

# Impact of Renewable Energy Use on Development in Sub- Saharan Africa

Kawthar Elhamdaoui

Dissertation written under the supervision of  
M. Waldemar Karpa

Dissertation submitted in partial fulfillment of requirements for the MSc in Strategy & Consulting, at Universidade Católica Portuguesa and for the MSc in Strategy & Innovation Management at Kozminski University, 2023.

## Abstract

The population of Sub-Saharan Africa will double by 2050. This population already has limitations when it comes to energy access and electrification, but with this growth, we are looking at 16% of the world's population entitled to only 3.3% of the global primary energy available.

The targeted electrification is not only essential but crucial to help build and improve lives within the continent. Whether it is health, education, or even the economy, access to energy is a must. Affordable and clean energy: UN's seventh Sustainable Development Goal ensures that by 2030, universal access to affordable, reliable, and modern energy services will be achieved through the expansion and upgrade of infrastructures better to serve modern and clean energy for all developing countries.

This study's major goal is to determine whether employing sustainable energy sources may aid Sub-Saharan African countries in achieving their development and growth objectives. Access to electricity is crucial to sustaining the requirements of connectivity and belonging that today's African youth have for the global community. Furthermore, in nations where traditionally the usage of renewable energy sources is not always accessible, electrification is paving the door for better education and employment prospects.

**Author of the dissertation:** Kawthar Elhamdaoui

**Title of the dissertation:** Impact of Renewable Energy Use on Development in Sub Saharan Africa.

**Keywords:** Renewable energy, Sustainable development, Climate change, Energy access, Sub-Saharan Africa

## Resumo

Até 2050, é esperado que a população da África subsaariana deva dobrar de tamanho. Esta população já tem limitações no acesso à energia e eletrificação, mas com este crescimento, estamos perante 16% da população mundial com direito a apenas 3,3% da energia primária global disponível.

A eletrificação visada não é apenas essencial, mas crucial para ajudar a construir e melhorar a vida no continente. Seja para a saúde, educação ou mesmo economia, o acesso à energia é fundamental. O sétimo Objetivo de Desenvolvimento Sustentável: energia acessível e limpa garante que, até 2030, o acesso universal a serviços de energia modernos, confiáveis e acessíveis seja alcançado por meio da expansão e atualização de infraestruturas para melhor servir energia moderna e limpa para todos os países em desenvolvimento.

O principal objetivo deste estudo é determinar se o emprego de fontes de energia sustentáveis pode ajudar os países da África Subsaariana a alcançar seus objetivos de desenvolvimento e crescimento. O acesso à eletricidade é crucial para sustentar os requisitos de conectividade e pertencimento que a juventude africana de hoje tem para a comunidade global. Além disso, em países onde tradicionalmente o uso de fontes de energia renováveis nem sempre é acessível, a eletrificação está abrindo as portas para melhores perspectivas de educação e emprego.

**Autor da dissertação:** Kawthar Elhamdaoui

**Título da dissertação:** Impacto do Uso de Energias Renováveis no Desenvolvimento da África Subsaariana.

**Palavras-chave:** Energia renovável, Desenvolvimento sustentável, Mudanças climáticas, Acesso à energia, África Subsaariana

# Table of Content

<b>ABSTRACT .....</b>	<b>1</b>
<b>RESUMO .....</b>	<b>2</b>
<b>TABLE OF CONTENT .....</b>	<b>3</b>
<b>LIST OF ABBREVIATIONS AND ACRONYMS.....</b>	<b>5</b>
<b>1. INTRODUCTION .....</b>	<b>6</b>
1.1. WHY DISCUSS THIS TOPIC? .....	7
1.2. HOW TO DISCUSS IT?.....	7
<b>2. LITERATURE REVIEW .....</b>	<b>9</b>
2.1. DEFINING SUSTAINABILITY .....	9
2.1.1. Sustainable Development Goal 7.....	9
2.2. DEFINING SUSTAINABLE ENERGY .....	11
2.3. DEFINING ENERGY POVERTY .....	12
2.3.1. Calculating energy poverty.....	14
2.4. INITIATIVES FOR SUSTAINABLE ENERGIES IN AFRICA .....	15
2.4.1. International initiatives .....	16
2.4.2. African local initiatives .....	19
2.5. DEFINING THE GROWTH NEEDS.....	21
2.5.1. Solutions « off-grid ».....	21
2.6. SUSTAINABLE ENERGY IN SUB-SAHARAN AFRICA.....	23
2.6.1. Types of available renewable energies: .....	23
2.6.2. Present challenges.....	25
2.6.3. Future opportunities.....	28
2.7. LIMITATIONS TO RENEWABLE ENERGY DEVELOPMENT IN SSA .....	31
2.7.1. Technical and human skill limitations.....	31
2.7.2. Financial and economic limitations .....	32
2.7.3. Political limitations.....	33
2.7.4. Socio-cultural and educational limitations.....	35
2.8. SUSTAINABLE ENERGY AND DEVELOPMENT INDICATORS IN SSA:.....	35
2.8.1. Research gap.....	37
<b>3. METHODOLOGY .....</b>	<b>39</b>
3.1. RESEARCH QUESTION.....	39
3.2. METHODOLOGY APPROACH .....	40
3.2.1. Quantitative study.....	40
3.2.2. Interview.....	41
3.3. RESEARCH DESIGN.....	42
3.3.1. Country scope.....	42
3.3.2. ENGIE Presentation: .....	45
3.4. DATA COLLECTION & ANALYSIS.....	47
3.4.1. Quantitative study.....	47
3.4.2. Qualitative study.....	48
3.5. LIMITATION AND CONCERNS .....	49
3.6. RESULTS .....	50
3.6.1. Quantitative study takeaways.....	50
3.6.2. Interview takeaways.....	52

3.6.2. Discussion.....	54
<b>4. CONCLUSION.....</b>	<b>58</b>
<b>BIBLIOGRAPHY .....</b>	<b>61</b>
<b>LIST OF FIGURES .....</b>	<b>68</b>
<b>LIST OF TABLE .....</b>	<b>68</b>
<b>APPENDIX.....</b>	<b>69</b>
<i>Interview transcript.....</i>	<i>69</i>
<i>Data Input.....</i>	<i>71</i>

## List of Abbreviations and Acronyms

AELG: African Energy Leaders Group

AfDB: African Development Bank

AFREC: African Energy Commission

AIRE: African Initiative for Renewable Energies.

ARDL: Autoregressive distributed lag

BU: Business Unit

EP: Energy Poverty

ESMAP: Energy Sector Management Assistance Program

FTC: Federal Trade Commission

GDP: Gross Domestic Product

GGDP: Green GDP

GHG: Greenhouse Gas

HDI: Human development index

IEA: International Energy Agency

IPP: Independent Power Producers.

IRENA: International Renewable Energy Agency

ISA: International Solar Alliance

Mtoe: Metric tons of oil equivalent

PV: Photovoltaic

SA: South Africa

SDG: Sustainable development goals

SHS: Solar Home System

SSA: Sub-Saharan Africa

TFEC: Total Final Energy Consumption

UN: United Nations

WEO: World Energy Outlook

WTER: Waste-To-Energy Routes

## 1. Introduction

Africa, the continent with the fastest population growth in the world. We expect that over half the global population growth up to 2050 will occur in the dark continent. More specifically, the population of sub-Saharan Africa is predicted to double by that same year.<sup>1</sup>

However, this continent has the world's lowest energy consumption per capita, this is 16 percent of the world's population (around 1.18 billion) entitled to only 3.3 percent of the global primary energy (UN, 2017).

This population will be eligible to access electrification by 2030, this is a market potential of \$64 billion for distributed energy and another \$98 billion for grid infrastructure. With that being said, to reach universal electricity access announced by the United Nations by 2030, an additional \$191 billions of investment is required. (Bloomberg New Energy Finance, 2018).

Attaining energy security goes along with maintaining a stable rate of economic growth. This is done by ensuring fair access to energy resources, but on a global scale, it can be rather a major challenge (Le and Nguyen, 2019). Due to the fact that nowadays, energy resources are comparable to production factors like labor and capital (Murshed, 2021). Additionally, a number of studies have noted that energy is crucial for promoting industrialization (Tvaronavičienė et al., 2015), creating jobs, and supporting a range of other economic activities. Because energy is crucial to the creation of practically all commodities and services, the World Economic Forum has declared energy to be the lifeblood of the global economy (Murshed et al., 2022).

In this context, we must specify that, according to the International Renewable Energy Agency's analysis, Africa got 2% of the global investments in renewable energy over the past two decades, and even more of these said investments were handed to a limited number of countries, despite the enormous need and potential this region has. The world won't be able to fulfill its global commitments to sustainable development and climate preservation without substantially ramping up investments in the energy transition.<sup>2</sup>

---

<sup>1</sup><https://www.un.org/en/global-issues/population#:~:text=More%20than%20half%20of%20global,projected%20to%20double%20by%202050> (10.04.2023)

<sup>2</sup> [www.weforum.org/agenda/2022/09/renewables-energy-transition-africa-jobs/](https://www.weforum.org/agenda/2022/09/renewables-energy-transition-africa-jobs/) (15.04.2023)

## 1.1. Why discuss this topic?

When it comes to energy resources, Africa is prosperous. Paired with poor infrastructure, at times even inexistent, many African countries face power shortages and unavailability that can put at risk the well-being of the population. Power is not only inaccessible but can, at times become unaffordable and unreliable for most of the Sub-Saharan people, causing poverty, thus the creation of the term ‘Energy Poverty.’ There are solutions, however, to facilitate energy access starting with investment in energy infrastructure which goes hand in hand with boosting the performance of existing utility companies, improving cross-border power trade, and lastly and most importantly, helping countries chart low-carbon growth paths(UN, 2017).

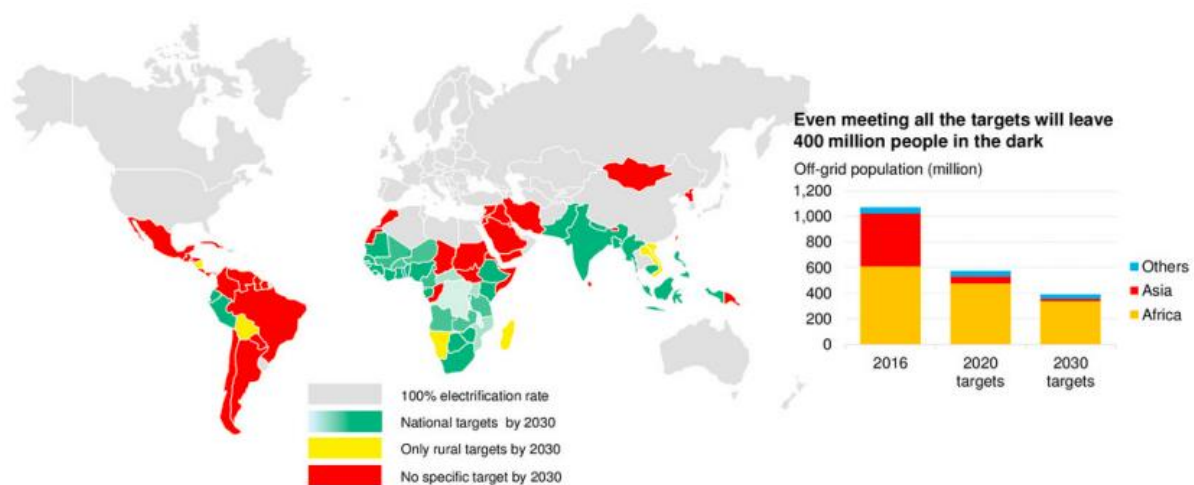


Figure 1: National target for electrification (Bloomberg New Energy Finance, 2018)

## 1.2. How to discuss it?

Therefore, I am glad to be working on this research paper, in which we will try to understand how the use of renewable resources in the energy mix positively impacts the development, growth, and overall economic health of a country.

First, the literature review starts by explaining the different terminologies from sustainability to energy poverty and some concepts about renewable energies for a better understanding of the research. This part will also discuss the correlation between the different aspects of development and energy, while highlighting the different limitations of renewable energy access in SSA. Plus, the current state of the legal and regulatory environment regarding Sustainable Development Goal number seven: affordable and clean energy in SSA.

Finally, the third section showcases the research findings on energy use and resources and their impact on development and economic growth. After describing the current status of the limited

power access and energy mix. This will be made through two main analysis, quantitative and qualitative.

A data analysis using Panel regression technique to understand the correlation of the different variable related to development and renewable energy. Followed by an Interview with 'ENGIE' French renewable energy company, present on the African continent.

## 2. Literature Review

### 2.1. Defining Sustainability

The definitions of both sustainability and sustainable development are not only often linked to one another but can even serve as synonyms (Olawumi and Chan, 2018; Sartori et al., 2014).

On a pure vocabulary level, sustainability implies the fact that an activity or an action is able to sustain itself (indefinitely) (Santillo, 2007).

For a background history of the terminology, we must look back at the US Federal Trade Commission (FTC) “Green Guides,” which exists to avoid making deceptive marketing claims and include the mention of “sustainable.” Used mainly, as there is no clear understanding of the word due to the lacking of a valid measurable definition (Morelli, 2011).

Rio de Janeiro Earth Summit 1992, sustainability started getting incorporated in international treaties, served a large proportion of the world's environmental-defense political slogans (Mebratu, 1998), and popped up within the constitution of many countries (Luke, 2005; Redclift, 2005). From then on it was linked to business (Amran et al., 2015; Dangelico and Pontrandolfo, 2015) agricultural production (Gouda et al., 2018; Lathuilière et al., 2018), industry (Lambert and Boons, 2002; Mayyas et al., 2012), urban development (Ahern, 2013; Shcherbina et al., 2017) and founded theoretical approaches like green economy (Bina, 2013; Wanner, 2015) or circular economy (Schroeder et al., 2019; Suárez-Eiroa et al., 2019).

Today, Sustainability is regarded as one of the most overused terms in the corporate vernacular. More of a corporate buzzword, it has been applied so commonly to simply become “a synonym for everything that is positive,”(Morelli, 2011).

#### 2.1.1. Sustainable Development Goal 7

In the light of the environmental and human crisis that the world is facing more frequently it has become clear that the ongoing approach to energy is qualified as unsustainable and inequitable hence the decision to include sustainable energy goals for the 2030 UN agenda.

tough, SDG7 has limitations due to the lack of clear metrical definition of ‘access to’, ‘modern’ or ‘sustainable’ energy (Bruce and Stephenson, 2016).



Figure 2: Primary indicators of global progress toward the SDG 7 targets (IEA et al., 2022)

As seen above the SDG7 has been represented into many different goals to facilitate traceability and measuring. Still the target 7.2 related to renewable energy is unclear and lacks ambition. While calling to increase the share of renewable energy in the global mix, it failed to define ‘substantially’, also, does not take into consideration the efforts that made to impact the global energy mix shares. The target aimed falls behind the needed and necessary adjustments to address the social, economic, and environmental challenges in the most vulnerable countries. (IRENA, 2014)

This target also makes no mention of how the 'sustainable increase' should occur or what factors should be taken into account when nations adopt renewable energy policies or support developments to achieve SDG7.(Villavicencio Calzadilla and Mauger, 2018)

## 2.2. Defining Sustainable Energy

We must distinguish between renewable energy and sustainable energy as both are not always synonyms.

Renewable energy refers to energy sources ( solar, wind, hydro, tidal, geothermal, and biomass) that are naturally able to restore to allow their use multiple times to generate power (Lebbihiat et al., 2021).

While sustainable energy resources are to be utilized to meet current energy needs (for each individual household) without jeopardizing the need for future energy resources (Kreith and Krumdieck, 2013). Energy sustainability places a focus on maintaining the supply of modern and cleaner energy options since using traditional unclean forms of energy is linked to negative environmental impacts (Grigoroudis et al., 2021; Murshed et al., 2022). Accordingly, energy sustainability is crucial when addressing challenges related to climate change (Pliousis et al., 2019).

With this in mind, we understand that renewable energy sources are not strictly sustainable. For example, Biomass is renewable due to its organic occurrence in plants and animals, it can be burned and used for heating or as a substitute for fuel. While this resource is renewable, it is strictly not sustainable nor clean as it emits greenhouse gasses novice to the environment (Murshed et al., 2022)

Climate change and energy source shortages are predominant challenges of our current world. With limited fuel reserves, growing CO2 emissions, and exponential growth of population, research for a new source of energy is highly important.

The switch to a sustainable renewable resource is encouraged especially in developing countries needing to reduce conflicts, pollution, and energy-related illnesses and deaths (Kothari et al., 2010).

In the literature, the lines are usually blurred between renewable and environmentally friendly energy, especially compared to conventional fossil fuels (Awan et al., 2022).

Considering these numbers moving from nonrenewable to fully renewable energy is not instantaneous and needs time and investments. This is where energy efficiency comes in, as it helps to balance the energy demand while providing time for technological development, relevant to enable renewable energy transition (Al-tal et al., 2021).

In the same spirit, the seventh Sustainable Development Goal (SDG7) of the United Nations has also emphasized the significance of a sustainable supply of accessible, clean, and renewable energy sources around the world (Al-tal et al., 2021).

More recently we even speak of 7.2 goal, which is a sub-category of SDG7. The aim here is to boost the use of sustainable energy in the total energy mix by 2030.<sup>3</sup>

SA nations are widely famous for relying on low-efficiency fuels which makes energy efficiency hardly applicable (IEA, 2019).

In this region, we face the highest energy inefficiency levels worldwide (Kohler, 2014), characterized by losses during transmission and distribution. In 2016, these losses summed up to 23% of the total energy transfer, better describing the inefficiency (Trimble et al., 2016).

This poor performance with energy efficiency is translated to SA not attaining sustainability-related targets under SDG7 (Murshed et al., 2022).

To look at more updated data, in 2019 we note a modest pace of growth points through energy efficiency. Trends differ across utility goals, as the largest increase was for the generation of electricity, while transportation and heating have seen much slower progress.

Including biomass, in 2019, the global weight of renewable energy sources in total final energy mix, was 17.7 percent, just 0.4 percentage points higher than the year before.

Although between 2010 and 2019 we could see an acceleration of consumption in renewable energy (excluding biomass), in 2019 the growth hit only 2,7 percentage points and represented only 11.5 percent of TFEC (IEA et al., 2022).

### 2.3. Defining Energy Poverty

The definition of Energy poverty varies depending on the different policy implications.

According to the European Commission, it refers to when a household's basic needs of energy are not met. This will include cooking, lighting, heating, or cooling. We say that a household suffers from energy poverty if the energy bills are taking most of its income, in this case forcing

---

<sup>3</sup> [www.indicators.report/targets/7-2/](http://www.indicators.report/targets/7-2/) (20.04.2023)

the residents to reduce their energy consumption and thus negatively impacting their well-being.<sup>4</sup>

In other words, lack of energy access is what we call energy poverty. However, much attention has not been paid to the challenge of energy poverty of the world's poorest people (Birol, 2007).

*Table 1: The state of electrification in Africa 2013 (UN, 2017)*

Region	Population without access to electricity (Millions)	Electrification rate (percentage)	Urban electrification rate (percentage)	Rural electrification rate (percentage)
World	1,201	83	95	70
Africa	635	43	68	25
North Africa	1	99	100	99
Sub-Saharan Africa	634	32	59	17

As seen in the table above from the (IEA, 2015) publication, in 2013 it is 1,2 billion people lacking access to electricity, of which half are in Africa alone more specifically in sub-Saharan Africa.

Energy poverty and economical poverty are linked but not always positively correlated. In Africa, energy poverty is consistent despite the high revenue of the households.

Seen by households, energy poverty can be defined by understanding the levels of energy demand compared to the total and end-use energy. This definition takes into consideration energy prices and conditions both impacted by the different policies (Ashigho, 2016).

For Barnes et al. (2011) energy poverty is the point where to sustain life, people use the minimum energy (regardless of the source). Above this point, energy helps welfare and increases economic well-being (as electricity, power, and other energy sources become available). Below this point, people are not sustaining their normal lives as energy resources are rare.

Energy poverty can also be linked to the ability to take part in customs, traditions, and rituals that validate the sense of belonging to a community. In this case, the poverty line would be the domestic energy level allowing this integration and expression of membership to society (Bouzarovski, 2014).

---

<sup>4</sup>[www.energy.ec.europa.eu/topics/markets-and-consumers/energy-consumer-rights/energy-poverty-eu\\_en#:~:text=in%20the%20EU-,Energy%20poverty%20in%20the%20EU,Related%20links](http://www.energy.ec.europa.eu/topics/markets-and-consumers/energy-consumer-rights/energy-poverty-eu_en#:~:text=in%20the%20EU-,Energy%20poverty%20in%20the%20EU,Related%20links) (20.04.2023)

From the perspective of final energy users, (Wang et al., 2015), energy poverty is not only limited to access to power but also depends on its quality (stable, reliable, and adequate ...). Meaning that beyond energy consumption we must be aware of how this energy performs to insure the basic human needs including but not limited to heating, cooking, and lighting....

