ATLAS OF AFRICA ENERGY RESOURCES

AFRICAN DEVELOPMENT BANK GROUP

ICA The Infrastructure Consortium for Africa

SUSTAINABLE ENERGY FUND AFRICA

UN environment United Nations Environment Programme

BACK OF COVER

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Low energy supply, complete with shortages, high costs and poor access, remains major impediments to Africa's social and economic progress. The African Union's Agenda 2063 commits to fast-tracking modern, efficient, reliable and cost effective renewable energy for all households, businesses, industries and institutions. To support this, in 2016, the African Development Bank approved its New Deal on Energy for Africa, which aspires to achieving universal access to energy by 2025, using the latest off-grid and technology solutions. This atlas illustrates the incredible transformation ahead.

Universal access requires large financial investments. By some estimates, Africa needs $43-55 billion per year until 2030-2040, compared to current energy investments of about $8-9.2 billion. To achieve close that gap, an improved understanding of energy availability, distribution and limitations is one of many crucial needs. In response, the African Development Bank, Sustainable Energy Fund for Africa and the Infrastructure Consortium for Africa, worked with UN Environment have produced this Atlas of Africa Energy Resources.

The atlas compiles and synthesizes regional and national information. It presents the scale and distribution of energy resources, production and consumption trends, as well as the existing potential for environmentally sustainable expansion.

Communities are at the forefront of sustainable energy in Africa. In Kajiado County in Kenya's Rift Valley, the Maasai women are leading a solar-power revolution. A local organization trains the women to install solar products in homes and villages and to market the products within the community. In only seven months, solar energy use rose from zero to 20 per cent in the area. Now, children can study by solar light after nightfall and teenagers can sleep indoors instead of guarding livestock from predators. The economic, social and environmental benefits to the community are tremendous. These include savings on the cost of kerosene, less exposure to harmful indoor smoke and fewer trees cut down in their surroundings. Women are now more empowered and have taken ownership of the technology.

The African nations understand the complexities of the progress needed to deliver the Agenda 2063. They are simultaneously moving forward with economic development, while working towards the Sustainable Development Goals and the targets of the Paris Agreement on Climate Change.

This Atlas will stimulate decision makers, planners, investors, energy experts, businesses and citizens to take actions to achieve sustainable, modern and affordable energy for all in Africa.

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Background

Africa is rich in energy resources but poor in its capability to exploit and use them. Many African countries face an energy crisis. Power is inaccessible, unaffordable and unreliable for most people, trapping them in poverty. There are solutions, however, including the following: significant investment in energy infrastructure; technology transfers; improving access to electricity on a large scale; boosting cross-border power trade; improving the performance of existing utility companies; and helping countries chart low-carbon growth paths. Understanding where the opportunities for tapping this wealth exist and where shortages occur is fundamental to developing these solutions, but until now, this kind of information has not been readily available all in one place.

Objective of this Atlas

There currently exist several good sources of information on Africa's energy at the continental scale and a wealth of data at the national level. However, there is need for a document that compiles and synthesizes relevant data and information in a format that is easily understandable to both the public and policy makers. To fill this gap, the African Development Bank (AfDB) and the Infrastructure Consortium for Africa (ICA), in cooperation with the United Nations Environment Programme (UNEP) have developed an *ATLAS OF AFRICA ENERGY RESOURCES* to graphically illustrate where the resources are, where the potential for expansion occurs and what the possible impacts on the environment could be. It provides visual information on the challenges and opportunities to providing Africa's population with access to reliable, affordable and modern energy services. Through maps, charts and images, this Atlas combines scientifically reliable data sources to provide a complete view of Africa's energy needs, resources and opportunities. Comparative satellite images illustrate the positive and negative changes that have taken place over the years to help policy-makers reach better- informed decisions.

Process for the Atlas Production

Extensive research was undertaken to compile and analyze information from various energy databases; global, regional and national reports; and web sites. Historical and current satellite images of relevant places were selected and analyzed using Geographic Information Systems (GIS) technology.

A number of experts continent-wide were involved and consultation meetings were organized to seek input from national experts, academics, international organizations and officials of regional power pools as well as from the African Power Utility Association. An intensive review process was undertaken to ensure quality control and scientific validity of the Atlas.

Scope of the Atlas

The content of the Atlas is organized in five chapters:

1. ENERGY RESOURCES OF AFRICA

This chapter presents the various energy resources that are available in Africa and shows production and consumption trends at the continental level. It takes stock of renewable and non-renewable energy reserves and links them with aspects of current and projected demand and production of energy at both continental and regional levels.

Key Messages

- Africa has the world's lowest per capita energy consumption: with 16 per cent of the world's population (1.18 billion out of 7.35 billion populations), it consumes about 3.3 per cent of global primary energy.
- At the end of 2015, Africa had about 7.6 per cent of the world's proven oil reserves.
- Africa's produces 9.1 per cent of total global oil production and accounts for 4.2 per cent of total global oil consumption.
- Africa has 7.5 per cent of the world's proved natural gas reserves; it produces about 6 per cent and consumes about 3.9 per cent of global reserves, respectively.
- Of all energy sources, Africa consumes most oil (42 per cent of its total energy consumption) followed by gas (28 per cent), coal (22 per cent), hydro (6 per cent), renewable energy (1 per cent) and nuclear (1 per cent).
- South Africa is the world's seventh largest coal producer and accounts for 94 per cent of Africa's coal production.

- Africa's renewable energy resources are diverse, unevenly distributed and enormous in quantity — almost unlimited solar potential (10 TW), abundant hydro (350 GW), wind (110 GW) and geothermal energy sources (15 GW).
- Energy from biomass accounts for more than 30 per cent of the energy consumed in Africa and more than 80 per cent in many sub-Saharan African countries.
- Sub-Saharan Africa has undiscovered, but technically recoverable, energy resources estimated at about 115.34 billion barrels of oil and 21.05 trillion cubic metres of gas.

2. ENERGY AND CROSS CUTTING ISSUES

Energy is required for all human endeavours. But its production and everyday use has profound impacts on the environment and human society. This chapter illustrates the interlinkages between energy and the environment, demographic trends, gender issues and economic growth, and the impacts of energy use and development on human health as well as the cross-cutting issues related to energy and transportation and agriculture.

Key Messages

- Rapid development in energy infrastructure is key for future economic growth, poverty reduction and access to affordable energy for all, however, energy installations can have important impacts on ecosystems and their goods and services. Africa's natural wealth and magnificent wildlife need to be protected.
- Africa contributes just 3.3 per cent of global energy-related CO_2 emissions but will suffer disproportionately from climate change impacts.
- Climate change is likely to exacerbate drought and affect the availability of biomass and hydropower for energy.
- Population growth and rapid urbanization will increase the use of inefficient fuels for cooking and lighting.
- More women than men suffer from energy poverty.
- Expensive transport fuel contributes to making the cost of transporting goods in Africa among the highest in the world; by 2050, however, its transport fuel consumption is expected to double.
- The agriculture sector uses only about 6 Mtoe of energy, which is very low by world standards.
- Human muscle power is still the dominant energy source in African agriculture; in sub-Saharan Africa, it represents 80 per cent of the initial energy used to prepare land for agriculture.
- An average of only 34 per cent of hospitals and 28 per cent of health facilities in sub-Saharan Africa have reliable electricity access; about 58 per cent of health care facilities in sub Saharan African countries have no electricity at all.
- Nearly 60 per cent of refrigerators used in health clinics in Africa have unreliable electricity, compromising the safe storage of vaccines and medicines; half of vaccines are ruined due to lack of refrigeration.
- Indoor pollution from biomass cooking — a task usually carried out by women — will soon kill more people than malaria and HIV/AIDS combined.

3. REGIONAL ENERGY INTEGRATION AND MARKETS

Considering the small size of many of the economies of African countries, regional energy integration is extremely important to attract investment, for the security of energy supply and mix and to reduce the cost of doing business (economies of scale) and costs to consumers. Regional energy generation provides an optimal economic solution to generating and using energy, because energy is produced where it is most economical and supported, and is provided where it is most highly needed. Power pools are also important because power trade is an indicator of energy integration; power pools themselves are key drivers of regional integration; there is high political commitment to regional energy markets; and regional energy integration through power pools is a prerequisite for sustainable development. This chapter looks at the current status of Africa's regional power pools, including the installed capacity and energy mix, future demand, power trade, and their institutional arrangements. Sections are devoted to describing and providing key information about each of the 5 regional power pools.

Key Messages

- Regional energy integration through power pools is a prerequisite for Sustainable Development.
- There is a high political commitment to regional energy markets, hence power pools are important.
- Considering the small size of many of the economies of African countries, regional energy integration is extremely important to attract investment, for security of energy supply and mix, and to reduce the cost of doing business (economies of scale) and costs to consumers.
- Regional energy generation provides an optimal economic solution to energy production and consumption, because energy is generated where it is most economical and supported and provided where it is most highly needed.
- Power trade is an indicator of energy integration, thus power pools themselves are key drivers of regional integration.
- In a full energy integration scenario, power pools would save US$43 billion per year by 2040.

4. ENERGY AND SUSTAINABLE DEVELOPMENT

This chapter looks at the energy components of high-level African-led strategies for future development of the continent. In May 2013, the Organization of African Union (OAU), now the African Union (AU), celebrated its Golden Jubilee. It reaffirmed its Pan-African vision of "an integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the international arena." Summit leaders asked the African Union Commission (AUC), supported by the New Partnership for Africa's Development (NEPAD) Planning and Coordinating Agency (NPCA), the African Development Bank (AfDB) and the United Nations Economic Commission for Africa (UNECA), to engage in a people-driven process to prepare a 50-year continental agenda.

The African Union's Agenda 2063 and its priority areas have inspired a number of initiatives to stimulate Africa's access to energy. One of them is the Africa Power Vision (APV), based on the Programme for Infrastructure Development in Africa (PIDA). PIDA is the continent's framework to close Africa's vast infrastructure gap across transport, energy and water sectors as well as Information and Communication Technologies. The African Heads of State unanimously endorsed PIDA at their Summit in 2012. The Africa Power Vision is a long-term plan to increase access to reliable and affordable energy. Its main aim is to drive and rapidly accelerate the implementation of critical energy projects in Africa under PIDA.

The Africa Renewable Energy Initiative (AREI) is another transformative, Africa-led effort to accelerate the exploitation of the continent's huge renewable energy potential. Under the AU's mandate and endorsed by African Heads of State, it aims to achieve at least 10 gigawatts (GW) of new renewable energy generation capacity by 2020 and to realize the continent's potential to generate at least 300 GW by 2030.

Likewise, in 2016, the African Development Bank approved its energy strategy, mainly based on the Bank's new initiative — the New Deal on Energy for Africa (NDEA). The NDEA has an aspirational overarching goal of achieving universal access by 2025.

The chapter also provides information about the commitments African nations have made towards energy for sustainable development. One of the main outcomes of the 2012 Rio+20 United Nations Conference on Sustainable Development was a new set of Sustainable Development Goals (SDGs), agreed upon in September 2015. Out of 17 goals, Goal 7 focuses on ensuring "access to affordable, reliable, sustainable and modern energy for all". Furthermore there are also energy related commitments under the Paris Agreement on Climate Change. This chapter highlights key messages and synergies between the overarching continental initiatives as well as the issues related to the SDGs and the Paris Agreement.

Key messages

- Rapid population and economic growth are important drivers that increase demand for energy in Africa. Sustainable Energy for All (SE4ALL) is a necessary pre-condition for sustainable development.
- Over 645 million people do not have access to electricity. Of the world's 20 countries with the least access to electricity, thirteen are in Africa, including Nigeria, Ethiopia, Democratic Republic of the Congo (DRC), Tanzania, Kenya, Uganda, (the former) Sudan, Mozambique, Madagascar, Niger, Malawi, Burkina Faso, and Angola.
- Africa uses more renewable energy than any other of the world's regions, deriving as much as 70 per cent of its energy consumption from renewable sources. One of the reasons, however, is its heavy reliance on traditional uses of biomass by both households and industry. It is estimated that 4 out of 5 rely on solid biomass, mainly fuelwood and charcoal for cooking.
- At the continental level, population growth still outpaces the increase in access to non-solid fuels; the population increased by 48 million but only 9 million gained access.
- The poorest African households spend 20 times more per unit of energy than wealthy households when connected to the grid.
- With current trends, it will take Africa until 2080 to achieve full access to electricity.
- Although Africa's per capita energy consumption is the lowest in the world, it is one of the most energy intensive regions, obtaining little economic output from its modest energy use.
- By some estimates, an investment of about US$43-55 billion per year is needed until 2030-2040 to meet demand and provide universal access to electricity, whereas currently, investment in the energy sector is about US$8-9.2 billion.
- Africa's enormous renewable energy potential remains untapped. It is estimated that around 93 per cent of economically feasible hydropower potential remains unused.
- Key continental programs and initiatives, such as the Program for Infrastructure Development in Africa (PIDA), the New Deal on Energy for Africa and the Africa Renewable Energy Initiative (AREI) provide good opportunities for investments.

5. ENERGY PROFILES OF THE COUNTRIES

The energy policy landscape in Africa's countries is rapidly evolving. This chapter presents an energy profile of each one of the 54 African countries, supplying specific information on their energy sectors. These profiles enable a better understanding of the energy resources available, the production and consumption trends and the potential for renewable alternatives. It describes each of the energy resources in the country, specifically hydropower, oil, natural gas, coal, wind, nuclear, and solar energy resources, as the case may be. It also presents some of the strategies and practices in place to effectively and efficiently use these resources.

Carbon dioxide emissions from the energy sector are recognized as a key factor contributing to climate change. To that end, the chapter mentions some of the pledges that the countries have made through their Intended Nationally Determined Contributions (INDCs) arising from the 2015 Paris Agreement. It gives a snapshot of progress towards achieving Sustainable Development Goal (SDG) number 7 on energy, with progress towards achieving this goal measured against three indicators, as follows:

- To ensure universal access to affordable, reliable and modern energy services by 2030;
- To increase substantially the share of renewable energy in the global energy mix by 2030; and
- To double the rate of improvement in energy efficiency by 2030.

Finally, based on available data, the profiles provide a matrix showing institutional and legal frameworks responsible for policy in the country, the energy regulator and some of the key elements that lay the foundation for managing the energy sector.

In conclusion Africa needs significant investment in energy infrastructure; technology transfers; improving access to electricity on a large scale; boosting cross-border power trade; improving the performance of existing utility companies; and helping countries chart low-carbon growth paths.

1

ENERGY RESOURCES OF AFRICA

Key messages

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- Sub-Saharan Africa has undiscovered, but technically recoverable, energy resources estimated at about 115.34 billion barrels of oil and 21.05 trillion cubic metres of gas.

Introduction

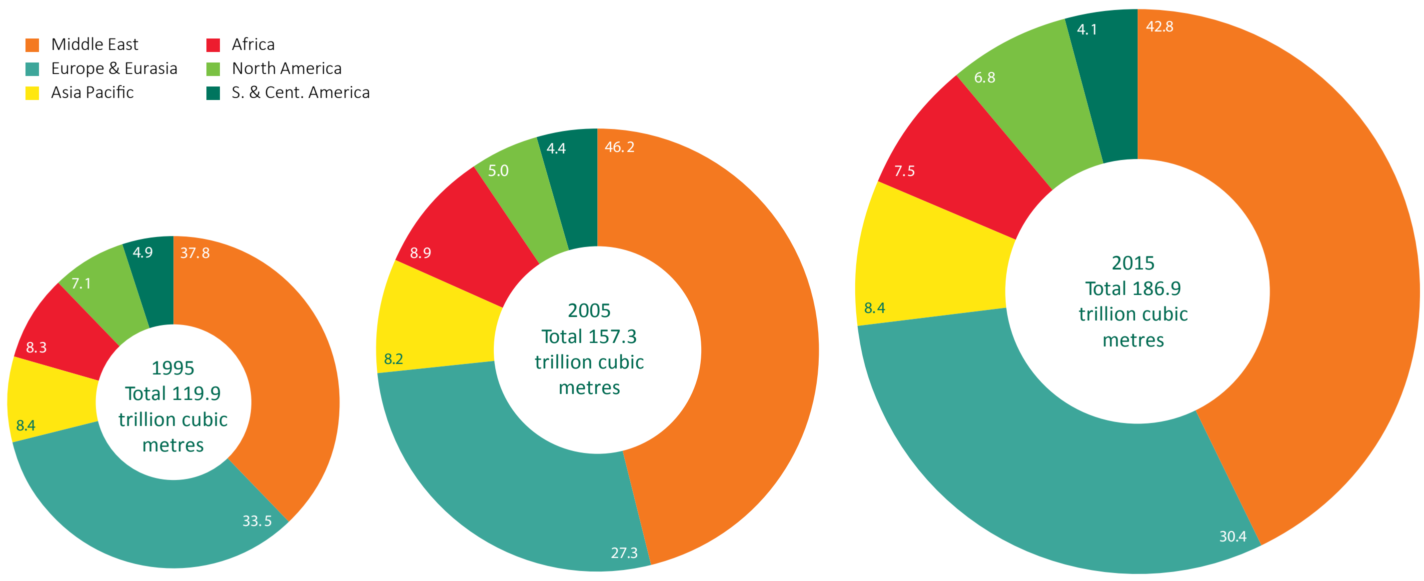
This chapter presents the various energy resources that are available in Africa and shows production and consumption trends. It takes stock of renewable and non-renewable energy reserves and links them with aspects of current and projected demand and production of energy at both continental and regional levels. This report uses data from reliable and authoritative sources, but alerts readers to the fact that nevertheless, published estimates often vary from source to source.

In the global context, Africa has 7.5 per cent of the world's proved gas reserves, 7.6 per cent of its proved oil reserves and 3.6 per cent of global coal reserves (of which South Africa alone accounts for 3.4 per cent) (BP, 2016) (Figures 1-3).

On the other hand, the amount of energy Africa uses remains extremely low. According to 2015 statistics, although Africa has 16 per cent of the world's population (1.18 billion out of a total 7.35 billion), it only consumes about 3.3 per cent of global primary energy (BP, 2016). It produces 9.1 per cent of the world's oil and consumes 4.2 per cent of it; its production of natural gas represents 6 per cent of the world total and it consumes 3.9 per cent ; and its coal production is 4 per cent while consumption is 2.5 per cent of the

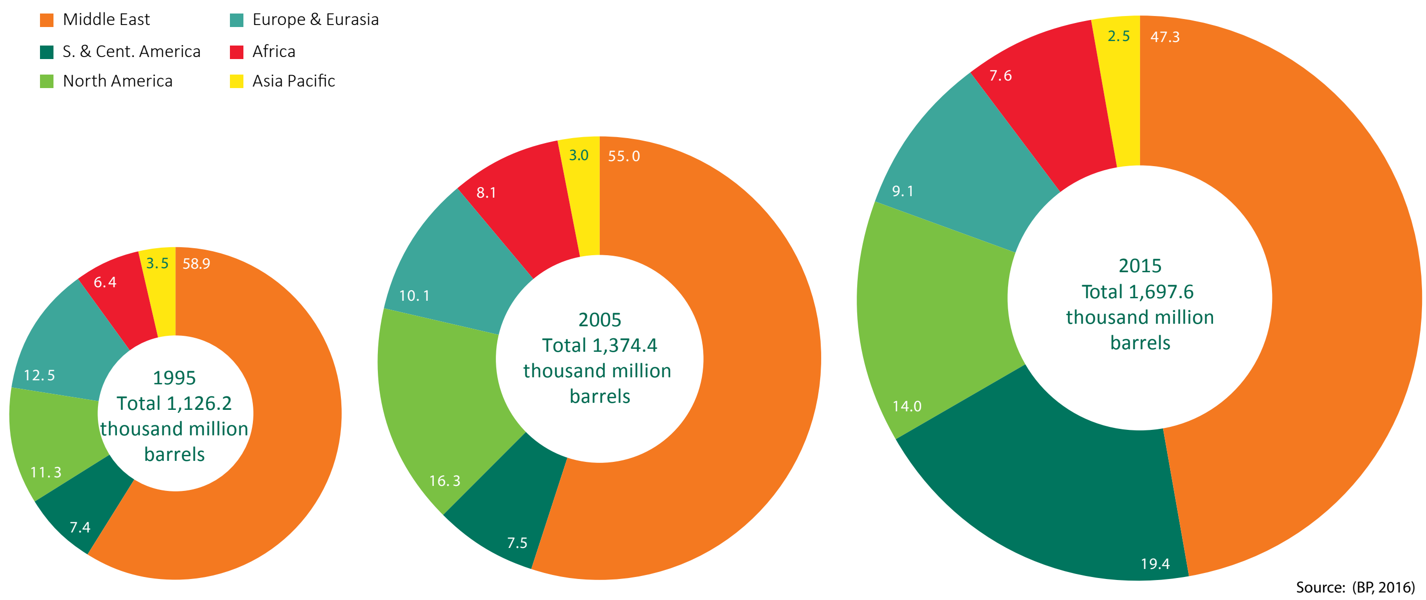
Opposite photo: Riccardo Annandale/ www.unsplash.com

Figure 1: Global distribution of proved natural gas reserves (percentage), 1995, 2005 and 2015



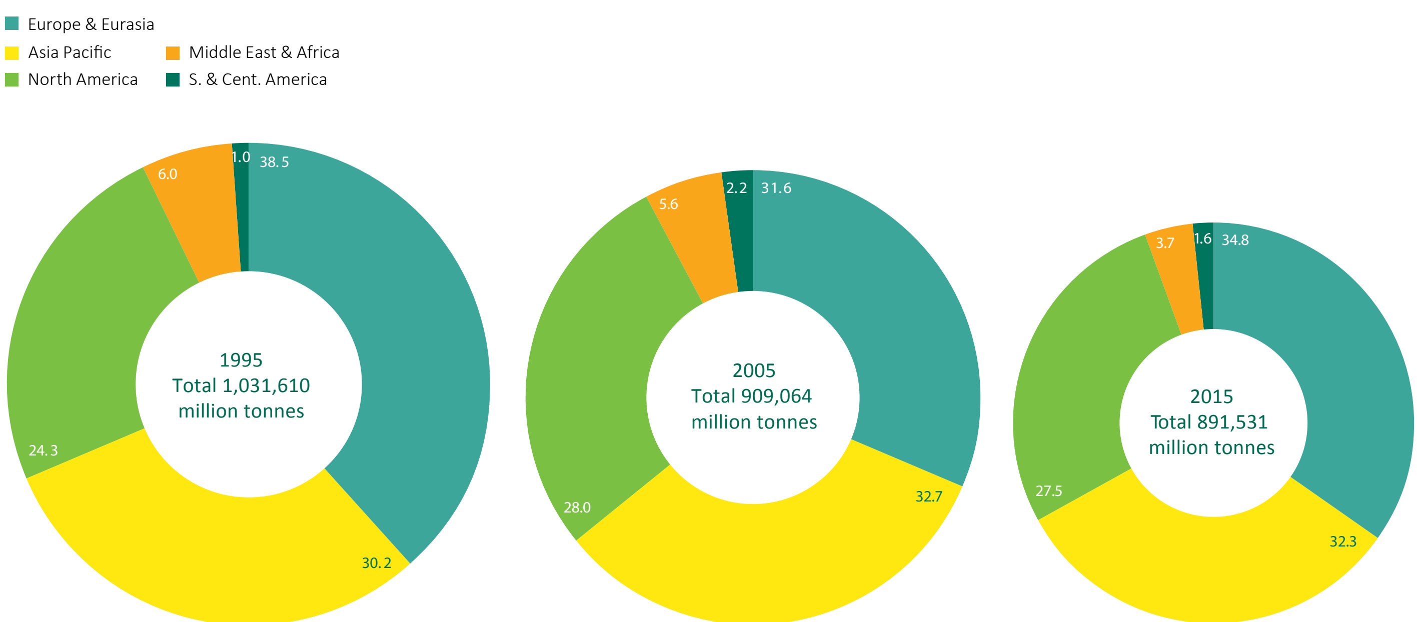
Source: (BP, 2016)

Figure 2: Global distribution of proved oil reserves (percentage), 1995, 2005 and 2015



Source: (BP, 2016)

Figure 3: Global distribution of proved coal reserves (percentage), 1995, 2005 and 2015



Source: (BP, 2016)

global total. Of the world's total consumption of other energy resources, it consumes 0.4 per cent of nuclear energy, 3 per cent of hydroelectricity and 1 per cent of other renewable energies. Africa remains a key net energy exporter, accounting for 8 per cent of global gas exports and 10 per cent of global oil exports.

A comparison between Africa and other continents highlights the low levels of installed power generation capacity per capita and per unit of Gross Domestic Product (GDP), as shown in Table 1.

Table 1: Generation capacity per capita and per unit of GDP, Africa and the rest of the world

Continent	Capacity per capita (MW/million population)	Capacity per unit of GDP (MW/$US billion of GDP)
Africa	123	106
Asia	3,600	121
Latin America	515	60
Eastern Europe/Cent. Asia	1,078	144

Source: (AfDB, 2014)

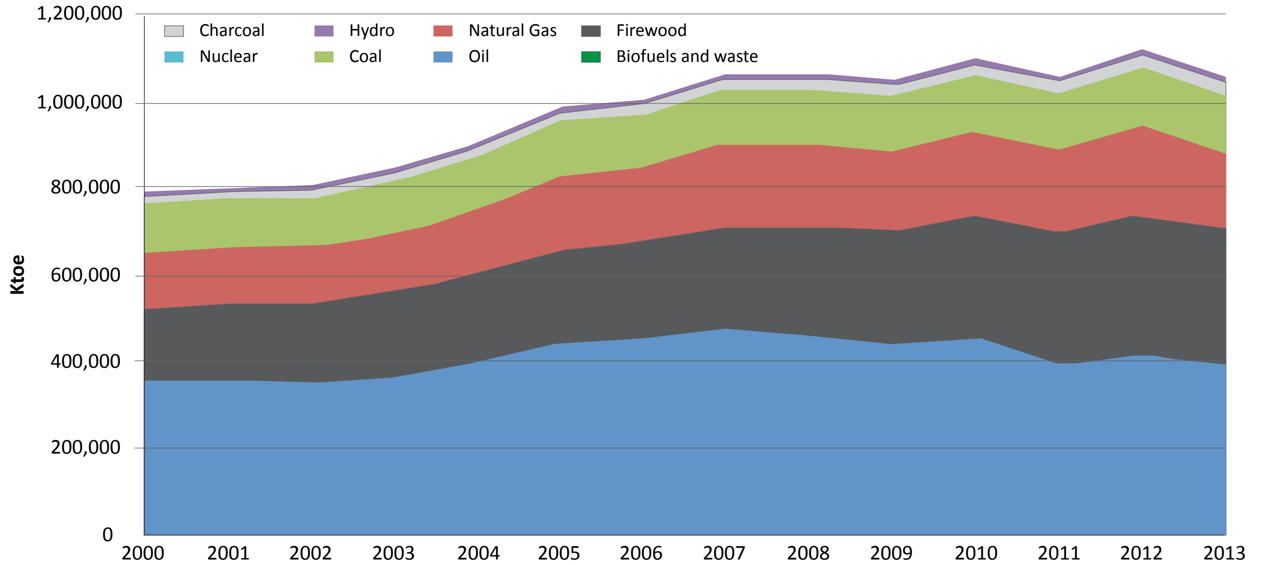
Overview of Production and Consumption

Energy supply

Power generation from various sources has increased in Africa in recent years (AfDB, 2014) (Figure 4). The total primary energy supply (TPES) of Africa has been increasing at an annual rate of about 3 per cent , the highest among all continents (IRENA, 2015a), although current production still remains highly insufficient to meet demand.

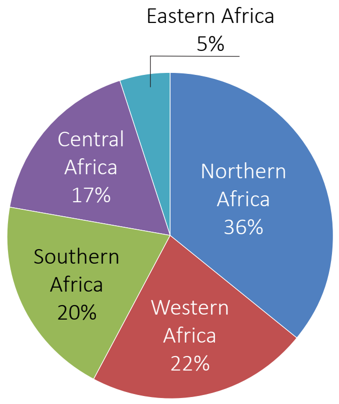
Africa's current energy needs are met through a mix of biomass and fossil fuels. Biomass accounts for approximately half of Africa's total primary energy supply. Of fossil fuels, oil accounts for 42 per cent , while coal and natural gas account for about 22 and 28 per cent , respectively. Hydropower represents about 1 per cent of the total primary energy supply in Africa (BP, 2016) (Figure 5). Figure 6 shows energy supply by region. Table 2 and Figures 7-9 illustrate the predominance of thermal energy generation and electricity generation by region.

Figure 4: Africa's total primary energy supply, by fuel (ktoe), 2000-2013



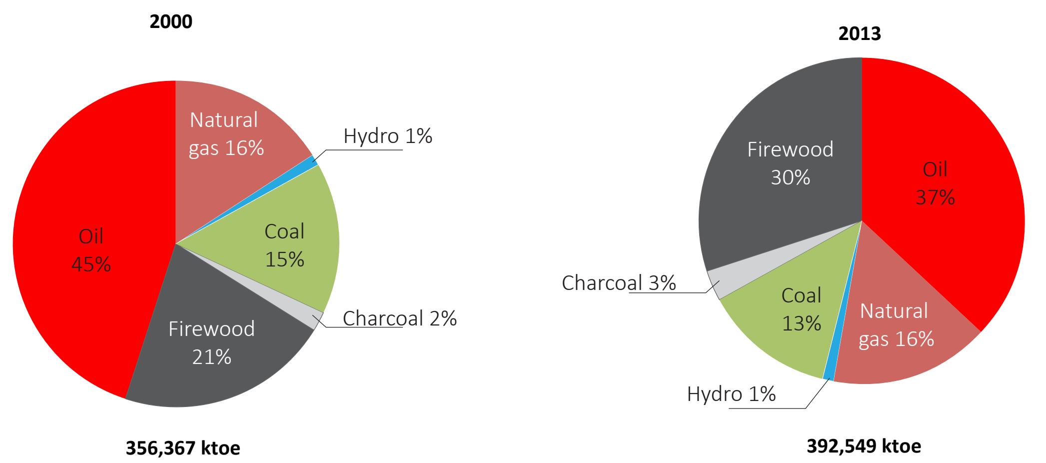
Source: (AFREC, 2015)

Figure 6: Regional shares of TPES, 2013



Source: (AFREC, 2015)

Figure 5: Africa's fuel shares of Total Primary Energy Supply (TPES), 2000 and 2013



Source: (AFREC, 2015)

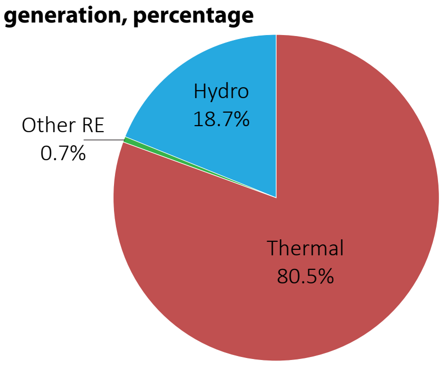
Energy generation

Table 2: Africa's existing installed generation capacity, in MW (plants> 50 MW)

Plant Type	Installed Capacity
Thermal	100,939
Hydro	24,273
Other	906
Total Africa	125,318

Source: (AfDB, 2014)

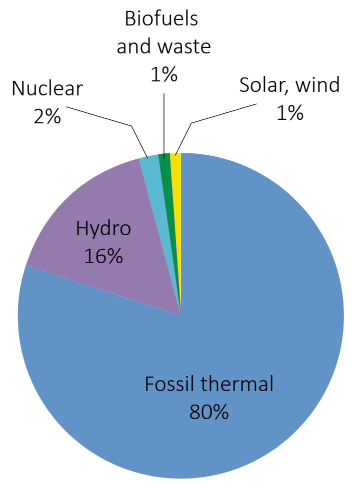
Figure 9: Technological mix of energy generation, percentage



Source: (AfDB, 2014)

Electricity generation

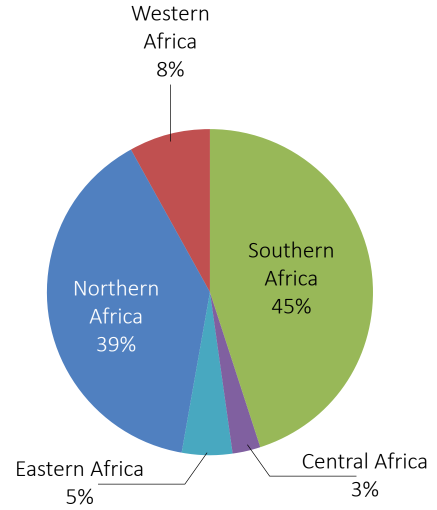
Figure 7: Fuel shares of electricity generation, 2013



* Electricity generation in 2013 was 570,678 GWh

Source: (AFREC, 2015)

Figure 8: Regional shares of electricity generation, 2013



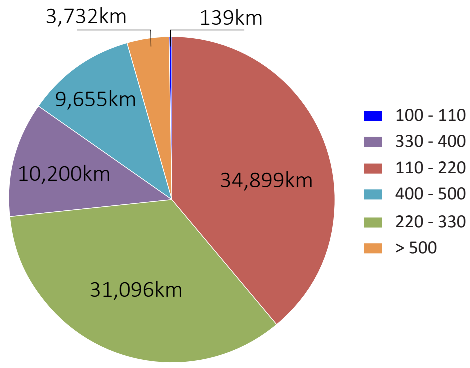
* Electricity generation in 2013 = 308,870 GWh

Source: (AFREC, 2015)

Transmission lines

Africa's existing power transmission system (defined as lines with a voltage equal or above 100 kilovolts (kV), has a total length of 89,731 km (Figure 10). It is small compared to the area of the continent, corresponding to a density of 3.29 metres of transmission line per square km. In addition to its low density, the other striking feature of the transmission system is the absence of unified or standardized specifications: Africa has at least 15 levels of transmission line voltages from 110 kV to 700 kV (AfDB, 2014) (Figure 11).

Figure 10: Africa's transmission system (length of transmission lines)



Source: (AFREC, 2015)

Figure 11: Africa's energy infrastructure (power plants and lines)

Source: (AEEP, 2016)

Current consumption and demand

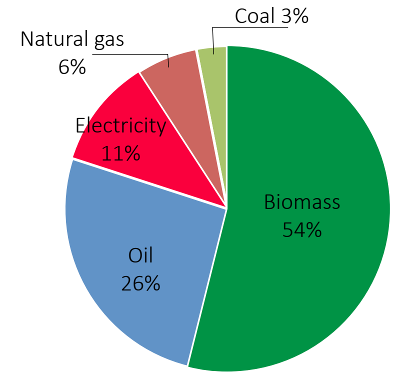
Combustible renewable resources (biomass, animal wastes, municipal and industrial wastes) largely dominate energy consumption in Africa (Figure 12). Energy from biomass accounts for more than 30 per cent of the energy consumed and more than 80 per cent in many sub-Saharan countries. Biomass constitutes the main energy resource for the large majority of African households for cooking, drying and space heating. While electricity access data varies widely depending on the reporting sources, the International Energy Agency (IEA) reports average rates ranging from 70 per cent to over 94 per cent in Northern Africa, and 25 per cent in sub-Saharan Africa, with large disparities between countries (for instance less than 5 per cent in Uganda, Chad and Sierra Leone compared to 66 per cent in South Africa or 100 per cent in Mauritius), and between urban and rural areas, where in the latter, rates can be as low as 1 per cent (AfDB, 2016). Figure 13 shows total final energy consumption by region and Table 3 provides a data summary of total energy production, consumption and imports from 2000 to 2015.

Table 3: Summary of Africa's total energy production, consumption and imports (ktoe), 2000-2015

Category	2000	2005	2010	2015 (P)
Production of coking coal	116,021	127,989	132,669	137,688
Production of charcoal	16,008	20,368	27,113	32,442
Production of crude oil, NLG and additives	356,367	442,942	453,810	386,056
Production of natural gas	127,580	169,496	193,540	207,998
TOTAL PRODUCTION	617,976	762,800	809,142	764,184
Production of electricity from biofuels and waste	135	163	187	349
Production of electricity from fossil fuels	29,921	37,321	44,975	62,212
Production of nuclear electricity	1,119	971	1,101	1,221
Production of hydro electricity	6,607	8,107	9,738	12,495
Production of geothermal electricity	37	77	126	329
Production of electricity from solar, wind, etc.	20	128	326	1,086
TOTAL PRODUCTION OF ELECTRICITY	37,840	46,767	56,490	77,567
Refinery output of oil products	113,476	130,903	125,401	109,426
Final consumption of coking coal	14,701	15,947	12,287	13,463
Final consumption of oil	91,041	126,983	133,907	137,569
Final consumption of natural gas	19,685	27,844	31,394	35,263
Final consumption of electricity	31,834	4,934	51,196	60,865
TOTAL FINAL CONSUMPTION	157,261	175,708	228,784	247,160
Consumption of oil in industry	15,085	16,102	18,889	17,039
Consumption of natural gas in industry	6,773	12,013	14,972	18,322
Consumption of electricity in industry	14,585	18,066	20,327	20,201
Consumption of coking coal in industry	11,555	8,706	9,130	7,248
TOTAL CONSUMPTION IN INDUSTRY	47,998	54,887	63,318	62,810
Consumption of oil in transport	48,640	60,590	70,783	85,650
Consumption of electricity in transport	522	559	449	483
TOTAL CONSUMPTION IN TRANSPORT	49,162	61,149	71,232	86,133
Net imports of coking coal	-32,730	-31,675	-30,717	-31,592
Net imports of crude oil, NGL, etc.	-238,829	-307,386	-304,898	-307,555
Net imports of oil product	-11,975	-9,696	27,915	49,775
Net imports of natural gas	-62,960	-96,305	-53,342	-75,764
Net imports of electricity	38	-173	333	516
TOTAL NET IMPORTS	-346,456	-445,235	-360,709	-364,620
TOTAL	713,096	868,741	1,048,102	1,060,357

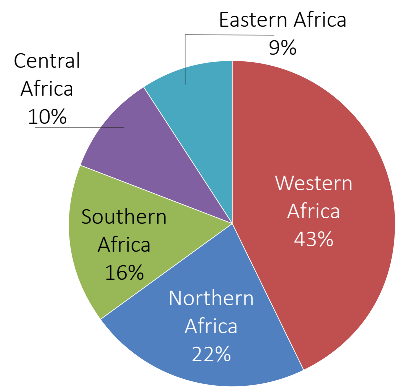
(P)= projected estimates
The minus (-) sign of Net imports the plus (+) sign means Net Exports
Source: (AFREC, 2015)

Figure 12: Fuel shares of total final consumption by fuel type, 2013



Total Final Consumption in 2013 = 285,978 ktoe
Source: (AFREC, 2015)

Figure 13: Regional shares of total final consumption, 2013



Total Final Consumption in 2013 = 230,834 ktoe
Source: (AFREC, 2015)

TreeAid/Flickr.com/CC BY 2.0

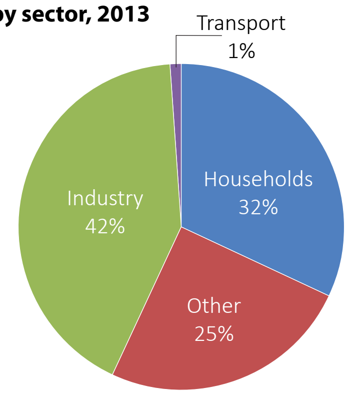
Cooking over a fire, Burkina Faso

Table 4: The state of electrification in Africa, 2013

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

Source: (EIA, 2015)

Figure 14: Shares of electricity consumption by sector, 2013



Africa's electricity consumption in 2013 was 20,195 ktoe

Source: (AFREC, 2015)

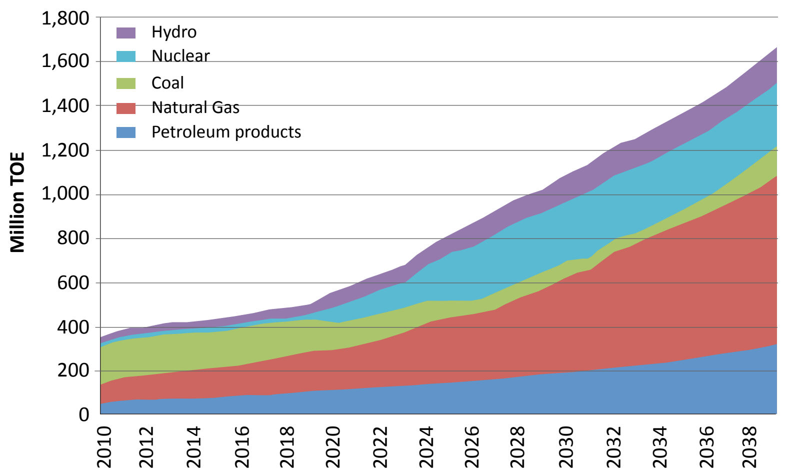
Current electricity demand and consumption

Electricity demand in much of Africa is constrained by available supply, resulting in people either not having any access or not being able to consume as much as they need. About 634 million people live without access to electricity in sub-Saharan Africa (Table 4). It is also the only region in the world where the number of people living without electricity is increasing, as rapid population growth is outpacing the many positive efforts to provide access (AfDB, 2016).

Electricity demand in Africa was 605 terawatt-hours (TWh) in 2012, with Northern Africa accounting for around 40 per cent of the total. In sub-Saharan Africa, total electricity demand increased by 35 per cent since 2000 to reach 352 TWh in 2012, just 70 per cent of the level of Korea, which has a population of only five per cent of that of Africa (OECD/IEA, 2014).

On a per capita basis, electricity demand in sub-Saharan Africa has remained largely unchanged for the last decade (at close to 400 kWh), with total consumption levels rising in step with the population. This is the lowest rate of per capita consumption of any major world region — 75 per cent below that of developing Asia and less than the electricity needed to power one 50-watt light bulb continuously for a year. By comparison, electricity demand per capita in Northern Africa increased by more than 80 per cent from 2000 to 2012, reaching 1,500 kWh (OECD/IEA, 2014). In sub-Saharan Africa, electricity constitutes 7 per cent of final energy consumption (4 per cent if South Africa is excluded), compared with 18 per cent globally and 19 per cent in Northern Africa. Industry and households account for about three-quarters of electricity consumption in Africa (Figure 14).

Figure 15: Projected consumption of primary energy from fossil fuels, hydro and nuclear (in million toe), 2010-2038



Source: (AfDB, 2014)

Projected demand

Primary energy

In its Outlook 2040 for the energy sector, the African Development Bank (2014) carried out energy demand projections for Africa, taking into account various energy-influencing factors including:

- Primary energy consumption;
- Energy access;
- Energy efficiency;
- Per capita energy consumption;
- Energy intensity; and
- Industrial development.

Results at the continental level show that the demand for primary energy (excluding biomass) by industry, power and transport will increase by 8.9 per cent a year. Within this overall demand, however, there are a variety of different trends depending on fuel type (Figure 15). For instance, the role of coal will decline, even in South Africa, as gas for power and industry and liquid petroleum products for transport and power develop, as well as nuclear power in South Africa, and later, in Egypt. However, gas is projected to increase gradually. The development of transport in Africa is the main cause for the surge in the consumption of liquid petroleum products (AfDB, 2014).

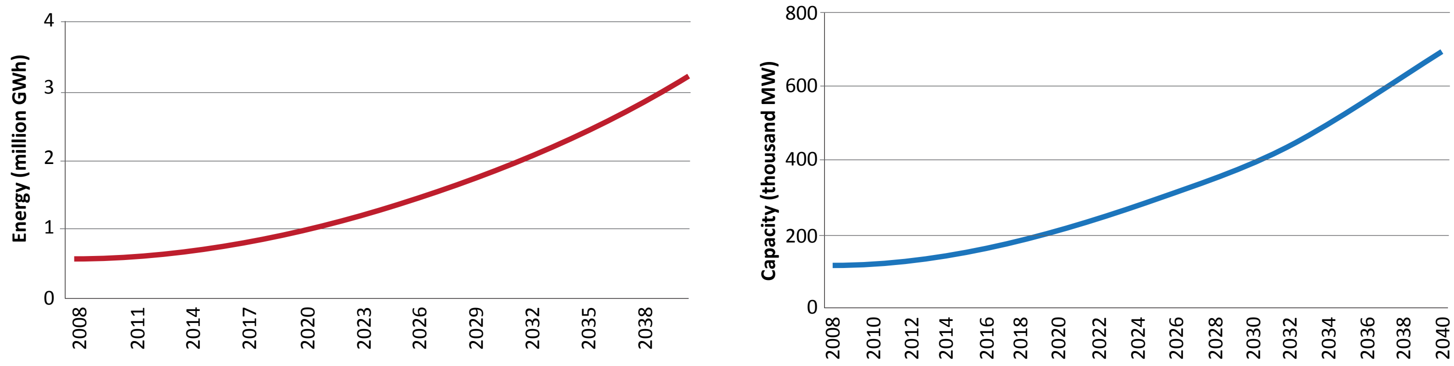
Table 5: Annual growth rate of primary energy consumption in Africa by fuel type (%)

Primary energy fuel type	Annual growth rate (percentage)
Petroleum products	6.5
Gas	8.6
Coal	2.7
Nuclear	18.5
Hydro	5.8
Total	8.9

Source: (AfDB, 2014)

Table 5 represents the disaggregated projected growth rate of primary energy consumption for each type of fuel. Despite the continent's significant hydro potential, as this potential is exhausted by 2030-32, Africa will continue to depend on nuclear and fossil fuels, especially gas, and increasingly so after 2030 (AfDB, 2014).

Figure 16: Projected African electricity demand in energy and capacity, 2011-2040



Source: (AfDB, 2014)

Continental electricity demand

The AfDB estimated electricity demand projections for each country and aggregated them by Regional Economic Community (REC) at the continental level. The increase in energy and capacity demand includes an additional requirement due to the increase in access, which is part of the policy priority of all governments in sub-Saharan Africa. Thus, by 2040, overall access is projected to increase from the current 40 per cent to 69 per cent (AfDB, 2014).

The continental demand for electricity is forecasted in terms of energy, which drives fuel consumption, CO_2 emissions and generation capacity needed to meet peak demand. Energy demand is projected to increase by an average of 5.7 per cent per year over the 2011-2040 period to 3,188 TWh, representing a 5.4-fold increase; the needed generation capacity would increase by 6 per cent per year to 694 GW by 2040, representing a 6-fold increase (Figure 16). These estimates were based on the Programme for Infrastructure Development in Africa's (PIDA) projections for population growth and for an average annual GDP growth rate of 6.2 per cent per year (AfDB, 2014).

Energy efficiency, per capita consumption and energy demand

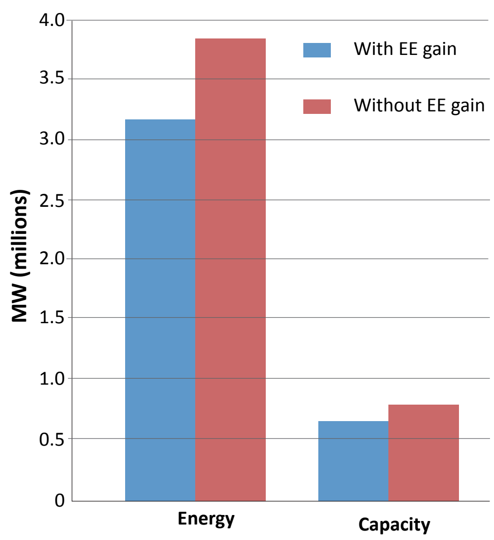
The energy intensity of the sub-Saharan economy (excluding South Africa) declined by around 2.5 per cent per year since 2000, but remains significantly higher than Northern Africa's and is more than double the world average. Projected gains from implementing energy efficiency (EE) policies are expected to save 139 MW (16.7 per cent) in capacity needs and 634 TWh in energy produced (16.6 per cent) (Figure 17).

In addition, per capita energy consumption is forecast to increase from the current world-lowest level of 612 kWh per capita to 1,757 kWh per capita by 2040 (Figure 18), corresponding to an unprecedented 3.7 per cent increase per year; this aligns with the African Union (AU) and Regional Economic Communities (REC) energy policies that prioritize the access to modern energy. The increase results from the ongoing modernization of African economies and social progress (AfDB, 2014).

Industry, energy intensity and demand

With increased industrialization and modernization across the continent, the total energy demand from industries is forecast to increase from 431 TWh in

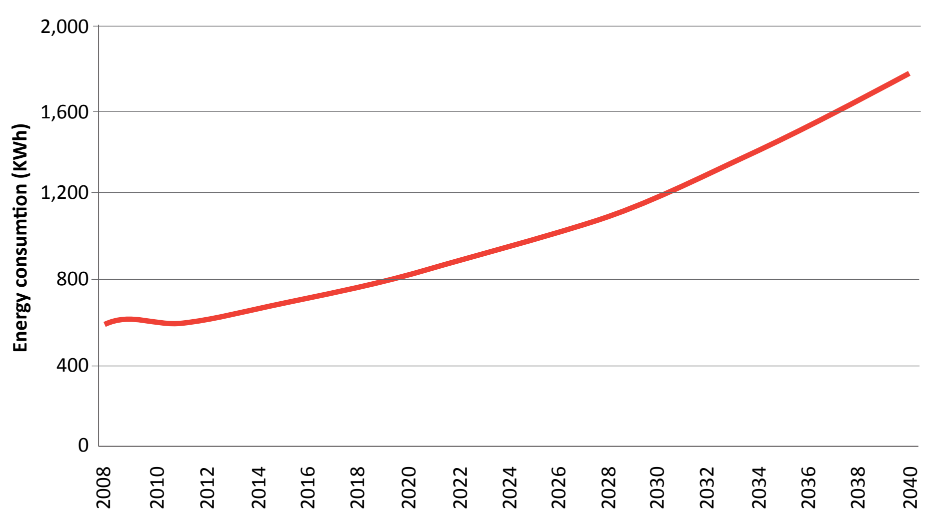
Figure 17: The impact of Energy Efficiency (EE) gains on demand



Source: (AfDB, 2014)

2011 to 1,806 TWh by 2040, representing a 5.1 per cent annual growth. This trend aligns with the expected rapid development of extractive industries, as self-generation is expected to meet the bulk of the demand from these industries; the projection only considers the demand from ancillary industries, which relates to the power grid. Over the same 2011-2040 period, it is projected that Africa's energy intensity will not change significantly. It will decline slightly from 0.181 TWh/billion GDP in 2011 to 0.157 TWh/billion GDP in 2040. This can be explained by the decrease in the energy intensity of industries linked to their modernization being offset by the increase in energy intensity of non-industrial activities (AfDB, 2014).

Figure 18 : Per capita energy consumption, 2011-2040



Source: (AfDB, 2014)

Energy Resources in Africa

Africa is endowed with a diversity of both non-renewable and renewable energy resources unevenly located across the continent (Table 6). They include relatively important reserves of oil, gas and coal that account for 7.6 per cent , 7.5 per cent and 3.6 per cent respectively of the world total. The continent's hydropower potential amounts to roughly 12 per cent of the world total (GTZ, 2010). The continent also has abundant renewable energy, with solar irradiation ranging from 5 to 7 kWh/m^2 all year round, relatively strong wind power potential in Northern, Southern and Eastern Africa, and large amounts of land suitable for biofuel production.

Table 6: The potential of some of Africa's energy resources

Energy sources	Potential
Coking coal (mt)	31,814
Crude oil, NLG and additives (thousand mt)	17.1
Natural gas (tcm)	14.1
Nuclear electricity	Not estimated
Hydroelectricity (GWh/year)	1,584,670
Geothermal electricity (GW)	15
Hydrokinetic (Tides, waves, etc.) (TWh/year)	3,500
Solar (TWh/year)	1,128,315
Wind (TWh/year)	457,665

Sources:
-Red-text: end 2015 data from (BP, 2016)
-Blue- text: end 2014 data from (IRENA, 2015a)
-Green- text: from (World Energy Council, 2016)
-Pink- text: 2014 data from (IRENA, 2014)

Non-renewable energy

Non-renewable energy sources refer to those that cannot be replenished in a short time period. They include fossil fuels such as crude oil, natural gas, coal and uranium used for nuclear energy (EIA, 2015). At the global level, most energy consumption (84 per cent) is satisfied by these non-renewable sources (DLIST Benguela, n.a.).

Peat

Peat is the lowest status of coal, having been subjected to the least amount of carbonization (NG, n.a.). It is generally less abundant than coal at the global level. In Africa, peat is harvested in only a few countries, as shown in Table 7.

Rwanda is the only country in Africa to operate a peat fired power plant, which adds 15 MW of electricity to the grid (ROR, 2013).

Table 7: Total peat resources (for fuel use) in Africa

Country	Year	Peat resources (thousand metric tonnes)
Burundi	2013	19
Senegal	2002	92,000
Rwanda	2002	2,000,000
Southern Africa	1993	47,000
Total		2,139,019

Source: (UNSD, 2016)

Coal

Currently, coal power plants are one of the cheapest ways to produce electricity. Many developing countries consider them to be viable options (DLIST Benguela, n.a.). Africa's coal reserves represent 3.6 per cent of the world's coal reserves, more than 95 per cent of which occur in South Africa, which is Africa's largest producer by far, as well as being a major global producer, after China, Australia, Canada, USA, India, Russia and Indonesia (AfDB, 2014). South Africa is also a major consumer of coal (Table 8).

Of the other African coal producing countries, Zimbabwe's single mine, Wankie, is an important coal producer; Zambia has a single operation, the Maamba colliery; Niger operates a single coal mine and Malawi produces approximately 50,000 tonnes of coal per year. Swaziland has two small collieries, which produce around 400,000 tonnes annually. Botswana has a single coalmine dedicated to supplying a coal-fired power station. Isolated coal-bearing sequences in Niger, Nigeria and Egypt represent the only other significant coal bearing potential in Africa.

Table 8: Coal production in Africa, (mtoe)

Country	Year						2015 share of global total
	2010	2011	2012	2013	2014	2015	
South Africa	144.1	143.2	146.6	145.4	148.2	142.2	3.7%
Zimbabwe	1.7	1.7	1.0	2.0	3.7	2.7	0.1%
Other Africa	1.0	1.3	4.5	5.4	5.9	5.9	0.2%
Total	146.8	146.1	152.1	152.8	157.8	151.4	4%

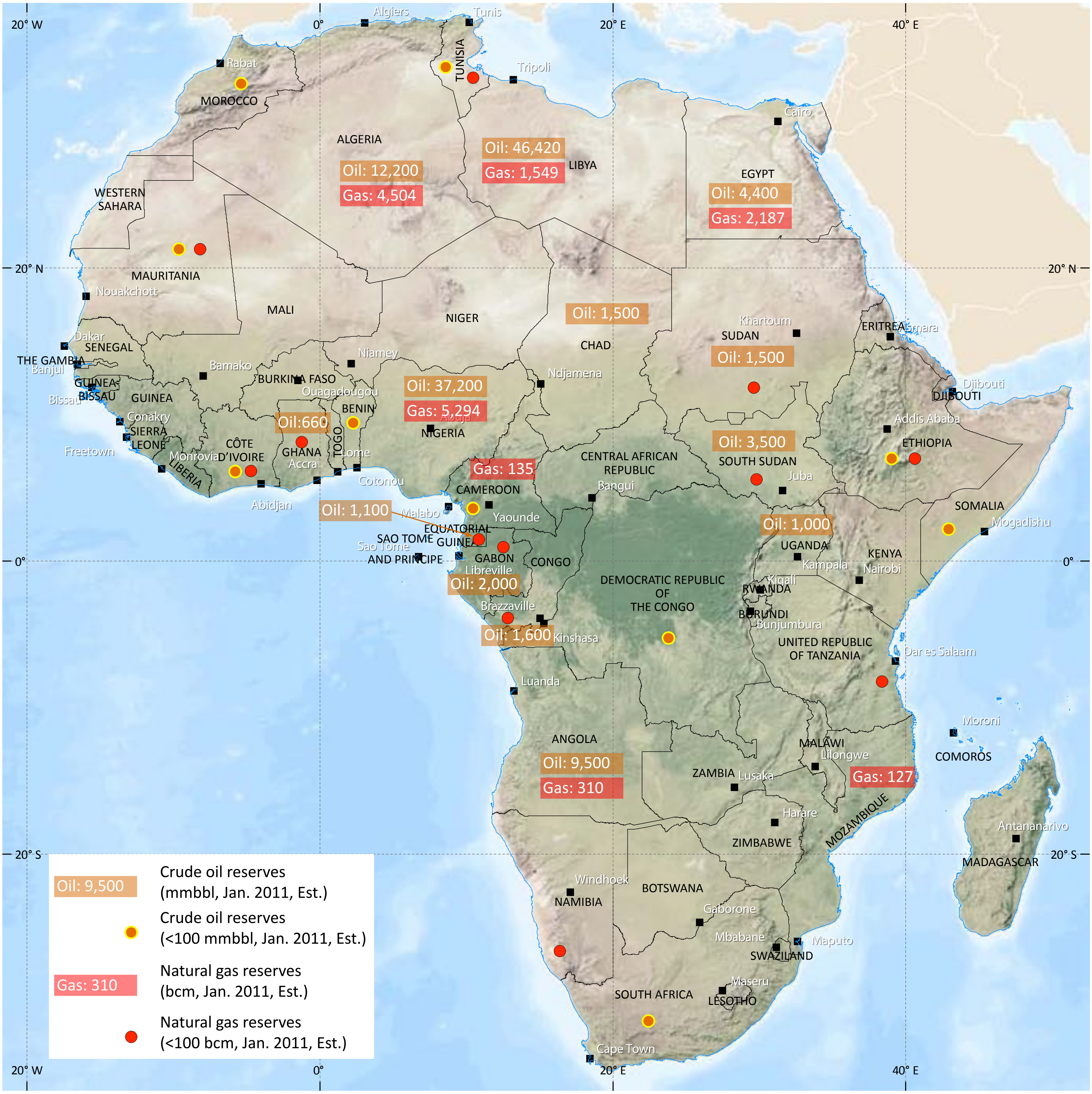
Source: (BP, 2016)

Fuel station in Nigeria

Oil

Continental Africa has an abundance of proven petroleum or crude oil reserves (Figure 19). They are largely concentrated in the north, and also in Western Africa, although further oil reserves are still being identified in new locations, and in some cases have already been developed commercially.

Figure 19: Africa's crude oil reserves



Source: (AfDB, 2014)

Table 9 gives estimates of proved oil reserves in Africa at the end of 2015. Libya and Nigeria alone have the largest share by far, accounting for about 63 per cent of the African total, with Algeria and Angola adding another 20 per cent . Figure 20 shows crude oil production shares by region and Figure 21 illustrates oil consumption by sector.

Table 9: Total proved oil reserves in Africa, 2015

Countries	Thousand million barrels	Thousand million tonnes	Share of total	R/P ratio
Algeria	12.12	1.5	0.7%	21.1
Angola	12.7	1.7	0.7%	19.0
Chad	1.5	0.2	0.1	52.4
Republic of Congo	1.6	0.2	0.1%	15.8
Egypt	3.5	0.5	0.2	13.2
Equatorial Guinea	1.1	0.1	0.1%	10.4
Gabon	2.0	0.3	0.1%	23.5
Libya	48.4	6.3	2.8%	306.8
Nigeria	37.1	5.0	2.2%	43.2
South Sudan	3.5	0.5	0.2%	64.9
Sudan	1.5	0.2	0.1%	39.2
Tunisia	0.4	0.1	*	18.6
Other Africa	3.7	0.5	0.25%	38.3
Total	129.1	17.1	7.6%	42.2

* = less than 0.05%
R/P ratio = Reserves-to-production ratio (If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate). Shares of total and R/P ratios are calculated using thousand million barrels figures.

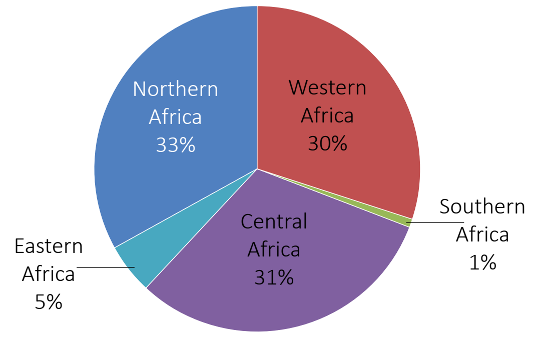
Source: (BP, 2016)

According to the BP Statistical Review of Energy 2016, Africa's proven oil reserves increased from 72.1 billion barrels to 129.1 billion barrels between 1995 and 2015, representing a growth of almost 79.1 per cent . Oil reserves grew particularly quickly since the mid-1990s as improved political situations made exploration more attractive to foreign oil companies. This also resulted in Africa's share in global reserves rising from 5.9 per cent in 1993 to as high as 8.6 per cent in 2006, although this ratio has declined to 7.7 per cent since then (KPMG Africa, 2015).

Africa accounted for over 11 per cent of global oil production over the past decade. As of 2015, Africa as a continent produced roughly 8.4 million barrels per day accounting for roughly 9.1 per cent of the world's crude oil production (BP, 2016).

As incomes in Africa are still low, oil consumption in most countries is also low. Africa's oil consumption, therefore, accounts for only 4.2 per cent of global consumption, leaving a large amount of oil to be exported. In 2013, Africa's net oil exports declined to 5.2 million bpd, down from an average of almost 6.3 million bpd over the previous five years. This decline in 2013 was mainly due to a sharp drop in Libyan output, although lower production in Nigeria, Algeria and the Sudans also contributed (OECD/IEA, 2014).

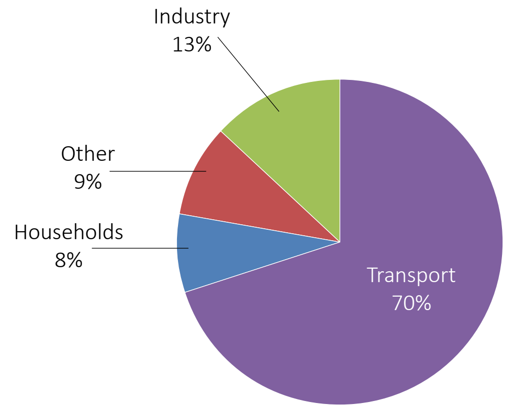
Figure 20: Regional shares of crude oil production, 2013



* Crude oil production in 2013 = 142,294 kt

Source: (AFREC, 2015)

Figure 21: Shares of Africa's oil consumption by sector, 2013



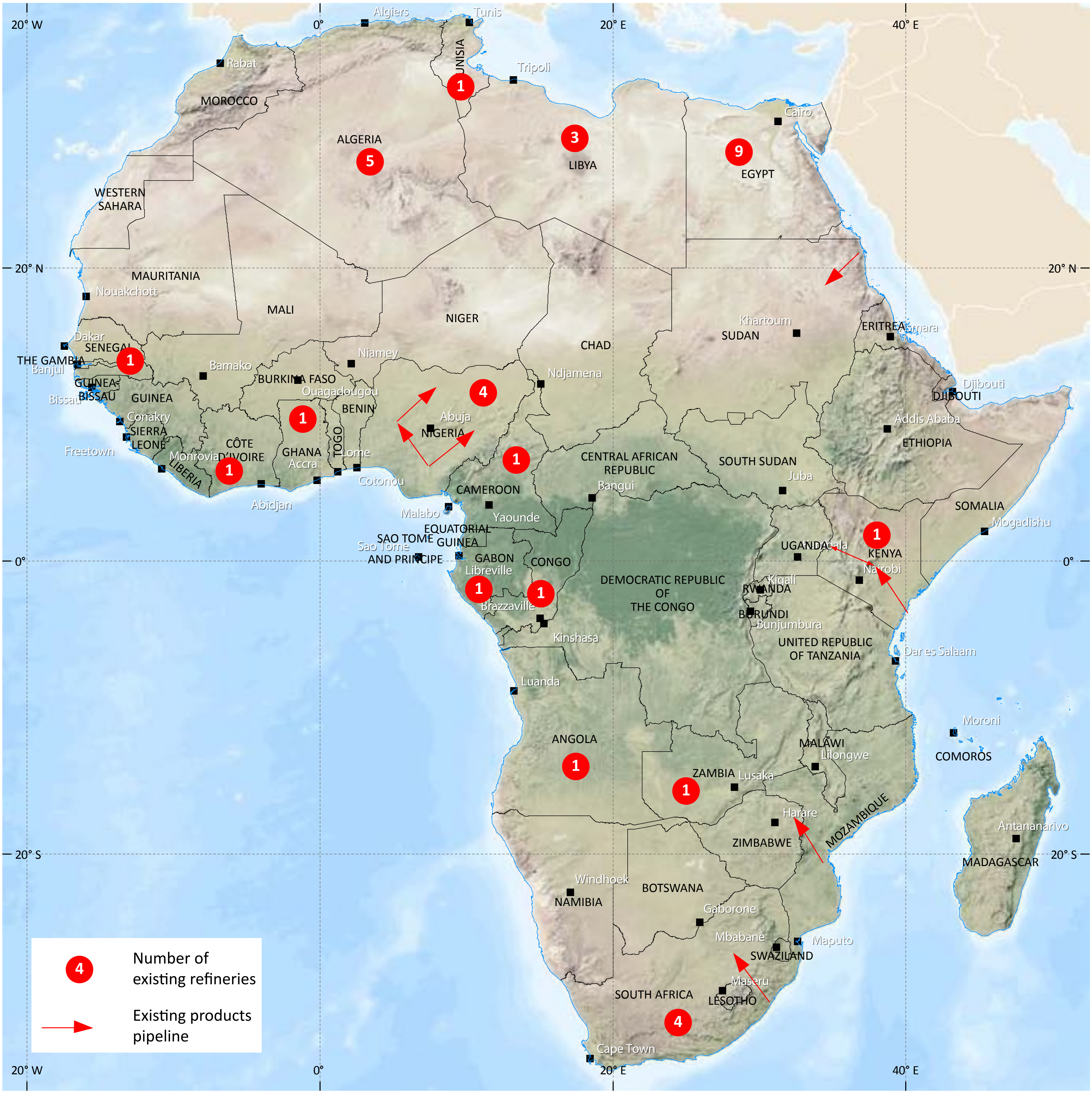
* Africa's oil consumption in 2013 = 88,942 ktoe

Source: (AFREC, 2015)

Oil products infrastructure

In Northern, Western and Central Africa, existing product pipelines are for national distribution only and are not extensive. In Southern Africa, the Mozambique (Biera) to Zimbabwe (Mutare/Harare) pipeline is for regional products and is used by Zimbabwe and Malawi to import refined products through the port of Beira. Products are transported by road from Mutare to Malawi. South Africa's products pipeline network is extensive but serves its domestic market. The possibility of a products pipeline from Maputo (Mozambique) to Witbank (near Pretoria) in South Africa, which would use part of the existing gas pipeline's route, has also been studied. In Eastern Africa, Kenya has an internal products pipeline distribution system, which links the port of Mombasa and its refinery to Nairobi. The system extends through two further pipelines to Eldoret and Kisumu. There are proposals to connect this system from Eldoret to Kampala in Uganda. Tanzania is proposing the construction of an oil refinery and a 1,200 km long pipeline from Dar es Salaam to Mwanza on the southern shores of Lake Victoria. If the project is successful, it could be extended to Uganda, Burundi and Rwanda. There is a crude oil pipeline between Dar es Salaam (Tanzania) and Ndola (Zambia). The Zambian Government has commissioned a study to examine upgrading options (AfDB, 2014).

