EIA, 2018) Egypt is the topmost consumer of natural gas and oil products in Africa, making up 22% of petroleum products and 37% of dry natural gas consumption in 2016. The issue of cleaner production has become so central to Egypt as this narrative shows the country is not producing and consuming clean fuels. Hence the government launched the Egyptian Pollution Abatement Project(EPAP), which seeks to encourage renewables production in Egypt(Hamed & El Mahgary, 2004). The issue of pollution is a primary concern for Egypt due to Egypt's importation of oil and gas to meet rising domestic consumption. As a result, the government has adopted measures to meet this increasing demand, neglecting energy efficiency (Sakr & Abo Sena, 2017). The growth in fossil fuel supply has worsened the pollution rate in

Egypt. The country bore the brunt of the most damage cost of air pollutions, which is 21% of its GDP in the MENA region, responsible for the overall 44% environmental costs to Egypt(Sakr & Abo Sena, 2017). According to (Sakr & Abo Sena, 2017), if a country implements an energy efficiency program that reduces per capita oil consumption by 10%, it could reduce particulate matter(PM) by 5.9%. Given this background, renewables are seen as cleaner energy sources to help Egypt achieve energy security and avoid pollution.

Nigeria has about 56.5% access to electricity of almost 200 million people. According to (Aliyu et al., 2018), Nigeria aims at a 75% electrification rate in 2020 but still lags in achieving the target. Urban Access to electricity is 81.9%, and rural access is woefully 30.9%. Also, renewable energy consumption in final energy consumption is 86.6%, and access to clean fuels and cooking technologies is 4.9%.In Nigeria, 91% is the total energy consumption in the housed hold, mostly done using wood fuels, causing an estimated 129 million Nigerian vulnerable to diseases and deaths due to pollution from cooking with unclean fuels. (Jewitt et al., 2020). Considering the importance of clean cooking technologies, Clean Cooking Alliance(CCA) was formed to press home the significance of creating ‘’clean’’ cooking systems(CCS) other than just stoves to deal with Household Air Pollution (HAP) and environmental pollution(Jewitt et al., 2020). And the total number of people without access to electricity across the country are 85 million people. Given this situation of Nigeria, the government plans to increase its cleaner energy technologies such as Biopower by 400 MW in 2025, small scale Hydropower to 2 G.W. by 2025, Solar power, large scale by 500MW by 2025, Windpower by 40MW in 25, CSP by 5MW in 2025(Aliyu et al., 2018). Furthermore, Nigeria has an estimated 14750 MW for small and large scale hydro reserves and about 3.5–7.0 kW h/m^2 /day Solar radiation and wind speed of 2–4 m/s at 10 m height(Aliyu et al., 2018).

Finally, South Africa is the most electrified country in Sub Saharan Africa, with 91.2% of the population hooked to the grid. Urban Access to electricity is 92.0%, and rural access to electricity is 84.6%. The percentage of renewables in final energy consumption is 17.1%, and access to clean fuels and technologies for cooking is 84.75%, the second-highest after Egypt in the study countries. South Africa sees renewables as a way to ensure sustainable development and promote sustainable consumption of energy. The renewable independent power producer program(REIPPP) had an initial plan of generating 45% for solar and 40% for Wind in the country, having all targets attaining a value of 65% for all auctioning rounds, creating a local content value of $4.7billions for all projected committed(IRENA, 2019).

Table 2. Macroeconomic indicators related to energy poverty

Country	Access to electricity(% of the population)	Access to electricity(% of urban population)	Access to electricity, rural (% of rural population)	Renewable energy consumption (% of total final energy consumption)	Access to clean fuels and technologies for cooking (% of the population)	Number of people without electricity(Millions)
DRC	19	50.7	1	95.8	4.02	68
Ethiopia	45	92	32.6	92.2	3.51	60
Egypt	100	100	100	5.7	97.6	0
Nigeria	56.5	81.7	30.9	86.6	4.9	85
South Africa	91.2	92.1	84.6	17.1	84.75	5

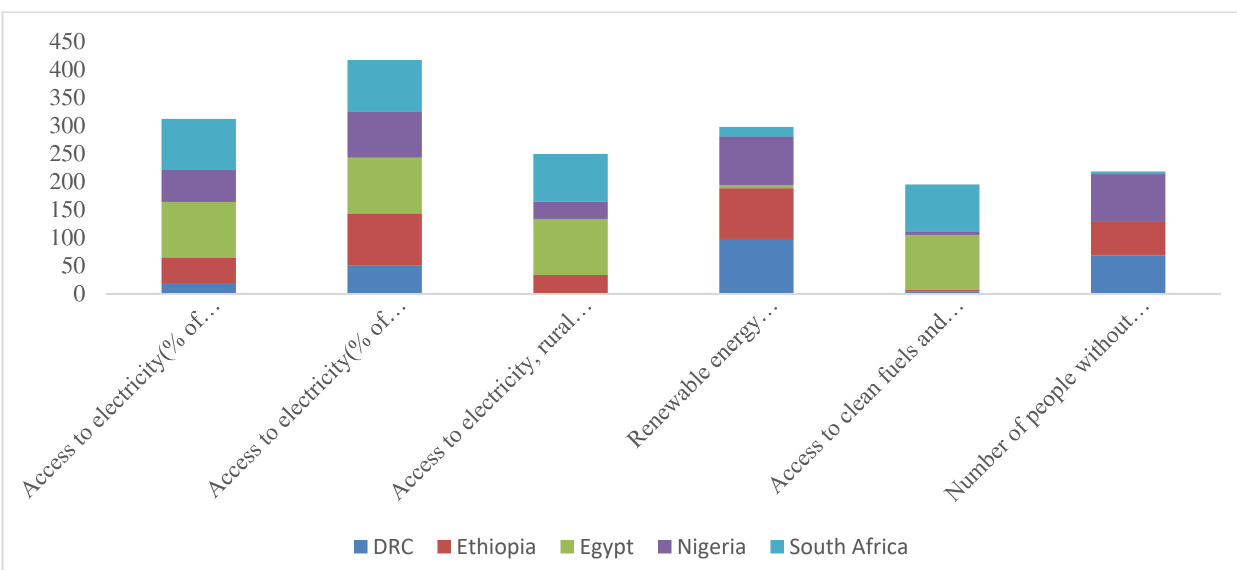

Figure 1. Electricity access map in Africa

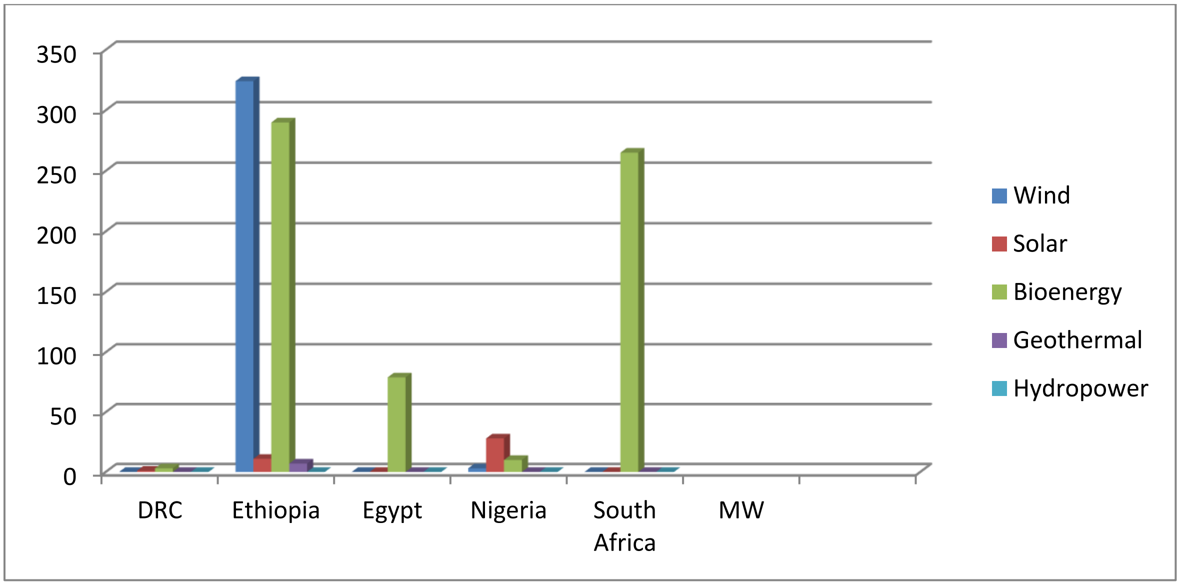

Figure 2. Electricity access map in Africa

The figure 1 and figure 2 shows that Ethiopia has more cleaner technologies, comprising five cleaner technologies. South Africa and Egypt followed her. Nigeria has lesser renewable energy generation, and DRC consumes nearly 100% hydropower, table,3.

Table 3. Total renewable capacities

Counntry	2011	2012	2013	2014	2015	2016	2017	2018	2019
DRC	2 514	2 514	2 515	2 516	2 529	2 551	2 566	2 762	2 772
Ethiopia	2 080	2 081	2 224	2 230	2 619	2 649	4 366	4 450	4 450
Egypt	3 503	3 503	3 503	3 503	3 713	3 736	3 857	4 814	5 972
Nigeria	2 119	2 134	2 136	2 138	2 140	2 143	2 143	2 143	2 152
South Africa	997	1 003	1 500	2 710	3 429	4 650	5 587	6 065	6 167

Source, IRENA RES Capacities 2020

3.3 Electricity Supply

The electricity supply situation in Africa, particularly SSA, is one of starvation. The study countries except Egypt from North Africa has 100% electrification, and South Africa above 80%. The rest are less than 80%making the populace live substandard lives. SSA power sector is underdeveloped, ranging from installed capacity, overall consumption, and access. The insufficient supply of power has damning consequences on the economies as countries struggle to have sustained economic growth. The GDP per capita growth of countries in Africa with an electrification rate of less than 80% is relatively low; those whose GDP per capita is more than $3500 are the natural resources endowed countries(Castellano et al., 2015). Today, about 565 million in Africa have no electricity access, and an estimated 900 million people without access to clean cooking fuels and technologies (SEforALL, 2020). Power utilities in SSA Africa find it challenging to meet their mandate regarding Quality, Access, and affordability of services. They are varied reasons attributable to this, but the most common ones are; the inability to find capital to invest in aging infrastructure and the inefficient revenue mobilization rates due to theft, improper billing, and non-payment(Utilities, 2020). Besides, electricity generation in Africa is skewed towards fossil fuels. Africa generates about 81% of its electricity from thermal sources (Alemzero et al., 2020). Fossil generation exposes the countries to exogenous shocks emanating from the world market due to fossil fuels' importation to power thermals and other related consumption. For Africa to achieve energy security, the continent has to move towards renewables such as Wind and solar and other cleaner energy production sources. Africa’s transition to cleaner sources can be achieved through public, private partnerships. Africa's power sector is vertically integrated, making power utilities controlling the generation, transmission, and distribution. However, some countries have started unbundling the power sector, giving concessions to the private sector to participate in the energy terrain (World Bank, 2011). This has injected an efficient management style and the needed finances to the power sector on the continent. According to (World Bank, 2011), the investment required to build transmission lines between 2015 and 2040 is around $3.2 billion to $4.3 billion. More so, Africa has an inadequate transmission lines capacity to carry large -scale loads to connect consumption centers. Of the 38 countries studied,9 have transmission lines less than 100Kv(World Bank, 2011).