In the same light, (Bazilian et al., 2014) identify energy access, broader than just physical accessibility but along with affordability in terms of pricing and reliability in terms of usage. From these different definitions, we can understand that EP is linked to both: the lack of physical opportunity to connect or acquire energy, and the inability of consuming modern forms of energy regardless of the reason (Siksnyte-Butkiene et al., 2021).

Statistically, 4 hours per day access to energy is the line defining poverty, this variable does not take into consideration again the quality, stability, and reliability of the energy (Fischetti, 2022).

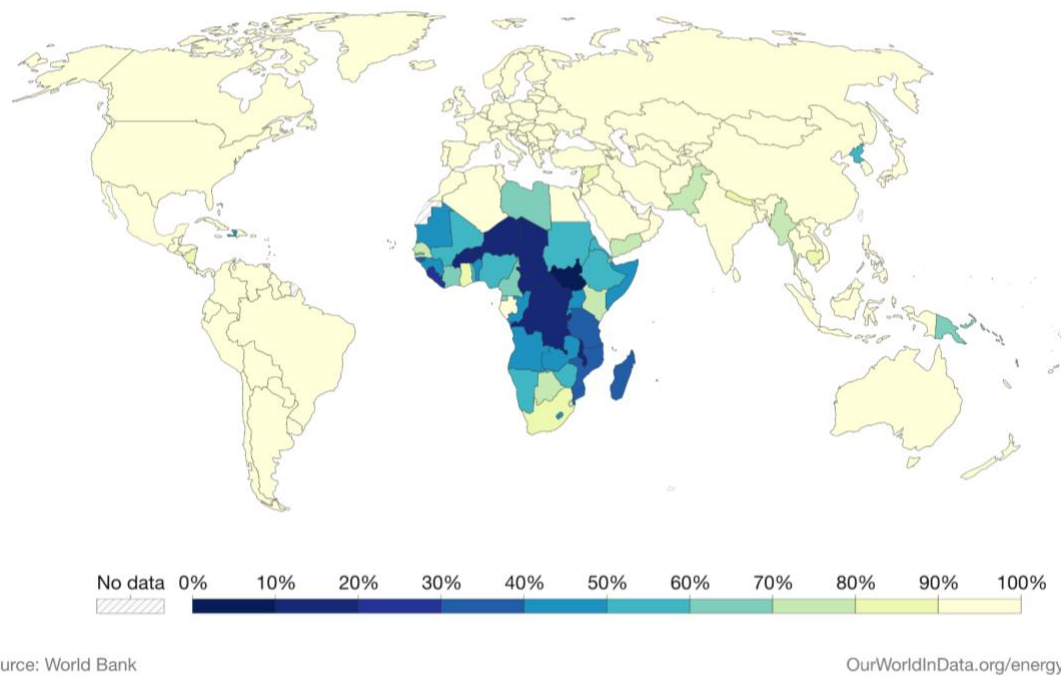


Figure 3: Population with access to electricity 2020.

### 2.3.1. Calculating energy poverty

As we understand from the previous readings, EP does not follow a single definition, and therefore to calculate it we will need to integrate different variables. Overall these can be

captured into two main categories: high share of household income spent on energy, and incapacity to consume modern energy regardless of the reason (Streimikiene et al., 2020).

For (Hernández, 2015) there is an important mention of rights and ‘energy justice’. In his paper, he included four needed rights that can be fulfilled with access to energy: The right to uninterrupted, stable, and reliable energy service, the right to harmless and green energy, the right to available energy, and lastly the right to reliable infrastructure. Also looking to (Fortier et al., 2019) energy justice is defined as the supply of secure, accessible, and sustainable energy for everyone.

Following this logic it is not enough to have energy from a sustainable source, the entire production and consumption line should be compatible with the principles of sustainability (Ibrahiem and Hanafy, 2020; Iqbal et al., 2019; Siksnylyte-Butkiene et al., 2021).

Classically, EP was mostly based on the economic aspects, and most metrics selected took into consideration this perspective. On a more modern take on EP, that, the UN (Goldemberg, 2001) defines as the inability to obtain a materially necessary level of high-quality and reliable energy that is affordable, safe, and environmentally friendly. a new approach was created integrating social and environmental elements.

This multifaceted measure of energy poverty also takes pricing and accessibility into account. Although accessibility has been the main issue in underdeveloped nations, measurement has mostly concentrated on access to modern energy services.

A multidimensional energy poverty measure needs to be defined and the fundamental needs of households must be estimated to include affordability. especially in highlighting the disparity between urban and rural areas in terms of accessibility and cost of modern energy services.

#### 2.4. Initiatives for Sustainable Energies in Africa

With a big potential in solar energy and a need for investment and development, the governments alone are not able to sustain the needs of the growing population.

So how can we provide the countries with sustainable energy?

Although state-triggered initiatives are multiplying over time, they are still not enough to provide the ‘Last mile’ with electricity, whether it is geographical and technical limitations or a lack of valuable infrastructure and skilled workers. Hence the importance of the efforts of

NGOs and the private sector in Africa or outside the continent to ensure sustainable development deployment across the countries.

We will discuss the different initiatives locally and internationally, responsible for providing support and grants to push the development agenda in Africa.

These organizations would usually make a call for tenders to which private institutions would reply. Currently, with the unclarity around the political and legal framework regarding grid installations, the mini-grid deployment has a tougher time being installed.

However, when it comes to ready-home Kits these are much easily integrated as the government doesn't see them as a concurrence for the national grid.

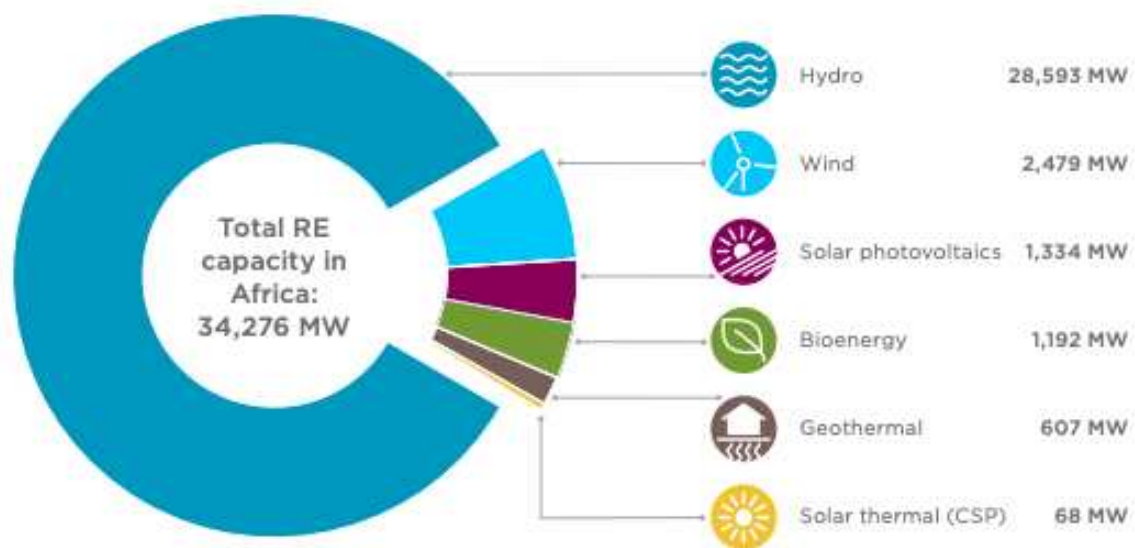


Figure 4: Renewable Energy Capacity In Africa (2014)(Quitow et al., 2016)

## 2.4.1. International initiatives

### 2.4.1.1. Les initiatives de la COP 21

COP 21 saw the beginning of various projects in support of sustainable energies to improve access to power in Africa, in compliance with the Paris Climate Agreement of 2015.

### **GOGLA**

The global off-grid solar industry association founded in 2012 as a neutral, independent, not-for-profit industry association, it represents more than 170 members.<sup>5</sup> It aims to support its members in creating sustainable markets that will reach as many households, companies, and communities as possible in the developing world with high-quality, reasonably priced goods

<sup>5</sup> [www.gogla.org/about-us](http://www.gogla.org/about-us) (25.04.2023)

and services. GOGLA works on enhancing health and education, producing employment possibilities, and increasing income.

### **International Solar Alliance**

the most significant initiative in support of solar power. Founded at France and India's initiative, it currently has 47 members, over fifty percent of which are African States. By 2030, the ISA plans to deploy 1000 GW of new solar power at a cost of \$1 trillion.<sup>6</sup>

### **Le New Deal for Energy in Africa**

The New Deal, the African Development Bank Group's flagship project to bridge Africa's energy deficit over the next ten years, was presented in September 2015. It is intended to coordinate all other ongoing projects and initiatives aimed at ensuring that everyone in Africa has access to energy. To have a quicker and broader impact, the New Deal will collaborate with and build upon these current projects (AfDB, 2018). Seven key concepts serve as the framework for the program. These areas of focus include giving governments guidance on effective sector regulation, offering technical assistance to restructure energy utilities, grouping project capital through private sector institutions, lowering the risk of energy projects through public financing, expanding the availability of financing for on- and off-grid projects, and fostering regional interconnections.

### **The Africa Renewable Energy Initiative (AREI)**

Receiving the support of 54 African Heads of State, while introduced at COP21 in Paris, its aim is to ensure that everyone has access to enough clean and affordable energy to achieve sustainable development, improve well-being, and experience strong economic growth. Additionally, it supports the transition of African nations to renewable energy systems that improve economy and energy security while supporting their low-carbon development objectives.

#### 2.4.1.2. The Intergovernmental International Renewable Energy Agency:

Founded in 2011, IRENA supports countries in making the transition to a sustainable energy future<sup>7</sup>. It acts as the main international collaboration platform, a hub of excellence, and a knowledge repository for laws, technologies, resources, and funding for renewable energy.

---

<sup>6</sup> [www.isolaralliance.org/about/background](http://www.isolaralliance.org/about/background) (25.04.2023)

<sup>7</sup> [www.irena.org/aboutirena](http://www.irena.org/aboutirena) (25.04.2023)

IRENA, which is mandated by countries all over the world, encourages governments to adopt policies that support investments in renewable energy, provides practical tools and policy guidance to hasten the deployment of renewable energy, and supports knowledge sharing and development to meet the needs of the growing global population.

#### 2.4.1.3. Electrification Financing Initiative:

ElectriFI is a small-scale project financing program with EU funding and a focus on sustainable energy and access to electricity in developing markets. It has a worldwide range of basis with a special emphasis on sub-Saharan Africa. The distinctive business strategy of ElectriFI depends on EU funds to enable it to make investments in regional markets in less developed regions. ElectriFI is able to take more risks than other investors because of the technological support and risk financing it receives (Institut Montaigne, 2020).

#### 2.4.1.4. Power Africa:

During his 2013 trip to Africa, President Barack Obama announced the five-year program in Tanzania. The initiative aims to provide access to reliable, affordable, and sustainable energy across Africa to support economic growth and development. The United States, Tanzania, Kenya, Ethiopia, Ghana, Nigeria, Liberia, and the African private sector are all partners in the multi-stakeholder initiative.<sup>8</sup>

#### 2.4.1.5. Clean Energy:

Transitions Program: The International Energy Agency and 13 nations started the Clean Energy Transitions Program in 2017, and it has a budget of 30 million euros. This initiative offers technical assistance to emerging nation governments in their pursuit of the development of renewable energy sources.

#### 2.4.1.6. Sustainable Energy for All:

SEforALL collaborates with the UN, senior officials from governments, business, finance, civil society, and philanthropic organizations to speed up the achievement of SDG7. SEforALL works to ensure that the transition to clean energy benefits everyone equally and offers new chances for everyone to realize their potential.<sup>9</sup>

---

<sup>8</sup> [www.usaid.gov/powerafrica](http://www.usaid.gov/powerafrica) (25.04.2023)

<sup>9</sup> [www.seforall.org/who-we-are](http://www.seforall.org/who-we-are) (25.04.2023)

#### 2.4.1.7. African Energy Leaders Group:

The mission of the African Energy Leaders Group 22 is to support the goals of the SEforALL program by fostering a sustainable energy transition in Africa (Institut Montaigne, 2020).

#### 2.4.2. African local initiatives

The surge in projects undertaken by independent power producers (IPP) is evidence that the private sector is becoming interested in powering Africa.

To enable African consumers to possess a more environmentally friendly energy source based on a rental with payment via mobile phone, energy corporations and start-ups have introduced the Pay-as-you-go model (also known as PayGo), which combines solar panels and batteries with financial innovations.

According to a report by Kleos Advisory, the PayGo method has gained popularity since its introduction in East Africa in 2012, with five million fee-for-service solar home systems sold in the preceding four years and more than one million systems sold in the first half of 2019 alone (KLEOS ADVISORY LTD, 2020).

Africa, and in particular East Africa, is by far the largest destination for off-grid investment to date. The main challenge awaiting industrial players is to improve the quality and availability of energy throughout the continent.

On the market, there are several French companies like ENGIE, EDF, and Total Energies, as well as foreign companies like Rubitec Solar, Bbox, Renewable Energy Innovators Cameroon (REIc), Winch Energy, and Oolu Solar. They are not the only ones, though, who are interested in rural electricity.

Telecom companies are actively attempting to distribute mobile phones outside of electrified areas on the African continent, where the mobile phone market is expanding with significant annual growth. These players have the huge benefit of being able to generate returns on investment through mobile payments since they are less bound by regulatory constraints. One of these newcomers is the Orange group. It brings its knowledge to support the creation of new digital services across Africa and the Middle East as a multi-service operator and prominent

partner in digital transformation. The Group's primary growing region is Middle East and Africa.<sup>10</sup>

In several of its subsidiaries, Orange deploys innovative solar solutions and the latest generation batteries with partners specializing in energy and joins forces with various groups to accelerate rural electrification.

New entrants bring new dynamics to the market through their new ideas and new processes. Their agility allows them to react quickly when faced with a problem and deploy flexible solutions to the many situations they encounter in the field.

To be meaningfully incorporated into the new vision of national and regional development, it is essential that domestic public and private sector actors take the lead in driving the Initiative. African governments must assess the extent of their financial capacity before raising and allocating funds for enabling national-level operations. As a rule, this necessitates improved coordination between ministries, especially finance ministries, and the incorporation of renewable energy planning as a key component of development goals. The Initiative will assist nations in pursuing these goals and in creating national and sub-regional plans for "unlocking" domestic finance.

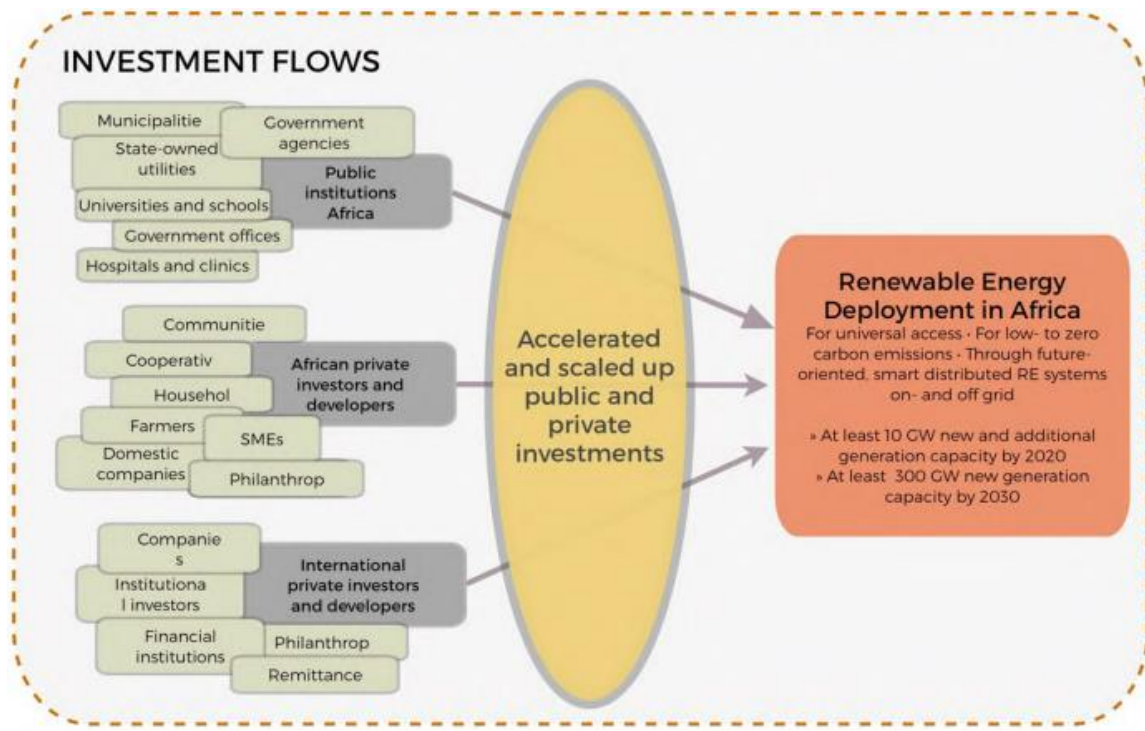


Figure 5: Funding from a variety of African and international sources supports a range of enabling activities and leverages investments in renewable energy infrastructure projects. (AREI, 2016)

<sup>10</sup> www.africanews.com, "Orange leads solar panel deployment across Africa and Middle East", 2021 (25.04.2023)

## 2.5. Defining the growth needs

Electricity networks are still being developed in Africa, and a substantial portion of sub-Saharan rural communities are still not connected to national infrastructures. This is primarily due to the low levels of consumption in these rural areas that prevent investments from being profitable as well as the tariffs in most African nations that do not cover the costs of producing electricity, making it impossible to maintain the electrical system or make the necessary investments to keep up with the rise in demand.

90 million people, or 6% of the world's present population, would need to get energy access starting in 2022, with 70 million of those coming from rural areas. Nearly three times as quickly as it was immediately before the pandemic, more than 99% of this population resides in sub-Saharan Africa, where the effort required translates to raising the average rate of access by six percentage points annually. Progress needs to be made even more quickly in rural regions, where more than 80% of Africans without access to electricity live today (IEA, 2022).

To electrify Africa, it is necessary to install and combine these three methods in the best possible way:

- Solar home systems (SHS): have a great deal of potential for powering rural areas and low-power appliances like lamps, TVs, and cell phones.
- Mini-grids: For larger settlements that are located far from the primary grid, mini-grids may be a more affordable solution. With installation times of three to eight months, they work well for serving 200 to 800 clients.
- The conventional method of offering energy services is grid extension able to supply electrical loads for higher consumption requirements.

### 2.5.1. Solutions « off-grid »

The term "off-grid electrification" refers to off-grid electrification. It is a strategy for gaining access to energy for use in places that are not wired into the national power system. Through decreasing technological costs, rapid innovation in finance and delivery methods, the beginning of a wider range of projects, and more engagement, significant progress has been accomplished in recent years.