Figure 22: Africa's oil refineries and pipeline network



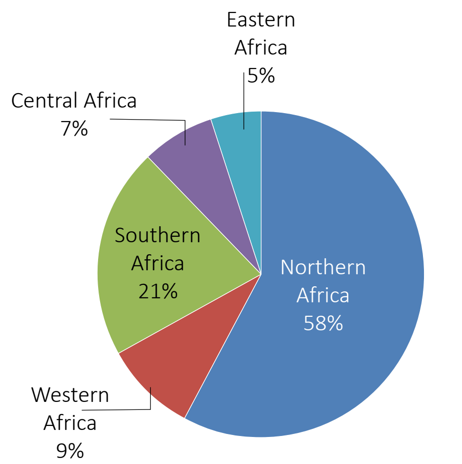
Source: (AfDB, 2014)

Refineries

Figure 22 shows Africa's existing oil refineries with nameplate (or installed) capacity, by country, and their relative locations around the continent. The locations of the major refineries are predominantly in the oil producing regions in Western and Northern Africa, although a number of other refineries using imported crude oils operate as well.

Of the thirty-eight oil refineries, twenty-five are simple processing plants of mostly low capacity, although some of those in Egypt have significant capacity. The total nameplate capacity is over 3 million barrels per day (bpd), but the actual production capacity is significantly lower than that figure (AfDB, 2014). Figure 23 shows the regional shares in refinery production.

Figure 23: Regional shares of refinery production, 2013



*Refinery production in 2013 = 60,570 kt

Source: (AFREC, 2015)

Unconventional oil resources

An unconventional oil resource is one that is produced or obtained through techniques other than traditional oil well extraction. Examples are bitumen, extra heavy oil, tar sands and oil shales. The term oil shale generally refers to any sedimentary rock that contains solid bituminous materials (called kerogen) that are released as petroleum-like liquids when the rock is heated in the chemical process of pyrolysis (BLM, n.a.). Such resources are reportedly present in many countries in sub-Saharan Africa, including Angola, DRC, Ethiopia, Madagascar, Nigeria, Congo and elsewhere (Table 10) (Ouedraogo, 2012).

Table 10: Some unconventional oil resources in the sub-Sahara region

Country	Unconventional oil reserves
Angola	Angola has two natural bitumen deposits located in Bengo province, which surrounds the capital, Luanda. They contain 4.65 billion barrels of oil in place and 465 million barrels of reserves of tar sands oil.
Democratic Republic of Congo (DRC)	Tar sands are present in several regions, including the Lake Tanganyika Graben in the east as well as in the western Congo bordering the Cabinda province of Angola. There are 300 million barrels of tar sands in place, with a proven reserve value of 30 million barrels. There is also bitumen in concession areas of approximately 400 km² in the Bas Congo western coastal basin.
Ethiopia	Ethiopia has 3.89 billion tonnes of oil shale located in Tigray province, which borders Eritrea. However, there is currently no exploration of the shale oil, possibly due to a previous dispute over the area, which led to conflict between Ethiopia and Eritrea.
Madagascar	The unconventional oil deposit in Madagascar is located on the western coast of the island in Melaky region. Tar sands resources are found in the Bemolanga field, and extra heavy oil resources are being explored at the Tsimiroro field. Both fields are approximately 70 km² in area. The bitumen content ranges from about 3.5 to approximately 11.0 weight per cent, with the effective mineable area at an average of 5.5 weight per cent bitumen in the ore.
Nigeria	There are tar sands in the Ikale region in Ondo state.
Republic of Congo	The bitumen resource is estimated to be at least 500 million barrels risked, with the potential for discovering up to 2.5 billion barrels (unrisked). The huge 1,790 km² tar sands concession covers two areas, Tchikatanga and Tchikatanga-Makola, in the south of the country near the oil capital of Pointe-Noire. The huge area stretches from the border with the Angolan exclave of Cabinda to the Conakouati-Douli national park bordering Gabon. The resources are deep, in the 100-200 m range, and so will require in situ technology to develop.
South Africa	There is oil shale in the Karoo region.

Source: (Ouedraogo, 2012)

In Africa, oil shale basins are mainly found in the northern and southern parts of the continent. Table 11 presents the individual countries with unproved technically recoverable shale oil and shale gas reserves in Africa. As of 2013, the total volume of wet shale gas was estimated at 39.81 trillion cubic metres. Algeria accounts for more than 50 per cent of the continental volume of unproved technically recoverable wet shale gas. Libya alone possesses almost 50 per cent of the continental volume of tight oil, which is estimated to be 54.3 billion barrels.

Table 11: Countries with recoverable shale oil and shale gas reserves

Country	Unproved technically recoverable		Date updated
	Wet shale gas (trillion cubic metres)	Tight oil (billion barrels)	
Algeria	20.02	5.7	5/17/13
Chad	1.25	16.2	12/29/14
Egypt	2.83	4.6	5/17/13
Libya	3.44	26.1	5/17/13
Mauritania	0.0	0.0	5/17/13
Morocco	0.34	0.0	5/17/13
South Africa	11.04	0.0	5/17/13
Tunisia	0.64	1.5	5/17/13
West Sahara	0.24	0.2	5/17/13
Total	39.81	54.3	

Source: (EIA, 2015)

Natural gas

Natural gas consists primarily of methane, a very clean and safe fossil fuel, although the by-products of its combustion, such as carbon dioxide, carbon monoxide and nitrogen oxides, are environmental pollutants and contribute to climate change. On the other hand, these emission are thought to be almost half that of coal use. It is also more economical than coal, as the costs and time periods required to build a gas plant are considerably less than for coal plants (DLIST Benguela, n.a.). Natural gas is often used in combination with other fuels to decrease pollution in electricity generation.

Continental Africa has an abundance of proven natural gas reserves, largely concentrated in the northern parts of the continent and also in Western Africa (Figures 24 and 25). Algeria, Libya, Egypt and Nigeria are amongst the largest gas producers in the world, but other reserves are being identified in new locations, and in some cases, have been developed (OECD/IEA, 2014). BP reports that in 2015, Africa had 14.1 trillion cubic metres of total proved reserves of natural gas (BP, 2016) (Table 12). Extensive offshore deposits have been found in existing mining operations off the coast of the Northern Cape and Southern Namibia, including the Kudu gas field developments by Nampower (DLIST Benguela, n.a.) and in the Western Indian Ocean (Richmond, 2015).

Table 12 provides the recent estimates of proven gas reserves in Africa. Nigeria has the largest share, accounting for 36 per cent of the African total. The three North African countries of Algeria, Egypt and Libya account for 56 per cent of the total, with other African countries accounting for only 8 per cent . Africa's reserves represent 7.5 per cent of the world total (BP, 2016).

Table 12: Total proved natural gas reserves, 2015

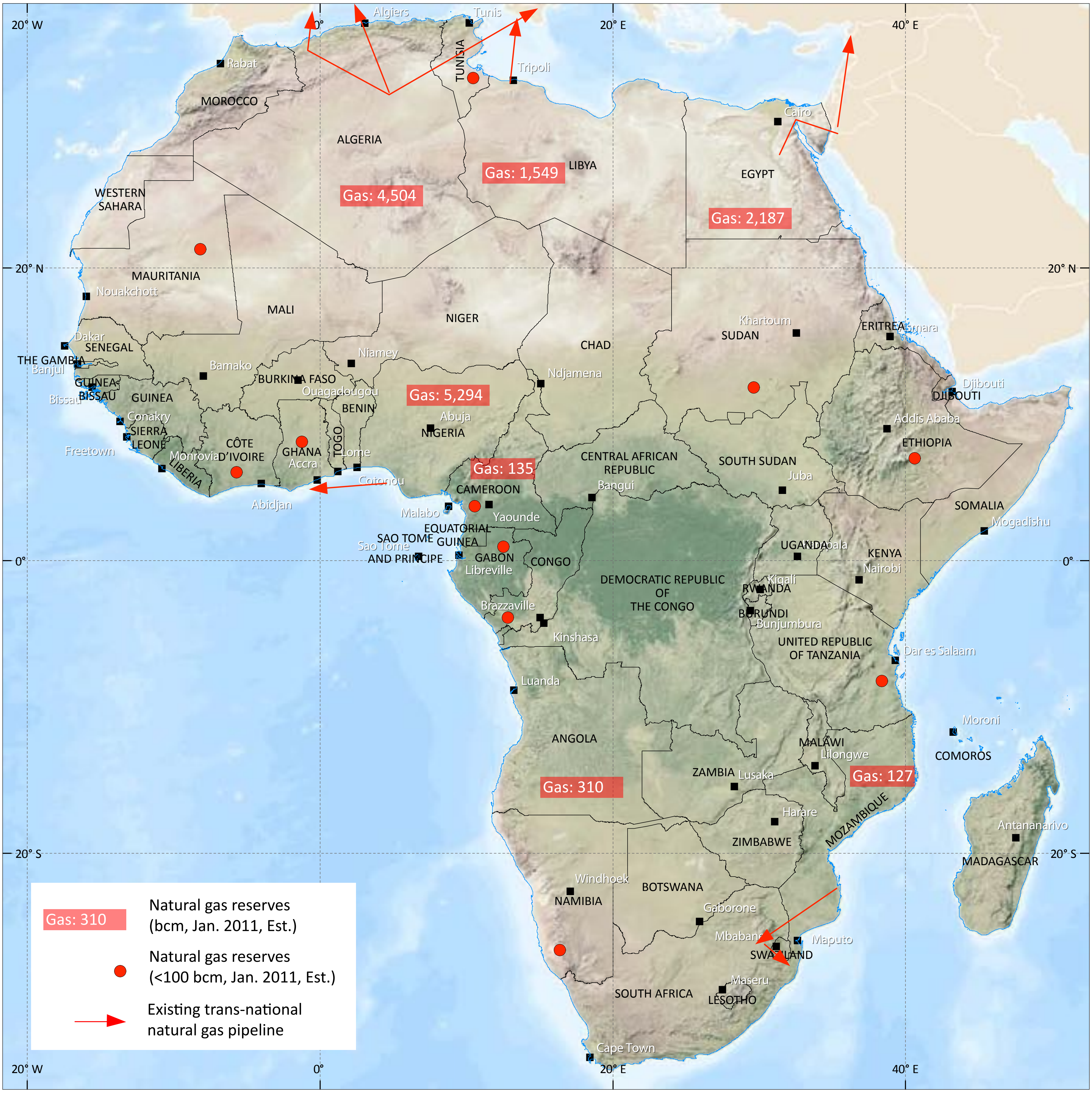
Countries	Trillion cubic metres	Trillion cubic feet	Share of global total	R/P ratio
Algeria	4.5	159.1	2.4%	54.3
Egypt	1.8	5.2	1.0%	40.5
Libya	1.5	53.1	0.8%	118.0
Nigeria	5.1	180.5	2.7%	102.1
Other Africa	1.1	38.8	0.6%	3.9
Total	14.1	496.7	7.5%	66.4

R/P ratio = Reserves-to-production ratio: if the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate.

Source: (BP, 2016)

Nigeria, Cameroon and Algeria also have significant associated gas, which has historically been flared in the earlier years of oil production due to the lack of commercial opportunities. This situation is now changing as the value of natural gas has increased since then. Africa is estimated to have

Figure 24: Africa's natural gas reserves (and existing pipelines)

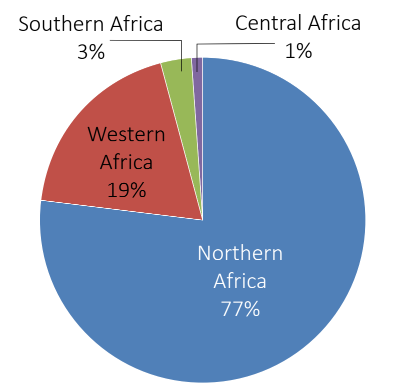


Source: (AfDB, 2014)

52 tcm of remaining recoverable conventional natural gas resources, of which 31 tcm are in sub-Saharan Africa. Proven gas reserves in sub-Saharan Africa have increased by 80 per cent since 2000 and now stand at 9 tcm (5 per cent of the global total), of which around 70 per cent is in deep water and 18 per cent on land. One-sixth of proven sub-Saharan natural gas reserves are associated with oil (OECD/IEA, 2014).

Important natural gas resources have been recently discovered in Mozambique and Tanzania. These resources can benefit the high population density region of the Rift Valley for different uses such as cooking, power generation, transportation and fertilizer production.

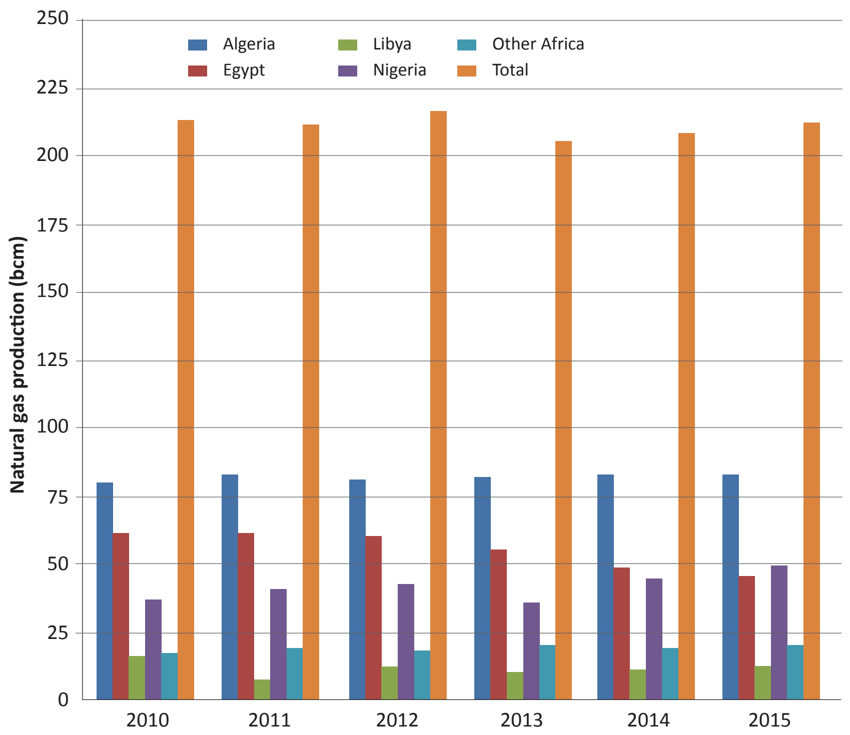
Figure 25: Regional shares of natural gas production, 2013



*Natural gas production in 2013 = 141,925 mcm

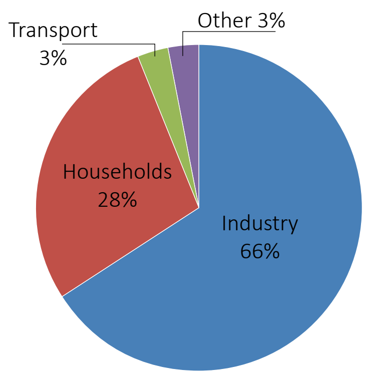
Source: (AFREC, 2015)

Figure 26: Volume of natural gas produced in Africa (bcm), 2010-2015



Source: adapted from (BP, 2016)

Figure 27: Shares of Africa's natural gas consumption by sector, 2013



*Africa's natural gas consumption in 2013 = 18,026 ktoe
Source: (AFREC, 2015)

Natural gas production in Africa reached 211.8 bcm in 2015, representing a 1.8 per cent increase from the 2014 volume (BP, 2016) (Figure 26). Sub-Saharan gas production increased from around 7 bcm in 1990 to 58 bcm in 2012, making it a small but growing contributor to global gas supply. Growth has come largely from associated gas linked to the Western African offshore oil boom (OECD/IEA, 2014). Figure 27 shows that industry and households consume the largest proportion of natural gas.

Natural gas infrastructure

In Northern Africa, Algeria has three existing export pipeline systems:

- Medgaz, the most recently completed, takes gas from the pipeline system at Arzew and crosses the Mediterranean from Beni Saf to a landfall near Almeria in southern Spain;
- PDF (Maghreb) goes directly from the major gas fields at Hassi R'Mel in central Algeria, crosses Morocco to Tangiers, and from there crosses the Straits of Gibraltar to Tarifa in Spain; and
- Trans-Mediterranean pipeline system, supplied by the GEM (Gazoduc Enrico Mattei) pipelines from Hassi R'Mel that cross Tunisia, consists of four parallel lines from south of Tunis to Sicily in Italy (Figure 24).

There are proposals for another pipeline system, Gasdotto Algeria to Sardegna Italia (GALSI), which would cross the Mediterranean from El Kala in Algeria to Sardinia and from there to a more northerly landfall in the south of Livorno in Italy. Algeria exported approximately 60 bcm of gas by pipeline or liquefied natural gas (LNG) to Europe in 2010, a volume that is expected to rise to 72 bcm by 2030. If GALSI were also completed, Algeria's total export pipeline capacity would probably be sufficient to accommodate the projected volumes available through the proposed Trans-Sahara pipeline from Nigeria (see below). Libya exports gas through the Green Stream pipeline, which crosses from Melitta to Sicily where it connects to the Italian transmission system. Libya exported around 10 bcm in 2009, mostly by pipeline with 0.7 bcm as LNG. Egypt exports gas by pipeline (to Jordan, Syria and Lebanon as well as to Israel) and LNG to Europe (AfDB, 2014).

In Western Africa, the West African Gas Pipeline (WAGP) is owned and operated by the West African Gas Pipeline Company. It transports gas from the Escravos to Lagos system (ELPS) in Nigeria to consumers in Benin, Togo and Ghana. It is 620 km in length and consists of both offshore and onshore sections. There is also interest in expanding the pipeline further west to Côte d'Ivoire. The pipeline was completed in 2009 and its current throughput is 100 million standard cubic feet (mmscf)/day. Ghana has recently discovered significant oil and gas reserves in its offshore waters. The National Petroleum Corporation (GNPC) is planning an offshore gas gathering system for the associated gas to feed into a gas processing plant at Domini and from there to power stations at Effasu and Aboadze. GNPC also sees the possibility of Ghanaian gas being transported through the WAGP. The expected increase in reserves following the new field discoveries could also generate other export opportunities, both regionally and for LNG export (AfDB, 2014).

In Southern Africa, the Mozambique to South Africa Pipeline exports gas from the Pande and Temane fields in Mozambique to the SASOL coal-to-liquids plant in Secunda and from there to Richard's Bay and Durban in South Africa. This southern Africa regional gas project was first developed in 2004 to supply natural gas from two fields in Mozambique, discovered during the 1960s, to the SASOL plant in South Africa (AfDB, 2014).

Nuclear

Nuclear power is generated using uranium or plutonium. Producing uranium generates a huge amount of radioactive waste in the process. It is enriched in nuclear reactors that generate heat through nuclear fission and steam to drive turbines and generators. Most nuclear plants are situated along the coast so that seawater can be used as a cooling mechanism instead of cooling towers (DLIST Benguela, n.a.).

South Africa is the only nation in Africa currently producing electricity from nuclear sources, with nearly 14,202 GWh produced in 2013 (AFREC, 2015). Some other countries, including Kenya and Namibia, are interested in introducing nuclear power into their domestic mix. Nigeria and Egypt have also used small reactors. Sub-Saharan Africa includes three of the global ten-largest uranium resource-holders in the world: Namibia, Niger and South Africa. Africa provides a significant share of global production (18 per cent) of uranium: Namibia provides 8.2 per cent of global production, Niger 7.7 per cent, Malawi 1.2 per cent and South Africa 1.1 per cent (OECD/IEA, 2014).

Renewable energy

Renewable energy, which are theoretically inexhaustible energy sources and are not derived from fossil or nuclear fuel, include solar, wind, geothermal, biomass, hydro and tidal. Energy generation from these sources typically produce no greenhouse gases and other polluting emissions. The cost of developing renewable energy technologies remains high, but the increased demand can lead to economies of scale and wider use, especially in developing regions like Africa where energy demand is rising and many renewable resources are abundant (DLIST Benguela, n.a.). Africa's renewable energy resources are diverse, unevenly distributed and plentiful (Desertec-Africa, n.a.).

Total theoretical potentials in the whole of Africa are estimated at around 470 Petawatt hours (PWh) for concentrating solar power (CSP), 660 PWh for photovoltaics (PV) and 460 PWh for wind (IRENA, 2014).

Bioenergy

Bioenergy is derived from biomass (Table 13). Figure 28 maps tree cover in Africa, the source of fuelwood. Figure 29 shows the regional contribution of firewood production, and Figure 30 illustrates the share of fuelwood consumption by sector., which is usually thought of as plant-based material, such as wood and vegetation, but can also be derived from animals and the waste from industries and cities. Biogas or methane is produced from the decomposition of biomass and sewage (DLIST Benguela, n.a.). Biomass supplies about a third of Africa's industrial-based heat (REN21, 2016).

Biomass

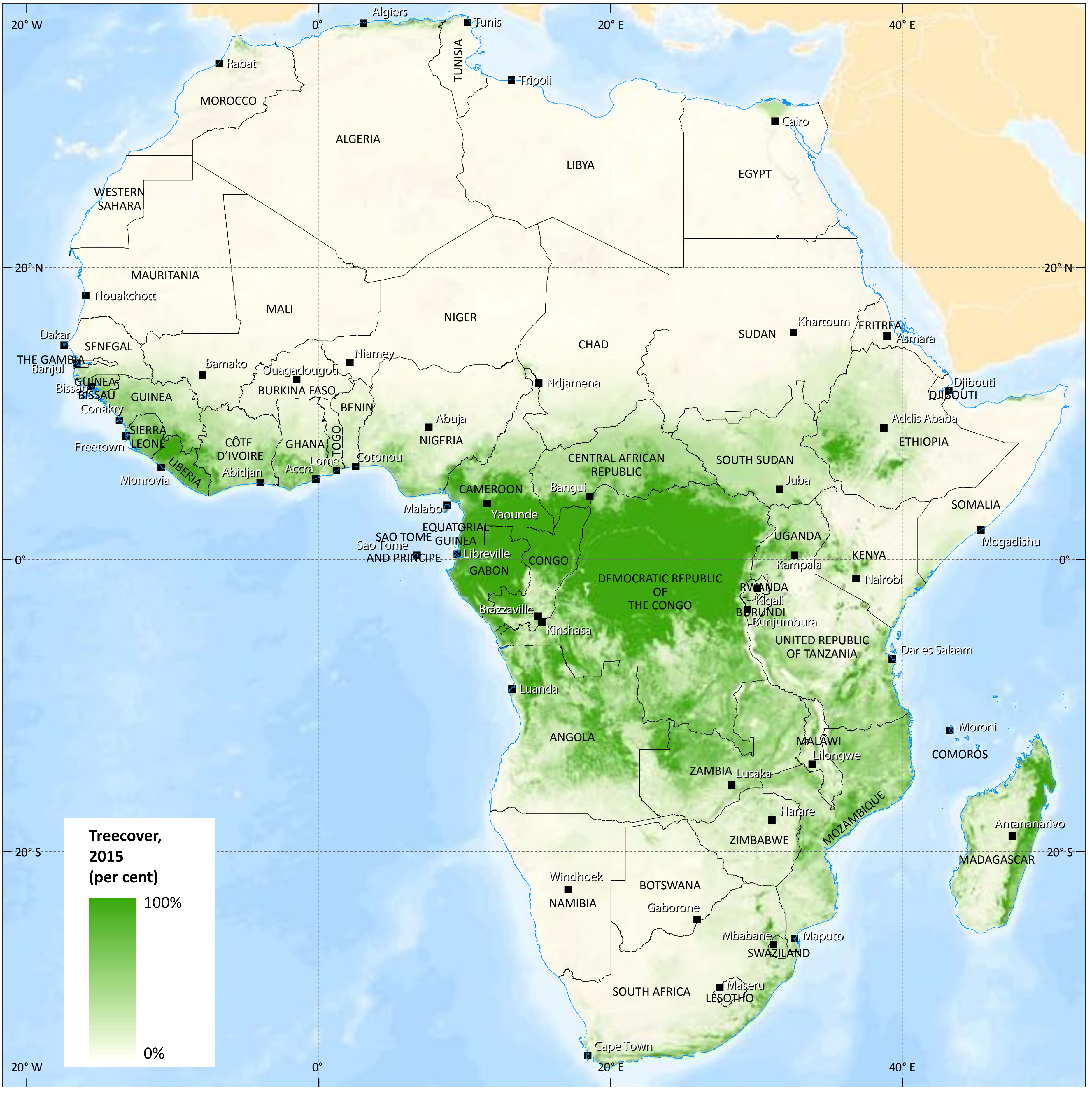
Fuelwood or wood fuel is the single most important primary energy source across the African continent (Table 13). Figure 28 maps tree cover in Africa,

Table 13: Traditional use of solid biomass for cooking

Region	Population relying on traditional use of biomass (millions)	Percentage of population relying on traditional use of biomass
World	2,722	38
Africa	754	68
North Africa	1	0
Sub-Sahara Africa	753	80

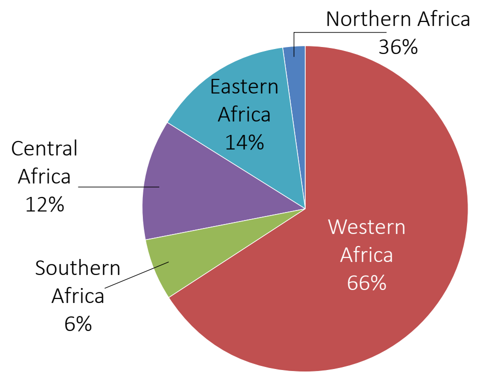
Source: (IEA, 2015)

Figure 28: Tree cover map of Africa



Tree cover derived from satellite data; the vegetation (green) is an indicator of biomass availability.

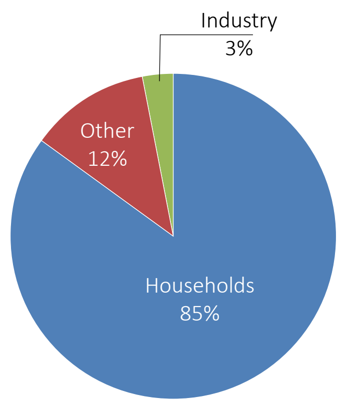
Figure 29: Regional shares of firewood production, 2013



*Production in 2013 = 624,037 kt

Source: (AFREC, 2015)

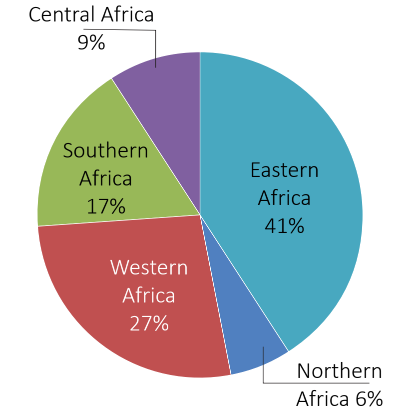
Figure 30: Fuelwood shares of total final consumption by sector, 2013



*Firewood consumption in 2013 = 240,465 ktoe

Source: (AFREC, 2015)

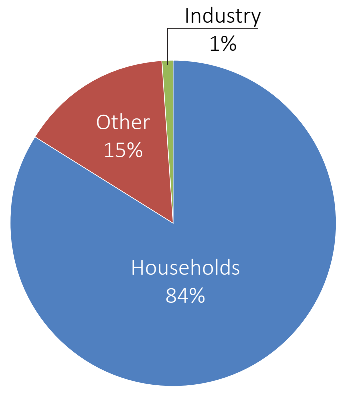
Figure 31: Regional shares of charcoal production



*Charcoal production in 2013 = 16,542 kt

Source: (AFREC, 2015)

Figure 32: Shares of Africa's charcoal consumption by sector, 2013



*Charcoal consumption in 2013 = 5,027 ktoe

Source: (AFREC, 2015)

Figure 33: Charcoal production in African countries, 2012

Source: (SCInet, 2015)

the source of fuelwood. Figure 29 shows the regional contribution of firewood production, and Figure 30 illustrates the share of fuelwood consumption by sector. It is primarily used for cooking and heating in the residential sector, though sizable amounts are also used by small and medium size industries for metal processing, food processing and brick making. Wood is used either directly as firewood or in the form of charcoal. It is estimated that about one-fifth of harvested wood fuel is converted to charcoal (IRENA, 2015a). Figures 31 and 32 show charcoal production by region and sector and Figure 33 maps charcoal production in Africa. Over the past 40 years, the annual production of charcoal has grown at an average annual rate of 6.3 per cent (IRENA, 2015).

Wood fuel accounted for nearly half (15 exajoules (EJ)) of total primary energy supply in 2013. Bioenergy currently contributes to an existing installed capacity of around 325 MW of electricity, mainly spread across Eastern and Southern Africa (OECD/IEA, 2014).

Biofuels

Biofuel is combustible matter derived from biomass (such as crops) to generate electricity and power and to produce liquid fuels such as bioethanol and biodiesel. Crops often used as biofuels in Africa include maize, sugar cane, sugar beets, sweet sorghum, cassava, *Jatropha curcas*, *Croton megalocarpus*, caster, cotton, sunflower, canola (rapeseed), coconut, oil palm (*Elaeis guineensis Jacq*), soybean (*Glycine max*) and *Crambe abyssinica*.

Bioethanol and biodiesels are blended with gasoline and petroleum products. To identify the ratio of ethanol to gas, an "E" code is applied to the product. For example, E10 consists of 10 per cent ethanol and 90 per cent gasoline. Other common blends are E85, E5 and E7. Likewise, a "B" code indicates the mixture for Biodiesel, which can be blended and used in many different concentrations (USDE, n.a.).

Liquid biofuels, such as ethanol, biodiesel and straight vegetable oil (SVO), account for a very small share of total energy supplies in Africa, but small quantities of biofuels have been produced and used for almost three decades. In 2013, Africa produced 318,935 ktoe of energy from biofuel and waste (AFREC, 2015). Malawi, for example, has produced ethanol from molasses and used it as a substitute for imported gasoline since the early 1980s. However, large-scale production of liquid biofuel to substitute for imported fossil fuels or for export is just beginning.

Most countries do not have policies for biofuels. This situation is changing however, as high fuel prices have encouraged many countries to develop biofuel policies and many investors to focus on Africa as a biofuel producer for export (Mitchell, 2011). Many African countries are now introducing biofuel policies. Mali, Nigeria, Senegal, Tanzania, Ethiopia, Angola, Mozambique, South Africa and Swaziland have implemented specific biofuels policies. Burkina Faso, Côte d'Ivoire, Ghana, Guinea-Bissau, Senegal, Sierra Leone, DRC, Equatorial Guinea, Kenya, Rwanda, Madagascar, Mauritius, Zambia and Botswana are also developing explicit policies (Hamelinck, 2013).

Sugarcane

The biofuels market in Africa considers sugarcane production to have a high potential for expansion (Johnson & Seebaluck, 2013). The average global yield is 70.8 tonnes per hectare and several countries, such as Tanzania, Malawi, Ethiopia and Zambia have already had yields ranging from 5 to 79 per cent higher. In fact, the Ethiopian average yield can be 59 per cent higher than the Brazilian average of 80 tonnes per hectare, which is an important benchmark for sugarcane production (UNU-IAS, 2012); (Khatiwada, 2013). In 2012, Africa produced 125 million litres of bioethanol. A significant development of sugarcane-based biofuel in Africa would require increasing sugarcane cultivation, since the region produces 10.6 metric tonnes (Mt) of sugar a year but consumes 10.1 Mt of it (Johnson & Seebaluck, 2013).

Jatropha and Soybean

Jatropha is a multipurpose plant with many attributes and considerable potential. It is a tropical plant that can be grown in low to high rainfall areas and can be used to reclaim land, as a hedge and/or as a commercial crop. Southern Africa has the highest potential for Jatropha, followed by Eastern Africa and Central Africa. Northern Africa and Western Africa have virtually no potential. The countries with the highest potentials are Madagascar (723,000 ha) and Mozambique (649,000 ha), which account for 92 per cent of the total available land area for Jatropha crops. Soybean (*Glycine max*) crops show a significantly higher potential than Jatropha crops in all regions. Southern Africa has the largest amount of available land area, followed by Eastern Africa, Northern Africa and Western Africa (Table 14). Countries with the highest potentials include Mozambique (3.9 million ha), Madagascar (2.8 million ha), Kenya (1.5 million ha), Tanzania (1.2 million ha) and Nigeria (1.2 million ha).

Table 14: Summary of land areas for Jatropha and soybean crops with yields over 2 tonnes/ha

Region	Thousand ha	
	Jatropha	Soybean
	>2 tonnes/ha	>4 tonnes/ha
Central Africa	59	430
Eastern Africa	59	3,982
Northern Africa	-	-
Southern Africa	1,373	8,269
Western Africa	-	2,234
Total	1,491	14,915

Source: (IRENA, 2014)

Biogas

Biogas is produced when microbial organic matter degrades in anaerobic conditions. It can be harvested from any number of places, such as landfill sites, wastewater plants and even breweries. Generally made using sludge or animal manures rich in carbohydrates, proteins and lipids, biogas contains a strong mixture of methane and carbon monoxide as well as some trace gases (Pollution Solutions, 2014).

Table 15: Potential electricity generation from waste (incineration and landfill gas recovery) in Africa, GWh

	2012				2025			
	Waste generation		Waste collected		Waste generation		Waste collected	
	Incineration	Landfills	Incineration	Landfills	Incineration	Landfills	Incineration	Landfills
Total Africa	5,716	2,640	2,541	1,000	13,988	6,152	9,071	3,420

Source: (Scarlat, Motola, Dallemand, Monforti-Ferrario, & Mofor, 2015)

Table 16: Total waste generation and collection in Africa, 2012 and 2025

2012		2025	
Generation (10^3 t/year)	Collection (10^3 t/year)	Generation (10^3 t/year)	Collection (10^3 t/year)
11,519	5,098	28,155	18,232

Source: (Scarlat, Motola, Dallemand, Monforti-Ferrario, & Mofor, 2015)

Waste and biomass residues (crop residues)

Energy recovery from waste can play a role in minimizing the impact of Municipal Solid Waste (MSW) on the environment, with the additional benefit of providing a local source of energy in Africa. The energy potential of all waste generated in Africa was 1,125 PJ (Pica Joule) in 2012 and projected to be 2,199 PJ in 2025. Nevertheless, if energy recovery through landfill gas (LFG) is considered and it is assumed that waste is or actually will be collected, about 155 PJ could be recovered in 2012 and 363 PJ in 2025. The electricity generated could reach 62.5 TWh in 2012 and 122.2 TWh in 2025 if all waste were collected, compared with electricity consumption in Africa of 661.5 TWh in 2010. These estimates decrease to 34.1 TWh in 2012 and 83.8 TWh in 2025 when calculating the waste that is actually collected (Scarlat, Motola, Dallemand, Monforti-Ferrario, & Mofor, 2015) (Table 15). Table 16 shows the data for waste generation and actual waste collection in 2012 and 2025.

By 2030, the total supply potential of crop harvesting and agro processing residue in Africa is estimated to be around 4.2 EJ. The Western Africa region has 40 per cent of this resource. Total supply potential of wood residues (including both logging and processing residue) and wastes and animal residues is estimated at around 1.1 EJ and 1.5 EJ per year, respectively. The Northern Africa region has 40 per cent of the wood residue and waste resource, and the Central region has the lowest wood residue potential (IRENA, 2015a).

Hydropower

Africa's hydro potential is significant and has been well known for many years. Africa's exploitable hydropower potential is estimated at 1,584,670 GWh per year (12 per cent of the world's total potential); currently, about 92 per cent of this potential remains unexploited (IRENA, 2015). Africa's hydro potential is located in four main hydroelectric hubs and involves seven main river basins:

- Western Africa on the Niger and Senegal Rivers and in Guinea;
- Central Africa on the Congo River, in particular the Inga scheme;
- Eastern Africa, the Nile River basin development; and
- Southern Africa, involving the Orange, Limpopo and Zambezi Rivers.

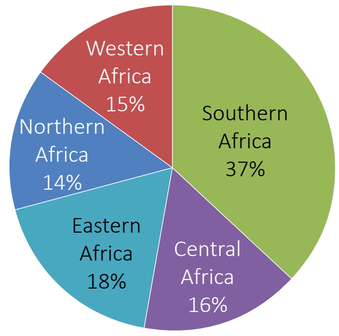
Several hydropower projects have been built in Ethiopia, Tanzania, DRC and Cameroon. At the regional level, Southern Africa has about 37 per cent of the continent's hydro resources (AFREC, 2015) (Figure 34 and Table 16). At the end of 2014, there was 28 GW of hydro capacity installed in Africa (IRENA, 2015b). The technical hydropower potential in Africa is estimated at 283 GW with a potential to generate close to 1,200 TWh per year — 12 per cent of the global technical potential. This amount

Table 17: Actual and technically feasible hydro generation, by region

Region	Hydro generation in 2013 or most recent/ average (GWh/yr)	Technically feasible hydropower potential (GWh/yr)	Ratio between hydro generation and technically feasible hydropower potential (percentage)
Northern Africa	16,728	59,693	28
Central Africa	14,614	570,730	3
Western Africa	19,445	101,492	19
Eastern Africa	26,215	334,600	8
Southern Africa	44,896	415,857	11
Total	122,538	1,584,670	8

Source: (IRENA, 2015a)

Figure 34: Regional shares of hydro production, 2013



*Hydro production for 2013 = 44,636 GWh
Source: (AFREC, 2015)

Pixabay.com/CC0 Public Domain

Hydroelectric dam in South Africa

Figure 35: Hydropower potential

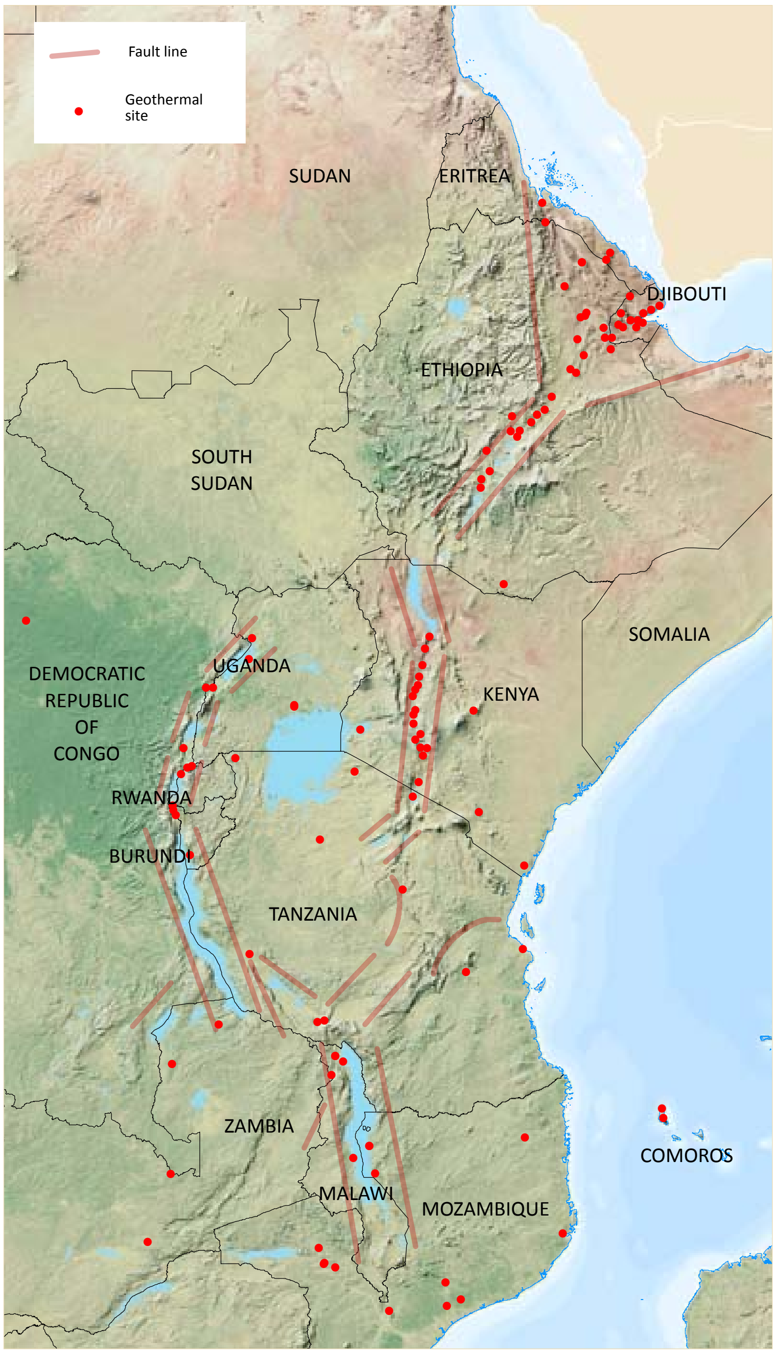
Source: (AfDB, 2014)

of electricity is more than three times the current electricity consumption in sub-Saharan Africa. So far, less than 10 per cent of the technical potential has been tapped. This makes hydropower by far the most important renewable power-generation option deployed today.

The Inga site on the Congo River has an estimated potential of between 39,000 and 44,000 megawatts (MW) or more than twice the power equivalent of the Three Gorges dam in China, which is currently the world's largest dam. However, only a small portion of this potential is used (1,774 MW) and less than half are operational. The Zambezi River is another strategic area, with a potential of 12,000 MW, which includes two further planned developments to the existing Cahora Bassa dam (2,075 MW) and Kariba dam (1,266 MW): the Mphanda Nkuwa dam in Mozambique (1,300 MW) and another plant of 850 MW north of Cahora Bassa (AfDB, 2014). Figure 35 maps Africa's major hydropower potential.

As of 2011, Africa had at least 588 small hydro plants with an average size of 2.5 MW for a total of around 1.5 GW (IRENA, 2012). Small hydropower has been credited for its suitability to improve rural electrification and for its potential for socially inclusive and sustainable development (REN21, 2015).

Figure 36: East African Rift System and geothermal prospects



Source: (AfDB, 2014)

Geothermal

Geothermal energy is the heat contained within the earth that can be recovered in the form of steam and hot water to be utilized for power generation and other direct use applications (Dickson and Fanelli, 2004). Africa's geothermal energy potential that can be used for power generation is mostly concentrated in the East Africa Rift System (EARS) whereas low temperature resources for direct use application spread across the continent.

Table 18: Selected countries with proved high geothermal potential in Africa from various sources

Countries	Potential (GW)
Kenya	7-10
Ethiopia	> 5
Djibouti	1

The EARS is one of the major tectonic structures of the earth where the flow of heat energy from the interior of the earth takes place in the form of volcanic eruptions, earthquakes and the upward transport of heat by hot springs and natural fumarole discharges. The EARS extends for about 6,500 km from the Middle East (Dead Sea-Jordan Valley) in the North to Mozambique in the South. The EARS passes through Eritrea, Djibouti, Ethiopia, Kenya, Tanzania, Uganda, Rwanda, the Democratic Republic of Congo (DRC), Zambia, Malawi, Mozambique and Madagascar. Estimated Geothermal energy resource potential in the EARS is more than 20,000 MWe (Teklemariam, 2016).

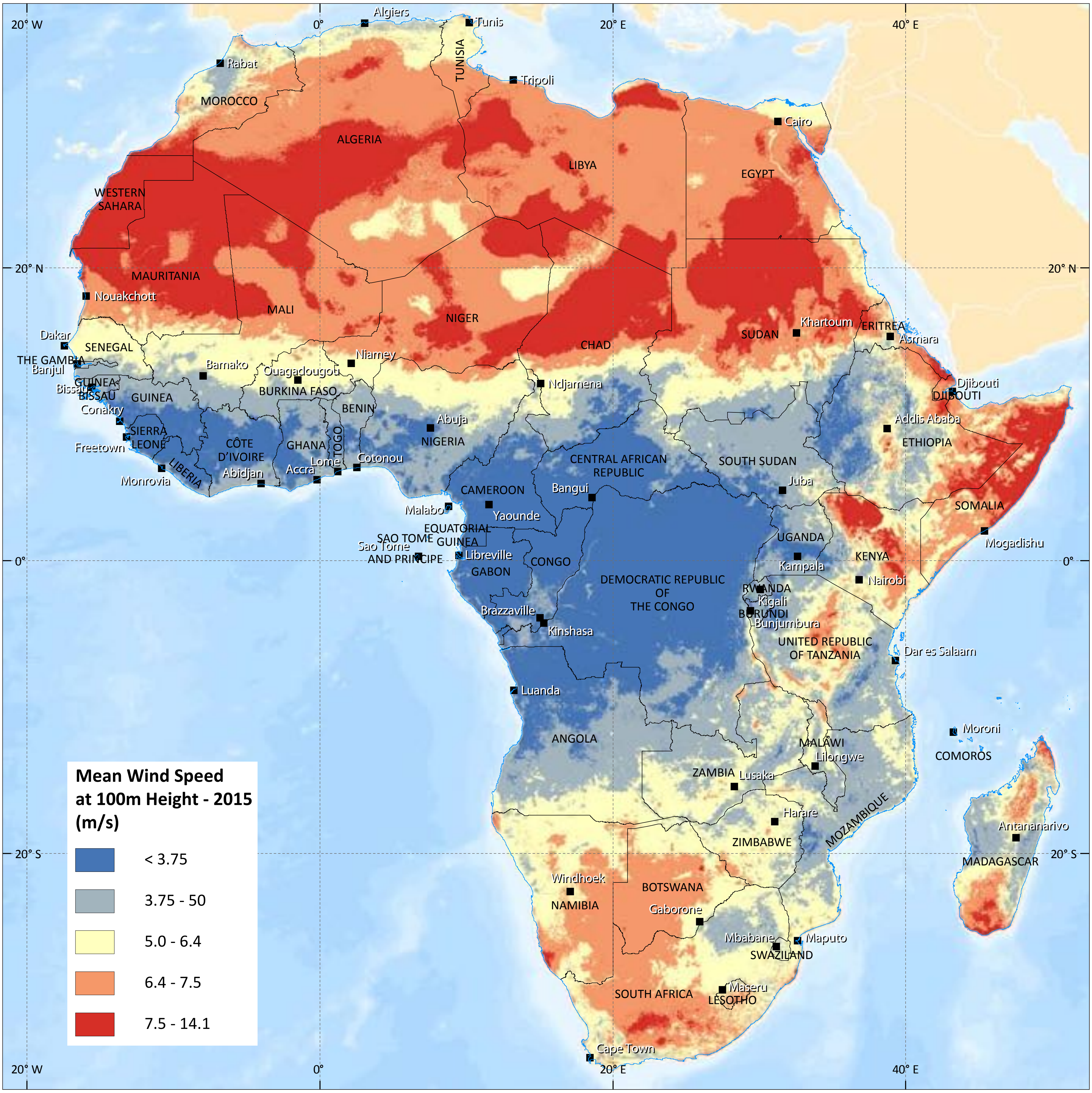
Geothermal energy has to date been developed for electric power generation with installed capacity of 674 MWe in more than five large power plants in Kenya and 7.3 MWe at a pilot geothermal power plant in Ethiopia. In 2016, electricity production from geothermal sources was 5,669 GWh/yr in Africa, with Kenya producing 5,609 GWh/yr (Omenda and Mangi, 2016) and Ethiopia 59.9 GWh/yr (Kebede, 2016). Direct use of geothermal resources in Africa in 2015 stood at about 683GWh/yr from six countries including Algeria, Egypt, Ethiopia, Kenya, Morocco, South Africa and Tunisia (Lund and Boyd, 2015). Direct use was mainly in agriculture and tourism.

While geothermal development has mainly been for national electricity markets, the geothermal potential, if fully utilized, could also benefit regional markets in Eastern Africa through the regional power pools. Further geothermal developments are underway in Djibouti, Eritrea, Ethiopia, Kenya, Tanzania and Uganda, which aim to increase the generating capacity of these countries by a total of 1,000 MWe by 2020.

KenGen

OLK IV-140 NWe Geothermal Power Plant, Kenya

Figure 37: Wind energy potential



Source: (AfDB, 2014)

Wind

Wind energy is one of the world's fastest growing sources of renewable energy. Windmills have either a horizontal–axis (the majority) or a vertical-axis. One wind machine can produce 1.5 to 4.0 million kilowatt hours (kWh) of electricity a year. Wind speed increases with altitude and over open areas with no windbreaks (DLIST Benguela, n.a.).

Africa's wind energy potential is substantial (Figure 37). However, this potential is less uniformly distributed than Africa's solar resources. The best prospects for wind power development are close to coastal locations, mountain ranges and other natural channels in the northern and southern regions of the African continent. Considering that an average wind speed of 7 metres per second (m/s) is the minimum needed for wind turbines to operate efficiently, wind potential exists only in Morocco and Egypt, with some in Tunisia, South Africa and Tanzania (AfDB, 2014). By 2020, wind turbines could add about 8,500 MW to Africa's general energy production.

In 2015, a total of nearly 1 GW of wind energy was installed, mainly from the following countries: Algeria (10 MW), which commissioned its first large-scale wind farm; Egypt (60 MW); Morocco (300 MW); and South Africa, which increased its capacity from 10 MW to 570 MW in a single year. Kenya initiated its project on Lake Turkana (310 MW) and projects also were under way in Ghana, Senegal, and Tanzania (REN21, 2015).

Hydrokinetic energy (tides and waves)

The marine environment stores energy in the form of heat, currents, waves and tides. It is thought that there is enough energy in the oceans to meet total worldwide demand for power many times over (DLIST Benguela, n.a.).

Tidal energy

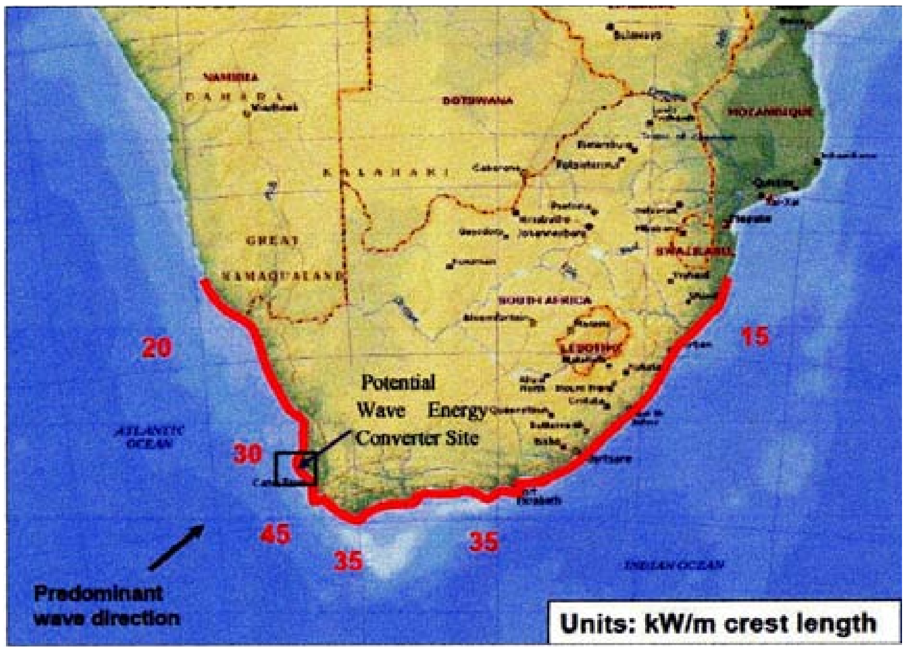
Tidal energy is created through the use of generators. Large underwater turbines are placed in areas with high tidal movements to capture the kinetic motion of the ebbing and surging of ocean tides to produce electricity (AR, 2014). Worldwide, the tidal resources are considerable and also largely unmapped. Power generation from its sources is early in the development stages. In Africa, studies show that Eastern Africa has large resources for tidal power (Kempener & Neumann, 2014).

Ghana is expected to commission its first undersea power generator by December 2016 at the Ada Estuary in the Greater Accra Region. A successful test generation of 14 MW was run in March 2015. When fully operational, the plant will produce up to 1,000 MW (Gale-Zoyiku, 2015).

Wave energy

Wave power is in the very early stages of development, although research estimates that there is an enormous potential for generating power. The energy density is typically around 30-40 kW for every metre (2.2 feet) of wave along the shore. Further into the ocean, there is generally about 100 kW for every metre. For instance, a wave farm occupying less than a half square mile of ocean would generate more than 30 MW of power (Maehlum, 2013). Western coastlines at latitudes between 30° and 60° experience the most powerful waves.

Figure 38: Varying off-shore annual average wave power levels along the southern African coast



Source: (Frick, 2014)

Africa is surrounded by the Indian Ocean on the east coast and the Atlantic Ocean on the west coast, with huge ocean winds and currents; if harnessed for electricity, they could generate enough power to cover all of Africa's electricity needs. In fact, ocean-current-turbines along just the 2,000 km-long coastline from Morocco to Senegal could potentially generate all of Africa's energy needs (Desertec-Africa, n.a.). The most powerful wave-energy power levels occur along South Africa's coast (Frick, 2014) and the country has identified a coastal spot for the Stellenbosch Wave Energy Converter (SWEC) (Frick, 2014) (Figure 38).

Solar

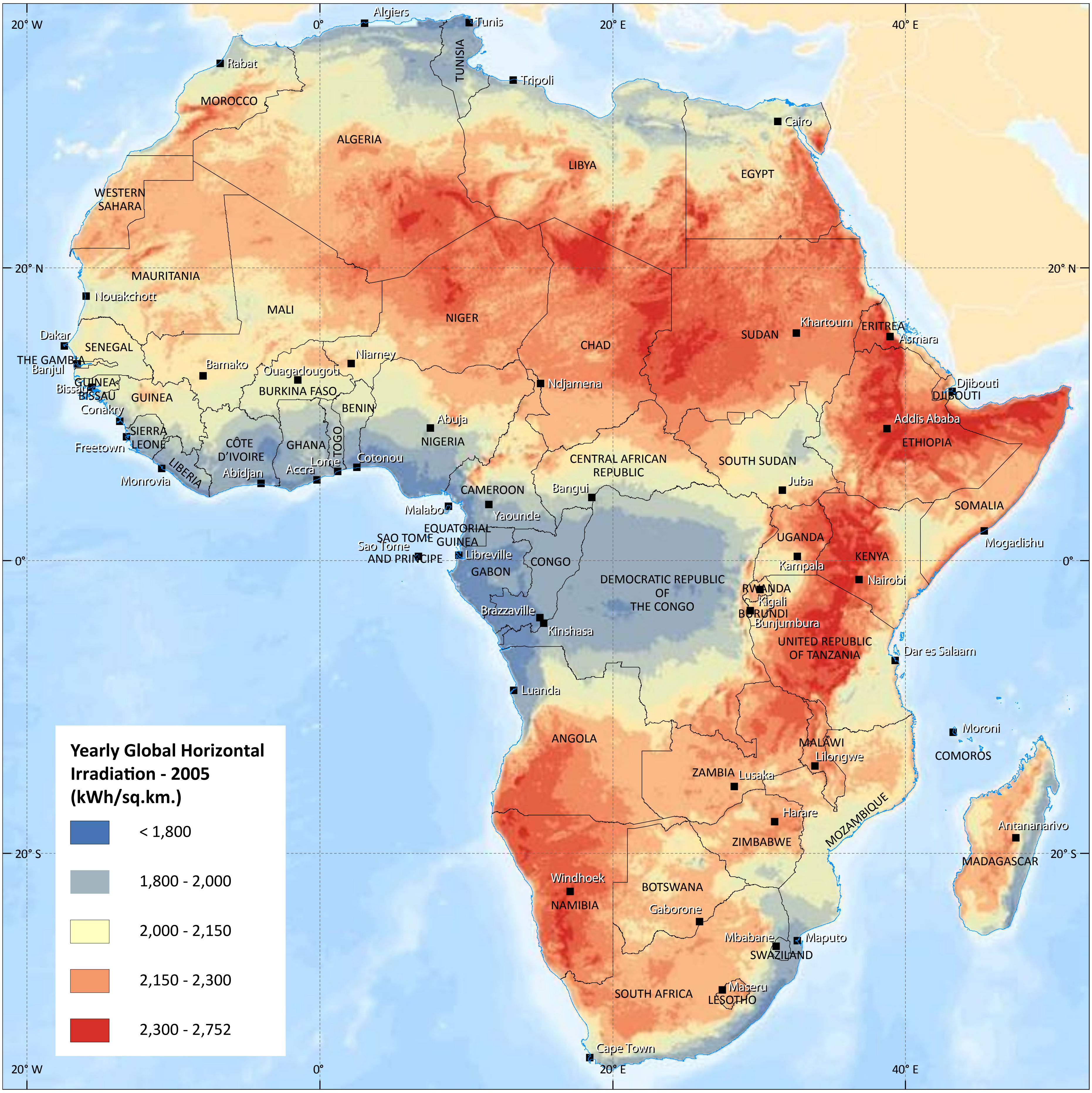
Solar energy is produced through a process called photovoltaics (PV), which use solid-state electronic cells to produce a direct electrical current from the sun's radiant energy. Solar cells are used to generate electricity for household power, street lighting, highway telephones, calculators, watches and water pumping, among other applications (DLIST Benguela, n.a.).

Potential capacity in Africa has been estimated as high as 10 terawatts (TW). Most of the region enjoys more than 300 days of bright sunlight and irradiance levels twice the average for Germany, where a thriving solar industry has developed. Estimates of prospective solar photovoltaic (PV) electricity supply by 2030 range from 15 GW to 62 GW (APP, 2015).

The potential for solar-based renewable energy technologies — photovoltaics (PV) and Concentrating Solar Power (CSP) — to reduce Africa's energy gap has been recognized for a long time. The distribution of sunlight across Africa is fairly uniform, with more than 80 per cent of Africa's landscape receiving almost 2,000 kWh per square metre per year (Figure 39). This gives solar power the potential to bring energy to most locations in Africa without the need for expensive large-scale grid infrastructure. Africa's abundant solar energy potential has been reinforced by a recent technical analysis

Solar field at the Agahozo Shalom Youth Village in Rwanda

Figure 39: Distribution of solar energy potential



Source: (AfDB, 2014)

undertaken by the US Department of Energy's National Renewable Energy Laboratory. The results from this analysis are shown below:

- Africa's solar energy potential is huge and equivalent to 90-100 million tonnes of oil per year. The solar radiation in Western Africa varies from 3-4 kWh/m^2/day in Cotonou (Benin) to 6.2 kWh/m^2/day in Agadez (Niger). In Northern Africa, southern Algeria's overall radiation reaches average levels of 6.1 kWh/m^2/day. In Southern Africa, the overall average radiation varies between 5-6 kWh/m^2/day. African nations have made notable progress in the use of solar photovoltaic power. Kenya, Ghana, South Africa, Tunisia and Senegal have promoted solar home systems;
- There is CSP generating potential in 17 countries in Africa, with variations from a low of 7 TWh/yr in Eritrea to a high of 40,500 TWh/yr in Libya; the main potential is in Libya, Egypt, the Kalahari Desert and some in Algeria;
- PV electricity generation potential varies from a low of 33 TWh/yr in Gambia to a high of 8,700 TWh/yr in Sudan, with the main potential in Algeria, Sudan and DRC (Cavallin, 2013).

Photovoltaic cumulative installed capacity at the end of 2014 was 1,334 megawatt (MW). South Africa is leading this rapid growth, adding nearly 780 MW between 2013 and 2014. Kenya has also seen sizable investments in solar PV, with 60 MW installed by 2014. Algeria, Egypt, Morocco and South Africa have deployed a total of six CSP projects as of March 2015. Their installed capacity amounts to just over 180 MW. Projects totalling 6.4 GW are underway, including some in Botswana, Namibia, Sudan and Tunisia (IRENA, 2015a). However, challenges related to storage remains daunting.

Conclusion

Africa is richly endowed with energy reserves from both renewable and non-renewable sources: reserves of coal, natural gas and oil represent 3.6 per cent, 7.5 per cent and 7.6 per cent of global reserves, respectively; energy from geothermal, bioenergy, solar and wind are also abundant, while new sources such as wave and tidal energy are being explored. Solar energy potential alone is believed to provide more than all the energy capacity needed in Africa. However, only an insignificant fraction of the existing potentials has been tapped into, making the continent the energy-poorest in the world. Energy demand in Africa is increasing but still accounts for only 3.3 per cent of the world total. This increase is due to a growing population, sustained industrialization and rising urbanization. In the power sector, Africa is the lowest in the world, and per capita consumption of electricity has barely changed since 2000. From 2015-2040, energy demand in Africa is projected to grow by 8.9 per cent a year; the expected generation capacity needed will rise to 694 GW, a growth of 6.2 per cent , representing a 6-fold increase. The biggest challenges facing Africa in meeting its energy demand by 2040 and sustaining its economic development are to find the necessary investments and policy coordination synergies at both the Regional Economic Community (RECs) and individual country levels to tap into its tremendous, but presently dormant, energy resources.

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Katse Dam, Lesotho

Chapter

2

ENERGY AND CROSS CUTTING ISSUES

Key messages

- Rapid development in energy infrastructure is key for future economic growth, poverty reduction and access to affordable energy for all; however, energy installations can have important impacts on ecosystems and their goods and services. Africa's natural wealth and magnificent wildlife need to be protected.
- Africa contributes just 3.3 per cent of global energy-related CO_2 emissions but will suffer disproportionately from climate change impacts.
- Climate change is likely to exacerbate drought and affect the availability of biomass and hydropower for energy.
- Population growth and rapid urbanization will increase the use of inefficient fuels for cooking and lighting.
- More women than men suffer from energy poverty.
- Expensive transport fuel contributes to making the cost of transporting goods in Africa among the highest in the world; by 2050, however, its transport fuel consumption is expected to double.
- The agriculture sector uses only about 6 Mtoe of energy, which is very low by world standards.
- Human muscle power is still the dominant energy source in African agriculture; in sub-Saharan Africa, it represents 80 per cent of the initial energy used to prepare land for agriculture.
- An average of only 34 per cent of hospitals and 28 per cent of health facilities in sub-Saharan Africa have reliable electricity access; about 58 per cent of health care facilities in sub-Saharan African countries have no electricity at all.
- Nearly 60 per cent of refrigerators used in health clinics in Africa have unreliable electricity, compromising the safe storage of vaccines and medicines; half of vaccines are ruined due to lack of refrigeration.
- Indoor pollution from biomass cooking — a task usually carried out by women — will soon kill more people than malaria and HIV/AIDS combined.