DRC is under electrified, given its huge population size. The country has an estimated 50% of the 350 gig watts of hydro potential in SSA(Castellano et al., 2015). Most African utilities experience transmission and distribution losses above 50%, making only power two utilities profitable in SSA(Utilities, 202). The Societe Nationale d'electricite(snel) is the State utility for DRC(Uken, 2006), with the primary task of creating electricity access to one of the least electrified countries in the world and Africa. Snel continues to be an indispensable player in energy access but is faced with never-ending commercial losses, high debts, and aging assets(*World Bank*, 2020.)(Uken, 2006). The country has transmission and distribution losses of 36%, which is relatively high from the analysis. That means for every 100kwh of power produced, 36% of kWh is lost. Its total consumption is estimated at 7.43 billion kWh and has an estimated Peak demand of 1000MW. The grid can carry only 5000 MW due to capacity constraints and saturation. Businesses cope with this demand deficit by having generators to back the poor and unreliable service from Snel. About 60% of firms in DRC own generators(*World Bank*, 2020.) The DRC is already on a sustainable pathway regarding cleaner technologies as it generates a majority of its electricity from renewables, traditional renewable, hydro, about 92% from hydro. And plans to make it nearly 100% in 2030(Selvakkumaran & Silveira, 2018).

Egypt has achieved universal access. From the analysis, the country has Transmission and distribution losses (T&D) of about 19.9%. But according to (Elsayed et al., 2018), they reported T&D losses of about 29%.On the other hand, (Nassar & Abdella, 2019) revealed T&D losses between 11.77% in 2014 and increased to 12.88% in 2017. As reported by the EEHC, the peak load was 17300 MW more than double to 29400 MW in 2017(Nassar & Abdella, 2019). The peak load from table 3 is 30800 for 2018 as in the EEHC report(EEHC, 2018). The country has the highest energy consumption among the study country of 159.70 billion kWh. This is plausible since the country is heavily industrialized and achieved universal Electrification. The government targets 20% of its electricity from cleaner sources by 2022(Nassar & Abdella, 2019)and has installed renewable energy of 4 813 MW. Egypt's power sector uses 50% of its natural gas, making renewables reduced its energy mix from 13% in 2010 to 10% in 2014%(Mondal et al., 2019). This has shown a decline in the share of RES in the power generation mix. Egypt needs to move to cleaner production sources, given that its fossil fuel sources are depleting(Mondal et al., 2019). The Ethiopian Electricity Company's total installed capacity is 4,206 MW, and the available generation capacity of 4,206 MW.

The country has one of the highest T&D losses of about 23% and 126MW of thermal sources. The country relies most on renewables, mostly hydro sources of about 4351. Its peak demand is 491MW. It has the least consumed electricity among the study countries of 9.06billio kWh. Ethiopia can transition to cleaner technologies for energy consumption and ensure energy security when it nips corruption in the bud, establishes rule of law, and makes financing available(Akintande et al., 2020). Together with DRC, Ethiopia has about 61% of Africa's hydro potential on the continent(Olanrewaju et al., 2019). It is no surprise that the two countries have the highest hydropower shares in their electricity generation mix. Nigeria is Africa's most populous country. However, the electricity supply situation there is not encouraging. PHCN has an installed capacity of 12,522MW, with only almost half that available for generation 6,056 MW. The country's total consumption is 24.72kwh billion and has T&D losses of 7.4%. As of 2014, the country's net energy import value was negative, indicating the government did not import energy. Nigeria's renewable capacity is 143MW. Nigeria can transition to cleaner technologies by attracting foreign direct investment(FDI), the rule of law, strong regulatory environment(Akintande et al., 2020); in contrast, this transition to cleaner technologies can be hampered by corruption, political instability, and the presence of violence (Akintande et al., 2020). According to (Ugwoke et al., 2020), in the third quarter of 2018, Nigeria had installed a cumulative generation capacity of 13,435MW. The available power was 8,200MW and a peak demand of 5,162MW. As alluded to by the Nigerian Electricity Regulatory Commission (NERC), the distribution companies(DISCOs) could not account for 1.9kwh of 10kwh of power sent from the Transmission System Provider(TSO) in the third quarter of 2018(Ugwoke et al., 2020). This represents a loss of ₦1.90 of every ₦ 10 received as a result of malfunctioning infrastructure due to technical challenges and light theft(Ugwoke et al., 2020). South Africa is a driver of renewable energy additions in SSA. The country has an installed capacity of 51,309MW. And about 46,776 MW disproportionally coal. Eskom controls and produces about 90% of South Africa's electricity, and the rest is produced by Independent power producers (IPPs) and municipalities(Bohlmann & Inglesi-lotz, 2018). Eskom has 28 power generation units, with a cumulative capacity of 42,810MW and the IPPs have a nominal capacity of 3392 MW and South Africa in 2016 generated 219 979GWh(Bohlmann & Inglesi-lotz, 2018). Table,4 provides total electrity consumption, power utilities and their installed capacities.

Table 4 Total Electrity Consumption, Power Utilities and their installed capacities

	DRC	Egypt	Ethiopia	Nigeria	South Africa
Utility Company	Societe Nationale D'electricite(snel)	Egyptian Electricity Holding Company(EEHC)	Ethiopian Electric Utility(EEU)	Power Holding Company of Nigeria(PHCN)	Eskom
Installed Generation Capacity (MW)	2579	58353	4,244	6,056	51,309
Total	2,677	58353	4,206	12,522	51,309
Thermal(MW)	318	51226	126	10,142	46,776
Renewables	2 750	4 813	4 351	2 143	6 065

Peak demand(MW)	1000	30800	2491	5,162	34,481

Total Electrity Consumption	DRC	Egypt	Ethiopia	Nigeria	South Africa
Consumption(kWh)Billion	7.43	159.7	9.06	24.72	207.1
Losses(%) 2015/16/18	36	19.89	23	7.4	8.59
Net energy imports(of Energy use), 2014	1.95	-7.39	5.92631	-93.0272	-14.484

Democratic Republic of Congo (DRC)

The Democratic Republic of Congo(DRC) is a vast country with about ten million households and nearly 1.6 million having access to electricity. It is the third most populated country with people having less access to electricity. If the trajectory continues as a business as usual approach, 80% or 84 million people will live without electricity in the DRC by two decades from now(World Bank DRC,2020.)Today, the country's electrification rate is 19%, with nominal consumption in 2018 at 8349GWh. The average price of electricity in the country goes for 0.07US$/kWh. Hydro accounts for 98% of the 2,579 installed capacity in 2018, and fossil fuels making up 2%. The country's power sector faces many challenges ranging from low generation capacity, limited and disjointed networks, institutional inefficiency, and low electrification rate(Smillie, 2013). The country's hydropower potential is about 40 GWh(Smillie, 2013). The DRC plans to finish constructing the grand Inga 3 bases Chute Dam as well as reduce its greenhouse gas emissions(GHG) by 17% in 2030 relative to BAU approach by (430 Mt CO_2-equivalent), nearly more than 70 Mt CO_2 reduction(Energy & Special, 2019).DRC is a significant leading producer of cobalt in the world and makes up two-thirds of the global supply, necessary for the energy transition(IEA Africa, 2019).

Egypt

The Cleaner production concept has gained traction globally. Egypt has responded to that by promulgating law 4 on the environment in 1994 to bring to the fore issues about the ecosystem such as pollution, emissions and to address them(Hamed & El Mahgary, 2004). Egypt's energy sector faces the challenges of increasing energy demand and the over-reliance on fossil fuel consumption. The country's energy strategy aims to achieve energy security and efficiency(Mondal et al., 2019). Egypt currently generates about two-thirds of its electricity from gas. The energy sector consumes more than 50% of the country's gas, with renewables reducing the energy mix from 13%from 2010 to 10% in 2014(Mondal et al., 2019). However, Egypt is faced with the hurdle of meeting home increasing demand even as productions are dwindling. The country's oil consumption outstrips its production, making crude oil consumption increased by 16% in 2007, in the region of 802,00 barrel per day in 2017(US EIA, 2018). This gives an energy insecurity situation for the country and needs to be addressed with renewables consumption. Egypt has good potential for solar as well as abundant Wind resources (US EIA, 2018). As a result, the Egyptian Electricity Holding Company(EEHC) has initiated steps to increase renewable energy resources(RES) to the power generation mix by 20% in 2022, by the end of 2022. Some of the conventional power plants would be shut down, with steam plants reducing from 43% to 31% and that of gas and combined plants reduced from 14% to 13% and 33% to 28%, respectively(Nassar & Abdella, 2019).

Ethiopia

Ethiopia's long term vision strategy is to ensure the development of affordable, clean, and modern energy and access for the rapid social and economic growth and structural transformation as well as for all citizens and become a renewable energy hub in the Eastern Africa Region by 2025(Government of Ethiopia, 2020). Ethiopia is one of the leading countries with robust economic performance in the East Africa Enclave. It is equally a major renewable energy exporter to the east Africa Power pool. It sends renewable energy to Sudan and Djibouti through a 230kv, with power flowing up to 250 MW and 90 M.W., respectively(Beyene et 2018.) And aiming to invest about 20% of yearly budgetary allocation on infrastructure in the energy, railway, and telecommunication sectors(Government of Ethiopia, 2020). About 90% of Ethiopians rely on biomasses for cooking (Guta, 2020). Amid these statistics, the country had a 44% electrification rate in 2018 and a national nominal consumption rate of 9,042 Gwh in 2018. The average electricity price is 0.03USDkwh.

Furthermore, its installed generation capacity is 4,244MW in 2018, with hydro forming 90% and Wind energy 8% (African Energy portal,2020). Ethiopia's hydro potential is estimated at 45GW, the prospect of Wind is 10GW, and geothermal is 5WG(Hossain et al., 2014). Ethiopia aims to attain GDP per capita by 1000 in 2030 and reduce economy-wide greenhouse gases(GHG) from 400 Mt-CO_2eq in 2030 to 145 Mt-CO_2eq in about two decades in a business as usual approach. (Selvakkumaran & Silveira, 2018).

Nigeria

Energy demand in Nigeria is increasing at an exponential rate. The trend is set to continue in the years to come as the country is expecting population growth. The country generates most of its electricity from conventional sources.86% of its generation comes from hydro sources and 14% from thermal(Government of Nigeria, 2020). Its average electricity price is 6USDckWh.Access to electricity was 54% in 2017, and final energy consumption was 25,537 Gwh in 2018. Losses recorded in the transmission network were 16% in 2014. (AEP,2020). Total generation capacity in 2018 was 13,560 MW.20% of the electricity is generated by the private sector, and demand growth per year 7%. Peak demand is estimated at 12.8GW, with a 7.7 generation deficit(Government of Nigerian, 2020). The transmission sector is vertically controlled by the state, with the transmission Company of Nigeria (TNC) under a management contract with the

Manitoba Hydro International, which was contracted to reduce the transmission and distribution of the TNC.