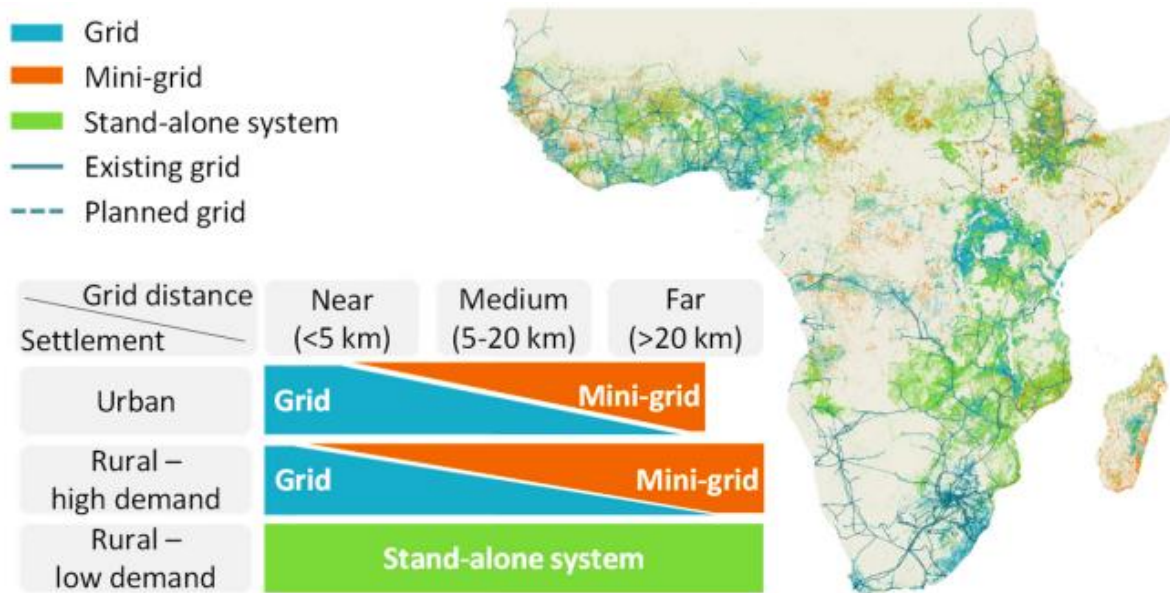


Figure 6: People gaining access to electricity by technology by 2030 in the SAS(IEA, 2022)

#### 2.5.1.1. Solar home systems

Made up of solar panels, batteries, and charge controllers, which allow for communication between the consumer and the supplier. With their built-in lighting and small appliances and "plug-and-play" functionality, more advanced SHSs mimic consumer electronics (such as radio and television) prevalent in developed countries (IRENA, 2016). In fact, due to the network's low quality in Nigeria, many urban households who are linked to it now utilize diesel generators as a backup, making them a target market for SHS.

Larger devices will still need a network connection, but technological advancements are blurring this line considerably, and someday decentralized networks may be able to provide these services. Generally, the present SHS capabilities, which offer numerous services more readily and at a cheaper cost than diesel, can meet the household power demand in rural areas. This is also true in metropolitan settings, where household uses are restricted to electric fans, lighting, and phone charging. SHS can power homes adequately, and technology is getting better, but it lacks the capacity to power larger commercial and industrial uses, necessitating the use of mini-grids and grids.

#### 2.5.1.2. Electric mini grids:

“Electrical power generating and distribution networks that serve people in a rural location” would be the official definition in dictionary. Electricity is supplied via mini grids to private residences, commercial buildings, government buildings, and important clients like telecommunications towers and sizable agricultural processing complexes. They are made to deliver dependable, superior electricity.

A typical mini grid is made up of solar panels, batteries, charge controllers, inverters, and diesel backup generators as part of a hybrid solar generation system.

Smart meters, which provide consumers with prepaid payment alternatives and real-time, granular information on energy usage trends and system performance, are frequently used in mini grids. Third-generation mini-grid producers encourage and reward customers for using efficient machinery for income-generating activities as well as efficient devices for home use. They also offer or facilitate access to financing options to help customers get beyond the hurdle of upfront expenses.

Blackouts are frequent in sub-Saharan Africa's electricity supply, which makes the region's economic growth less robust. One of the biggest problems facing Africa is the lack of power-producing capacity to increase to fulfill the continent's overall demand for electricity. Numerous African countries' energy systems are experiencing crises for a variety of causes that vary by nation.

Common causes include: drought, poor maintenance, which decreases plant availability, systems disrupted by conflict, as well as high demand growth and structural problems in the electricity sector.(IRENA, 2016)

## 2.6. Sustainable energy in sub-Saharan Africa

### 2.6.1. Types of available renewable energies:

Given the aged infrastructure, most of the power networks in SSA perform poorly and are unreliable technically.

While biomass fuel and charcoal are receiving more attention, some of the regional nations are using solar, wind, hydro, and geothermal energy sources less frequently.

#### 2.6.1.1. Bioenergy sources:

One of the main renewable energy sources in SSA is biomass, which is primarily used by people with low incomes due to its low price. The amount of biomass consumed in SSA varies from one nation to another depending on the availability of resources, access to electricity, and renewable energy policies.

Because biomass is the energy source that people from low-income backgrounds can most easily access, the rate at which it is consumed in SSA cannot be compared to that of other renewable energy sources.

Domestic trash, forest tree resources, animal waste, crop waste, wastepaper products, wastewater, and industrial biodegradable waste make up most of the exploitable biomass energy in SSA.

#### 2.6.1.2. Solar energy sources

It can be utilized by converting the energy produced by the Sun into electrical energy using specialized solar energy collecting sensitive devices like photovoltaic panels. Although solar energy potential is unevenly distributed throughout Africa, the SSA region's solar radiation intensity has the potential to support the domestic electricity required to power household appliances.

Solar irradiation on the entire continent of Africa exceeded the typical daily home load requirement of 2324 Wh/m<sup>2</sup> in urban and rural areas at all sites (Adeoti et al., 2001). When compared to the vast desert area of the region, which has enormous potential for profitable development, present applications are still only used on a small scale.

However, among those influencing the growth of solar power consumption in the area are ineffective policy mechanisms as well as financial barriers.

Private individuals are strongly encouraged to use solar power applications as one type of renewable energy to meet their energy needs, but the initial capital investment required is one of the biggest obstacles for most households in the region, given the financial issues brought on by mass unemployment and the typical low wage environment in the area.

#### 2.6.1.3. Wind energy source

One of the main renewable energy sources, wind energy has the potential to meet the growing demand for energy and, to a certain extent, to ensure the security of the world's energy supply, particularly in desert and cold regions of the planet. Contrarily, the SSA region's flimsy renewable energy policy, and execution are among the things slowing down efforts to promote the utilization of wind energy there.

#### 2.6.1.4. Hydropower sources

The kinetic energy of moving water is captured and transformed into electrical energy during the hydroelectric power generation process. It is the most environmentally friendly renewable energy source and can maintain the freshness of the air around it.

Currently, both small and large hydroelectric systems are used in the area, but energy experts contend that large hydropower systems are preferred due to their lower unit cost of energy delivery than small hydropower systems.

The amount of precipitation in each SSA nation affects the potential for hydropower generation in that nation. Seasonal variations are the key factor influencing the water resources' availability for electricity generation.

#### 2.6.1.5. Geothermal energy

The technique of turning thermal energy from any geological structure on the earth's crust to electrical energy is known as geothermal power generation. In contrast to traditional steam plants, where the boiler is built to produce hot steam for operating the plant, the steam generated in the geothermal power system is received from natural sources (the earth).

### 2.6.2. Present challenges

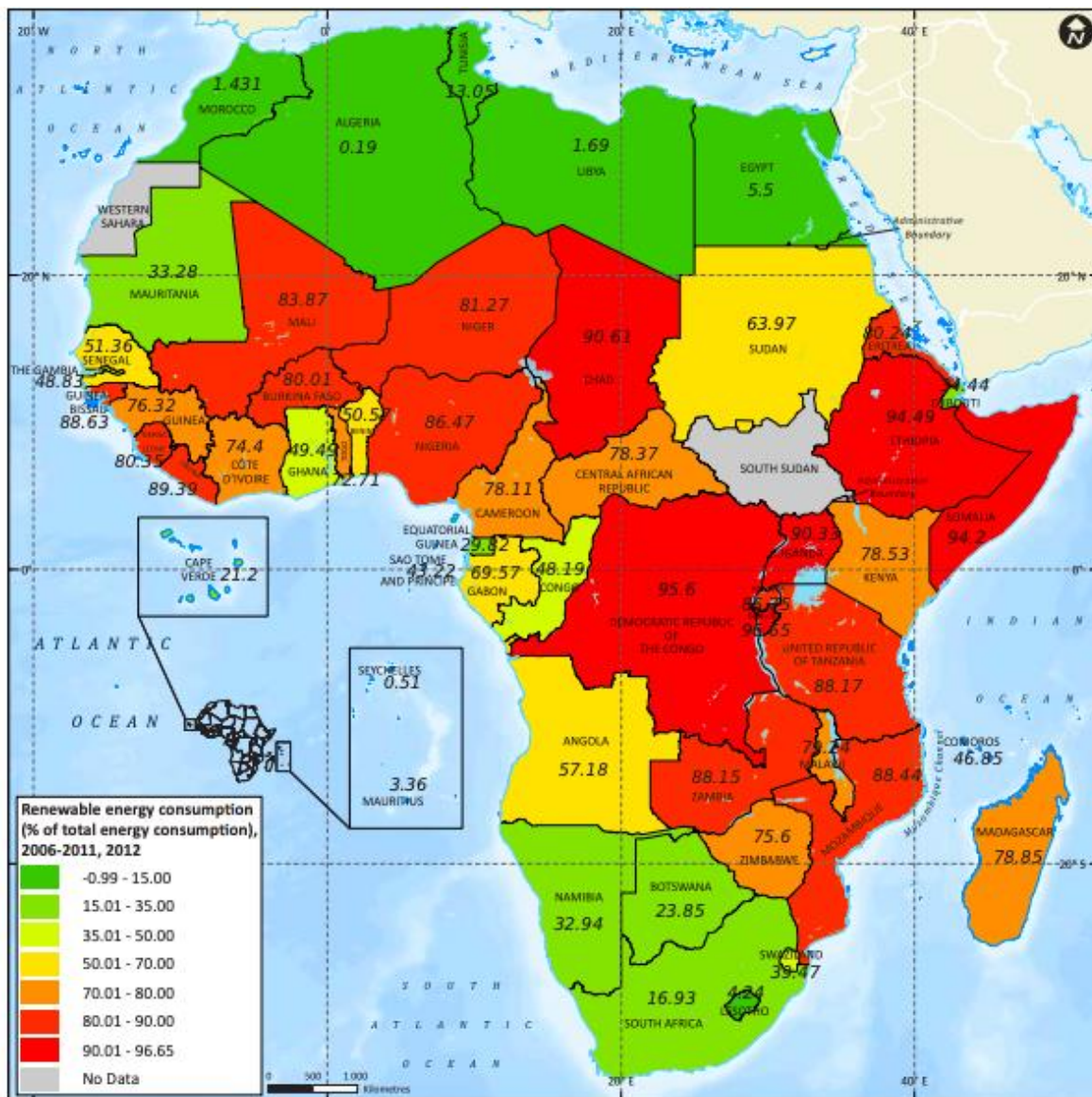


Figure 7: Renewable energy consumption (World Bank 2016)

The primary energy demand and final energy consumption in Africa are still quite modest. In 2015, Africa's energy demand was 795 million metric tons of oil equivalent (Mtoe) (IEA, 2014).

Asia, the second-least energy-rich area in the globe, uses double the energy per person as Africa. The dark continent amounts to one-third of the average across the world (2.1 metric tons of oil equivalent per capita) (IEA, 2014)

As for primary energy and final consumption, it is dominated by bioenergy. Four out of five individuals cook using solid biomass, usually on failing stoves in congested environments (IEA, 2014). The widespread use of firewood and charcoal contributes to greenhouse gas (GHG) emissions and causes deforestation. Africa is the source of one-fifth of the worldwide

emissions linked to changes in land use (Africa Progress Report 2015 - Power, People, Planet, 2015).

Following this trend, fossil fuels (including oil, gas, and coal) represented 50 percent of consumption in 2015, and energy use in Africa (IEA, 2014). Despite being high, this ratio is still better than the 80 percent global average (IEA, 2015).

In Africa, there is limited and irregular access to electricity. With 645 million people lacking access to electricity, Africa, which has 16% of the world's population, has the lowest energy access and availability rates. Rural areas make up over 80% of the population in sub-Saharan Africa without access to electricity (IEA, 2014), with 700 million people lacking access to clean cooking energy.

There are also significant differences in how much of Africa is electrified. Less than one in ten inhabitants in the Democratic Republic of the Congo, Liberia, Malawi, and Sierra Leone have access to electricity (Africa Progress Report 2015 - Power, People, Planet, 2015). Sub-Saharan Africa (excluding South Africa) has the lowest per capita power consumption of any continent, with an estimated 181 kWh annually, compared to 6,500 kWh in Europe and 13,000 kWh in the United States (AfDB, 2016). The average amount of electricity used per person is less than what is required to continually run a 50-watt light bulb (IEA, 2014).

Also, where economic development is still in the early stages, the residential sector accounts for 67% of total energy consumption, compared to an average of 25% in other emerging nations (IEA, 2014). Only 11% of total energy consumption is used for transportation, compared to 21% for all productive uses (including industry, agriculture, and services) (IEA, 2014).

Inadequate access to modern energy services in Africa limits agricultural productivity and production. Power is required for transport infrastructure, post-harvest storage and processing, irrigation, and agricultural mechanization (such as land preparation, cultivation, and harvesting). Energy is required to pump, transport, treat, and distribute water, specifically in the processing of drinking water using desalination and waste-water treatment plants, Children's poor academic performance is influenced by the fact that over 90% of elementary schools in Africa lack power. As a result, their chances for a successful life after graduation are compromised. The healthcare industry is particularly impacted since intermittent power and power outages make it impossible to use life-saving machinery and refrigerate the medicine. In the house, individuals are compelled to utilize stoves, which are frequently not only

ineffective but dangerous as well (“Africa Progress Report 2015 - Power, People, Planet,” 2015).

Africa lost 12.5 percent of its production time because of power outages, compared to South Asia's 7 percent. More than 30 African nations often endure power outages. Opportunity costs, as a result, can be as high as 2 to 4 percent of GDP and are damaging to long-term economic growth, employment, and investment. (Africa Progress Report 2015 - Power, People, Planet, 2015) Due to the unreliability of the grid electricity in many nations, businesses are frequently forced to employ pricey diesel generators, which cost roughly USD 0.40 per kilowatt-hour (AfDB, 2015).

Renewable energy percentage in the total final energy consumption is the indicator to measure the progress towards target 7.2. As seen above on the map, the percentage of total energy use from alternative energy sources (non-fossil fuels), including nuclear, for each African country. Today the continent uses more renewable energy than any other of the world's regions, amounting to 70 percent of its total energy consumption mix. This is due to the heavy reliance on traditional uses of biomass by both households and industry.

On the other hand, renewable energy consumption is growing in Africa and now outpaces the growth of total final energy consumption.

Besides biomass, solar energy is expanding in Africa; from 2009 to 2012, the proportion of households in sub-Saharan Africa using some form of solar lighting grew five folds: from 1 to 5 percent (“Africa Progress Report 2015 - Power, People, Planet,” 2015) and the total modern renewable energy consumption grew by 7 percent with the most extensive use going to hydropower for electricity generation (IEA, 2015).

The installed capacity of Africa's grid-based power generation has been rising gradually, reaching 194 GW in 2015 (AfDB, 2016). According to estimates, gas-fired generation capacity today makes up 38% of all continental capacity, followed by coal-fired generation (24%), oil-fired generation (18%), renewable energy sources such as hydropower (17%), and nuclear power (1%) (IEA, 2014).

### 2.6.3. Future opportunities

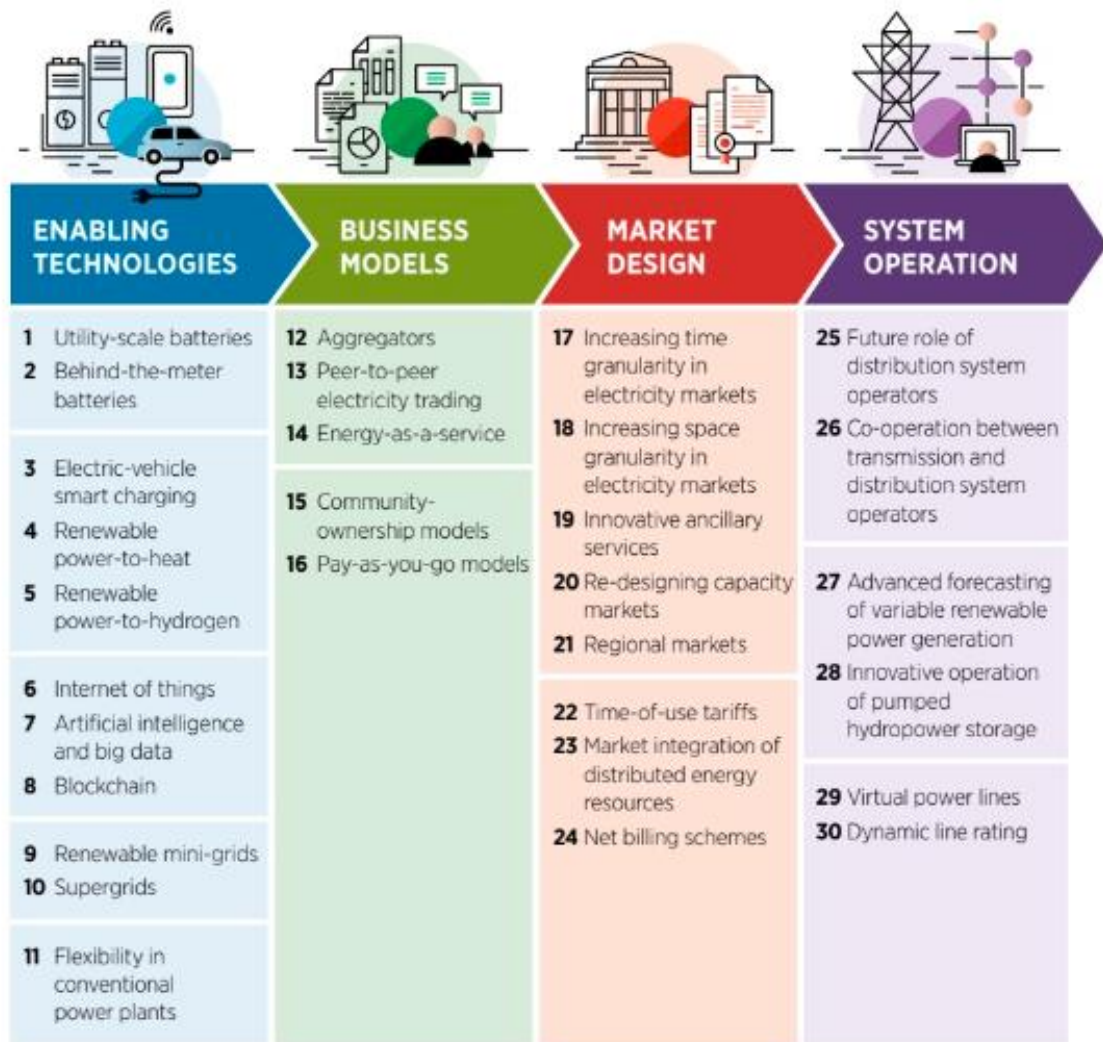


Figure 8: IRENA's innovation landscape for integrating renewable energy ((IRENA, 2019)

By 2030, only one-third of the necessary energy infrastructure will be constructed. Energy demand is expected to rise sharply as a result of urbanization, population growth, and economic expansion (“Africa Progress Report 2015 - Power, People, Planet,” 2015).

Since the early 2000s, the share of renewable energy in the global energy mix has been increasing, reaching 11.5% in 2019 (IEA et al., 2022). Although renewable energy generation capacity in Africa has increased by 7% between 2010 and 2020 (IRENA, 2022), SSA is still falling behind the rest of the world.

In SSA, the inefficient institutional setting is the cause of the low levels of renewable energy generation, and not the lack of resources (UNIDO, 2009). Exploiting this huge, untapped potential is key to respond to the energy needs of the African growing population and economy. It will require a long-term vision, effective planning, adequate policies, and significant

investments, including in the framework of Africa's relations with international partners, such as the EU, which can offer financial and technical support.

There are two prerequisites that must be completed to alter this picture. First, there must be a significant rise in the volume of power generation. Some forecasts for the area have been made by the IEA, but they are not ambitious enough or compatible with what is occurring throughout Africa.

Second, the needs of the most marginalized individuals must be considered: Prioritizing the generation of additional gigawatts is essential. But doing so shouldn't come at the expense of everyone having access to electricity equally.

#### 2.6.3.1. Impact of COVID & Ukrainian War

The Covid-19 outbreak, and the accompanying economic crisis have slowed down social and economic growth on the continent, with significant repercussions on the energy industry. Numerous promising development trends in Africa were reversed because of Covid-19 and the continent experienced its first economic recession in 25 years in 2020 (-2.3% in GDP). Its comeback has, however, been more robust than anticipated. The International Monetary Fund (IMF) increased its predictions for sub-Saharan GDP growth in 2021 from 4% to 4.5% (IMF, 2022).

The initial effects of the crisis were most severe in nations reliant on tourism and exports of raw materials. The poorest people were worst harmed by the pandemic's economic blow. Over 40% of people in sub-Saharan Africa experienced extreme poverty in 2021 (World Bank, 2022).

The economic repercussions of Russia's invasion of Ukraine, most notably rising commodity prices, are making things worse for African nations with little resources. By the end of 2022, the pandemic's effects might push nearly 25 million more people in sub-Saharan Africa into extreme poverty (World Bank, 2022).