Introduction

Energy is required for all human endeavours. But its production and everyday use has profound impacts on the environment and human society. This chapter illustrates the interlinkages between energy and the environment, the implications of demographic trends and gender on energy issues, the impacts of energy use and development on human health and the cross-cutting issues related to energy and transportation and agriculture, and energy and peace and stability.

Energy and the Environment

Energy development and use — mining for fossil fuels and burning them, building infrastructure such as dams, building and extending transport corridors to access energy, harvesting and burning wood, making and using charcoal, and flaring gas and oil spills (see case studies in this chapter), etc. — is a major pressure on the natural environment. The impacts can include landscape changes and destruction, the loss of biodiversity, pollution and greenhouse gas (GHG)

Box 1: The environmental impacts of various energy sources

Source		General	Land Use	Water use	Wildlife and habitat	Pollutants	GHG emissions
Non-Renewable	Coal	- Limited availability in Africa	- Loss of land from mining - Water pollution from mine effluents and solid and liquid wastes from the power plants	- Mountain-top removal and strip mining increase risk of mudslides that also contaminate water sources	- Impact on health of forests, crops and animals from coal combustion and pollution	- Methane and short-lived pollutants - Toxic metals such as arsenic, lead, mercury, cadmium and chromium, as well as radioactive materials from coal waste	- Burning emits GHG
	Oil	- Found in limited areas - Supply may be exhausted before natural gas/coal resources	- Drilling, transporting and oil spills alter/pollute terrestrial ecosystems	- Water pollution due to solid and liquid effluents from oil transportation and accidents and from the power plant	- Drilling may affect ocean and terrestrial habitats - Impact on health of forests, crops and animals from oil combustion and pollution	- Methane and short-lived pollutants	- CO_2 emissions from oil fuel combustion
	Gas	- Explosions and gas flares	- Pipelines alter or destroy terrestrial ecosystems		- Ocean habitats can be disturbed - Impact on health of forests, crops and animals	- Methane: short-lived pollutants	- CO_2 from fuel combustion - Burns cleanly, but still has emissions
	Nuclear	- Higher capital costs - Potential nuclear proliferation issue	- Excavation of uranium and plutonium and improper storage of radioactive waste can impact the surrounding environment	- Water pollution from liquid effluents from uranium mines - When improperly stored, waste contaminates surface and groundwater - Water heating by waste heat	- Heated waste water from nuclear plants harms aquatic life - Effects of radiation on plants and animals in the case of severe reactor accidents	- Problem of long-term storage of radioactive waste	- Minor climate impact from construction - No GHG emissions
Renewable	Solar	- High initial investment - Depends on sunny weather - Other energy may be needed in low sunlight areas - Limited availability of polysilicon for panels	- Requires large physical space for PV cell panels	- Some water used to manufacture solar PV - Water needed to clean solar panels		- Impacts of discharges from energy backup or storage systems	- Minor climate impact from equipment manufacture
	Wind	- Output is proportional to wind speed - Not feasible for all geographic locations - High initial investment and on-going maintenance costs	- Turbines and infrastructure occupy a small land base - Offshore wind facilities require larger amounts of space	- There is no water impact associated with the operation of wind turbines	- Visual impact on the landscape - Bird kills, especially of raptor species - Other impacts: Noise and TV interference		

Distribution of propane, South Africa

emissions that contribute to climate change (Box 1). In turn, environmental deterioration also has impacts on the energy sector; for example, changes to water availability and flow due to human interventions or climate change can deprive hydro developments of their energy source.

The rise in the extractive energy industries in Africa is contributing to the expansion of road and rail corridors to move high-volume minerals such as iron and coal. These corridors and other energy-related infrastructure, such as pipelines and port facilities, are expanding into rural and other sparsely populated areas, with accompanying growth in settlements and associated environmental impacts. Research suggests that many such corridors will likely attract large-scale immigration, including legal and illegal miners, and will also encourage the influx of commercial agricultural developments. The potential environmental impacts of existing and planned large-scale growth corridors include extensive land-use

Source		General	Land Use	Water use	Wildlife and habitat	Pollutants	GHG emissions
	Biofuel	- Collecting the waste in sufficient quantities can be difficult - Energy inputs to grow, fertilize and harvest crops then process them can exceed energy value of final fuel	- Land usually must be removed from agriculture already producing food or fibre	- Available fresh water for growing biofuel crops such as maize and sugarcane and for processing them may be a major constraint	- May encroach upon forests or natural ecosystems - Land use by a monoculture and associated problems with biodiversity	- Emits some pollution as gas/liquid waste - Increases emissions of polluting nitrogen oxides	- GHG emissions can be similar to those from equivalent fossil fuels - In a balanced system, the CO_2 releases during plant operation are equalized by CO_2 absorption in plants during fuel growing
	Hydroelectric	- Changes the ecology in the dam area - Hydroelectric dams are expensive to build - Dams may be affected by drought - Local populations are displaced	- Flooding land destroys forest, wildlife habitat, agricultural land, and scenic lands - Negative influence on neighbouring land, with significant changes in groundwater levels in the vicinity of the reservoir - Sedimentation of reservoir and accumulation of toxic substances in sediments	- Changes to local or regional climate - Affects fishing industry - Requires water management, but can control floods - Water lost through evaporation in reservoirs is much higher than in flowing river - Reservoir water more stagnant, with more sediments and nutrients; can cause excess algae and other aquatic weeds - Potential to lead to drying out of downstream flows	- Can have a major impact on aquatic ecosystems - Loss of forests, land, crops, plant species, animals and their habitats, and historical sites		- After the area is flooded, the vegetation and soil in these areas decomposes and releases both carbon dioxide and methane
	Geothermal	- Geothermal fields found in only a few areas around the world - Expensive start-up costs - Wells could eventually be depleted	- Amount of land required by a geothermal plant varies - Land subsidence may result from removal of water from geothermal reservoirs	- Impacts on both water quality and consumption - Water is used for cooling and re-injection - Hot water pumped from underground reservoirs often contains high levels of sulphur, salt, and other minerals	- Many geothermal sites are located in remote and sensitive ecological areas - Sulphur dioxide causes acid rain, which damages crops, forests, and soils, and acidifies lakes and streams	- Open-loop systems emit hydrogen sulphide, carbon dioxide, ammonia, methane, and boron - Some geothermal plants also emit small amounts of mercury	In open-loop geothermal systems, approximately 10 per cent of the air emissions are carbon dioxide
	Hydrokinetic (Tidal Waves)	- There are few suitable sites for tidal barrages	- Only provides power when the tide is actually moving in or out - A barrage across an estuary is very expensive to build	- Installations can require large expanses of ocean space, which could compete with other uses, such as fishing and shipping - A barrage affects a very wide area	- Turbidity, salinity and sediment movements are affected	- Installations damage marine life and habitats - If in ecologically-sensitive estuary systems, could change hydrology and salinity, impacting animal, plant and bird life	

Sources: (Wang & Orris, 2015); (IAEA, 1999); (DLIST Benguela, n.a.); (Energy4me, 2015); (UCS, 2013) and (World Nuclear Assoc., 2016)

change and the loss or weakening of ecosystem goods and services, such as endangered and endemic species, carbon storage, water resources and filtration and climate-regulation, for example (Laurance, Sloan, Weng, & Sayer, 2015); (Weng, Klintuni, Dirks, Dixon, Lubis, & Sayer, 2013).

In addition to transport corridors, energy infrastructure includes dams and reservoirs, mining sites, oil production sites, wind turbines, solar panels, etc. that also changes landscapes and can destroy natural habitat. Large-scale wood energy production is usually very environmentally destructive, especially in “depletion hotspots” in East Africa (Bailis, Drigo, Ghilardi, & Masera, 2015) and although less devastating, rural woodfuel collection for local consumption can also have important impacts on surrounding ecosystems and their services (Cerutti, et al., 2015).

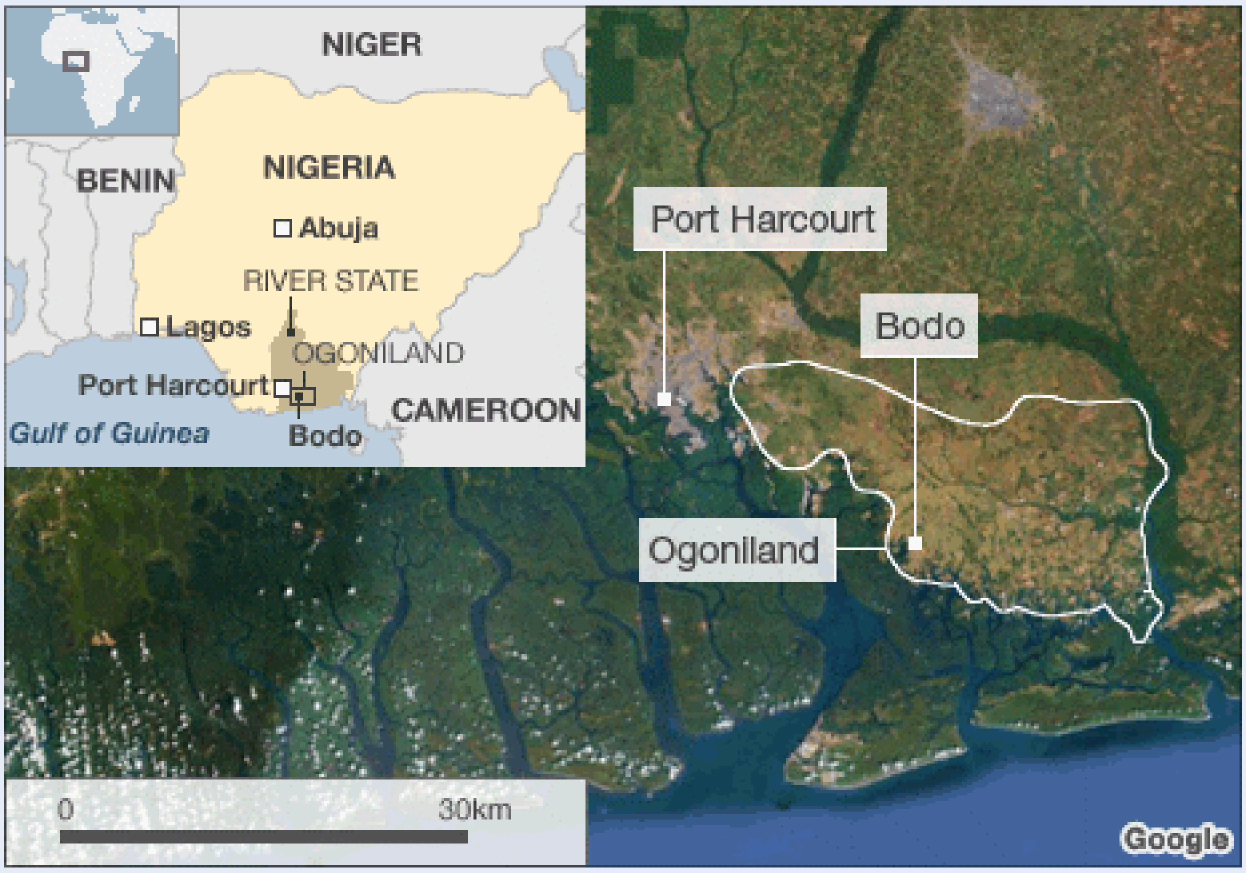
The potential for wide-scale biofuel production in Africa also has significant environmental risks, including adverse impacts on biodiversity. Already, the expansion of biofuels farming is threatening some biodiversity-rich areas (Wilcove & Koh, 2010). For example, research suggests that sugarcane production in Uganda’s Mabira forest saw the clearing of 7,100 ha, threatening 312 plant, 287 butterfly and 199 bird species (Senelwa, Etiegni, Osano, Balozi, & Imo, 2012). The allocation for biofuels production of 640,000 ha of forested areas in Tanzania, which villagers used for food and livestock grazing, threatens both biodiversity and local livelihoods (Balehegn, 2015). One of the major environmental consequences of biofuels agriculture is the high use of water for irrigation and processing, a requirement that could limit its expansion (Faeth, 2012). The average amount of water needed to produce one litre of fuel is almost a thousand times more than for conventional oil and gas (Searchinger, et al., 2008). In addition to depleting water resources, other impacts include GHG emissions, genetic contamination, invasive species (Balehegn, 2015) and the potential to reduce terrestrial carbon storage if biofuels agriculture extends into forested areas (IPCC, 2014b).

Case study: Oganiland oil spills

Oil spills are one of the energy industry's major environmental hazards. They contaminate land, groundwater, surface water, wildlife, vegetation and living organisms and generally destroy ecosystem goods and services, and they cause air pollution and public health problems (UNEP, 2011).

Oil spills occur regularly in the Niger Delta, a densely populated region that extends over about 70,000 km^2 and makes up nearly 8 per cent of Nigeria's land mass. Nigeria is Africa's main crude oil producer and in 2010, it accounted for most of the world's oil spills from its oil installations (pipelines, flowlines, well-heads, flow-stations, storage tanks, etc.). According to the National Oil Spill Detection and Response Agency (NOSDRA), oil companies reported 2,054 cases of oil spill incidents (spills of more than one barrel) between June 2006 and June 2010 (ten Kate, 2011). At that time, the Delta, once an ecological sanctuary, became a no-fishing zone due to the oil slicks that contaminated its waters (The Observers, 2010).

Location of Ogoniland, Nigeria



The oil industry has been operating in Ogoniland, which covers around 1,000 km^2 in Rivers State in southern Nigeria, since the late 1950s. There is a long history of pollution from oil spills and oil well fires in the region (UNEP, 2011). Oil theives cause most of the oil spills and resulting land and water pollution. Theft accounts for roughly 15 percent of Nigeria's 2.4 million barrels produced per day (Campbell, 2015).

Even though the oil industry is no longer active in Ogoniland, oil spills continue to occur. In 2011, the United Nations Environment Programme's environmental assessment of the impacts of oil spills in Ogoniland reported the following:

- serious groundwater contamination from hydrocarbons spilled on the surface;
- soil contamination exceeding Nigerian national standards;
- oil pollution in many intertidal creeks that degraded or destroyed mangroves, which are spawning areas for fish and nurseries for juvenile fish, impacting fish life-cycle;
- floating layers of oil on surface water throughout the creeks; in the worst affected areas, the wetlands risked total disintegration and the loss of the fishing industry;
- drinking wells at Nisisioken Ogale contaminated with benzene, a known carcinogen, at levels over 900 times above the World Health Organization (WHO) guideline;
- hydrocarbon contamination in water taken from 28 wells at 10 communities adjacent to contaminated sites; communities continued to use the water for drinking, bathing, washing and cooking as they have no alternative; and
- benzene in all air samples, with concentrations that WHO deems correspond to a 1 in 10,000 cancer risk in 10 per cent of the sites.

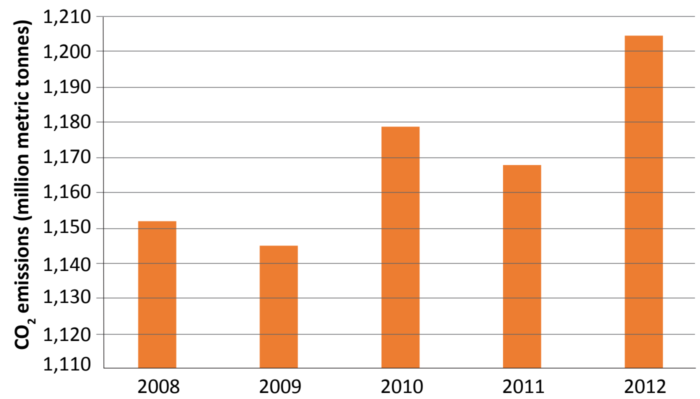
In addition to the thievery, oil spills have also occurred from freighters. For example, an oil leak from a tanker resulted in what is likely to be Nigeria's worst spill in the decade: in 2011, oil from a Royal Dutch Shell offshore spill spread to nearly 100 nautical miles after a leak occurred while loading a tanker. Shell estimates the Bonga spill to be around 40,000 barrels or 1.68 million gallons (6.36 million litres) of oil (Utilities, 2011).

Energy and climate change

Climate change and energy consumption

Africa currently accounts for a small share of global GHG emissions, but will suffer disproportionately from its impacts. In 2013, it contributed just 3 per cent of global energy-related CO_2 emissions, of which South Africa accounted for more than one-third. However, carbon dioxide emissions from the energy sector in Africa (Figure 1) are expected to rise by about 40 per cent by 2030 (IEA, 2015). This is a challenge to respecting the global carbon budget (Box 2). On the other hand, if its clean energy sector vastly improves, it is projected that Africa could potentially reduce CO_2 emissions by 27 per cent by 2040 (Munang & Mgendi, 2015). Research suggests that after reaching a peak, improved energy efficiency, less use of

Figure 1: Trend in total CO_2 emissions from the consumption of energy (million metric tonnes) in Africa, 2008-2012



Source: (EIA, n.d.)

Box 2: The carbon budget and unburnable carbon in Africa

The “carbon budget” refers to the amount of carbon dioxide the world can afford to emit between 2000 and 2050 so that the rise in global temperature remains below 2°C — which amounts to 886 gigatons (Gt). During the first 10 of those 50 years, the global economy had already emitted over a third of the budget. This means that to reach the goal and avert a major climate crisis, many oil, gas and coal reserves must remain unexploited; these are referred to as “unburnable carbon”. At the current global energy consumption rate, unburnable carbon will be reached in just 16 years. To keep the temperature rise to 2°C, a third of global proven oil reserves, 49 per cent of gas reserves and 83 per cent of coal reserves must not be burned. In Africa, it means that 21 per cent of the continent’s proven oil reserves, 33 per cent of its proven gas reserves and 85 per cent of its coal reserves must remain underground. In terms of oil alone, the unburnable carbon is equal to the total combined proven oil reserves of Angola, Chad, Congo-Brazzaville, Egypt, Equatorial Guinea and Gabon.

Source: (McGlade & Ekins, 2015)

coal for power and more reliance on renewables and nuclear energy will eventually drive down emissions in more developed regions of the continent. For example, in South Africa, emissions are expected to peak from 2020 to 2025 then begin to decline in the 2030s (IEA, 2015).

The latest report by the International Panel for Climate Change (IPCC) notes the high likelihood that in the residential and commercial sectors, climate change will reduce energy demand for heating while demand for cooling will increase; the balance between the two depends on geographic, socioeconomic and technological conditions. As incomes increase in presently poorer areas, people will use more air conditioning even in the absence of climate change, leading to a rapid growth in energy demand (IPCC, 2014a).

Case study: emissions from gas flaring in Nigeria

Nigeria, Africa’s largest economy and most populous country (over 180 million), is also the continent’s biggest oil producing country. The oil sector is Nigeria’s most important industry, accounting for about 35 per cent of GDP, 75 per cent of government revenue and 90 per cent of export earnings (Kottasova, 2016). Although it has been illegal since 1984, gas flaring is common in Nigeria. Until recently, the amounts of gas being flared was unknown, but now the Gas Flare Tracker measures how much flaring is taking place across the Niger Delta using real-time satellite data. Table 1 shows data related to gas flaring in Nigeria as calculated by the Gas Flare Tracker (MOE, 2016). Nigeria flares more gas than any other country in the world with the exception of Russia (Martinelli, 2015).

Nigeria’s gas flares release over 250 identifiable toxins and contribute more CO_2 to the atmosphere than the whole of sub-Saharan Africa combined (AAER, 2010).

Table 1: Gas flaring statistics in Nigeria, estimated totals per year[1]

Attribute	Amount
Volume (Mscf)	313,553,980.00
Fines (US$)	1,097,438,930.00
Gas value (US$)	783,884,950.00
Power generation potential (GWh)	27,091.0672
CO_2 emissions (tonnes)	16,531,992.0850

Note: 1: Calculated from incomplete satellite data and calibrated to other available statistics by multiplying yearly totals by 6.

Source: (MOE, 2016)

Other hazardous air pollutants emitted from gas flaring include oxides of nitrogen, carbon and sulphur (NO_2, CO_2, CO, SO_2), particulate matter, hydrocarbons and ash, photochemical oxidants and hydrogen sulphide (H_2S). In local areas, these pollutants combine with atmospheric moisture to form sulphuric acid and nitric acid, which also contribute to global climate change (MOE, 2016); (AAAS, 2011). In addition, these noxious gases are associated with a variety of adverse health impacts, including cancer, neurological, reproductive and developmental effects as well as deformities in children, lung damage and skin problems (MOE, 2016).

Figure 2(a): Flaring and other hotspots in Nigeria

Nigeria is taking action to stem gas flaring and its dangerous impacts: it is now a member of the World Bank Global Gas Flaring Reduction (GCFR) Partnership; with the support of the legislature, it intends to sign the United Nations Agreement on Zero Routine Flaring by 2030 and it has national target to reduce routine flaring to zero by 2020 (World Bank, 2016b).

Figure 2(b): Multiple gas flares located near a village (MOE, 2016)

The impacts of climate change on energy sources and development

Climate change will also affect the major sources of Africa's energy, although the literature is still sparse on the subject. It will affect the various energy sources and technologies differently, depending on the resource (water, wind, solar, nuclear, and fossil), the technological processes involved and the location. Changes in temperature, precipitation, windiness, cloudiness, etc. and the frequency and intensity of extreme weather events will increasingly affect energy operations.

The main climate-related problems for thermal and nuclear power plants are changes in the availability and temperature of water for cooling and the potential decline in thermal conversion efficiency. There is also concern for climate change's potential to influence the integrity and reliability of pipelines and electricity grids, which may require changes in construction and operation design standards (IPCC, 2014a). Due to Africa's high dependence on biomass, climate change will no doubt have adverse effects on the sector, since potential declines in rainfall and increasing drought will lead to vegetation loss and ultimately to desertification. Other human impacts on the environment, such as land use change and deforestation, will exacerbate climate change effects (Habtezion, 2012).

In a recent study on the effects of climate change on the potential for expanding wind and solar energy resources in southern Africa for future planning purposes, the authors looked at the long-term mean of wind speed and Global Horizontal Irradiance (GHI), which are reliable indicators of change in the potential for electricity production. They found that changes in wind and solar potential by 2050 are expected to be small (Fant, Schlosser, & Strzepek, 2016).

Climate change and hydropower

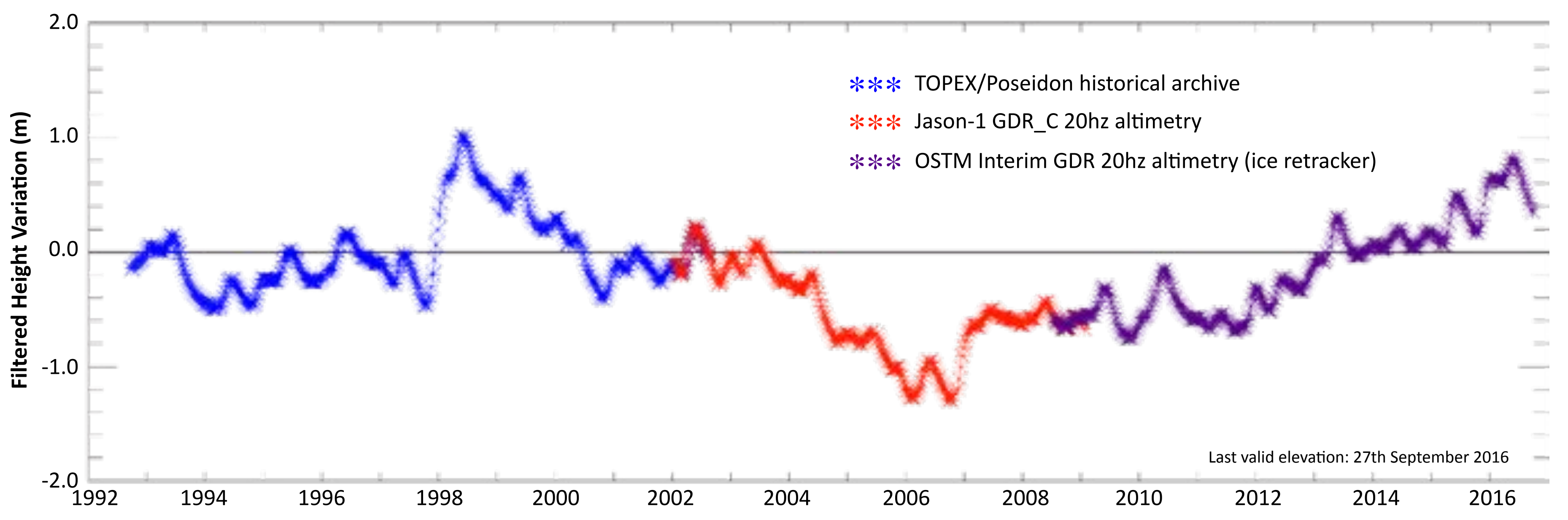
The IPCC reports that the impact of climate change in Africa on future water scarcity will be modest relative to other drivers, such as population growth, urbanization, agricultural development and land use change. There will be regional and subregional variations, however, with already water-stressed regions such as northern Africa and parts of southern Africa projected to become drier (IPCC, 2014b). In East Africa, climate change has already contributed to varying rainfall patterns with impacts on hydropower. Severe droughts reduce water supplies for hydroelectric power generation, while excessive flooding contributes to silt deposits in hydropower reservoirs, affecting the amount of water available for electricity generation (Habtezion, 2012).

By way of example, Ghana's electricity demand is increasing by 10 per cent a year while declining precipitation and higher temperatures due to climate change are reducing hydropower output leading to a national power crisis (REN21, 2015).

Box 3: The impacts of climate change on the energy economy

Some research suggests that repeated droughts are creating a power crisis in East Africa, which derives almost 80 per cent of its electric supply from hydropower (Habtezion, 2012). For example, hydroelectricity accounts for about half of all electricity generated in Uganda. Lake Victoria is very sensitive to rainfall variability and the impacts of climate change. The IPCC reports that the rise in global temperatures is already affecting the lake's water levels (IPCC, 2014b). Rainfall variability led to an approximate two metre drop in Lake Victoria's water level over three years in the mid-2000s (Figure 3), reducing the amount of power generated at the Kira and Nalubale hydropower stations. The shortage of power and need for alternative sources increased operation costs and affected industry in particular, which in turn led to a drop in GDP growth and increased power tariffs.

Figure 3: Changes in Lake Victoria's water level



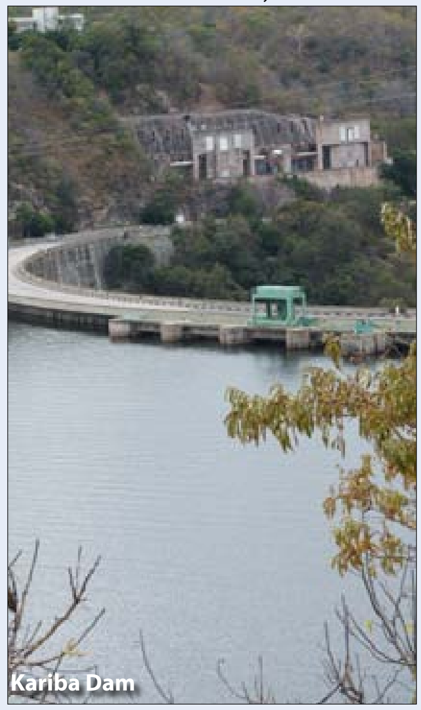
Case study: the Kariba Dam

Figure 4: The Kariba Dam as seen from space

Source: Google Earth 04/30/2016

The Kariba Dam is one of the largest dams in the world. It was constructed on the Zambezi River along the border between Zimbabwe and Zambia and is jointly owned by the two countries. In February 2016, Lake Kariba water levels near the dam of the Zambezi River dropped to near record lows. The drop was attributed to persistent drought, compounded by El Niño.

casey/Flickr.com/CC BY 2.0



The Kariba Dam, the world's largest man-made reservoir, is located in the Kariba Gorge of the Zambezi River Basin between Zambia and Zimbabwe (Figure 4). Constructed between 1956 and 1959, this double curvature concrete arch dam supplies water to two underground hydropower plants, one on the north (left) bank in Zambia and the other on the south (right) bank in Zimbabwe, with a total capacity of 1,830 MW and generating more than 10,035 GWh of electricity annually. The power stations were built in 1975. The North Bank Power Station is operated by ZESCO in Zambia and has an installed capacity of 1,080 MW. The South Bank Power Station is operated by ZPC in Zimbabwe and currently has an installed capacity of 750 MW, with projects underway to increase this to 1,050 MW (World Bank, 2015). Six sluice gates located some 80 m above the river level downstream of the dam release water from the reservoir (AfDB, 2014b).

The impacts of climate change will affect the reservoir's reliability. World Bank projections indicate that under the driest scenarios, hydropower generation could fall by more than 60 per cent , and in the Zambezi basin, unmet irrigation demand could decrease by more than 25 per cent . Under wetter scenarios, hydropower production could increase by up to 25 per cent and irrigation water provision potential would rise by a few per cent , illustrating how climate change is an important factor in water and power infrastructure performance in the Zambezi (AfDB, 2014b).

Power from the Kariba dam helped to make Zambia's economy one of the fastest growing in Africa. The country relies on hydropower for 95 per cent of its electricity and the dam usually generates more than 40 per cent of its power. A severe drought in 2015, exacerbated by climate change, led to near-record lows in water levels and blackouts that hurt the economy. Impacts were especially significant in the copper and steel industries, which suffered from increased production costs, declines in production capacity and prices and lost jobs. This power crisis focused attention on the contribution climate change makes to natural temperature and rainfall variations that affect lake levels over time (Onishi, 2016). More recently, water levels appear to be increasing.

Energy and Population

Population and energy access

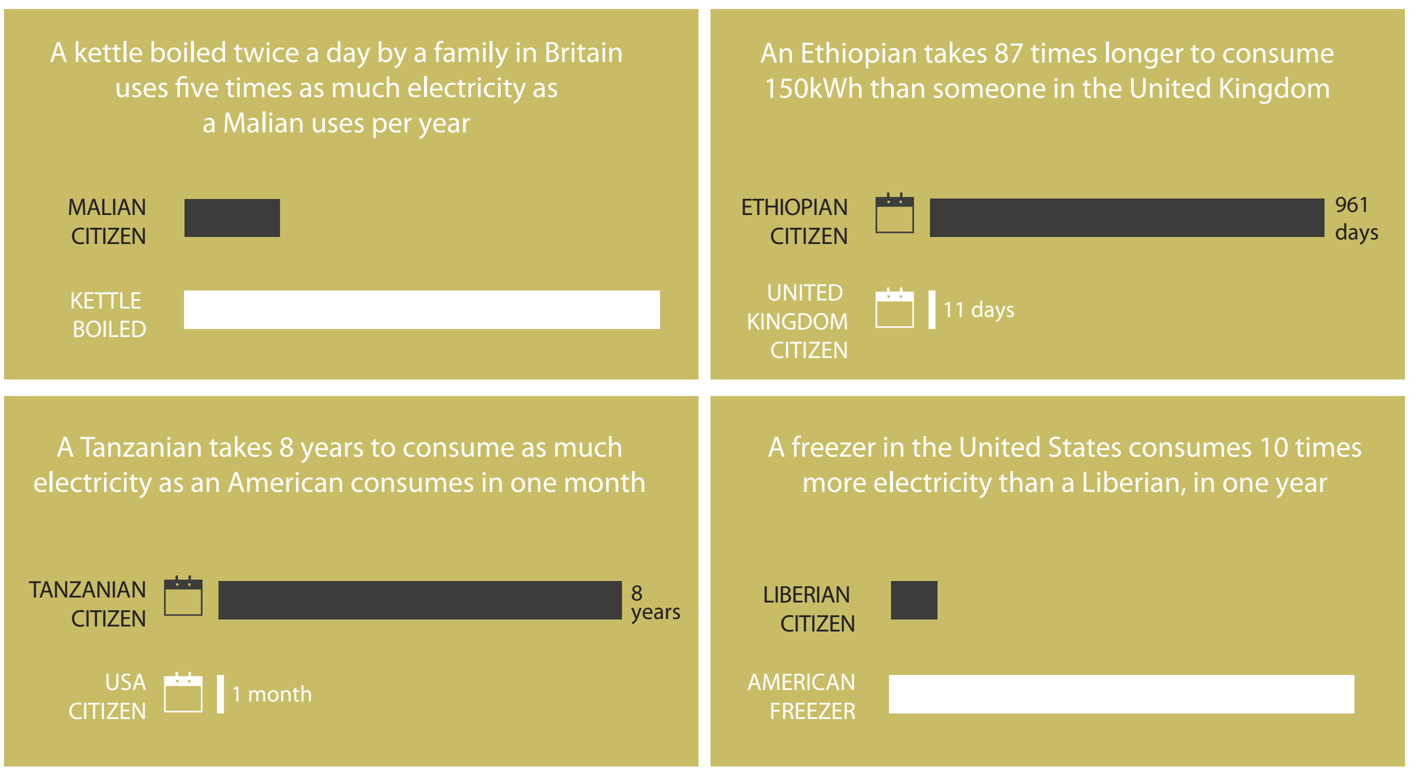
Depending on the region, there are significant disparities in access to energy, installed capacity and overall consumption among Africa's population of about 1.1 billion people. While all North African countries have achieved universal access to electricity and universal use of modern non-solid cooking fuel, sub-Saharan Africa is energy poor. The region represents almost 13 per cent of the world's population but nearly 60 per cent of that population lacks access to reliable energy. In addition, two in every three people in the region live without electricity, and almost four in five rely for cooking on solid biomass, mainly fuel wood and charcoal (APP, 2015) (Figures 6 and 7). Access to clean, non-polluting cooking facilities is even more restricted; as a result, 600,000 people in the region die each year of household air pollution. Almost half are children under five. Even where electricity is available, the supplied capacity is usually insufficient, causing energy shortages for both households and businesses. Rapid population growth, high urbanization rates and economic growth associated with very weak electrification rates cause more than 30 sub-Saharan African countries to experience regular power shortages. Although the overall electrification rate grew from 38 per cent in 2005 to 42 per cent in 2013, the energy deficits remain very large. In rural areas, for instance, electrification rates are as low as 10 per cent . South Africa is the region's only country with energy generation, consumption and demand rates close to those in North Africa.

Average electricity consumption in Africa has grown from 666 to 690 KWh/year during the same decade (APP, 2015); this consumption rate is still the lowest in the world, however, and represents fractions of that of emerging markets such as India and Brazil. The average electricity consumption rate of sub-Saharan Africa, excluding South Africa, is only about 150 KWh/capita per year compared to a global average of 7,000 KWh. Figure 5 compares some common uses of electricity between sample sub-Saharan African countries and developed countries.

With 13 per cent of the world's population, sub-Saharan Africa accounts for 1.8 per cent of world capacity for generating electricity and the share is shrinking. Installed grid-based capacity is around 90 GW, and at any one time, as much as one-quarter of that capacity is not operational. Moreover, South Africa alone accounts for around half of that power-generation capacity. Around 30 countries

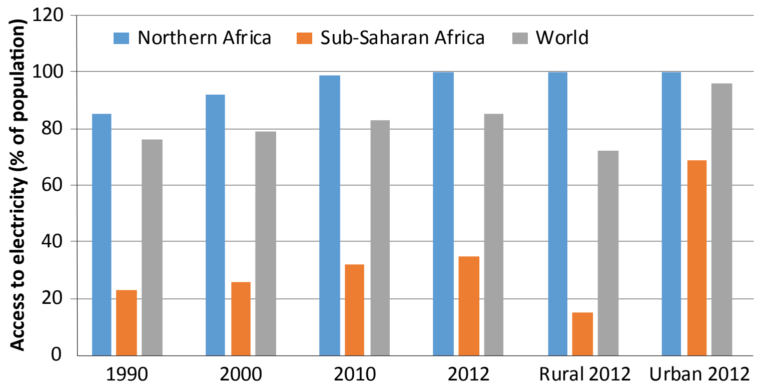
Charcoal market in Yaounde, Cameroon

Figure 5: Sub-Saharan African power consumption compared to other parts of the world



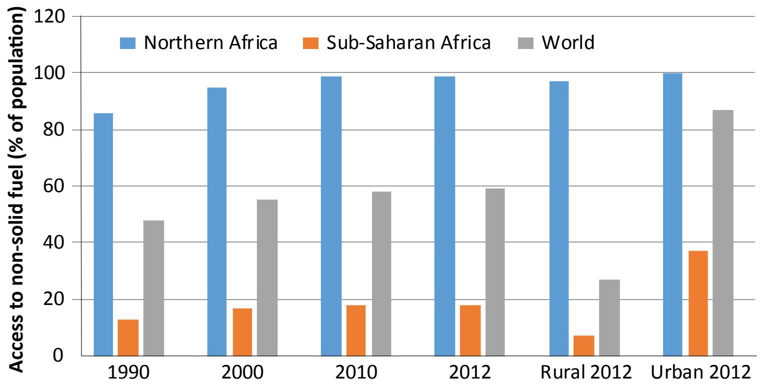
Source: (APP, 2015)

Figure 6: Access to electricity, 1990-2012



Source: (World Bank/IEA, 2015b)

Figure 7: Access to non-solid fuels, 1990-2012



Source: (World Bank/IEA, 2015b)

in the region have grid-connected power systems smaller than 500 MW, while another 13 have systems smaller than 100 MW (APP, 2015) (Figures 6 and 7).

Africa's poorest households bear the brunt of the energy-sector blockages. For example, an estimated 138 million households comprising people living under the poverty line spend some $10 billion a year on unhealthy and polluting energy-related products such as charcoal, candles, firewood and kerosene; this represents an equivalent of $10/KWh on lighting, or about 20 times the amount spent by high-income households with connection to the grid for their lighting. In the meantime, the proportion of African households using some form of clean and renewable energy, especially solar lighting, is growing slowly, from about one per cent in 2009 to approximately 5 per cent by 2015 (APP, 2015).

Table 2: Demographic data and projected population numbers

Region/Country	Population mid 2015, millions	Births per 1,000 pop	Deaths per 1,000 pop	Projected population (millions)	
				Mid-2030	Mid-2050
World	7,336	20	8	8,505	9,804
Africa	1,171	36	10	1,658	2,473
Sub-Saharan Africa	949	38	11	1,369	2,081
Northern Africa	222	29	6	289	392
Western Africa	349	39	12	509	784
Eastern Africa	388	36	9	562	841
Middle Africa	149	44	14	229	378
Southern Africa	63	23	10	69	77

Source: (PRB, 2015)

Population growth and energy

Of all the world's regions, population growth will be highest in Africa over the next few decades. By 2050, it is expected to more than double to at least 2.4 billion, with most of the growth occurring in sub-Saharan Africa (Table 2). This projection is based on the assumption that birth rates will decline evenly in all African countries due to effective family planning. Since youth make up a large proportion of the populations in these countries, however, the pace of population growth will still be fairly rapid after 2050 (PRB, 2015).

Population growth has an important effect on energy demand and use. Electricity demand for both residential and commercial/industrial needs will grow. For example, in sub-Saharan Africa, the rise in household numbers will increase the residential demand by fivefold from 2010 to 2040 (from 91 TWh to about 463 TWh), representing an annual 5.6 per cent growth in demand.

The annual average growth rate of commercial and industrial demand in Africa is expected to rise by 4.1 per cent during the same time period, with variations ranging from 3.1 per cent in southern Africa to 7.2 per cent in eastern Africa. By 2050, South Africa and Nigeria together will account for more than a half the demand (McKinsey & Company, 2015).

Energy and gender

Since the Beijing Conference of 1995, the concept of Gender and Energy has evolved from focusing on clean cook stoves to analyzing the complex relationship between the access to and use of energy, and economic development, especially for women, due to the importance of energy in women's lives (Clancy & Khamati-Njenga, 2005). More women than men suffer from energy poverty in Africa (World Bank, 2013).

In Africa, as in many other regions, cultural norms include gender roles and power dynamics that affect how women and men access and use energy (UNEP, 2016). Women's roles in rural Africa generally continue to include providing household energy supplies, including gathering fuelwood or paying for energy for cooking, lighting and heating.

Increasing energy access in Africa benefits both men and women, but affects them differently because of their different energy needs (Dutta & Clancy, 2005). Because of their important role in the household, improved access to timesaving electric appliances has transformed women's lives more significantly than men's (Deloitte, 2014). Reducing poverty is inherently linked to energy because it enables greater productivity (APP, 2015).

Compromised health and time poverty are two gender-specific problems related to energy that rural African women face (Habtezion, 2012). In terms of health, both the use and production of energy among rural and poor women in Africa is physically demanding and often dangerous. The energy used for cooking is unsafe and polluting; their food-processing technologies are basic and arduous; and fuel transport is physically demanding and can potentially expose them to attacks (Ndwiga, Kei, & Jepngetich, 2014). In conflict settings in particular, when women and girls leave their communities to collect fuel, they are more vulnerable to physical (including sexual) violence (UNEP, 2016).

Table 3: Examples of average weight of fuelwood head-loads carried by women in some African countries

Countries	Fuelwood head-loads weight (kg)
Botswana	27-31
Congo	25-50
Ethiopia	≈36
Other countries in Southern Africa	24-38
Malawi	27-31
Tanzania	27-31

Source: (UNEP, 2016)

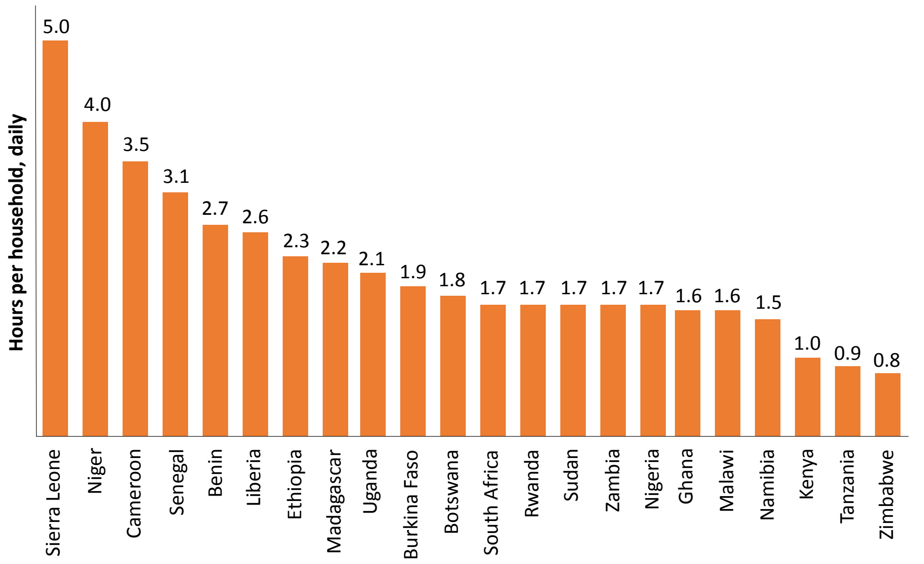
The physical burden of energy use and provision on women

Women carry greater loads than men but have a lower intake of calories because custom usually requires that men receive more food and water (WHO, 2011); (Dankelman, 2010), although women spend much of their own energy collecting firewood (UNEP, 2016). Examples of the average weight of fuelwood head-loads that women typically carry in Africa can be as much as 25 to 50 kilograms (Table 3).

The physical ramifications of carrying heavy loads over long time periods include the early ageing of the spine due to the cumulative damage of vertebrae, neck muscles and the lower back (WHO, 2011).

Another major health impact of energy use that affects women more than men is the burning of traditional biomass fuels and coal, which exposes low-income households and women in particular to serious health hazards (Figure 8). Depending upon the type of fuel used, smoke from these sources can contain fine particulate matter (PM), carbon monoxide, nitrous oxides, sulphur oxides (mainly from coal), formaldehyde and other toxic compounds, the most damaging of which are fine particles known as PM (particulate matter less than 2.5 micrometres) (UNEP, 2015). WHO estimates that indoor air pollution from burning biomass for cooking and heating in Africa is responsible for 41,000 deaths a year due to Chronic Obstructive Pulmonary Disease (COPD) and 350,000 deaths due to Acute Lower Respiratory Infection (ALRI) (Ndwiga, Kei, & Jepngetich, 2014) (Figure 8). Women, and children in their care, are more exposed to smoky kitchens than men, and hence have higher levels of lung and eye diseases (Clancy & Khamati-Njenga, 2005). In sub-Saharan Africa, girls are more likely to die from breathing the fumes and smoke from indoor cooking fires than from malaria or malnutrition (REN21, 2015). The World Health Organization (WHO) estimates that indoor pollution from biomass cooking—a task usually carried out by women—will soon kill more Africans than malaria and HIV/AIDS combined (AfDB, 2014a).

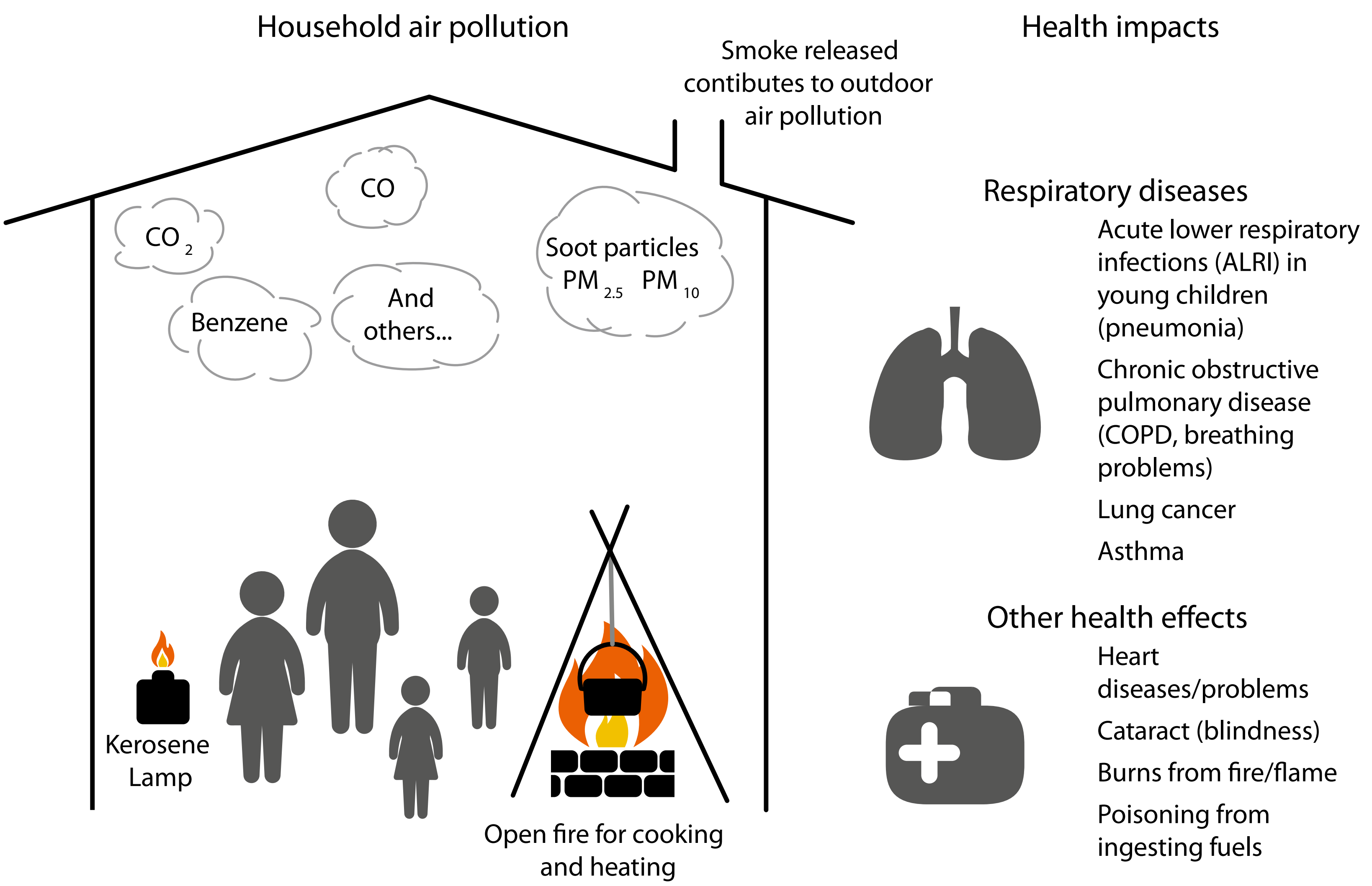
Figure 9: Hours spend gathering fuelwood in a selection of 22 African countries



Source: (AfDB, 2016b)

Another way energy provision affects women is the lack of adequate energy in health care facilities in many regions of Africa, which can jeopardize maternal care and childbirth deliveries, especially at night. About 550 women die in Africa every day from preventable causes related to pregnancy and childbirth (WHO, 2015).

Figure 8: The impacts of cooking indoors with woodfuels and kerosene



Source: (UNEP, 2015)

Box 4: Women are bringing solar energy to Maasai communities in Kenya

Maasai women are at the forefront of a solar-power revolution in rural Kenya. For example, in Kajiado County, Green Energy Africa trains women to install solar products in homes and villages and market the products through its Women and Entrepreneurship in Renewable Energy Project (WEREP). In only seven months, solar energy use rose from zero to 20 per cent of the area. Now, children can study by solar light after nightfall and teenagers can sleep indoors instead of guarding livestock from predators, a job that solar powered lighting now does. As well, women and girls spend far less time collecting firewood or traveling long distances to charge cellphones and purchase fuel. The benefits include savings on the cost of kerosene, less exposure to harmful indoor smoke and fewer trees cut down in their surroundings, not to mention the empowerment of women in communities where customs deny them property ownership; now, women own the solar technology.

Sources: (Froelich, 2015); (Obi, 2015)

Gender and time poverty

Depending on the region, season and availability, the average time spent collecting biomass in Africa is four to ten hours per week (Figure 9), with women spending more time in this pursuit than men in most regions (UNEP, 2016).

Thus, women experience time poverty more severely than men, since the time it takes to supply household energy prevents them from other productive activities such as waged labour and educational pursuits, as well as other life-enhancing exchanges outside the home (UNIDO/UN WOMEN, 2013) (Blackden & Wodon, 2006). Evidence of this is revealed in the difference between men and women in literacy rates and school enrolment levels. In sub-Saharan Africa, the primary school enrolment rate for girls is 85 for every 100 boys, and 83 and 71, respectively, for secondary and tertiary education (UNDESA, 2010). Climate change, which is likely to make natural resources increasingly scarce, will increase women's time poverty as they are forced to travel farther to collect fuelwood (World Bank, 2009); (Habtezion, 2012).

Gender and energy, employment and economic empowerment

Women can also be disadvantaged by employment opportunities in the energy sector. For example, since more women than men hold informal and precarious jobs that may not be covered by labour regulations and inspection, they are more likely to be exploited. The gender-related impacts of work on large-scale energy projects can include sexual harassment, prostitution and human trafficking during and after construction (UNEP, 2016).

Women entrepreneurs in the energy sector in Africa can be challenged by inadequate education and training and a lack of access to credit and other financial services. Of the total number of employees in Africa's formal energy industry, women represent only 20 per cent , most of who work in non-technical fields such as administration and public relations (UNIDO/UN WOMEN, 2013). Box 4 is an example of the potential for women to become energy entrepreneurs in Africa.

Another disadvantage for women has been their lack of influence in the design and introduction of new energy technologies, such as efficient cookstoves (UNEP, 2016). Women can also be more affected than men by a community's displacement for large-scale energy projects, such as hydropower, since less than 10 per cent of land titles in most parts of Africa are registered in women's names. As well, when compensation is provided, women receive less or none at all because they hold no title and have no recourse to claims processes (UNEP, 2016).

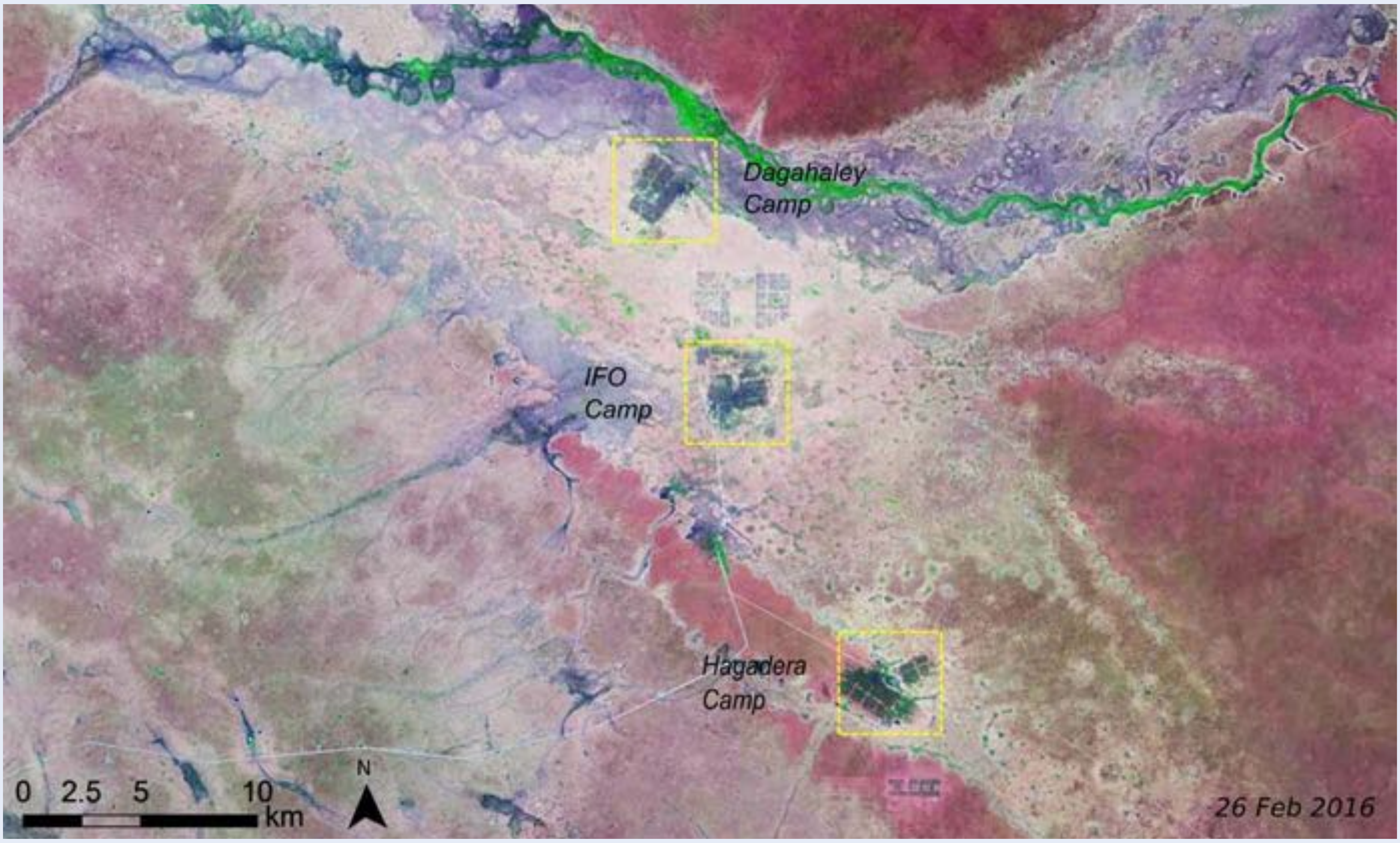
Energy and refugees and internally displaced people

The number of people leaving their homes to migrate elsewhere is growing at a rate faster than the world's population. In 2015, there were over 244 million migrants globally. There are roughly 65 million forcibly displaced persons, including over 21 million refugees, 3 million asylum seekers and over 40 million internally displaced persons (UNHCR, 2014).

In 2015, there were about 14.9 million refugees and internally displaced people in Africa (Figure 11), representing a slight decrease from 2014 (from 15.1 million), due to repatriation, resettlement and other solutions (UNHCR, 2015).

For these refugees, access to safe, secure and reliable energy is usually inadequate and they may lack fuel for cooking and light. In many places, including sub-Saharan Africa, refugees frequently need to compete for dwindling resources, triggering tensions with host communities. In addition, it can lead to acute deforestation of the immediate surroundings, causing

Women installing solar panels, Mauritania



Case study: Dadaab refugee camp

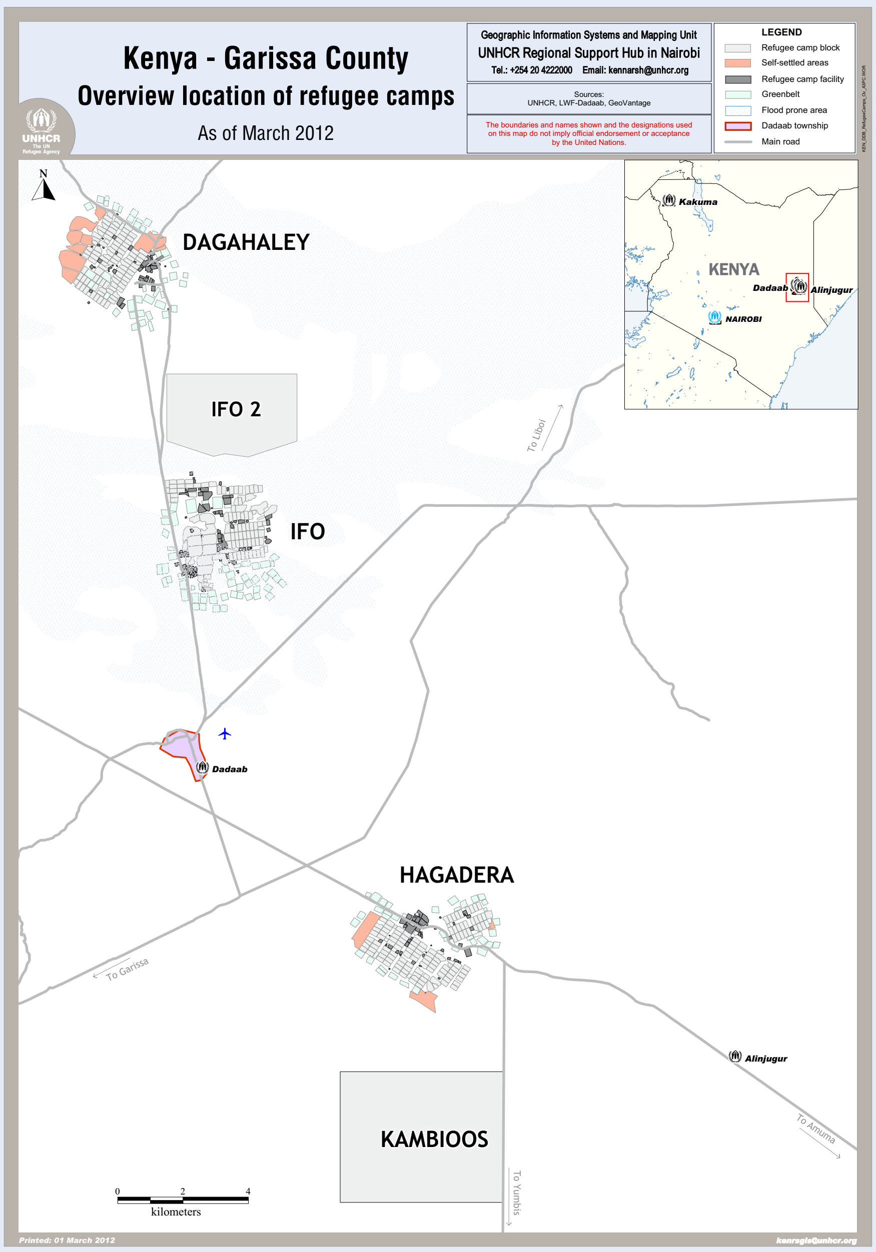
The UNHCR set up the first camps at Daabab, located in Garissa County in northeastern Kenya (Figure 10), between October 1991 and June 1992 following a civil war in Somalia that saw the overthrow of the central government (Redden, 2012). In 2011, thousands of more refugees were arriving at the camps every day due to severe drought in Eastern Africa.

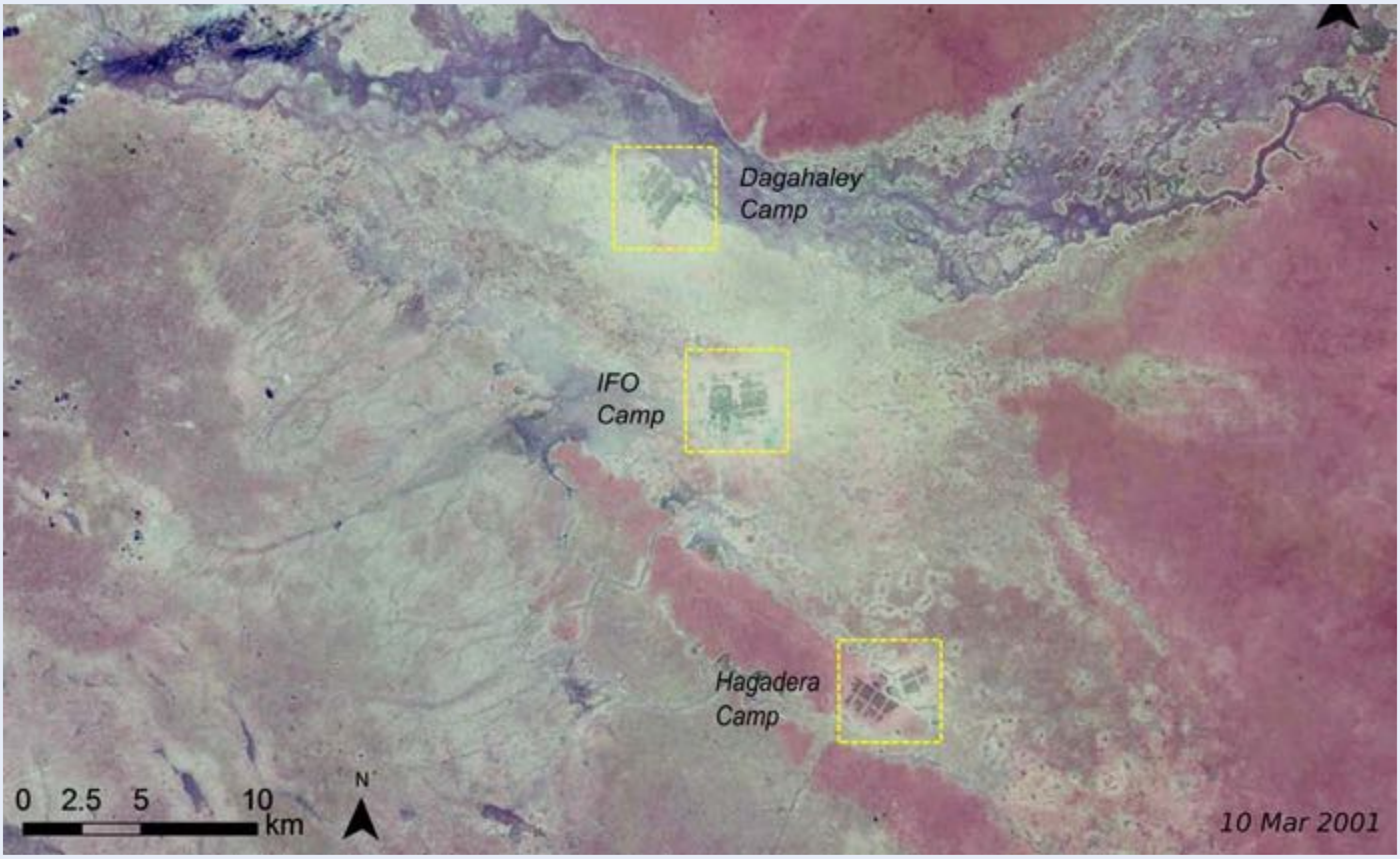
The area has grown over the years to cover an area of fifty square kilometres and is now a complex of five sub camps. It is Kenya's fourth-largest population centre (Okello, 2016), with a total refugee population of 278,945 at the end of August 2016 (UNHCR, 2016) occupying a camp originally intended for 90,000 (Redden, 2012). Women reperesent 50.6 per cent of the total population. Although the majority of refugees originated from Somali, there are other significant groups from Ethiopia and South Sudan.