South Africa

South Africa is the second biggest economy in Sub-Saharan Africa. It has made notable progress in its socio-economic life since the end of the apartheid era. However, there is still a vast income disparity and high unemployment prevailing in the country. The Gini coefficient for South Africa in table 1 is the highest among the study countries. South Africa is the world's 14th emitter of CO2 due to its over-reliance on coal consumption. The energy sector is faced with numerous challenges, such as supply deficit, load shedding, and Eskom's financial difficulties. The country's leading electricity provider and, as of 2019, South Africa had about 56,392MW installed generation capacity. The IPPs had about 5,492MW of installed generation capacity and a peak load of 34,256MW(Roche et al., 2020). South Africa's energy mix is tilted toward coal, which is about 73%, and will continue to be a larger part of the energy mix up to 2024. The Wind is roughly about 3.8%, Solar 3.6%, and hydro 6.4%. These capacities were delivered through the Renewable energy independent power procurement program (REIPPP)(Roche et al., 2020)

4. Cleaner Energy Potential

Cleaner energy sources are the panacea to the energy insecurity situation in African and in the study countries. The natural resource rich countries such as ; Egypt, Nigeria, and the like are facing dwindling reserves due to increased domestic consumption and the finite nature of conventional energies. For these countries to have energy security and sustainably meet the increasing demand and create green jobs and reduce carbon dioxide emissions, renewable energy consumption is the best way to pursue.Distributed Renewables Energy access(DREA) is the most sure means to ensure energy access and benefited about 150 millionin 2019(REN21, 2020)

4.1 Solar Energy

Solar energy has a vast potential to meeting the energy needs of African countries. Africa is the most solar endowed continent. Solar costs have plummeted drastically over the decades, making solar cost competitive to fossil fuel plants. According to the (IRENA 2019), the generation cost of solar and Wind have fallen by 16% and 3% since 2010. Despite these falling costs, most African countries have not scale up due to limited institutional capacity, lack of scale, lack of competition, high transaction costs, and high understood risks. Solar is focused, according to the IEA (RES4, 2020), to make up about 63% of electricity generation in SSA by 2040, while non-hydro sources are constituting 37% for the Africa case scenario (RES4, 2020). Solar and Wind are anticipated to be the leading emerging technologies consisting of a bulk of the installations. Solar P.V. could reach 124GW by 2030 and 316 by 2040; on the other hand, Wind could reach 51GW and 94 G.W. to power grids in Africa by 2030 and 2040(RES4, 2020).According to the (Bloomberg NEF, 2020), there is about 62% forcasted gowth in Solar PV installations in 2021 than in 2018, in SSA. The DRC, for instance, has a vast and different potential for renewables. The potential for solar is spread across the entire country, and Wind is located around the country's eastern part. According to the (IRENA 2019), Africa can significantly generate a quarter of its energy consumption from local and clean energy sources by 2030. Clean energy sources making up 310 GW can satisfy about half of the continent's electricity generation demand (IRENA, 2019). South Africa intends to generate 8.4GW by 2030. The country equally has an estimated 194,000 km2 of strong solar radiation potential in the Northern Cape, which is noted globally for solar potential, and solar anticipates to make up 14% of electricity generation by 2050(Aliyu et al., 2018). Egypt has rich solar energy. It is among the global Sunbelt countries. As (Aliyu et al., 2018) revealed, the government had on about 3200h sunshine of annual direct energy intensity of 1970–3200 kW h/m2 and the technical solar generation electricity potential of 73.6Petawatt(Aliyu et al., 2018). Africa's leading total installed capacities for Wind and solar in 2018 was South Africa with 1.8 GW and 2.1GW, and third in concentrated Solar thermal power(CSP) in the world, with 400MW(RES4, 2020).

Nigeria has the mean daily radiation of 14.4 MJ m−2 day-1 in the southern part and 21.6 MJ m−2 day-1 prevailing in the northern region. If Nigeria can utilize 1% of its land area with the mean 6 hours a ray of daily sunshine for P.V. power, it could generate about 1850,000 GW h yearly(Aliyu et al., 2018. Ethiopia equally has good potential for solar. Its solar radiation is around 5.2 kWh/m2/day, conducive to the deployment of utility-scale solar, and the government targets to install 500 MW of solar by 2020(Dorothal, 2019). The country currently installs bout 14 M.W. of solar, but the increase has been steady yearly(Dorothal, 2019).

4.2 Wind

Africa deploys wind energy to tackle the hydra-headed challenges of energy security, sustainable generation, and green job creation. The continued fall in wind energy costs makes it more compelling economically to scaling up deployment in Africa. Thus, it is not only an economic justification to deploy Wind in Africa but a political reason to meet the Paris Accord. Countries with the most wind installations on the continent are in the northern and southern parts. The continent is addressing the socio-economic and environmental issues facing the sector for it to take off. South Africa is a driver of Wind energy capacity in Africa. The country had more than 2GW of installed wind capacity in 2019 and above 3GW of planned capacity through the REIPPP and targets to make Wind generates 17.8% of electricity in 2030(RES4, 2020). The technical wind potential of South Africa Energy (TWh/year) with no grid restriction is 6306.7Twh, and with grid restriction is 6040.7Twh. Its capacity greater than 20% can generate about 4773.3Twh(Mentis et al., 2015). This analysis shows that South Africa has massive potential for wind energy.

On the other hand, DRC has 450.1TWh yearly generated power without grid restrictions and 378.9Twh with grid restriction and a capacity factor greater than 20% generation of 20.4Twh yearly(Mentis et al., 2015). This correctly describes DRC'S wind energy potential as the Wind energy potential is more promising in its eastern part. Furthermore, Egypt is endowed with one of Africa's most significant wind speeds for generating wind energy. Egypt's yearly energy generation from Wind without restriction is estimated at 5155.9Twh and with grid restriction is 3560.8Twh yearly. The capacity factor greater than 20% generation is 2724.3Twh(Mentis et al., 2015). Ethiopia equally has an enormous wind potential as the generation yearly without grid restriction is estimated at 1159.7Twh, and the capacity factor greater than 20% gives a yearly age of 238.9Twh(Mentis et al., 2015). The country experiences wind speed more than 8m/s in certain areas required for utility-scale wind generation. Nigeria has a wind energy potential of 50,046MWh/year, with better rates along the coasts and offshore(Government of Nigeria, 2020).

4.3 Hydropower

Africa has a lot of hydro resources. Africa's hydro potential is about 12% of the global hydro potential(RES4, 2020). The continent's hydropower is estimated at 1750GW(RES4, 2020). Nigeria plans to install 2 G.W. of hydro sources by 2025. (Aliyu et al., 2018). Nigeria equally has 1,4750 MW of hydro potential with an installed capacity of 1,930MW, representing only 14% of the total installed(Government of Nigeria, 2019).In South Africa, the hydro potential is 4,000GWh/year(Roche et al., 2020). The DRC has the most significant hydro potential in Africa, estimated at 774GW. It can generate revenue of over 6% to its GDP(Atlas Africa, 2017). The country has only exploited its economically feasible level of 3%, and it provides nearly a hundred percent of its electricity(Atlas Africa, 2017). Hydro supplies about 88.9% of Ethiopia's electricity and has an economically viable hydro reserve of 45,000MW(Government of Ethiopia, 2019.) .Egypt relies mostly on fossil fuel sources. Egypt's total installed capacity for hydro as in 2019 stood at 2832 MW(EEHC, 2018).Hyropower froms about 12% of the Egypt's electricity consumption.(Aliyu et al., 2018).

4.4 Bioenergy

Bioenergy is the energy that is gotten from the processing of Biomass. It is a dominant fuel in Africa and can generate significant power for national consumption. The DRC has the potential for bioenergy due to its 125 million hectares of forest, representing 67.7% of its land's surface and plant and animal waste(Atlas Africa, 2017). However, the issue has to do with the cost of buying digesters and installing them since most people are low income earners(Atlas Africa, 2017). South Africa has the potential for bioenergy around the Kwa-Zulu natal and Mpumalanga. (Aliyu et al., 2018). Furthermore, Egypt has the potential for bioenergy with about 2 or 3 times crop yield seasons and alot of animal waste and municipal solid waste. (Aliyu et al., 2018) Municipal waste was estimated to 15.3 million tonnes in 2001, with 75% generated from urban centers (Aliyu et al., 2018). In addition, Ethiopia has great bioenergy, as estimates put the national woody biomass to be 1,149 million with a yearly yield of 50 million tonnes in 2000. The country equally has sugar cane plantation needed for bioenergy(Atlas Africa, 2017)

4.5 Geothermal Energy

Geothermal energy is limited to a select few countries in the African continent; Kenya is leading the way. However, Ethiopia has geothermal energy with 7.3 MW by the end of 2011. The resource potential is at the Rift Valley, and the Afar depression has immense potential and can generate about 5000MWe of electricity(Atlas Africa, 2017). Nigeria has the potential for geothermal, according to recent studies carried out in selected states in Nigeria(Atlas Africa, 2017). And South Africa reliance on coal shows the country has no utility-scale geothermal energy production in the country(Atlas Africa, 2017).

3. Methodology

To carry out this research, data from the world development Bank development Indicators and the World Bank Governance Indicators(WGI) were derived and analyzed for what I termed the ‘’ Big five’’ of African countries. These are the most populous of the African countries from the period 2001-2019. The variables were obtained relevant to our analysis, with renewable energy consumption as a percentage of total consumption being the dependent Variable. The essence for selecting this dependent Variable is to see how the factors will influence or cause the upscale of renewable energy capacity in Africa. Given that African countries have put in measures to scale up renewables deployment on the continent, with the formation of the African renewable energy initiative (AREI). It is coded as _RESCON. The rest of the independent variables are electricity consumption from fossil fuel sources (EFOS). This Variable was selected to determine the correlation between renewable energy consumption on the continent. It stands to reason that, if fossil fuels are used for generating electricity, then there is the need to increase renewables consumption for electricity generation. Hence there is an inverse relation relationship between these two variables. Another independent variable is access to clean fuels and technologies for cooking (% of the population).

Most Sub Saharan Africans Access to these clean cooking technologies is very abysmal, having harmful effects on the population. Hence the need to measure it with renewables consumption. A direct relationship is expected between them. It is coded as CleanT&FC. Of course, the big elephant in the room is Electrification; all these variables can’t be measured without people having access to electricity. Access to clean electricity, especially renewables, is very key to ensuring energy security on the continent. Indeed, Energy imports have security implications for a country. The more a country depends on external sources to meet its energy needs, the more vulnerable the country is to negative exogenous shocks such as oil price volatility and other market shocks. The correlation is anticipated to be a positive one. It is coded as Eneimprt. Another important variable is that of the Quality of the regulatory environment operating in the country. It shows how the government can formulate and implement sound regulations and policies for effective private sector participation and development. It is encoded as regquality, And finally, effective compliance talks about the Quality of government policies, free interference from political actors in state institutions, and government credibility to see such policies come to fruition. As the literature has revealed and given the theoretical basis for the analysis, a pooled model at the firm level is used as done in (García-Álvarez et al., 2017). At first, we thought of applying a panel data methodology such as the GMM model pioneered by Arellano and Bond for dynamic panel data models(García-Álvarez et al., 2017). Using that methodology would mean the number of instruments would be more than the number of countries as alluded to by (García-Álvarez et al., 2017). The model estimated is given below:

$$X_{it}= y_o + \beta x_{it} + \sum_{t=2001}^{2019} +\varepsilon_t \qquad (1)$$

Where X_{it} is the vector of the independent variables in the equation. If the equation is subject to reparameterization, it takes the form,

$$RESCCONS_i = Y_1 + \beta_1 + \beta_2 CLEAN - FC_i + \beta_3 CO2_i \ \beta_4 \, EFFECTCOMP_i + \beta_5 REGQUlTY_i \ \beta_6 \, EFOS_i \ \beta_7 ELECTRIFICAT_i \ \beta_8 ENEIMPRT_i \ \beta_9 GDPGRWTH_i + \sum_{2001}^{2019} + \varepsilon_i \qquad (2)$$

$RESCCONS$= Renewable energy consumption (% of total final energy consumption)

$CLEAN - FC$=Access to clean fuels and technologies for cooking (% of the population)

$CO2_i$= Total Carbon dioxide emissions

$EFFECTCOMP$= Quality of the country’s public workforce and their freedom from political interference.