In 2020, net imports will account for more than 5% of the GDP in several African nations, which are largely dependent on imports of fuel and food. Many of these nations have exhausted their budgetary reserves due to emergency assistance relating to COVID-19, policies to lower the cost of fuel and food, and a rise in the cost of debt payments. These issues are expected to

make Africa's post-pandemic economic recovery gradual (IMF, 2022). It won't be until 2024 that GDP per capita on the continent is predicted to return to pre-crisis levels (IEA, 2022).

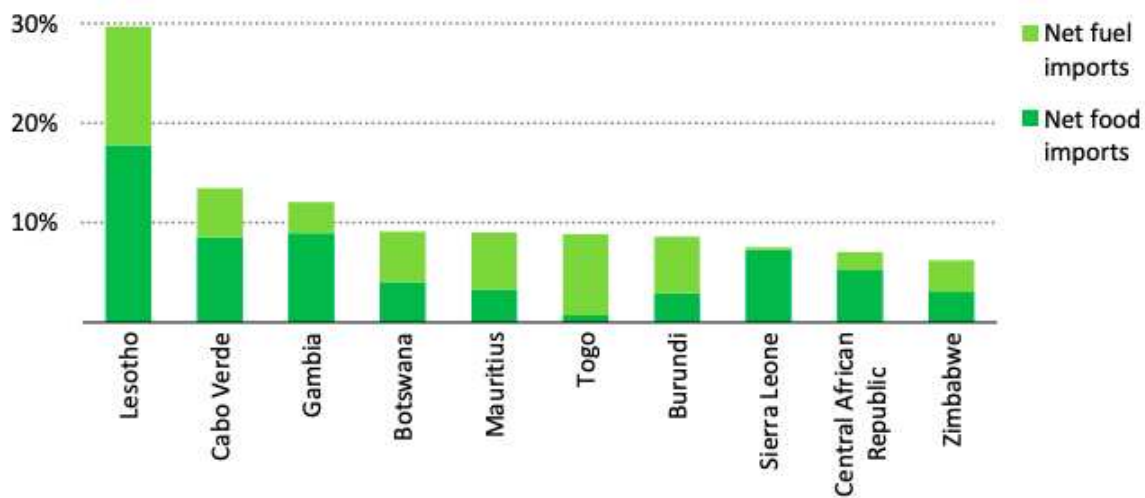


Figure 9: Net Imports of food and Fuel as a share of GDP in African countries, 2020 (IEA, 2022)

The COVID-19 crisis was expected to exacerbate the stark global disparities in access to dependable energy and health care, particularly in rural and peri-urban areas, and highlighted the significance of access to clean and efficient energy to help take control of the effects of both the health and environmental crises. The COVID-19 crisis was also projected to coincide with another year of extreme weather events and climate change (IEA, 2022).

## 2.7. Limitations to renewable energy development in SSA

Economic and financial, regulatory, political, and technological constraints are three main categories that can be used to categorize the existing barriers to the deployment of renewable energy in Africa:

### 2.7.1. Technical and human skill limitations

A significant barrier to the development of renewable energy in many African nations is the absence of transmission and distribution infrastructure facilities, as well as the tools and services required by power companies (Luthra et al., 2015). The placement of production facilities is mostly determined by the availability of infrastructure (such as roads and

electricity). Because most renewable energy equipment is imported, a scarcity of spare parts on the African markets is a barrier to the mass production of renewable energy in Africa.

Additionally, their adoption in Africa is hampered by a shortage of skilled labor. Equipment failure caused by a lack of competent repair and/or maintenance abilities can impede the flow of energy.

### 2.7.2. Financial and economic limitations

High finance prices, high transaction costs, a lack of long-term loans, and subsidies for conventional energy sources are a few examples of financial and economic impediments.

Although the cost of renewable energy has significantly decreased recently (IRENA, 2015a), high investment costs continue to be a major obstacle to the deployment of renewable energy in SSA. When compared to conventional energy sources, the upfront costs of developing and implementing renewable technologies continue to be relatively high (IRENA, 2015a). Due to the high initial investment expenses, potential investors in Africa are discouraged (Zhang and Gallagher, 2016).

Small-scale and neighborhood-based initiatives are becoming more and more well-liked throughout Africa as sources of alternative energy. However, even small-scale renewable energy projects have high transaction costs. Because of this, producers and even consumers cannot afford renewable energy technologies (IRENA, 2015b).

If not financially supported and subsidized, the high initial capital expenditures of renewable technologies may result in high energy production costs that are unaffordable to potential users when compared to energy derived from fossil fuels (Mohammed et al., 2013). As a result, even though the cost of renewable energy has decreased, it still has a lower level of commercial viability than fossil fuels (Huh and Lee, 2014).

It is difficult to find credit facilities in Africa, and when they do, the interest rates are so high that investors are reluctant to take on the high risk involved. Furthermore, most energy investors have inaccurate knowledge of the development of renewable energy due to a lack of information regarding financial and technical prospects (Mohammed et al., 2013).

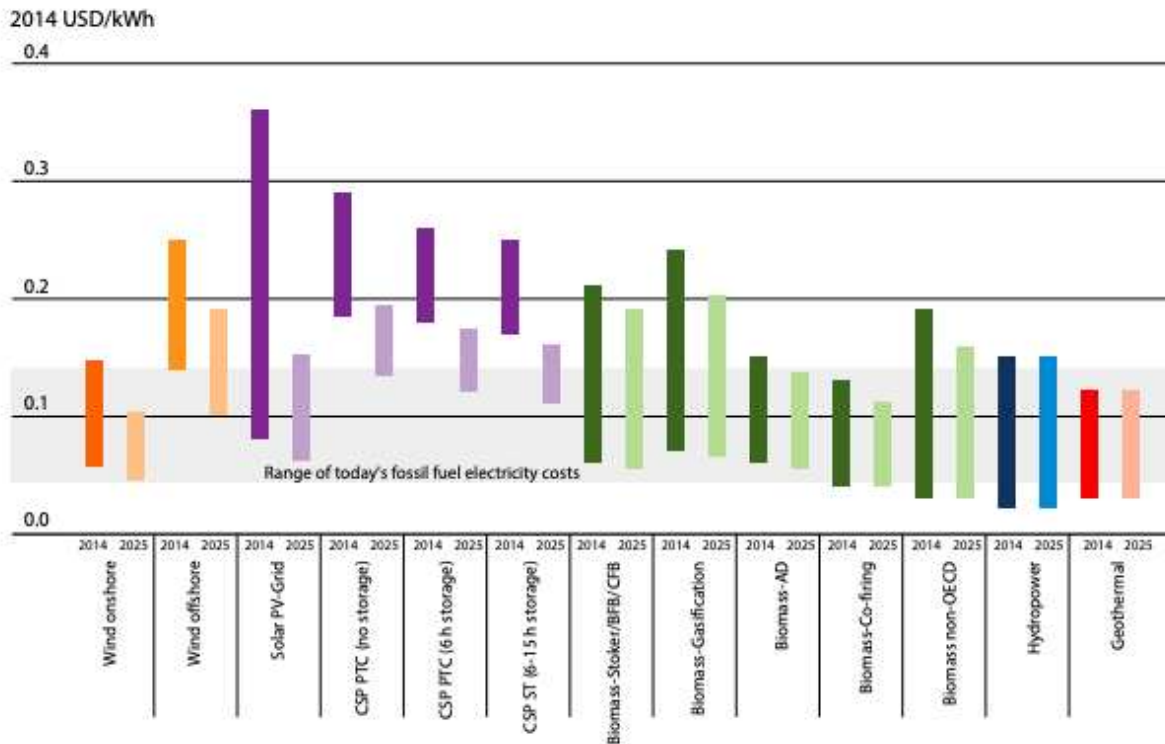


Figure 10: Ranges by renewable power generation technology, 2014 to 2025 (IRENA, 2015)

The ability of many utilities in sub-Saharan Africa to maintain grid infrastructure, participate in long-term energy planning, and attract funding has been severely hampered by underinvestment in these utilities and their poor financial performance.

Due to their inability to cover their operational costs, many utilities in the area are in danger of going out of business (IEA, 2022). The unsustainable state of utilities has led to an inadequate or poorly maintained grid infrastructure with significant loss rates. The weighted average transmission and distribution losses across sub-Saharan Africa, excluding South Africa, were roughly 23%; in contrast, in the Comoros, So Tomé and Prncipe, the Republic of Congo, and the Central African Republic, these losses approached 40% (Trimble et al., 2016).

### 2.7.3. Political limitations

The legal and regulatory frameworks for renewable energy in Africa are fragmented and incoherent (Quitow et al., 2016). Due to a lack of laws, inadequate regulation enforcement, poor management of the energy sector, and a complicated bureaucracy, Africa lacks the policies necessary to create an effective market for renewable energy technologies. Investments may also be hampered by challenges in getting licenses and permissions. Finally, investors in mini-grid systems may be discouraged by the lack of clarity surrounding grid expansion and

the procedure for integrating current mini-grids when local grid expansion occurs (EUEI et al., 2018).

Additionally, private sector participation in renewable energy projects is hampered by a lack of clear policies on private investment and lengthy approval processes for private sector projects (Luthra et al., 2015). African nations each have their own unique national renewable energy policies, but due to ineffective implementation strategies, regional policies are still in the early stages of development (Mohammed et al., 2013).

Modernizing grids in preparation for the expansion of variable renewable energy sources like solar PV and wind will require investment. Beyond the utilities' overall financial stability, project cost overruns and inefficiencies continue to be a major worry. The number of energy connections, for instance, grew because of a project run by the Kenya Power and Lighting Company (which manages transmission and distribution systems). The effectiveness of the program has been jeopardized by cost overruns and a failure to recoup costs from the additional connections (Shirley, 2018).

A recent study that examined 32 years' worth of data from more than 100 countries found that successful reform initiatives increased residential consumption and power connection rates, with sub-Saharan African nations seeing the strongest effects (Dertinger and Hirth, 2020). They also found that each reform mentioned above when effectively implemented, led to a 20% increase in the number of electricity connections in sub-Saharan African countries.

(Ahlborg et al., 2015), who discover a positive correlation between institutional quality and per capita household power use, also identify this association between institutional capacity and enhanced benefits to the population. Over the past few years, Sub-Saharan Africa has improved its readiness for renewable energy, but the continent still lags behind other regions of the world in terms of its legal and policy frameworks (ESMAP, 2020).

To help increase interest in the use of renewable energy, in recent years several regulatory authorities, private sector organizations, and corporate entities have been established. We can point out to The Energy Commission of Nigeria (ECN), The Energy Commission of Ghana (ECG), The Ghana Energy Development and Access Project (GEDAP), and The Capacity Building Project in Energy Efficiency and Renewable Energy (CaBEERE) in South Africa as examples. All these organizations support the use of contemporary technologies to exploit renewable energy sources.

Poorly implemented policy reforms have raised questions about the region's ability to provide 100% of the population with access to power by 2030 and beyond. Less than 25% of the SSA's 47 member countries have access to electricity at or above a 45% level.

To make a significant advancement in the development of renewable energy, however, it is necessary to strengthen current energy policies and perhaps introduce new ones that can advance a level playing field for the penetration of renewable energy investors operating under the conditions of sustainable market development.

#### 2.7.4. Socio-cultural and educational limitations

Another obstacle to the adoption of renewable energy technology in Africa is a lack of knowledge and awareness of the degree of understanding about the potential utility of these technologies (Stigka et al., 2014). Comparatively speaking, Africa has a high rate of illiteracy. Uninformed people are likely to be unaware of the advantages of renewable energy (Polzin et al., 2015) or the negative effects that nonrenewable energy has on the environment (Mohammed et al., 2013). Due to this, the region's infrastructure and technological adoption of renewable energy has slowed down (Koua et al., 2015).

### 2.8. Sustainable energy and development indicators in SSA:

After checking the Scopus Database, we notice that there are many references connecting Sustainable energy to development indicators.<sup>11</sup>

The references to SSA are more recent than their counterpart in the US or EU.

Starting in the US, (Menyah and Wolde-Rufael, 2010) looked at the 1960–2007 data to establish the causal links between CO<sub>2</sub> emissions, per capita GDP, nuclear energy, and renewable energy. The study found that unidirectional causation runs from nuclear energy to CO<sub>2</sub> emissions by using the condensed version of Granger causality analysis.

However, there was evidence of a neutral relationship between CO<sub>2</sub> emissions and renewable energy. According to their findings, the consumption of renewable energy has not yet grown and has little effect on reducing greenhouse gas emissions.

---

<sup>11</sup> [www.scopus.com/search/form.uri?display=basic#basic](https://www.scopus.com/search/form.uri?display=basic#basic) (01.05.2023)

By utilizing the Turkish economy and the techniques of ARDL Autoregressive distributed lag and Johansen cointegration, it is possible to investigate the causal relationship between renewable energy and real GDP in a multivariate context. There was no consistency and agreement on the direction of causation between the variables under inquiry since the data do not show a causal relationship between renewable energy and real GDP. (Ocal and Aslan, 2013)

Using the Global Multiregional MARKAL model and an econometric model that took into account the main socio-economic determinants impacting access to electricity to evaluate the growth of the power sector in sub-Saharan Africa. (Panos et al., 2015) demonstrated that one of the main impediments to Sub-Saharan Africa's growth is a lack of access to power. According to the research, having access to electricity is inversely associated to poverty. They clarified that when electrification programs are offered, the program participants are not always able to cover the associated expenditures. Consequently, electrification programs might not have the desired effects.

In their analysis, (Ebhotu and Tabakov, 2017) emphasized that the lack of access to electricity and the deteriorating state of infrastructure are the main causes of the slowdown in economic growth in some Sub-Saharan African nations. Several nations in the region have the capacity to produce electricity from renewable sources at the same time. However, infrastructure provision, a rise in the proportion of qualified workers, and the promotion of an investment-friendly environment are all required for this purpose.

Findings from (Chakamera and Alagidede, 2018) indicate that the efficiency of the region's energy industry is negatively impacted by rising atmospheric carbon dioxide emissions. In addition, their analysis shows that SSA has some of the highest electricity prices in the world and that the industry still relies largely on traditional fuels.

From 1995 to 2015 using the ARDL approach (Saint Akadiri et al., 2019) analyzed cross-sectional time series of data on the economies of the EU. The results of the analysis show that the series under investigation have a favorable and significant long-term association. Furthermore, according to the findings of the empirical analysis, sustainable environments, real gross capital formation, and renewable energy are the main drivers of long-term economic growth.

### 2.8.1. Research gap

According to the afore mentioned literature review, SSA needs are still being studied and focused on in comparison to the rest of the globe, which has already advanced in its electrification. Consequently, there is a basic awareness of the actual contemporary issues that the continent is experiencing. Particularly considering how much of an influence climate change has on it compared to how little Africa impacts it. This can be applied to the pressing need for electrification via renewable energy sources.

Also, in the research done, they limit most of the development to GDP which by today's standards is not always relevant. Since development especially in Africa is also linked to education, health, and safety. This is highly important as unlike Asia and South America that also face challenges, the African continent is highly affected by low education levels, poor access to health and unstable political environment causing many internal civil wars. To develop the continent cannot only rely on economic growth, due to the high level of inequalities. Where this development is only accessible to the richest who already have the monopoly of the limited resources, it is important to include other indicators in the analysis that go beyond the GDP aspect, and include social, health and safety variables.

Lastly, most of the research is based on numerical studies without taking into consideration company expertise. Meaning that it is important to fact check the growth in Africa during the last years, however a good understanding of other qualitative variables is important to understand this environment and to prevent any upcoming trends to better canalize it. This can provide a comprehensive understanding of the indicator variables displayed as well, for a better assessment of the current situation and an optimal planning of next steps to follow to insure a sustainable, equitable access to energy and electrification throughout the SSA. This approach is also valuable as it humanizes the numbers, today we are not looking at just a number 600 million. But we are getting an insider look on the lives of few of the 600 million people that live on the continent, with all the different challenges and aspirations that number and data cannot necessarily translate, including culture, rituals, and beliefs. This also a for profit company who has a different outlook on the project, and that not only sees the immediate impact but must calculate the potential future impact electrification may have on the villages.

To better understand how the weight of renewable energy in a country's overall energy mix changes, we shall first define development in this article beyond merely GDP. Additionally, we will confine our analysis to SSA nations because they represent the area with the greatest potential for solar energy while also experiencing the fastest projected demographic development. Lastly, we will consider ENGIE input, a French company leader in sustainable energy that works to provide electrification through mini grids and at home solar panels installation to some of the most rural villages in Africa.

### 3. Methodology

#### 3.1. Research question

The choice of the research question in this research paper ‘‘ Impact of sustainable energy on development in SSA’’ comes from the pressing need to discuss sustainable energy, climate change, and development impact.

In the other parts of the world the development did not come from sustainable and climate-respecting growth, and today we are expecting the least developing countries to integrate this dimension to their plans. This research paper is dedicated to these countries, especially SSA.

First, we will try to understand the part of sustainable energy in the country’s energy mix, and if it has any impact on the GDP (as an indicator of development) this research will include analysis of different economic variables as well as energy prices, energy imports and inflation to better understand these dynamics. We relied on 14 countries that are working to develop their environmental footprint, over a time period from 2008 to 2017, as more recent data was not available.

Second through an interview with an expert, we will understand how companies can promote this development in the most rural places, and how electrification through sustainable energy can encourage business opportunities and ensure a better life quality for the communities.

Here we will understand better the development aspects impacted by integrating this renewable energy approach, but also what are the different limitations to this integration.

The development will be defined as larger than just GDP and will include health and education metrics. As for the limitations, not only technical or political but also cultural and social.

Hypothetically, sustainable energy use may have no to very little impact on development and just as the rest of the world couple of decades ago the easier way is just to have access to electrification regardless of the sources and origins of energy.

However, it's equally crucial to look for workable answers that benefit the SSA nations while harnessing the region's natural resources. In this instance, we might suppose speculatively that obtaining energy in a sustainable manner has a stronger impact on development and is even more essential for it to occur.

Lastly, we can also assume that sustainable energy has an even negative impact on development or has a slowing effect, as some SSAs are exporters of fuel, and refusing to use this resource does indeed impact their GDP. However, is the weight of these countries on total SSAs heavy enough to cause a disruption in energy consumption objectives? Hence this solution can also be applicable to a few of the countries in this scope.

## 3.2. Methodology approach

To answer this research question, it is necessary to go through two types of approaches, quantitative and qualitative, to better assess the problem not only from a numerical side but also have a more in-depth look at non-numerical variables that may impact the correlation between sustainable energy and development.

### 3.2.1. Quantitative study

In this study, we used the Panel Data Regression method, as this is longitudinal data and a combination of time series and cross-section observations.

This method allows more observations, more cross-sectional information, and more degrees of freedom. It also incorporates changes within a country as well as changes across countries. Lastly, it accounts for the impact on country-specific attributes like population, resources, and employment rate....

In our research specifically, a few explanatory variables are combined in this statistical process: multiple linear regression (MLR):

$$\text{Predicted GDP} = 1369,314 - 972,381 \text{ Sustainable Energy} + 1872,036 \text{ CO}_2 \text{ Emission} - 513,049 \text{ Energy Import} - 5,260 \text{ Electricity Price} - 630,747 \text{ Inflation}$$

Assuming:

- There is a linear correlation between the independent and dependent variables.
- There aren't many significant correlations between the independent variables.
- The observations are picked at random and separately from the population.
- The residuals' distribution need to be uniform, with a mean of 0 and variance.

The minimal sample size for any regression, according to Green (1991), (Wilson Van Voorhis and Morgan, 2007).

In this research paper we are looking at the impact of 5 variables on development (GDP):

- Share of renewable energy consumption in the energy mix in %: Consumption of energy from renewable sources in all final energy consumption.
- CO2 emission metric ton / capita: From the production of cement and the combustion of fossil fuels both produce carbon dioxide emissions.
- Energy imports % energy usage: Energy use less production, both expressed in oil equivalents, is the estimation of net energy imports. A low number signifies that the nation exports more than it import.
- Inflation rate in %,
- Energy prices

Hence:

Number of countries: 17

Number of years: 11

Types of data: Annual

Sample size: 187

### 3.2.2. Interview

First step was to identify the different stakeholders based in Africa who are closely working on sustainable energy development in the SAA region.

Connecting with NGOs or governmental institutions was hard as I received no feedbacks after contacting them through LinkedIn or via email. I was aware of this difficulty while doing my research, hence my interest in for-profits companies.

I contacted 4 of the biggest sustainable energy providers in the continent, through LinkedIn again, sending messages to the communication department. I was then answered by ENGIE. This communication department referred me to the Sales department, who is in direct contact with the populations in Africa and are providing solutions on the everyday basis. Their knowledge of the field is precious when it comes to giving more of personalized feedback that goes beyond numerical aspects, as they have multiple visits a year to different regions of the continent.