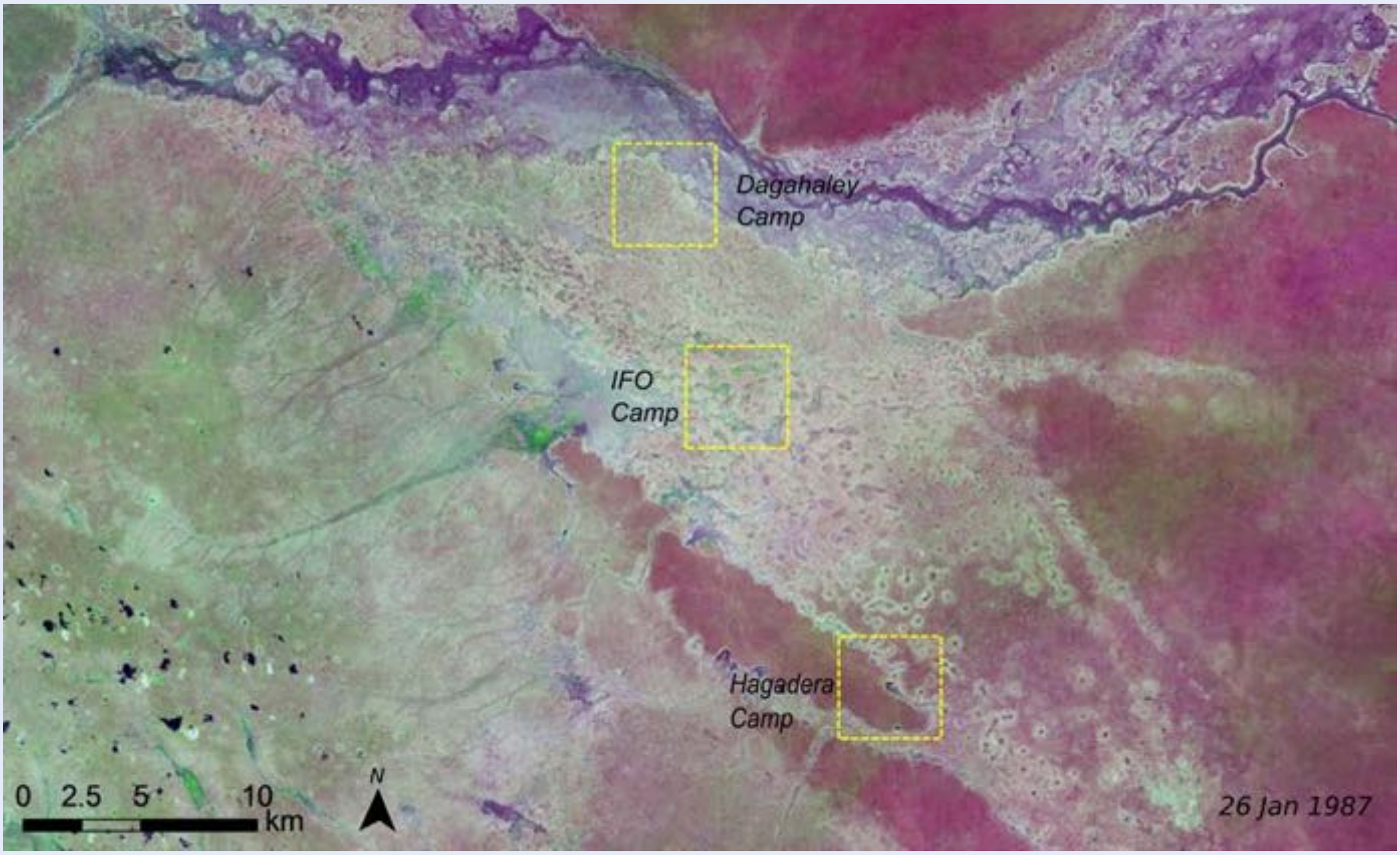
The area is arid, with a hot and dry climate and occasional flooding in poorly drained areas. The quality of household cooking energy accessed in Dadaab remains poor. A 2016 study of the energy situation in the camp showed that about 98 per cent of residents in the sample use wood as their main cooking fuel. Refugee households in Dadaab spend an estimated US$6.3 million per year on wood fuel. In addition, 49 per cent of households collect firewood at no financial cost from the surrounding woodlands. The combination of the camps' population and that of the host community (approximately 148,000 within a 20-kilometre radius) constitutes a huge burden on the local biomass resource (Okello, 2016).

The camp complex is not connected to the national grid, so the only way residents can access electricity is through stand-alone or off-grid power systems. Dry-cell battery torches are the primary source of household light for 60.8 per cent of refugee households, costing them a total of US$1.6 million per year. Another 11.2 per cent of households use indirect lighting from streetlights or neighbours'

Figure 10: Location of the Dadaab refugee camp



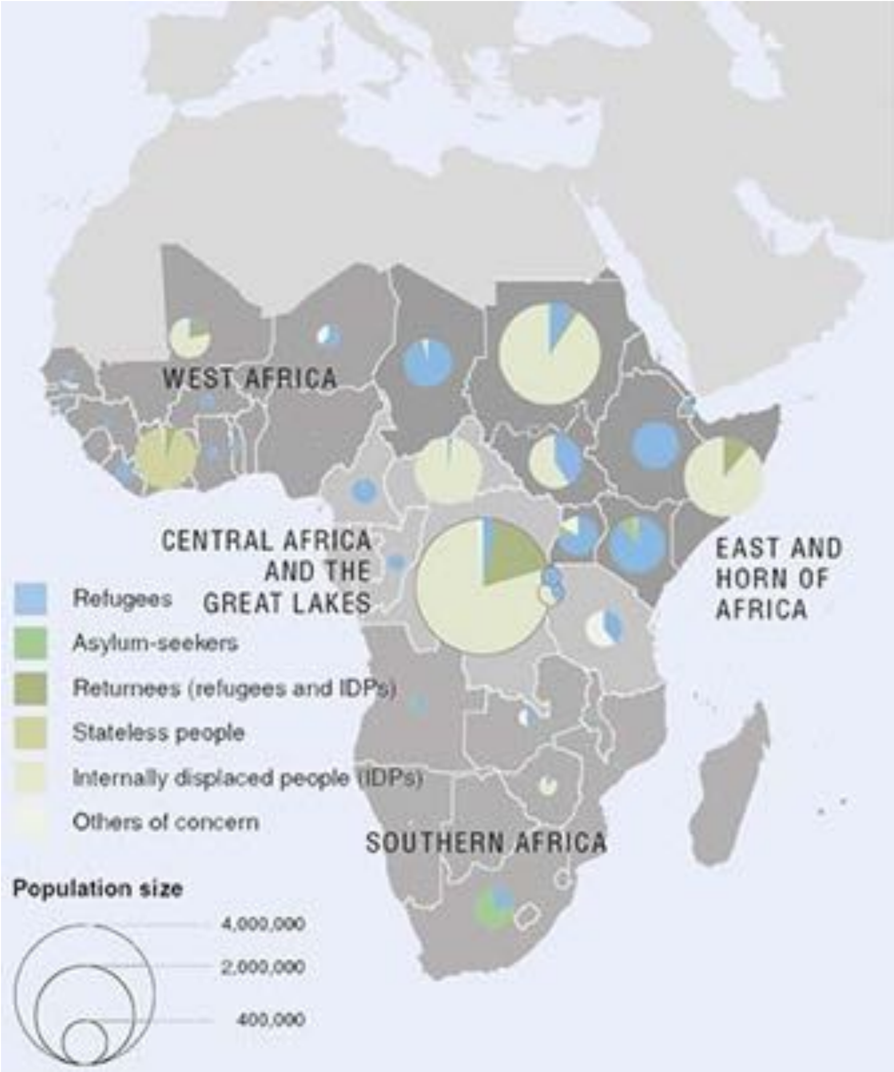




houses, 10.5 per cent use electricity from generators, 7 per cent use solar lanterns and 4.4 per cent use kerosene lamps (Okello, 2016).

Wood fuel is used to meet a significant proportion of cooking energy needs in Dadaab. This has contributed greatly to environmental degradation, as well as to conflict between the displaced population and host communities. Significant health risks are also associated with indoor air pollution; in nearly all cases these risks are not adequately addressed by the introduction of fuel-efficient stoves (Okello, 2016).

Figure 11: Numbers of refugees in Africa, 2015



Source: (UNHCR, 2015)

profound erosion and exposing the area to flash floods or drought, or other serious secondary impacts. These situations can lead to irreversible environmental degradation, as well as total bans of firewood collection, with significant impacts of refugee well-being (UNHCR, 2014).

On 19 September 2016, the United Nations General Assembly adopted the New York Declaration for Refugees and Migrants, committing to protect the rights of refugees and migrants, to save lives and share responsibility for large movements on a global scale (UNHCR, 2014).

Energy and Socioeconomic Development

Introduction

Although the energy sector may not contribute a great share of most countries' GDP (except for those in which fossil fuels are especially abundant), energy is needed for nearly every economic good and service and research establishes a clear link between quality of electricity supply and per capita GDP. The African Development Bank's New Deal on Energy for Africa has the aspirational goal of achieving universal access by 2025, recognizing that "Energy is the engine that powers economies" (AfDB, 2016a). It points out that countries with low power consumption per capita have low GDP per capita and that high power consumption per capita appears to be correlated with high GDP per capita (AfDB, 2016b).

> "In Africa, access to affordable and reliable energy is fundamental to reducing poverty, improving health, increasing productivity, enhancing competitiveness and promoting economic growth. Inadequate power supplies take a heavy toll on the private sector, and the economic costs of outages are substantial. Many African enterprises experience frequent outages, and in many countries backup generators represent a significant proportion of the total installed power capacity. Undoubtedly, the provision of electricity to countries in Africa will not only fulfil their needs but will help them advance towards sustainable development" (WEC, 2012).

This emphasizes the importance of reliable and available electricity in creating jobs and economic growth. Seventy per cent of businesses in sub-Saharan Africa identify unreliable power as a major constraint to growth (AfDB, 2015b), highlighting the lack of reliable electricity as limiting private sector development; access to reliable and affordable energy can help companies penetrate new markets and enables farmers to diversify their income sources and support agro-processing industries that link agricultural producers to national, regional and global markets (APP, 2015). Energy-sector hurdles and power shortages cost sub-Saharan Africa 2-4 per cent of GDP annually. For instance, companies in Tanzania and Ghana are losing 15 per cent of the value of sales as a result of power outages (APP, 2015).

In addition, the lack of clean fuels has huge social, environmental and economic costs; it is estimated that Africa loses US$30-60 billion a year due to a combination of negative health effects, environmental degradation, climate change and lost economic productivity associated with high levels

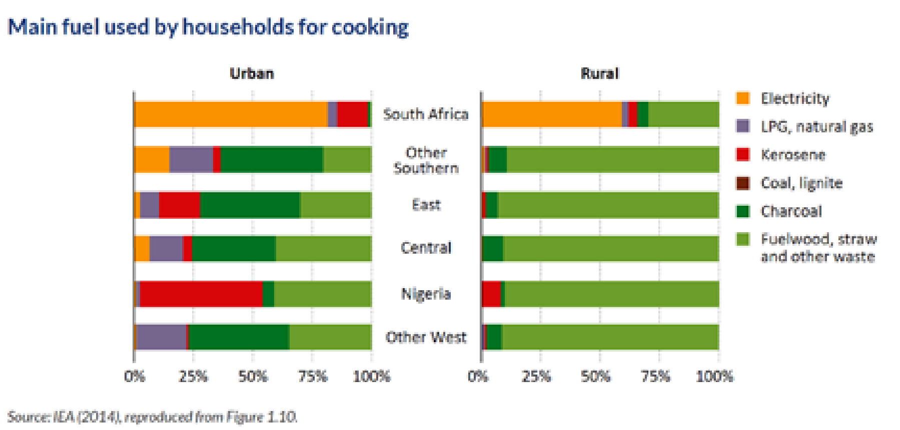
Box 5: The costs of power shortages in sub-Saharan Africa

"In the commercial, industrial, and residential sectors, many individuals and businesses own their own generators to make up for the lack of access to and supply of energy. In Kenya, 57 per cent of businesses own generators, with numbers reaching 42 per cent for Tanzania and 41 per cent for Ethiopia. On average, generator power is four times the price of grid power, and would still be two to three times as expensive if grid power reflected actual costs (rather than benefiting from subsidies). For many businesses, however, grid power is intermittently or entirely unavailable, making the additional price for generator power a necessary and acceptable cost of doing business. Nonetheless, the widespread use of generators in sub-Saharan Africa distorts the cost of doing business. For heavy industry such as smelters, energy is expected to be a significant proportion of a company's cost base. However, in Nigeria, diesel fuel is also a major expense for banks to ensure their branches have electricity. Similarly, diesel fuel is often a leading expense for the major African mobile-phone companies, representing up to 60 per cent of operators' network costs. As a result, businesses that do operate in sub-Saharan Africa have much higher relative energy expenses than their counterparts in other countries. In addition, many enterprises that do business in other parts of the world never succeed in sub-Saharan Africa, because local energy costs make them uncompetitive."

Source: (McKinsey & Company, 2015)

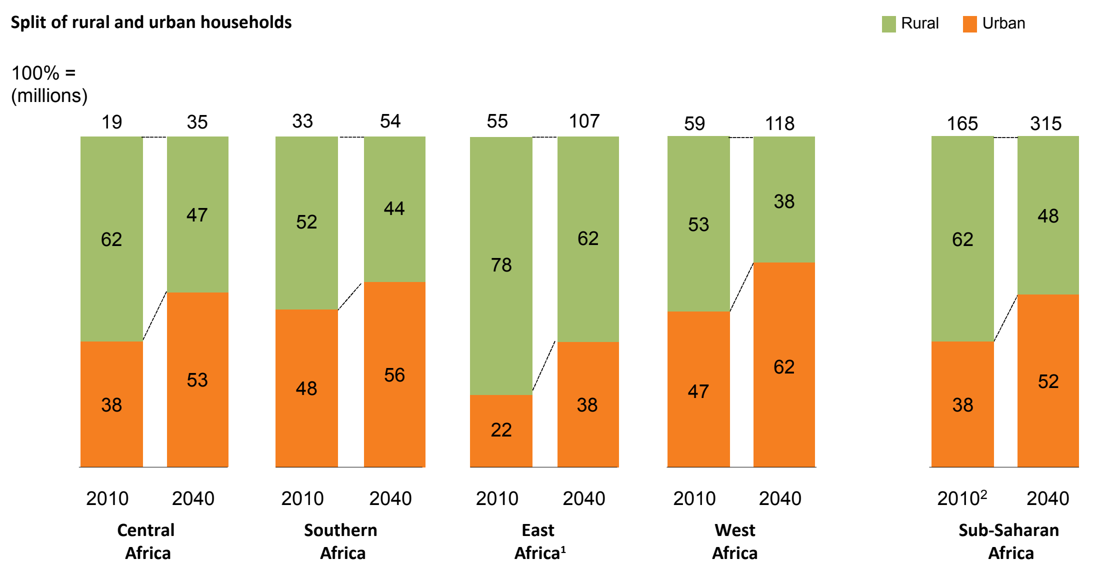

Nightlights, Algeria

Figure 12: Main fuel used by households for cooking, urban versus rural



Source: (Jaeger & Cavis, 2015)

Figure 13: Growth in urban households by region, 2010-2040



Source: (McKinsey & Company, 2015)

of biomass consumption instead of using clean cooking and heating solutions (AfDB, 2015b).

It is projected that Africa can create a flourishing renewable energy industry that could supply about 2.5 million temporary and permanent jobs. The potential for solar energy to improve local economies is substantial, given the presence of abundant sunshine and the demand for solar home systems (SHS) by half of Africa's population that is not connected to the grid. Making grid and off-grid renewable options available to Africa's poor households could reasonably save up to $8 billion, given that they presently spend as much as 20 times more on energy for lighting than high-income households connected to the grid. Indeed, it is estimated that in sub-Saharan Africa, clean and accessible grid energy could reduce poverty for 16 to 26 million people (Munang & Mgendi, 2015).

Energy and Urbanization

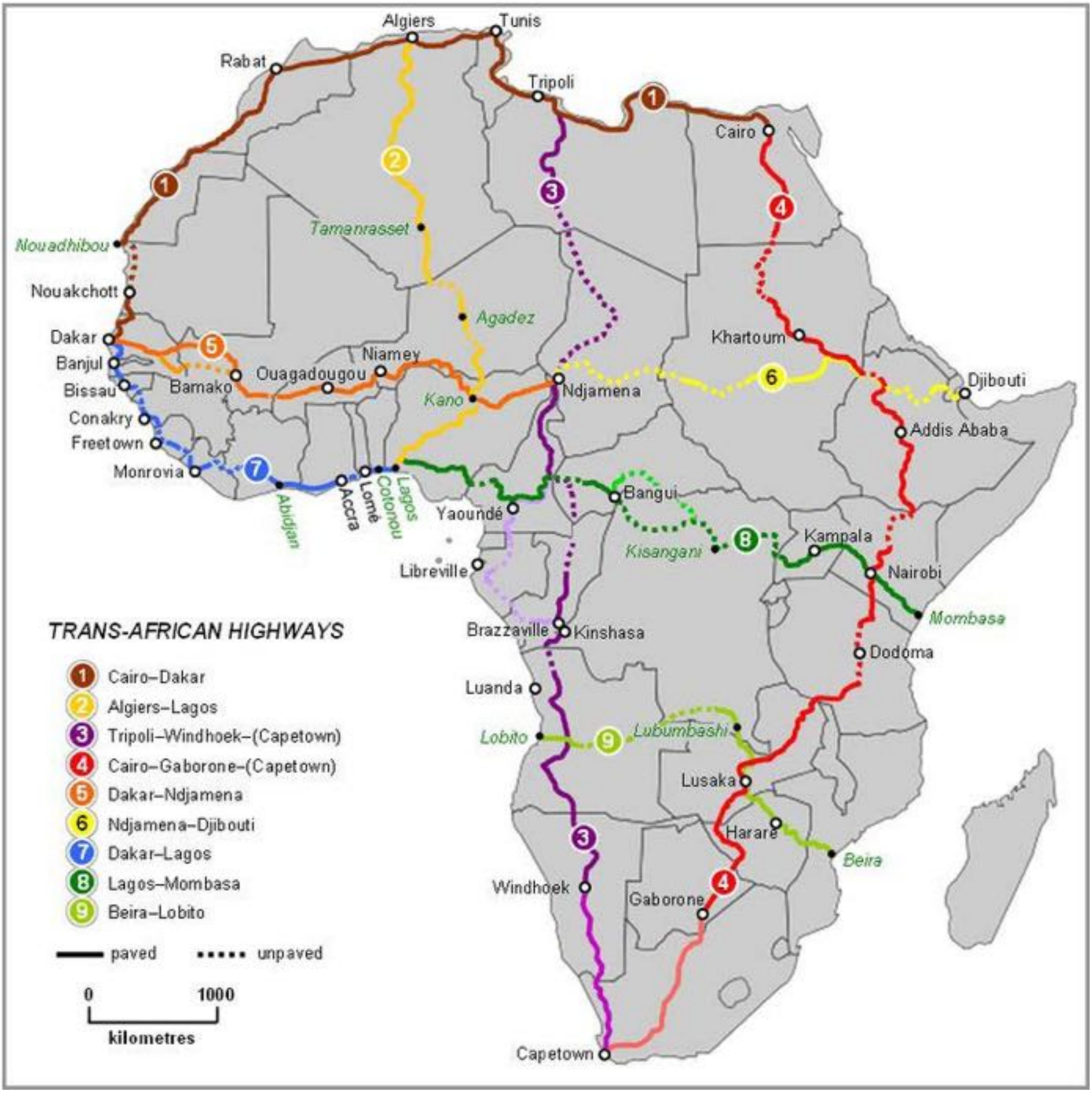
Urban consumers use more energy than rural ones (Figure 12). Connected urban households in sub-Saharan Africa (excluding South Africa), for example, each use 1,400 KWh/year per compared to 400 KWh for rural households. Rapid urbanization rates are thus contributing to increased energy demand. The use of electricity is higher in urban than rural households. The proportion of people living in cities in sub-Saharan Africa will increase to more than 50 per cent by 2040, compared to 38 per cent in 2010. Figure 13 shows the increase and projected rise in urban households by region. To satisfy this growing demand, electrification rates supplied by the grid would need to increase from an average of 34 per cent in 2010 to 71 per cent by 2040; in addition, 8 per cent of the rural population would need to receive off-grid electricity through mini-hydro and solar photovoltaics (PV) (McKinsey & Company, 2015).

One of the challenges with the rapid growth in urbanization is the associated rise in outdoor air pollution and its deleterious impacts on human health and the economy (OECD, 2016) (see the energy and health section further on).

Energy and Transport

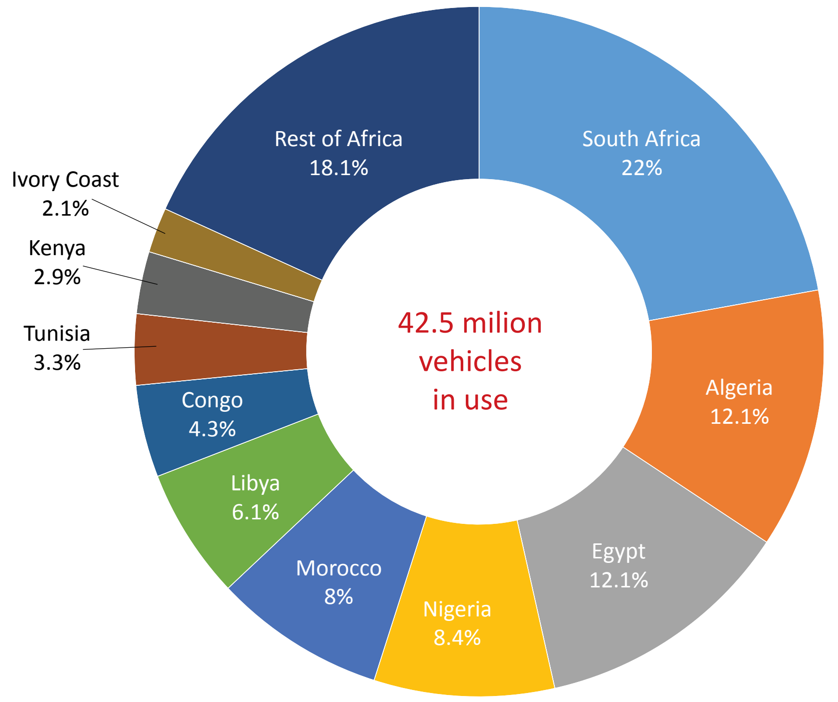
Because the region is vast, there is little rail infrastructure, and only a tiny proportion of the world's airline traffic goes to and from Africa, transport energy use in sub-Saharan Africa concentrates heavily on vehicles (IEA, 2014). Energy consumption for transport in sub-Saharan Africa has been increasing by only 4 per cent since 2000 and was about 50 Mtoe in 2012.

Figure 14: Trans-African corridors



Source: (Sidler, 2014)

Figure 15: Vehicles in use in Africa, 2014



Source: (Deloitte, 2016)

Africa's road infrastructure is also underdeveloped, with an extremely low road density of 89 km per 1,000 km^2 of area, representing less than a third of the global average. Furthermore, less than 20 per cent of African roads are paved and about 60 per cent of the rural population lives more than 2 km from an all-season road (IEA, 2014).

The Trans-African Highway network comprises transcontinental road projects in Africa being developed by the UNECA, the African Development Bank and the African Union. The total length of the nine Trans-African Highways network is 56,683 km.

Although several African countries subsidize transport fuel, it is still relatively expensive. Combined with the poor road infrastructure, this makes the cost of transporting goods in Africa among the highest in the world. Diesel is the main source of oil consumption for road vehicles in sub-Saharan Africa (almost 0.4 mb/d (millions of barrel per day) and accounting for 39 per cent), especially for buses and trucks. Countries with higher vehicle ownership levels (such as South Africa, with 42 per cent diesel) and those with relatively low gasoline prices (such as Nigeria, with only 12 per cent diesel) heavily influence the figures on diesel consumption. For most of the rest of Africa, diesel shares in road transport are about 45 per cent (IEA, 2014).

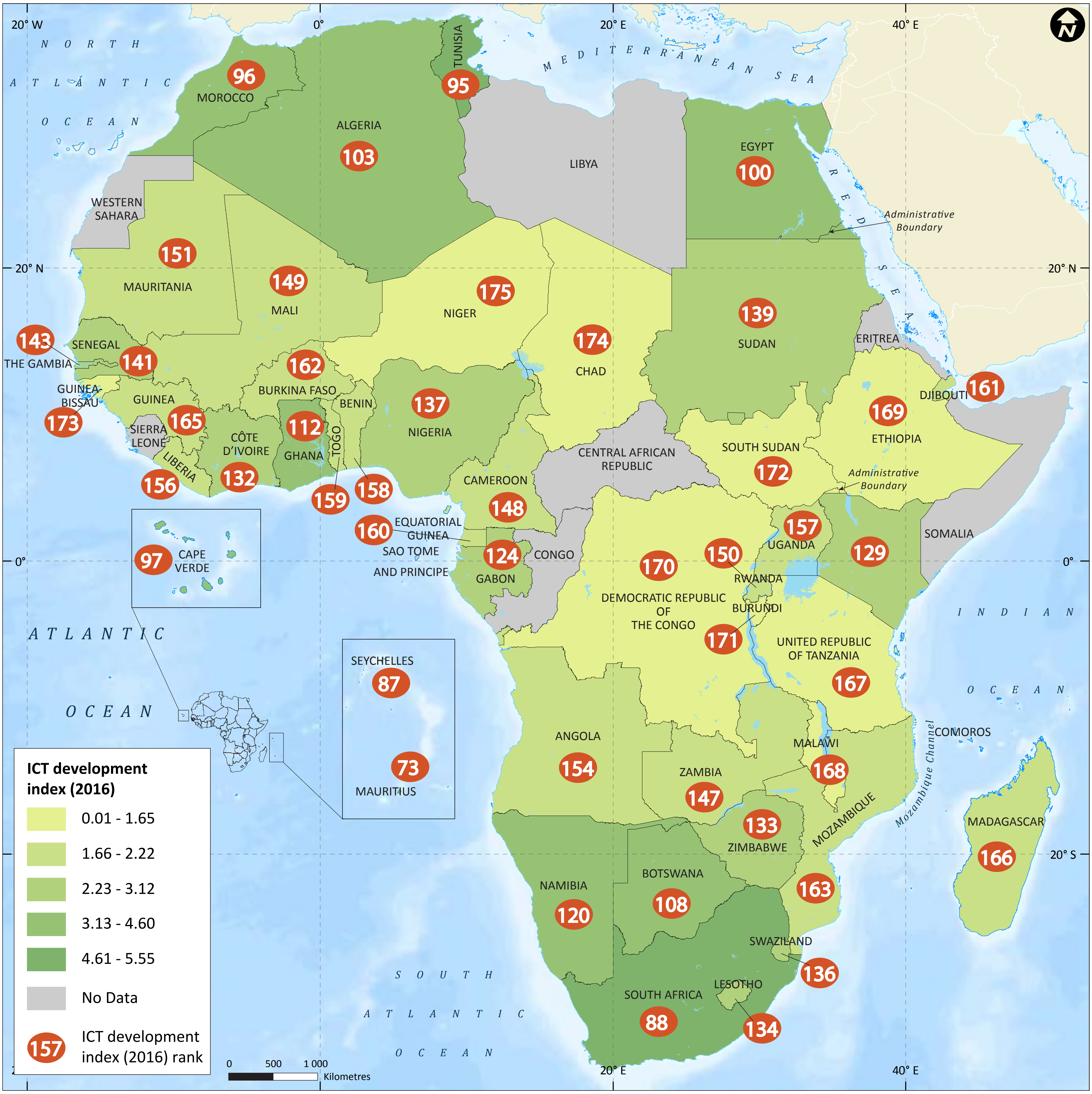
Although increasing, private car ownership levels in Africa are one of the world's lowest and present huge disparities among countries, with only South Africa, Botswana and Namibia having ownership rates of at least 50 cars per 1,000 people. In 2014, there was only an average of 44 vehicles per 1,000 people in Africa, far below the global average of 180 vehicles per 1,000 people. In the same year, there were just over 42.5 million registered vehicles in use in Africa (Figure 15). In 2015, approximately 1.55 million new vehicles were sold or registered across the continent (Deloitte, 2016).

Conventional gasoline and diesel internal combustion engines (ICEs) dominate existing stocks of both new and used car sales and ICEs are expected to continue to dominate through 2050. The potential for hybrids, electric vehicles (EVs), compressed natural-gas vehicles (CNGVs), fuel cell vehicles (FCVs) and even high-speed rails (HSRs) is expected to remain low while passenger and freight air traffic in Africa is expected to grow at a high yearly rate of 5–6 per cent per by 2020, with the passenger fleet doubling from 660 planes to 1,130 planes. These developments in the region's transportation and transport are expected to benefit from the fact that most of the region's countries have energy reserves or access to them, which will help fuel the higher level of motorization expected through 2050 (WEC, 2011). In 2008, Africa consumed 28 Mtoe (about 0.564 million barrels per day) of gasoline and about 38 Mtoe (about 0.765 million barrels per day) of diesel. By 2050, its consumption is expected to double (WEC, 2011).

Energy and ICT (Information and Communications Technology)

Although Africa's services sector, mainly comprising of telecommunications and a variety of small businesses, uses only 22 Mtoe, this amount still represents almost four times the energy used in the continent's agriculture sector (IEA, 2014). If energy supplies were to further support Africa's already booming information and communications technology (ICT) sector, economic performance could radically shift upwards (Africa Energy, 2014). Already,

Figure 16: ICT Development Index, 2015

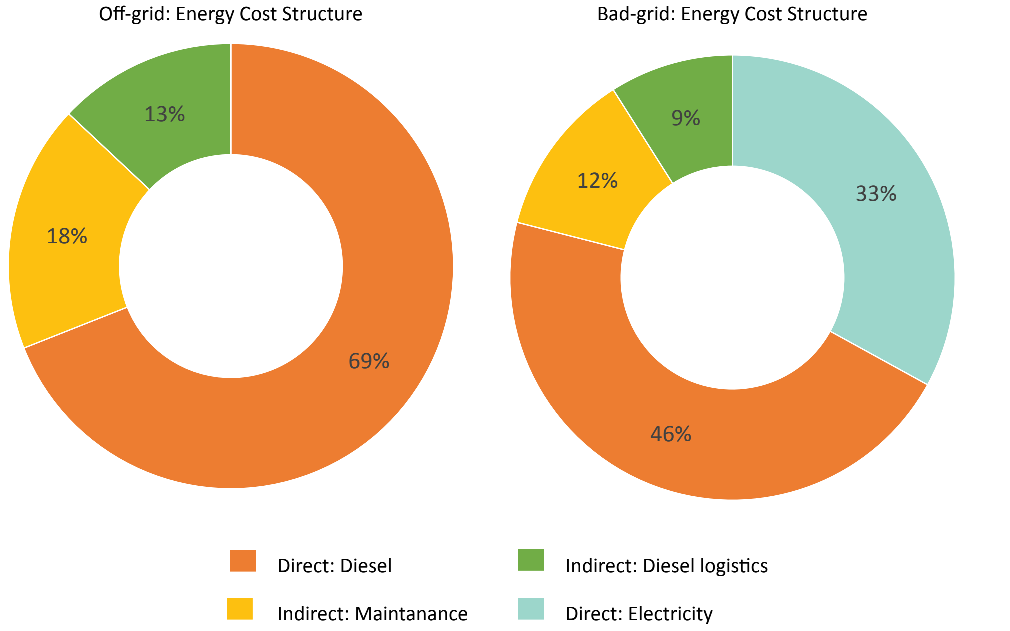


Source: (Essoungou, 2013)

reliable power is more available to this sector because payment procedures and tariff-setting are more straightforward for mobile telecoms than they are for electricity and water utilities, which are expected to be provided at a low cost (Africa Energy, 2014). Figure 16 shows the scores by country on the ICT Development Index in 2015, which measures progress in ICT access, use and skills.

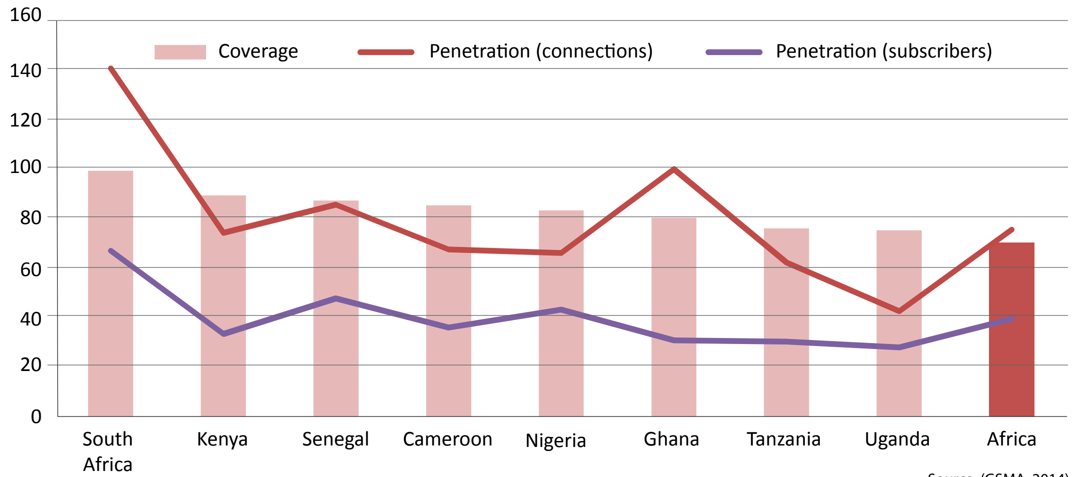
In 2014, there were over 800 million mobile connections and nearly 450 million unique subscribers in Africa. Depending on the country, mobile network coverage ranges from 10 to 99 per cent with an average of 70 per cent . Despite huge growth and potential future opportunities, there are many infrastructural and operational challenges to the mobile industry in Africa, including powering both existing on- and off-grid networks due to unreliable power supplies and the heavy reliance on expensive diesel power

Figure 17: Cost of powering tower sites (off-grid)



Source: (GSMA, 2014)

Figure 18: Mobile coverage and subscriber penetration in sample countries, 2014



Source: (GSMA, 2014)

(Figure 17), and the challenges related to the higher operational costs of expanding infrastructure into remote rural areas that lack grid electricity and road infrastructure (GSMA, 2014).

Energy costs are a major part of network operating expenses for African mobile operators. The share of energy costs for a typical tower site in Africa is as high as 40 per cent . Off-grid sites are hugely financially and environmentally expensive, consuming nearly 13,000 litres of diesel every year, with operating costs for energy alone at over US$21,000 and the cost to the environment of nearly 35 metric tonnes of CO_2 emissions. Unreliable grid sites consume around 6,700 litres of diesel and produce 18 metric tonnes of CO_2 emissions. In addition, there is the cost of diesel pilferage, a very common practice in many African countries, which can amount to 10-15 per cent of the cost (GSMA, 2014).

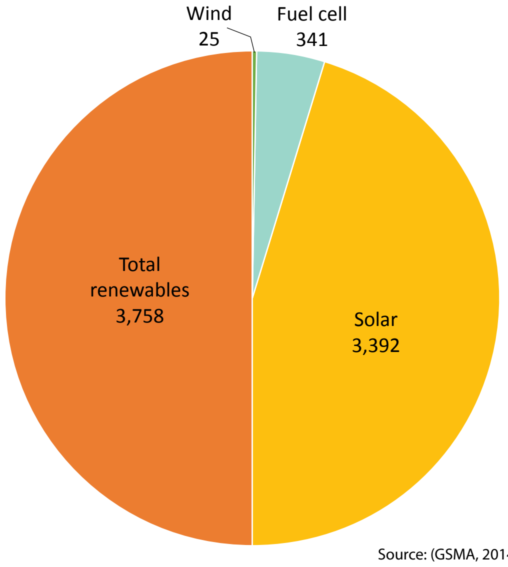
In sub-Saharan Africa, there was a total over 240,000 towers providing mobile coverage in 2014, with the number expected to rise to over 325,000 towers by 2020. About 145,000 were in off-grid sites and 84,000 in badly served areas; these numbers are expected to grow to 189,000 and 100,000 sites, respectively, by 2020. Green alternatives powered less than 4,000 sites (almost all of them off-grid sites) in 2015, representing less than 3 per cent of the total off-grid sites in Africa, compared to the global average of 13 per cent . About 3,300 deployments are powered with solar technology, which alone among green energies has reached a stage of commercial adoption across African markets; they account for nearly 90 per cent of total green deployments. Wind turbines are still in the pilot stages of deployment because

Table 4: Green alternative potentials for telecom power deployments

	Solar	Wind	Biomass	Fuel Cell	Micro-Hydro
Resource potential	High	Low to medium	Medium	Medium	Low to medium
Technology availability	High	Medium	Medium	Medium	Low to medium
Market acceptance and commercial viability	High	Low to medium	Low	Low	Low
Supply chain readiness	High	Medium	Low	Medium	Low
Stage of adoption	Commercial	Pilot/early commercial	Evaluation/ pre-pilot	Pilot/early commercial	Evaluation/ pre-pilot

Source: (GSMA, 2014)

Figure 19: Green telecom deployments in Africa



Source: (GSMA, 2014)

they remain unreliable and involve high maintenance costs and risky operations (GSMA, 2014).

Nigeria has the largest mobile connections market and most unique subscribers in sub-Saharan Africa, followed by South Africa and Kenya. With 99 per cent of its population with access to mobile network signals, South Africa leads the continent in mobile network coverage (GSMA, 2014) (Figure 18).

By adopting green power alternatives, telecom towers could reduce CO_2 emissions by 60-70 per cent and save nearly US$ 17,000 per site in operational expenses per year. This would require an initial investment of US$42,000 per site, but the return on investment would be over 35 per cent and payback would be less than 3 years (GSMA, 2014). Table 4 provides an overall summary of green options and their level of suitability for telecom power applications in Africa. Green technology adoption depends on the availability of technology, vendors, local technical support and market acceptance. Figure 19 presents the number of green telecom deployments by energy source (GSMA, 2014).

Energy and Agriculture

Although agriculture in Africa (excluding South Africa) accounts for one-quarter of value added and employs most of the working population, it makes limited use of modern energy. There is relatively little use of synthetic fertilizers and most farming is conducted at the subsistence level. Access to fuels or electricity for farm operations or crop processing is inadequate and costly in most African countries. Thus, the sector uses only about 6 Mtoe of energy, which is very low by world standards (IEA, 2014).

There is a significant potential for improved access, which would stimulate rapid growth in agricultural production and associated rural and overall economic development, since food security and exports of agriculturally based products would improve (SEI-Boston, 1995).

Increasing energy access and use is thus essential to transforming Africa's agriculture (APP, 2015). Fuel is needed for agricultural machinery, irrigation systems and pumps, processing and conserving agricultural products, and transporting and storing them (Gueye, 2008).

The agricultural sector is also a potential source of energy generated from products and by-products of the agriculture and forestry sectors in Africa in the form of biofuels, including sugar cane, sugar beet, maize, sorghum and cassava for ethanol production and peanuts, jatropha and palm oil to produce biodiesel. Africa's sustainable bioenergy potential in 2050 is between 317 and 410 Exajoules (EJ) of energy. This is close to the World Energy Council's estimate of global total annual primary energy consumption of 450 EJ in 2007 (Gueye, 2008).

Although tapping this potential could help countries decrease their heavy oil import dependence, the inherent challenge in using food crops for energy is to ensure producing cereals such as maize, soya and wheat to create biofuels in other parts of the world does not jeopardize food security in Africa. Non-food crops such as jatropha and agricultural and forest residues, on the other hand, could generate energy more sustainably (Gueye, 2008).

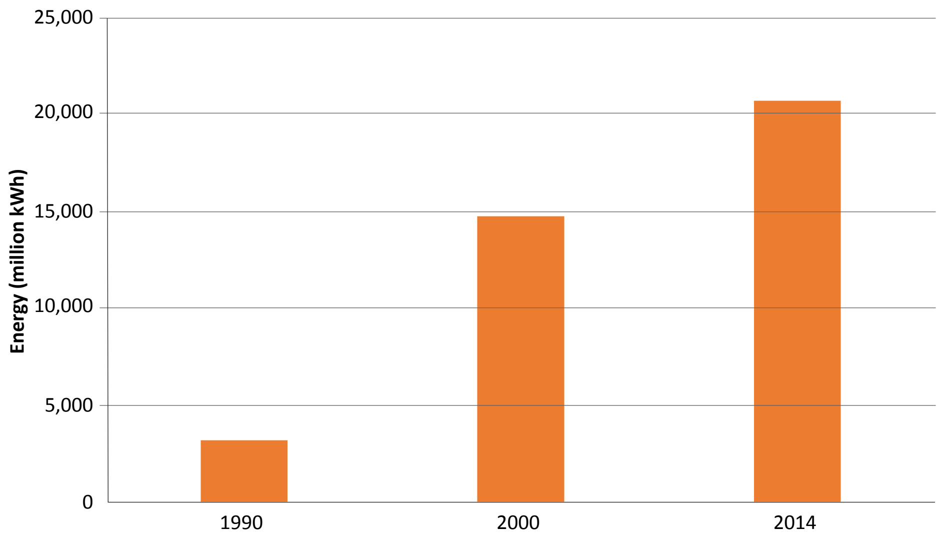
Another way to improve the agriculture sector through energy investments is by reducing postharvest food loss, which occurs during harvesting, handling and transportation. Research reveals that a reduction of just 1 per cent in postharvest food losses leads to a yearly gain of US$40 M. Energy investments in infrastructure (such as roads, electricity and water) could significantly reduce market transaction costs and food waste (Obayelu, 2014).

Irrigation

Water scarcity is a major constraint to raising agricultural production in Africa. Only 6 per cent (or 13 million ha) of Africa's land is irrigated, compared to 37 per cent in Asia and 14 per cent in Latin America, making it the world's region with the lowest proportion of land under irrigation. Two thirds of the continent's irrigated land is concentrated in five countries: Egypt, Madagascar, Morocco, South Africa and Sudan. By one estimate, if Africa's irrigated land area increased by 29 per cent , it would meet food demand by 2025 (Chiroro, 2015).

Solar powered sunflower pump

Figure 20: Evolution of energy consumption for irrigation in Africa (Million kWh), 1990-2014



Source: (FAO, 2015)

Water access technologies require energy. They include gas- or diesel-powered motor pumps and community-scale solar-powered water pumps. In addition to improving yields and incomes, these technologies save on labour and can relieve girls and women in particular from the demanding chore of fetching water (Burney, Naylor, & Postel, 2013). At the continental level, total energy consumption to power irrigation has exponentially increased since 1990 (Figure 20).

A number of options are increasingly available to spread sustainable irrigation throughout Africa. Inexpensive motorized pumps (most running on gas or diesel fuel) are expanding in some areas of sub-Saharan Africa. The capital cost of $250 per pump is competitive with higher-end treadle pumps. They have the advantage of being more time- and labour-saving than manual pumps and can access groundwater at greater depths. Recent research estimates that the expansion by about 30 million ha of irrigation using small-scale motorized pumps in sub-Saharan Africa could generate net revenues of $22 billion yearly and improve food security and earnings for about 185 million people, depending on fuel prices and supply reliability (Burney, Naylor, & Postel, 2013).

Photovoltaic- (or solar-) powered drip irrigation (PVDI) systems efficiently save water and labour. Although they are initially costly to install, they last a long time, cost less than liquid-fuel-based pumping systems, are battery-free and provide emissions-free pumping power (Burneya, Woltering, Burke, Naylor, & Pasternak, 2009).

Mechanization

Human muscle power is still the dominant energy source in African agriculture (Figure 21). It represents 80 per cent of the initial energy used to prepare land for agriculture in sub-Saharan Africa (IRENA, 2015), where it provides over 60 per cent of total farm power, mostly from women, the elderly and children; drudge animals represent only 25 per cent of farm power and engine power provides less than 20 per cent of mechanized services (CEMA, 2014).

The latest data on tractor use from 2008 revealed there were 470,000 tractors in Africa, with little information on their age or working condition (FAO, 2008). According to the United Nations Industrial Development Office (UNIDO), which defined 12 levels of agricultural mechanization, the USA and Western European countries have the highest levels (levels 9–12) while African countries have exceptionally low mechanization levels. Examples include Morocco (level 5), Botswana (4) and Cameroon (1). In sub-Saharan Africa, land productivity is among the lowest in the world, and agricultural mechanization has either stagnated or retrogressed in recent years (CEMA, 2014).

Some of the challenges in advancing the use of tractors and other agricultural machinery in Africa include underdeveloped supply chains for spare parts, advice and other services (especially clean fuel) and difficulties related to accessing remote rural areas. Mechanization in Africa's agriculture sector has the potential to expand production, improve the timeliness of operations, increase the power to process crops, improve irrigation and infrastructure, offset shortages and alleviate hard manual labour, especially for aging female farmers (AfDB, 2015a).

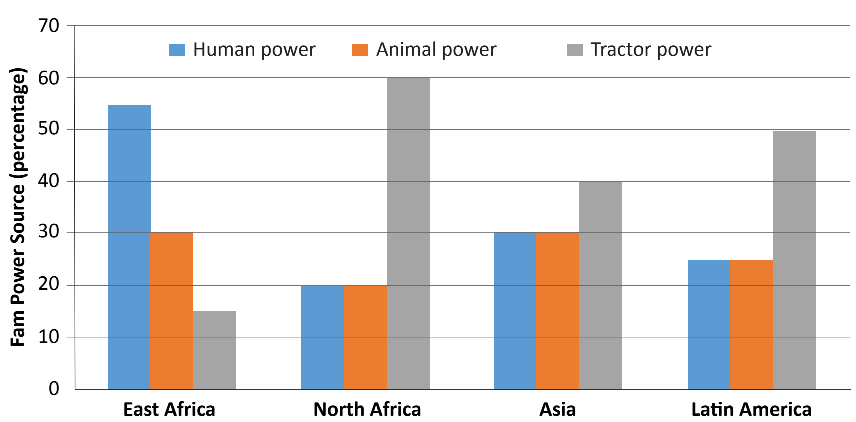
Energy and industry and commerce

The amount of energy used in the residential sector is an indicator of the stage of economic development in a given region. Economic development is at an early stage in many sub-Saharan countries given that the residential sector uses an average of two-thirds of total energy use—mostly for cooking —compared to an average of 25 per cent in other developing countries and just 20 per cent in the OECD region (IEA, 2014).

Industry in sub-Saharan Africa represents more than two-thirds of total energy use, although it employs far fewer people than agriculture and generates less value added than services. The proportion of energy consumed by other end-use sectors, however, is much lower than in other world regions, reflecting the limited availability of energy services. For example, of final energy consumption, transport accounts for only 11 per cent, while the total of productive uses (including industry, agriculture and services) represent only 21 per cent. Most economic activity in Africa, such as agriculture, tourism and textiles, is not energy intensive (IEA, 2014).

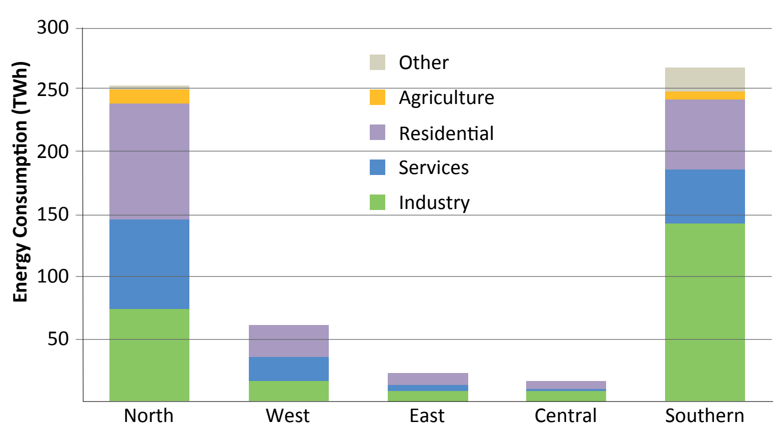
Data on energy use by specific industries is lacking, although mining is clearly a major energy consumer, supplying modern extractive power to a number African countries with significant mining sectors, including Zambia (copper), the DRC (copper and cobalt), Ghana (gold), Botswana (diamonds), Namibia (uranium) and Guinea, Liberia and Sierra Leone (iron ore) (IEA, 2014). Other key energy-intensive industries in Africa include cement production, which is growing (Nigeria's Dangote plant is the largest in Africa); petrochemicals

Figure 21: Farm power sources (in percentages) in Africa, Asia and Latin America, 2008



Source: (FAO, 2008)

Figure 22: Energy consumption by industry compared to other sectors, by region, 2012

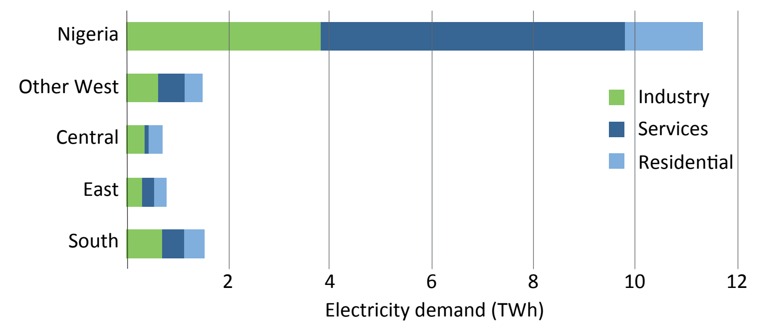


Source: (IEA, 2014)

in South Africa and Nigeria; aluminum smelting in Mozambique; and South Africa's automotive and iron and steel sectors (IEA, 2014).

In 2012, industry (led by mining and refining activities) accounted for the largest share of electricity consumption in sub-Saharan Africa (50 per cent), but much of it was concentrated in South Africa, Nigeria, Ghana and Mozambique (IEA, 2014). Figure 22 compares the amount of energy used by various sectors, by region.

Figure 23: Electricity demand for industry met by back-up generators compared to other sectors, by region, 2012



Source: (IEA, 2014)

Diesel and gasoline are used to fuel back-up generators, which are common throughout Africa to allow power during frequent blackouts. In 2012, services and industry used more than 80 per cent of the estimated 16 TWh of electricity demand served by back-up generators in sub-Saharan Africa. Figure 23 shows that in Nigeria, almost three quarters of electricity supply is provided by back-up generators, while levels are relatively low in Eastern and Central Africa, where grid access is more limited (IEA, 2014).

Energy and Africa's social sectors

Health

Access to health services and improved health and well-being are directly linked to access to modern energy services, Table 5 shows the many links between energy provision and use and health outcomes (ECREEE, 2015).

Table 5: Links between energy and health

Energy services and end uses	Health outcomes
• Incubation facilities for infants • Cold chain for vaccine, medicine, and blood bank refrigeration • Laboratory and diagnostic equipment • Powering medical equipment • Lighting surgery and examination rooms • Household energy • Electricity for prevention and cure • Indoor lighting, for examination, surgery, reading, and ambient light and outdoor, including security lighting • Clean water supply • Pressurized water distribution water heating • Space cooling • Cooking • Sterilization • Transport • Waste management • Improved cook stoves • Water pumping/purification • Computers • Radios • Television • Single side-band radios • Charging mobile phones and rechargeable flashlights • Energy-efficient lighting • Heating • Energy services for health clinics and for housing for doctors, nurses, and clinic staff.	• Reduced child and adult mortality and morbidity • Improved maternal health • Reliable access to clean/safe drinking water • Enhanced communications (especially for emergencies), technologies and education for health data and information • Combat HIV/ AIDS, malaria and other diseases • Improved life expectancy • Improved health service delivery (staff retention, motivation and training, lab services and end uses), evening health training for local communities, reduced fertility rates, reduced waste and environmental pollution, reduced indoor air pollution, improved nutrition • Night birthing and safety • Lower respiratory disease and macular degeneration • Cleaner living conditions at home

Source: (ECREEE, 2015)

Ambient air pollution

The health impacts of air pollution from burning solid fuels have already been mentioned in the section on gender and energy because of their important effects on women's health. The World Health Organization (WHO) reports that ambient air pollution — outdoor and indoor — is the biggest environmental risk to people's health and responsible for about one in every nine deaths annually worldwide (WHO, 2016). Figure 24 maps the number of deaths per 100,000 people attributable to ambient air pollution in African countries. Energy production and consumption are significant contributors to ambient air pollution. Particulate matter is emitted from transportation sources such as cars, trucks, buses, airplanes and trains that burn fossil fuels, and from stationary sources of emissions from energy use, such as power plants, oil refineries, industrial facilities and factories, as well as from flaring gas at oil production sites. Other energy-related sources include wood burning from cooking stoves and fireplaces. Unrelated emissions included in ambient air pollution are natural sources such as windblown dust and smoke from wildfires and volcanoes.

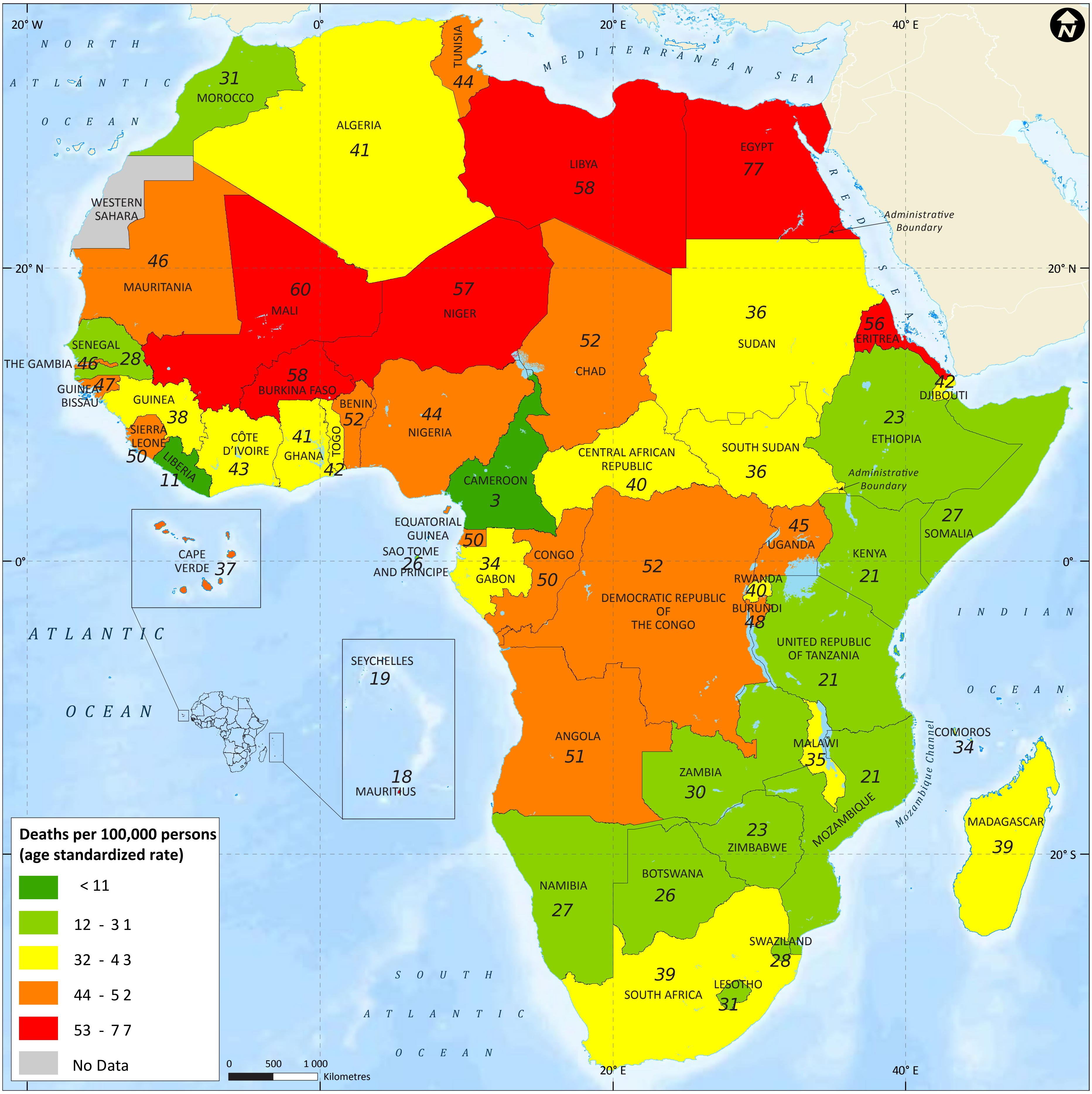
Gas flares can be important sources of ambient air pollution (as well as environmental damage, including greenhouse gas emissions). Natural gas rises to the surface when crude oil is extracted from onshore and offshore oil wells. It is often burned off (flared) when situations such as barriers to developing gas markets, or insufficient technologies or infrastructure, prevent the gas from being used. Such flaring wastes the valuable energy resource, releases millions of tonnes of CO_2 to the atmosphere (see gas flaring case study above) and emits hazardous air pollutants that severely impact human health and ecosystems (World Bank, 2016a).

Earlier, the lack of reliable electricity was shown to limit economic and human development. Ambient air pollution from energy use also has costs to society and thus limits economic growth. An OECD report on the cost of air pollution in Africa suggests that the growing human and economic costs of air pollution are surpassing the costs associated with unsafe sanitation and underweight children. Energy generation and use is responsible for a large portion of outdoor air pollutants. The OECD reports that between 1990 and 2013, total annual deaths from ambient particulate matter pollution (APMP), mostly caused by road transport and power generation (with contributions from industrialisation, which is low in Africa), rose by 36 per cent to around 250,000. Over that time, household air pollution (HAP) from domestic energy use rose (from a higher base) by 18 per cent , to well over 450,000. It estimates that the economic costs of those premature deaths from outdoor air pollution in Africa as a whole in 2013 is about US$215 billion; the cost related to HAP is US$232 billion (OECD, 2016).

Access to energy in the health sector

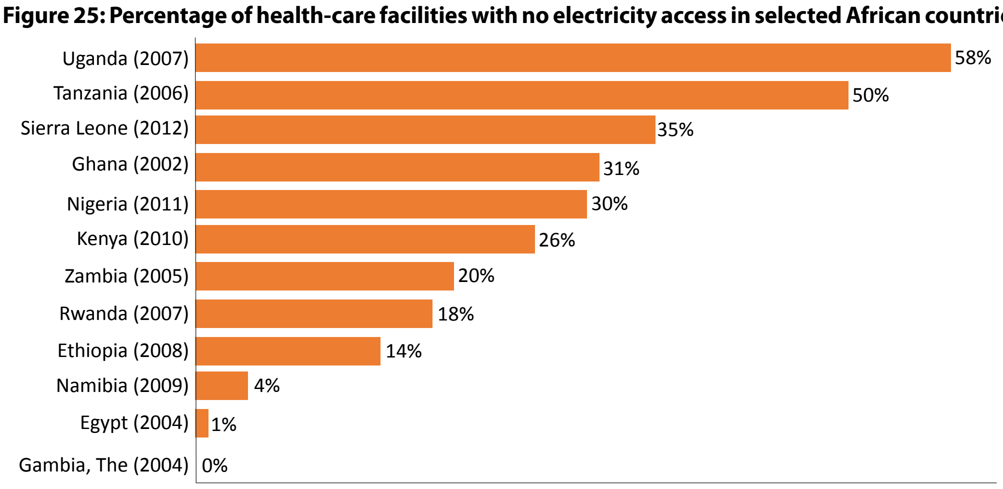
The provision of reliable energy supplies for lighting, sterilization, powering equipment and cooling is vital for safe, affordable and effective health services (ECREEE, 2015). Access to energy in the health sector in Africa is still limited, however. In 2013, the

Figure 24: Number of deaths in Africa attributable to ambient air pollution, per 100,000 people, 2012



Source: (WHO, 2016)

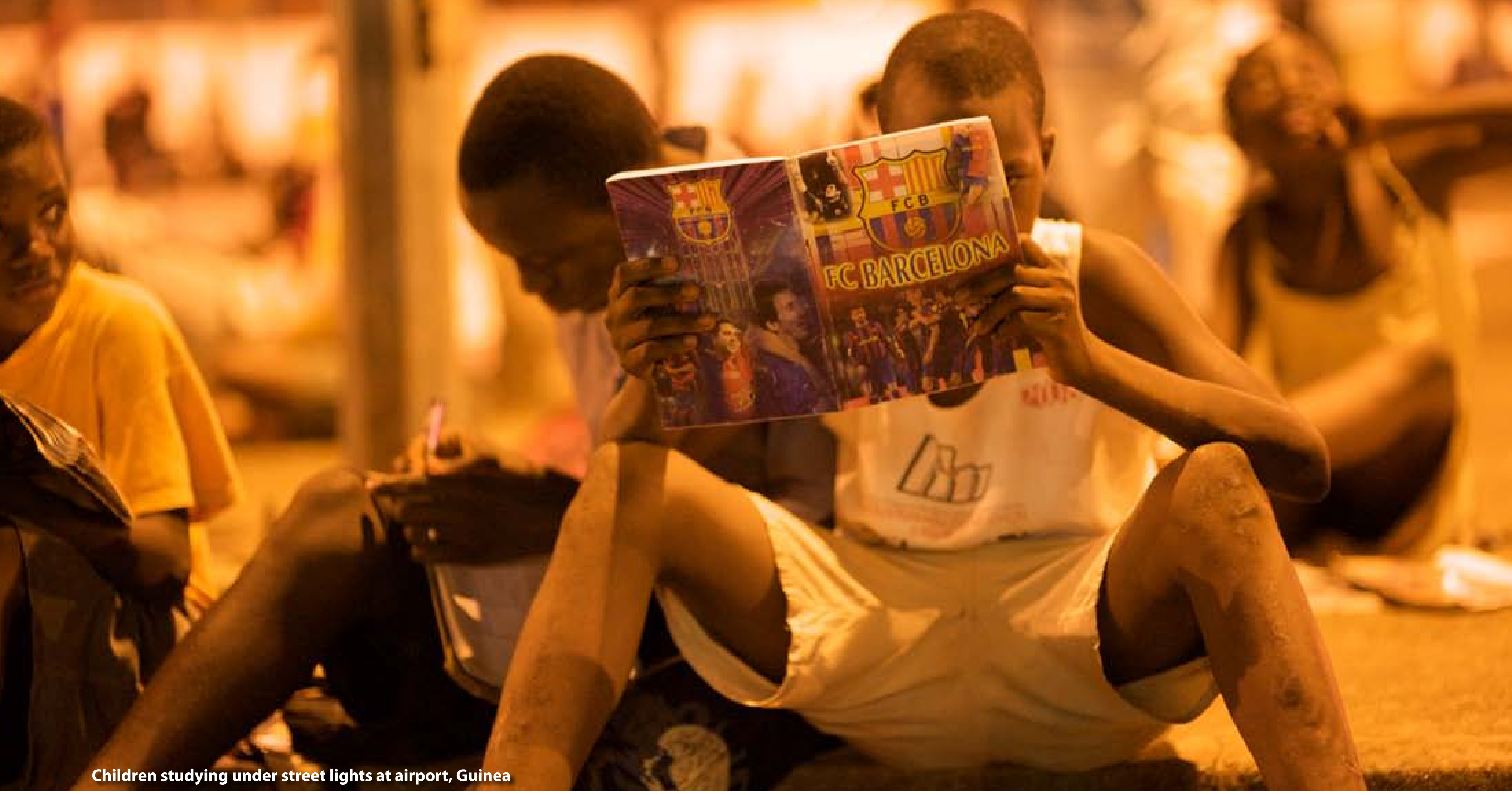
Figure 25: Percentage of health-care facilities with no electricity access in selected African countries



Source: (WHO/World Bank, 2015)

first multi-country analysis of electricity access in health facilities found that an average of only 34 per cent of hospitals and 28 per cent of health facilities in sub-Saharan Africa have reliable electricity access (WHO/World Bank, 2015). About 58 per cent of health care facilities in sub-Saharan African countries have no electricity at all (AfDB, 2014a). Figure 25 presents the proportion of health care facilities with no electricity access in select countries. Health care workers frequently have to work by flashlight or polluting and dangerous kerosene lamps (Adair-Rohani, et al., 2013).