$ELECTRIFICAT$ = access to electricity (% of the population)

$ENEIMPRT$=Energy imports, net (% of energy use)

$GDPGRWTH$ =GDP growth (annual %). Therefore, β_1 Is the vector of the explanatory variables, which estimates the impact of the independent variables on the percentage of renewables in final energy consumption? The stochastic term ε_i are distributed across the years, country, and has a zero mean and constant throughout. Interaction occurs when the independnent Variable has a different impact on the outcome reacting to the values of another independent variable.When the interaction is created the effect on one Variable depends on the level of the other Variable.Therefore an interaction is created on the equation below: The possible equation for the three variable interaction is showed below.

$$RESCCONS_i = Y_1 + \beta_1 + \beta_2 CLEAN - FC_i + \beta_3 CO2_i \ \beta_4\, EFFECTCOMP_i + \beta_5 REGQUTY_i \ \beta_6\, EFOS_i \ \beta_7 ELECTRIFICAT_i \ \beta_8 ENEIMPRT_i \ \beta_9 GDPGRWTH_i\, \beta_{10}\, CLEAN - FC * \ EFOS_i * REGQULTY + \sum_{2001}^{2019} + \varepsilon_i \quad (3)$$

From equation three 3. A three variable interaction is being made among EFOS,CLEAN_FC and REGULTY.

3.1 First generation Panel Root test

Estimators are inefficient if the varibles in the panel are nonstationary unless they are conintegrated.How can one know whether the variables are stationarty or not? We applied the frist generation panel root tests , such as Hadri (2000), Levin et al. (2002, LLC), 2003, IPS) Fisher-ADF (Choi, 2001), states that cross section independence or homogenuity of the units:In addition, all the first generation unit root tests test for null hypothese of the root unit,except Hadri test. The equation is specified below:

$$\Delta y_{i,t} + a_i + py_{i,_{t-1}} + \sum_{k=1}^{n} \ \Phi_i \, \Delta y_{i,t-1} + \delta_i t + \theta_t + \varepsilon_i, t \qquad (4)$$

From the equation (4) i=1 ,,,,N and $T = 1, \dots, T$. The stocahstoc terms ε_i, t i.i.d$(0, \delta^{\,2} \varepsilon i)$ are said to be independent across the uits of the sample(Hurlin & Mignon, 2007). Do they have the same panel root process with

$$H_o: \rho < 1$$

Verses $H_A: \leq 1$

The Null hypothesies of the panel root test assumes that Y variables are stationary, and the alternative says Y variables are nonstationary.Diffference in unit roots:No unit root.

$$t_{1PS} = \frac{\sqrt{N}\left(t-1\frac{1}{N}\sum_{K=1}^{N} \ E[t_{iT}|\rho_{i=0}]\right)}{\sqrt{\frac{1}{N\sum_{K=1}^{N}} var\left[[t_{iT}|\rho_{i=0}]\right]}} \Rightarrow N(0,1) \ Fisher \qquad (5)$$

A second generational Panel root test

A second generation panel root tests waters down the cross sectional independence assumption. In order to respond to ways to deal with the panel root tests, dealing with cross section dependence. For the puropses of this study, we have used the second generation tests by the Bai and Ng (2001, 2004), Im, pesaran and Shin Unit root test(1993 &2003). Bai and Ng (2001, 2004) proposed the first test for unit root tests for the null hypotheses taking cognizance of the cross sectional dependence.They suggested the following factor analytical approach.

$$y_{i,t} \ = D_{i,t} \ + \lambda_i' \, F_t + e_{i,t} \qquad (5)$$

$D_{i,t}$ denotes the plynomial time function of ordere t, F_t is a real(r,1) vector of common factors, and λ_i' is a vector of factor laodings.Hence the individual series $y_{i,t}$ is broken down into different heterrogenous determinisitic parts, $D_{i,t}$ is a common part of $\lambda_i' \, F_t$, and $e_{i,t}$ is the stochastic term, which is mainly indiosyncratic.In the equation (5) above, $y_{i,t}$ nonstationary, if thr common factor of the vector F_t is non stationary or the error term $e_{i,t}$ is nonstationary.Furthemore, it is not certain that some will have stationarity and others will not.Other components of F_t couldbe I(0) and the rest of the 1(I) and others at different orders integrated. Another test for the cross section dependence is the Im, pesaran and Shin Unit root test(1993 &2003), from that time came the IPS (Hurlin & Mignon, 2007). From the equation below, Unlike the LL test approach, this method allows for heterrogeunity in the value of ρ_i in the alternative hypotheses.The IPS adapts the model (1), and changes ρ_i for ρ a model with trend and no time individual effects is shown below:

$$\Delta y_{i,t} = a_i + \rho_i y_{i,t-1} + \sum_{z=1}^{\rho_i} \beta_{i,z} \Delta y_{i,t-z} + \varepsilon_{i,t} \qquad (6)$$

From the model, the null hypothesis is given as $H_o: \rho_i=0$ for all is equal to $i = 1, \ldots N$ aandthe alternative hypothesis is given as $H_1 = \rho_i < 0$ for $i = 1, \ldots \ldots, N_1$ and $\rho_i = 0$ for $i = 0 = N_1 +$ 1,…,N with $0 < N_1 \leq$ N.The other hypotheses make room for individual hypotheses to have unit root(Hurlin & Mignon, 2007).The IPS uses a separate unit root tests for the N cross section units, rather than pooling them.The tests is grounded on the the augumented Dicker Fuller statistics mean groups(Hurlin & Mignon, 2007). The testing of quantile long-term equilibrium impact of energy consumption on ecological disorder is ensured through the QARDL model. The Wald test is also used to assess The time-varying integration relationship as follows:

$$EC_t = \alpha + \sum_{i=1}^{p} \varphi_i \, EC_{t-i} + \sum_{i=0}^{q1} \omega_i \, G_{t-i} + \sum_{i=0}^{q2} \lambda_i \, GDP_{t-i} + \sum_{i=0}^{q3} \theta_i \, K_{t-i} + \varepsilon_t \qquad (7)$$

$$CO_2 = \alpha(\tau) + \sum_{i=1}^{p} \varphi_i \, (\tau) CO_2 + \sum_{i=0}^{q1} \omega_i \, (\tau) G_{t-i} + \sum_{i=0}^{q2} \lambda_i \, (\tau) GDP_{t-i} + \sum_{i=0}^{q3} \theta_i(\tau) \, K_{t-i} + \varepsilon(\tau)_t$$

Ecological disorder measured through carbon dioxide. It can be argued that energy consumption cointegrated CO_2 emission. Where,

$$\gamma_G(\tau) = \sum_{i=0}^{q1} \omega_i(\tau), \qquad \delta_{G_i} = -\sum_{j=i+1}^{q1} \omega_i(\tau) \tag{8}$$

$$\gamma_{GDP}(\tau) = \sum_{i=0}^{q1} \lambda_i(\tau), \qquad \delta_{GDP_i} = -\sum_{j=i+1}^{q1} \lambda_i(\tau) \tag{9}$$

$$\gamma_K(\tau) = \sum_{i=0}^{q1} \theta_{i_i}(\tau), \qquad \delta_{K_i} = -\sum_{j=i+1}^{q1} \theta_{i_i}(\tau) \tag{10}$$

4 Results and Discussion

Table.5 Pooled Effects Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2	-1.45968	0.231227	-6.31275	0
EFFECTCOMP	-0.02974	0.057026	-0.52147	0.6034
ELECTRIFICAT	0.598742	0.127169	4.708233	0
ENEIMPRT	0.097498	0.048608	2.005794	0.048
GDP_GROWTH	-0.17968	0.074408	-2.41477	0.0179
REGQULITY	0.094006	0.054233	1.733351	0.0866
R-squared	0.983777	Mean dependent var		60.81072

From the table,5 it is apparent from the analysis that access to clean fuels and technologies is very perfectly significant, showing a strong correlation to the dependent Variable. This is because clean cooking more or less has to do with distributed generation and from Liquefied natural gas(LPG) then with Electrification. Fewer people cook with electricity in Africa, even though they are connected to the grid(Jewitt et al., 2020)(Dagnachew et al., 2019). Due to the high cost of the ecook method, most rural dwellers cannot afford them(cooking with Electricty, 2020). This, however, makes a strong point that Africa needs to transition to renewables energy consumption, which is sustainable and healthier to consume. Also, CO_2 emission levels is a major factor to be considered. It is strongly significant. This explains the reason why the world wants to transition to renewables consumption. It is the main greenhouse gas (GHG) that causes climate change. Even though Africa's general emission levels are generally lower relative to the rest of the world(IEA Africa, 2019), South Africa is the first emitter in African and fourteen in the world. But an interesting result relationship is that it is having a negative correlation to the dependent Variable. It was indicating an inverse relationship.

This result was also gotten by (da Silva et al., 2018). The correlation means as CO_2 increases, renewables consumption decreases. South Africa relies on coal about 80% to generate electricity, emitting so much CO_2(Edkins et al., 2010). The effectiveness of compliance is a major factor in considering how effective state institutions are and their independence from political interference. It came out not significant in the analysis. Another variable that met anticipation before the analysis is _EFOS, which is electricity generated from fossil fuel sources. A country that generates a bulk of its electricity from fossil fuel sources should strive to switch and generate more renewables. This will make the country dependent on local resources and not be exposed to geopolitical risks in the energy market. Indeed a variable that equally satisfied our curiosity during the analysis is the electrification rate. It came out perfectly significant. As some of the study countries don't have universal access, it is expected that they will embrace and scale up renewables to achieve this objective, as the Paris Accord envisages(IRENA, 2019) and (Olanrewaju et al., 2019). Furthemore, the correlation is a positive one, meaning as electrification rate increases, renewables consumption of total energy consumption increases (Sun et al., 2020).

Besides, another variable that came very significant is ENEIMPRT. It is highly significant and directly correlates to renewable energy capacity—all other things; being equal, when energy imports increase, renewable consumption increases. As a country imports energy to meet its domestic demand, it exposes the country to adverse exogenous shocks and economic ramifications

(Alemzero et al., 2020). For instance, importing countries are exposed to oil price volatility making economic planning difficult(Alemzero et al., 2020). Besides, GDP_GROWTH was significant in determining the relationship with the dependent Variable, renewable energy consumption. However, the correlation is negative, implying that the countries have decoupled their economic growth from energy consumption. And so, as the economy grows, energy demands reduces, creating an inverse relationship.