An initial draft of my questions was shared with M. Karpa my thesis supervisor, who corrected me and helped me better structure them. We ended up agreeing on a series of 9 questions that

include different aspects, from critical point of view about sustainability in Africa to the role and impact of the company on sustainability in this region.

Our meeting was made on Zoom as the HQ of the company is in Paris and planed for a one-hour discussion. The interview was made in French language, and I took the time to translate the full transcript which is available in my appendix.

The participant received the questions before hand via email, to make sure she feels confident answering them and can provide answers with clear and aligned DATA.

In this paper I worked on open ended questions asked to my participant to give her liberty in explaining their approaches to sustainable energy deployment in Africa.

The time planed for the interview was not sufficient to go through all the questions and I was only able to ask 6 out of the 9 approved of. However, I also received some of the company's Fact sheets and yearly reports to consolidate the answer received during the interview.

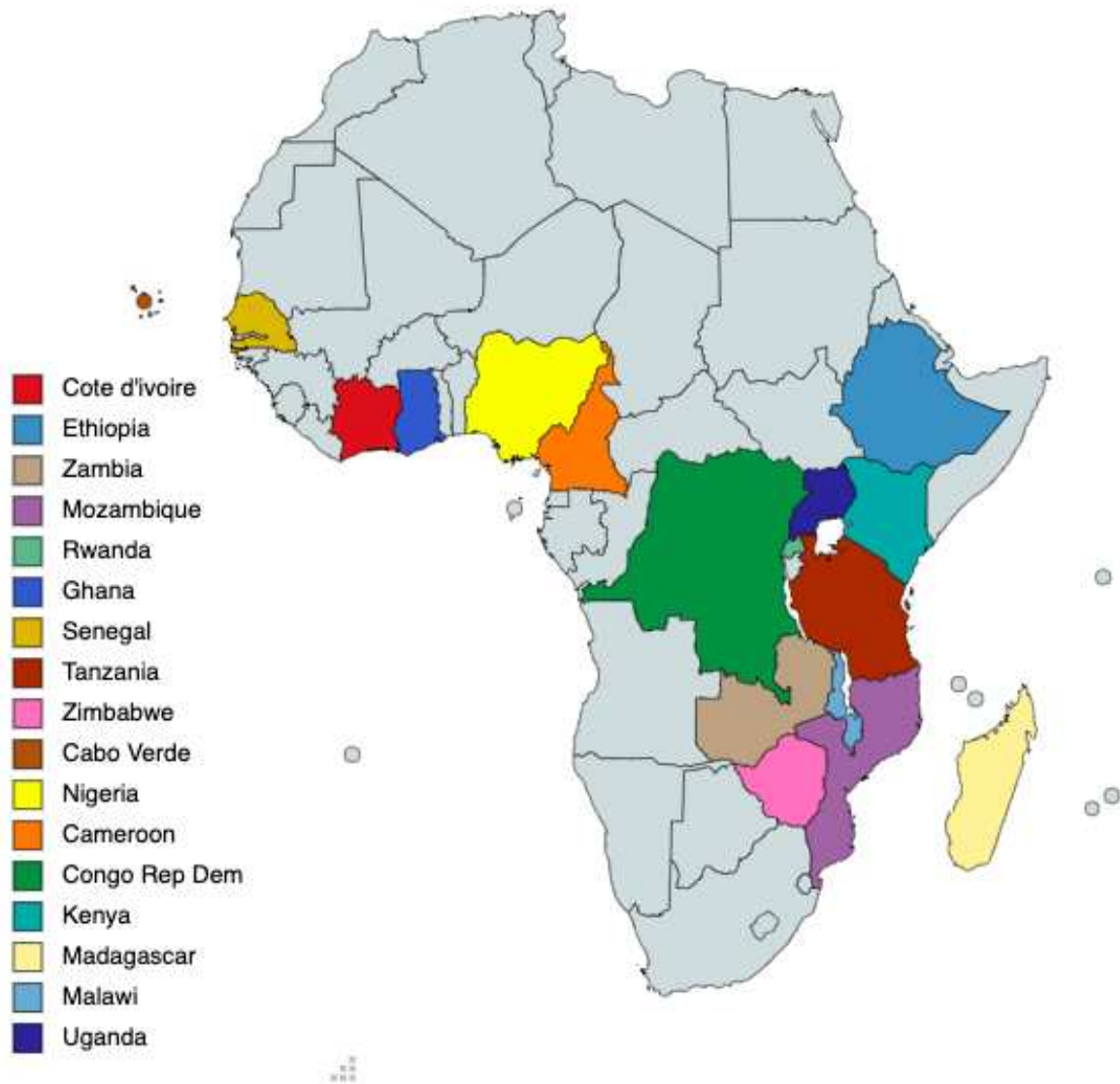
This interview helped me have a better understanding of the environmental aspects of this research.

### 3.3. Research design

#### 3.3.1. Country scope

This study includes 12 SSA countries: Ethiopia, Senegal, Cote d'ivoire, Ghana, Cameroon, Nigeria, Zambia, Kenya, Mozambique, Rwanda, Zimbabwe, Tanzania, Democratic republic of Congo, Madagascar, Malawi, Uganda, and Cabo Verde.

The country's choice relied on the data availability, sourced from the world bank Data base, The mix of the countries was based on geographical location: Est, West, and South. This comes with different natural restrictions and development aspirations. Also, the energy production profile mix, includes exporters of fuel. Development here represented by GDP needs to also take into consideration the nature of the exports (portfolio) of the country.



The country selection also relied on the SDG score Index. With an average in the region of 53,6 it is important to select countries that are actively pushing the sustainable agenda and utilizing renewable energy as an alternative. Ghana is leading this selection with a score of 63,4, the rest of the countries fall around the average with Mozambique the lowest on this selection at 53,6.<sup>12</sup>

<sup>12</sup> [www.dashboards.sdgindex.org/rankings](http://www.dashboards.sdgindex.org/rankings) (01.05.2023)

Table 2: Oil in SSA countries

Mature Production	Production Management	Production Growth	New Producers
Production is forecast to decrease because of natural decline in mature fields. New production may come onstream, but volumes are not large enough to offset declines.	Forecast production is flat or steadily increasing. New production coming onstream equals or exceeds the natural decline in mature fields.	Production is forecast to grow in countries that are relatively new producers as additional fields come onstream.	Oil production is expected to start sometime within the next five years.
Sudan and South Sudan Equatorial Guinea Gabon Cameroon Chad Congo (Kinshasa) Mauritania	Nigeria Angola Congo (Brazzaville) South Africa Ivory Coast	Ghana Niger	Uganda Madagascar

The SDG Index evaluates each nation's overall performance in relation to the 17 SDGs, assigning each Goal the same weight. The score represents where a nation is in relation to the best-case scenario (score of 100) and the worst-case scenario (score of 0). The trend arrows and dashboard show which activities are most important to take next and whether a country is on track or off track to meet its objectives and targets by 2030 based on the most recent trend data. One third of the data comes from non-traditional sources such research institutions, universities, and non-governmental groups, while two thirds come from official statistics (usually UN custodian agencies).<sup>13</sup>

Furthermore, Nigeria is a unique scenario since by 2050, renewable energy is expected to meet 57% of Nigeria's primary energy needs. In addition to other contemporary energy sources, electrification significantly contributes to the achievement of this renewable energy share, with the proportion of electricity in final energy usage nearly doubling to 27% from 2015 levels by 2050. The conventional route is more expensive than investing in renewables. This equates to USD 35 billion (2010) per year as opposed to USD 36 billion (2010) per year in terms of average yearly investment values. This demonstrates the effectiveness of investing in renewable energy because it is less expensive than the projected scenario, regardless of the level of economic growth attained. Therefore, Nigeria could affordably provide sustainable energy for all its population by utilizing its numerous and largely unexplored renewable energy resources. However, under very high economic growth (10% annual GDP growth rate), current energy policies would not be sufficient to meet all of Nigeria's electricity needs by 2050,

<sup>13</sup> [www.unsdsn.org/sdg-index-and-monitoring](http://www.unsdsn.org/sdg-index-and-monitoring) (01.05.2023)

necessitating the continued use of significant portions of distributed oil-based generation in the country's electricity supply mix. (IRENA, 2023)

### 3.3.2. ENGIE Presentation:

Engie is a French industrial energy group, a leader in low-carbon energy and services. It is the second largest global group in the energy sector (excluding oil) in terms of turnover according to the Forbes ranking.

The main shareholder is the French State, which holds a quarter of the capital (23.64% of the capital and 33.84% voting rights of Engie), the public shareholders, made up of investors institutions, individual shareholders, etc. hold 67.74% of the capital and 57.60% of the voting rights.<sup>14</sup>

The ENGIE Group places responsible growth at the heart of its businesses (electricity, gas natural resources, energy services) to meet the major challenges of the energy transition towards a low-carbon economy: access to sustainable energy, attention, and adaptation to climate change and the rational use of resources.

Engie is a global group dedicated to accelerating the transition to a carbon-neutral future. They believe in achieving this target through two central adaptations: decreased energy usage and more environmentally friendly solutions. It is an energy provider with a focus on infrastructure and renewable energy. The "raison d'être" of ENGIE aims to act to hasten the transition to a carbon-neutral economy.

The company has 96,000 collaborators, including workers, customers, partners, and stakeholders.

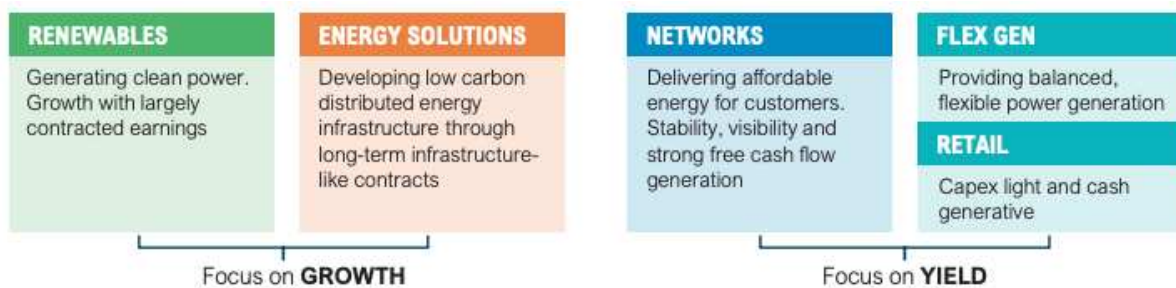


Figure 11: ENGIE business model (Engie fact sheet 2021)

<sup>14</sup> [www.engie.com/espace-finance](http://www.engie.com/espace-finance) (01.05.2023)

The ‘raison d’etre’ of ENGIE, or the reason for being of this entity, is to balance economic performance and positive environmental footprint around their core business (renewable energy, energy solutions, networks, and thermal production & energy supply).

By 2030, the company aims to limit its geographic footprint to 30 countries (down from 70 in 2018).

The company is reorganizing several of its services to provide quality technical support strengthened by a vital data and digitalization focus.<sup>15</sup>

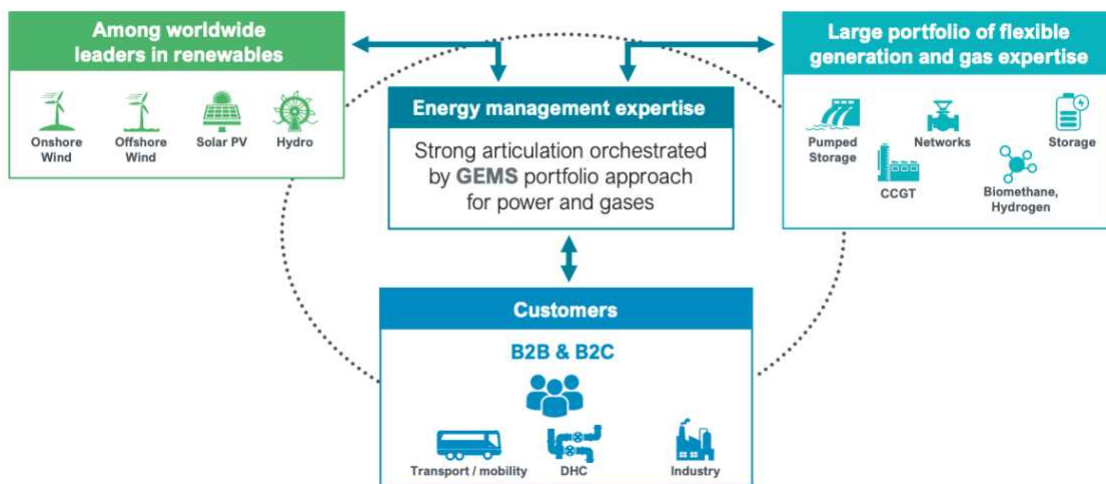


Figure 12: ENGIE's integrated business model in action

In Africa today, innovation in solar energy, energy efficiency, remote connectivity and data analytics has created a strong belief in the potential of these technologies to close the energy gaps quickly and cheaper.

Present since the beginning of the 20th century in Africa through the companies that constitute and determined to meet the continent's energy needs, ENGIE has created 2016 a Business Unit (BU) entirely dedicated to Africa to support countries Africans in their economic and social development, by ensuring sustainable access to energy and meeting the goods and services needs of communities, industries, and African households. The group implements integrated solutions throughout the chain of energy value, from centralized power generation to off-grid solutions (solar home systems, mini-grids) and energy services.

For years, ENGIE Africa has had nearly 4,000 employees, a capacity power generation of 3.15 GW and has been a leader in the energy market decentralized network providing clean energy

<sup>15</sup> [www.engie.com/en/group/who-we-are](http://www.engie.com/en/group/who-we-are) (01.05.2023)

to more than 4 million people, in several countries, thanks to solar home installations and local mini grids.

ENGIE was able to provide solutions adapted to their needs to improve access to energy and develop renewable energies with the means and know-how of the continent. The Africa BU is present throughout the continent with four main offices, corresponding to the 4 regions where its activities are deployed: Casablanca, Abidjan, Nairobi, and Johannesburg.

### 3.4. DATA Collection & Analysis

#### 3.4.1. Quantitative study

The data needed for this analysis was extracted from the world bank.

- GDP, unemployment rate, energy import, inflation, CO2 emission, population, and share of sustainable energy in total energy consumption.

For the energy import ratio, the recent data needed for Ethiopia, Ghana, Zambia, Kenya, Senegal, Cote d'Ivoire, Nigeria, Cameroon, Zimbabwe, the democratic republic of Congo, and Tanzania was created based on the previous year's averages.

First, the average growth year was calculated based on the available data, this ratio has been added to each year for the remaining years.

For the countries Rwanda, Cabo Verde, Uganda, Madagascar, and Malawi, we used the sub-Saharan Africa average available.

HDI extracted from the UN Human Development Report (UNDP, 2022). Data for the years 2000, 2010, 2015, 2018. The rest has been assumed using the average growth for each country.

For energy prices, I utilized the available data for 2010 from the world bank, for a restricted number of countries covering 13 of my 17 studied ones. As the information for each year was not available, we used the inflation ratio to deduct the energy prices throughout the years.

For the remaining Zambia, Tanzania, Zimbabwe, and Uganda the estimation is based on the yearly average of the countries available.

These data have been collected and analyzed using SPSS, Linear regression to understand the correlation between these different variables and the GDP.

Through the analysis some variables were dropped: population energy prices and inflation as they were not necessarily correlated to the GDP growth.

Check full DATA in Data analytics in Appendix.

### 3.4.2. Qualitative study

During this thesis writing, I only got to speak to one company and ask my questions.

During the interview, I took the necessary notes to review the communication, as mentioned earlier the time of our interview was not sufficient to provide all the necessary information, however, I did receive complementary documentation to be able to build on it to form my final interview transcript.

I synthesized the answers to be able to reference them better, I elected the most relevant ones to my thesis and the ones that can connect between both variables ‘sustainable energy’ and ‘development’. Which are questions 2, 5, and 6. I made sure to highlight takeaways and keywords to have a better and more in-depth look into them through my extra documentation provided by the company.

I then chose the most important aspect for my study; in this case I chose to speak about Limitations to the definition of GDP and the limitations faced on the field in Africa when it comes to sustainable energy deployment.

For both topics I also used references from previous studies to better explain and showcase the concepts introduced and discussed during my interview, as the limited time frame didn’t allow me to do it during my call with Mlle Randa Mrabat. The core of the answer has not been modified, but only translated from French to English which helped me convey them in a more concise manner.

I included references and definitions of Green GDP for instance as it is a relatively new concept, compared to the Human Development Index for instance. For this section I used studies from different regions not necessarily Africa, as the concept of GGDP is not widely discussed in the continent, due to the limited resources and relatively new wave of integrating sustainability in countries' development plans. Hence the choice of Asia second biggest market of sustainable energy after Africa, although with different challenges, the concepts are applicable for both regions.

The challenge would be to combine the output from the two analyses and see if both complement each other.

### 3.5. Limitation and concerns

This research is conducted on results from 2008 to 2018 due to the lack of data, this time frame is outdated for the new challenges of the decades these countries are knowing. With accelerating climate change, growth in deforestation, and drought the SSA are facing far more challenges.

For the missing exact data, an estimation was provided based on the previous years' averages. This is the case for energy imports and energy prices as in some countries it is very hard to access information. This data manipulation can cause the outcome not to be exact or representative of reality evolutions but rather an estimate.

Also, the geopolitical instability of some countries: this is the case of Sudan (Sudan and South Sudan split in 2011) would have some implications on the different variables impacting development. This also shows that the potential of these countries can be different than what is officially estimated as an unstable environment that lacks to provide a solid basis for investments has always been present.

This study does not take into consideration the Covid impact that decelerated the sustainable development agenda of Africa and built more inequality and gap between the continent and the western world. The war in Ukraine has as well changed power balances and created even more scarcity around energy sources, as of today this research did not take into consideration these impacts as no viable sources were found relating the energy consumption in Africa and the Russian-Ukrainian war.

All of these can be considered as variables that could alter the results of this study if taken more into consideration and updated to a more recent data profile.

For the interview part, the main concern to highlight is the lack of time dedicated to the meeting, which depended on my interlocuter availability, as mentioned some of the information were collected from the company's communications (journals and reports) which fails to convey the personal outcome a field professional can have.

Also, only one interview was conducted, representing only one company. ENGIE as a group has a specific growth plan and target locations to work with Like Kenya and Cote d'Ivoire both

represented in the first part of the study, however, some other locations may have other specificities that were discussed neither on the quantitative nor the qualitative part.

Lastly, as the interview was conducted in French, most of the notes and transcript have been translated and adapted to my best capabilities. It is important to note that an extensive version of it could be provided, but to provide comprehensive answers, parts of the exchange have been shortened to better match a cleaner, simpler translation.

### 3.6. Results

#### 3.6.1. Quantitative study takeaways

We find that the adjusted  $R^2$  of our model is 0,726 with the  $R^2 = 0,734$  that means that the linear regression explains 73,4% of the variance in the data.

The Durbin-Watson  $d = 0.313$ , can assume that there is positive autocorrelation in the data.

Table 3: Model Summary, Multivariable Regression

Model Summary <sup>b</sup>										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			Sig. F Change	Durbin-Watson
						F Change	df1	df2		
1	.857 <sup>a</sup>	.734	.726	413.37720	.734	90.614	5	164	<.001	.313

a. Predictors: (Constant), Inflation, Energy Import, Sustainable Energy, Electricity Price, CO2 emission

b. Dependent Variable: GDP

The null hypothesis for the linear regression's F-test is that there isn't a linear relationship between the variables ( $R^2=0$ ). Since the test is very significant with  $F = 90.614$ , we may infer that the variables in our model are related linearly. Sig value: Typically, the study's significance level is set at 5% or the 95% confidence interval. Consequently, the p-value must be lower than 0.05. It is .001 in the table. The outcome is significant as a result.

Table 4: ANOVA Table Multivariable Regression

ANOVA <sup>a</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	77421345.0	5	15484269.0	90.614	<.001 <sup>b</sup>
	Residual	28024435.7	164	170880.706		
	Total	105445781	169			

a. Dependent Variable: GDP

b. Predictors: (Constant), Inflation, Energy Import, Sustainable Energy, Electricity Price, CO2 emission

The test in our examination of linear regression examines the null hypothesis that the coefficient is 0. We may argue that both the intercept and the variable are different from zero because the t-test indicates that they are both highly significant (p 0.001).