In addition, nearly 60 per cent of refrigerators used in health clinics in Africa have unreliable electricity, compromising the safe storage



Children studying under street lights at airport, Guinea

of vaccines and medicines (ONE.org, 2015). About half of vaccines are ruined due to lack of refrigeration (AfDB, 2014a).

Making energy part of the solution to heath care challenges in Africa will help to improve maternal and children's health, food security and nutrition; prevent disease; and increase the number of doctors, health-care workers and health facilities (ECREEE, 2015). Such improvements would contribute to preventing 80 per cent of maternal and new-born deaths (Lassi, Das, Salam, & Bhutta, 2014). Thus, as the costs of renewable energy technologies fall, they become more affordable for health facilities, both as primary or backup energy sources. This is particularly true in the case of photovoltaic (PV) solar power. The recent WHO-led review of sub-Saharan African health facilities found a trend towards increasing use of onsite PV solar either as a primary or backup electricity source. In Uganda, some 15 per cent of hospitals used PV solar to complement grid electricity access, and in Sierra Leone, 36 per cent of all health facilities and 43 per cent of hospitals used solar systems in combination with other electricity sources (WHO/World Bank, 2015).

Table 6: Links between energy and education

Energy services and end uses	Education outcomes
• Electricity (DC or AC) for lighting • Computers • Radio/Television • Telecommunications • Thermal energy for cooking (students and staff) • Water pumping/purification • Energy-efficient lighting and appliances • Electricity and modern fuel services both for schools and for teachers' housing	• Poverty reduction • Income generation • Improved quality of education • Improved grades • Enhanced school enrolment/retention rates • Improved ability to attract and retain teachers and staff • Improved sanitation • Gender balance/equity • Facilities for evening classes and adult education.

Source: (ECREEE, 2015)

Education

There is a clear link between energy poverty and education (Table 6). In sub-Saharan Africa, 90 per cent of children attend primary schools that lack electricity or any form of energy services, which impedes their chances of receiving adequate and quality education. For example, only 2 per cent of schools in Guinea and Burundi and 8 per cent of schools in the DRC have electricity. In the latter, the population is 75.5 million, 43 per cent of whom are under 14 years old (UNESCO, 2012); (ECREEE, 2015).

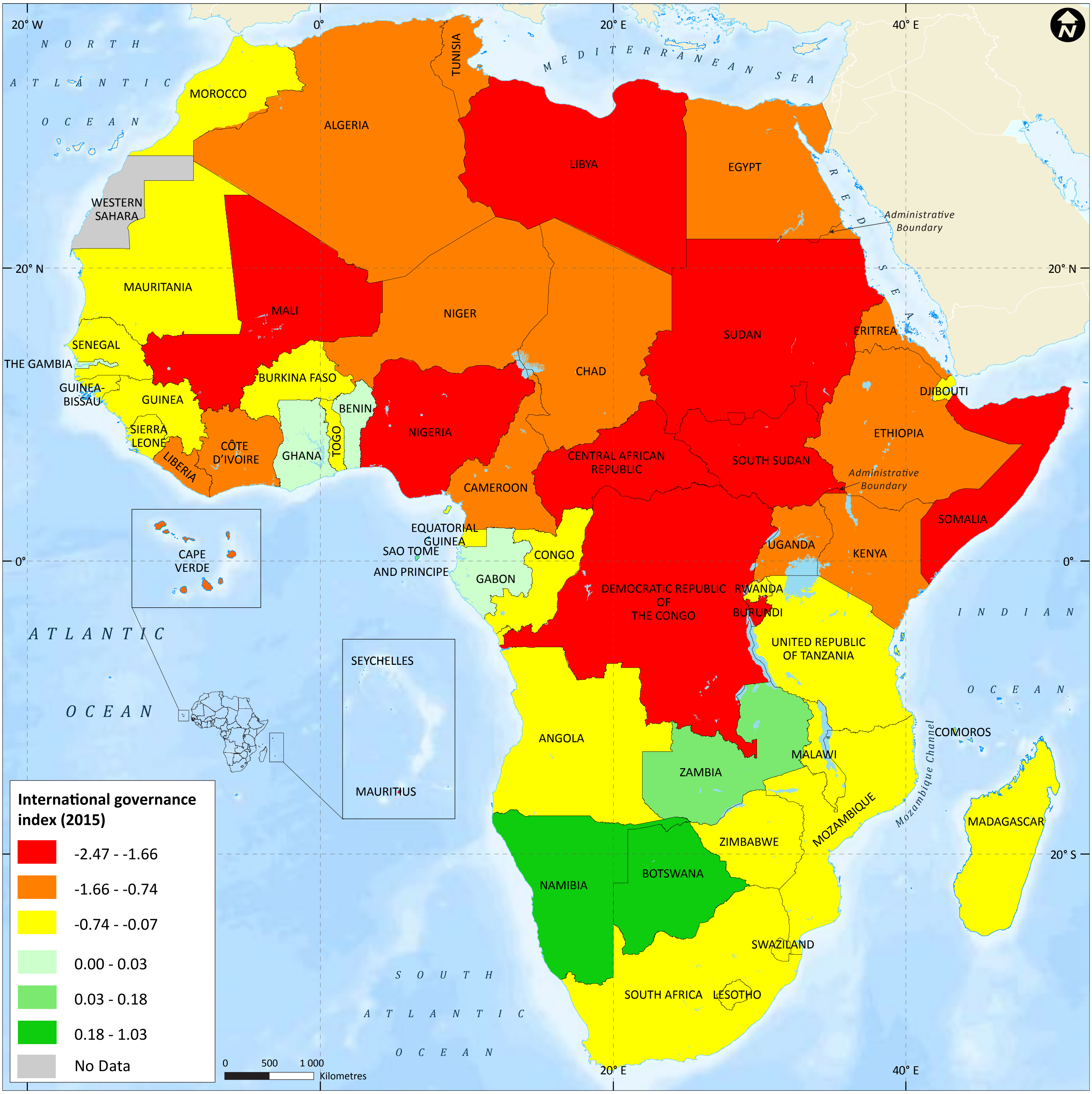
Energy, peace and stability

Volatile energy and security situations

Energy access also has implications for peace and political stability. In some cases, where both energy resources and unstable political situations are volatile, the links between the two can cause potentially dangerous situations. For example, countries that export oil and gas are frequently also some of the world's most politically unstable regions, including such countries in Africa (UNECA, 2014).

The World Bank proposes two governance indicators that can point to the potential for political stability when assessing short-term energy security: regulatory quality and political stability/absence of violence. According to these two indicators, oil-exporting countries worldwide have average and below average regulatory characteristics, and their ranking for political stability is between 0 and 25 percentile globally, making these regions politically unsafe as a source of petroleum. Thus, given the almost total reliance on imported fuels in many African countries, a situation of political instability in oil-exporting countries would create dire energy insecurity for the economies of importing states (UNECA, 2014). Figure 26 provides a map of political stability and absence of

Figure 26: Regulatory quality and political stability/absence of violence map



violence/terrorism drawn from the Worldwide Governance Indicators (World Bank, 2015a).

The rise in piracy in the Red Sea and Indian Ocean due to crises in Somalia has had a significant impact on the transportation of fuel imports. Piracy activity in the Gulf of Aden has been high compared to the total number of piracy incidents globally; it increased from 4.7 per cent in 2000 to 17.2 per cent by 2005, and to 53.4 per cent in 2009. As a result, insurance premiums have risen along with the risk to physical disruption, which in turn led to a rise in the cost of fuel delivery. Piracy activity is concentrated mainly in the Somali territory of the Gulf of Aden, but piracy threats have steadily moved as far north as the Red Sea's Eritrean waters, as far south as the Indian Ocean territories of Mozambique, and extending into the Arabian Sea and Gulf of Oman (UNECA, 2014). For example, Somali pirates have seized oil tankers interrupting fuel supply in Kenya and Uganda, and as the risks of piracy spread northwards, they threatened to disrupt fuel deliveries to the Red Sea States of Eritrea and Djibouti (UNECA, 2014).

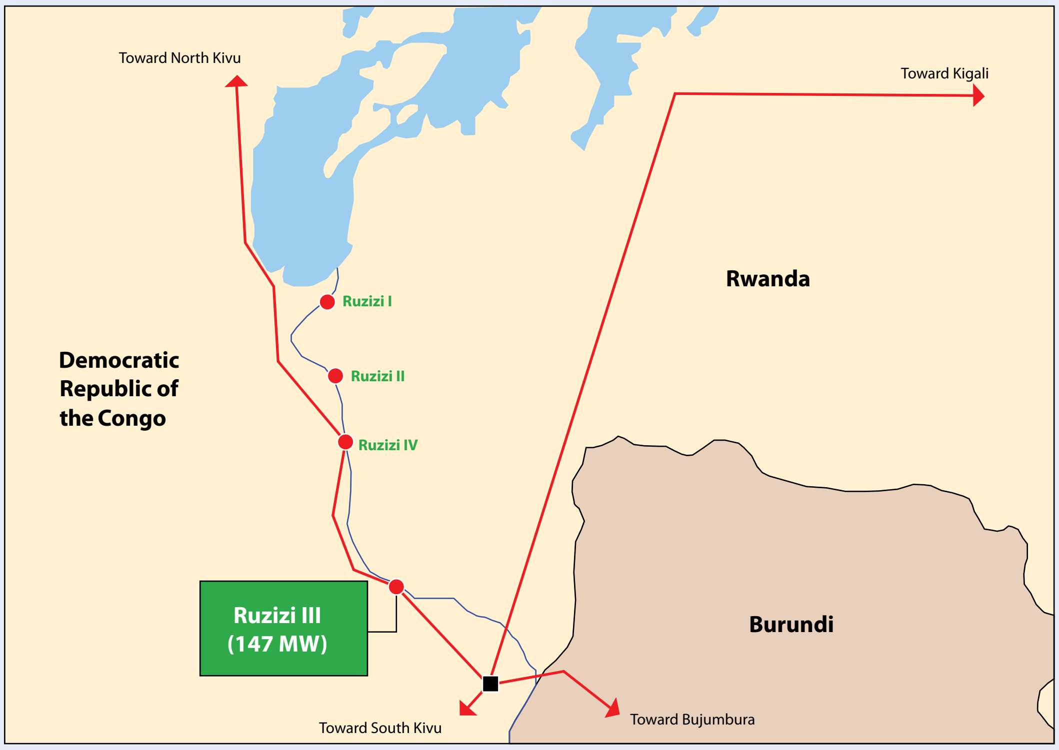
Case study: Ruzizi power plants

The Ruzizi River forms the border between the DRC and Rwanda. The south-flowing river connects Lake Kivu with Lake Tanganyika. Lake Kivu, which is surrounded by Rwanda to the east and the DRC to the west, drains at the south into the Ruzizi River, also known as the Ruzizi Cascades, which flows into Lake Tanganyika.

In 1959, a small hydropower project, Ruzizi I, with a capacity of 29.8 MW was developed near Buakavu (DRC), located 3 km downstream of the outlet from Lake Kivu. The DRC's national utility, SNEL, owned and operated this plant. Due to technical problems, however, only 21.2 MW are currently available.

In 1989, a second plant, Ruzizi II, was commissioned further downstream with a capacity of 43.8 MW. The Organisation de la CEPGL Pour L'Energie des pays des Grands Lacs (EGL), a sub-regional body that coordinates energy development in East Africa, began the project and the Société Internationale d'Electricité des Pays des Grands Lacs (SINELAC), a multi-national organization established by a treaty among Burundi, the DRC and Rwanda, manages it. SINELAC operates the plant and its dependencies and sells the energy to REGIDESO in Burundi, SNEL in the DRC and RECO in Rwanda, the three national utilities.

Figure 27: Location of the Ruzizi dams



The three countries commissioned EGL to develop Ruzizi III, since the river's hydrology indicates the potential for more power to be generated downstream of the existing operations. Figure 27 shows the location of the three dams.

The project takes advantage of the region's low-cost renewable hydropower and easily harnessed geothermal energy, which will increase power generation and interconnectivity. Developing the DRC's hydropower potential, in particular, will provide access to low-cost power for Burundi and Rwanda and foster regional stability.

Unlike other parts of sub-Saharan Africa that are experiencing high growth rates, the Great Lakes countries have had exceptionally high poverty levels and low access to key services such as electricity.

This project could provide electricity to an estimated 107 million people living in the Great Lakes region, who currently depend on charcoal for cooking.

Although there was a decade of war, the three countries never ceased to cooperate in generating power from the Great Lakes and the EU selected the initiative to support the Great Lakes peace process. The enhanced cooperation between the three countries and increased access to energy, the lack of which has hampered development, is expected to contribute to enhancing economic stability in the region.

The Ruzizi III hydropower plant is part of the Programme for Infrastructure Development in Africa (PIDA). On 16 December 2015, the African Development Bank (AfDB) Group formally approved US$138 million in loans and grants to finance the Ruzizi III Hydropower Plant Project. The project's total implementation cost will be US$625.19 million, with the balance borne by the private sector. As such, it is East Africa's first public-private partnership (PPP).

A run-of-river dam will be built to straddle the Ruzizi River between the DRC and Rwanda, as well as a 147 MW power plant and distribution station. They will provide an independent, reliable and affordable source of green energy, increasing the region's access to electricity by 300 per cent . The project will contribute to the region's sustainable socioeconomic transformation by providing energy for the growing energy needs of the three countries, which have had difficulty meeting their electricity demands for the past decade as their populations and economies have risen in the absence of major energy infrastructure investments.

The electricity will also feed into the entire region's East African Power Pool (EAPP). The NEPAD Infrastructure Project Preparation Facility (NEPAD-IPPF) awarded a grant of US$1.4 million to ELG in 2011 to finance transaction advisory services for the project, helping to garner development expertise and sound knowledge of the region's context and actors. The African Development Bank hosts the NEPAD-IPPF, which is a multi-donor Special Fund that provides grants to African countries through Regional Economic Communities (RECs), Power Pools (PPs) and other specialized regional institutions to help prepare regional or cross-border infrastructure projects

Source: (AfDB, 2015c); (AfDB, 2015d)

The International Maritime Bureau (IMB) reports that in 2014, there were 41 incidents of oil theft in West Africa, but notes the undoubted occurrence of further unreported attacks (MarEx, 2015). Off the coast of Nigeria, 14 of a reported 18 attacks that year involved tankers and vessels associated with the oil industry. Product tankers are hijacked to steal and tranship their cargo into smaller tankers.

Vessels in Ghanaian waters have also been hijacked and robbers boarded seven vessels anchored at Pointe-Noire, Republic of the Congo (MarEx, 2015).

Peaceful energy and security situations

The development of energy resources in Africa has the potential to bring about economic and social stability and peace when their access improves quality of life and development opportunities. Such is the case of the Ruzizi dam projects, for example, where three countries have cooperated in generating power despite a decade of war.

Conclusion

This chapter points out some vexing paradoxes that illustrate the complexity of Africa's energy crisis: although Africa contributes just 3.3 per cent of global energy-related CO_2 emissions, it will suffer disproportionately from climate change impacts; on the other hand, the continent badly needs increased energy development and provision, since 645 million people lack access to reliable energy. Similarly, although the use of cleaner energy and cooking stoves is rising fast, population growth and rapid urbanization will increase energy demand and the use of inefficient fuels for cooking and lighting; likewise, progress in advancing access to modern energy is nevertheless being offset by continuing rapid population growth such that the proportion of people in Africa without electricity will actually rise. Over half of all health care facilities in sub-Saharan African have no electricity at all, only 6 per cent of Africa's land is irrigated and indoor pollution from biomass cooking will soon kill more people than malaria and HIV/AIDS combined; these facts point to a dire situation that will require massive efforts and financial inputs to overcome.

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A retired windpump at a watering hole in Augrabies Falls National Park, South Africa. The windpump no longer has a pump-shaft and the pair of solar panels now power an electric pump.

Chapter

3

REGIONAL ENERGY INTEGRATION AND MARKETS

Key messages

- Regional energy integration through power pools is a prerequisite for Sustainable Development.
- There is a high political commitment to regional energy markets, hence power pools are important.
- Considering the small size of many of the economies of African countries, regional energy integration is extremely important to attract investment, for security of energy supply and mix, and to reduce the cost of doing business (economies of scale) and costs to consumers.
- Regional energy genertion provides an optimal economic solution to energy production and consumption, because energy is generated where it is most economical and supported, and provided where it is most highly needed.
- Power trade is an indicator of energy integration, thus power pools themselves are key drivers of regional integration.
- In a full energy integration scenario, power pools would save US$43 billion per year by 2040.

Introduction

For African countries to ensure energy security for their growing economies, they must promote regional (and to some extent continental) integration when developing their respective energy sectors. As intra-Africa trade grows in the next two decades, there will be pressure to integrate energy markets. The reasons for a regional/continental approach to energy sector development are twofold. Firstly, investment outlays in energy infrastructure development are often prohibitively expensive (because their viability relies on economies of scale), thus necessitating the pooling of resources. For example, the construction cost of the Grand Ethiopian Renaissance Dam is estimated at around US$6.4 billion. Not many African countries can afford such massive investments on one project. Secondly, there is the issue of markets. With 16 per cent of the world's population, Africa consumes a meager 3.3 per cent of the world's electricity. Underlying challenges include the existence of large, rural, often poor populations who frequently live in remote, dispersed locales to which centralized power and other public services are expensive to deliver, as well as large impoverished, underserved urban populations who may be unable to pay for electrical services.

Power trading in Africa started in the 1950s, in the form of bilateral agreements between the Democratic Republic of the Congo (DRC) and Zambia. This trade involved a 500 kV high voltage direct current (DC) power supply that was 1,700 km in length. Other bilateral agreements followed in different parts of the continent until the development of the first power pool (Kambanda, 2013).

Today, there are five main power pools in Africa (Table 1) that act as specialized agencies of their respective Regional Economic Communities (RECs). They are dedicated specifically to the interchange of energy between electricity utilities that are party to the

Table 1: Member countries by regional pools

Central African Power Pool (CAPP)	Eastern Africa Power Pool (EAPP)	Comité Maghrébin de l'Electricité (COMELEC)	Southern Africa Power Pool (SAPP)	West Africa Power Pool (WAPP)
Angola	Burundi	Algeria	Angola	Benin
Burundi	DR Congo	Libya	Botswana	Burkina Faso
Cameroon	Egypt	Mauritania	DR Congo	Côte d'Ivoire
Central African Republic	Ethiopia	Morocco	Lesotho	Gambia
Chad	Kenya	Tunisia	Malawi	Ghana
Republic of Congo	Libya		Mozambique	Guinea
Democratic Republic of the Congo	Rwanda		Namibia	Guinea Bissau
Equatorial Guinea	Sudan		South Africa	Liberia
Gabon	Tanzania		Swaziland	Mali
São Tomé & Príncipe	Uganda		Tanzania	Niger
			Zambia	Nigeria
			Zimbabwe	Senegal
				Sierra Leone
				Togo

power pool agreement. The following section looks at the challenges and opportunities associated with each of these pools:

1. The Central Africa Power Pool (CAPP) for the Economic Commission for Central Africa States (ECCAS);
2. The Comité Maghrébin de l'Electricité (COMELEC) for the Union of Maghreb Arab (UMA);
3. The Eastern Africa Power Pool (EAPP) for the Common Market of Eastern and Southern Africa (COMESA);
4. The Southern Africa Power Pool (SAPP) for the Southern African Development Community (SADC); and
5. The West Africa Power Pool (WAPP) for the Economic Community of West African States (ECOWAS) (ICA, 2011).

The overall situation in regional power pools

Some of the findings of the overall situation in the regional power pools are summarized below:

- Electricity production by the major power source is as follows: CAPP: 77.4 per cent from hydropower; COMELEC: 98 per cent from fossil fuels; EAPP: 77.2 per cent from fossil fuels; SAPP: 76.8 per cent from fossil fuels; and WAPP: 77.4 per cent from fossil fuels.
- Total electricity production is the highest in COMELEC, with approximately 76,021 ktoe produced in 2015, followed by SAPP, EAPP and WAPP, which produced respectively 31,319; 25,084 and 10,836 ktoe. CAPP produced the least electricity, with a total of 2,400 ktoe, due to limited basic infrastructure.
- COMELEC has the largest final electricity consumption, with almost 62,000 ktoe consumed in 2015, representing approximately twice the

Table 2: Comparison of the five African power pools in the production, consumption and importation of the major energy sources, based upon projected 2015 data[1]

Category	CAPP	EAPP	COMELEC	SAPP	WAPP	Total[2]	Adj. Total[3]
Production of coking coal	0	222	0	137,517	158	137,897	137,687
Production of charcoal	4,514	15,353	1,227	9,457	8,197	38,748	30,751
Production of crude oil, NLG and additives	129,390	81,458	101,279	80,422	110,898	503,447	378,281
Production of natural gas	1,458	68,570	3,151,750	6,361	55,749	3,283,888	3,271,004
Production of electricity from biofuels and waste	7	87	0	171	30	295	286
Production of electricity from fossil fuels	526	19,367	74,641	24,049	8,384	126,967	123,301
Production of nuclear electricity	0	0	0	1,221	0	1,221	1,221
Production of hydroelectricity	1,860	4,638	610	5,804	2,379	15,291	13,325
Production of geothermal electricity	0	329	0	0	0	329	329
Production of electricity from solar, wind, etc.	9	661	770	74	43	1,557	1,556
Total production of electricity	2,400	25,084	76,021	31,319	10,836	145,660	140,157
Refinery output of oil products	6,298	39,464	39,444	23,581	10,570	119,357	109,355
Final consumption of coking coal	0	1,256	72	11,982	216	13,526	13,485
Final consumption of oil	7,900	49,774	36,558	34,803	20,602	149,637	134,679
Final consumption of natural gas	2,168	13,945	524,891	2,722	3,772	547,498	535,692
Final consumption of electricity	2,066	19,954	61,536	26,676	5,920	116,152	111,152
Consumption of oil in industry	908	8,559	5,230	3,166	1,570	19,433	16,896
Consumption of natural gas in industry	706	7,313	153,473	2,804	3,622	167,918	166,859
Consumption of electricity in industry	842	4,601	16,539	11,863	1,457	35,302	34,134
Consumption of coking coal in industry	0	603	81	6,416	228	7,328	7,287
Consumption of oil in transport	4,667	29,957	23,345	22,383	14,622	94,974	84,419
Consumption of electricity in transport	1	29	830	348	9	1,217	1,217
Net imports/exports of coking coal	0	843	3,620	-36,430	208	-31,759	-31,759
Net imports/exports of crude oil, NGL, etc.	-126,377	-73,564	-92,789	-58,536	-194,422	-545,688	-399,517
Net imports/exports of oil product	3,448	24,138	108	14,631	14,180	56,505	46,156
Net imports/exports of natural gas	0	-11,941	-1,904,421	225	-22,368	-1,938,505	-1,932,438
Net imports/exports of electricity	13	-67	377	-22	175	476	459

Notes:

1. All values are expressed in ktoe per year. Cells highlighted in yellow indicate the highest value for that category. A minus value indicates exported products.

2. Data from countries that occur in 2 or more pools are included.

3. Adjusted totals – duplicate country data removed.

Source: (AFREC, 2015)

final electricity consumed in SAPP and three times that consumed in EAPP. CAPP and WAPP consumed respectively 2,066 and 6,000 ktoe, the lowest of the regions.

- As far as power trade is concerned (mainly within power pools), EAPP and SAPP respectively exported 67 and 22 ktoe of electricity in 2015, while WAPP and CAPP imported 175 and 13 ktoe. COMELEC is the biggest importer of electricity, with roughly 377 ktoe. SAPP is at a more advanced stage, with many bilateral contracts already signed between the member countries, and with an active role played by the Short Term Electricity Market (STEM) since 2001, and by the Day Ahead Market (DAM) since 2009 (AFREC, 2015; AfDB, 2014).

Some recent statistics aggregated from individual country data are given in Table 2.

To summarize: CAPP had the highest production and exports of crude oil, NGL, etc. EAPP produced the most charcoal and electricity from geothermal, solar, wind, etc., and it consumed the most oil in both industry and transport. COMELEC had the highest production of natural gas and refined oil output. It produced the most electricity from fossil fuels, had the highest consumption of natural gas and electricity by industry and consumed the most electricity in transport. It imported the most coking coal and exported the most natural gas. SAPP produced the most coking coal and produced the most electricity from biofuels, nuclear and hydropower. It consumed and exported the most coking coal and imported the most natural gas and electricity.

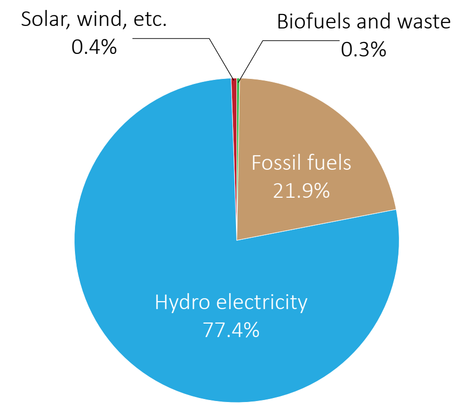
The power pools' energy mix is also diverse: hydropower is strong in the central area (77 per cent in CAPP) but less so in other regions (only about 1 per cent in COMELEC), which have ample reserves of coal (SAPP) or gas (WAPP, EAPP, and COMELEC).

The Individual Regional Power Pools

Central Africa Power Pool (CAPP)

The Central African Power Pool (CAPP) was established in 2005 with the assistance of the Union of Power Utilities in Africa (UPDEA, now APUA). The member countries include Angola (which is also a member of SAPP), Burundi (which is also a member of EAPP), Cameroon, Central Africa Republic (CAR), Chad, Republic of Congo, Democratic Republic of the Congo (DRC) (which is also member of EAPP and SAPP), Equatorial Guinea, Gabon and São Tomé and Príncipe.

Figure 1: Production of electricity by source in CAPP



Source: (AFREC, 2015)

CAPP is small compared to other regional systems. It has the largest share of existing hydro generation because of the large share of hydro in Cameroon's and the DRC's energy systems (ICA, 2011). Hydro accounts for around two-thirds of output. At 4 GW, the sub-region has the most limited grid capacity and that capacity's growth has been very slow (APP, 2015).

Compared to other regions on the continent, Central Africa has limited basic infrastructure and the Central African energy sector is the least developed in Africa. Access to electricity remains precarious and falls far short of Africa's overall level: energy consumption is 12.5 kWh per inhabitant compared to the continental average of 17.3 kWh.

Figure 1 shows the production of electricity by source in CAPP. Hydropower produces the majority of electricity.

The Republic of Congo accounted for more than one half (54 per cent) of electricity demand in CAPP in 2015, and Cameroon accounted for one-third. Electricity demand is expected to increase significantly in the coming decades.

Regional trade is very low in CAPP (0.2 per cent in 2009), except for power exports from Inga 1 and 2, mainly to Zambia. The situation is expected to change in the short term, with implementation of the vast cross-border program, and in the medium term, with implementation of regional generation and interconnection projects. However, market rules, institutions and capacity building still need to be developed (ICA, 2011).

Table 3: Total electricity production, consumption, imports and exports by country in CAPP[1], (ktoe/)[2]

Category	Angola	Burundi	Cameroon	Central Arican Republic	Chad	Republic of Congo	Democtratic Republic of the Congo	Equatorial Guinea	Gabon	São Tomé & Príncipe	CAPP total
Total production of electricity	617	17	628	18	28	132	676	82	199	3	2,400
Final consumption of electricity	535	23	526	15	20	127	613	36	169	2	2,066
Net imports/ exports of electricity	0	8	0	0	0	5	0	0	0	0	13

Notes:

1 All values are expressed in ktoe per year. Cells highlighted in yellow indicate the highest value for that category. A minus value indicates exported products. 0 = Data not applicable or not available.

2 Cells highlighted in yellow indicate the highest value for that category. A minus value indicates exported products. 0 = Data not applicable or not available.

Source: (AFREC, 2015)

Grand Renaissance Dam-Ethiopia

Grand Ethiopian Renaissance dam 2010

Grand Ethiopian Renaissance dam 2016

(Source: Google Earth)

The dam is located approximately 500 km north west of the capital Addis Ababa, in the region of Benishangul–Gumaz along the Blue Nile. At the end of the works, the Grand Ethiopian Renaissance Dam will be the largest dam in Africa.

An image from February 2010 shows pre-construction conditions of the Blue Nile. By April 2016, the hydraulic structures and settlement areas are visible.

Investments in generation projects and transmission lines

Since the adoption in 2006 of the first CAPP Regional Power Plan, the Secretariat General of CAPP regularly reports on its investment status and funding requirements. Investment activities in CAPP focus primarily on generation capacity, mainly in hydropower projects, power transmission priority projects and transboundary priority projects.

Investments in CAPP have also been geared toward projects related to the overall interconnection strategy adopted in light of the Study on Interconnection Projects in Central African Region. It was finalized in November 2010 and contributed to defining the overall development of interconnection schemes up to 2030, and to selecting the priority projects to be developed in the medium term. These priority projects consist of "the coastal backbone" linking Angola to Chad, including connection with DRC, Republic of Congo, Equatorial Guinea, Gabon and Cameroon and of two other interconnections linking Cameroon to CAR, and DRC to CAR, respectively.

CAPP is working with SAPP to establish a 3,800 km interregional connection line from DRC to South Africa through Angola and Namibia, and to the north to Equatorial Guinea, Cameroon and Chad, to be completed in 2018. This transmission line is expected to have a 4,000 MW capacity by 2020 and 12-17 GW by 2040, depending on the segment (PIDA, 2016).

To summarize: Within the CAPP, Angola had the highest production of crude oil, NLG and additives, natural gas and electricity from fossil fuels. It had the

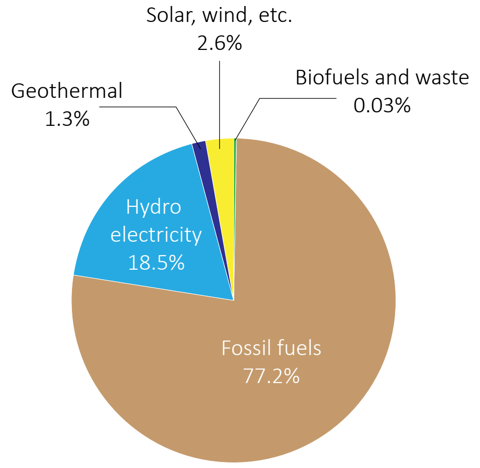
Figure 2: Power pools

Table 4: Summary of interconnection projects in CAPP

Interconnections	Sub-station	Voltage kV (AC)	Capacity MW	Length km	Total cost US$ m
Angola – DRC	Maquelo do Zombo – Inga 3	400	800	192	187.29
Republic of Congo – Gabon	Mongo Kamba – Bongolo – Chutes de l'Impératrice	400	600	482.1	435.13
Gabon – Equatorial Guinea	Ntoum – Bata	400	600	271.4	296.65
Equatorial Guinea – Cameroon	Bata – Menve'ele	400	600	95.4	146.22
Cameroon – Chad	Maroua – N'Djamena	220	125	205.8	115.71

Source: (ICA, 2011)

Figure 3: Production of electricity by fuel source in EAPP



Source: (AFREC, 2015)

highest consumption of oil in industry and transport and the highest consumption of natural gas in industry. It exported the most crude oil, NGL, etc., and imports the most oil products; Cameroon produced the most electricity from biofuels and wastes and has the highest output of refined oil products; Republic of Congo consumed the most natural gas; the DRC produced the most charcoal and hydroelectricity and it also consumes the most electricity in industry; Gabon exported the most oil products; and Rwanda had the highest production of electricity from solar, wind, etc. (AFREC, 2015).

East Africa Power Pool (EAPP)

The East Africa Power Pool is made up of Burundi (which is also member of CAPP), DRC (which also shares power with CAPP and SAPP), Egypt, Ethiopia, Kenya, Libya, Rwanda (which also shares power with CAPP), Sudan, Tanzania (which also shares power with SAPP) and Uganda.

EAPP was established in 2005 by seven East African countries (Burundi, DRC, Egypt, Ethiopia, Kenya, Rwanda and Sudan). It was adopted in 2006 as the specialized electric power institution for COMESA. Tanzania, Libya and Uganda joined in 2010-2012; EAPP now has ten member countries. Djibouti is in the process of joining while Eritrea and South Sudan are potential members.

State-owned Ethiopian Electric Power Corporation (EEPCo) recently announced a revised 25-year-power-sector strategy, aiming to boost generating capacity to 37,000 MW annually by 2037. A substantial amount is intended to be surplus power earmarked for export as a reliable source of precious hard currency (KPMG, 2014).

The Ethiopian government has been actively addressing the country's energy problem, which until recently severely constrained economic development. Several new projects have been initiated aiming to increase the country's electricity production. The vast natural resources and favourable climate could place Ethiopia at the centre of an emerging electricity network across the region, driven largely by renewable energy (KPMG, 2014).

The generation systems of most EAPP countries have a high share of hydro, particularly Ethiopia and to a lesser extent Tanzania, Kenya and Uganda, but the presence of Egypt, which is mainly thermal, leads to an overall share of hydro of only 18 per cent . EAPP also has some non-hydro renewable energy in geothermal (Kenya) and wind (Egypt and Kenya).

The total grid capacity in East Africa has tripled since 2000 as a number of major hydropower projects have come on stream, including the Merowe dam in Sudan and Ethiopia's Beles II and Gilgel Gibe II dams. Hydropower accounts for around half of grid capacity, with oil-fired generation accounting for over 40 per cent of the remainder (APP, 2015).

Figure 3 shows the production of electricity by source in EAPP. The majority of electricity is produced by fossil fuels.

There is a plan to link the EAPP to states outside of East Africa as part of COMESA. The 19-state COMESA bloc has an installed capacity of 52 MW (69 per cent thermal and 30 per cent hydro) and in 2009 COMESA initiated a process to harmonize regulation and energy policy (Opalo, 2013).

EAPP requires technical assistance to be able to coordinate all regional power sector integration activities currently undertaken by a range of organizations with overlapping mandates. This will optimize the use of scarce human and material resources in the region. The organizations concerned are those developing master plans for power generation and transmission and regional power trade, and also involved in project analysis and development. These include EAPP, the East African Community (EAC) and the Nile Basin Initiative. Similar organizations include those harmonizing regulations, like the EAPP Independent Regulatory Board (IRB) and the Regional Association of Energy Regulators of East and Southern Africa of the Common Market of Eastern and Southern Africa (COMESA) (IRENA, 2015).

The growth in electricity demand in the region requires large investments in new generation. Significant investments in renewable energy in the form of

Table 5: Total electricity production, consumption, imports and exports by country in EAPP, (ktoe/year)

Category	Burundi	Democratic Republic of Congo	Egypt	Ethiopia	Kenya	Libya	Rwanda	Sudan	Tanzania	Uganda	EAPP total
Total production of electricity	17	676	16,505	1,707	868	3,105	92	1281	555	276	25,082
Final consumption of electricity	23	613	13,385	654	738	2,690	38	1,087	526	200	19,954
Net imports/exports of electricity	0	0	-34	-34	1	4	0	0	5	-9	-67

Note: All values are expressed in ktoe per year. Cells highlighted in yellow indicate the highest value for that category. A minus value indicates exported products. 0 = Data not applicable or not available.
Source: (AFREC, 2015)

Table 6: Status of interconnection projects in EAPP

From	To	Type/length	Capacity (MW)
Tanzania	Kenya	400 kV, 2 circuits, 260 km	1,520
Rusumo (Rwanda)	Other parts of Rwanda	220 kV, 1 circuit, 115 km	320
Rusumo (Rwanda)	Burundi	220 kV, 1 circuit, 158 km	280
Rusumo (Rwanda)	Tanzania	220 kV, 1 circuit, 98 km	350
Ethiopia	Kenya	500 kV-DC, bi pole, 1,120 km	2,000
Ethiopia	Sudan	500 kV, 4 circuits, 570 km	3,200
Egypt	Sudan	600 kV-DC, bi pole, 1,120 km	2,000
Uganda	Kenya	400 kV, 2 circuits, 254 km	300
Uganda	Rwanda	220 kV, 2 circuits, 172 km	250
Rwanda	Democratic Republic of the Congo	220 kV, 1 circuit, 68 km	370
Democratic Republic of the Congo	Burundi	220 kV, 1 circuit, 105 km	330
Burundi	Rwanda	220 kV	330

Source: modified from (IRENA, 2015)

hydro, geothermal and wind power are to take place from 2020 to 2025. In addition, there will be investments in fossil-based generation, mostly natural gas and large investments in natural gas-fired power plants in Egypt and Libya, as well as significant geothermal investment in Kenya and Ethiopia and significant investment in hydropower in Ethiopia, Tanzania, Uganda and the DRC (Tesfaye, 2014).

Constraints in energy supply hamper economic growth throughout the whole of Eastern Africa. Alongside hydropower plants, which often need to be shut down in periods of drought, new energy sources are required to increase electricity production. Using geothermal energy (geothermal heat) has massive potential; it is a renewable source of energy that can be exploited across the Great Rift Valley in Eastern Africa (KFW, 2015).

Regional trade in EAPP is very modest (0.4 per cent in 2008), but the situation may change substantively with the recent operation of the Ethiopia-Djibouti interconnection and the ongoing implementation of the Ethiopia-Kenya interconnection. The EAPP, however, has still to design and develop its power market institutions and rules (ICA, 2011).

To summarize: Within the EAPP, Burundi imported the most electricity; Ethiopia produced the most charcoal; Egypt led in the production of crude oil, NLG and additives, electricity production from fossil fuels and from solar, wind, etc., as well as in the total production of electricity, refinery output of oil products, consumption of coking coal, oil, natural gas, electricity, oil in industry and transport, natural gas in industry, and electricity in industry and transport. It tied with Kenya in the consumption of coking coal in industry. It also led in net imports of coking coal and oil products and in the export of crude oil, NGL, etc. and natural gas, and tied with Ethiopia in the exportation of electricity. Ethiopia had the highest production of electricity from biofuels and waste and hydropower. It tied with Egypt in the exportation of electricity. Kenya was the leader in the production of geothermal electricity and the importation of crude oil, NGL, etc. It tied with Egypt in the consumption of coking coal in industry. Tanzania was the leader in the production of coking coal (AFREC, 2015).

Electricity Committee of the Maghreb (COMELEC)

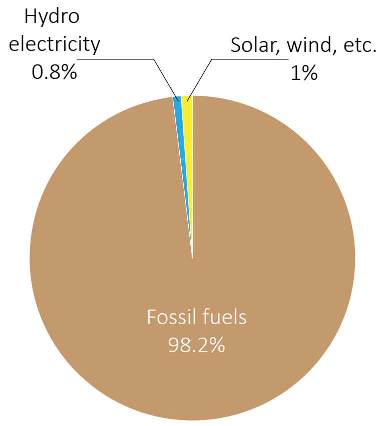
In 1974, the Maghreb region Ministers of Economy and Finances approved the creation of the Electricity Committee of the Maghreb region (COMELEC) and its legal texts were adopted in 1975. After a period of inactivity between 1975 and 1988, the three countries resurrected COMELEC with a first meeting held in Casablanca on October 3-6, 1989. The ratification of the Marrakech treaty by the five Heads of States on February 17, 1989, which formally created the Union of the Maghreb Arab, gave a supplementary dimension to COMELEC in its role of coordinating electricity utilities companies' activities in the

Industrial development, Ethiopia

region. COMELEC currently comprises companies in charge of producing, conveying and distributing electricity in the five countries. They include:

- SONELGAZ (Algérie - Algeria)
- ONE (Maroc - Morocco)
- STEG (Tunisie - Tunisia)
- GECOL (Libye - Libya)
- SOMELEC (Mauritanie - Mauritania)

Figure 4: Production of electricity by fuel source in COMELEC



Source: (AFREC, 2015)

At the international level, COMELEC has maintained relationships with counterpart organizations including EURELTRIC (Electricity of Europe, which is an association of electricity companies of 28 EU members states, current EU accession countries and other European OECD countries, and Mediterranean countries including Algeria, Morocco and Egypt), the UPDEA (Union of African Electricity Producers, Distributors and Conveyors) and the Arab Union (UAE). It is also a very active member of MEDELEC, the Liaison Committee that comprises all the neighbouring countries' associations of electricity producing companies of the Mediterranean region. As such, COMELEC participated in carrying out a systems study of the development of electrical grids in neighbouring countries (COMELEC, n.d.).

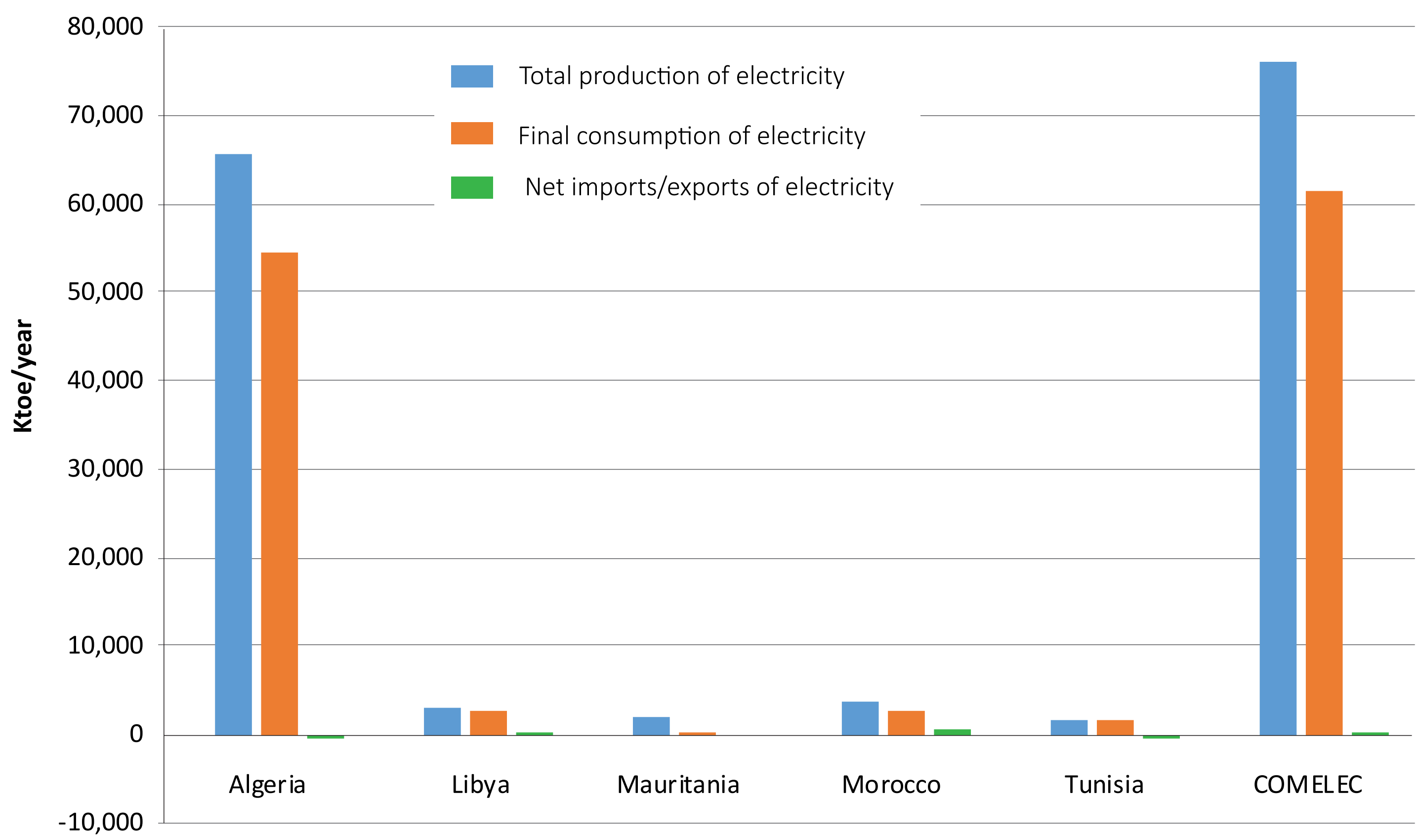
Most North African countries are highly dependent on oil and gas to satisfy domestic energy needs. However, the region is highly suitable for both wind and solar energy generation. In addition, Egypt and Morocco are the two countries with the highest wind power capacity in Africa. As part of Morocco's National Renewable Energy and Efficiency Plan launched in 2008, the government hopes to improve grid efficiency and generate 42 per cent of its energy requirements from renewable sources by 2020. This would necessitate 4,000 MW being generated from renewable sources, the expectation being that it will be split equally between solar and wind energy. In this regard, the Moroccan government is in the process of recruiting foreign investors to fund a US$9 billion solar power project in Western Sahara in addition to domestic wind and solar energy projects (KPMG, 2014).

The COMELEC sub-region has the highest connectivity and the best infrastructure. The region is also linked to the Middle East via the Egypt-Jordan interconnector line and to Europe via the Morocco-Spain line (part of the future Mediterranean Electricity Ring, MEDRING) (Opalo, 2013).

The interconnection capacity is well developed in COMELEC; the trade volume, however, is dominated by Moroccan imports from Spain (88 per cent). Trade among COMELEC countries is very low due to lack of generation capacity, but also due to lack of a regional approach reflected by the low profile adopted by COMELEC member countries to develop regional regulation and market rules, as well as for strengthening COMELEC's role as a regional institution (ICA, 2011). COMELEC exports crude oil and natural gas.

To summarize: Within the COMELEC region, Angola led in all categories except in the production of hydroelectricity, importation and exportation of crude oil, NGL, etc., and importation of coking coal, oil products, natural gas and electricity; Libya exported the most crude oil, NGL, etc.; Morocco produced the most hydro power and imported the most coking coal, crude oil, NGL, etc., as well as oil products and electricity; and Tunisia had the highest importation of natural gas (AFREC, 2015).

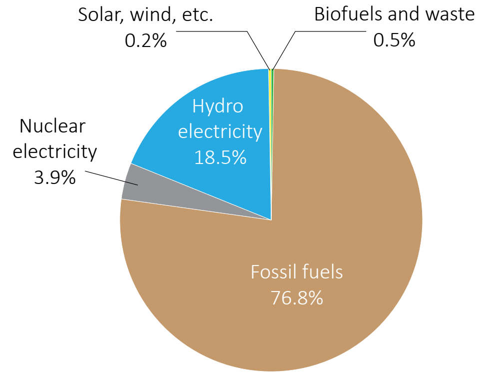
Figure 5: Total electricity production, consumption, imports and exports by country in COMELEC (ktoe/year)



Note: All values are expressed in ktoe per year. A minus value indicates exported products.

Source: (AFREC, 2015)

Figure 6: Production of electricity by fuel source in SAPP



Source: (AFREC, 2015)

Southern Africa Power Pool (SAPP)

The Southern Africa Power Pool (SAPP) is made up of the following countries: Angola (which is also a member of CAPP), Botswana, DRC (which is also a member of CAPP and EAPP), Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania (which is also a member of EAPP), Zambia and Zimbabwe.

SAPP was created in 1995. It is now the most advanced power pool on the continent (Kambanda, 2013). It is a cooperation of the national electricity companies in Southern Africa under the auspices of the Southern African Development Community (SADC). The members of SAPP have created a common power grid between their countries and a common market for electricity in the SADC (KPMG, 2014).

SAPP introduced the Short-Term-Energy Markets (STEM) in April 2001, which runs on daily and hourly contracts. This ignited the development of a competitive energy market in the form of a Day-Ahead Market (DAM) in 2003 (with short-term contracts made anonymously through the power pool and where guarantees are required) (Kambanda, 2013).

While South Africa, Zambia and Mozambique are the largest energy producers in the pool, South Africa has often made use of the facility to supplement its energy supply. Large hydropower projects in Mozambique and Zambia will increase the available resources in the common power grid, allowing regional countries to take advantage of these developments (KPMG, 2014).

In addition, the hydroelectric plants will allow other countries, particularly South Africa, to improve their current carbon-intensive energy generation mixes. The Cahora Bassa hydropower plant on the Zambezi River (Mozambique) currently represents 40 per cent of Eskom's carbon-free generation (KPMG, 2014).

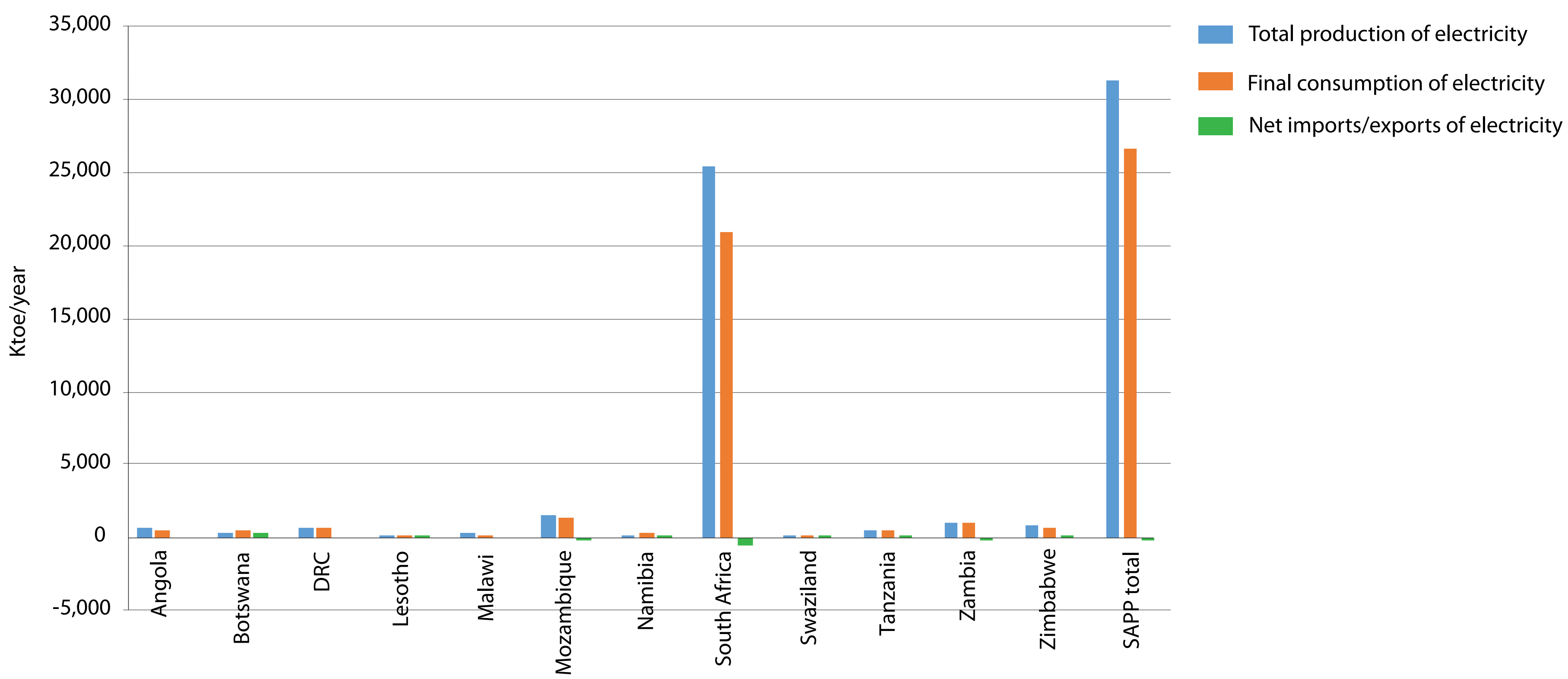
Angola plans to connect the province of Cabinda with the DRC's Inga hydroelectric plant, in addition to becoming a regional energy exporter over the long term. Angola's electricity output is expected to reach 5,000 MW by 2017, according to government figures. With regard to nuclear power, South Africa is the only country in Africa with nuclear production facilities. According to the BP Statistical Review 2016, the country consumed 2.4 Mtoe of nuclear energy in 2015, representing a 25 per cent decrease from 2014 consumption (BP, 2016). While some other African countries also produce uranium, particularly the DRC, Namibia and Niger, South Africa remains the only country to derive electricity from the mineral (KPMG, 2014).

Swaziland is the major importer of electricity and South Africa the major exporter (AFREC, 2015).

As for power trade, SAPP is at a more advanced stage, with 28 bilateral contracts already signed between the member countries and with an active role played by the Short Term Electricity Market (STEM) since 2001 and by the Day Ahead Market (DAM) since 2009. Institutional set up and market rules and regulations are already implemented. Further development of the regional market, however, is constrained by the lack of generation capacity linked with congested and insufficient interconnections capacity (ICA, 2011).

To summarize: Within the SAPP, Angola led in the production of crude oil, NLG and additives and in the exportation of the same; the DRC produced the most charcoal; Mozambique had the highest production and exportation of natural gas; Namibia imported the most coking coal; South Africa was the leader in all other categories except the use of electricity in transport and the importation of electricity; and Swaziland consumed the most electricity in transport and imported the most electricity (AFREC, 2015).

Figure 7: Total electricity production, consumption, imports and exports by country in SAPP, (ktoe/year)



Note: All values are expressed in ktoe per annum. A minus value indicates exported products.
Source: (AFREC, 2015)

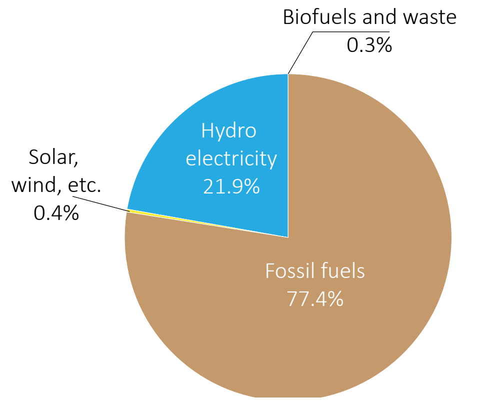
West Africa Power Pool (WAPP)

Benin, Burkina Faso, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo are the member countries of the Western Africa Power Pool (WAPP).

WAPP was established in 2001 to promote energy trade between member countries. The updated WAPP 2011 Master Plan foresees a number of projects that will help achieve adequate energy trade (which includes a renewable energy proportion of 10 per cent) by 2020. In 2013, the power trade in WAPP was still under bilateral or multilateral agreements and energy trade through WAPP had not yet started (Kambanda, 2013).

The primary objectives of the WAPP are to develop a power transmission network that interconnects the entire West African Region; create an attractive environment for investments to facilitate the funding of power generation and transmission facilities; and establish a legal and regulatory framework conducive for investments and suitable for enforcing common operating standards and rules in the sector (Nigeria Electricty System Operator, 2015). Nigeria is the major producer of electricity from fossil fuels.

Figure 8: Production of electricity by fuel source in WAPP

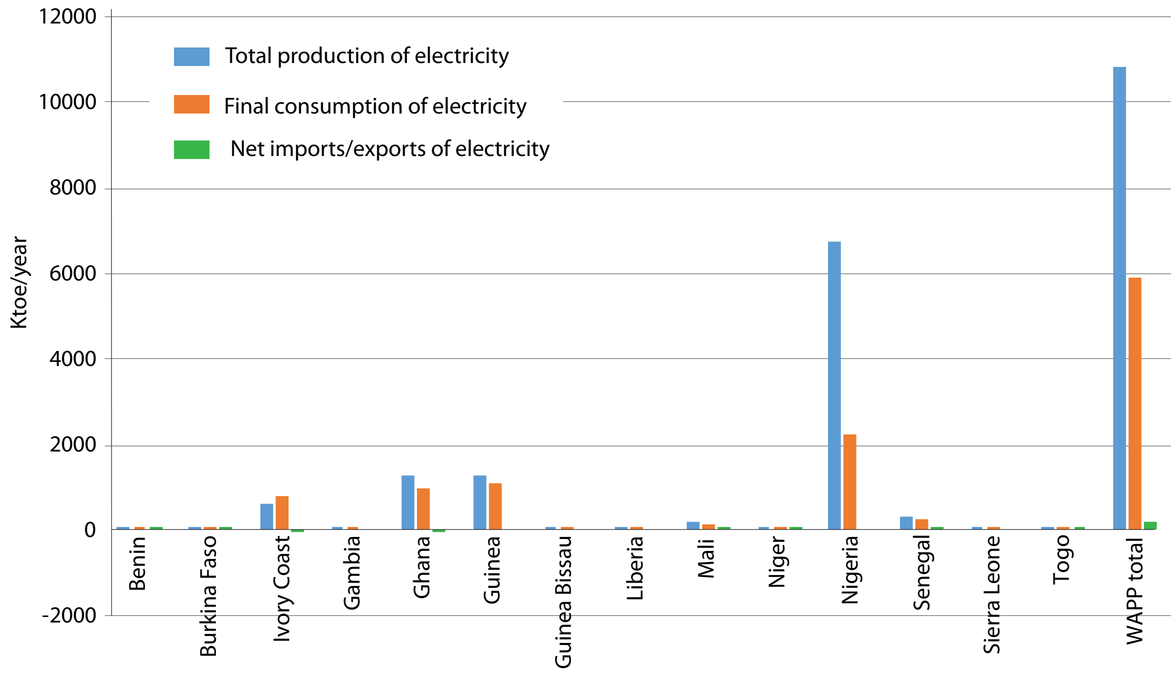


Source: (AFREC, 2015)

The WAPP generation system is small compared to other regional systems and is dominated by thermal generation capacity. Most power plants use imported diesel and heavy fuel oil (HFO), except Nigeria, which uses gas for power generation. The hydro potential of the region is significant in Guinea, (though not yet developed) and in the Senegal, Gambia and Niger basins (which are under development) (ICA, 2011).

The lack of existing connections among West African national power grids is a great obstacle to increased electricity trading and to the resulting beneficial effects of grid-wide stability. The West African Power Pool is thus heavily focused on regional infrastructure development, rather than the trading mechanisms themselves. The eventual goal, the same as any power

Figure 9: Total electricity production, consumption, imports and exports by country in WAPP (ktoe/year)

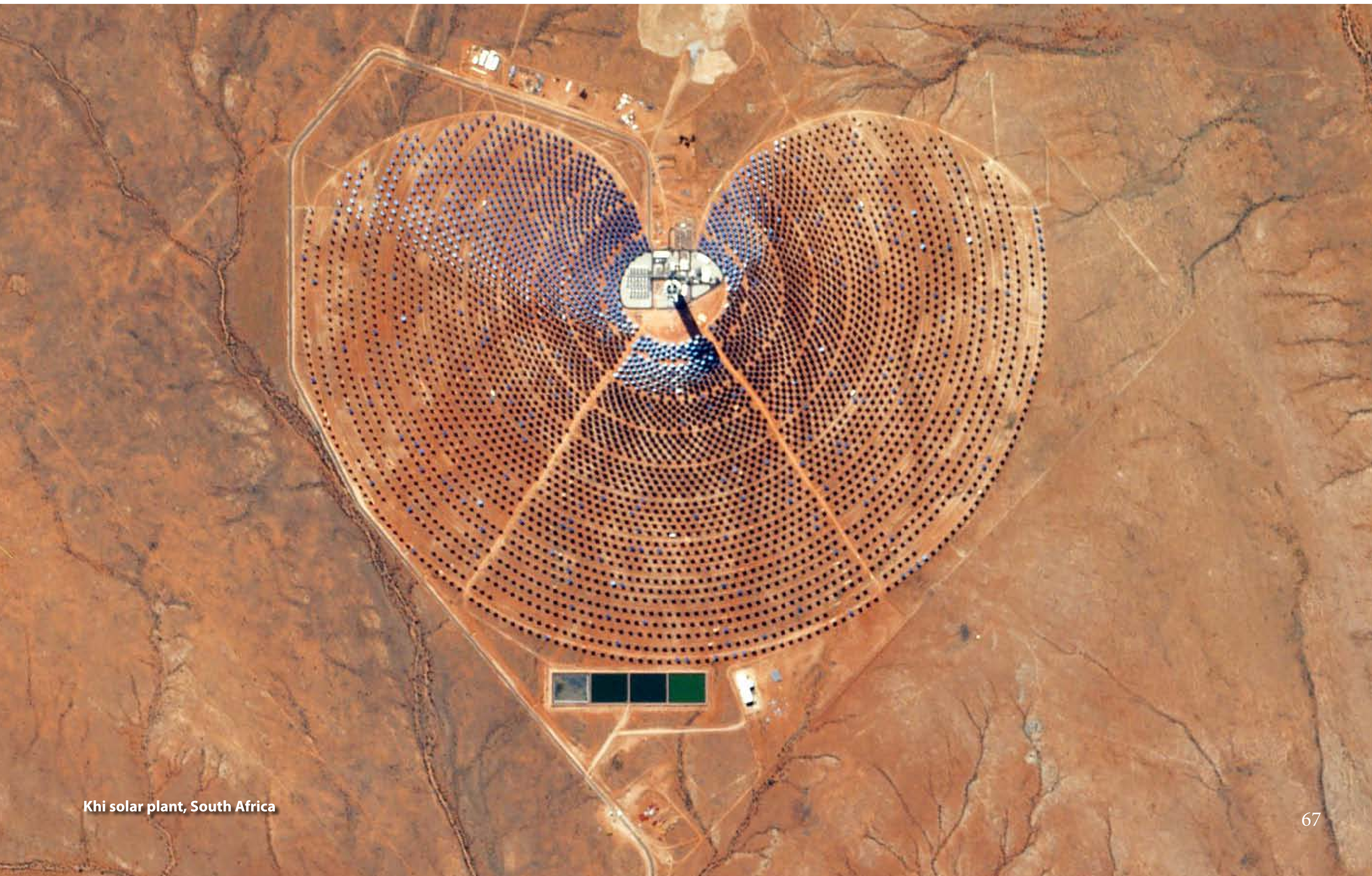


Note: All values are expressed in ktoe per annum. A minus value indicates exported products.

Source: (AFREC, 2015)

pool, is to set up a regional trading mechanism that would facilitate the procedures to transfer electricity, thus addressing short-term local shortfalls. But in West Africa, regional transmission and generation infrastructure have not yet evolved enough to support this. Power trading between West African Power Pool member states continues to be based on bilateral and multilateral agreements rather than unified pool trading (Stratfor, 2014). Benin is the major importer of electricity in WAPP and Ghana the major exporter (AFREC, 2015).

As the West African Power Pool continues to further develop, the main focus for securing investment and developing infrastructure will likely be



Khi solar plant, South Africa

Ain Beni Mathar Integrated Combined Cycle Thermo-Solar Power Plant in Morocco

to increase transmission capabilities. Countries will also seek to increase their own power generation capacity and ongoing privatization efforts may lead to higher cost efficiency over time. Apart from Nigeria, other countries in West Africa will also push to develop their offshore oil and natural gas deposits. This will lead to some of the natural gas being fed back inland for power generation (Stratfor, 2014).

Regional trade in WAPP is significant, at nearly 7 per cent . Trade primarily takes place between coastal countries: exports from Nigeria, Ghana and to a lesser extent from Côte d'Ivoire, with Benin and Togo as major importers. However, WAPP is implementing an important investment program in regional generation and interconnection projects. WAPP has also developed its institutional set up and market structure. It is expected that regional trade will increase substantially when regional projects are implemented (ICA, 2011).

To summarize: Within the WAPP, Benin had the highest electricity imports; Côte d'Ivoire produced the most electricity from biofuels and waste, imported the most crude oil, NGL, etc., and Nigeria exported the most oil products and electricity; Ghana had the highest production of hydroelectricity and importation of natural gas; Niger led in the production of coking coal; and Nigeria led in all other categories except for the consumption and importation of coking coal (AFREC, 2015).

Regional Power Pools: Future Scenarios

This section presents the Outlook to 2040 through scenarios at the levels of regional power pools operating in Africa. It compares the demand and the requirements to meet those demands at the regional levels.

The Africa Energy Sector Outlook 2040 was produced by the AUC, NEPAD Secretariat and AfDB, which jointly sponsored the Programme for Infrastructure Development in Africa (PIDA). One of PIDA's overarching objectives was to establish an infrastructure development program over a time horizon up to 2040 using the strategic framework/sector policies. The Outlook 2040 attempts to project the balance between energy demand and supply for the 53 African countries with a focus on the potential of regional energy market integration and for regional trade of energy, and a special consideration of synergies between different infrastructure modes (AfDB, 2014).