Finally, the Quality of regulatory environment prevailing in a country; REGQULITY is significant as was anticipated. For renewables to scale up in the ‘’Big five’’ countries in Africa, there has to be a robust regulatory environment to ensure that policies are implemented to encourage and promote private sector participation in the renewables sector. (IRENA, 2019)

Table.6 Total panel (balanced) observations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	97.56274	2.006324	48.6276	0
CLEANT_FC	-1.20878	0.097505	-12.3971	0
CO2	-1.44447	0.230685	-6.26164	0
EFFECTCOMP	-0.04992	0.062976	-0.7927	0.4301
EFOS	-0.37911	0.07452	-5.08733	0
ELECTRIFICAT	0.615831	0.127944	4.813294	0
ENEIMPRT	0.099424	0.04852	2.049117	0.0435
GDP_GROWTH	-0.16906	0.073344	-2.30502	0.0236
REGQULITY*EFOS*CLEANT_FC	1.51E-05	8.03E-06	1.879338	0.0636
Root MSE	5.154061	R-squared		0.983873
Mean dependent var	60.81072	Adjusted R-squared		0.982372

From table 6 above the three variable interaction terms is created to determine the effect on the dependent variable, renewable energy consumption, as a percentage of total energy consumption. The variables that are interacted are REGULTY, EFOS, and CLEANT_FC. The results proved the same significance levels as in the pooled OLS in the first equation. Effective compliance was not significant, as in the first equation. These shows the results are robust. It must be noted that the interaction term is significant. This implies that the interaction of regulation quality, Electricity generation from fossil fuel sources, and access to clean fuels and cooking technologies impacts the scaling up of renewables in Africa positively. More so, the direction of the relationship is a direct relationship. The correlation, therefore, implies that when renewables capacity increases, the interaction term increases. In essence, when any of the study countries generate more electricity from fossil fuels, has a good regulatory environment as well as the need for increased access to clean cooking fuels and technologies, it is very imperative for the country to increase the deployment of renewables.

4.1 Unit Root Test Analysis

Overall, the results of the stationarity test of the variables are presented in table 7 below. We adopted the first generation unit root test of Hadri (2000), Levin et al. (2002, LLC), 2003, IPS) Fisher-ADF (Choi, 2001) and Hadri (2000). The results from table three show that all the variables have unit root at level and therefore non stationarity.However, after taking their first difference, the variables became stationary at I (1) and therefore we accept the alternative hypothesis that the variables have no root unit and reject the null there that there is unit root in as depicting in table 7.

Table 7 Stationarity test of the variables

Variable	LLC Constant	PP-Fisher constant	Fisher-ADF constant	IPS constant	Hadri constant
Rescons	0.477	3.964	4.036	1.437	3.929
	(0.6834)	(0.9490)	(0.9457)	(0.9246)	(0.000)
Clean-FC					
	0.436	43.181	12.103	1.467	5.873
	(0.6685)	(0.000)	(0.27820)	(0.9288)	(0.000)
CO2	0.557	57.554	4.429	1.923	6.032
	(0.711)	(0.000)	(0.926)	(0.973)	(0.000)
EffectComp	-3.168	130.907	-5.123		-0.549
	(0.008)	(0.000)	(0.000)	45.674	(0.709)
				(0.000)	

Regqulty	-1.094	49.808	34.329	-3.972	-0.849
	(0.137)	(0.000)	(0.000)	(0.000)	(0.802)
Efos	0.872	24.690	15.554	-0.365	3.790
	(0.192)	(0.006)	(0.113)	(0.358)	(0.000)
Electrifcant	-2.031	9.286	10.061	0.219	6.347
	(0.0212)	(0.505)	(0.435)	(0.589)	(0.000)
Eneimprt	2.468	10.355	7.548	2.418	3.520
	(0.993)	(0.401)	(0.673)	(0.992)	(0.000)
GDPgwrth	-15.505	38.081	271.028	-10.771	3.027
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)

p-values in squared parentheses.The test indicates that the variable is stationary at 5%.

Source:Authors' calcularion

Table.8 shows the first difference of the statitionariy of the variables.

Table 8. First difference of the statiority of the variables

Variable	LLC constant	PP-Fisher Constant	Fisher-ADF constant	IPS constant	Hadri constant
Rescons	-2.565	32.265	21.781	-2.147	3.945
	-0.005	0.000	-0.016	-0.016	0.000
Clean-FC	-4.646	37.842	22.814	-2.537	3.534
	0.000	0.000	-0.012	-0.006	-0.002
CO2	2.932	414.196	38.348	-4.441	0.008
	-0.998	0.000	0.000	0.000	-0.497
EffectComp	-1.421	136.994	52.008	-6.009	0.008
	-0.078	0.000	0.000	0.000	-0.496
Regqulty	-2.923	335.583	42.156	-4.918	-1.261
	-0.001	0.000	0.000	0.000	-0.896
Efos	-1.799	308.519	25.619	-2.845	3.785
	-0.036	0.000	-0.004	-0.002	-0.001
Electrifcant	-7.431	137.029	65.199	-7.695	1.209
	0.000	0.000	0.000	0.000	-0.113
Eneimprt	-3.456	61.665	27.904	-3.091	4.233
	0.000	0.000	-0.001	-0.001	0.000
GDPgwrth	-15.459	189.699	281.85	-10.919	4.694

Source:Authors'calculation p-values in squared parentheses. The test indicates that the variable is stationary at 5%.

Table 9. Second generation Unit root tests

Variables	Bai and NG	Pesaran's CADF test
_rescons	5.721	-5.781
	0	-0.01
Clean-FC	-0.416	-604322
	-0.677	-0.01
CO_2	2.512	-0.073
	-0.12	-0.1
EffectComp	-1.553	0.003
	-0.12	-0.1
Regqulty	-1.694	-2.040
	-0.090	-0.1
Efos	-1.300	-6.157
	-1.194	-0.01
Electrifcant	2.160	-2.710
	-0.308	-0.01
Eneimprt	0.587	-22173
	-0.558	-0.01
GDPgwrth	-0.641	-0.099
	-0.522	-0.1

Source:Authors'compilation: p-values in squared parentheses.

The test indicates that the variable is stationary at 5%. From the analysis in table 9. all most of the varibales are nonstationary, using the Bai and Ng (2001, 2004) to test cross sectional he augments dependence. On the other hand, all the varibales became stationary using the Pesaran's CADF test, the standard Dickey-Fuller or Augmented Dickey-Fuller regressions which allows for the cross section of average lagged levels and first difference of the series. Thus, all the varibles are stationary without taking their 1(I).Hence the null hypothesis is rejected that there is unit root in the panel. Now comparing the results of the Peasaran's CADF's test in the second generation in table 5 to the IPS in the frist generation, showes the varibales in Table 9 are nonstationary and only became stationary after their I(1). However, with the Peasaran test in the second generation, the varibles assume statioanrity without taking their I(1).

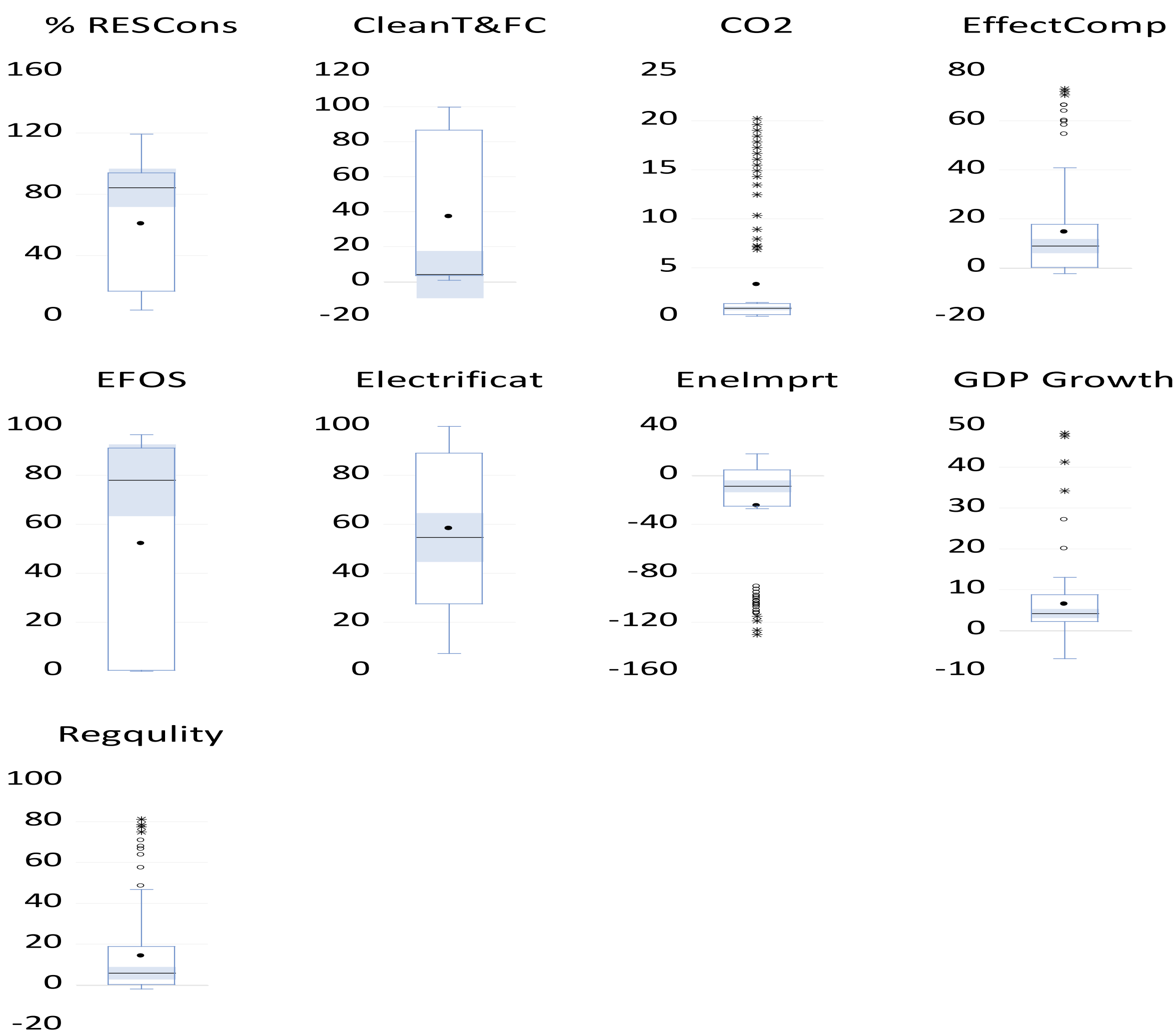

Figure 3. Boxpot of the underlying variables

From gigure 3 the Boxplot maximum value for _rescons is about 85% and the median value 40. On the other hand, the variable on Clean T and FC has a low maximum value of 19 and the minimum of nearly [-20].This explains how insiginficant the variable is in the study countries. Electricity from fossil fuels sources has the higest Boxplot maximum value of nearly 100, followed by electricifaction in the study countries. Africa generates about 81% of its electricity from fossil fuels sources(Alemzero et al., 2020). CO_2 has the least Boxplot value of less than 1.That explains the negiglible levels of CO_2 emission among gthr study countris, other than south Africa and Egypt.