According to the findings, Sustainable Energy has a negative coefficient of -972.381, which indicates that, when all other factors are held constant, for every unit increase in Sustainable Energy, GDP is expected to decline by 972.381 units. The GDP is anticipated to increase by 1872.036 units for every unit increase in CO2 emissions, assuming all other variables remain constant. CO2 emission has a positive coefficient of 1872.036.

Additionally, Energy Import has a negative coefficient of -513.049. This means that, if all other factors remain constant, GDP is expected to decline by 513.049 units for every unit increase in Energy Import.

Finally, since the t-test results for the electricity price and inflation variables do not substantially differ from zero, they are not statistically significant predictors of GDP in this model.

Table 5: Coefficients table Multivariable Regression

		Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1369.314	299.856		4.567	<.001	777.238	1961.390
	Sustainable Energy	-972.381	271.169	-.236	-3.586	<.001	-1507.814	-436.949
	CO2 emission	1872.036	190.847	.645	9.809	<.001	1495.202	2248.871
	Energy Import	-513.049	86.313	-.246	-5.944	<.001	-683.478	-342.620
	Electricity Price	-5.260	4.999	-.048	-1.052	.294	-15.131	4.610
	Inflation	-630.747	530.251	-.056	-1.190	.236	-1677.746	416.251

a. Dependent Variable: GDP

The histogram indicates that the residuals approximate a normal distribution. The Q-Q-Plot of z\*pred and z\*presid shows us that in our linear regression analysis there is no tendency in the error terms.

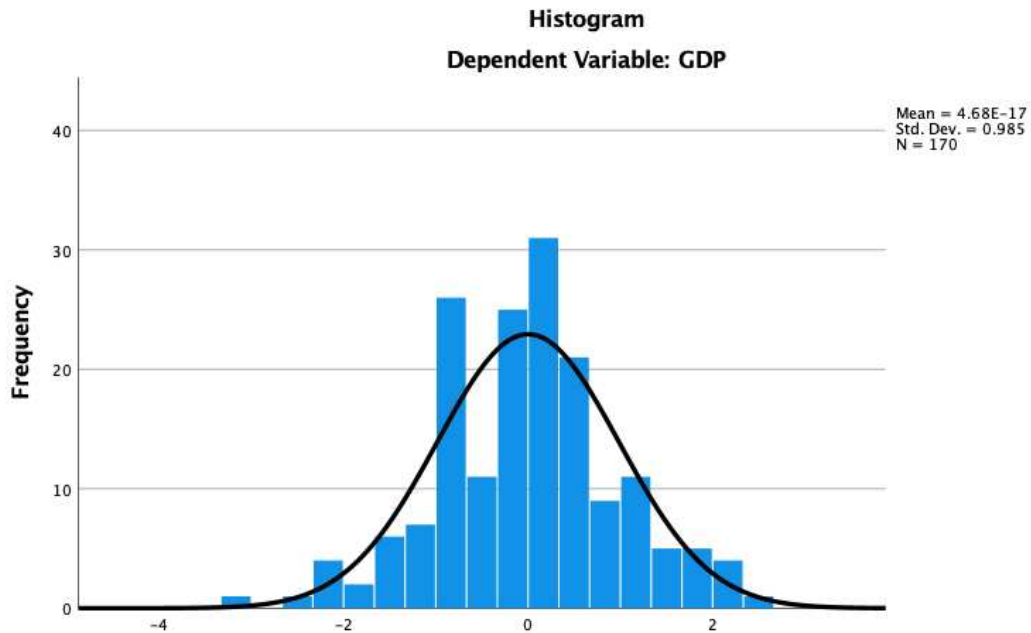


Figure 13: Regression Standardized Residual

The scatter does not exhibit any pattern. The assumption has been met because the scatter's width roughly stays the same as anticipated values rise.

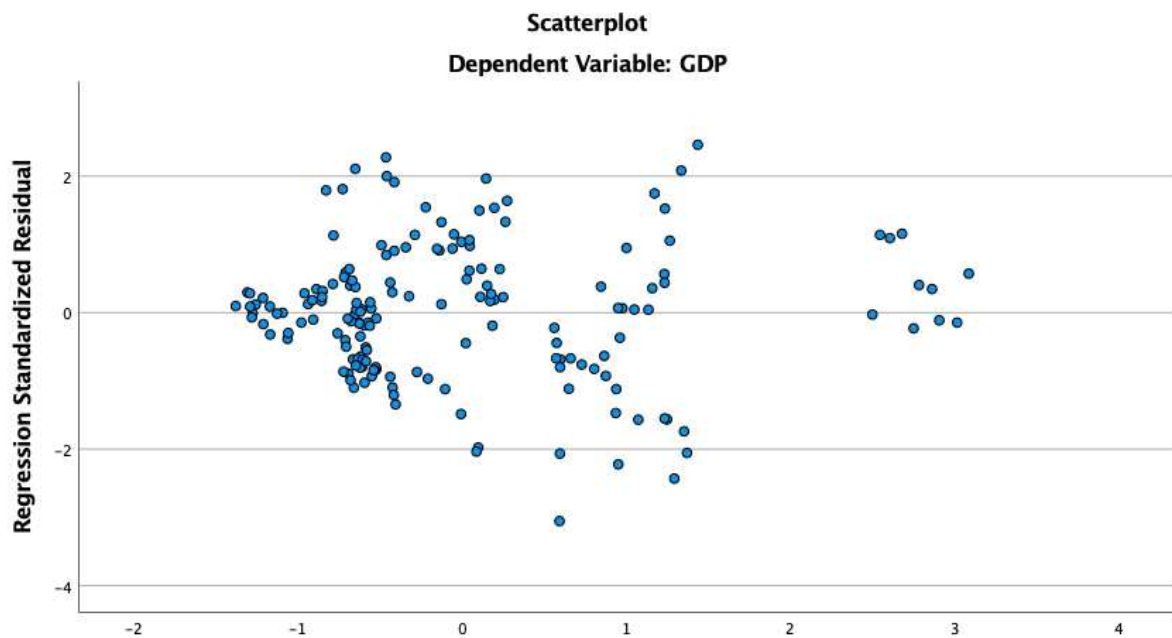


Figure 14: Regression Standardized Predicted Value

### 3.6.2. Interview takeaways

From the Interview I got the opportunity to have with Mlle Randa MRABAT Head of Product & commercial, I could highlight two key takeaways:

The first one is relative to the use of GDP as a measure of development:

A growing GDP is often seen as a measure of economic success. However, it fails to account for the multi-dimensional nature of development including but not limited to education, health, equality, equity, and sustainability. This is specifically impactful in SSA countries.

The Human Development Index would therefore be a superior measure of development. By considering indices across three dimensions—life expectancy, average years of education, and gross national income per capita—the HDI prioritizes individuals when assessing a nation's success.

The HDI offers a more comprehensive view of an economy that takes social development into account. Additionally, it shows that while social and economic development is related, one does not necessarily follow the other. Life expectancy at birth is used to evaluate the health component, while the education dimension is evaluated using the average number of years spent in school for 25-year-olds and the anticipated number of years spent in school for young children. The measure of the standard of living is the gross national product per person.

Despite being excellent, the HDI may hide widespread inequality because it doesn't consider factors like upholding individual liberties, environmental pollution, or gender disparity.

The Green GDP (GGDP), which measures the cost of environmental damage as a result of economic growth by deducting factors like resource depletion and environmental degradation from GDP and holds local governments responsible for ecological conservation, is another indicator that can be used in this situation. (Qi et al., 2021)

$$\text{GGDP} = \text{GDP} - \text{Cost R} - \text{Cost E} + \text{Save R-E}$$

Cost R: the expense of depleting natural resources

Cost E: the expense of deteriorating the environment.

Save R-E: advantage of improving the resource environment.

The drawback of this indicator is that local governments have been reluctant to use it as a substitute for GDP because they don't want environmental variables to distort their estimates of economic growth.

The second related to the challenges facing the installation of the mini grids:

In nations that do not differentiate between small-scale and utility-scale projects and consider mini-grids as competition to the national grid, there are fewer opportunities for developing smaller projects. Given that most rising nations will require hundreds of mini grids during the following few years, this argument is crucial. Licensing difficulties Off-grid project development is discouraged by time-consuming, expensive, and complex licensing processes for retail or production.

Africa lacks the regulations required to establish an efficient market for renewable energy technology due to a lack of laws, ineffective regulation enforcement, inadequate management of the energy industry, and a convoluted bureaucracy. Finally, the need for clarity surrounding grid expansion and the process for integrating current mini-grids when local grid expansion occurs may deter investors in mini-grid systems.

Sub-Saharan Africa has been more prepared for renewable energy over the past few years. However, the continent still trails behind other parts of the world regarding its legal and legislative frameworks.

Additionally, setting up a "one-stop shop" that issues all required permits over a project can lower bureaucratic barriers to obtaining the proper license. This strategy reduces the workload for governments and prevents duplication of effort.

Also, financial, and economic barriers: high finance costs, high transaction costs, a lack of long-term loans, and subsidies for traditional energy sources.

The lack of transmission and distribution infrastructure facilities and the equipment, skilled workers, and professionals needed by companies is a significant obstacle to developing renewable energy in most African countries.

Lastly, Africa has a high illiteracy rate. People who lack knowledge are likely unaware of the benefits of renewable energy or the harm that nonrenewable energy causes to the environment. The infrastructure and technological adoption of renewable energy in the area has slowed as a result.

### 3.6.2. Discussion

While moving towards a more sustainable energy system, several researchers have hypothesized that there might be a short-term detrimental association between these two variables.

This is because switching to more sustainable energy sources may, in the short term, involve sizable upfront investments and be more expensive than utilizing conventional fossil fuels. While a result, nations that are dependent on fossil fuels extensively and have rapid economic growth might see a brief decline in GDP while they switch to a more sustainable energy system.

On the other hand, there may be a long-term link between sustainable energy usage and economic expansion. This is so that we can reduce greenhouse gas emissions and lessen the effects of climate change. Sustainable energy sources like solar, wind, and hydropower can offer a stable and predictable source of energy that can support economic growth over the long term.

Overall, it is crucial to remember that the connection between sustainable energy use and GDP is complicated and is influenced by a variety of elements, including governmental regulations, technology improvements, and market conditions.

In general, a long-term positive link between GDP and sustainable energy usage is possible. This is because, over time, sustainable energy sources are frequently more affordable and dependable than conventional fossil fuels. For instance, recent technical developments have significantly increased the efficiency and cost-competitiveness of solar and wind power while also lowering their carbon footprint. This is also real when we know that fuel is a limited resource and will eventually not be available to use at some point in time, that is why a transition to green energy and sustainable resources is important to answer the needs of the growing population.

In addition, the transition to sustainable energy sources might open new business opportunities in sectors including clean energy production, energy efficiency, and transportation. These sectors can boost economic development, create new jobs, lower greenhouse gas emissions, and improve public health by reducing air pollution.

However, some nations may find it difficult to afford the short-term expenditures of making the switch to sustainable energy. For instance, developing nations may experience severe financial constraints and limited access to technology, which can make it challenging for them to invest in infrastructure for sustainable energy. Additionally, as they switch to more

sustainable methods, some sectors that depend on conventional fossil fuels may see employment losses or necessitate considerable reorganization.

Overall, there is a complicated and context-specific link between sustainable energy usage and GDP. While switching to sustainable energy sources may have some short-term expenses, the long-term advantages may surpass these costs and promote continued economic growth while also reducing the effects of climate change.

Lastly, it is important to note that in the case of SSA countries, it is not much of a choice but rather the only possible option available for the communities. Being in an urban center with proximity and availability to fuel is a luxury. To convey electricity to 'the last miles' utilizing the local energy resources is the solution for the lack of infrastructure and inaccessibility to national grids. By creating small independent units and strengthening the communities to be more self-reliant entrepreneurs, mini grids help improve the environment and encourages development in these regions.

In many areas of sub-Saharan Africa, where a sizable segment of the population still lacks access to modern energy services, access to energy is a serious concern. For that it is important to encourage the use of off-grid solutions because many villages in sub-Saharan Africa are not wired into the main energy system and might not have access to dependable power. Off-grid options including solar household systems, mini-grids, and distributed renewable energy systems can offer these communities safe, cost-effective electricity.

Increasing energy efficiency is also an important challenge as of today even when dependent on fossil fuel and non-renewable sources, increasing energy efficiency can assist to stretch the available energy resources further and cut down on energy expenditures by requiring less energy to provide the same level of service.

Achieving this can be done by taking steps in enhancing building insulation, utilizing energy-efficient equipment, implementing more productive industrial operations, and investing in energy infrastructure, such as transmission and distribution networks and power-producing facilities, which can help increase energy access and support regional economic growth. By offering incentives to investors, fostering public-private partnerships, and reducing the regulatory framework, governments can incentivize investments in energy infrastructure.

Also, SSA being different in resource profiles, enabling countries to exchange energy resources and infrastructure, regional energy integration can help to increase access to dependable and affordable energy. This can be accomplished by creating regional energy markets, coordinating

energy policy, and creating cross-border transmission networks. In addition to lowering greenhouse gas emissions and decreasing the effects of climate change, promoting the production and usage of renewable energy can aid in increasing energy availability in the area.

#### 4. Conclusion

Sub-Saharan Africa has a lot of potential for sources of renewable energy like solar, wind, hydro, and geothermal energy. It is essential for sustainable development to increase access to clean and affordable energy since it may increase economic productivity, improve healthcare and education, and stop environmental damage.

One of the major obstacles to Africa's sustainable development is the lack of access to safe and sustainable power. This can be explained by several challenges. The methods of current financing are not suitable for the project's requirements, lengthy procedures, undervaluation of costs, and underbidding of candidates. Africa will require more than ever reliable, and easily available energy supply as its population expands and its urbanization rate rises. To achieve sustainability, governments, civil society organizations, businesses, and international partners must work together. Supporting sustainable development efforts necessitates forming reliable alliances, exchanging skills, securing funding, and encouraging technology transfer.

Sub-Saharan Africa won't have universal access to power without significant structural changes. Significant progress must be made in terms of allocating resources, establishing programs, and their governance at the national level.

Africa's rapid urbanization creates both opportunities and difficulties for sustainability. Slums, poor infrastructure, pollution, and socioeconomic inequality are just a few of the problems that urban regions deal with. However, thoughtfully designed, and inclusive urban growth can advance service accessibility, green infrastructure, and resource efficiency. Sustainable cities can be developed in the area by incorporating sustainability into urban planning, investing in public transit, and fostering democratic government.

Technology advancements in fields like mobile payments, solar home systems, and smart mini grids open new possibilities for the widespread electrification of the African continent.

From our study we can conclude that for countries that rely largely on fossil fuels, the switch to sustainable energy sources may initially require large upfront investments and be more expensive resulting in a short-term drop in GDP.

However, using sustainable energy over the long term can promote economic growth and slow down climate change. Solar, wind, and hydropower are examples of sustainable energy sources that provide consistent and predictable energy that promotes economic expansion.

Although there is a chance for long-term benefits, the relationship between sustainable energy use and GDP is complicated and influenced by numerous factors. With time and technological improvements, sustainable energy sources become more cost-effective and dependable while becoming more and more competitive. However, making the move may be difficult for some countries due to technological and financial limits.

Despite these challenges, using sustainable energy can boost economic growth while lessening the effects of climate change and outweigh short-term expenses. Additionally, off-grid options like solar home systems and mini-grids can deliver affordable and dependable electricity in Sub-Saharan Africa, where many people lack access to modern energy services. Other vital initiatives for enhancing access to inexpensive and dependable energy, promoting economic growth, and lowering greenhouse gas emissions include increasing energy efficiency and regional energy integration.

Lastly, it is fair to mention that using GDP as a gauge of development: GDP falls short of capturing the multifaceted nature of development, which includes equality, sustainability, and health. The Green GDP (GGDP), which measures economic development while taking ecological protection into account, subtracts environmental costs from GDP. However, due to worries that it could skew predictions of economic growth, local governments are reluctant to adopt it.

The development of effective markets for renewable energy is hampered by inadequate rules, enforcement, and administrative barriers. To draw in investors, there needs to be clarity on grid expansion and the integration of mini grids during local grid expansion. In comparison to other regions, Sub-Saharan Africa lags in terms of legal and legislative frameworks.

Financial and economic constraints include high transaction and finance costs, a dearth of long-term loans, and subsidies for conventional energy sources. The development of renewable energy is hampered by a lack of professionals, competent laborers, and adequate transmission and distribution infrastructure.

Despite the worldwide energy crisis brought on by Russia's invasion of Ukraine in 2022, the demand for electricity around the world remained stable.

Globally, the electrification of the transportation and heating industries accelerated. Nevertheless, record-high energy prices hammered economies all over the world that were only just beginning to recover from the effects of COVID-19.

Power generation costs dramatically increased because of rising energy commodity prices, notably those for natural gas and coal, which also hastened the rise in inflation. In most parts of the world, economic slowdowns and high electricity costs restrained the rise of electricity consumption.

## Bibliography

- Adeoti, O., Oyewole, B.A., Adegboyega, T.D., 2001. Solar photovoltaic-based home electrification system for rural development in Nigeria: domestic load assessment. *Renewable Energy* 24, 155–161. [https://doi.org/10.1016/S0960-1481\(00\)00188-9](https://doi.org/10.1016/S0960-1481(00)00188-9)
- AfDB, A.D.B., 2018. Le New Deal pour l'énergie en Afrique.
- AfDB, A.D.B., 2016. AfDB Annual Report 2016 [WWW Document]. African Development Bank - Building today, a better Africa tomorrow. URL <https://www.afdb.org/en/documents/document/afdb-annual-report-2016-95954> (accessed 4.19.23).
- AfDB, A.D.B., 2015. AfDB Annual Report 2015 [WWW Document]. African Development Bank - Building today, a better Africa tomorrow. URL <https://www.afdb.org/en/documents/document/afdb-annual-report-2015-88761> (accessed 4.19.23).
- Africa Progress Report 2015 - Power, People, Planet: Seizing Africa's energy and climate opportunities - World | ReliefWeb [WWW Document], 2015. URL <https://reliefweb.int/report/world/africa-progress-report-2015-power-people-planet-seizing-africas-energy-and-climate> (accessed 4.19.23).
- Ahern, J., 2013. Urban landscape sustainability and resilience: the promise and challenges of integrating ecology with urban planning and design. *Landscape Ecol* 28, 1203–1212. <https://doi.org/10.1007/s10980-012-9799-z>
- Ahlborg, H., Boräng, F., Jagers, S.C., Söderholm, P., 2015. Provision of electricity to African households: The importance of democracy and institutional quality. *Energy Policy* 87, 125–135.
- Al-tal, R., Murshed, M., Ahmad, P., Alfar, A.J.K., Bassim, M., Elheddad, M., Nurmakhanova, M., Mahmood, H., 2021. The non-linear effects of energy efficiency gains on the incidence of energy poverty. *Sustainability (Switzerland)* 13. <https://doi.org/10.3390/su131911055>
- Amran, A., Ooi, S.K., Mydin, R.T., Devi, S.S., 2015. The Impact of Business Strategies on Online Sustainability Disclosures. *Business Strategy and the Environment* 24, 551–564. <https://doi.org/10.1002/bse.1837>
- AREI, 2016. A framework for transforming Africa towards a renewable energy powered future with access for all.
- Ashigho, T.G., 2016. Energy Poverty and trends in Sub-Saharan Africa (masterThesis).