Outlook 2040 scenarios for the electricity sector are based on projection assumptions that take into consideration main factors including: GDP growth, GDP elasticity of electricity demand, fuel prices, increase in electricity access, mineral resources development and future power plants' characteristics:

- Average GDP growth was estimated at 6.2 per cent for all Africa, differentiated by country;
- GDP elasticity of demand has been estimated through an econometric model as ranging from 0.8 to 1.3 with an average of 1.25, which is normal for economies in the process of modernization;
- Access to electricity is expected to increase so all countries will have an access rate above 60 per cent by 2040. Average access will improve from 40 per cent at present (including North Africa) to 69 per cent by 2040;
- Increase in access will be faster in EAPP, SAPP and CAPP, because they start from a lower level, but then converge to the African average;
- Investment needed to connect 140 million households (800 million people) is a relatively modest US$3.5 billion per year, mainly in EAPP, WAPP and SAPP;
- The additional demand resulting from an aggressive continental access policy is only 7 per cent of demand in 2020 and 13 per cent in 2030;

Figure 10: Trend in electricity demand by REC/Pool, 2008-2040

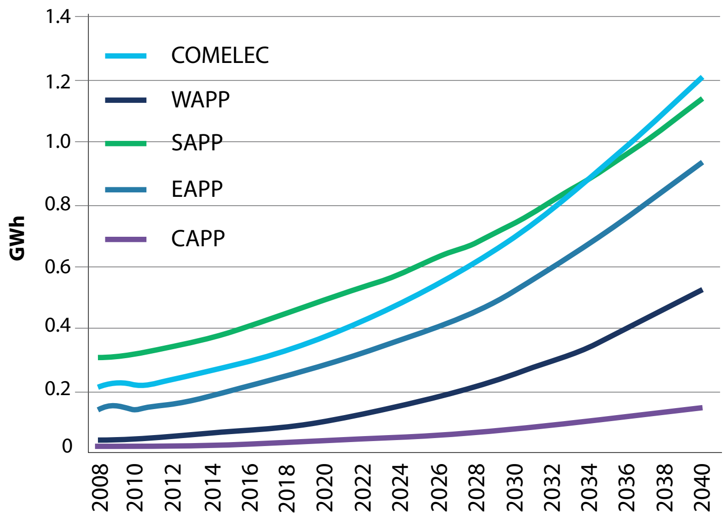
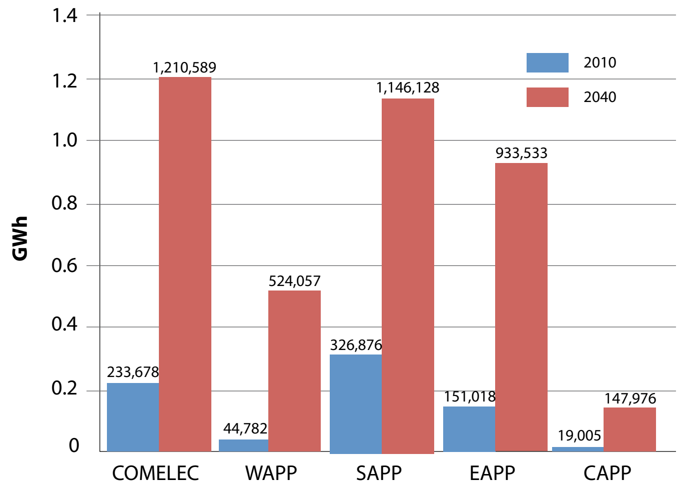


Figure 11: Electriciy demand by REC/Pool, 2010 and 2040



- Despite the development of mineral resources, the share of industry in demand is expected to decrease from 69 per cent to 57 per cent , as most extractive industries are self-generators and do not rely on the grid for their electricity supply;
- All candidate plants for meeting future demand are considered with their site-specific costs and characteristics, except for generic gas turbine costs for peaking purposes, with fuel costs adjusted for delivery at the plant door;
- Future generation investments are mainly in hydropower projects (e.g., Ethiopia: Gibe III with 1,870 MW); this is also the case for SAPP (80 per cent of 13,015 MW generation priority projects are hydro) (AfDB, 2014).

In addition, the scenarios' planning incorporates the following key parametres:

- Energy efficiency gains of up to 20 per cent will materialize over the coming 20 years;
- Energy security is projected to improve by reducing imports of fuels through regional trade;
- Three trade development scenarios are envisaged: Low, High and Medium. The Medium trade development is taken as the base case with imports allowed to increase from 30 per cent to 100 per cent of demand (except for South Africa);
- Fuel prices are forecast based on future oil price reaching US$820 per tonne (US$113.bbl) in 2000 prices;
- A concern for CO_2 emissions — although Africa represents less than 4 per cent of global GHG emissions, a sensitivity analysis with a shadow CO_2 price of US$30/tonne was projected (AfDB, 2014).

Primary energy demand by Regional Economic Communities (RECs)

Regional power pools (RPPs) will continue to have very diverse primary energy mixes, with COMELEC and EAPP (Egypt) relying heavily on gas and petroleum products, while WAPP has a more balanced mix, with petroleum products, gas and coal. CAPP relies essentially on petroleum products and SAPP reduces its consumption of coal but increases the share of nuclear in

Figure 12: Primary energy demand by power pool (in million toe), 2010-2040

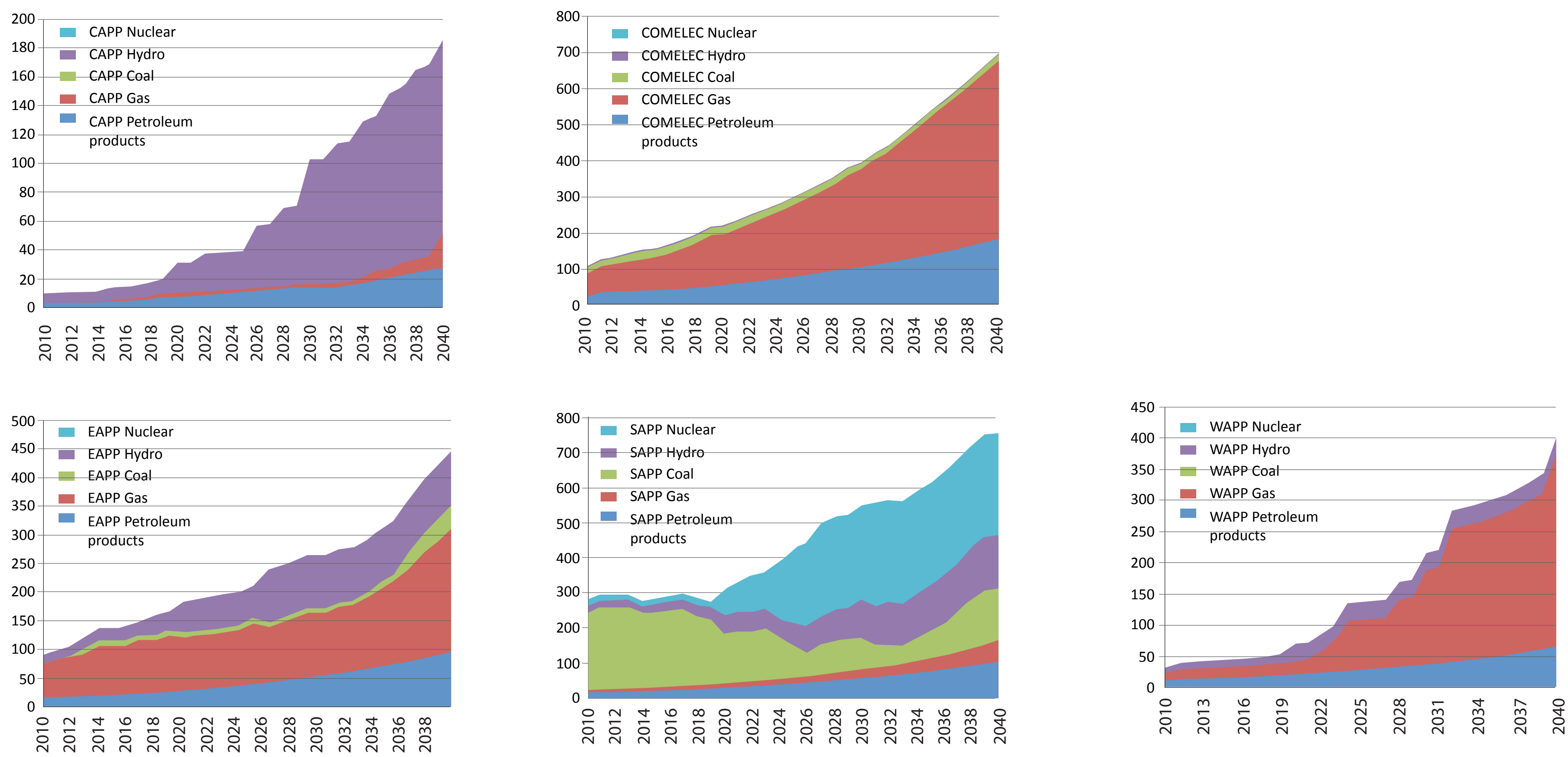
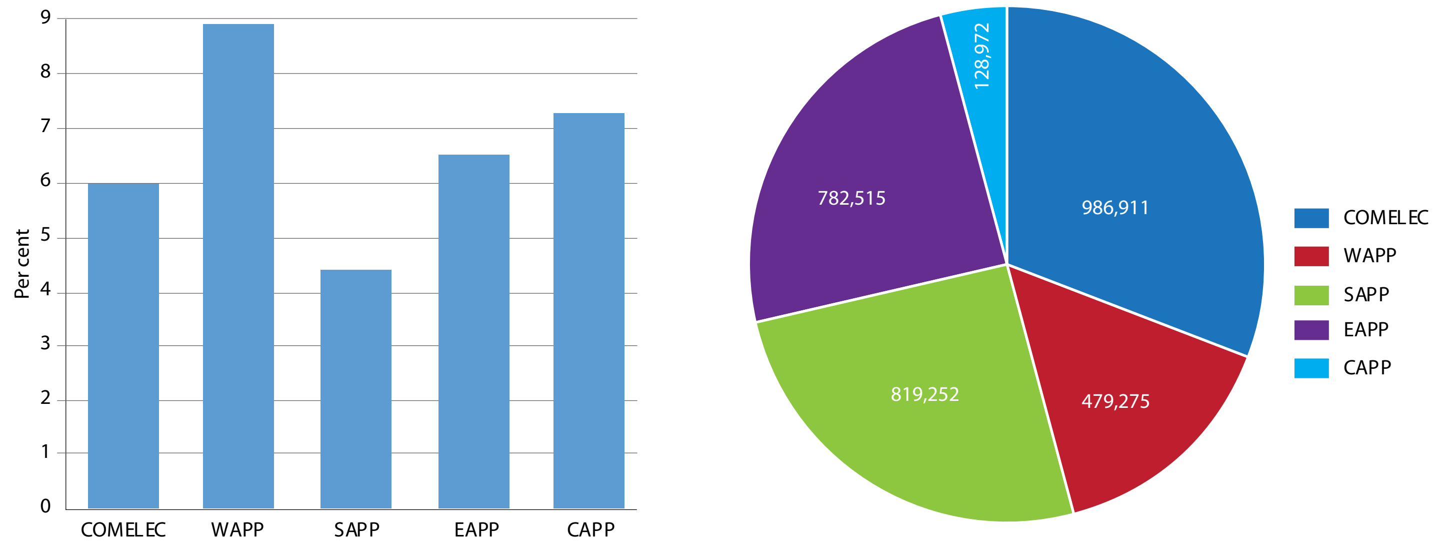
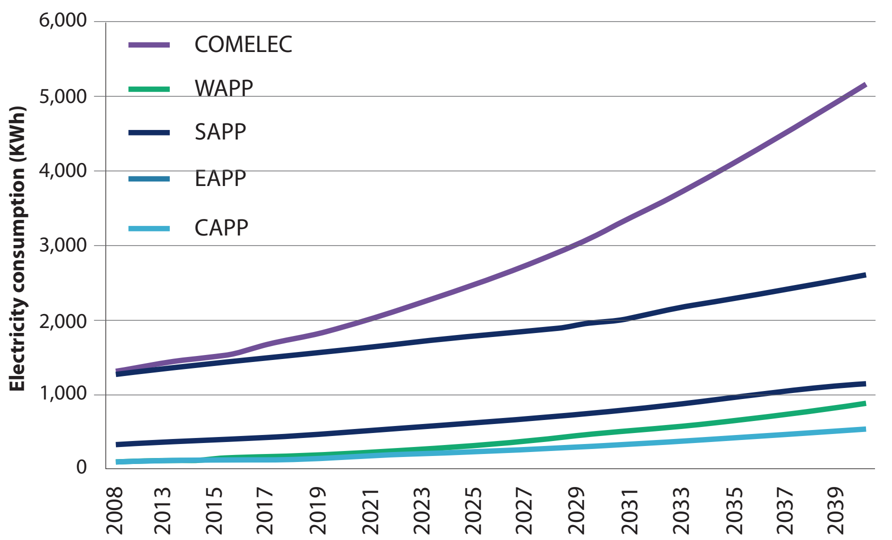


Figure 13: Annual growth rate by power pool, 2011-2040, and increase in demand in power pools, 2011-2040 (in GWh)



Source: (AfDB, 2014)

Figure 14: Trend in per capita electricity consumption by REC/Pool (in kWh), 2011-2040



Source: (AfDB, 2014)

its energy mix. Except in SAPP (with a continuing, though decreasing, high consumption of coal) and COMELEC (with a strong presence of gas), most RPPs will continue to rely on petroleum products.

Electricity demand

Electricity demand varies among sub-national entities: demand increases faster in WAPP (8.9 per cent) and CAPP (7.3 per cent) compared to SAPP (4.4 per cent), EAPP (6.5 per cent) and COMELEC (6 per cent), because the demand of large countries, including South Africa and Egypt, is moderate and low-income countries catch up with more advanced countries.

In annual growth rate, WAPP and CAPP perform better than the other power pools, although they start from a lower level in terms of energy consumption and per capita consumption.

In terms of consumption per capita, the rapid demographic growth of sub-Saharan Africa pulls down the average per capita consumption of electricity. Per capita energy consumption is growing faster in COMELEC because its population growth is significantly lower than that of the rest of Africa, at 1.2 per cent per year compared to more than 2 per cent , respectively, while demand is projected to increase at a similar rate of 6 per cent . Figure 14 presents the comparisons.

The Outlook 2040 for each power pool is characterized by the peak load, including network losses needed and its growth rate; the increase in generation capacity; and the electricity access rate.

Using the above characteristics, Figures 12 to 14 illustrate the comparative regional projections over the period 2011-2040.

Mobile phone charging outlets, Uganda

CAPP

With an average annual growth capacity of 7.3 per cent , the system will need an additional 26 GW for a 670 per cent increase in capacity needs over the 2011-2040 period. This high expansion is due to the forecasted high GDP growth and to the increase in access rate. This additional capacity will be able to sustain an increase in access from 21 per cent in 2011 to 63 per cent by 2040, provided US$14 billion are invested in access.

Table 7: Outlook of CAPP energy demand and access growth, 2011-2040

Statistics	2011	2020	2030	2040	Total Period
Peak load including losses (MW)	3,915	7,409	15,713	30,114	
Annual growth rate capacity preceding 10 s (%)		8.3	7.8	6.7	7.3
Increase over the period (GW)		3.4	8.3	14.4	26.1
Access rate (%)	21	37	54	63	+42
Investment in access (previous period, million US$)		4,102	5,689	5.022	14,813

Source: (AfDB, 2014)

EAPP

With an average annual growth capacity of 6.5 per cent , the system will need an additional 140 GW to meet a 525 per cent increase in capacity needs over the 2011-2040 period. This high expansion is due to the forecasted high GDP growth and to the increase in access rate. This additional capacity will be able to sustain an increase in access from 37 per cent in 2009 to 68 per cent by 2040, provided US$44.5 billion are invested in access.

Table 8: Outlook of EAPP energy demand and access growth, 2009-2040

Statistics	2011	2020	2030	2040	Total Period
Peak load including losses (MW)	26,906	49,625	93,728	169,192	
Annual growth rate capacity preceding 10 s (%)		7.9	6.6	6.1	6.5
Increase over the period (GW)		22.7	44.1	75.4	140.2
Access rate (%)	37	49	63	68	+31
Investment in access (previous period, million US$)		12,683	17,537	14,084	44,304

Source: (AfDB, 2014)

COMELEC

Capacity is forecast to increase by 6.2 per cent over the 2011 to 2040 period and an additional 298 GW in capacity is needed. Access is forecast to increase slightly by 1 per cent to 97 per cent , but US$8 billion will have to be invested in access to maintain the rates, given the growing population, and to progress by another 1 per cent .

Table 9: Outlook of COMELEC energy demand and access growth, 2011-2040

Statistics	2011	2020	2030	2040	Total Period
Peak load including losses (MW)	62,364	105,219	204,758	360,786	
Annual growth rate in capacity preceding 10 s (%)		6.7	6.9	5.8	6.2
Increase over the period (GW)		42.8	99.5	156.0	298.4
Access rate (%)	96	96	97	97	+1
Investment in access (previous period, million US$)		3,048	2,747	2,218	8,013

Source: (AfDB, 2014)

SAPP

The future demand pattern in SAPP is dominated by the prospects for South Africa. With an average annual growth capacity of 4.4 per cent , the system will need an additional 129 GW for a 250 per cent increase in capacity over the 2011-2040 period. This additional capacity will be able to sustain an increase in access from 25 per cent in 2011 to 63 per cent by 2040, for an investment in access of US$27 billion.

Table 10: Outlook of SAPP energy demand and access growth, 2011-2040

Statistics	2011	2020	2030	2040	Total Period
Peak load including losses (MW)	50,957	76,610	116,049	179,794	
Annual growth rate capacity preceding 10 s (%)		5.2	4.2	4.4	4.4
Increase over the period (GW)		25.6	39.4	63.7	128.8
Access rate (%)	25	41	58	63	+38
Investment in access (previous period, million US$)		8,510	11,144	7,816	27,470

Source: (AfDB, 2014)

WAPP

With an average annual growth capacity of 8.9 per cent , the system will need an additional 90 GW for a 1,200 per cent increase in capacity over the 2011-2040 period. This high expansion is due to the forecasted high GDP growth and to the increase in access rate. This additional capacity will be able to sustain an increase in access from 45 per cent in 2011 to 67 per cent by 2040, provided US$32 billion are invested in access.

Table 11: Outlook of WAPP energy demand and access growth, 2011-2040

Statistics	2011	2020	2030	2040	Total Period
Peak load including losses (MW)	8,204	17,864	45,748	98,157	
Annual growth rate capacity preceding 10 s (%)		10.8	9.8	7.9	8.9
Increase over the period (GW)		9.6	27.8	52.4	89.9
Access rate (%)	45	58	65	67	+22
Investment in access (previous period, million US$)		11,724	10,927	9,583	32,234

Source: (AfDB, 2014)

Energy Policy and Markets: Challenges and Opportunities

Energy policy strongly varies from one power pool to another and from one country to another. Financial incentives are currently the preferred policy options. Policies could encourage investment in renewable energy and accelerate their development throughout Africa and should be tailor-made for each individual power pool.

Cross-border power trade has yet to be adopted outside of the Southern Africa Power Pool (SAPP). In the meantime, many sub-Saharan African countries continue to experience an acute shortage in energy supply, which will take time to eliminate. Expanding regional energy integration is an essential step to improve availability at the household level if the universal access goal is to be achieved.

In 2008, about 10 per cent of total consumption in SAPP came from trade activities. But this share dropped significantly thereafter due to generalized capacity shortages. However, even in the SAPP, most of the trade — e.g., South Africa-Mozambique, Zambia-Namibia — is governed primarily by bilateral contracts. In West Africa, power trade is only 7 per cent of total consumption, also structured through bilateral arrangements.

Africa's investment needs in the energy sector are enormous, with the bulk of this investment required in electric power. Estimates in the context of the PIDA Outlook 2040 Study indicate that US$43 billion annually will be needed in new investment to meet the total investment needs by 2040, which compares with a current investment of less than US$5 billion annually. Given the magnitude of future needs, private sector participation in power sector investment is essential.

Worldwide, the power sector has been successful in attracting private investment. In 2009, the power sectors in South Asia and Latin America were able to attract $68.5 billion through private participation. In contrast, private sector participation in Africa in 2009 contributed only US$450 million (equivalent to 10 per cent of total investment).

The evaluation of the investment required by each power pool is given below:

1. EAPP, with a large population of 400 million and a low access rate of 36 per cent , needs most investment (US$1.52 billion per year);

2. WAPP, with a smaller population of 300 million and a low access rate of 44 per cent , needs significant but lower investment (US$1.1 billion per year);

3. SAPP has a lower population of 244 million, but the low access rate of 24 per cent requires nearly as much investment as WAPP; it needs US$0.95 billion per year;

4. CAPP has a low access rate of 20 per cent and needs to make special efforts to reach the 60 per cent plus access level, but because of its relatively small population of 150 million, it needs to invest only US$0.95 billion per year;

5. COMELEC, with a population of only 160 million and a current access rate of 96 per cent , needs relatively little investment in access (US$0.276 billion per year).

Table 12: Investment in access by REC, 2011-2040, in million US$

Power Pool	2011-20	2020-30	2030-40	Total
CAPP	4,102	5,689	5,022	14,813
EAPP	12,683	17,537	14,084	44,304
COMELEC	3,048	2,747	2,218	8,013
SAPP	8,510	11,144	7,816	27,470
WAPP	11,724	10,927	9,583	32,234

Source: (PIDA, n.d.)

Challenges

The major constraints and challenges to transboundary agreements and power pool development and operation in Africa include the following:

- Inadequate generating capacity and reserve margins;
- Difficulties in mobilizing investment for power projects;
- Low level of public funding and limited access to private finance;
- Policies that both constrain and fail to incentivize investment in the energy sector;
- Insufficient demand-side management mechanisms;
- Lack of medium- and long-term human resources planning and development;
- Vulnerability to the volatile world hydrocarbon markets;
- High power prices and the existence of a variety of regulatory interventions that distort the market; and
- Inadequate information and data on the African energy situation.

Opportunities

On the other hand, there are many opportunities that can be acted upon, including the following:

- Existence of conducive regional legal and regulatory frameworks for private sector participation;
- Enhanced regional and national political will and prioritization of the energy sector in regional and national development strategies;
- Greater willingness by countries to harmonize national and regional policies;
- Enhanced willingness by countries and RECs to contribute financially to project preparation and implementation;
- Enhanced collaboration among power pools and RECs in energy development programs and projects; and
- Profiting from new financing schemes, such as infrastructure bonds, pension funds, central bank reserve, levies and infrastructure funds. In fact, some countries and RECs have already started considering infrastructure bonds. The African Development Bank has also appealed African countries to use Central Bank reserves for infrastructure development. There is also an emerging idea of using pension funds. For this, the AfDB has set up the Africa50 Fund, as a tool to facilitate the implementation of this idea, including clouding in the Central Banks' reserves and pension funds.

Conclusions

The electrification of sprawling urban and isolated rural communities is a major challenge for a continent of such diverse countries, large expanses of territory and limited resources. The high costs of building and operating an electricity grid is reflected in low electrification rates and the poor condition of much existing infrastructure. The technical challenges of delivering electricity from sources of generation to consumer areas, often across large distances, have proved a barrier to investment in large conventional forms of energy production. The heavy investment required to build modern electricity grids may result in over-dependence on the cheapest forms of production — such as polluting diesel power, which further increases energy insecurity.

The interconnection of national grids across the continent is a major component in the Programme for Infrastructure Development in Africa (PIDA) and other international initiatives because it promotes economies of scale and comprises an important step towards energy security. The construction of cross-border transmission lines allows the import and export of electricity generated by various sources, providing a means of balancing system costs while also allowing African countries to take advantage of cheap generation in neighbouring countries.

The development of large-scale projects such as the Ruzizi III hydropower project shared by Burundi, DRC and Rwanda, or Ethiopia's Grand Renaissance Dam, which will generate 6 GW — not to mention the Grand Inga dam in DRC, which could eventually produce 50 GW — make more sense when they can supply multiple markets.

However, achieving such interconnections is a complex process in regions that lack harmonized legislation, compatible grids and integrated currencies or economies. This is not helped by the instability of many national grids and shortages of installed generation capacity. These bottlenecks have stalled several of the continent's many planned projects. However, the future looks brighter as plans are under way to reinforce existing grids and build a number of high-voltage transmission backbones across the continent (AEEP, 2016b).

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Solar panel on a hut, Bazaruto island, Mozambique.

Chapter

4

ENERGY AND SUSTAINABLE DEVELOPMENT

Key messages

- Rapid population and economic growth are important drivers that increase demand for energy in Africa. Sustainable Energy for All (SE4ALL) is a necessary pre-condition for sustainable development.
- About 621 million people out of Africa's 1.1 billion do not have access to electricity. Of the world's 20 countries with the least access to electricity, thirteen are in Africa, including Nigeria, Ethiopia, Democratic Republic of the Congo (DRC), Tanzania, Kenya, Uganda, (the former) Sudan, Mozambique, Madagascar, Niger, Malawi, Burkina Faso, and Angola.
- Africa uses more renewable energy than any other of the world's regions, deriving as much as 70 per cent of its energy consumption from renewable sources. One of the reasons, however, is its heavy reliance on traditional uses of biomass by both households and industry. It is estimated that 4 out of 5 rely on solid biomass, mainly fuelwood and charcoal for cooking.
- At the continental level, population growth still outpaces the increase in access to non-solid fuels; the population increased by 48 million but only 9 million gained access.
- The poorest African households spend 20 times more per unit of energy than wealthy households when connected to the grid.
- With current trends, it will take Africa until 2080 to achieve full access to electricity.
- Although Africa's per capita energy consumption is the lowest in the world, it is one of the most energy intensive regions, obtaining little economic output from its modest energy use.
- By some estimates, an investment of about US$43-55 billion per year is needed until 2030-2040 to meet demand and provide universal access to electricity, whereas currently, investment in the energy sector is about US$8-9.2 billion.
- Africa's enormous renewable energy potential remains untapped. It is estimated that around 93 per cent of economically feasible hydropower potential remains unused.
- Key continental programs and initiatives, such as the Program for Infrastructure Development in Africa (PIDA), the New Deal on Energy for Africa and the Africa Renewable Energy Initiative (AREI) provide good opportunities for investments.

Introduction

This chapter focuses on plans and actions African countries, together and on their own, are undertaking to address energy issues within the context of their commitments to global agreements for sustainable development, especially in light of the Post-2015 development agenda.

The African Union's Agenda 2063

In May 2013, the Organization of African Union (OAU), now the African Union (AU), celebrated its Golden Jubilee. It reaffirmed its Pan-African vision of "an integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the international arena." Summit leaders asked the African Union Commission (AUC), supported by the New Partnership for Africa's Development (NEPAD) Planning and Coordinating Agency (NPCA), the African Development Bank (AfDB) and the United Nations Economic Commission for Africa (UNECA), to engage in a people-driven process to prepare a 50-year continental agenda (AU, 2016).

The process was a broad consultation of African stakeholders, including youth, women, civil society organizations, the diaspora, African think tanks and research institutions, government planners, the private sector, the African media, inter-faith leaders, the Forum for Former African Heads of State and Government and African islands states, among others. The Agenda 2063 process also captured input from continent-wide meetings with sectoral ministers and regional economic communities. The results form the basis for Aspirations of the African People, the Agenda's main driver. The Agenda encompasses the three dimensions of sustainable development (environment, economy and society) and has three key components: the vision, the transformation framework and the first 10-year

Opposite photo: Pixabay.com/CC0 Public Domain

Box 1: Seven Aspirations of the African People

1. A prosperous Africa based on inclusive growth and sustainable development;
2. An integrated continent, politically united based on the ideals of Pan Africanism and the vision of Africa's Renaissance;
3. An Africa of good governance, democracy, respect for human rights, justice and the rule of law;
4. A peaceful and secure Africa;
5. An Africa with a strong cultural identity, common heritage, values and ethics;
6. An Africa, whose development is people-driven, relying on the potential of African people, especially its women and youth, and caring for children; and
7. Africa as a strong, united, resilient and influential global player and partner.

Source: (AU, 2016)

Box 2: Agenda 2063 commitments to improving energy provision

Connect Africa through world-class Infrastructure, with a concerted push to finance and implement the major infrastructure projects in:

- **Transport:** connecting all African capitals and commercial centres through the Africa Integrated High Speed Train Initiative, the Programme for Infrastructure Development in Africa (PIDA) transport corridors; improved efficiency and connections of the African aviation sector and implement the Yamoussoukro Declaration, and strengthening the African port and shipping sector as regional and continental assets.
- **Energy**: harnessing all African energy resources to ensure modern, efficient, reliable, cost effective, renewable and environmentally friendly energy to all African households, businesses, industries and institutions, through building the national and regional energy pools and grids, and PIDA energy projects.
- **ICT:** a continent on equal footing with the rest of the world as an information society, an integrated e-economy where every government, business and citizen has access to reliable and affordable ICT services by increasing broadband penetration by 10 per cent by 2018, broadband connectivity by 20 percentage points and providing access to ICT to children in schools and venture capital to young ICT entrepreneurs and innovators.

Source: (AU, 2016)

implementation plan. Anchoring the framework are 7 aspirations (Box 1), 20 goals and 34 priority areas (AU, 2016).

Agenda 2063 commits Africa to speed up actions in a number of areas, including infrastructure projects related to providing energy for transport, households, businesses and institutions as well as for Information and Communication Technologies (ICT) (Box 2).

Africa-led initiatives to increase access to modern energy

The African Union's Agenda 2063 and its priority areas have inspired a number of initiatives to stimulate Africa's access to energy. One of them is the Africa Power Vision (APV), based on the Programme for Infrastructure Development in Africa (PIDA). PIDA is the continent's framework to close Africa's vast infrastructure gap across transport, energy and water sectors as well as ICTs. The African Heads of State unanimously endorsed PIDA at their Summit in 2012. The Africa Power Vision is a long-term plan to increase access to reliable and affordable energy. Its main aim is to drive and rapidly accelerate the implementation of critical energy projects in Africa under PIDA (NEPAD, n.d.).

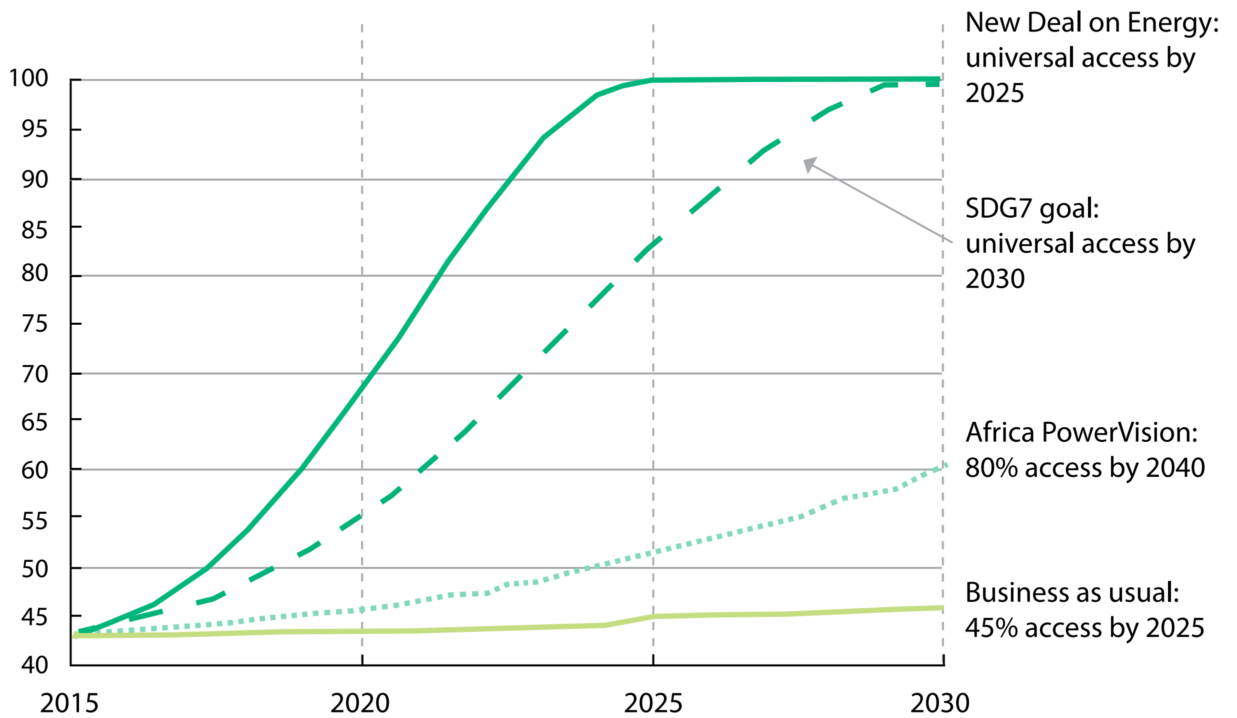
The Africa Renewable Energy Initiative (AREI) is another transformative, Africa-led effort to accelerate the exploitation of the continent's huge renewable energy potential. Under the AU's mandate and endorsed by African Heads of State, it aims to achieve at least 10 gigawatts (GW) of new renewable energy generation capacity by 2020 and to realize the continent's potential to generate at least 300 GW by 2030 (AfDB, 2015).

Spurred by the recognition that energy shortages, high costs and poor access remain major impediments to Africa's continued social and economic progress, in 2016, the African Development Bank approved its energy strategy, mainly based on the Bank's new initiative — the New Deal on Energy for Africa (NDEA). The NDEA has an aspirational overarching goal of achieving universal access by 2025: 100 per cent access in urban areas and 95 per cent access in rural areas and leveraging on and off-grid solutions and related technological advances.

The New Deal directly contributes to achieving the SDGs, in particular, SDG7 on ensuring access to affordable, reliable, sustainable and modern energy for all (Figure 1).

Figure 2 illustrates the huge changes that are needed to transition from the current energy situation to universal access by 2025 as aspired by the New Deal for Africa.

Figure 1: The New Deal's aspirations compared to SDG 7 and the Africa Power Vision



Source: (AfDB, 2016)

Figure 2: The New Deal for Africa's requirements for universal access by 2025

	From current energy situation in Africa		To universal access in 2025	
Population, *M*	1,174	x1.3	1,499	
GDP, *$ bn*	2,175	x1.7	3,742	
Electrification rate, *%*	43	x2.3	97	
Households connected, *M*	87	x3.63	292	
Grid	83	x2.6	213	+130 M new on-grid connections
Off-grid	4	x20	79	+75 M new off-grid connections
Grid capacity, *GW*	170	x1.9	332	+160 GW of new capacity
Consumption, *kWh/capita*	613	x1.5	941	
Households using clean cooking, *M*	70	x3.1	220	+150 M with clean cooking solutions

* Assuming 100% urban electrification and 95% rural electrification

* Out of 234m households in 2015 and 300m households in 2025

Source: (AfDB, 2016)

United Nations Sustainable Development Goals (SDGs)

One of the main outcomes of the 2012 Rio+20 United Nations Conference on Sustainable Development was a new set of Sustainable Development Goals (SDGs), agreed upon in September 2015. They build on the Millennium Development Goals and frame the post-2015 development agenda. At the General Assembly on 25 September 2015, Member States adopted Transforming Our World: the 2030 Agenda for Sustainable Development. This Agenda is a plan of action for people, the planet and prosperity (UN-DESA, n.d.).

Abu Shawka / Wikimedia Commons

Solar heating in Capetown

Shop for solar panels in Ouagadogou

The goals and targets will stimulate action over the next fifteen years in areas of critical importance for humanity and the planet. On 11 March 2016, the 47th Session of the United Nations Statistical Commission proposed a global indicator framework for the SDGs, intended as a means to follow up and review progress at the global level towards achieving the 17 goals (UNSTATS, 2016).

There are 17 Sustainable Development Goals (SDG) (Figure 3) and 169 accompanying targets. The goals are an integrated, indivisible set of global priorities, integrating the economic, social and environmental aspects of sustainable development and recognizing their interlinkages. They are action oriented, global in nature and universally applicable, while accounting for different national realities, capacities and development levels and respecting national policies and priorities.

The 17 Goals

The global targets are aspirational, while each government sets its own national targets. Box 3 presents the 17 goals, emphasizing goals 7 and 13, which refer explicitly to the energy-related matters that are the subject of this chapter.

Figure 3: The 17 SDGs

Source: (UN-DESA, n.d.)

Box 3: The text of the 17 SDGs

Goal 1: End poverty in all its forms everywhere;

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture;

Goal 3: Ensure healthy lives and promote well-being for all at all ages;

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all;

Goal 5: Achieve gender equality and empower all women and girls;

Goal 6: Ensure availability and sustainable management of water and sanitation for all;

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all;

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all;

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation;

Goal 10: Reduce inequality within and among countries;

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable;

Goal 12: Ensure sustainable consumption and production patterns;

Goal 13: Take urgent action to combat climate change and its impacts;

Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development;

Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss;

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels; and

Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Linkages between Agenda 2063 and the Sustainable Development Goals

Table 1 highlights the synergies between Agenda 2063 and the SDGs, which are mutually supportive. Goal 7 of Agenda 2063 affirms the need for environmentally sustainable and climate resilient economies and communities, which implies access to modern energy, as expressed in SDG 7.

Table 1: Linkages with the SDGs

Agenda 2063			UN Sustainable Development Goals	
	Goals	Priority Areas		
1.	A high standard of living, quality of life and well-being for all citizens.	• Incomes, jobs and decent work • Poverty, inequality and hunger • Social security and protection, including persons with disabilities • Modern, affordable and liveable habitats and quality basic services	1. 2. 8. 11.	End poverty in all its forms everywhere in the world End hunger, achieve food security and improved nutrition and promote sustainable agriculture. Promote sustained, inclusive and sustainable Economic growth, full and productive employment and decent work for all. Make cities and human settlements inclusive, safe, resilient and sustainable.
2.	Well educated citizens and skills revolution underpinned by science, technology and innovation.	• Education and science, technology and innovation (STI) driven skills revolution	4.	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
3.	Healthy and well-nourished citizens.	• Health and nutrition	3.	Ensure healthy lives and promote well-being for all at all ages.
4.	Transformed economies.	• Sustainable and inclusive economic growth • STI driven manufacturing,	8.	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
		industrialization and value addition • Economic diversification and resilience	9.	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
5.	Modern agriculture for increased productivity and production.	• Agricultural productivity and production	2.	End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
6.	Blue/ocean economy for accelerated economic growth.	• Marine resources and energy • Port operations and marine transport	14.	Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
7.	Environmentally sustainable and climate resilient economies and communities.	• Bio-diversity, conservation and Sustainable natural resource management. • Water security • Climate resilience and natural disasters preparedness	6. 7. 13. 15.	Ensure availability and sustainable management of water and sanitation for all. Ensure access to affordable, reliable, sustainable and modern energy for all. Take urgent action to combat climate change and its impacts. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
8.	A United Africa (Federal or Confederate).	• Frameworks and institutions for a United Africa		

Agenda 2063				UN Sustainable Development Goals	
	Goals	Priority Areas			
9.	Continental financial and monetary institutions established and functional.	• Financial and monetary institutions			
10.	World class infrastructure criss - crosses Africa.	• Communications and infrastructure connectivity.	9.	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	
11.	Democratic values, practices, universal principles of human rights, justice and the rule of law entrenched.	• Democracy and good governance • Human rights, justice and the rule of law	16.	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.	
12.	Capable institutions and transformative leadership in place.	• Institutions and leadership • Participatory development and local governance.	16.	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.	
13.	Peace, security and stability is preserved.	• Maintenance and preservation of peace and security	16.	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.	
14.	A stable and peaceful Africa.	• Institutional structure for AU instruments on peace and security • Defence, security and peace			
15.	A fully functional and operational APSA	• Fully operational and functional APSA all pillars			
16.	African cultural renaissance is pre-eminent.	• Values and ideals of Pan Africanism • Cultural values and African Renaissance • Cultural heritage, creative arts and businesses			
17.	Full gender equality in all spheres of life.	• Women and girls empowerment • Violence and discrimination against women and girls	5.	Achieve gender equality and empower all women and girls.	
18.	Engaged and empowered youth and children.	• Youth empowerment and children's rights	4. 5.	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Achieve gender equality and empower all women and girls.	
19.	Africa as a major partner in global affairs and peaceful co-existence.	• Africa's place in global affairs • Partnerships	17.	Strengthen the means of implementation and revitalize the global partnership for sustainable development.	
20.	Africa takes full responsibility for financing her development Goals.	• African capital markets • Fiscal systems and public sector revenue • Development assistance	10. 17.	Reduce inequality within and among countries. Strengthen the means of implementation and revitalize the global partnership for sustainable development.	

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Targets of Goal 7

In the context of this Atlas, Goal 7 and its targets are especially relevant. There are three applicable targets as shown in Box 4..

Due to the integrated nature of Targets 7a and 7b and lack of credible data, it is beyond the scope of this chapter to discuss these targets.

Tracking progress towards Goal 7

To track and monitor the implementation of Goal 7, four main indicators have been proposed. These indicators are meant to capture data covering various aspects of energy, including access, reliability, sustainability and cleanness of forms and sources of energy. A summary of the indicators is presented in Table 2 and the data measuring the level of Africa's achievement of these goals are presented in a series of maps (Figures 4 to 9).

Box 4: Goal 7 targets

Target 7.1:	By 2030, ensure universal access to affordable, reliable and modern energy services;
Target 7.2:	By 2030, increase substantially the share of renewable energy in the global energy mix;
Target 7.3:	By 2030, double the global rate of improvement in energy efficiency;
Target 7.a:	By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology;
Target 7.b:	By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, and small island developing States.

Source: (UN-DESA, n.d.)

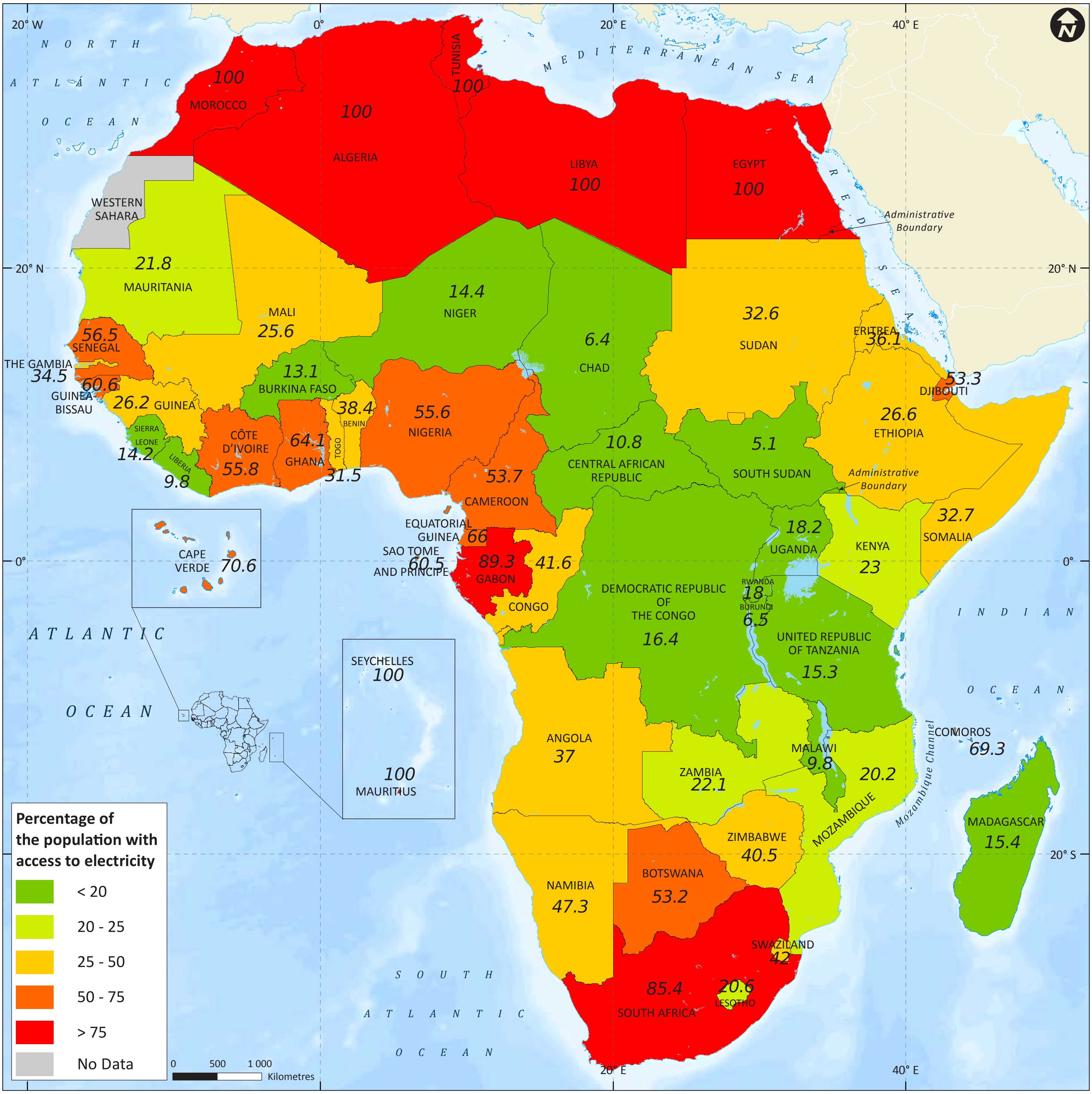
Katse dam, Lesotho

Table 2: Goal seven's targets and indicators summar

SDG Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all	
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	**7.1.1 Percentage of population with access to electricity** It reports the proportion of the population in a country that has access to electricity either through a grid connection or through connection to an off-grid generating device, such as a solar panel, small-scale wind turbine, hydro facility or generator based on national households surveys. Connection to an electricity supply is an indicator of access to a modern energy service. Inclusion and disaggregation of off-grid electricity access also gives insights into affordability and reliability as well as the extent to which access is being provided to all within a country (rather than just people connected to the grid, who are predominantly in urban areas in many places). **7.1.2 Percentage of population with primary reliance on clean fuels and technology** The indicator is calculated as the number of people using clean fuels and technologies for cooking, heating and lighting divided by total population reporting any cooking, heating or lighting, expressed as percentage. "Clean" is defined by the emission rate targets and specific fuel recommendations (i.e. against unprocessed coal and kerosene) included in the normative guidance **WHO guidelines for indoor air quality: household fuel combustion**. The indicator uses the type of primary fuels and technologies used for cooking, heating, and lighting as a practical surrogate for estimating human exposure to household (indoor) air pollution and its related disease burden, as it is not currently possible to obtain nationally representative samples of indoor concentrations of criteria pollutants, such as fine particulate matter and carbon monoxide. **Note**: Until March 2016, this indicator used to be named "percentage of population with primary reliance on non-solid cooking fuels". The indicator's name has been changed not only to account for data related to non-solid cooking fuels that are considered clean but also to capture data on the type of device or technology that households are using for cooking as well as lighting and heating. As such, this indicator captures reliance on a larger spectrum of data pertaining to modern, non-polluting sources and forms of energy needed and used in homes. However, the only data collected so far for this indicator is the "percentage of population with primary reliance on non-solid cooking fuels"
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	**7.2.1 Renewable energy share in the total final energy consumption** The renewable energy share in total final consumption is the percentage of final consumption of energy that is derived from renewable resources. It is calculated by dividing consumption of energy from all renewable sources by total final energy consumption. Renewable energy consumption includes consumption of energy derived from: hydro, solid biofuels, wind, solar, liquid biofuels, biogas, geothermal, marine and waste. Total final energy consumption is calculated from national balances and statistics as total final consumption minus non-energy use. Data on renewable energy consumption are available through national Energy Balances produced by the International Energy Agency and the United Nations Statistics Division (UNSD) for more than 180 countries. The energy balances make it possible to trace all the different sources and uses of energy at the national level.
7.3 By 2030, double the global rate of improvement in energy efficiency	**7.3.1 Energy intensity (%) measured in terms of primary energy and GDP** Primary energy intensity is obtained by dividing total primary energy supply over gross domestic product. Total primary energy supply, as defined by the International Energy Agency (IEA), is made up of production plus net imports minus international marine and aviation bunkers plus-stock changes. For international comparison purposes, GDP is measured in constant terms at purchasing power parity. Energy intensity is an indication of how much energy is used to produce one unit of economic output. It is a proxy of the efficiency with which an economy is able to use energy to produce economic output. A lower ratio indicates that less energy is used to produce one unit of output. Primary energy supply is typically calculated in the making of national energy balances. Energy balances are available for larger economies from the International Energy Agency and for all countries in the world from UN Statistics, although typically with an additional year of lag.

Source: adapted from (UN-DESA, 2016)

Figure 4: Access to electricity (percentage of population), 2012



Source: Map created using data from (World Bank, 2016c)

Indicator 7.1.1: Percentage of population with access to electricity

The percentage of the population with access to electricity is measured by the availability of a connection to a source of electricity or the use of electricity as the primary source of lighting. Electrification data are collected from industry, national surveys and international sources (World Bank, 2016a). The percentage of the population with access to electricity in Africa is presented in Figure 4. Figures 5 and 6 show the percentage by rural and urban areas, respectively.

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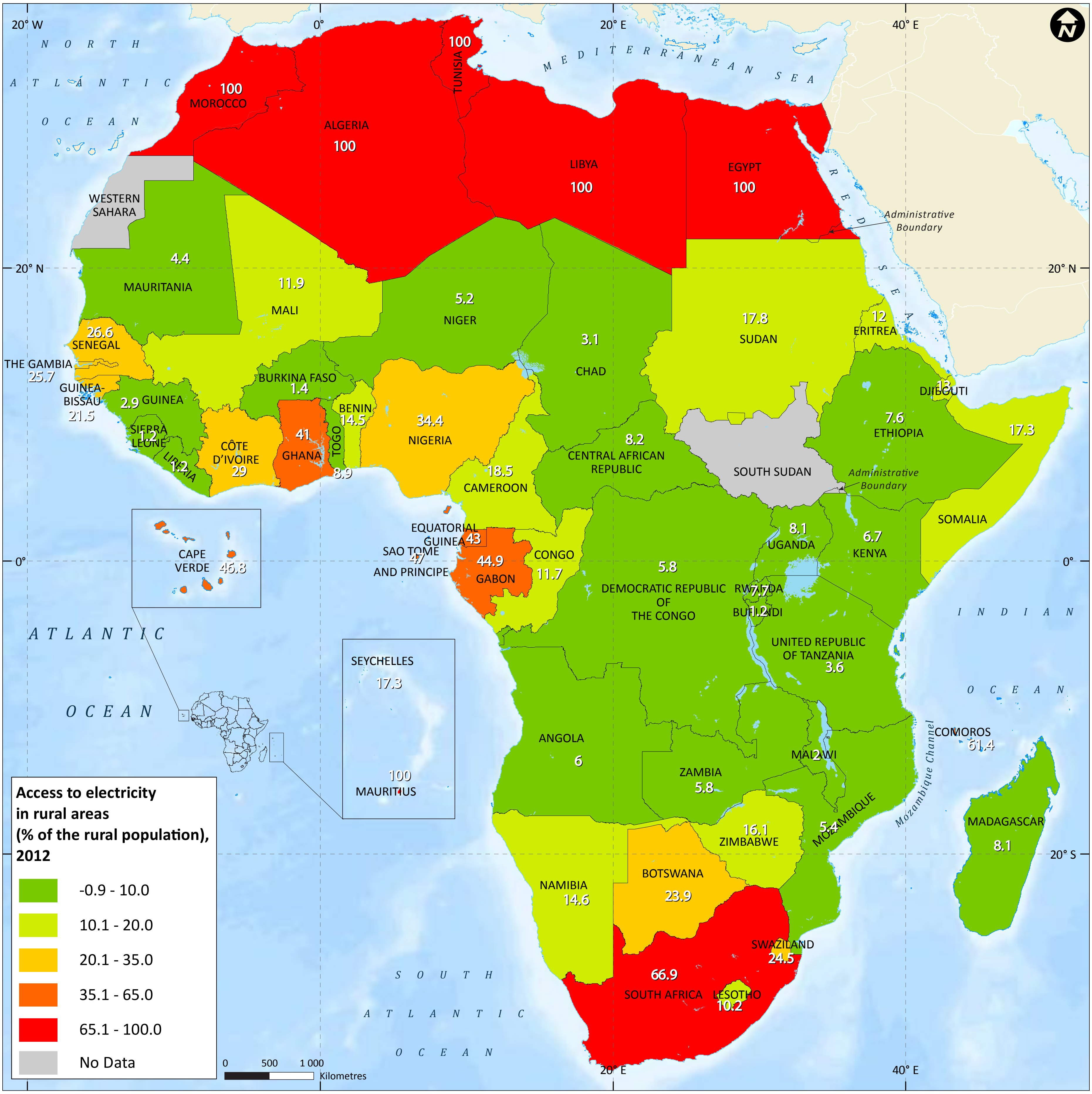
Dam in South Africa

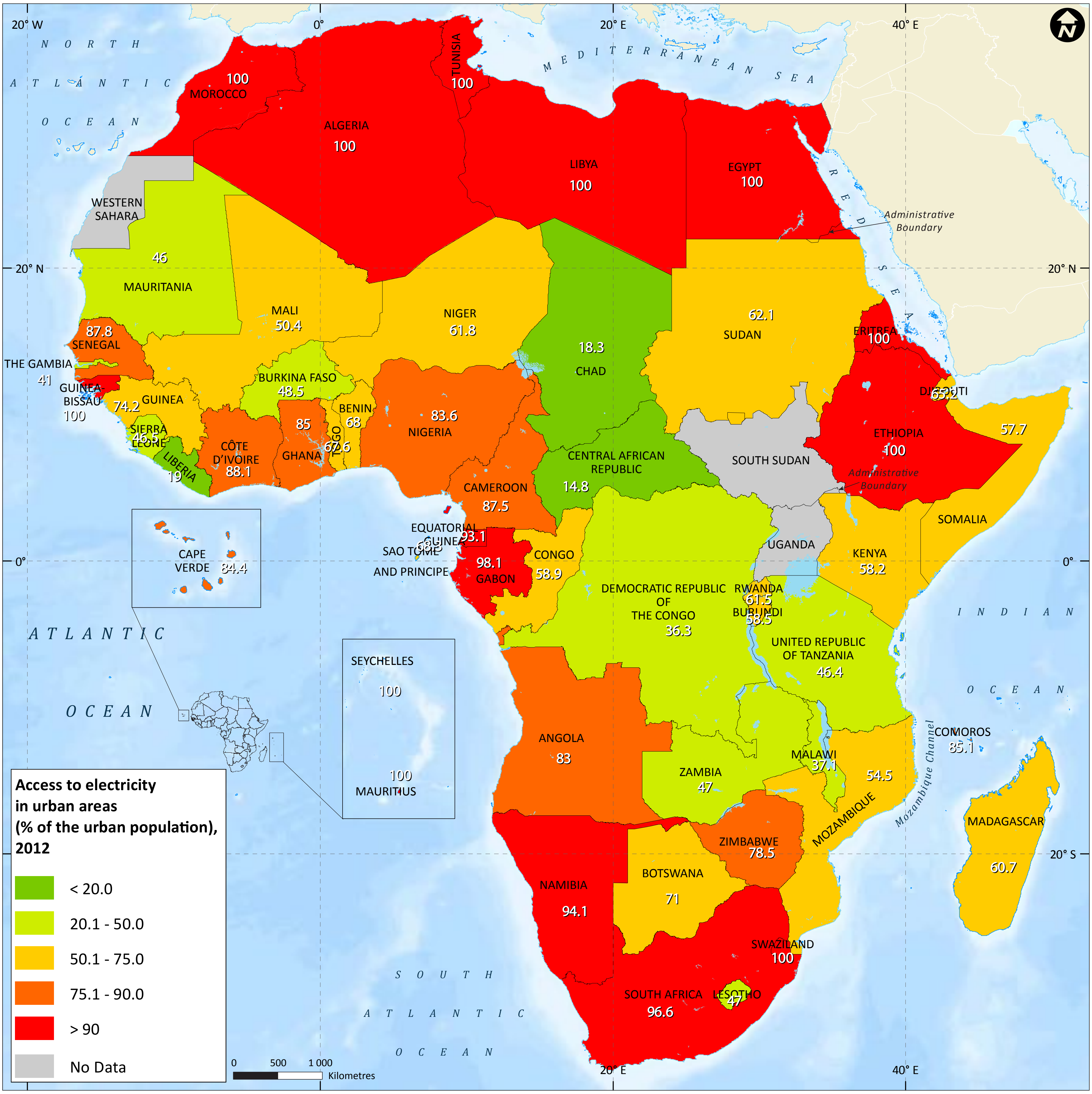
Figure 5: Access to electricity in rural areas (percentage of the rural population), 2012



Source: Map created using data from (World Bank, 2016c)

Globally, the electrification rate increased from 76 per cent in 1990, to 83 per cent in 2010 and 85 per cent by 2012. Between 2010 and 2013, the rate of access to electricity increased from 30 to 35 per cent in sub-Saharan Africa, marking a notable improvement and earning it the rank of third among world regions (World Bank/IEA, 2015). In 2012, the lack of access in Africa was concentrated in sub-Saharan rural areas, with the largest numbers of people without access to electricity living in Nigeria and Ethiopia, at 75 and 67 million, respectively. Of the world's 20 countries with the least access to electricity, thirteen are in Africa, including Nigeria, Ethiopia, Democratic Republic of the Congo (DRC), Tanzania, Kenya, Uganda, (the former) Sudan, Mozambique, Madagascar, Niger, Malawi, Burkina Faso, and Angola (World Bank/IEA, 2015).

Figure 6: Access to electricity in urban areas (percentage of the urban population), 2012



Source: Map created using data from (World Bank, 2016c)

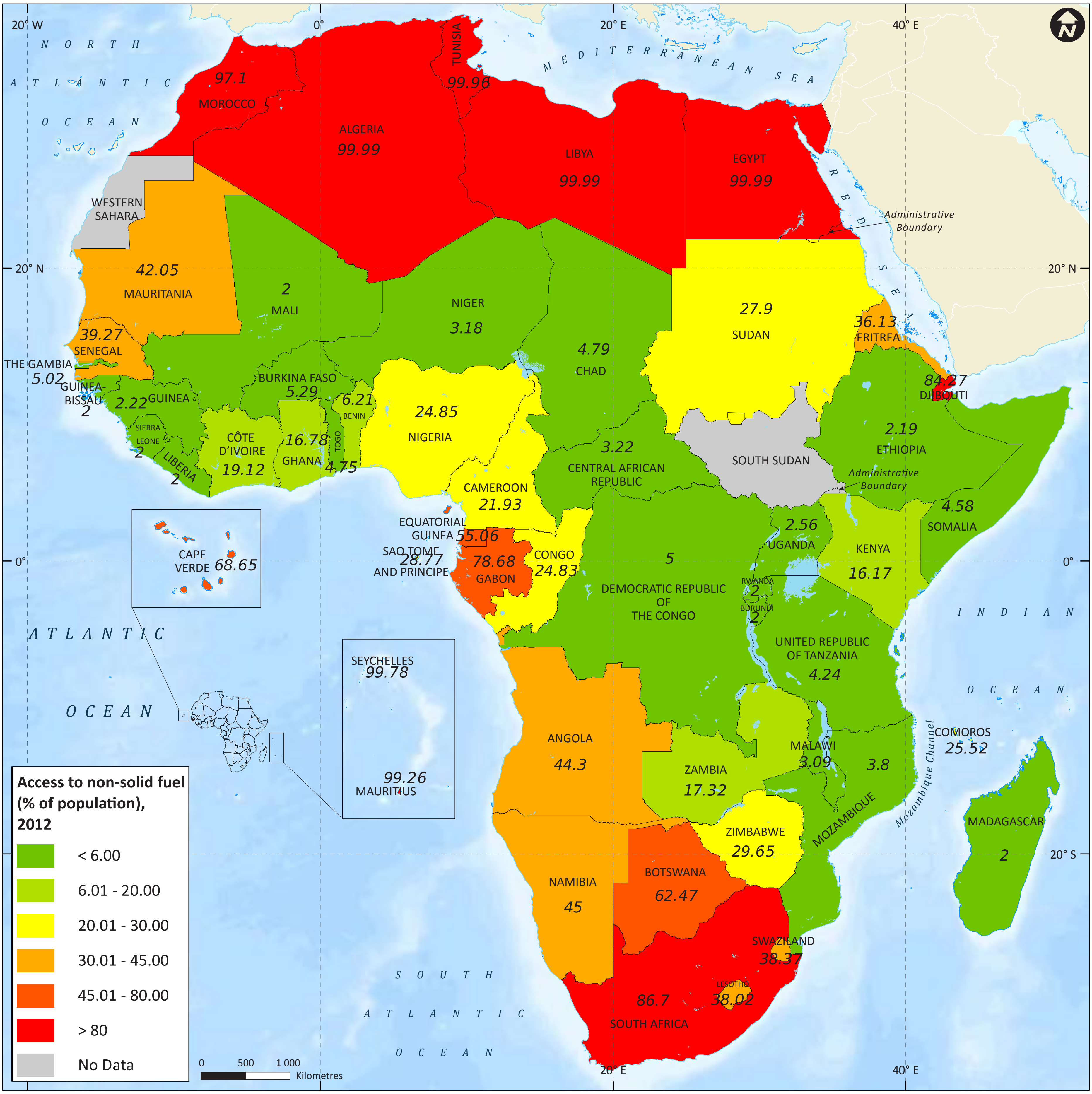
Indicator 7.1.2: Percentage of population with primary reliance on clean fuels and technology

The following 12 products are used to assess clean technology penetration and use:

1. solar photovoltaic (PV) cells;
2. light emitting diodes (LEDs);
3. small hydro turbines (capacities below 1 megawatt [MW] and 1–10 MW);
4. wind turbines;
5. biodiesel fuels;
6. insulation materials;
7. fluorescent lamps;
8. heat pumps;
9. reversible heat pumps for air conditioning;
10. electric vehicles;
11. portable electric lamps; and
12. parts of portable electric lamps.

Africa derives nine per cent of its energy and 21 per cent of its electricity from these modern renewables, putting it ahead of Asia in this category.

Figure 7: Access to non-solid fuel (percentage of population), 2012

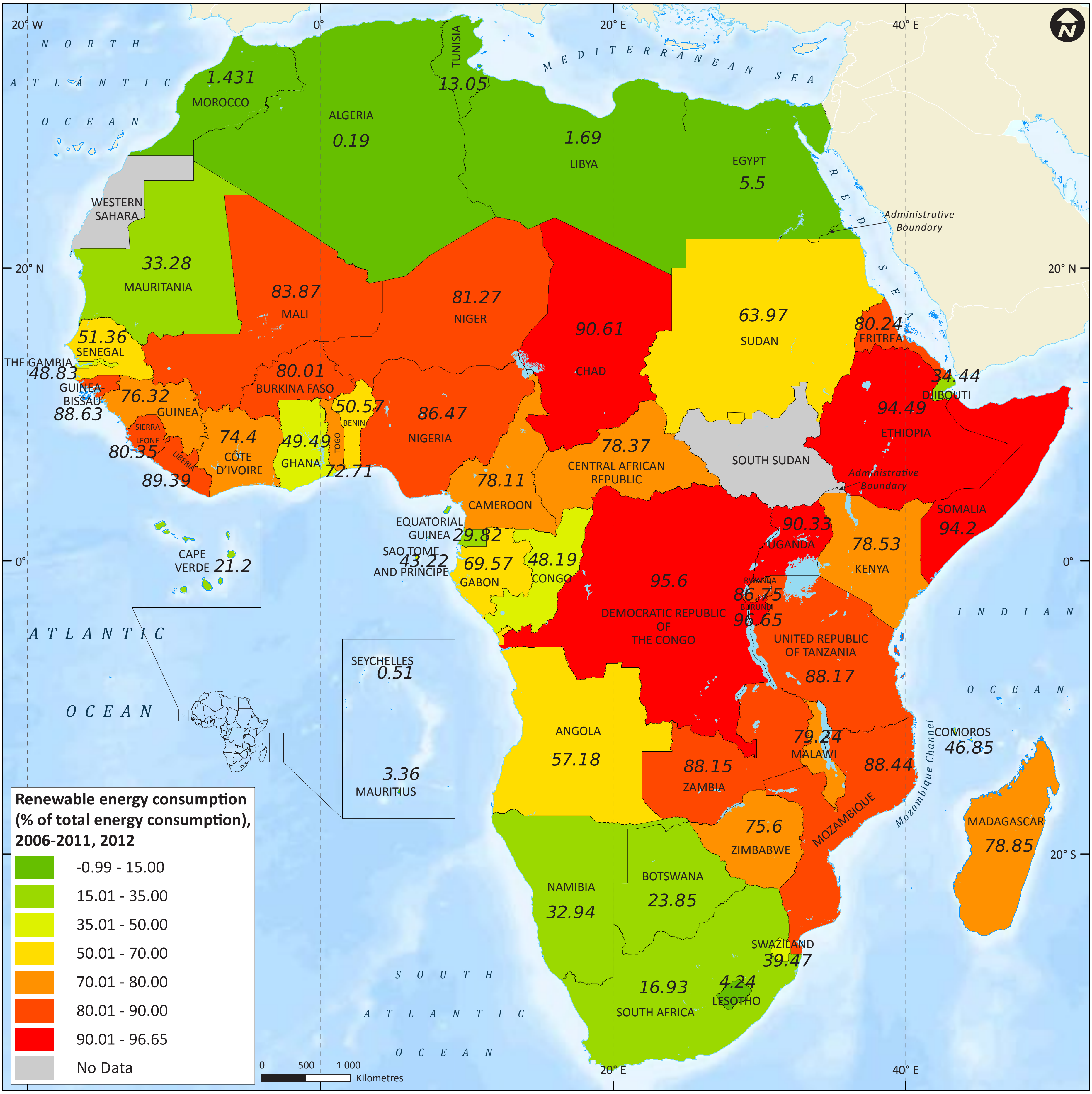


Source: Map created using data from (World Bank, 2016c)

Access to these clean technologies varies, however. For example, over the period 2010-2012, access to portable electric lamps powered by energy from hydro turbines (<1 MW) was very low. Access to non-solid cooking fuel was even lower, especially in rural areas, where it is practically non-existent. On the other hand, North Africa has a higher access rate than any other developing region and South Africa leads in making progress between 2010 and 2012, with 2.4 million people gaining access, followed by Nigeria and Angola. Figure 7 presents the percentage of the population with access to non-solid fuel.