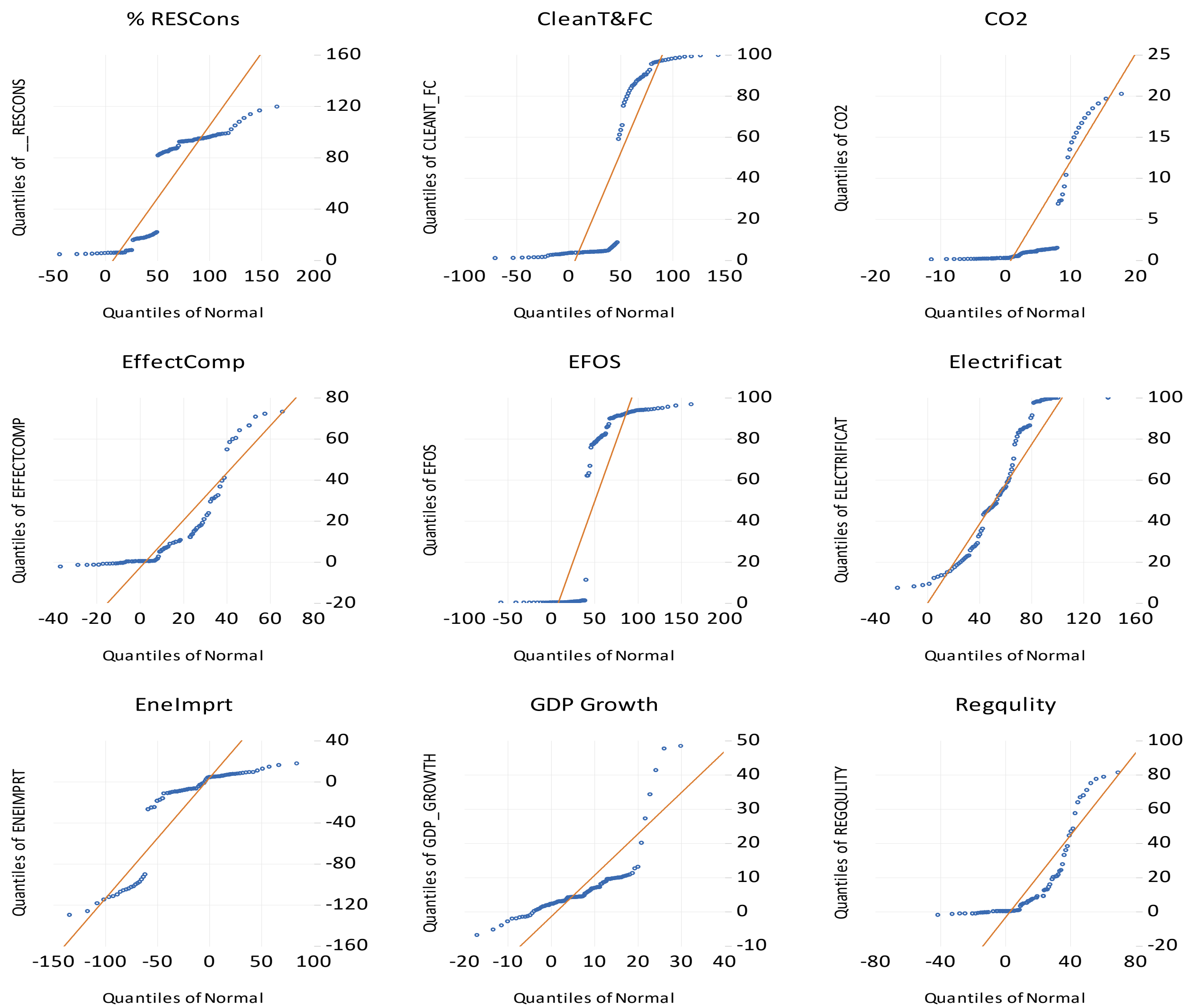

Figure. 4 Quantile Dispersion of the underlying variables

Figure.4 shows the quantile dispersion of the underlying variables. From the descriptive statistics, Electrification has the highest mean score, suggesting that most countries are fully electrified. EFOS has the second highest mean value, implying the countries generate a lot of their electricity from fossil fuel sources. Another striking mean value is ENEIMPRT, which is negative, showing that the countries are energy exporters.CO_2 has the least mean value, which is anticipated as the study countries don't emit so much CO_2, except South Africa. The correlation matrix explains the relationship between the variables, which has the highest correlational value and sees the variables' relationships. The interaction of CLEANT_FC and _RESCONS has the highest correlation among them. However, the relationship is a negative one of[-0.979], whichs indicates as one varibales increases the other variable decreases. That is followed by the interaction of ELECTRIFICAT and__RESCONS, which as the correlation value of [-0.933]. The correlation is a negative one as well. The variables that have the weakest correlation is the interaction of REGQULITY and ENEIMPRT,also has a negative correlation[-0.006]. Electrification has a strong correlation close to 1, which is preferable. Also, access to clean fuels and technologies has a strong correlation to the dependent Variable too. CO_2, as well as ENEIMPRT, has the least correlation values. The relationship, will give insight as to which Variable needs further investigation. Linear regression correlation does not necessarily have to have a high correlation; thus, these results show a high sense of reliability, making inferences from the table 10.

Table.10 Westerlund error correction

Variables	Statistics	Z-value	p-value
GDP vs. RER			
$G\tau$	−4.652	−6.582	0.000
$G\alpha$	−31.712	−6.466	0.000
ρ_τ	−12.828	−5.944	0.000
$\varphi_1\alpha$	−32.782	−8.332	0.000
GDP vs. NRER			
$G\tau$	−5.212	−6.764	0.000
$G\alpha$	−30.322	−5.852	0.000
ρ_τ	−09.564	−6.443	0.000
$\varphi_1\alpha$	−30.754	−5.773	0.000

The Westerlund error correction is shown in Table. 10. A range of 4.665 to -32.712 defines the GDP vs RER parameters. On the other hand, a range of -5.212 to −30.754 defines the GDP vs NRER values.

Table.11 OLS Estimators

τ	α_τ	ρ_τ	$\beta_{CO_2}(\tau)$	$\beta_{GDP}(\tau)$	$\beta_K(\tau)$	$\varphi_1(\tau)$	$\omega_0(\tau)$	$\lambda_0(\tau)$	$\lambda_1(\tau)$	$\omega_1(\tau)$
0.691***	−0.116***	−0.311	0	0.145**	0.492***	0.168**	−0.041	0.045	−0.395***	0.344***
-0.16	-0.02	-0.2	-0	-0.06	-0.1	-0.07	-0.03	-0.028	-0.08	-0.088

Results indicating the rejection of the null hypothesis. Whereas, the alternative hypothesis parameter for long-term quantile integration implies the rejection of βGDP in case of emerging African economies. A negative relationship between GDP growth and greenhouse gasses' emission is evident from the results shown in Table. 11 for the African countries under consideration.

5 Conclusion and Policy Implication

It analyzed these factors to see how they impact deploying renewables by employing panel data using the pooled ordinary least squared(OLS) at frim level analysis. After the analysis, we proved that access to clean fuels and technologies for cooking needs the study countries to deploy renewables as most Africans cook with polluting fuels having detrimental health implications. The analyses further revealed that these countries generate a chunk of their electricity from fossil fuel sources, making it imperative to jettison fossil fuels and embrace renewables cheaper and environmentally friendly. This study researched how to scale up renewables in Africa's five most populous countries 2001-2019 using the world bank development indicators (WDI) and the world bank governance indicators (WGI). The explanatory variables employed in the study are energy imports, CO_2, Quality of regulatory environment, access to electricity nationally, access to clean fuels and technologies for cooking, the effectiveness of compliance, GDP growth rate, and electricity generation from fossil fuel sources and renewable consumption of total energy consumption as the dependent Variable. Furthermore, the lack of electrification is important to developing renewal energy sources in the study countries while deploying renewables will bridge the access gap. Countries have the practical and theoretic potential for all the renewable energies required to guarantee sustainable consumption. The financial policy de-risking instruments to crowd in private capital since the renewables sector is perceived as a high-risk area.

The paper provides an empirical analysis of renewable energy deployment in the five populous countries with an econometric approach.We discovered that all the explanatory variables except EFFECTCOMP were significant in determining renewables' scaling up in Africa. Thus, if the study countries want to achieve universal access to electricity in their countries, renewables are the best bet. Electrification has a direct correlation to renewable energy generation in the analysis and also perfectly significant. For instance, the DRC has the least electrification rate among the “Big Five”; thus, renewables for that matter off-grid solutions will be the panacea to creating access in the DRC and Africa in generation.

Access to clean cooking fuels and technologies is equally significant but has an inverse relationship to the dependent Variable. Most people in the study countries except South Africa and Egypt cook with Biomass hurting their health and sometimes deadly. Thus renewables will be the solution here.

The analysis also confirmed that most of the study countries generate the bulk of their electricity from fossil fuels source, which is not sustainable. The correlation to the dependent Variable is negative, which is appropriate, implying fossil electricity generation increases, renewables consumption on the final consumption decreases. Given this, it is recommended that policies be formulated to speed up renewables deployment.

Furthermore, the Quality of the country's regulatory environment is very important in scaling renewables in Africa. The Variable is significant. The fact is, Africa cannot transition to renewables without the right policy mix.

Ethical Approval and Consent to Participate

The authors declare that they have no known competing financial interests or personal relationships that seem to affect the work reported in this article. We declare that we have no human participants, human data or human tissues.

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Competing interest statement

We declare that there is no conflict of interest

Availability of data and materials

The data that support the findings of this study are attached

Reference

AfDB. (2020). African Economic Outlook 2020 Amid O VID-19 SUPPLEMENT. https://www.afdb.org/sites/default/files/documents/publications/afdb20-04_aeo_supplement_full_report_for_web_0705.pdf#page=60

Akintande, O. J., Olubusoye, O. E., Adenikinju, A. F., & Olanrewaju, B. T. (2020). Modeling the determinants of renewable energy consumption: Evidence from the five most populous nations in Africa. Energy, 206, 117992. https://doi.org/10.1016/j.energy.2020.117992

Alemzero, D. A., Sun, H., Mohsin, M., Iqbal, N., & Nadeem, M. (2020). Assessing energy security in Africa based on multi-dimensional approach of principal composite analysis.

Aliyu, A. K., Modu, B., & Tan, C. W. (2018). A review of renewable energy development in Africa: A focus in South Africa, Egypt and Nigeria. Renewable and Sustainable Energy Reviews, 81(February 2016), 2502–2518. https://doi.org/10.1016/j.rser.2017.06.055

Bank African Development. (2019). African Economic Outlook 2019: Macroeconomic performance and prospects Jobs, growth, and firm dynamism Integration; Integration for Africa's economic prosperity.https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/2019AEO/AEO_2019-EN.pdf

Beyene, G. E., Kumie, A., Edwards, R., & Troncoso, K. (2018.). Opportunities for transition to clean household energy in Ethiopia.

Bohlmann, J. A., & Inglesi-lotz, R. (2018). Analysing the South African residential sector ' s energy pro fi le. Renewable and Sustainable Energy Reviews, 96(December 2017), 240–252. https://doi.org/10.1016/j.rser.2018.07.052

Bloomberg NEF, C. C. (2020). Sub-Saharan Africa Market Outlook 2020.Available at: http://global-climatescope.org/assets/data/docs/updates/2020-02-06-sub-saharan-africa-market-outlook-2020.pdf

Castellano, A., Kendall, A., Nikomarov, M., & Swemmer, T. (2015). Powering Africa. February.