- Awan, A., Abbasi, K.R., Rej, S., Bandyopadhyay, A., Lv, K., 2022. The impact of renewable energy, internet use and foreign direct investment on carbon dioxide emissions: A method of moments quantile analysis. *Renewable Energy* 189, 454–466.  
<https://doi.org/10.1016/j.renene.2022.03.017>
- Bazilian, M., Nakhoda, S., Van de Graaf, T., 2014. Energy governance and poverty. *Energy Research & Social Science* 1, 217–225. <https://doi.org/10.1016/j.erss.2014.03.006>
- Bina, O., 2013. The Green Economy and Sustainable Development: An Uneasy Balance? *Environ Plann C Gov Policy* 31, 1023–1047. <https://doi.org/10.1068/c1310j>
- Birol, F., 2007. Energy Economics: A Place for Energy Poverty in the Agenda? *The Energy Journal* Volume 28, 1–6.
- Bloomberg New Energy Finance, 2018. POWERING THE LAST BILLION, THE OUTLOOK FOR ENERGY ACCESS.
- Bouzarovski, S., 2014. Energy poverty in the European Union: landscapes of vulnerability. *WIREs Energy and Environment* 3, 276–289. <https://doi.org/10.1002/wene.89>
- Bruce, S., Stephenson, S., 2016. SDG 7 on Sustainable Energy for All: Contributions of International Law, Policy and Governance. *SSRN Journal*.  
<https://doi.org/10.2139/ssrn.2824835>
- Chakamera, C., Alagidede, P., 2018. Electricity crisis and the effect of CO2 emissions on infrastructure-growth nexus in Sub Saharan Africa. *Renewable and Sustainable Energy Reviews* 94, 945–958. <https://doi.org/10.1016/j.rser.2018.06.062>
- Dangelico, R.M., Pontrandolfo, P., 2015. Being ‘Green and Competitive’: The Impact of Environmental Actions and Collaborations on Firm Performance. *Business Strategy and the Environment* 24, 413–430. <https://doi.org/10.1002/bse.1828>
- Dertinger, A., Hirth, L., 2020. Reforming the electric power industry in developing economies evidence on efficiency and electricity access outcomes. *Energy Policy* 139, 111348. <https://doi.org/10.1016/j.enpol.2020.111348>
- Ebhota, W., Tabakov, P.Y., 2017. Hydropower Potentials and Effects of Poor Manufacturing Infrastructure on Small Hydropower Development in Sub-Saharan Africa. *International Journal of Energy Economics and Policy* 7, 60–67.
- ENGIE, 2022. AN INCLUSIVE AND SUSTAINABLE BUSINESS TO CLOSE THE ENERGY GAP IN AFRICA.
- ESMAP, 2020. Energy Sector Management Assistance Program (ESMAP) Annual Report 2020: Main Report (English) (Text/HTML).
- Fischetti, C., 2022. Energy Poverty and the Green Transition in Sub-Saharan Africa:

- Fortier, M.-O.P., Teron, L., Reames, T.G., Munardy, D.T., Sullivan, B.M., 2019. Introduction to evaluating energy justice across the life cycle: A social life cycle assessment approach. *Applied Energy* 236, 211–219.  
<https://doi.org/10.1016/j.apenergy.2018.11.022>
- Goldemberg, J., 2001. Energy and Human Well Being (Human Development Occasional Papers (1992-2007) No. HDOCPA-2001-02). Human Development Report Office (HDRO), United Nations Development Programme (UNDP).
- Gouda, S., Kerry, R.G., Das, G., Paramithiotis, S., Shin, H.-S., Patra, J.K., 2018. Revitalization of plant growth promoting rhizobacteria for sustainable development in agriculture. *Microbiological Research* 206, 131–140.  
<https://doi.org/10.1016/j.micres.2017.08.016>
- Grigoroudis, E., Kouikoglou, V.S., Phillis, Y.A., Kanellos, F.D., 2021. Energy sustainability: a definition and assessment model. *Oper Res Int J* 21, 1845–1885.  
<https://doi.org/10.1007/s12351-019-00492-2>
- Hernández, D., 2015. Sacrifice Along the Energy Continuum: A Call for Energy Justice. *Environmental Justice* 8, 151–156. <https://doi.org/10.1089/env.2015.0015>
- Ibrahiem, D.M., Hanafy, S.A., 2020. Dynamic linkages amongst ecological footprints, fossil fuel energy consumption and globalization: an empirical analysis. *Management of Environmental Quality: An International Journal* 31, 1549–1568.  
<https://doi.org/10.1108/MEQ-02-2020-0029>
- IEA, 2022. Africa Energy Outlook 2022.
- IEA, 2019. Africa Energy Outlook 2019.
- IEA, 2015. World Energy Outlook 2015.
- IEA, 2014. World Energy Outlook 2014.
- IEA, IRENA, UNSD, World Bank, WHO, 2022. TRACKING SDG7THE ENERGY PROGRESS REPORT 2022.
- IMF, 2022. World Economic Outlook, October 2022: Countering the Cost-of-Living Crisis.
- Institut Montaigne, 2020. Bright Perspectives for Solar Power in Africa.
- Iqbal, S., Chu, J., Hali, S.M., 2019. Projecting impact of CPEC on Pakistan’s electric power crisis. *Chinese Journal of Population Resources and Environment* 17, 310–321.  
<https://doi.org/10.1080/10042857.2019.1681879>
- IRENA, 2022. World Energy Transitions Outlook 2022: 1.5°C Pathway - Executive Summary.

- IRENA, 2019. Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables.
- IRENA, 2016. Solar PV in Africa: Costs and Markets.
- IRENA, 2015. Renewable Power Generation Costs in 2014.
- IRENA, 2014. Rethinking Energy: Towards a new power system.
- IRENA, I., 2023. Renewable Energy Roadmap: Nigeria.
- KLEOS ADVISORY LTD, 2020. The grid won't connect Africa, but solar can.
- Kohler, M., 2014. Differential electricity pricing and energy efficiency in South Africa. *Energy* 64, 524–532. <https://doi.org/10.1016/j.energy.2013.11.047>
- Kothari, R., Tyagi, V.V., Pathak, A., 2010. Waste-to-energy: A way from renewable energy sources to sustainable development. *Renewable and Sustainable Energy Reviews* 14, 3164–3170. <https://doi.org/10.1016/j.rser.2010.05.005>
- Kreith, F., Krumbieck, S., 2013. *Principles of Sustainable Energy Systems*, Second Edition. CRC Press.
- Lambert, A.J.D., Boons, F.A., 2002. Eco-industrial parks: stimulating sustainable development in mixed industrial parks. *Technovation* 22, 471–484. [https://doi.org/10.1016/S0166-4972\(01\)00040-2](https://doi.org/10.1016/S0166-4972(01)00040-2)
- Lathuilière, M.J., Coe, M.T., Castanho, A., Graesser, J., Johnson, M.S., 2018. Evaluating Water Use for Agricultural Intensification in Southern Amazonia Using the Water Footprint Sustainability Assessment. *Water* 10, 349. <https://doi.org/10.3390/w10040349>
- Le, T.-H., Nguyen, C.P., 2019. Is energy security a driver for economic growth? Evidence from a global sample. *Energy Policy* 129, 436–451. <https://doi.org/10.1016/j.enpol.2019.02.038>
- Lebbihiat, N., Atia, A., Arıcı, M., Meneceur, N., 2021. Geothermal energy use in Algeria: A review on the current status compared to the worldwide, utilization opportunities and countermeasures. *Journal of Cleaner Production* 302, 126950. <https://doi.org/10.1016/j.jclepro.2021.126950>
- Luke, T.W., 2005. Neither sustainable nor development: reconsidering sustainability in development. *Sustainable Development* 13, 228–238. <https://doi.org/10.1002/sd.284>
- Mayyas, A., Qattawi, A., Omar, M., Shan, D., 2012. Design for sustainability in automotive industry: A comprehensive review. *Renewable and Sustainable Energy Reviews* 16, 1845–1862. <https://doi.org/10.1016/j.rser.2012.01.012>

- Mebratu, D., 1998. Sustainability and sustainable development: Historical and conceptual review. *Environmental Impact Assessment Review* 18, 493–520.  
[https://doi.org/10.1016/S0195-9255\(98\)00019-5](https://doi.org/10.1016/S0195-9255(98)00019-5)
- Menyah, K., Wolde-Rufael, Y., 2010. CO<sub>2</sub> emissions, nuclear energy, renewable energy and economic growth in the US. *Energy Policy, The Role of Trust in Managing Uncertainties in the Transition to a Sustainable Energy Economy, Special Section with Regular Papers* 38, 2911–2915. <https://doi.org/10.1016/j.enpol.2010.01.024>
- Morelli, J., 2011. Environmental Sustainability: A Definition for Environmental Professionals. *JES* 1, 1–10. <https://doi.org/10.14448/jes.01.0002>
- Murshed, M., 2021. Modeling primary energy and electricity demands in Bangladesh: An Autoregressive distributed lag approach. *Sustainable Production and Consumption* 27, 698–712. <https://doi.org/10.1016/j.spc.2021.01.035>
- Murshed, M., Khan, S., Rahman, A.K.M.A., 2022. Roadmap for achieving energy sustainability in Sub-Saharan Africa: The mediating role of energy use efficiency. *Energy Reports* 8, 4535–4552. <https://doi.org/10.1016/j.egyr.2022.03.138>
- Ocal, O., Aslan, A., 2013. Renewable energy consumption–economic growth nexus in Turkey. *Renewable and Sustainable Energy Reviews* 28, 494–499.  
<https://doi.org/10.1016/j.rser.2013.08.036>
- Olawumi, T.O., Chan, D.W.M., 2018. A scientometric review of global research on sustainability and sustainable development. *Journal of Cleaner Production* 183, 231–250. <https://doi.org/10.1016/j.jclepro.2018.02.162>
- Panos, E., Turton, H., Densing, M., Volkart, K., 2015. Powering the growth of Sub-Saharan Africa: The Jazz and Symphony scenarios of World Energy Council. *Energy for Sustainable Development* 26, 14–33. <https://doi.org/10.1016/j.esd.2015.01.004>
- Pliousis, A., Andriosopoulos, K., Doumpos, M., Galariotis, E., 2019. A Multicriteria Assessment Approach to the Energy Trilemma. *EJ* 40.  
<https://doi.org/10.5547/01956574.40.SI1.apli>
- Qi, S., Huang, Z., Ji, L., 2021. Sustainable Development Based on Green GDP Accounting and Cloud Computing: A Case Study of Zhejiang Province. *Scientific Programming* 2021, e7953164. <https://doi.org/10.1155/2021/7953164>
- Quitow, R., Roehrkasten, S., Jacobs, D., Bayer, B., Jamea, E.M., Waweru, Y., Matschoss, P., 2016. The Future of Africa’s Energy Supply.
- Redclift, M., 2005. Sustainable development (1987–2005): an oxymoron comes of age. *Sustainable Development* 13, 212–227. <https://doi.org/10.1002/sd.281>

- Saint Akadiri, S., Alola, A.A., Akadiri, A.C., Alola, U.V., 2019. Renewable energy consumption in EU-28 countries: Policy toward pollution mitigation and economic sustainability. *Energy Policy* 132, 803–810.  
<https://doi.org/10.1016/j.enpol.2019.06.040>
- Santillo, D., 2007. Reclaiming the Definition of Sustainability (7 pp). *Env Sci Poll Res Int* 14, 60–66. <https://doi.org/10.1065/espr2007.01.375>
- Sartori, S., Latrónico, F., Campos, L.M.S., 2014. Sustainability and sustainable development: a taxonomy in the field of literature. *Ambient. soc.* 17, 01–22.
- Schroeder, P., Anggraeni, K., Weber, U., 2019. The Relevance of Circular Economy Practices to the Sustainable Development Goals. *Journal of Industrial Ecology* 23, 77–95. <https://doi.org/10.1111/jiec.12732>
- Shcherbina, E., Gorbenkova, E., Slepnev, M., 2017. Urban-planning sustainability problems in a city natural framework. *MATEC Web Conf.* 106, 01032.  
<https://doi.org/10.1051/matecconf/201710601032>
- Shirley, R., 2018. Millions of urban Africans still don't have electricity: here's what can be done. *The Conversation*.
- Siksnylyte-Butkiene, I., Streimikiene, D., Lekavicius, V., Balezentis, T., 2021. Energy poverty indicators: A systematic literature review and comprehensive analysis of integrity. *Sustainable Cities and Society* 67, 102756.  
<https://doi.org/10.1016/j.scs.2021.102756>
- Streimikiene, D., Lekavičius, V., Baležentis, T., Kyriakopoulos, G.L., Abrhám, J., 2020. Climate Change Mitigation Policies Targeting Households and Addressing Energy Poverty in European Union. *Energies* 13, 3389. <https://doi.org/10.3390/en13133389>
- Suárez-Eiroa, B., Fernández, E., Méndez-Martínez, G., Soto-Oñate, D., 2019. Operational principles of circular economy for sustainable development: Linking theory and practice. *Journal of Cleaner Production* 214, 952–961.  
<https://doi.org/10.1016/j.jclepro.2018.12.271>
- Trimble, C.P., Kojima, M., Perez Arroyo, I., Mohammadzadeh, F., 2016. Financial Viability of Electricity Sectors in Sub-Saharan Africa: Quasi-Fiscal Deficits and Hidden Costs.
- Tvaronavičienė, M., Mačiulis, A., Lankauskienė, T., Raudeliūnienė, J., Dzemyda, I., 2015. Energy security and sustainable competitiveness of industry development. *Economic Research-Ekonomska Istraživanja* 28, 502–515.  
<https://doi.org/10.1080/1331677X.2015.1082435>
- UN, U.N., 2017. Atlas of Africa Energy Resources. UNEP - UN Environment Programme.

- UNDP (Ed.), 2022. Uncertain times, unsettled lives: shaping our future in a transforming world, Human development report. United Nations Development Programme, New York, NY.
- UNIDO, 2009. Scaling up Renewable Energy in Africa.
- Villavicencio Calzadilla, P., Mauger, R., 2018. The UN's new sustainable development agenda and renewable energy: the challenge to reach SDG7 while achieving energy justice. *Journal of Energy & Natural Resources Law* 36, 233–254.  
<https://doi.org/10.1080/02646811.2017.1377951>
- Wang, K., Wang, Y.-X., Li, K., Wei, Y.-M., 2015. Energy poverty in China: An index based comprehensive evaluation. *Renewable and Sustainable Energy Reviews* 47, 308–323.  
<https://doi.org/10.1016/j.rser.2015.03.041>
- Wanner, T., 2015. The New 'Passive Revolution' of the Green Economy and Growth Discourse: Maintaining the 'Sustainable Development' of Neoliberal Capitalism. *New Political Economy* 20, 21–41. <https://doi.org/10.1080/13563467.2013.866081>
- Wilson Van Voorhis, C.R., Morgan, B.L., 2007. Understanding Power and Rules of Thumb for Determining Sample Sizes. *TQMP* 3, 43–50.  
<https://doi.org/10.20982/tqmp.03.2.p043>
- World Bank, 2022. Annual Report 2022.

**Online sources:**

[www.africanews.com](http://www.africanews.com)  
[www.dashboards.sdgindex.org](http://www.dashboards.sdgindex.org)  
[www.energy.ec.europa.eu](http://www.energy.ec.europa.eu)  
[www.engie.com](http://www.engie.com)  
[www.gogla.org](http://www.gogla.org)  
[www.indicators.report](http://www.indicators.report)  
[www.irena.org](http://www.irena.org)  
[www.isolaralliance.org](http://www.isolaralliance.org)  
[www.seforall.org](http://www.seforall.org)  
[www.usaid.gov](http://www.usaid.gov)  
[www.unsdsn.org](http://www.unsdsn.org)  
[www.weforum.org](http://www.weforum.org)

## List of Figures

Figure 1: National target for electrification (Bloomberg New Energy Finance, 2018).....	7
Figure 2: Primary indicators of global progress toward the SDG 7 targets (IEA et al., 2022).....	10
Figure 3: Population with access to electricity 2020. ....	14
Figure 4: Renewable Energy Capacity In Africa (2014)(Quitow et al., 2016).....	16
Figure 5: Funding from a variety of African and international sources supports a range of enabling activities and leverages investments in renewable energy infrastructure projects.(AREI, 2016) .....	20
Figure 6: People gaining access to electricity by technology by 2030 in the SAS(IEA, 2022) .....	22
Figure 7: Renewable energy consumption (World Bank 2016) .....	26
Figure 9: IRENA’s innovation landscape for integrating renewable energy ((IRENA, 2019) .....	29
Figure 10: Net Imports of food and Fuel as a share of GDP in African countries, 2020 (IEA, 2022)..	31
Figure 11: Ranges by renewable power generation technology, 2014 to 2025 (IRENA, 2015) .....	33
Figure 12: ENGIE business model (Engie fact sheet 2021) .....	45
Figure 13: ENGIE’s integrated business model in action .....	46
Figure 14: Regression Standardized Residual .....	52
Figure 15: Regression Standardized Predicted Value .....	52
Figure 16: Engie impact as of Oct 2022 (ENGIE, 2022) .....	69
Figure 17: Business model application to the UN’s Sustainable Development Goals (ENGIE, 2022)	70

## List of Table

Table 1: The state of electrification in Africa 2013 (UN, 2017) .....	13
Table 2: Oil in SSA countries.....	44
Table 3: Model Summary, Multivariable Regression.....	50
Table 4: ANOVA Table Multivariable Regression .....	50
Table 5: Coefficients table Multivariable Regression .....	51

## Appendix

### Interview transcript

- 1. What is your relevance in Africa?

The company is a rare player, providing different tailored solutions both off-grid / mini-grid and Pas as you go.

Off-grid communities need long-term commitment and skill to bring permanent transformation. We meet consumers where they are and assist them in climbing the energy ladder through fair pricing plans paid in installments using mobile money, ranging from simple solar lighting equipment to mini grids powering entire towns.

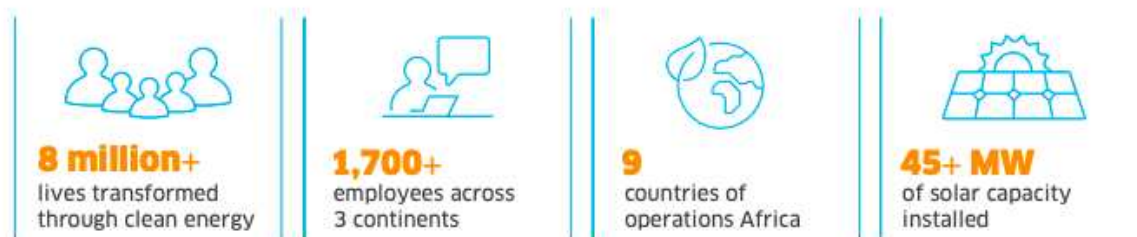


Figure 15: Engie impact as of Oct 2022 (ENGIE, 2022)

Solar Home Systems: MySol, a Paygo Solar Home Systems line, focuses on customer-centric design and innovation.

Mini-grids: MySol Grid, our mini-grid solution, is ideal for tying together thousands of clients in rural areas. By allowing for the productive use of electricity and creating commercial opportunities for entrepreneurs in rural areas, it promotes economic development.

Software: Our cutting-edge, in-house platform Paygee enables business owners to launch a Pay-As-You-Go (PAYGo) company and manage last-mile delivery for any goods globally while providing real visibility on customer behavior.

- 2. What is your role as a mediator between the government's sustainability plans and the people?

Engie is not an NGO, and the company's priority is ensuring its sustainability in time. Engie answers the calls for tenders usually received from World Bank or French Development

Agency. These organizations typically sponsor energy development projects and electrification in Africa.

If selected, the company should either have an open possibility to target a location in SSA to electrify or, in some cases, choose from a list of regions with the most critical demand.

- 3. What countries are you targeting with your projects? And why?

Economic development potential is crucial in choosing which project and region to start electrification. Installing Mini grids can be challenging, regardless of the legal aspect of it; the technical and natural specificities of the SSA regions add more limitations to the infrastructure. Hence, while choosing a village, it is crucial to pick the one with the most growth potential, with schools, small businesses, and other centers needing electricity to function better.

The company works on a scope covering 10 SDGs and adapts its impact according to the region's needs.



Figure 16: Business model application to the UN's Sustainable Development Goals (ENGIE, 2022)

- 4. What type of solar energy system would you recommend for these countries and why?

First, in the continent, solar is the most available renewable and sustainable energy source.

In Engie, we work with different technologies that answer different customer needs.

Our mini-grid solution targets small villages and can produce enough energy to cover their needs. They are often seen as a competition to the national grid. Hence, making the implementation at times complicated depending on the legislation in some countries.

We also have home systems, a type of KIT that can be installed in a couple of hours, but the transformative capacity is relatively low, enough to cover the needs of one only household.

So, depending on our target and the region's needs, we will choose an adaptable solution.

- 5. Can development be achieved without the need for sustainable energy?

Development is often seen as economical only, which is not the case.

Yes, access to electricity can help with economic growth, but if it is done with polluting agents like diesel causing fatalities and lung problems in the community.

Therefore, clean energy is essential to fulfill proper development.

- 6. Is sustainable energy the answer for African countries' needs, knowing that some of them are exporters of nonreusable energy?

The world is currently going through a fossil energy crisis. The war in Ukraine and Covid aftermath are still impacting African communities.

Usually, the political environment in the continent is unstable, and there are considerable discrepancies in wealth distribution. With, even if the country has some good fuel resources, the population doesn't benefit from it, and with limited purchasing power, a solution, even if available, is not always accessible either because of money or infrastructure (need of travel to get some fuel). Engie's goal is to provide power to the 'last mile,' meaning people disconnected from accessibility.