At the continental level, population growth still outpaces the increase in access to non-solid fuels, however; between 2010 and 2012, the population increased by 48 million but only 9 million gained access. For Africa to achieve universal access to non-solid fuels, countries with the least access, such as Nigeria, Ethiopia, the DRC, Tanzania, Kenya, Uganda, North and South Sudan, Mozambique and Madagascar, need to maintain an access growth rate higher than population growth and stay above the global growth rate, which was -0.1 over the period 2010-2012 (World Bank/IEA, 2015).

Figure 8: Renewable energy consumption (percentage of total final energy consumption)



Source: Map created using data from (World Bank, 2016c)

Indicators for Target 7.2

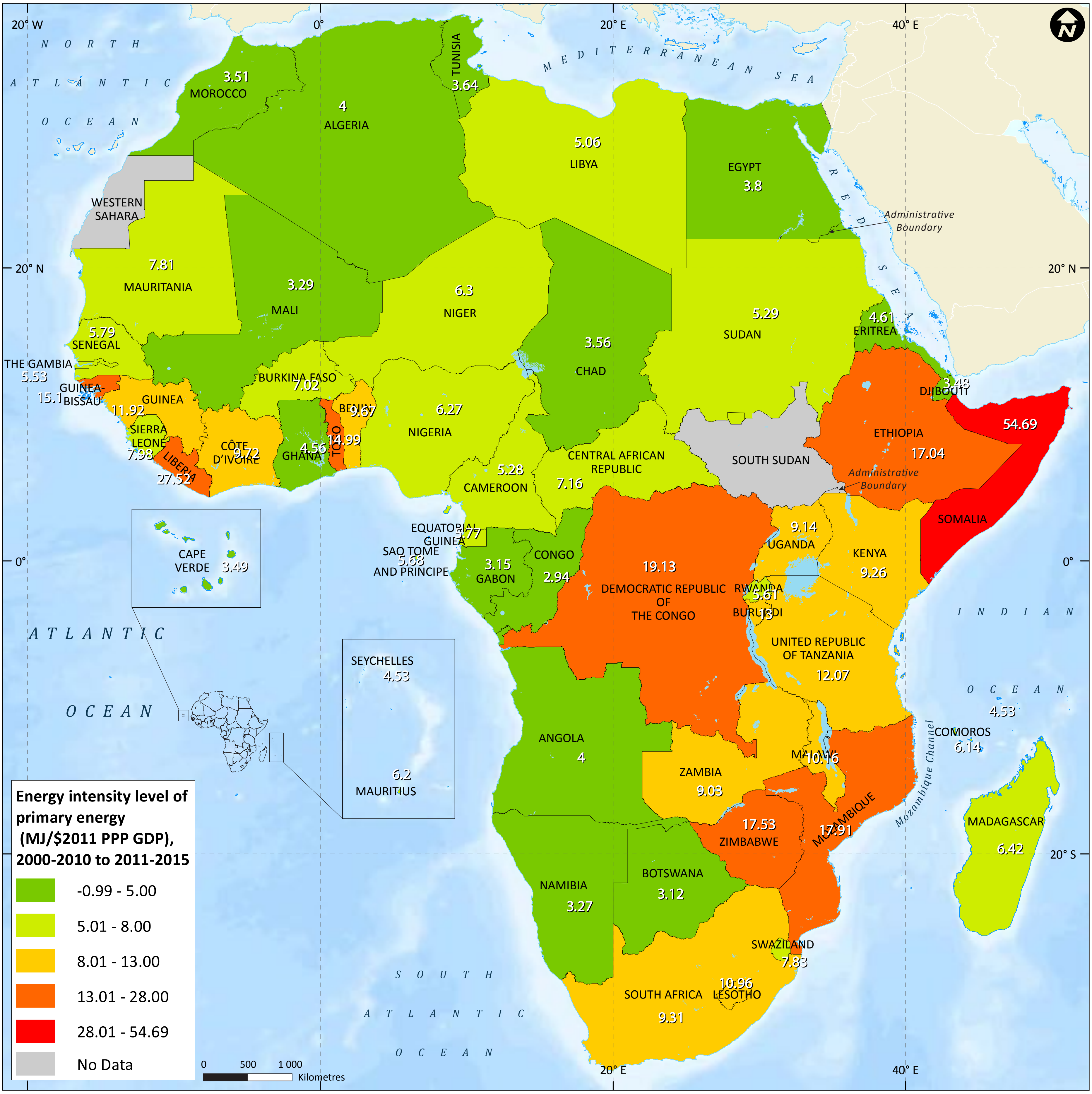
Indicator 7.2.1: Renewable energy share in the total final energy consumption

This indicator to measure progress toward Target 7.2 (by 2030, increase substantially the share of renewable energy in the global energy mix) calculates the share of renewable energy in total final energy consumption. Figure 8 shows the percentage of total energy use that is supplied by alternative energy sources (non-fossil fuels), including nuclear.

Renewable energy consumption is growing in Africa and now outpaces the growth of total final energy consumption. Africa uses more renewable energy than any other of the world's regions, deriving as much as 70 per cent of its energy consumption from renewable sources. One of the reasons, however, is its heavy reliance on traditional uses of biomass by both households and industry (World Bank/IEA, 2015).

On the other hand, power-generation plants that use different forms of renewable energy are growing in some countries, such as Ethiopia, Ghana, Kenya and South Africa. In addition, solar energy is expanding. For example, between 2009 and 2012, the proportion of households in sub-Saharan Africa that use some form of solar lighting grew from 1 to 5 per cent (APP, 2015) and total modern renewable energy consumption increased by 7 per cent . The largest use of renewable technologies in Africa remains hydropower for electricity generation (World Bank/IEA, 2015).

Figure 9: Energy intensity level of primary energy (MJ/$ 2011 per PPP GDP)



Source: Map created using data from (World Bank, 2016c)

Indicators for Target 7.3

Indicator 7.3.1: The energy intensity measured in terms of primary energy and gross domestic product (GDP)

This indicator measures progress towards Target 7.3 (by 2030, double the global rate of improvement in energy efficiency). Energy intensity level of primary energy is the ratio between energy supply and Gross Domestic Product (GDP) measured at Purchasing Power Parity (PPP). Energy intensity is an indication of how much energy is used to produce one unit of economic output, with lower ratios indicating the use of less energy (World Bank, 2016b). Figure 9 shows the level of primary energy intensity by country.

Compared to other regions, Africa contributes little to the global decline in energy intensity over the period 2010-2012. From 1990-2000, the compound annual growth rate in improving primary energy intensity was -0.8 per cent and 0.5 per cent for northern and sub-Saharan Africa, respectively (World Bank/IEA, 2015), although between 2010-2012, the rate rose to 2.15 per cent in North Africa (IEA/World Bank, 2015).

Box 5: In summary

- Africa's rate of electricity access rose from 32 per cent in 2010 to 35 per cent in 2012; although 25 million people a year gained access, electrification is barely keeping pace with population growth;
- More than 70 per cent of Africa's total energy consumption comes from renewable sources, but almost all comes from traditional uses of biomass; there are still huge opportunities to include other sources;
- Although Africa's per capita energy consumption is the lowest in the world, it is one of the most energy intensive regions, obtaining little economic output from its modest energy use.

Source: (UN-DESA, n.d.)

Although Africa's per capita energy consumption levels are very low, it is one of the world's most energy intensive regions because traditional biomass uses are so inefficient. For example, Africa needs twice as much energy as Europe to produce the equivalent of one dollar of GDP. Among the world's top-20 primary energy consumers in 2012, South Africa and Nigeria are the only African countries with respective energy intensities (mega joules per 2011 PPP $) of almost 10 and 6 (World Bank/IEA, 2015).

Goal 13: Take urgent action to combat climate change and its impacts

Targets of Goal 13

Box 6 presents the targets related to Goal 13.

Box 6: Goal 13 targets

Target 13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries;

Target 13.2: Integrate climate change measures into national policies, strategies and planning;

Target 13.3: Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning;

Target 13.a: Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible; and

Target 13.b: Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries, including focusing on women, youth and local and marginalized communities (World Bank/IEA, 2015).

The Paris Agreement on Climate Change

In Paris, on 12 December 2015, 195 nations made an historic agreement to combat climate change and act on and invest in a low carbon, resilient and sustainable future. For the first time, the Paris Agreement bound all nations in a common cause based on their historic, current and future responsibilities. Its main aim is to ensure the global temperature rise this century is kept well below 2 degrees Celsius and to motivate efforts to further constrain the rise to 1.5 degrees Celsius above pre-industrial levels, a limit that provides significantly better protection from the worst impacts of a changing climate. As well, the agreement strengthens the ability to adapt to climate change (UNFCCC, 2015a).

The Paris Agreement and the outcomes of the UN Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP21) cover the following crucial areas:

- Mitigation — reducing emissions fast enough to achieve the temperature goal;
- A transparency system — a global stock-taking to account for climate action;
- Adaptation — strengthening the ability of countries to deal with climate impacts;
- Loss and damage — strengthening the ability to recover from climate impacts; and
- Support — including finance, for nations to build clean, resilient futures (UNFCCC, 2015a).

In addition to setting the long-term direction, the Agreement requires countries to reach their highest emission levels as soon as possible and to continue submitting national climate action plans specifying their future goals to address climate change. Countries are expected to submit their updated climate plans, called Nationally Determined Contributions (NDCs), every five years, marking a steady increase their long-term ambitions (UNFCCC, 2015a).

Countries should also engage in climate actions in the period before 2020 by taking opportunities to mitigate their emissions as well as focusing on adaptation measures. In addition, they will work to define a clear roadmap on increasing climate finance to US$100 billion by 2020 (UNFCCC, 2015a).

Intended Nationally Determined Contributions (INDCs)

The NDCs represent a major step on the path toward a low-carbon, climate-resilient future. The COP invited all Parties to communicate to the secretariat their Intended NDCs (INDCs) well in advance of COP 21. To ensure clarity, transparency and understanding, Parties communicating their INDCs were instructed to include, as appropriate, the following information:

- quantifiable information on the reference point (including, as appropriate, a base year);
- time frames and/or periods for implementation;
- scope and coverage;
- planning processes;
- assumptions and methodological approaches, including those for estimating and accounting for anthropogenic greenhouse gas emissions and, as appropriate, removals; and
- to show how the Party considers that its NDCs are fair and ambitious, in light of its national circumstances and how it contributes towards achieving the objective of the Convention as set out in its Article 2 (UNFCCC, 2015b).

As of 29 June 2016, 162 INDCs had been received, covering 189 Parties to the Convention. Given that some sectors and gases are not covered by the communicated INDCs, 98.8 per cent of the global emissions are covered by the communicated INDCs (UNFCCC, 2016)

Under the umbrella of mitigating and adapting to climate change, most African countries have developed several intended actions and plans in the energy sector, as illustrated in their INDCs.

Financing gap to achieve these energy goals

Large capital investments will be needed to achieve the goals highlighted in this chapter. Currently, investments are highly inadequate. In 2015, the Africa Progress Panel (APP) reported that energy-sector investment levels are just US$8 billion a year, or 0.49 per cent of gross domestic product (GDP) (APP, 2015). Similarly, the Infrastructure Consortium for Africa, made up of bilateral donors, including all G8 countries, multilateral agencies and African institutions, reported that US$9.2 billion was committed to Africa's energy sector in 2014, of which the private sector financed US$2.5 billion (ICA, 2014).

Various agencies have estimated the financial input that will actually be needed. For example, the APP estimates that US$55 billion a year, or 3.4 per cent of Africa's GDP in 2013, is required until 2030 to achieve universal access to electricity and meet projected demand (APP, 2015). Similarly, the Programme for Infrastructure Development in Africa (PIDA) reports that the energy sector will need US$43.6 billion per year until 2040, of which 42.3 would be devoted to the power sector. It notes the crucial need to increase private sector financing and sector cash flow, which will need to rise by some 7-10 fold from current levels. The largest proportion is needed for power generation ($33.1 billion). To allow the electricity trade to develop, it suggests the need for the significant investment of $3.7 billion in transmission, particularly between 2011 and 2020, a critical period because of the sector's financing gap of 50 per cent of the needs. Access will require an annual investment of $2.5 billion and gas and petroleum product pipelines will need about $1.3 billion a year (PIDA, 2014).

Conclusion

In summary, African countries are committed to various energy-related goals and actions to achieve the post-2015 Agenda at global, continental and national levels. These include the African Union's Agenda 2063, which commits to harnessing Africa's energy resources to ensure modern, efficient, reliable, cost effective, renewable and environmentally friendly energy supplies for all people of Africa; the African Development Bank's very ambitious goal to achieve universal access by 2025; and the Sustainable Development Goals, which Agenda 2063 echoes. In the context of this Atlas, Goals 7 and 13 are particularly relevant; goal 7 commits Parties to ensuring access to affordable, reliable, sustainable and modern energy for all while goal 13 urges countries to combat climate change and its impacts. Finally, the African countries have submitted their Intended Nationally Determined Contributions (NDCs) to the UNFCCC process enshrined in the Paris Agreement on Climate Change, listing country-specific energy-related actions and plans; they must update their NDCs every five years and continually escalate their long-term ambitions to increase access to energy for all while simultaneously diminishing greenhouse gas emissions and fostering adaptation to climate change impacts.

However, at only US$8 or 9 billion a year, energy-sector investment in sub-Saharan Africa is inadequate to attain these goals. A ten-fold increase in power generation is needed to achieve the United Nations sustainable development goal of universal access to energy by 2030; if current trends continue, the goal won't be reached until 2080. A massive effort and huge financial investments are needed if there is any hope of achieving that goal or AfDB's goal for universal access by 2025, five years earlier than the SDG's. Already, Africa's energy financing gap — the extra investment it needs to bring modern energy to all — is US$43-55 billion a year until 2030-2040 (APP, 2015).

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Transporting firewood on Lake Tana

Chapter

5

ENERGY PROFILES OF EACH COUNTRY

Introduction

The energy profiles in this chapter provide detailed information about the energy sector in each of Africa's 54 countries. The data are displayed graphically to provide readers with accessible snapshots of the energy situation. For example, a map of the country shows the location and distribution of power plants and transmission networks. Similarly, pie charts neatly capture information about the current relative energy produced by various sources, such as coal, crude oil, gas, etc. as well as the amounts of those energy resources consumed within the country. As well, trends in production and consumption over time are shown along with amounts used by various economic sectors and import and export figures. An important section of the profile lists each energy source — hydropower, oil, natural gas, coal, wind, geothermal, nuclear, solar, etc. — showing availability, the current state of development and the potential for further exploitation.

Another section of the profile highlights the progress achieved in providing energy to the country's urban and rural populations, especially access to electricity and non-solid fuels, within the context of international goals for Sustainable Energy For All (SE4All).

Carbon dioxide emissions from the energy sector are recognized as a key factor contributing to climate change. Thus, the chapter mentions pledges the countries have made through their Intended Nationally Determined Contributions (INDCs) arising from the 2015 Paris Climate Agreement.

Next, the profiles track progress towards achieving Sustainable Development Goal number 7 — "ensure access to affordable, reliable, sustainable and modern energy for all". Progress is measured against the following three indicators:

- To ensure universal access to affordable, reliable and modern energy services by 2030
- To increase substantially the share of renewable energy in the global energy mix by 2030
- To double the rate of improvement of energy efficiency by 2030.

Finally, a matrix of the country's institutional and legal frameworks names some of the institutions responsible for policy, the energy regulator and the key documents that lay the foundation for managing the energy sector. Efforts were made to provide the most recent information, but since the policy landscape is changing rapidly, some of the information is subject to change.

Note: In the *Figure 4: SDG 7 Indicators* of the country profiles, the symbol and number size varies proportionally (not to any scale) to data for the indicators. Also, in some cases, there are different numbers for indicators due to discrepancy in estimates from different sources.

Wind turbine farm, Tunisia.

Algeria

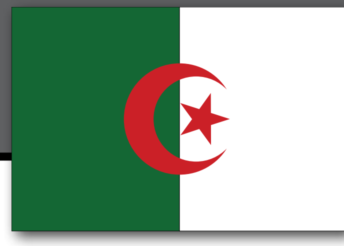


Figure 1: Energy profile of Algeria

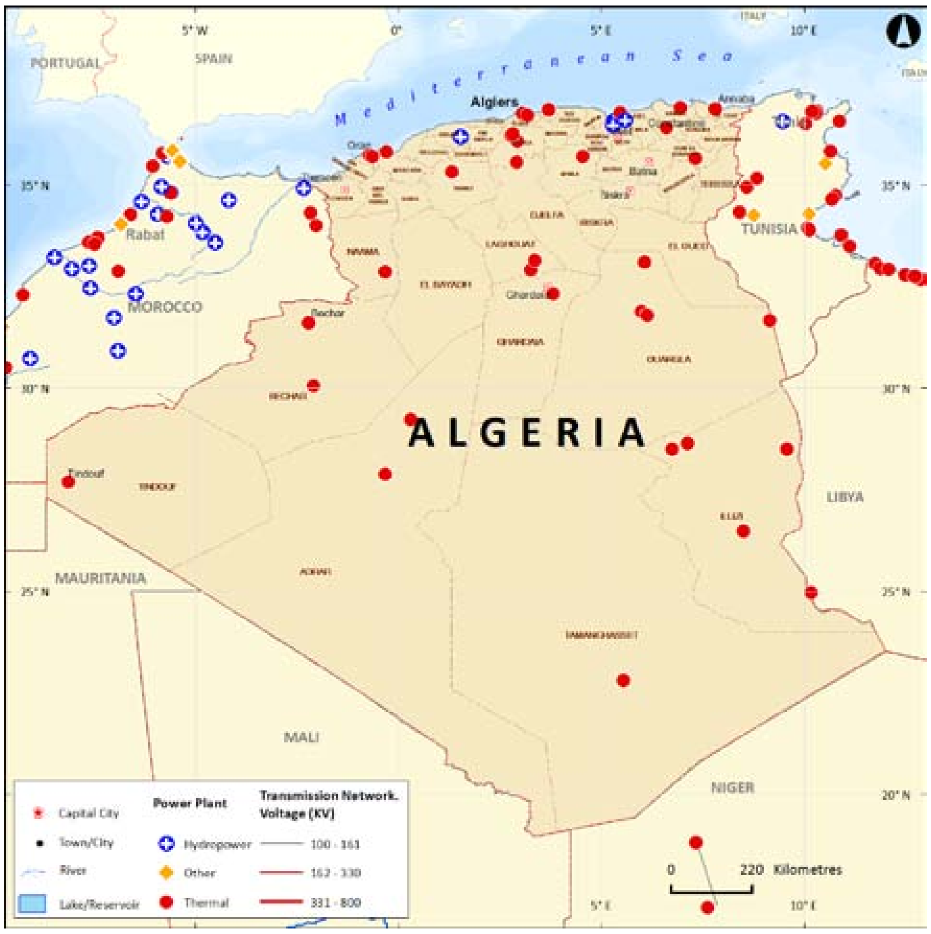


Figure 2: Total energy production, (ktoe)

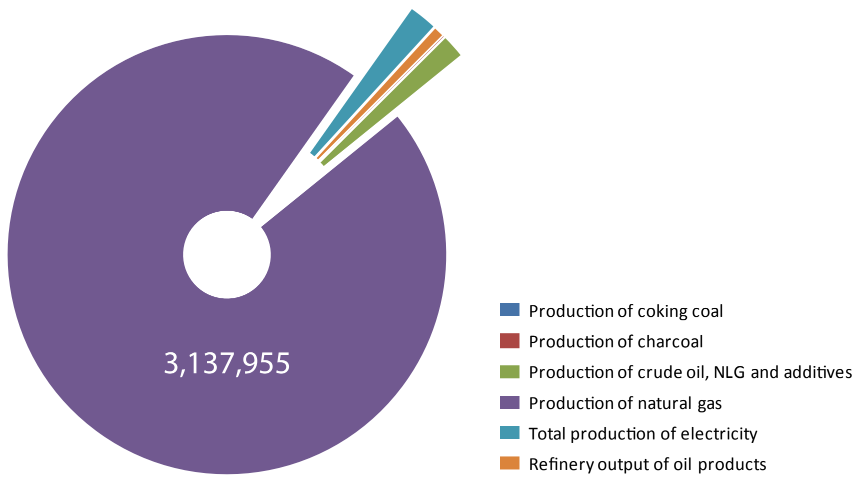
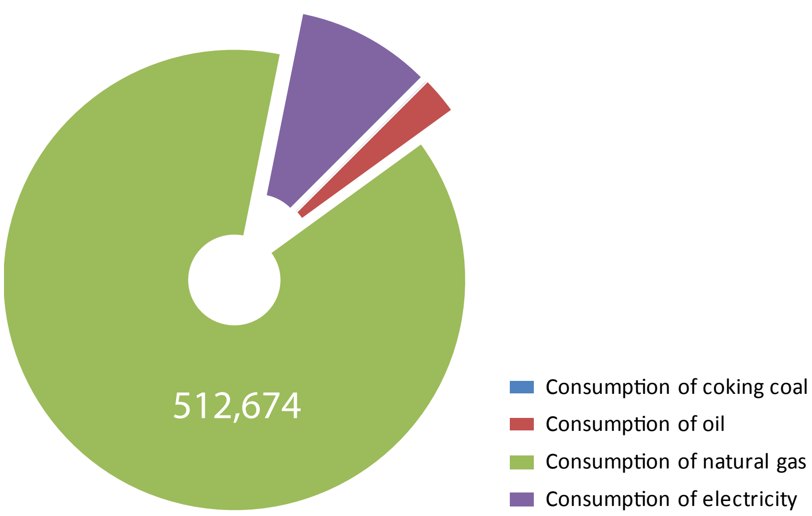


Figure 3: Total energy consumption, (ktoe)



Energy Consumption and Production

The population of Algeria in 2013 was just over 39 million (Table 1). In 2015, total production of electricity in the country was 65,588 ktoe with most (99.3 per cent) produced from fossil fuels. Generation from renewable sources is almost negligible. Final consumption of electricity has been increasing over the years from a low of 18,595 ktoe in 2009 to 54,313 ktoe in 2015 (Table 2) (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Algeria's Key Indicators

Key indicators	Amount
Population (2013 million)	39.21
GDP (billion 2005 USD)	127.19
CO_2 emission (Mt of CO_2)	113.87

IEA, 2016

Energy Resources

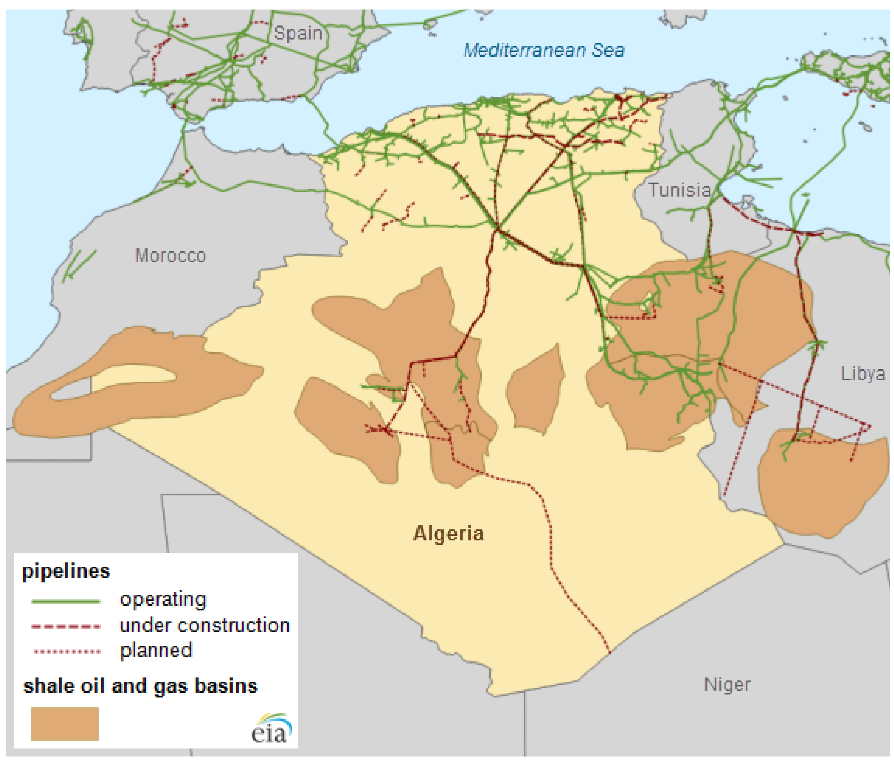
Hydropower

About 50 dams are currently operational and the combined capacity of the largest 13 dams is roughly 269 MW (REEEP, 2012). Installed capacity and production in 2011 was 278 MW (WEC, 2013). Environmental factors that restrict the uptake of hydropower are poor rainfall, high levels of evapouration and quick evacuation to the sea.

Oil

Algeria's indigenous oil reserves are the third largest in Africa, after Libya and Nigeria (WEC, 2013). In 2014, Algeria was the world's seventh top oil-products exporter (WEC, 2013) and ranked 17th globally in 2014 with a total of 1.721 million barrels a day. Much of its crude oil is exported to Western Europe and North America (IEA 2014). The principal oil provinces are located in the central and southeastern parts of the country. Hassi Messaoud, discovered in 1956, is the largest oil field. Others include Ourhoud oil field

Figure 4: Algeria's oil and gas fields



IEA, 2016

Table 2: Total Energy Statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	682	715
Production of crude oil, NLG and additives	68,008	86,133	78,120	54,209
Production of natural gas	3,611,288	3,908,975	3,376,884	3,137,955
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	25,358	33,360	42,663	65,170
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	54	555	171	43
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, etc.	0	0	0	375
Total production of electricity	25,412	33,915	42,834	65,588
Refinery output of oil products	20,033	18,321	26,402	22,613
Final consumption of coking coal	856	1,120	434	66
Final consumption of oil	7,852	10,123	13,558	14,545
Final consumption of natural gas	246,993	358,386	424,028	512,674
Final consumption of electricity	18,595	29,524	36,576	54,313
Consumption of oil in industry	1,203	1,564	1,842	1 592
Consumption of natural gas in industry	63,245	82,704	139,342	152,171
Consumption of electricity in industry	6,907	8,855	12,700	14,987
Consumption of coking coal in industry	33	172	111	75
Consumption of oil in transport	2,388	5,064	9,525	11,956
Consumption of electricity in transport	354	451	618	792
Net imports of coking coal	593	840	501	429
Net imports of crude oil, NGL, etc.	-37,023	-58,497	-38,734	-29,456
Net imports of oil product	-21,384	-16,367	-21,708	-13,261
Net imports of natural gas	-2,465,007	-2,841,927	-2,312,772	-1,902,106
Net imports of electricity	223	84	-67	-46

- : Data not applicable
0 : Data not available
(P): Projected
Source: AFREC, 2015

and Rhourde El Baguel oil field. Substantial volumes of Natural Gas Liquids (NGLs) — condensate and LPG — are produced at Hassi R'mel and other gas fields. Algerian crudes are of high quality, with low sulphur content. Algeria is estimated to have oil reserves of 12.2 billion barrels (WEC, 2013).

Natural gas

Algeria's largest natural gas field is located at Hassi R'Mel in the east of the country. Algeria has the tenth largest reserves of natural gas worldwide and second largest in Africa after Nigeria (WEC, 2013). It is thought to have proven reserves of 2,405 bcm (WEC, 2013) with more recent government estimates put at 2,745 (Aissaoui, 2016). Other natural gas reserves occur alongside crude oil reserves and non-associated fields in the southeast and southern parts of the country (Figure 4). Algeria is a major natural gas supplier to Europe; with the establishment of the liquefied natural gas (LNG) plant at Arzew in 1964, it was the world's first supplier of LNG. A new LNG plant at Gassi Touil with capacity of 218 bcf/y began operation in late 2013 (WEC, 2013).

Peat

Algeria has 10 km^2 of peatland (WEC, 2013).

Coal

At the end of 2011, Algeria had 59 million tonnes of proven coal (bituminous, including anthracite) recoverable reserves (WEC, 2013).

Wind

Studies indicate that high average wind speeds occur over half the country's surface. The best wind energy potential is in the south, especially the southwestern region where wind velocity is higher than 6m/s (REEEP, 2012). Six pilot projects for electrification and telecommunication are on-going at Adrar, Tindouf, Bordj Badji Mokhtar, Bechar, Tamanrassat and Djanet (REEEP, 2012).

Geothermal

The geothermal sector is underdeveloped even though there are numerous hot springs with geothermic energy potential. Temperatures in geothermal sources in the western part of the country are as high as 98˚C and 118˚C in Hamam El Maskhoutin and Biskra, respectively (REEEP, 2012). The geothermal potential is estimated at 700 MW (REEEP, 2012). Other geothermal resources exist north of the Tellian Atlas Mountains and to the south in the Saharan platform (WEC, 2013). The hot springs are used mainly for therapeutic purposes and for limited greenhouse heating. Recently, alternative uses for this energy have included geothermal aquaculture projects, such as in the fish farms in Ghardaia and Ouargla, which use the Albian geothermal water of the Sahara to produce about 1,500 tonnes/year of tilapia. Aquaculture is also being carried out at another site (Ain Skhouna) near Saida. A small geothermal reverse-heat pump project has also been started in this region in a primary school to heat and cool 12 classrooms, the library and the restaurant using Hammam Sidi Aissa geothermal water (46°C) with similar projects expected to be implemented around the country (Fekraoui, 2010). These various applications of geothermal water are as follows: 1.4 MWt and 45.1 TJ/yr for individual space heating; 9.8 MWt and 308 TJ/yr for fish farming; 44.27 MWt and 1,368.65 TJ/yr for bathing and swimming; and 0.17 MWT and 1.38 TJ/yr for geothermal heat pumps (WEC, 2013).

Solar

The average annual solar radiation ranges between 2,000 and 3,900 hours giving an average solar energy of 6.57 kWh/m^2/day. Of the available renewable energies, solar is thought to have the greatest potential in Algeria (REEEP, 2012).

By 2015, the combined energy from solar and wind was 375 ktoe (AFREC, 2015). The Ministry of Energy and Mines supports the development of solar energy plants and Sonelgaz and other private companies implement them. The IEA suggests that as it becomes increasingly connected to European energy networks, Algeria could one day be an exporter of solar energy to Europe. The IEA also indicates that within two decades, solar power could provide the same amount of electricity as 72 coal-fired power stations, which is enough to supply almost three times the current population of Algeria. (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

Access to electricity is high in Algeria. In 2010, 100 per cent of people in urban areas were served; in rural areas, the proportion was 98 per cent , leaving about 240,000 people with no access to electricity at that time (World Bank, 2015). Since then, however, new data show that by 2012, all Algerians had access to electricity Table 3 and Figure 5.

In 2000, about 1.85 million people did not have access to non-solid fuels, but by 2012, these fuels were available to everyone (World Bank, 2013). Algeria is one of the top 20 countries in the world that registered the greatest annual increases in access to non-solid fuels between 1990 and 2010 (World Bank, 2015). Annual incremental access is 0.7 million people (World Bank, 2015).

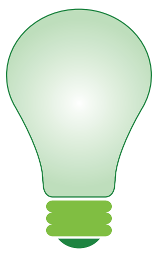
Algeria's energy intensity increased at a compound annual growth rate (CAGR) of 0.18 per cent over the 20 years between 1990 and 2010; and at 4.28 CAGR from 2010 to 2012. The rate of increase decreased slightly by 0.06 per cent during the period 2000-2010 compared to 0.29 per cent from 1990 to 2000 (World Bank, 2015).

Table 3: Algeria's progress towards achieving SDG7 - Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	94	98	99	100		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	86	96	100	99.99		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	0.2	0.6	0.3	0.19		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	-	-	11.5	11.4 (2011)		
	Level of primary energy intensity(MJ/$2005 PPP)	3.5	-	3.6	3.9	3.68	4

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 5: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
100% 	99.99% 	11.02	0.19%

Between 2010 and 2012, the Algerian economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) increased from 3.6 MJ to 3.9 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015). The residential and service sectors may have driven this rise. For example, in the Algiers area, annual housing consumption is 632 MJ/m^2, with heating constituting the largest share (46 per cent), followed by cooking (22 per cent), hot water (13 per cent) and electrical appliances (19 per cent). There is significant potential to reduce residential consumption, by substituting traditional fuels with more efficient fuels and appliances, for example (REEEP, 2012).

The share of renewable energy in total final energy consumption (TFEC) grew from 0.2 to 0.6 per cent between 1990 and 2000 before declining back to about 0.2 per cent in 2012. Biomass forms the biggest share of renewable sources at 0.3 per cent of TFEC in 2010 (World Bank, 2015). Renewable sources contributed only 0.4 per cent of the share of electricity generation in 2010, increasing to 1.1 per cent in 2012 (World Bank, 2015). Over the 2010-12 period, Algeria was one of the top 20 fastest-moving countries in the annual growth in modern renewable energy consumption (World Bank, 2015).

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Algeria is doing its part to combat climate change and limit future climate risks. The energy-related Intended Nationally Determined Contributions (INDC) that were articulated in October 2015 are highlighted in Table 4. One of the renewable energy policy goals is to produce 27 per cent of its electricity for domestic consumption from renewable energy sources by 2030, to reduce hydrocarbon dependence by increasingly exploiting renewable energy resources, especially solar power.


Kechba gas plant, Algeria

Table 4: Algeria's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

*Reach 27 per cent of electricity generated from renewable sources of energy by 2030;
*Generalize high-performance lighting; implement thermal insulation of buildings between 2021 and 2030;
*Increase the share of liquefied petroleum and natural gas in the consumption of fuels between 2021 and 2030.

Source: (PDRA, 2015)

Institutional and Legal Framework

The Ministry of Energy and Mines is in charge of the energy sector. The energy regulator is the Algerian Electricity and Gas Regulation Commission (CREG). SONELGAZ — the National Society for Electricity and Gas — is in charge of electricity and natural gas distribution in the country. The sector is vertically organized and there are other companies that handle generation, transmission and distribution. On a regional level, the country is a member of Comité Maghrébin de l'Electricité (COMELEC) Power Pool. The legal framework is provided by the Law on Electricity and Distribution of Gas No. 02-01. Table 5 highlights the key energy laws and policies in the country.

Table 5: Algeria's institutional and Legal Framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Mines • Ministry of Environment • The Renewable Energy Development Centre (Centre de Développement des Energies Renouvelables (CDER) • New Energy Algeria (NEAL) • National Agency for Promotion and Rationalization of Energy Use (APRUE)
Presence of a Functional Energy Regulator	Algerian Electricity and Gas Regulation Commission (CREG)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	SONELGAZ has been restructured as a holding company along with: • Société Algérienne de Production de l'Electricité - (SPE) • Opérateur Système Electrique - (OS) • Société Algérienne du Gestion du Réseau de Transport de L'Electricité - (GRTE) • Société Algérienne du Gestion du Réseau de Transport du Gaz - (GRTG) • Société de Distribution de l'Electricité et du Gaz d'Alger - (SDA) • Société de Distribution de l'Electricité et du Gaz du Centre - (SDC) • Société de Distribution de l'Electricité et du Gaz de l'Est - (SDE) • Société de Distribution de l'Electricité et du Gaz de l'Ouest - (SDO)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Hydrocarbons Regulatory Agency responsible for all technical regulation in the hydrocarbons sub-sector, including transportation tariffs, third-party access to pipelines and construction standards for health, safety and environmental protection
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Ministry of Energy and Mines. But contractual matters are the responsibility of the National Agency for the Efficient Exploitation of Hydrocarbon Resources (ALNAFT)
Presence of Functional (Feed in Tariffs) FIT systems	CREG sets specific feed-in tariffs for Integrated Solar Combined Cycle (ISCC) power plants
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Sector Policy • National Energy Efficiency Programme (PNME) • National Rural Electrification Programme • National Programme for the promotion of RE until 2020 • National Energy Efficiency Fund of Algeria (FNME)
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	• Law No. 02-01 establishing the Algerian Electricity and Gas Regulation Commission (CREG) as the national energy regulator • Decree no. 2000-116) establishing National Energy Efficiency Fund of Algeria (FNME) • Energy Efficiency Law of July, 1999 • Law on Renewable Energy of August 2004 • Decree on the Diversification of Power Generating Costs adopted in January 2004 • Electricity re-structuring Law enacted in 2002 • Hydrocarbons Law of March 2005

This table was prepared with material from (REEEP, 2012), (MINEA, 2016) and (MINEA and UNDP, 2015)

Angola

Figure 1: Energy profile of Angola

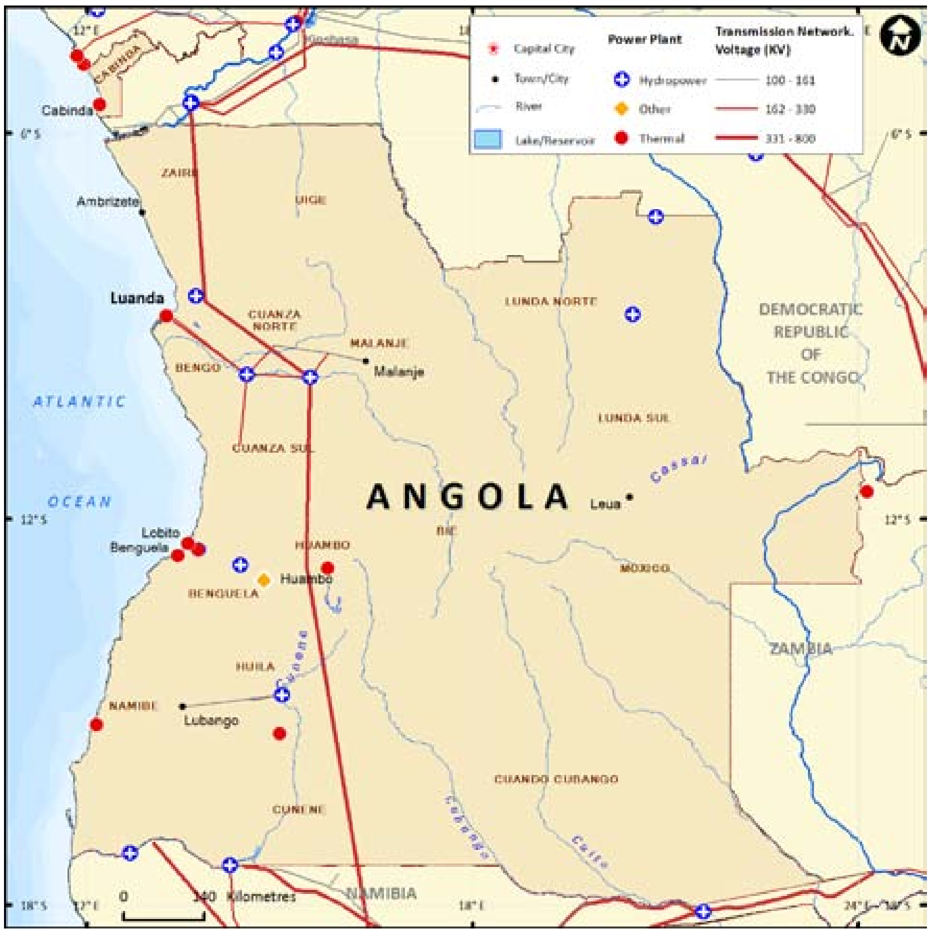


Figure 2: Total energy consumption, (ktoe)

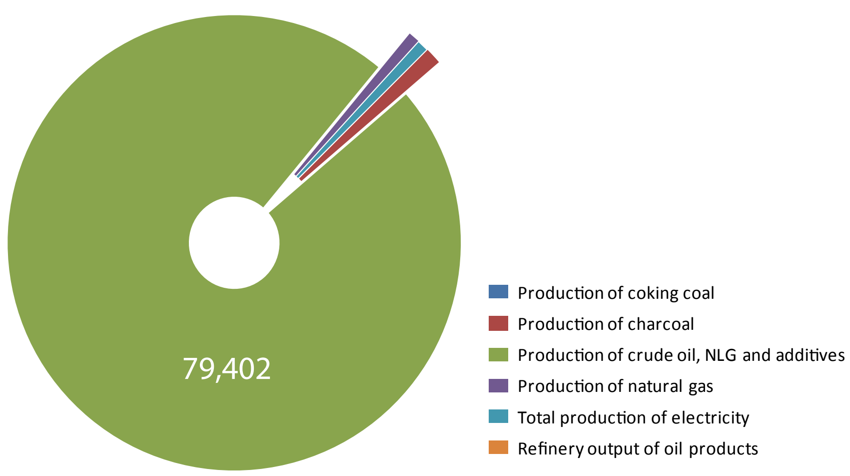
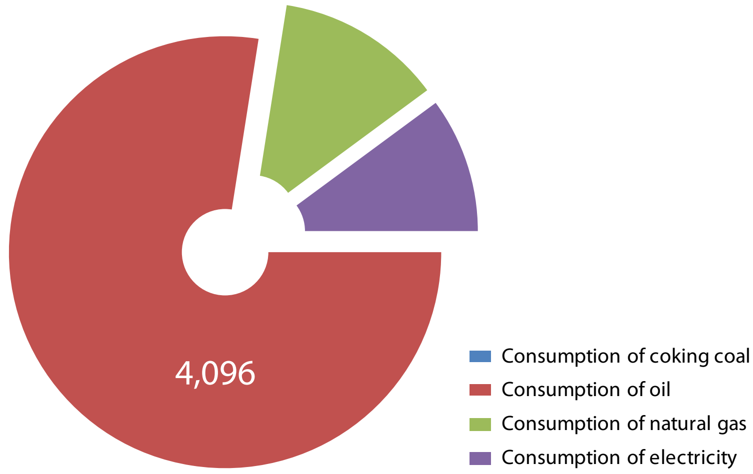


Figure 3: Total energy consumption, (ktoe)



Energy Consumption and Production

In 2013, Angola had a population of just over 21 million with an energy sector dominated by hydropower and oil (IEA, 2016) (Table 1). Electricity production in 2015 was 617 ktoe with 73.2 per cent of it generated from hydro and 24.7 per cent from fossil fuels (Table 2) (AFREC, 2015). Total final consumption (TFC) of electricity has been steadily increasing in recent years, rising from 132 ktoe in 2009 to 535 ktoe in 2015. In 2015, industry used 27.4 per cent of total electricity consumption (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Angola's Key Indicators

Key indicators	Amount
Population (million) (2013)	21.47
GDP (billion 2005 USD)	58.79
CO_2 emission (Mt of CO_2)	18.49

(IEA, 2016)

Energy Resources

Hydropower

Angola's hydropower potential is a whopping 150 TWh/yr and supplies most of the countries electricity (WEC, 2013). The installed capacity is 790 MW and by 2011, 80 MW of hydro was under construction (WEC, 2013). For example, studies are underway on major hydro schemes at Lauca and Caculo-Cabaca on the River Kwanza, for a combined installed capacity of 4,000 MW, as well as the Baynes Mountain transboundary project on the River Kunene along the border with Namibia (WEC, 2013).

The hydroelectricity potential that is commercially viable is 72 TWh/year (18 GW) but only less than 5 per cent has so far been exploited. The technical hydroelectricity potential is estimated at 80 TWh/annum (Liu, Masera, & Esser (eds), 2013).

Table 2: Total Energy Statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	626	725	849	956
Production of crude oil, NLG and additives	34,390	58,194	82,070	79,402
Production of natural gas	526	681	626	652
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	46	78	150	165
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	78	150	318	452
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, etc.	0	0	0	0
Total production of electricity	124	228	468	617
Refinery output of oil products	1,806	1,946	1,944	1,949
Final consumption of coking coal	0	0	0	0
Final consumption of oil	1,499	2,159	4,381	4,096
Final consumption of natural gas	526	681	665	656
Final consumption of electricity	132	195	415	535
Consumption of oil in industry	212	517	458	456
Consumption of natural gas in industry	526	681	663	704
Consumption of electricity in industry	31	53	136	147
Consumption of coking coal in industry	0	0	0	0
Consumption of oil in transport	790	1,209	2,153	2,354
Consumption of electricity in transport	0	0	0	0
Net imports of coking coal	0	0	0	0
Net imports of crude oil, NGL, etc.	-34,623	-54,826	-78,587	-77,736
Net imports of oil product	-89	552	2,706	2,841
Net imports of natural gas	0	0	0	0
Net imports of electricity	3	0	0	0

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Oil

Oil first started being produced in Angola in 1956. By the end of 2011, proven oil reserves were estimated at 9,500 million barrels, and by 2013, this had increased to 13 million barrels. Between 2011 and 2013, production grew from an estimated 623,050 barrels a day to 11 million barrels (WEC, 2013); (OECD/IEA, 2014; Cristovao, Undated).

Natural gas

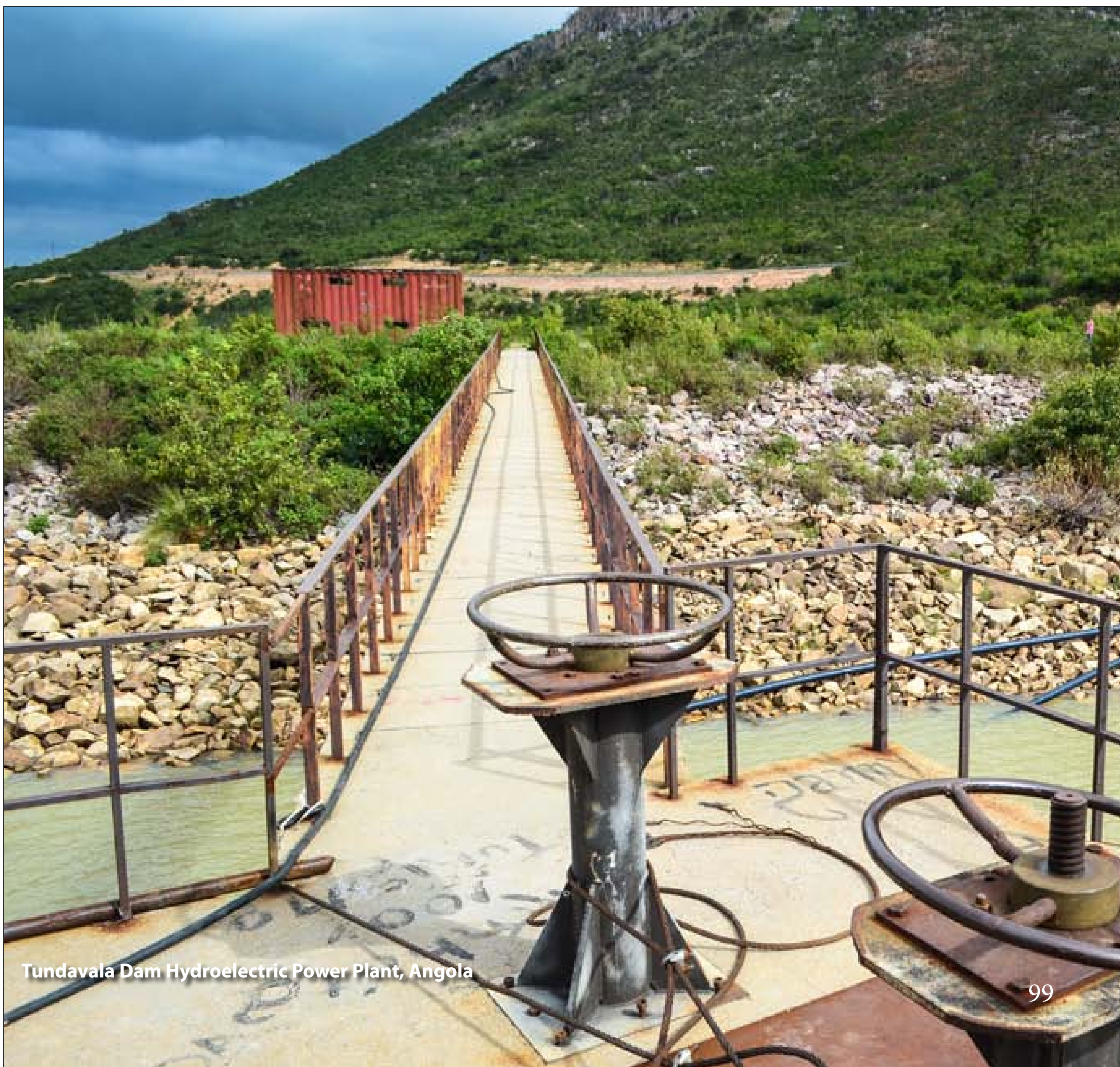
Estimated reserves of gas are equivalent to 5,685.7 bcm, while production is currently 0.7 bcm (WEC, 2013).

Peat

Peatland covers a total extent of 264 km^2 (WEC, 2013), but it is currently not an important source of energy.

Wind

Wind mapping of the country is underway but the potential for exploitation is not fully known. It is estimated that in Namibe province, however, there is potential to install wind farms that could generate up to 100 MW of electricity (Cristovao, Undated).



Tundavala Dam Hydroelectric Power Plant, Angola

Tracking progress towards sustainable energy for all (SE4All)

National access to electricity was 37 per cent in 2012 and access to non-solid fuels was 44 per cent in 2012 (Table 3 and Figure 4). About 13.12 million people are without access to electricity, mostly in rural areas. This means that most people use traditional solid biomass and waste (typically consisting of wood, charcoal, manure and crop residues) to meet off-grid heating and cooking needs, mainly in rural areas where the electrification rate is only 6 per cent (World Bank, 2016). The urban electrification rate is 83 per cent . Between 2010 and 2012, a total of 416,000 people gained access to electricity. The national grid is divided into three systems — the central, northern and southern systems. Outside of these, localities are either electrified using isolated systems or do not have access to electricity at all (IEA, 2011).

The level of energy intensity of the Angolan economy fell during the 22 years between 1990 and 2012 from 5.6 to 4.0 MJ per US dollar (2011 dollars at PPP). The literature indicates that Angola's power sector is among the least efficient in Africa, with financial losses in the region of 1.6 per cent of GDP (REEEP, 2012).

The share of renewable energy in total final energy consumption (TFEC) grew from 54.9 per cent in 2010 to 57.2 per cent in 2012. Most of this energy was provided by solid biofuels and traditional biomass (53.3 per cent). Hydropower contributed only 2.6 per cent (World Bank, 2015). Renewable energy as a share of electricity generated is 70.9 per cent.

Table 3: Angola's progress towards achieving SDG7 - Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	28	31	35	37		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	21	40	44.3		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	72.3	75.5	54.9	57.18		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	-	-	10.3	10.5 (2011)		
	Level of primary energy intensity(MJ/$2005 PPP)	5.6	-	4.1	4.0	4.05	4.0

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2011	Renewable energy consumption (% of total final energy consumption), 2012
37%	44.3%	10.88	57.18%

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Angola is committed to addressing the global fight against climate change and has articulated its intention to reduce greenhouse gas (GHG) emissions, which in 2013 were estimated at 18.49 MT of CO_2 (IEA, 2016). The energy-related Intended Nationally Determined Contributions (INDC) that were published in November 2015 are highlighted in Table 4.

Table 4: Angola's Key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

*Reach 27 per cent of electricity generated from renewable sources of energy by 2030;
*Generalize high-performance lighting; implement thermal insulation of buildings between 2021 and 2030;
*Increase the share of liquefied petroleum and natural gas in the consumption of fuels between 2021 and 2030.

Source: http://www4.unfccc.int/

Table 5: Angola's institutional and Legal Framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Water (MINEA) • National Directorate for Energy that supervises generation, transmission and distribution activities • Empresa Nacional de Electricidade (ENE) is in charge of generation, transmission and distribution of electricity to the country's three main grids and remote systems • Ministry of Finance sets tariffs
Presence of a Functional Energy Regulator	• Instituto Regulador de Sector Eléctrico (IRSE) • Atomic Energy Regulatory Agency (AREA)
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	• A Public Utility (merging GAMEK and ENE generation assets) to manage the generation assets • A Public Utility dedicated to network management and the transmission of electricity along the high voltage lines • A Distribution Utility (merging ENE, EDEL and the Municipalities) devoted to power distribution
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	Hidrochicapa (Russian-led consortium) that built a 16-MW hydropower facility to facilitate its diamond mining operations in Lunda Sul province. Others include Kahrama, Shariket Kahraba Berrouaghia (SKB), Shariket Kahraba Koudiet Eddraouche (SKD), Shariket Kahraba Hadjret Ennouss (SKH), Shariket Kahraba Skikda (SKS) and Shariket Kahraba Terga (SKT)
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	National Energy Security Strategy and Policy of 2011 authenticated by Presidential Decree No. 256/11 of 29 September
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• General Electricity Act No. 14-A/96 of May 1996. Decree 20/90 of 1990 that gives the Ministry of Finance the authority to set tariffs • Decree 45/01 of 2001 on standardizing tariffs • Decree 4/02 of 2002 establishing the sector regulator, the Instituto Regulador de Sector Eléctrico (IRSE)

This table was prepared with material from (REEEP, 2012), (MINEA, 2016) and (MINEA and UNDP, 2015)

Institutional and Legal Framework

The Ministry of Energy and Water is in charge of the energy sector (Table 5). The energy regulator is Instituto Regulador de Sector Eléctrico (IRSE). The electricity sector is vertically integrated with different utilities managing electricity generation, transmission and distribution. On a regional level, the country is a member of the Southern Africa Power Pool. The legal framework is provided by the General Electricity Act No. 14-A/96 of May 1996. The main sector policy is the National Energy Security Strategy and Policy of 2011.

Benin

Figure 1: Energy profile of Benin

Figure 2: Total energy consumption, (ktoe)

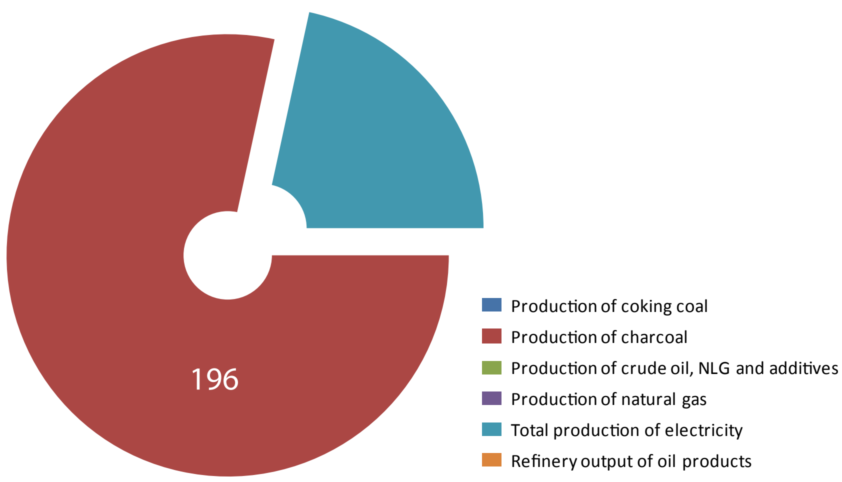
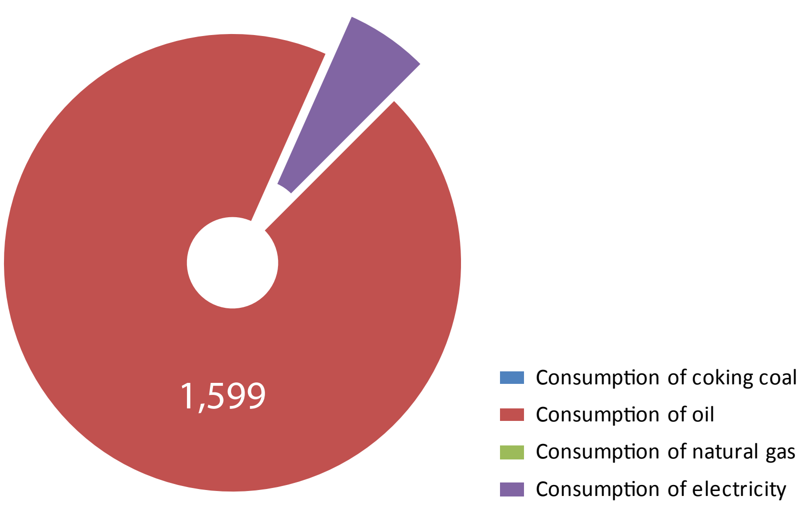


Figure 3: Total energy consumption, (ktoe)



Energy Consumption and Production

By 2013, Benin had a population of 10.32 million (Table 1). Electricity production in 2015 was 54 ktoe with 99.2 per cent of it generated from fossil fuels. Industry consumed 22.2 per cent of electricity produced in 2015 (Table 2). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Benin's key indicators

Key indicators	Amount
Population (2013 million)	10.32
GDP (billion 2005 USD)	6.02
CO_2 emission (Mt of CO_2)	5.22

(IEA, 2016)

Energy Resources

Biomass

Benin's domestic energy sector is dominated by the use of biomass-based energy sources. There is potential for biodiesel from crops such as Jatropha, castor, palm, cotton, peanut and soy. Other sources of biomass energy include agricultural residues, ethanol and biofuels. The potential for agricultural residues is estimated at about 5 million tonnes (REEEP, 2012). Ethanol production is limited to two plants: The Benin Sugar Plant (YUEKEN) and the Benin International Plant produce 4,200 m^3 and 3,000 m^3 of ethanol a year from sugar and cassava, respectively. However, a poor distribution infrastructure limits its usage in the transport sector (REEEP, 2012).

Two installations that process vegetable oil to transport fuels are operational, with a combined capacity of 210,000 tonnes, one located in Bohicon and the other, a palm oil plant, in Hinvi. However, only 30 per cent of the installed capacity is currently being exploited (REEEP, 2012).

Hydropower

Benin has huge potential for hydroelectricity generation. There is commercially viable potential of 760 MW on the River Oueme and there is also potential to support rural electrification through exploiting the over 80 other sites with small-scale hydropower plants (REEEP, 2012).

Table 2: Total Energy Statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	128	150	180	196
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	1
Production of electricity from fossil fuels	11	20	13	51
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	0	0	0	0
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, etc.	0	0	0	2
Total production of electricity	12	20	13	54
Refinery output of oil products	-	-	-	-
Final consumption of coking coal	-	-	-	-
Final consumption of oil	459	917	1 568	1 599
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	34	51	75	99
Consumption of oil in industry	48	42	47	48
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	9	10	12	12
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	315	476	1 009	1 152
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, etc.	-	-	-	-
Net imports of oil product	527	1 144	1 603	1 799
Net imports of natural gas	-	-	-	-
Net imports of electricity	32	51	80	85

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Oil and natural gas

The crude oil reserves in Benin are divided into 17 blocks for exploration purposes. Seven of these have active exploration activities with extensive geological and geophysical studies being conducted. Oil production from the Sèmè oil field off Cotonou came on line in 1982 and closed in 1998. At its height, it had a production of 8,000 bpd. Currently, South Atlantic Petroleum (SAPETRO) from Nigeria is looking to produce in one of these blocks.

By the end of 2011, there was 1.0 bcm (35.3 bcf) of proved recoverable natural gas reserves (WEC, 2013). Although these reserves are moderate, Benin produces no natural gas and imports all it needs. The Société Béninoise de Gaz is responsible for importing natural gas, which is supplied by the West African Gas Pipeline.

Peat

Benin has about 100 km^2 of peat but is not yet exploiting this as an energy source (WEC, 2013).

Wind

Wind speeds vary between 3 and 6 m/s but detailed information is unavailable, so an overview of the existing energy potential of wind power cannot be made (REEEP, 2012).

Geothermal

There is a dearth of information on the geothermal potential of Benin. The topography is generally flat and there is little active volcanism, suggesting a low potential (REEEP, 2012).

Solar

About 448 kW of solar energy is currently being used to support rural solar electrification systems such as health care units and telecommunication in Benin. The documented solar energy potential ranges between 3.9 and 6.2 kWh/m^2 (REEEP, 2012).

Rural Benin

Tracking progress towards sustainable energy for all (SE4All)

By 2012, access to electricity in Benin was only 38.4 per cent , with 68 per cent in urban areas and only 14.5 per cent in rural areas (Table 3 and Figure 4). Access to modern fuels is also low, with only 6.21 per cent using non-solid fuel nationwide; only 2 per cent have access in rural areas and 11 per cent in urban areas (World Bank, 2015); (World Bank, 2016). Low electrification rates are linked to the insufficient and unreliable power supply and this has severe economic consequences. For instance, in 2009, firms indicated that around 6.2 per cent of value was lost because of power outages (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Benin economy was 9.7 MJ per US dollar (2005 dollars at PPP) in 2012, down from 10.2 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010 and 2012 was -0.63 (World Bank, 2015).

The share of renewable energy in the total final energy consumption decreased from 93.7 in 1990 to 50.57 per cent in 2012 (World Bank, 2016). Traditional solid biofuels form the biggest share of renewable sources at 42.1 per cent of TFEC in 2012, while modern solid biofuels contributed 8.5 per cent (World Bank, 2015). Renewable sources contributed a 0.6 per cent share of electricity generation in 2012.

Table 3: Benin's progress towards achieving SDG7 - Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	22	25	28	38.4		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	6	6	6		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	93.7	70.3	51.5	50.57		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			4.3	4.3 (2011)		4.74 (2013)
	Level of primary energy intensity(MJ/$2005 PPP)	10.2		9.8	9.7	9.81	9.67

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
38.4%	6.21%	**4.9**	50.57%

Table 4: Benin's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Promote solar photovoltaic powered public lighting in rural and peri-urban areas by providing households with up to 1 million solar lamps and bulbs;
*Promote solar power plants construction by building 40 MW total capacity of solar power plants;
*Increase hydroelectricity production;
-Build hydroelectric dams of 259.9 MW total capacity
-Increase rural electrification: with a goal of electrifying 1,000 villages
-Promote households access to low electricity consumption bulbs with a target to reach 1.2 million lamps
-Support the acquisition and distribution of 200,000 household connection kits by the SBEE (national electricity utility company)
*Promote households' access to liquefied natural gas (LNG) and its related equipment for cooking: roughly 275,000 households are considered for this programme and 35 per cent of the gas refill rate will be subsidized for households;
*Increase electricity production from natural gas by building a 400 MW natural gas plant;
*Build an LNG storage and regasification unit as well as a connecting pipeline to the gas terminal in the port of Cotonou;
*Promote affordable cooking stoves: disseminate 140,000 improved cooking stoves;
*Promote high efficiency carbonization stoves;
*Create plantations for fuel wood industry for a total area of 5,000 ha;
*Develop lagoon and lake transport in Benin using existing systems of river and lake routes in the five riparian regions of Lake Nokoue;
*Develop intra- and intercity public transport system in and between Parakou and Porto-Novo;
*Establish a differential taxation policy in favor of imported used cars less than five (5) years of age;
*Establish a policy that levies importation taxes on public transportation vehicles, and continue to promote 4T motorbikes to the detriment of 2T motorbikes by applying fiscal and tariff levy on 4T mopeds and their spare parts.