Connecting the dots, why 2% of RE in Africa C. (2020). Available at: https://www.res4africa.org/2020/07/08/connecting-the-dots-why-only-2-of-global-re-in-africa/1.

da Silva, P. P., Cerqueira, P. A., & Ogbe, W. (2018). Determinants of renewable energy growth in Sub-Saharan Africa: Evidence from panel ARDL. Energy, 156, 45–54. https://doi.org/10.1016/j.energy.2018.05.068

Dagnachew, A. G., Hof, A. F., Lucas, P. L., & Vuuren, D. P. Van. (2019). Scenario analysis for promoting clean cooking in Sub-Saharan Africa : costs and benefits. Energy, 116641. https://doi.org/10.1016/j.energy.2019.116641

Dorothal, M. (2019). Ethiopia Solar Report. Solar Plaza International, July, 18. https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/White_Paper_-_Ethiopia_Solar_Report_2019.pdf

Edkins, M., Marquard, a., & Winkler, H. (2010). South Africa's renewable energy policy roadmaps. Energy, June, 1–28.

Egyptian Electricity Holding Company. (2018). Egyptian Electricity Holding Company Annual Report 2017/2018. Eehc, 1–85. https://doi.org/10.1017/CBO9781107415324.004

Elsayed, A. M., Mishref, M. M., & Farrag, S. M. (2018). Distribution system performance enhancement (Egyptian distribution system real case study). International Transactions on Electrical Energy Systems, 28(6), 1–24. https://doi.org/10.1002/etep.2545

Ethiopian. Governmnet. (2018.). Africa Energy Market Place (AEMP).Available at: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/AEMP/AEMP_Concept_Note_v.15.pdf

For, V., & Efficiencycompetitiveness, I. (n.d.). NCPC-SA : South Africa.Available at: http://ncpc.co.za/

García-Álvarez, M. T., Cabeza-García, L., & Soares, I. (2017). Analysis of the promotion of onshore wind energy in the EU: Feed-in tariff or renewable portfolio standard? Renewable Energy, 111, 256–264. https://doi.org/10.1016/j.renene.2017.03.067

Godinho, C., & Eberhard, A. (2019). Learning from Power Sector Reform : The Case of Kenya. World Bank Policy Research Working Paper, 8819.

Government of Nigerian. (2018.). Africa Energy Market Place (AEMP). Government of Nigeria (2018). Africa Energy Market Place (AEMP).Available at:l https://africa-energy-portal.org/country/Nigeria

Guta, D. D. (2020). Determinants of household use of energy-efficient and renewable energy technologies in rural Ethiopia. Technology in Society, 61, 101249. https://doi.org/10.1016/j.techsoc.2020.101249

Hamed, M. M., & El Mahgary, Y. (2004). Outline of a national strategy for cleaner production: The case of Egypt. Journal of Cleaner Production, 12(4), 327–336. https://doi.org/10.1016/S0959-6526(03)00037-4

Hepburn, C., O'Callaghan, B., Stern, N., Stiglitz, J., & Zenghelis, D. (2020). Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change? Oxford Review of Economic Policy, 36(Supplement_1), S359–S381. https://doi.org/10.1093/oxrep/graa015

Hossain, A., Getaneh, A., Gebrehiwot, K., & Ringler, C. (2014). Ethiopian Universal Electrification Development Strategies.

Hurlin, C., & Mignon, V. (2007). Second Generation Panel Unit Root Tests To cite this version : HAL Id : halshs-00159842 Second Generation Panel Unit Root Tests. 1–25. https://halshs.archives-ouvertes.fr/halshs-00159842

IEA. (2019). Africa Energy Outlook 2019 Africa Energy Outlook 2019.Available at https://www.iea.org/reports/africa-energy-outlook-2019

Increasing Access To Electricity in The Democratic Republic of

Congo.(2020.).Available:http://documents1.worldbank.org/curated/en/743721586836810203/pdf/Increasing-Access-to-Electricity-in-the-Democratic-Republic-of-Congo-Opportunities-and-Challenges.pdf

IRENA.(2019). Renewable Power Generation Costs in . Available at:https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019

IRENA. (2017). Renewable energy auctions. In Renewable Energy Auctions : Analysing 2016 (Vol. 1, Issue 14). https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Jun/IRENA_Renewable_Energy_Auctions_2017.pdf

IRENA. (2019). Scaling Up Renewable Energy Development in Africa: Impact of IRENA's Engagement. January, 1–4. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Africa_impact_2019.pdf?la=en&hash=6B16ABE754FF6F843601E1E362F5D6B730ADF7A2

Jewitt, S., Atagher, P., & Clifford, M. (2020). Energy Research & Social Science " We cannot stop cooking ": Stove stacking , seasonality and the risky practices of household cookstove transitions in Nigeria. Energy Research & Social Science, 61(May 2019), 101340. https://doi.org/10.1016/j.erss.2019.101340

Mentis, D., Hermann, S., Howells, M., Welsch, M., & Siyal, S. H. (2015). Assessing the technical wind energy potential in Africa a GIS-based approach. Renewable Energy, 83, 110–125. https://doi.org/10.1016/j.renene.2015.03.072

Mondal, M. A. H., Ringler, C., Al-Riffai, P., Eldidi, H., Breisinger, C., & Wiebelt, M. (2019). Long-term optimization of Egypt's power sector: Policy implications. Energy, 166, 1063–1073. https://doi.org/10.1016/j.energy.2018.10.158

Narula, K. (2019). Energy security and sustainability. Lecture Notes in Energy, 68(October 2018), 3–22. https://doi.org/10.1007/978-981-13-1589-3_1

Nassar, I. A., & Abdella, M. M. (2019). Effects of Increasing Wind and Solar Power Energy on the Voltage Stability and Losses of the Egyptian Power System. 2018 20th International Middle East Power Systems Conference, MEPCON 2018 - Proceedings, 887–893. https://doi.org/10.1109/MEPCON.2018.8635114

Olanrewaju, B. T., Olubusoye, O. E., Adenikinju, A., & Akintande, O. J. (2019). A panel data analysis of renewable energy consumption in Africa. Renewable Energy, 140, 668–679. https://doi.org/10.1016/j.renene.2019.02.061

Roche, M., Ude, N., & Donald-Ofoegbu, I. (2017). True Cost of Electricity: Comparison of Costs of Electricity Generation in Nigeria. Nigerian Economic Summit Group and Heinrich Böll Stiftung Nigeria, June, 1–34. https://ng.boell.org/sites/default/files/true_cost_of_power_technical_report_final.pdf

REN21, R. E. N. (2020). Renewables 2020 global status report 2020.Available at:

https://www.ren21.net/gsr-2020/

RES4(2020) SCALING Up renewable Africa's Power. The need for de-risking investments and the case for renewafricAhttps://culture.go.th/mculture_th/download/king9/Glossary_about_HM_King_Bhumibol_Adulyadej’s_Funeral.pdf

Sakr, D., & Abo Sena, A. (2017). Cleaner production status in the Middle East and North Africa region with special focus on Egypt. Journal of Cleaner Production, 141, 1074–1086. https://doi.org/10.1016/j.jclepro.2016.09.160

SEforALL Sustainable Energy for All. (2020). The recover better with sustainable energy guide for african countries. United Nations Publications, 53(9), 21. https://doi.org/10.1017/CBO9781107415324.004

Selvakkumaran, S., & Silveira, S. (2018). Exploring synergies between the intended nationally determined contributions and electrification goals of Ethiopia , Kenya and the Democratic Republic of Congo (DRC). Climate and Development, 0(0), 1–17. https://doi.org/10.1080/17565529.2018.1442800

Smillie, I. (2013). The world bank. Stakeholders: Government-NGO Partnerships for International Development, 278–287. https://doi.org/10.4324/9781315071299-37

Sun, H., Khan, A. R., Bashir, A., Alemzero, D. A., Abbas, Q., & Abudu, H. (2020). Energy insecurity, pollution mitigation, and renewable energy integration: prospective of wind energy in Ghana. Environmental Science and Pollution Research, 27(30), 38259–38275.

Ugwoke, B., Gershon, O., Becchio, C., Corgnati, S. P., & Leone, P. (2020). A review of Nigerian energy access studies: The story told so far. Renewable and Sustainable Energy Reviews, 120(June 2019), 109646. https://doi.org/10.1016/j.rser.2019.109646

Uken, E. (2006). The electricity supply industry in the Democratic Republic of the Congo. 17(3), 21–28.Available at: http://www.erc.uct.ac.za/sites/default/files/image_tool/images/119/jesa/17-3jesa-lukamba.pdf

US EIA. (2018). Country Analysis Brief: Egypt. Country Analysis Brief: Iran, 18, 1–7. https://www.eia.gov/beta/international/analysis_includes/countries_long/United_Arab_Emirates/uae.pdf

Wall, R. F. (1960). An Atlas of Africa. In International Affairs (Vol. 36, Issue 3). https://doi.org/10.2307/2610110

World Bank G. (2020.) Cooking with electrcity avaialble at: https://openknowledge.worldbank.org/handle/10986/34566

World Bank, G. (2011). Linking Up : Public-Private Partnerships in Power Transmission in Africa Linking Up : Public-Private Partnerships in Power Transmission in Africa.Available at:

https://openknowledge.worldbank.org/bitstream/handle/10986/32335/9781464814426.pdf?sequence=10&isAllowed=y