Data Input

Coutry	Years	GDP / capita US\$	Share of renewable energy consumption in energy mix in	CO2 emmission metric ton / capita	energy imports %	HDI	Inflation in %	electricity prices	Unemployment rate in %	Population
Ethiopia	2016	705.62	90.49%	0.14	6.29%	0.47	6.63%	9.03	0.00	105293228
	2015	630.31	91.56%	0.13	6.11%	0.46	9.57%	8.47	0.00	102471895
	2014	557.53	91.25%	0.12	5.93%	0.45	6.89%	7.73	0.00	99746766
	2013	490.79	92.49%	0.10	5.59%	0.44	7.46%	7.23	2.25	97084366
	2012	458.55	93.30%	0.09	4.95%	0.43	23.60%	6.73	0.00	94451280
	2011	348.00	93.56%	0.08	4.94%	0.42	33.25%	5.45	0.00	91817929
	2010	335.44	94.11%	0.07	4.57%	0.41	8.15%	4.09	0.00	89237791
	2009	373.89	94.18%	0.08	4.79%	0.40	8.48%	3.77	0.00	86755585
Ghana	2018	320.86	94.09%	0.08	4.84%	0.39	44.36%	2.61	0.00	84357105
	2018	2180.04	41.48%	0.61	-41.68%	0.62	7.81%	21.25	0.00	30870641
	2017	1998.74	44.43%	0.56	-33.31%	0.62	12.37%	19.71	3.37	30222262
	2016	1900.41	45.22%	0.54	-24.94%	0.61	17.45%	17.54	0.00	29554303
	2015	1711.29	44.02%	0.55	-16.57%	0.61	17.15%	14.93	6.81	28870939
	2014	1942.91	47.69%	0.54	-8.19%	0.60	15.49%	12.75	0.00	28196358
	2013	2282.35	46.19%	0.57	-7.49%	0.59	11.67%	11.04	2.17	27525597
	2012	1536.59	46.50%	0.54	2.88%	0.59	11.19%	9.88	0.00	26858762
	2011	1501.08	50.09%	0.45	5.31%	0.58	8.73%	8.89	0.00	26205941
	2010	1258.95	51.91%	0.44	45.91%	0.57	10.73%	8.17	5.38	25574719
Zambia	2009	1043.98	51.90%	0.40	44.88%	0.57	19.25%	6.86	0.00	24950762
	2008	1178.93	57.34%	0.36	42.05%	0.56	16.49%	5.88	0.00	24326087
	2018	1475.20	82.28%	0.43	10.69%	0.57	7.49%	19.31	5.03	17835893
	2017	1495.75	81.89%	0.39	10.21%	0.57	6.58%	18.48	8.52	17298054
	2016	1249.92	83.07%	0.32	9.73%	0.57	17.87%	17.59	0.00	16767761
	2015	1307.91	83.09%	0.31	9.25%	0.56	10.11%	16.83	0.00	16248230
	2014	1724.58	83.77%	0.30	8.77%	0.56	7.81%	16.18	0.00	15737793
	2013	1840.32	84.56%	0.28	8.29%	0.55	6.98%	15.66	0.00	15234976
	2012	1729.65	84.63%	0.27	6.78%	0.54	6.58%	15.12	7.85	14744658
	2011	1644.46	87.28%	0.21	6.39%	0.54	6.43%	14.24	0.00	14265814
Kenya	2010	1469.36	88.59%	0.19	4.77%	0.53	8.50%	13.35	13.19	13792086
	2009	1150.94	88.68%	0.19	5.01%	0.52	13.40%	12.19	0.00	13318087
	2008	1393.52	89.36%	0.17	5.89%	0.51	12.45%	11.08	7.93	12852966
	2018	1845.78	72.47%	0.35	17.58%	0.58	4.69%	26.72	0.00	49953304
	2017	1675.97	71.30%	0.39	17.47%	0.57	8.01%	25.52	0.00	48948137
	2016	1562.08	70.94%	0.40	17.37%	0.57	6.30%	23.63	2.76	47894670
	2015	1496.65	72.04%	0.37	17.27%	0.56	6.58%	22.23	0.00	46851488
	2014	1489.92	74.95%	0.33	17.17%	0.56	6.88%	20.86	0.00	45831863
	2013	1376.83	76.73%	0.31	18.14%	0.55	5.72%	19.52	0.00	44792368
	2012	1289.78	78.71%	0.28	16.99%	0.55	9.38%	18.46	0.00	43725806
Kenya	2011	1099.32	77.31%	0.31	18.71%	0.55	14.02%	16.88	0.00	42635144
	2010	1093.64	76.50%	0.30	19.22%	0.55	3.96%	14.80	0.00	41517895
	2009	1049.12	78.35%	0.29	18.70%	0.54	9.23%	13.55	9.60	40364444
	2008	916.00	80.64%	0.25	16.56%	0.53	26.24%	10.73	0.00	39186895

Coutry	Years	GDP / capita US\$	Share of renewable energy consumption in energy mix in	CO2 emmission metric ton / capita	energy imports %	HDI	Inflation in %	electricity prices	Unemployment rate in %	Population
Senegal	2018	1484.24	36.15%	0.65	52.39%	0.51	0.46%	16.36	3.57	15574909
	2017	1385.20	37.93%	0.65	52.46%	0.51	1.32%	16.28	4.08	15157793
	2016	1290.75	36.72%	0.69	52.54%	0.51	0.84%	16.07	4.46	14751356
	2015	1238.13	39.11%	0.65	52.62%	0.51	0.14%	15.94	6.76	14356181
	2014	1417.10	42.53%	0.61	52.69%	0.50	-1.09%	15.92	0.00	13970308
	2013	1391.53	42.69%	0.59	51.17%	0.49	0.71%	16.09	0.00	13595566
	2012	1334.73	49.60%	0.56	44.91%	0.48	1.42%	15.98	0.00	13231833
	2011	1383.54	47.97%	0.59	46.66%	0.48	3.40%	15.76	10.36	12875880
	2010	1286.60	49.55%	0.56	45.52%	0.47	1.23%	15.24	0.00	12530121
	2009	1323.97	51.31%	0.55	44.12%	0.46	-2.25%	15.59	0.00	12195029
2008	1419.53	39.81%	0.54	53.15%	0.45	7.35%	14.52	0.00	11872929	
Cabo Verde	2018	3442.74	22.93%	1.07	-43.00%	0.67	1.26%	28.20	12.17	571202
	2017	3132.62	22.87%	1.04	-44.45%	0.67	0.78%	27.85	12.24	564954
	2016	2978.20	24.62%	0.98	-45.90%	0.67	-1.41%	27.63	0.00	558394
	2015	2891.88	26.35%	0.91	-47.35%	0.66	0.13%	28.03	31.31	552166
	2014	3405.93	26.11%	0.92	-48.80%	0.66	-0.24%	27.99	0.00	546076
	2013	3427.18	25.94%	0.94	-48.13%	0.66	1.51%	28.06	0.00	539940
	2012	3262.65	24.26%	0.99	-51.57%	0.65	2.54%	27.64	0.00	533864
	2011	3537.14	20.78%	1.08	-54.58%	0.65	4.47%	26.96	0.00	527521
	2010	3192.39	21.22%	1.04	-58.18%	0.64	2.08%	25.80	10.67	521212
	2009	3292.50	22.08%	0.99	-55.22%	0.64	0.99%	25.55	0.00	515638
2008	3503.51	23.81%	0.94	-57.50%	0.63	6.77%	23.93	0.00	510336	
Mozambique	2018	504.54	79.57%	0.24	-75.48%	0.45	3.91%	12.00	0.00	29423878
	2017	462.70	78.90%	0.25	-70.26%	0.45	15.11%	11.55	0.00	28569441
	2016	430.99	78.20%	0.26	-65.04%	0.44	17.42%	10.03	0.00	27696493
	2015	594.23	80.80%	0.21	-59.82%	0.44	3.55%	8.54	3.43	26843246
	2014	680.38	81.92%	0.19	-54.60%	0.43	2.56%	8.25	0.00	26038704
	2013	672.20	83.73%	0.17	-53.48%	0.42	4.26%	8.04	0.00	25251731
	2012	667.72	85.15%	0.15	-50.85%	0.42	2.60%	7.71	0.00	24487611
	2011	605.27	85.97%	0.14	-24.98%	0.41	11.17%	7.52	0.00	23760421
	2010	481.27	84.89%	0.12	-22.55%	0.40	12.43%	6.76	0.00	23073723
	2009	531.03	86.12%	0.11	-22.17%	0.39	3.79%	6.52	0.00	22436660
2008	574.77	88.11%	0.10	-23.28%	0.38	14.50%	6.28	0.00	21845571	
Cote d'Ivoire	2018	2275.50	62.99%	0.40	19.51%	0.54	0.36%	13.41	0.00	25493988
	2017	2076.15	62.54%	0.42	16.40%	0.53	0.69%	13.36	3.27	24848016
	2016	1980.88	64.04%	0.40	13.29%	0.52	0.72%	13.27	1.90	24213622
	2015	1941.57	64.51%	0.42	10.18%	0.51	1.25%	13.18	0.00	23596741
	2014	2124.02	71.91%	0.40	7.08%	0.51	0.45%	13.01	0.00	22995555
	2013	1903.05	72.16%	0.39	4.60%	0.50	2.58%	12.96	4.25	22469268
	2012	1649.30	74.90%	0.37	1.13%	0.49	1.30%	12.63	7.22	22010712
	2011	1701.70	79.11%	0.28	-5.45%	0.48	4.91%	12.47	0.00	21562914
	2010	1654.18	75.42%	0.30	-9.86%	0.47	1.23%	11.88	0.00	21120042
	2009	1638.80	73.71%	0.29	-15.42%	0.47	1.02%	11.76	0.00	20677762
2008	1683.34	74.21%	0.32	-11.56%	0.47	0.06%	11.76	0.00	20244449	

Country	Years	GDP / capita US\$	Share of renewable energy consumption in energy mix in	CO2 emission metric ton / capita	energy imports %	HDI	Inflation in %	electricity prices	Unemployment rate in %	Population
Nigeria	2017	1941.88	82.32%	0.56	-87.04%	0.53	16.52%	7.36	8.39	193495907
	2016	2144.78	82.02%	0.59	-89.04%	0.52	15.68%	6.31	7.06	188666931
	2015	2679.55	82.15%	0.59	-91.03%	0.52	9.01%	5.46	4.31	183995785
	2014	3200.95	80.64%	0.64	-93.03%	0.51	8.06%	5.01	4.56	179379016
	2013	2976.76	82.19%	0.62	-90.58%	0.50	8.48%	4.63	3.71	174726123
	2012	2728.02	84.57%	0.56	-99.14%	0.50	12.22%	4.27	0.00	170075932
	2011	2504.88	84.63%	0.57	-104.39%	0.49	10.84%	3.81	3.77	165463745
	2010	2280.11	86.46%	0.56	-111.90%	0.48	13.72%	3.38	0.00	160952853
	2009	1883.89	88.68%	0.49	-102.35%	0.48	12.55%	3.35	0.00	156595758
2008	2227.79	86.25%	0.57	-104.99%	0.48	11.58%	3.33	0.00	152382506	
Cameroon	2018	1594.06	79.25%	0.38	-16.90%	0.58	1.07%	16.29	0.00	25076747
	2017	1479.86	79.17%	0.38	-19.75%	0.57	0.64%	16.12	0.00	24393181
	2016	1426.07	78.78%	0.38	-22.61%	0.57	0.86%	16.01	0.00	23711630
	2015	1399.68	78.06%	0.37	-25.46%	0.56	2.69%	15.88	0.00	23012646
	2014	1631.71	76.79%	0.37	-28.32%	0.55	1.83%	15.46	3.53	22299585
	2013	1559.14	77.60%	0.35	-22.82%	0.54	2.06%	15.18	0.00	21632850
	2012	1433.72	78.53%	0.33	-21.17%	0.53	2.74%	14.88	0.00	21032684
	2011	1497.93	78.61%	0.33	-21.29%	0.52	2.94%	14.48	0.00	20448873
	2010	1383.81	78.76%	0.35	-20.65%	0.51	1.28%	14.07	4.11	19878036
2009	1445.86	79.25%	0.36	-27.93%	0.51	3.04%	13.65	0.00	19319274	
2008	1476.01	80.82%	0.34	-45.46%	0.50	0.05%	13.64	0.00	18777081	
Rwanda	2018	769.44	84.50%	0.10	-43.00%	0.53	-0.31%	22.97	10.76	12531808
	2017	756.55	85.98%	0.10	-44.45%	0.52	8.28%	23.04	11.88	12230339
	2016	728.43	86.23%	0.10	-45.90%	0.52	7.17%	21.28	0.00	11930899
	2015	733.44	86.31%	0.08	-47.35%	0.52	2.53%	19.85	0.00	11642959
	2014	724.35	87.95%	0.08	-48.80%	0.51	2.35%	19.36	1.17	11368451
	2013	704.06	88.47%	0.07	-48.13%	0.50	5.92%	18.92	0.00	11101350
	2012	705.76	88.78%	0.07	-51.57%	0.50	10.27%	17.86	0.00	10840334
	2011	650.60	89.64%	0.06	-54.58%	0.49	3.08%	16.19	0.00	10576932
	2010	593.80	90.66%	0.06	-58.18%	0.49	-0.25%	14.57	0.00	10309031
2009	564.69	90.54%	0.06	-55.22%	0.47	12.94%	13.15	0.00	10043737	
2008	529.26	90.63%	0.06	-57.50%	0.46	15.44%	11.03	0.00	9781996	
Zimbabwe	2018	2269.18	80.23%	0.82	26.44%	0.60	10.62%	19.31	0.00	15052184
	2017	1192.11	82.46%	0.70	24.22%	0.60	0.89%	18.48	0.00	14751101
	2016	1421.79	81.90%	0.76	21.99%	0.59	-1.54%	17.59	0.00	14452704
	2015	1410.33	80.82%	0.88	19.00%	0.58	-2.43%	16.83	0.00	14154937
	2014	1407.03	80.27%	0.87	17.54%	0.57	-0.20%	16.18	4.77	13855753
	2013	1408.37	78.87%	0.91	15.31%	0.55	1.63%	15.66	0.00	13555422
	2012	1290.19	77.50%	0.91	13.31%	0.54	3.73%	15.12	0.00	13265331
	2011	1082.62	79.27%	0.88	10.65%	0.53	3.47%	14.24	5.37	13025785
	2010	937.84	82.27%	0.75	4.59%	0.51	3.02%	13.35	0.00	12839771
2009	762.30	82.09%	0.61	3.82%	0.51	2.56%	12.19	0.00	12679810	
2008	351.84	81.86%	0.61	4.17%	0.50	2.09%	11.08	0.00	12550347	

Country	Years	GDP / capita US\$	Share of renewable energy consumption in energy mix in	CO2 emission metric ton / capita	energy imports %	HDI	Inflation in %	electricity prices	Unemployment rate in %	Population
Congo, Dem. Rep.	2018	546.21	96.38%	0.04	5.57%	0.48	6.49%	22.38	0.00	87087355
	2017	451.09	96.70%	0.03	4.67%	0.47	4.69%	21.02	0.00	84283273
	2016	456.03	97.03%	0.03	3.77%	0.47	2.89%	20.08	0.00	81430977
	2015	482.06	95.82%	0.04	2.86%	0.46	0.74%	19.51	0.00	78656904
	2014	472.27	92.87%	0.07	1.96%	0.46	1.24%	19.37	0.00	76035588
	2013	444.86	93.92%	0.05	0.22%	0.45	0.81%	19.13	0.00	73460021
	2012	412.78	95.47%	0.04	-1.55%	0.44	9.72%	18.98	4.49	70997870
	2011	376.37	96.21%	0.04	-2.12%	0.44	15.32%	17.30	0.00	68654269
	2010	324.83	96.81%	0.04	-2.87%	0.43	7.10%	15.00	0.00	66391257
	2009	290.16	97.02%	0.04	-3.44%	0.42	2.80%	14.59	0.00	64270232
2008	317.89	96.97%	0.04	-3.46%	0.42	17.30%	12.44	0.00	62249724	
Tanzania	2018	1010.94	85.24%	0.21	15.20%	0.54	3.49%	19.31	0.00	58090443
	2017	976.21	84.92%	0.21	14.42%	0.53	5.32%	18.48	0.00	56267032
	2016	942.47	85.70%	0.21	13.64%	0.53	5.17%	17.59	0.00	54401802
	2015	928.81	84.62%	0.22	12.85%	0.52	5.59%	16.83	0.00	52542823
	2014	1012.77	85.37%	0.21	12.07%	0.51	6.13%	16.18	2.12	50814552
	2013	955.22	85.39%	0.22	11.29%	0.51	7.87%	15.66	2.93	49253643
	2012	854.54	86.15%	0.21	11.22%	0.50	16.00%	15.12	0.29	47786137
	2011	768.93	88.47%	0.18	9.12%	0.50	12.69%	14.24	3.47	46416031
	2010	730.81	89.73%	0.15	7.52%	0.49	6.20%	13.35	1.65	45110527
	2009	681.24	90.92%	0.13	6.55%	0.48	12.14%	12.19	2.50	43957933
2008	671.57	90.31%	0.14	7.37%	0.47	10.28%	11.08	0.00	42870884	
Uganda	2018	793.13	90.07%	0.14	-43.00%	0.52	2.62%	19.31	0.00	41515395
	2017	766.18	90.76%	0.13	-44.45%	0.52	5.21%	18.48	3.64	40127085
	2016	753.68	90.83%	0.13	-45.90%	0.52	5.71%	17.59	0.00	38748299
	2015	864.18	91.07%	0.13	-47.35%	0.52	5.59%	16.83	0.00	37477356
	2014	897.51	91.84%	0.11	-48.80%	0.51	3.08%	16.18	0.00	36336539
	2013	819.76	92.55%	0.10	-48.13%	0.51	4.91%	15.66	1.91	35273570
	2012	796.71	92.95%	0.11	-51.57%	0.51	12.68%	15.12	3.55	34273295
	2011	837.10	92.79%	0.11	-54.58%	0.51	16.56%	14.24	0.00	33295738
	2010	824.74	93.18%	0.10	-58.18%	0.50	3.98%	13.35	0.00	32341728
	2009	799.93	93.87%	0.11	-55.22%	0.49	13.02%	12.19	3.60	31412520
2008	473.30	93.73%	0.10	-57.50%	0.48	12.05%	11.08	0.00	30509862	
Madagascar	2018	512.54	83.74%	0.12	-43.00%	0.51	8.59%	44.94	0.00	26846541
	2017	503.50	81.32%	0.13	-44.45%	0.51	8.61%	41.38	0.00	26169542
	2016	464.62	83.85%	0.12	-45.90%	0.51	6.04%	38.10	0.00	25501941
	2015	455.64	80.55%	0.13	-47.35%	0.50	7.40%	35.94	1.79	24850912
	2014	517.14	80.12%	0.12	-48.80%	0.50	6.08%	33.46	0.00	24215976
	2013	526.69	81.17%	0.12	-48.13%	0.50	5.83%	31.54	0.00	23588073
	2012	504.17	83.40%	0.12	-51.57%	0.50	5.71%	29.80	0.60	22966240
	2011	516.90	84.60%	0.10	-54.58%	0.49	9.48%	28.19	0.00	22348158
	2010	459.38	86.66%	0.09	-58.18%	0.49	9.25%	25.75	4.28	21731053
	2009	455.41	87.07%	0.08	-55.22%	0.49	8.95%	23.63	0.00	21117092
2008	522.83	86.14%	0.09	-57.50%	0.48	9.30%	21.62	0.00	20513599	

Country	Years	GDP / capita US\$	Share of renewable energy consumption in energy mix in	CO2 emission metric ton / capita	energy imports %	HDI	Inflation in %	electricity prices	Unemployment rate in %	Population
Malawi	2017	500.17	75.94%	0.07	-44.45%	0.50	11.54%	11.98	3.54	17881167
	2016	312.14	78.69%	0.06	-45.90%	0.50	21.71%	10.74	0.00	17405624
	2015	376.25	80.87%	0.05	-47.35%	0.49	21.87%	8.82	0.00	16938942
	2014	367.02	82.70%	0.05	-48.80%	0.48	23.79%	7.24	0.00	16477966
	2013	344.40	79.68%	0.06	-48.13%	0.48	27.28%	5.85	4.98	16024775
	2012	386.91	80.11%	0.06	-51.57%	0.47	21.27%	4.59	0.00	15581251
	2011	528.45	80.17%	0.06	-54.58%	0.46	7.62%	3.79	1.74	15146094
	2010	472.85	81.21%	0.06	-58.18%	0.46	7.41%	3.52	0.00	14718422
	2009	432.98	80.01%	0.07	-55.22%	0.45	8.42%	3.52	0.00	14298932
	2008	383.10	80.39%	0.07	-57.50%	0.44	8.71%	3.52	0.00	13889423