Figures

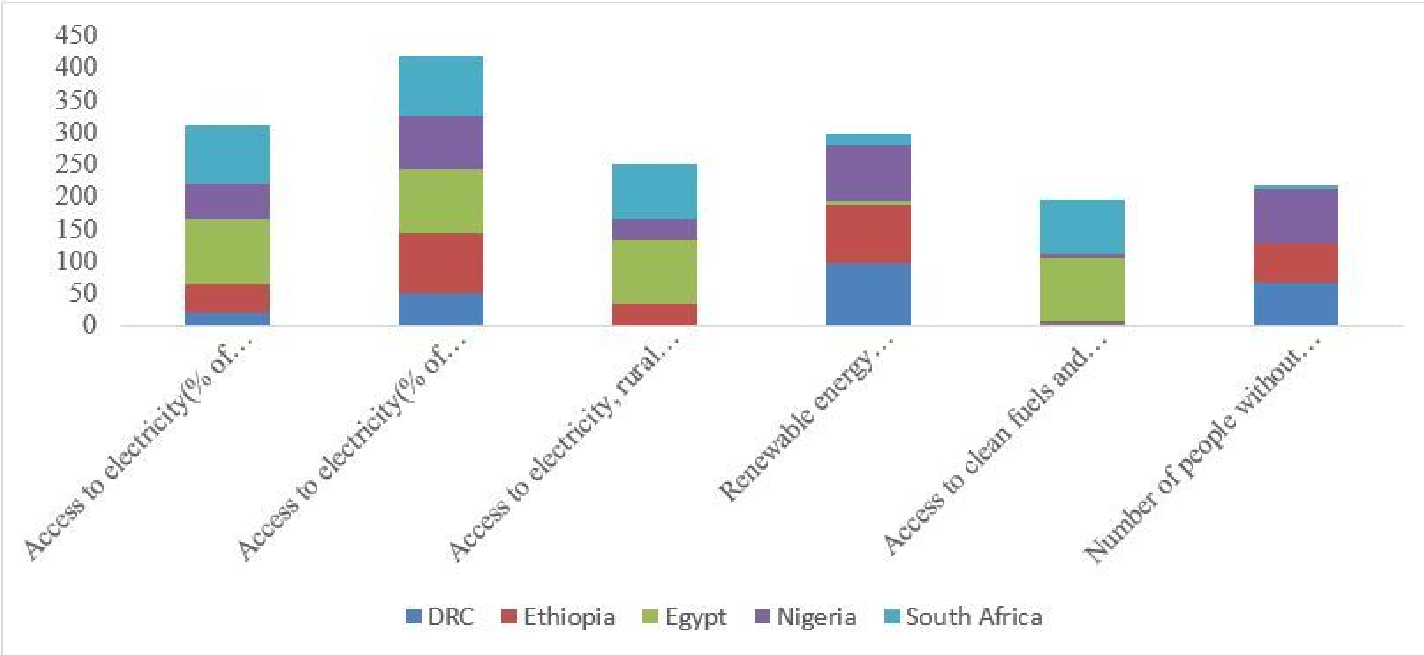

Figure 1

Electricity access map in Africa

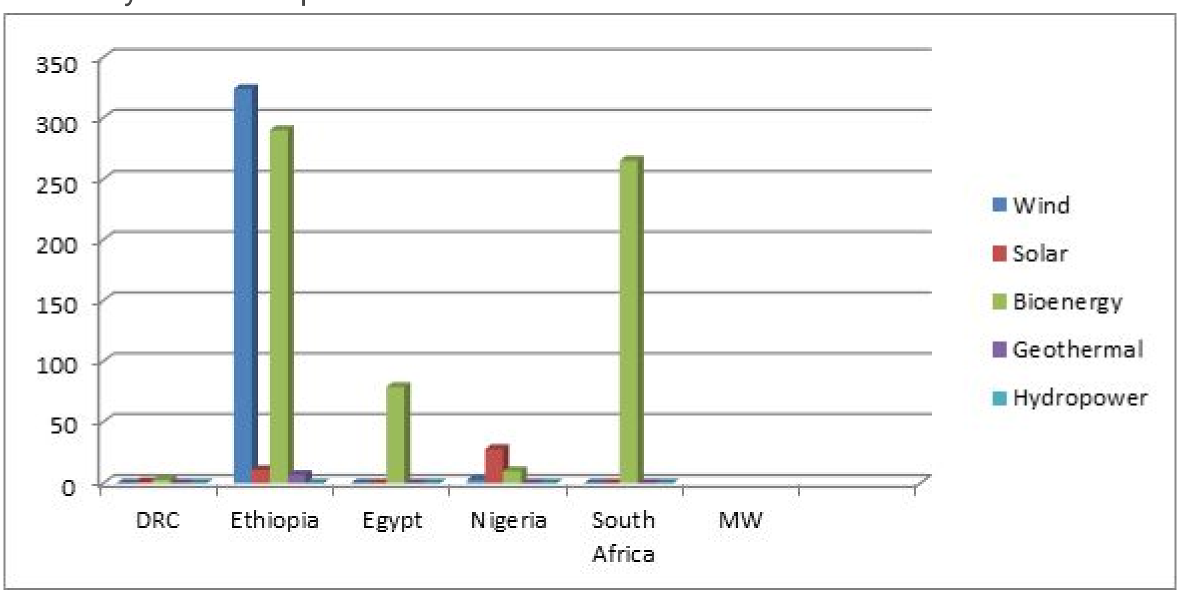

Figure 2

Electricity access map in Africa

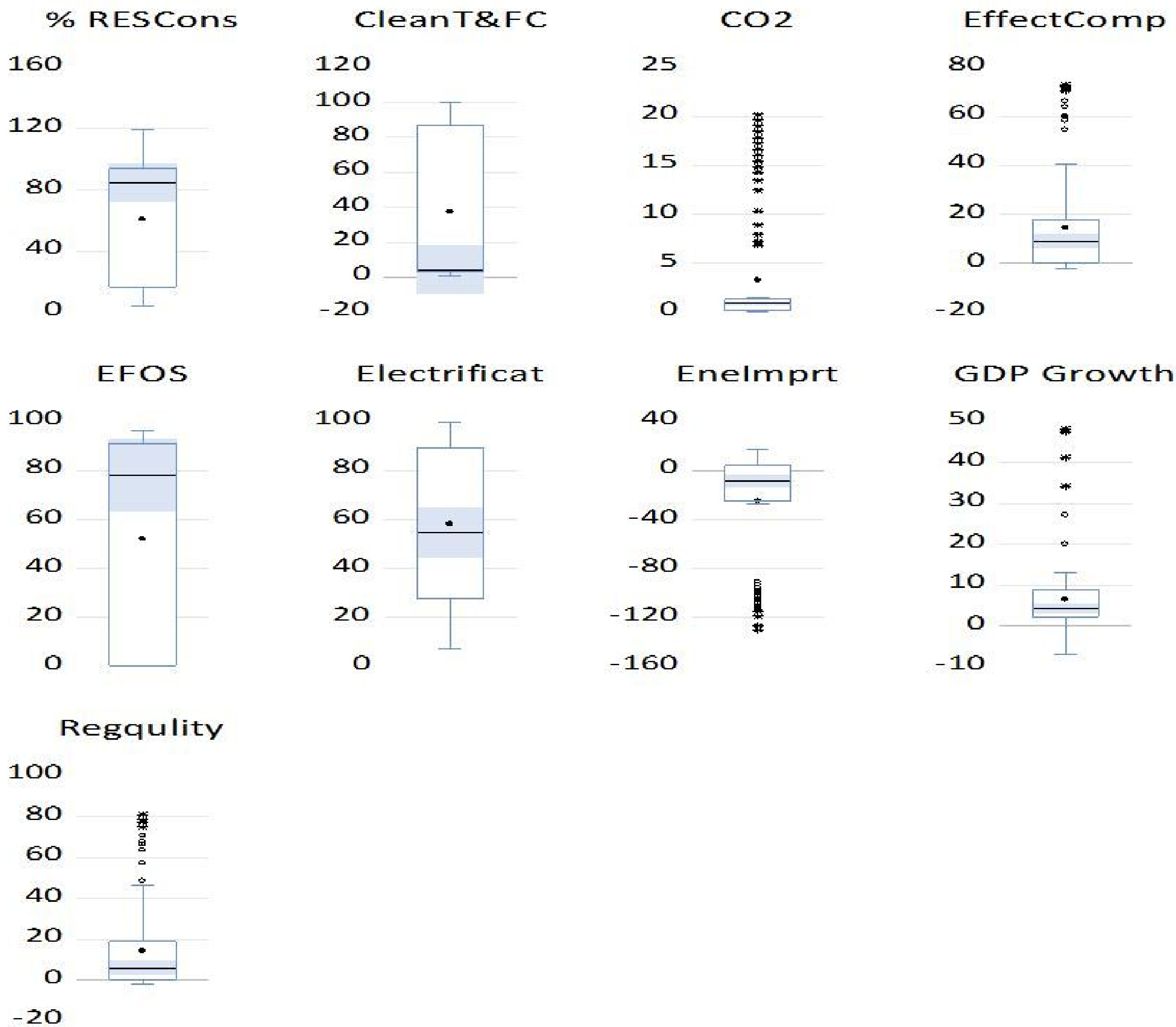

Figure 3

Boxpot of the underlying variables

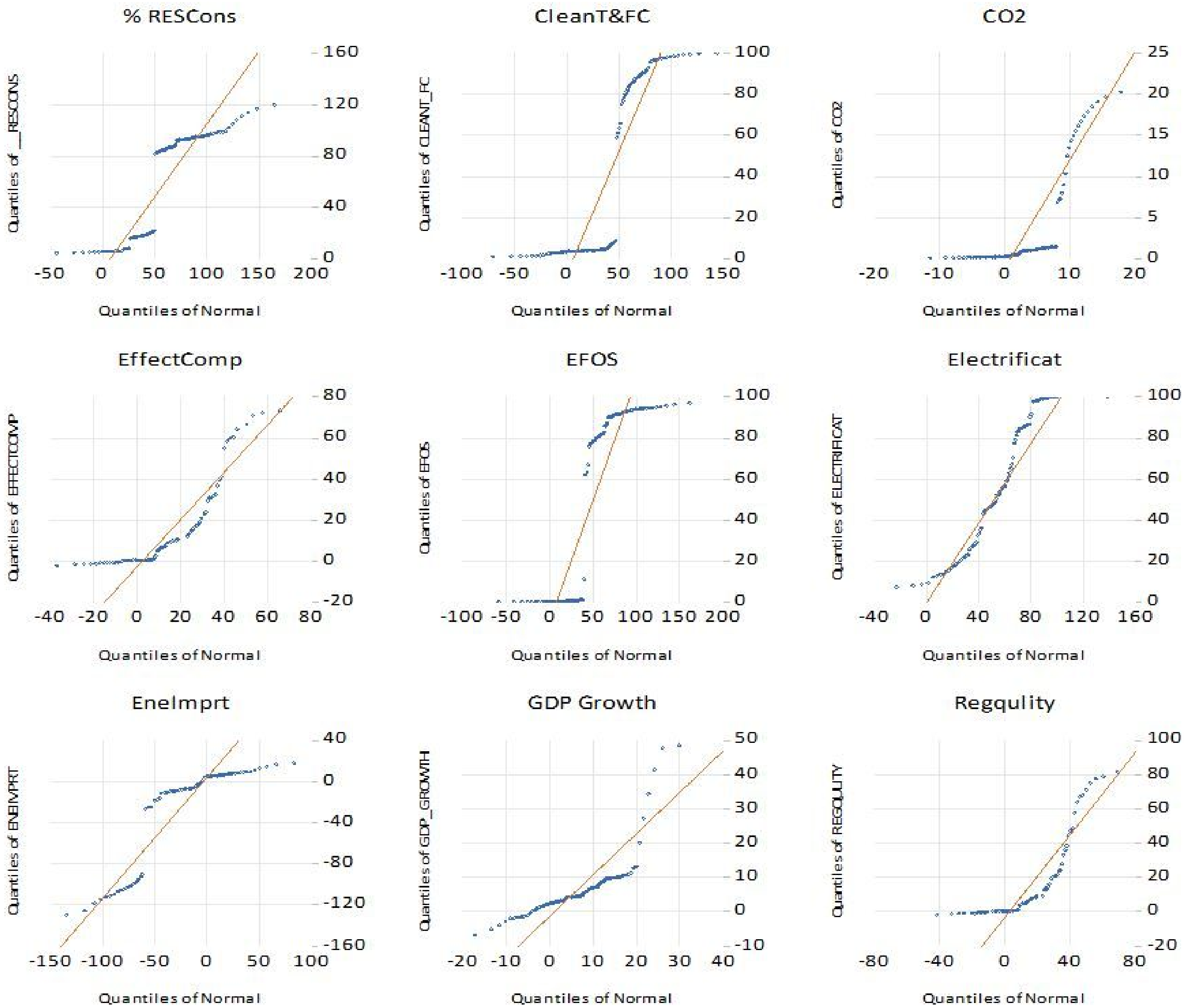

Figure 4

Quantile Dispersion of the underlying variables