Source: (ROB, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

In September 2015, Benin articulated its energy-related Intended Nationally Determined Contributions (INDCs) (Table 4). The

Table 5: Benin's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Water • Directorate General for Energy (DGE) • Beninese Agency for Rural Electrification and Energy Control (ABERME) - policy • Electrical Community of Benin (CEB) • Agency for the Control of Internal Electrical Installations (CONTRELEC)
Presence of a Functional Energy Regulator	Ministry of Energy and Water (MEE) Benin Agency for Rural Electrification and Energy Control (ABERME) Regulatory Authority created in 2013
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	• Ministry of Energy and Water • National oil company SONACOP • Other licensed companies include Total Benin, Texaco Benin S. A. and Oryx Benin S. A.
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West African Power Pool (WAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	• Communaute Electrique du Benin (CEB) - production, distribution and the import of electricity in both Togo and Benin • Societe Beninoise d'Energie Electrique (SBEE) – handles distribution
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Policy and Strategy Document for the Development of the Electricity Sector that provides the long term vision and the strategy of the country by 2025 • Rural Electrification Fund
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Law No.98-032 1998, Portant Réforme du Secteur de l'Électricité: Structural Reform of the Electricity Sector, is the current power sector law • Decree No.2001-173, fixing the condition and applicable mode of the Law No.98-032 1999 for structural reform of the electricity sector

This table was prepared with material from (REEEP, 2012), (MINEA, 2016) and (MINEA and UNDP, 2015)

main aim is to contribute to reducing cumulative GHG emissions from current emissions.

Institutional and Legal Framework

The Ministry of Energy and Water is in charge of the energy sector. The energy regulator is the Benin Agency for Rural Electrification and Energy Control (ABERME). The Communauté Electrique du Benin (CEB) handles production, distribution and importation of electricity in both Togo and Benin and the Société Béninoise d'Energie Electrique (SBEE) handles distribution. On a regional level, the country is a member of the West Africa Power Pool. The legal framework is provided by the Law No.98-032 1998, the Structural Reform of the Electricity Sector (Table 5).

The main sector policy is the Policy and Strategy Document for the Development of the Electricity Sector that provides the long-term vision and the strategy of the country by 2025.

Botswana

Figure 1: Energy profile of Botswana

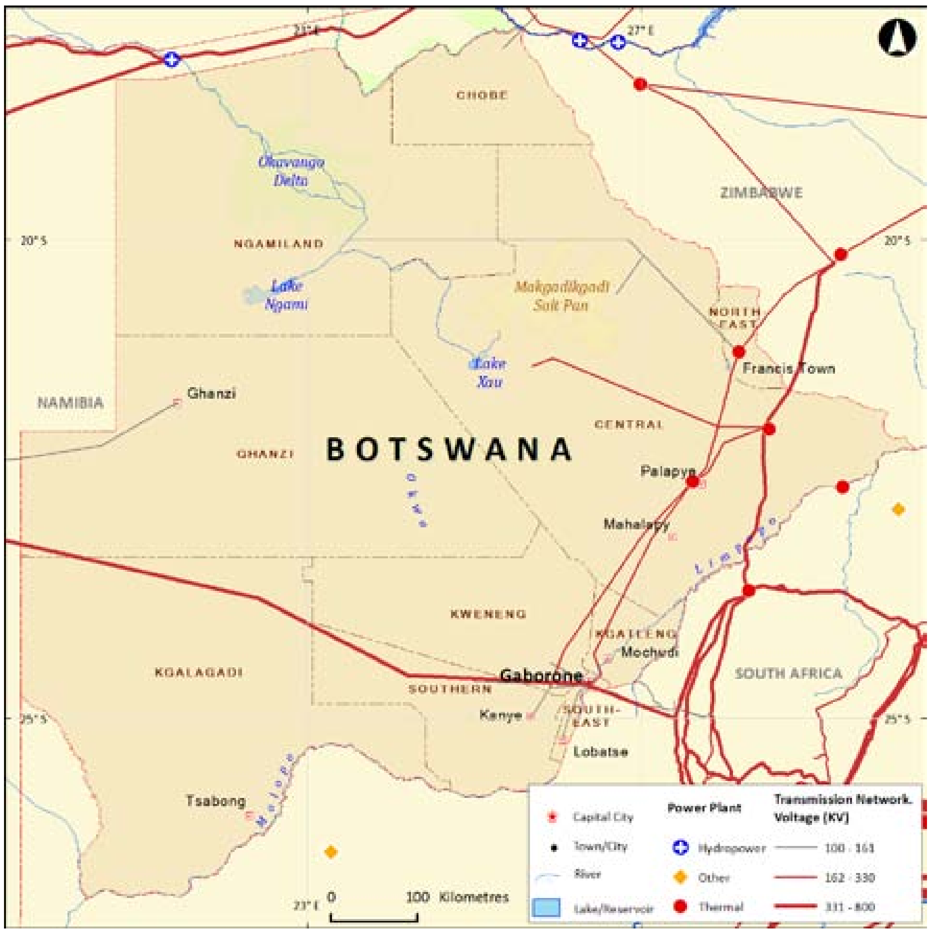
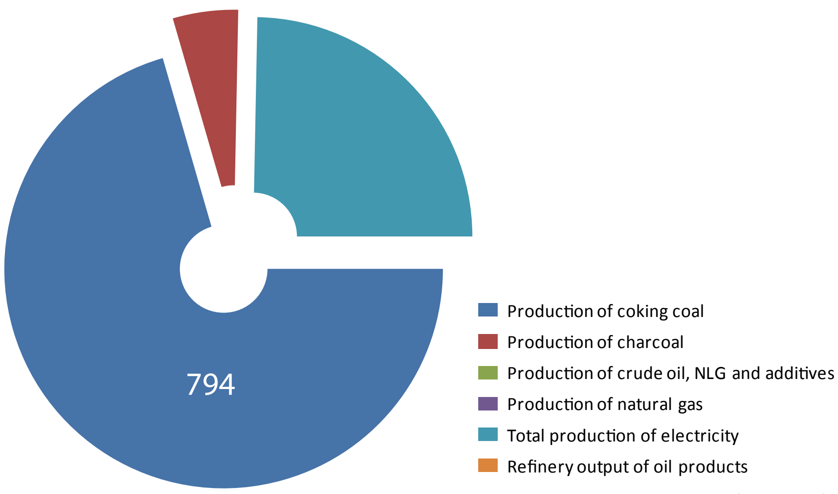
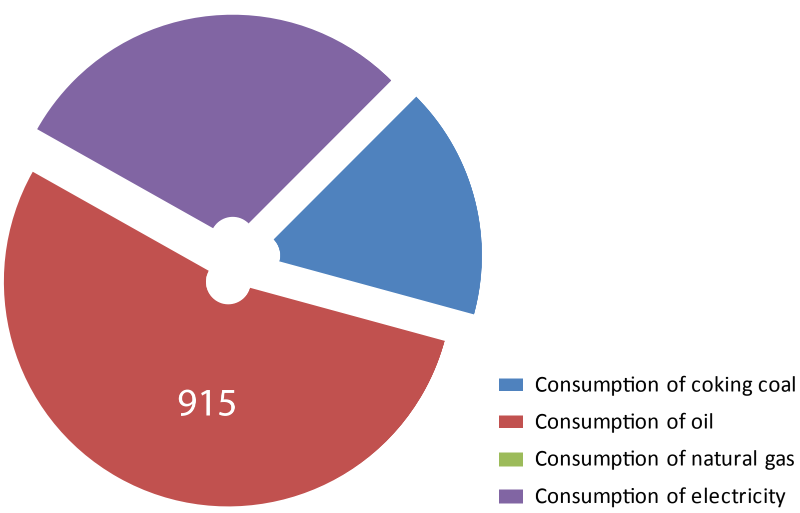


Figure 2: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

By 2013, Botswana had a small population of only 2.02 million people (Table 1) (IEA, 2016). According to the African Energy Commission (AFREC, 2015), total electricity produced in 2015 was 278 ktoe with 99.6 per cent of it produced from fossil fuels. Industry consumed 25.1 per cent of all electricity consumed in 2015 (Table 2). Botswana's energy capacity is thermal, produced mostly in coal-fired plants with a few small diesel generators in rural areas. The 132 MW Morupule coal-fired station generates most of the domestic electricity supply. More than 50 per cent of Botswana's power requirements are imported from South Africa and Zambia. Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Botswana's key indicators

Key indicators	Amount
Population (million)	2.02
GDP (billion 2005 USD)	14.20
CO2 emission (Mt of CO2)	5.48

(IEA, 2016)

Energy Resources

Biomass

Wood fuel is the main source of energy for rural households. It accounts for about 30 per cent of the country's primary energy supply and 38 per cent of total final energy consumption. Biomass supplies 46 per cent household energy nationally, increasing to 77 per cent at the rural level (Nachmany, et al., 2015).

Oil and natural gas

Botswana meets its energy demand mainly by importing petroleum products to supply thermal power stations since internal electricity generation is insufficient to meet demand (REEEP, 2014). South Africa supplies all the country's refined oil needs but limited supply routes lead to intermittent shortages in fuel supply. Insufficient internal strategic storage capacity and the huge travel distances required to supply the entire country exacerbate the situation. Improving energy security in terms of energy supply is one of Botswana's policy objectives.

About 70.7 per cent and 40.5 per cent of households in urban and rural areas respectively use LPG for cooking (Unpublished, 2015). The sector is liberalized and private sector control of supply and pricing has led to a large market for LPG. Although the government subsidizes kerosene to

Table 2: Total Energy Statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	484	503	505	794
Production of charcoal	0	0	0	54
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	81	83	37	277
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	-
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	81	83	37	278
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	158	112	332	284
Final consumption of oil	542	656	818	915
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	137	222	274	498
Consumption of oil in industry	87	87	157	182
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	85	109	116	125
Consumption of coking coal in industry	134	110	152	182
Consumption of oil in transport	398	498	649	683
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	48	1	2	1
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	561	658	971	927
Net imports of natural gas	-	-	-	-
Net imports of electricity	70	151	257	304

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

increase access for low-income groups, uptake as a cooking fuel is still low.

Peat

The area of peatland in 2011 was 2,625 km^2 (WEC, 2013).

Coal

The country is overly dependent on coal, mainly because it is abundant and cost effective. The proven recoverable reserves at the end of 2011 was 40 million tonnes and total production of coal in 2011 was 0.9 million tonnes (WEC, 2013). Although coal reserves are found in various locations around the country, only the one at Morupule Colliery is currently being mined. However other coal-to-electricity generation plants are being considered. The Morupule reserve accounts for 80 per cent of domestic production. Since 2012, the government has been actively exploring the prospects for coal-bed methane extraction.

Wind

Average wind speeds are lower than 4 m/s, the minimum for wind energy to be viable. However, studies show that there may be superior wind speeds at higher altitudes. For instance, there are signs that at heights over 80 m, wind speeds have the potential to reach between 5-7 m/s. However, more research is needed. Kwai Pan has the highest winds speeds recorded to day, with wind velocities between 6 to 9 m/s (Unpublished, 2015).

Solar

Botswana has one of the highest levels of solar insolation worldwide, with direct normal irradiation (DNI) of 3,000 kwh/m^2/year. It is estimated that using less than 1 per cent of the country area, Botswana could meet its current electricity consumption (GOB, 2010). Global irradiation is highest in the west, averaging 2,350 kWh/m^2/year near a place called Kang and around Kalahari Gemsbok National Park. The lowest potentials are on the northeastern side of the country.

The first solar power generation plant opened in September 2012 and solar is currently used for domestic water heating, home lighting, electricity supply for telecommunications equipment and in rural areas where access to conventional electricity is difficult. The potential for business in the manufacture and assembly of solar energy equipment is huge.

Tracking progress towards sustainable energy for all (SE4All)

In 2012, just over half of Botswana's population (53.2 per cent) had access to electricity, with rural and urban access at 23.9 per cent and 71 per cent , respectively (World Bank, 2016) (Table 3 and Figure 4). The national target for access to electricity by 2016 is 82 per cent while the goal for 2030 is 100 per cent . Access to non-solid fuels is at 62.47 per cent of the population with 39 per cent in rural areas and 90 per cent in urban areas (World Bank, 2013). The National Development Plan target is to reach an electrification rate of 80 per cent nationwide and 60 per cent rural by 2016.

Electricity access is partially constrained by inadequate supply in South Africa, which during the 2008 to 2012 period reduced its power sale commitments to importing countries. including Botswana. As a result, since 2008, Botswana has been experiencing load shedding.

Botswana's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 4.6 MJ per US dollar

Table 3: Botswana's progress towards achieving SDG7 - Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	37	40	43	53.2		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	37	51	61	62.47		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	47.1	35.7	26.4	23.85		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			11.9	12.9 (2011)		13.66 (2013)
	Level of primary energy intensity(MJ/$2005 PPP)	4.6		3.5	3.1	3.23	3.12

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
53.2%	62.47%	14.11	23.85%

Resevoir of Gaborone Dam, Botswana

Table 4: Botswana's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Minerals, Energy and Water Resources (MMEWR) • Botswana Power Corporation • Botswana Power Corporation Leased • Rural Industries Innovation Centre (RIIC) • Botswana Technology Centre (BOTEC) • Ministry of Environment, Wildlife and Tourism (MEWT) • Ministries of Local Government (MLG) and Ministry of Education and Skills Development (MoESD)
Presence of a Functional Energy Regulator	Botswana's Energy and Water Regulatory Agency
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	Botswana Power Corporation
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Not unbundled (vertically integrated)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• A National Energy Policy • Botswana Energy Master Plan 2004-19 • Renewable Energy Fund for off-grid solutions • 10th National Development Plan 2009-2016 (NDP10) • National Photovoltaic Rural Electrification Programme • Public Notice on electricity supply act requiring generation license - May 2012
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Electricity Supply Act 2007 • Petroleum (Exploration and Production) Act

This table was prepared with material from (REEEP, 2012), (MINEA, 2016) and (MINEA and UNDP, 2015)

(2005 dollars at PPP) in 1990, decreasing to 3.1 in 2012. The government target is to achieve 10 per cent power savings through energy efficiency schemes by 2020. The compound annual growth rate (CAGR) between 1990 and 2010 was -1.34 and between 2010 and 2012 was -5.37 (World Bank, 2015).

The share of renewable energy in the total final energy consumption was 47.1 per cent in 1990 decreasing to 23.85 per cent in 2012 (World Bank, 2016); (World Bank, 2015).

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

In October 2015, the government articulated its energy-related Intended Nationally Determined Contributions (INDC). The overall aim is to achieve an emissions reduction of 15 per cent by 2030, from the energy sources categorized as stationary and mobile sources.

Institutional and Legal Framework

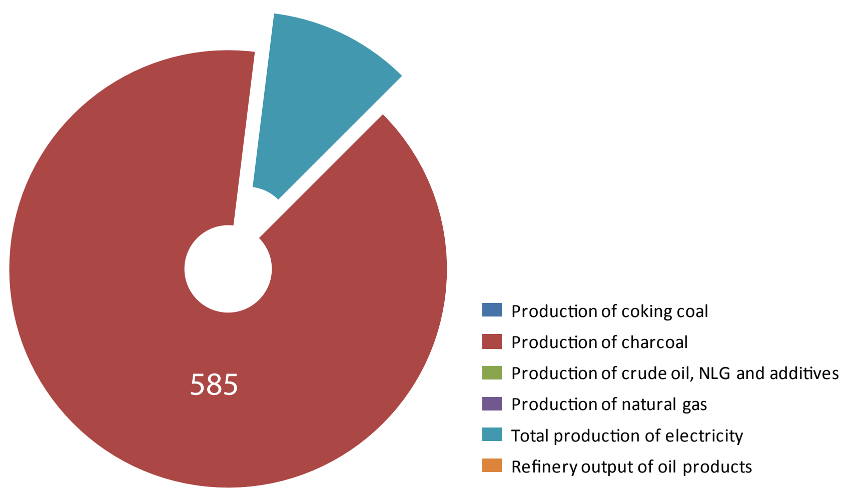
The Ministry of Minerals, Energy and Water Resources (MMEWR) is in charge of the energy sector. The energy regulator is the Botswana Energy and Water Regulatory Agency (BEWRA). The electricity sector is vertically integrated and is managed by Botswana Power Corporation. On a regional level, the country is a member of the Southern Africa Power Pool. The legal framework is provided by the Electricity Supply Act 2007.

There is a national energy policy, which aims to provide 80 per cent access to the country as a whole and 60 per cent access in rural areas by 2016 through the increased use of renewable energy. This would reduce the dependence on coal, which is a greenhouse gas emitter.

Burkina Faso

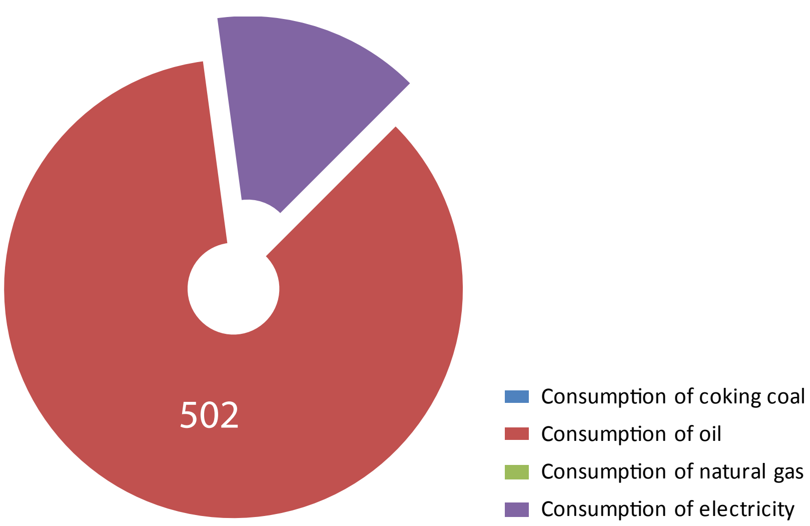
Figure 1: Energy profile of Burkina Faso

Figure 2: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Burkina Faso has a population of 17.08 million (Table 1). Electricity production in 2015 was 69 ktoe with 89.8 per cent of it generated from fossil fuels (Table 2). Final consumption of electricity in 2015 was 86 ktoe (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Burkina Faso's key indicators

Key indicators	Amount
Population (million)	17.08
GDP (billion 2005 USD)	1.57
CO_2 emission (Mt of CO_2)	1.93

Source: (World Bank, 2015)

Energy Resources

Biomass

Biomass (fuelwood and charcoal) energy is used by about 90 per cent of the population, followed by hydrocarbons, hydroelectricity and renewables (mainly solar). The Sudano-Sahelian and Sudanian Zone of the country has high biomass resources to supply energy (REEEP, 2012).

Carrying wood fuel to market

Table 2: Total Energy Statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	144	297	499	585
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	1	0	0	0
Production of electricity from fossil fuels	26	34	39	62
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	8	9	10	6
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	35	42	49	69
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	241	418	597	502
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	30	50	69	86
Consumption of oil in industry	11	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	12	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	191	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	313	424	585	677
Net imports of natural gas	-	-	-	-
Net imports of electricity	0	11	33	45

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

Hydropower

Hydroelectricity use represents about 20 per cent of national electricity consumption (including imports from Ghana and Côte d'Ivoire) (REEEP, undated). There are a number of sites that are suitable for decentralized hydroelectric power generation. The capacity ranges between 65 and 550 kW with 5 to 15 GWh/year, and 550 to 1,700 kW with at least 5 GWh/year (REEEP, 2012).

Oil and natural gas

Burkina Faso depends on imports of refined petroleum products from Ivory coast for use in its transport, electricity generation and other industries. About 15 per cent of the electricity it uses is also imported. The *Société Nationale Burkinabe d'Hydrocarbures* (SONABHY) controls the supply of petroleum products. It is a state-owned company supervised by the Ministry of Trade and the Ministry of Finance.The Bureau of Mines and Geology ensures quality control for retailed petroleum products (REEEP, undated).

Peat

Burkina Faso has 10 km^2 of peat land (WEC, 2013).

Wind

Burkina Faso's location on the west coast of Africa is not ideal for wind energy. The average wind speeds recorded are between 1 and 3 m/s, with the faster speeds recorded in the northern parts of the country. Although this is rather low, it is currently being used to support small-scale water pumping and desalination systems (REEEP, 2012).

Geothermal

No study has been conducted to assess the geothermal potential of Burkina Faso (REEEP, 2012).

Solar

Annually, Burkina Faso receives about 3,000-3,500 hours of peak sunshine and this has the potential to generate an average of 5.5 kWh/m2/day. Solar systems are currently being used for communication, lighting, refrigeration, water pumping and television (REEEP, 2012). There are plans for a 71.5 MW photovoltaic installation (World Bank, 2015).

Tracking progress towards sustainable energy for all (SE4All)

Burkina Faso is one of the top 20 countries that have a serious deficit in access to electricity as well as one of the lowest global rates of electrification (World Bank, 2015). In 2012, access to electricity was only 1.4 per cent in rural areas while in urban areas it was 48.5 per cent (Table 3 and Figure 4). Access to modern energy services is also very low with 2 per cent in rural areas and 20 per cent in urban areas using non-solid fuels (World Bank, 2015). As with other African countries, most of the energy supply is derived from biomass — firewood in rural areas and mostly charcoal in urban areas. Consumption of biomass is estimated at 0.69 kg of firewood per person per day. Charcoal production currently utilizes inefficient technologies and could increase pressure on forest resources.

Energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of Burkina Faso's economy was 7.0 MJ per US dollar (2005 dollars at PPP) in 2012, down from 14.1 MJ per US dollar in 1990 (World Bank, 2015). The compound annual growth rate (CAGR) between 2010 and 2012 was -2.36 (World Bank, 2015).

The share of renewable energy in total final energy consumption (TFEC) has been steadily declining. Between 2006 and 2011, it was 80.01 per cent (World Bank, 2016). Traditional solid biofuels form the biggest share of renewable sources at 78.0 per cent of TFEC in 2012, while modern solid biofuels contributed 0.7 per cent and hydro only 0.4 per cent . Renewable sources contributed a 24.5 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Burkina Faso's progress towards achieving SDG7– Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	6	7	13	13.1		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	4	5	5.29		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	92.4	96.5	85.3	79.1		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	-	-	-	-		
	Level of primary energy intensity(MJ/$2005 PPP)	14.1		7.4	7.0	7.32	7.02

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
13.1%	5.29%	NA	80.01%

Carsten ten Brink/Flickr.com/CC BY-NC-ND 2.0

Gas station in Burkina Faso

Table 4: Burkina Faso's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Diversify energy sources (solar, wind, biogas)
*Promote energy-saving technologies in industry and construction
*Produce and distribute 540,000 improved cook stoves with at least 50 per cent in urban and semi-urban areas
*Promote at least 80 per cent of traditional Dolo beer brewers use an improved cook stove, 95 per cent of which are in rural areas and 100 per cent in urban and semi - urban areas. This contributes to a reduction of YY per cent in the demand for firewood
*Promote the use of Dolo cook stoves with the aim of affecting 97 per cent of dolo brewers at the 2030 horizon, with a biomass energy/ waste recovery energy score = 935.
*Produce and distribute improved cook stoves in urban and semi-urban areas, with a biomass energy/ waste recovery energy = 865
*Promote methane recovery from used water from the Ouagadougou municipal purification station, with a biomass energy/ waste energy recovery = 770.
*Promote methane recovery from the solid waste of the city of Ouagadougou's landfill, with a biomass energy/ waste energy recovery = 725
*Produce and distribute improved cook stoves in urban and semi - urban areas. Net emissions to be avoided = 610 $GgCO_2$. with a targets of distributing 540,000 household cook stoves over 15 years.
*Promote Dolo cook stoves with the aim of reaching 97 per cent of dolo brewers at the 2030 horizon. Net emissions to be avoided= 610 $GgCO_2$, with a target of distributing 180,000 Dolo cook stoves over 15 year

Source: (ROBF, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

In October 2015, the government stated its the energy-related Intended Nationally Determined Contributions (INDCs). These are listed in Table 4.

Institutional and Legal Framework

The Ministry of Mines and Energy is in charge of the energy sector (Table 5). The energy regulator is the Electricity Regulatory Authority (ARSE). The National Electricity Company of Burkina (SONABEL) is the main vertically-integrated electricity operator with a national monopoly on the generation and distribution of electricity in the urban centres. On a regional level, the country is a member of the West African Power Pool. The legal framework is provided by the Electricity Law of 2007. The main sector policy is the Energy Sector Policy 2014-2025.

Table 5: Burkina Faso's Institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Mines and Energy • National Agency for Renewable Energy and Energy Efficiency
Presence of a Functional Energy Regulator	Electricity Regulatory Authority (ARSE)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	National Electricity Company of Burkina (SONABEL)
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Société Nationale Burkinabé d'Hydrocarbures (SONABHY)
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Sector Policy 2014-2025 • Electrification Development Fund • Strategy for Accelerated Growth • Sustainable Development (SCADD 2011-2015)
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	• Electricity Law of 2007 • Decree No. 2001-342/PRES/PM/MEE of 17 July 2000 requiring EIA

This table was prepared with material from (REEEP, 2012)

Burundi

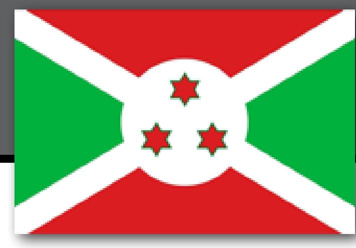
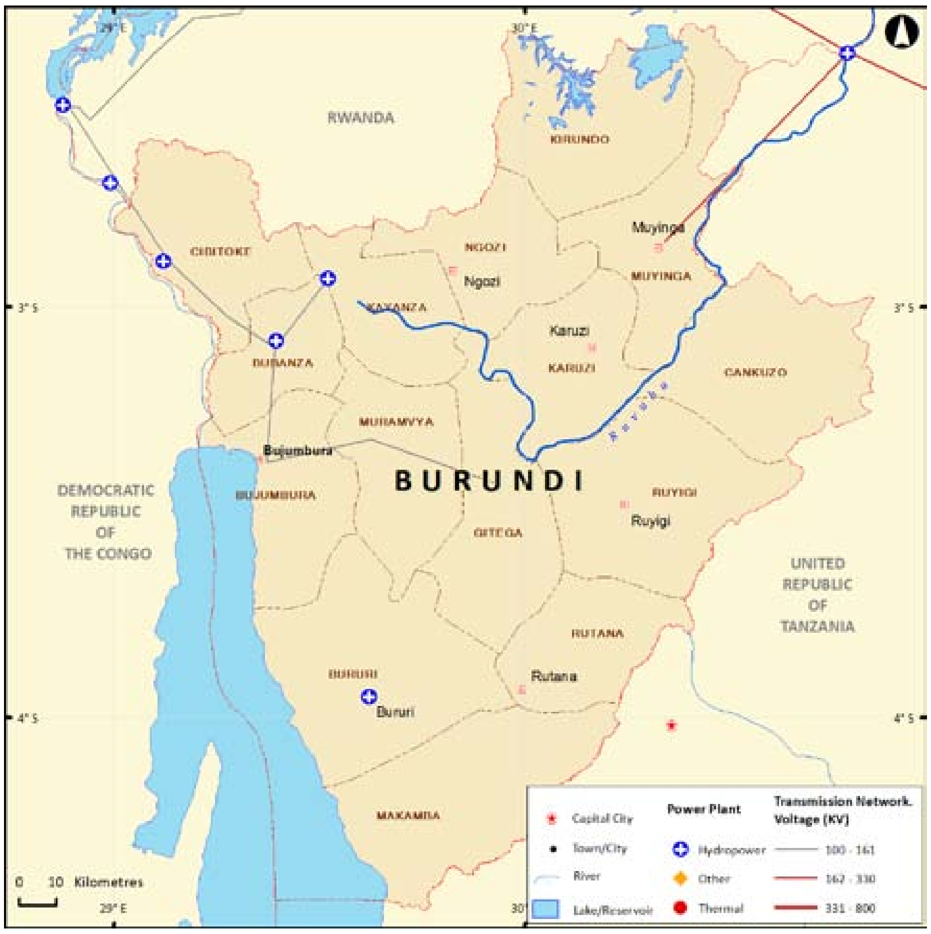


Figure 1: Energy profile of Burundi



Energy Consumption and Production

Burundi's population in 2013 was 10.4 million (Table 1). Total electricity produced in 2015 was 17 ktoe down from 21 ktoe in 2010 (Table 2). Key energy indicators are shown in Figures 2 and 3 (IEA, 2016).

Table 1: Burundi's key indicators

Key indicators	Amount
Population (million)	10.4
GDP (billion 2005 USD)	1.57
CO_2 emission (Mt of CO_2)	0.21

Source: (World Bank, 2015)

Energy Resources

Biomass

Most of the energy consumed in Burundi comes from biomass. Domestic clients are the main consumers and utilize about 96 per cent of this total energy. Based on current consumption patterns, the current forest coverage is 174,000 ha against forecast production needs of 180,000 ha. This presents a challenge in satisfying this unmet energy need. The total sustainable fuelwood supply in 2007 was assessed at 6.4 million m^3 (REEEP, 2012).

Hydropower

Most of Burundi's energy supply (95 per cent) comes from hydropower. This high dependence on hydropower makes the country vulnerable to climate extremes such as drought. For instance, during the 2009 and 2011 droughts, electricity supply was reduced by as much as 40 per cent , drastically affecting the economy (REEEP, 2012).

Given the topography and abundant precipitation, there is considerable potential for developing small hydropower. The country's theoretical hydropower capacity is estimated at about 1,700 MW, but less than 20 per cent is commercially viable and to date only about 2 per cent has been harnessed (REEEP, 2012). Most (85 per cent) of the installed electric capacity is currently generated from the Rwegura and Mugera hydroelectric plants averaging 19 MW and 8 MW of electricity respectively. And there are an additional five plants in operation (REEEP, 2012).

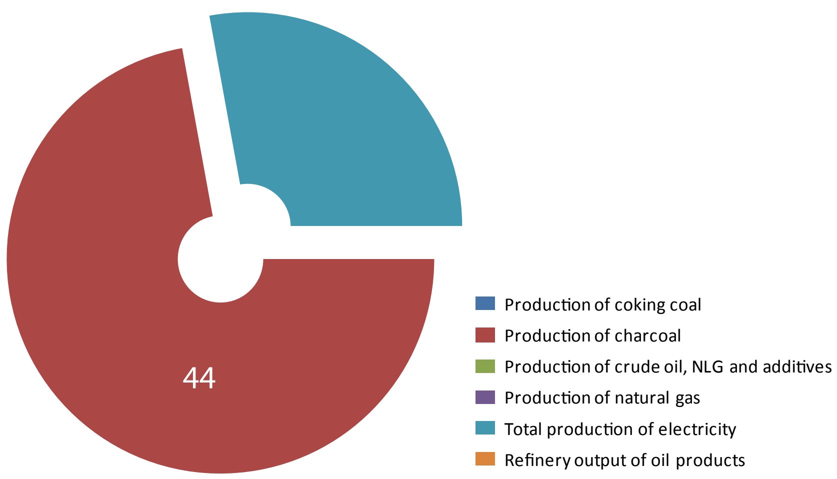
Oil and natural gas

Burundi has no local sources of oil or natural gas and neither are there any facilities for oil refining. So all refined oil products are imported from neighbouring Kenya and Tanzania (REEEP, undated). Approximately 3,000 barrels of oil is imported daily. This is costly since they have to be transported overland. Petroleum products are mostly used in industry, power generation in thermal plants and for transportation.

Peat

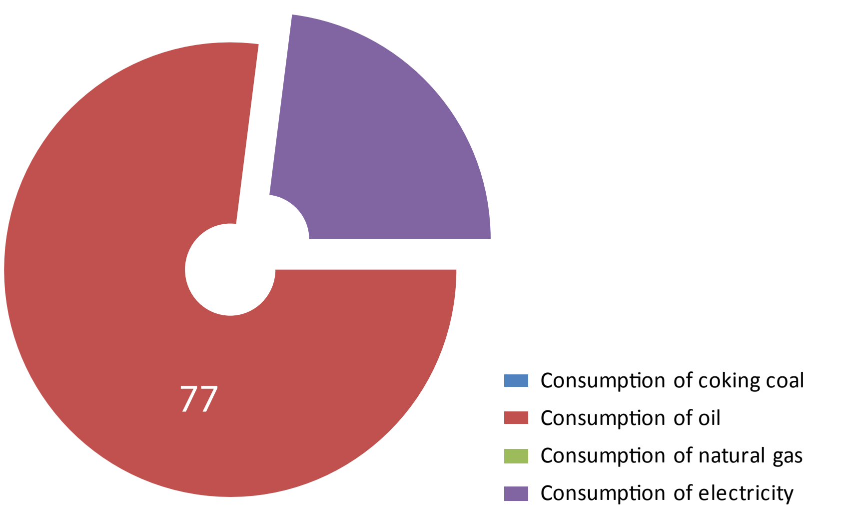
Peat resources in Burundi amount to about 323 km^2 (WEC, 2013). Of the known peatland, the most extensive is located beneath the Akanyaru swamp complex in the north, an area of about 123 km^2 with an estimated 1.42 billion m^3 of peat in situ (Joosten, 2010). Peat production in 2008 was 20,000 tonnes and all of this was consumed. This constituted the entire production and consumption total for Africa (WEC, 2013). As an

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	44	44
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	0	0	1	2
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	8	8	20	15
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	9	8	21	17
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	0	0	0	0
Final consumption of oil	132	132	73	77
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	11	14	19	23
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	0	0	0	0
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	132	132	72	77
Net imports of natural gas	-	-	-	-
Net imports of electricity	3	6	7	8

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

alternative to wood, the use of peat would help to reduce pressure on Burundi's forests. Commercialisation of this resource, for use in agriculture and industry is being driven by the National Peat Officer (ONATOUR). ONATOUR was established in 1977 and in Africa, is the only is the facility that produces turf or dried-out peat sods using mechanical means. So far, only 0.5 per cent of the 6 million tonnes peat reserves have been processed. Most of this (90 per cent) has been used by the military and prisons. With the rehabilitation of the processing facilities, peat production is expected to rise (WEC, 2013).

Coal

There are no indigenous sources of coal.

Wind

The Institute of Agronomic Sciences of Burundi (ISABU) gathers data on wind patterns, primarily for agricultural purposes, recording a mean wind speed between 4 and 6 m/s. More potential sites probably exist in higher elevations. A number of private-sector schemes are currently being piloted (REEEP, 2012). Studies have been ongoing on the geographical and technical wind power potential. It is estimated that the total area available for the installation of wind turbines is 10,047 km^2 as shown in Table 3. Table 4 highlights the technical wind potential in Burundi.

Table 3: Burundi's geographical wind power potential

		Grid restriction		No grid restriction	
Country	Total PCS[14] (km^2)	Total available area for wind farms (km^2)	Percentage of area availability	Total available area for wind farms (km^2)	Percentage of area availability
Burundi	27 235	10 047	36.89%	11 941	43.84%

Source: (Mentis, 2013)

Table 4: Burundi's technical wind power potential

Country	Energy (TWh/year) - no grid restriction	Energy (TWh/year) - grid restriction	Energy (TWh/year) - CF > 20%	Electricity TFC (TWh)
Burundi	15.2	12.1	0.0	0.3

Source: (Mentis, 2013)

Geothermal

The Western Rift Valley region on the border of DR Congo has the potential for geothermal resources. Studies to assess commercial viability are necessary (REEEP, undated).

Solar

The potential for solar is great, especially in rural areas, as most regions are not connected to the grid. Some private institutions, such as Solar Electric Light Fund have invested in solar systems for public buildings such as health and education centres (REEEP, 2012). Average solar insolation is 4-5 kWh/m^2/day.

Tracking progress towards sustainable energy for all (SE4All)

Burundi has a very low electrification rate — in 2012 it was only 6.5 per cent (see Table 5 and Figure 4). Only 1.2 per cent of people in rural areas have access to electricity, increasing to 58.5 per cent in urban areas (World Bank, 2016). Almost all (95 per cent) of the electricity consumed is used in Bujumbura. Gitega and Bujumbura are the only two cities that have a municipal electricity service. The national average electricity consumption per capita is only 20 kWh per year (REEEP, undated); thus, alternative fuels to supply the required energy are important. The proportion of people with access to non-solid fuels remained constant at 2 per cent between 1990 and 2012 (World Bank, 2015). Power cuts are a daily occurrence, especially during the dry season. In addition to its low generating capacity, Burundi's energy sector is fraught with a scarcity of technical and management skills impacting the sector's strategic development, effective policy-making and planning and operations of all stakeholders in the energy institutions.

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Burundi economy has been increasing over time from 10.8 MJ per US dollar (2005 dollars at PPP) in 1990 to 13.0 6 MJ per US dollar in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was -2.05 (World Bank, 2015).

Table 5: Burundi's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	0	4	5	6.5		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	2	2		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	82.6	93.2	96.8	96.6		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	-	-	-	-		
	Level of primary energy intensity(MJ/$2005 PPP)	10.8		13.5	13.0	13.29	13.0

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
6.5%	2.0%	NA	96.65%

Bags of tightly packed charcoal

Table 6: Burundi's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Mines • Burundian Agency for Rural Electrification (ABER) • Rural Electrification Agency
Presence of a Functional Energy Regulator	Ministry of Energy and Mines
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Régie de Production et Distribution d'Eau et d'Electricité (REGIDESO), which operates and controls all of Burundi's thermal power stations.
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	National Energy Supply Strategy
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Law No. I/014 of 2000 liberalizes and provides for the regulation of the public services of water and electricity. • A law on PPP (Public Private Partnership) • Law No. 1/24 of 2008 created an investment code encouraging foreign investment. • Law No. 1/23 of 2008 has defined all the tax benefits underway for investors • Decree No. 100/318 of 2011 created the Rural Electrification Agency.

This table was prepared with material from (REEEP, 2012); (ROB, 2015)

The share of renewable energy in the total final energy consumption increased from 82.6 per cent in 1990 to 96.6 per cent in 2012. Traditional solid biofuels form the biggest share of renewable sources at 94.9 per cent of Total Final Energy Consumption (TFEC) in 2012, while modern solid biofuels contributed 0.6 per cent and hydro 1.1 per cent only. Renewable sources contributed 98.2 per cent of electricity capacity in 2012 (World Bank, 2015).

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

In recognition that climate change has the potential to affect almost every sector of the economy, Burundi defined its Intended Nationally Determined Contributions (INDC) targets in September 2015 (Table 6). The country aims to reduce greenhouse gas emissions by 3 per cent compared to the business-as-usual (BAU) scenario for 2030 through implementing a National Reforestation Programme of 4,000 hectares of annual reforestation over the course of 15 years, starting in 2016.

Specifically, for energy, the aim is to increase the national electrification rate to 35 per cent by building an additional three hydroelectric power plants (ROB, 2015).

Institutional and Legal Framework

The Ministry of Energy and Mines is in charge of policy making and regulating the energy sector (Table 6). The Régie de Production et Distribution d'Eau et d'Electricité (REGIDESO) operates and controls all of Burundi's thermal power stations. On a regional level, the country is a member of Eastern Africa Power Pool. The legal framework is provided by the Law No. I/014 of 2000, which liberalizes and provides for the regulation of the public services of water and electricity. Conflict has greatly affected the country's infrastructure as well as energy generation, transmission and distribution systems.

The Energy Strategy and Action Plan guides the sector policy. It contains key objectives to aid the recovery and expansion of the energy sector.

Cameroon

Figure 1: Energy profile of Cameroon

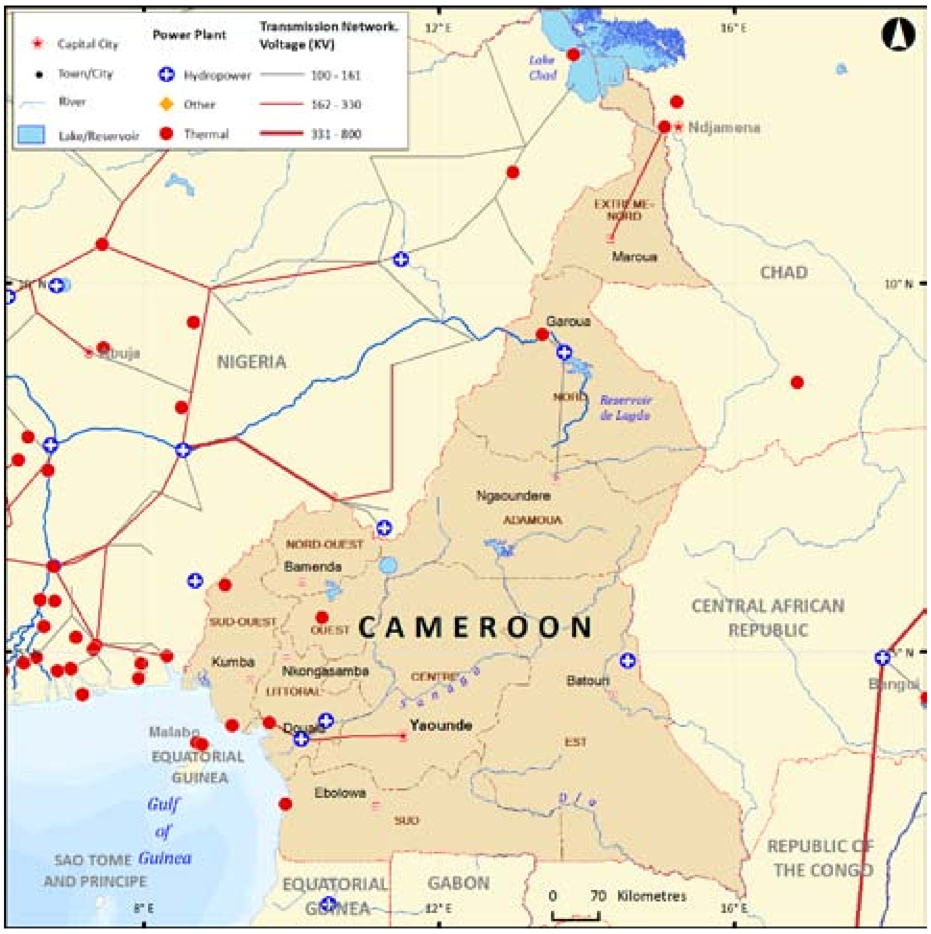
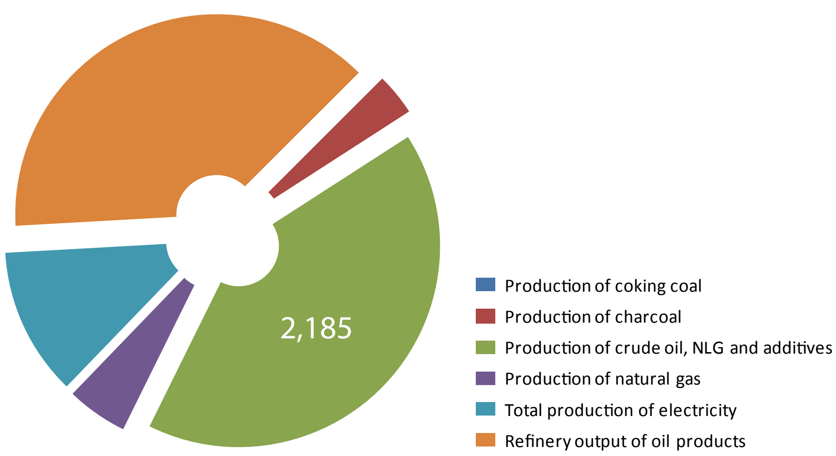
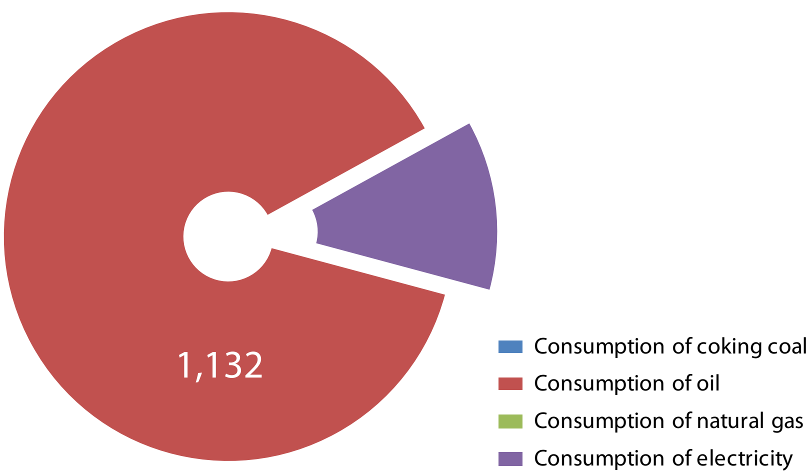


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, the population of Cameroon was 22.25 million (Table 1) (IEA, 2016). Total electricity produced in 2015 was 628 ktoe with 75 per cent of it from hydroelectricity. In 2015, electricity consumption was 526 ktoe; industry consumed 43.3 per cent of this (Table 2). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Cameroon's key indicators

Key indicators	Amount
Population (2013 million)	22.25
GDP (billion 2005 USD)	22.02
CO_2 emission (Mt of CO_2)	5.90

Source: (World Bank, 2015)

Energy Resources

Biomass

Cameroon has 18.8 million hectares of forest, amounting to the third largest biomass potential in sub-Saharan Africa (FAO, 2015); (FUAS, undated). Deforestation is a major issue occurring at a rate of 220,000 ha/yr between 1990 and 2015, with less than 2 per cent of that being replanted annually. Primary uses for biomass in the country include heating and light for the majority of the rural population (REEEP, 2012).

Use of palm oil for biodiesel is also a viable prospect for the country. However, this contributes to deforestation, as forests are often cleared to make way for palm oil farms. In 2010, estimates indicated that palm oil is grown on about 190,000 ha of land (Hoyle & Levang, 2012).

Hydropower

Hydropower is probably the most available form of energy in the country. Technically exploitable hydropower resources are 115,000 GWh, the fourth largest in Africa. The installed capacity in 2011 was 729 MW and actual generation in 2011 was 3,850 GWh (WEC, 2013). Cameroon's major power stations are Lagdo (72 MW), Edéa (263 MW) and Songloulou (388 MW) (FUAS, undated).

Oil and natural gas

According to the EIA, (2015), Cameroon is ranked 47th globally in terms of volumes of reserves and is estimated to have proven reserves of natural gas of 4.8 trillion cubic feet (4,800 bcm). Kribi-Campo basin and Ebome are the major oil fields.

The amount of oil produced has been steadily declining as reserves are depleted. For instance, between 2000 and 2015, the volume of crude oil, natural gas and additives produced declined from 6,860 to 2,185 ktoe (AFREC 2015).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	73	77	157	178
Production of crude oil, NLG and additives	6860	3904	3169	2185
Production of natural gas	0	0	286	259
Production of electricity from biofuels and waste	0	0	5	6
Production of electricity from fossil fuels	3	20	136	146
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	266	336	366	471
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	5	6
Total production of electricity	269	356	512	628
Refinery output of oil products	1548	1821	2182	2025
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	968	976	1108	1132
Final consumption of natural gas	0	0	288	157
Final consumption of electricity	234	300	457	526
Consumption of oil in industry	93	89	118	123
Consumption of natural gas in industry	0	0	0	0
Consumption of electricity in industry	130	124	239	228
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	649	730	857	890
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-5330	-4051	-1037	-489
Net imports of oil product	-547	-833	-699	-205
Net imports of natural gas	0	0	0	0
Net imports of electricity	0	0	0	0

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Peat

Peatland covers an area of 1,077 km^2 (WEC, 2013).

Wind

The potential for wind energy exists in the coastal and northern regions of Cameroon. However, wind speeds are not sufficient to develop sustainable wind energy projects (REEEP, 2012).

Geothermal

There have not been any efforts to seriously develop geothermal energy. However, hot springs are found in many areas, such as the Ngaoundéré, Mt. Cameroon and Manengoumba regions and Lake Moundou (REEEP, 2012).

Solar

Although there is potential for exploitation, solar energy is not widely used across Cameroon with only about 50 installations recorded. These are mainly small-scale localised generation systems and are mostly used for powering the cellular telecommunications network. The average solar irradiance is estimated at estimated at between 4.9-5.8 kWh/day/m^2 (REEEP, 2012). By 2015, combined production of energy from solar and wind amounted to 6 ktoe (AFREC, 2015).

Charcoal market in Yaounde, Cameroon

Tracking progress towards sustainable energy for all (SE4All)

Access to power has steadily improved, increasing from 29 per cent in 1990 to 53.7 per cent in 2012 (Table 3 and Figure 4) (World Bank, 2016). Access to electricity in Cameroon shows a big rural-urban divide: by 2012, 87.5 per cent of the urban population compared to 18.5 per cent of the rural population had access to electricity (World Bank, 2015); (World Bank, 2016). A contributing factor could be the discontinuity of the national grid, thus making the transmission of power between the three separate grids (the Eastern Isolated Grid, the Northern Interconnected Grid and the Southern Interconnected Grid) impossible. The Energy Sector Development Plan 2030 sets a target of 75 per cent total and 20 per cent rural electrification rates by 2030.

In 2012, only 21.93 per cent of Cameroonians were using non-solid fuels; 4 per cent of these are from the rural areas and 41 per cent in urban centres (World Bank, 2015); (World Bank, 2016).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 6.5 MJ per US dollar (2005 dollars at PPP) in 1990 falling to 5.3 MJ per US dollar in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was -4.04 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) decreased from 81.6 to 78.1 per cent between 1990 and 2012. Traditional solid biofuels form the biggest share of renewable sources at 66.3 per cent of TFEC in 2012, while the modern solid biofuels contributed 6.7 per cent and hydro only 5.1 per cent . Renewable sources contributed 73.0 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Cameroon's progress towards achieving SDG7– Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	29	46	49	53.7		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	14	20	22	22		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	81.6	84.5	78.6	78.1		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			7.6	8.2 (2011)		
	Level of primary energy intensity(MJ/$2005 PPP)	6.5		5.7	5.3	5.37	5.28

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

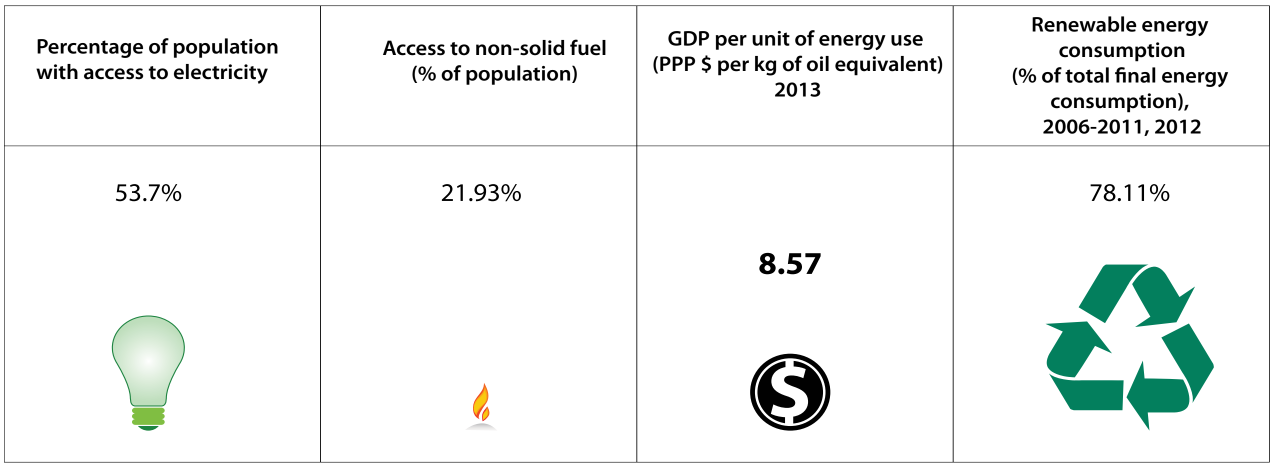


Table 4: Cameroon's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Put in place a regulation on energy efficiency (EE) based on the 2014 "National Policy, Strategy and Action Plan for Energy Efficiency in the Electricity Sector in Cameroon" document with a prospective goal to save 2,250 GWh of energy corresponding to 450MW of installed capacity by 2025
*Create and operationalize the Agency for the Promotion and Rationalization of Energies Utilization (APRUE)
*Develop economic incentives to promote and eliminate barriers to investments in EE
*Interconnect the three existing networks (North, South and East) in Cameroon to optimize transportation and distribution and reduce losses
*Enhance and promote Cameroon's integration and participation in regional energy market through interconnection with the other countries of the region, especially the Central Africa Power Pool (PEAC) and West Africa Power Pool (WAPP) via Nigeria
*Encourage and make regular energy audits compulsory in heavy industries with high energy intensity
*Sensitize and encourage energy audits in small and medium sized enterprises (SMEs); optimize processes by adopting more efficient technologies as well as leveling and erasure
*Assess substitution or optimization potentials (for example cogeneration or recovery)
*Limit losses (through flaring, connections, waste) by implementing regulations, and norms, taxation and incentives;
*Revisit the building code to improve energy performance through construction's thermal and retrofitting norms, and a green certification process
*Train and organize the entire low-energy consumption's construction/renovation value chain
*Regulate and impose energy rating labels for domestic appliances
*Limit constrained mobility and develop low-carbon transportation' supply
*Promote an integrated approach to the transport sector and a low-carbon transport system development through a national transport infrastructure scheme
*Embed a climate/energy dimension into national planning documents as a way to reduce distances, work on the functional mix and propose efficient public transportation policies
*Assist and support the State and local collectivities in the development of intra- and intercity low carbon public transportation plans (E.g.: tramway Yaoundé Douala)
*Encourage the purchase of less polluting vehicles and the systematic ban on very polluting ones through regulations, incentives and prohibitive measures
*Integrate climate change and households waste management, collect and recovery
*Diversify energy supply in a climate change context
Account for climate change in developing tourism and craft industries' activities regarding resources utilization in the craft industry (water, natural resources, etc.), and the development and adaptation to touristic sites
Account for climate change in industry development in Cameroon especially environment/space management, protection of climate-vulnerable areas, energy supplies, water and services, waste and pollution, and GHG emissions

Source: (ROC, 2015)

Table 5: Cameroon's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Mines, Water and Energy Electricity Administration
Presence of a Functional Energy Regulator	Agence de régulation du secteur de l'électricité (ARSEL) Rural Electrification Agency (AER)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Integrated SONEL (Société National d'Eléctricité) National Refining Company (Sonara for Société Nationale de Raffinage) Caisse de stabilisation des prix de hydrocarbures, CSPH) - an oil price stabilization fund Cameroon Oil Storage Company (Société Camerounaise des dépots pétroliers)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	ExxonMobil, Royal Dutch Shell and Total S.A.
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	State owned by Société Nationale des Hydrocarbures
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Policy, Strategy and Action Plan for Energy Efficiency in the Electricity Sector in Cameroon 2014 • Energy Sector Development Plan (PDSE 2030) • Renewable energy policy • Rural electrification master plan
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	• Law No. 98/022 of 24 December 1998 governing the electricity sector • Decree No. 99 /125 of 15 June 1999 to set up the organization and functioning of the Electricity Sector Regulatory Agency • Decree No, 99 /193 of 8 September 1999 to set up the organization and functioning of the Rural Electrification Agency • Decree No. 2000/464/PM of 30 June 2000 governing the activities of the electricity sector

This table was prepared with material from (REEEP, 2012); (MINEE, 2016)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

In September 2015, Cameroon submitted its new climate action plan to the UNFCCC, the energy-related Intended Nationally Determined Contributions (INDCs). The main aim is to reduce greenhouse gas emissions by 32 per cent compared to a business-as-usual scenario for 2035. The commitments are laid out in Table 4.

Institutional and Legal Framework

The Ministry of Water and Energy is in charge of the energy sector. The energy regulator is the Agence de regulation du secteur de l'électricité (ARSEL). The Electricity Development Corporation (EDC) is the sole generator, transmitter and distributor of electric energy. On a regional level, the country is a member of the Central Africa Power Pool. The legal framework is guided by the Law n°98/022 of 24 December 1998 governing the electricity sector.

The main sector policy is the Energy Sector Development Plan known as the PDSE 2030. It focuses on attracting investment and strengthening the energy sector through the development of renewables and especially the hydroelectric sector, since the hydro potential ranks second highest in Central Africa after that of the Democratic Republic of the Congo (DRC) (REEEP, 2012).

Cape Verde

Figure 1: Energy profile of Cape Verde

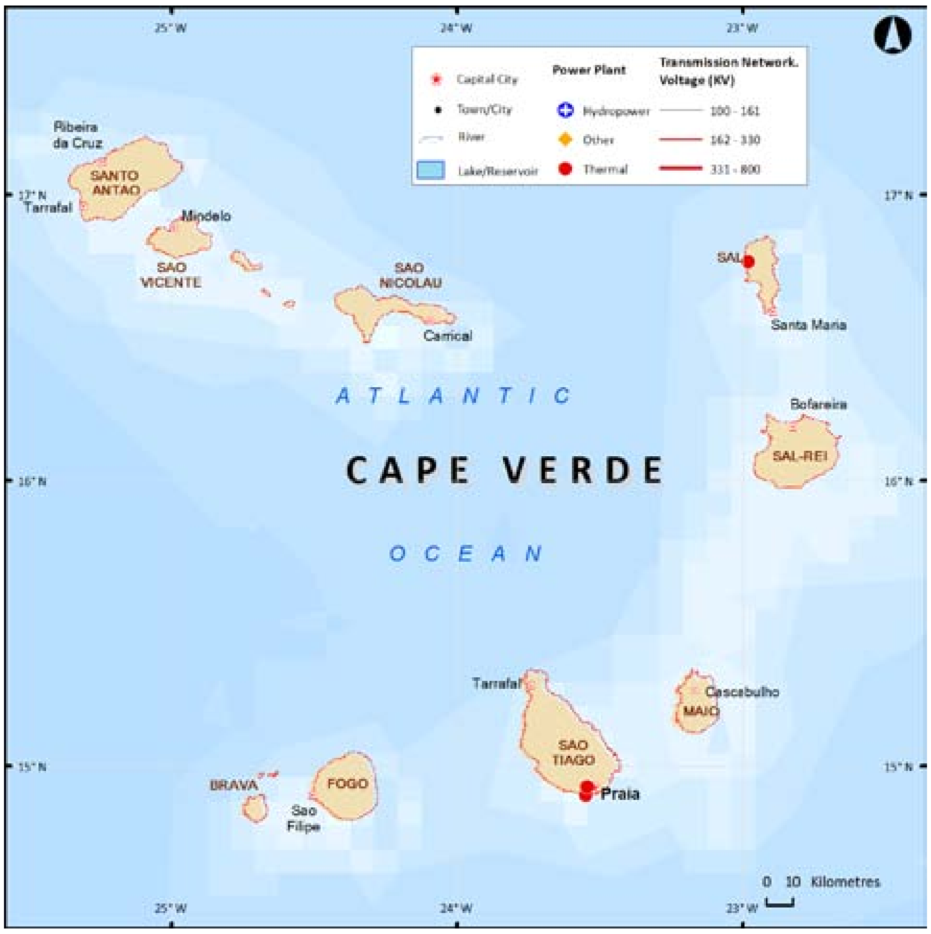
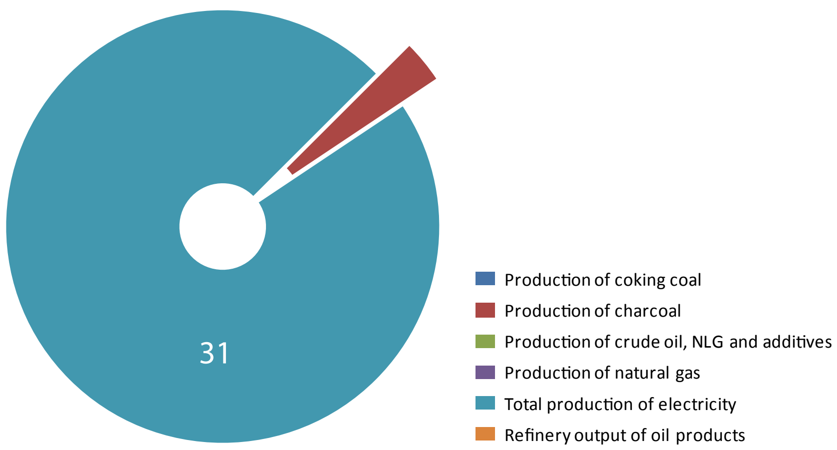
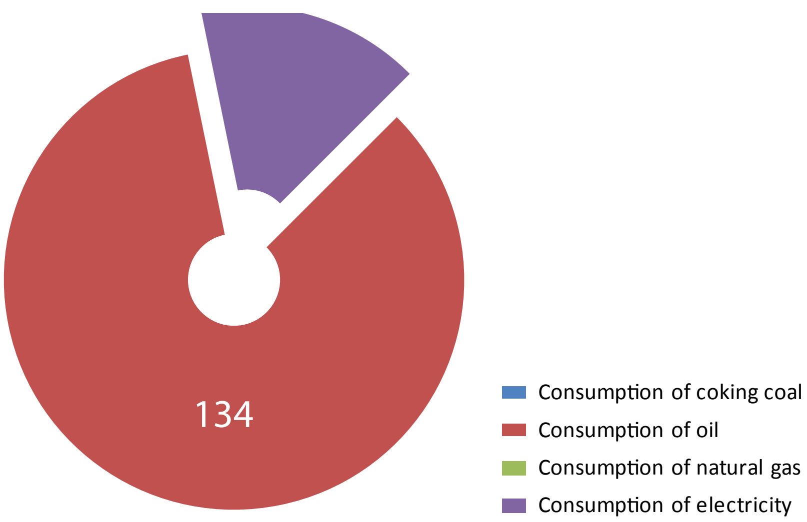


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Cape Verde had a population of just over half a million people in 2013 (Table 1) (World Bank, 2015). Total electricity produced in 2015 was 31 ktoe, 87 per cent of which was generated from fossil fuels (AFREC, 2015). Table 2 shows the main energy statistics. Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Cape Verde's key indicators

Key indicators	Amount
Population (million)	0.507
GDP (billion 2005 USD)	1.37
CO_2 emission (Mt of CO_2)	0.42

Source: (World Bank, 2015)

Energy Resources

Biomass

The biomass potential is low, with total production in 2004 estimated at 22,264 toe. This presents a challenge for rural households where the need for biomass energy for domestic purposes is urgent (REEEP, 2012).

Hydropower

Water resources are limited and this precludes the availability of economically viable hydropower potential. The possibility of harnessing wave power has been considered, with studies indicating a potential of approximately 17 kW/m, mostly around the islands of Sal and Santo Antão (REEEP, 2012).

Oil and natural gas

There are no known crude oil reserves nor oil refining capacity on Cape Verde and all petroleum products have to be imported. There are also no known reserves of natural gas. The Empresa Nacional de Combustíveis (ENACOL) and Shell Cape Verde are responsible for the commercial supply of petroleum products (REEEP, 2012).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	0	1
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	11	19	24	27
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	-
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	1	1	1	4
Total production of electricity	12	19	25	31
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	75	90	133	134
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	11	18	23	25
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	75	90	133	195
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

(AFREC, 2015)

-   : Data not applicable
0   : Data not available
(P): Projected

Wind

Cape Verde has great wind potential, with average wind speeds of 7.5 m/s (REEEP, 2012). According to the Global Wind Energy Council (GWEC, Various years), by the end of 2013, installed wind energy capacity amounted to 24 MW (Table 3). The landscape for investment in the sector shows promise and there is also potential for small scale projects for small electrical grids in remote locations, given the demand for electricity and the electrical grid. Afavourable investment climate for potential developers is needed (REEEP, 2012).

Nuclear

The National Energy Policy (2008) indicates that the government will explore the introduction of micro-nuclear plants for electricity generation.

Geothermal

Data on geothermal potential is limited. Any geothermal investigations have been carried out mainly on Fogo Island where there have been favourable findings of a high-temperature reservoir with a possible 3 MW of geothermal capacity (REEEP, 2012).

Solar

Solar energy potential is very high, estimated at 6 kWh/m^2/day. Based on this, the energy policy target was to use solar to cover 2 per cent of the total energy consumption by 2010, however implementation of this target has been slow. PV is currently used for lighting, water pumping and telecommunication systems (REEEP, undated).

Table 3: Installed wind power capacity in Cape Verde (MW)

Region	Year						
	End 2007	End 2008	End 2009	End 2010	End 2011	End 2012	End 2013
Cape Verde		12	12	2	24	24	24
Africa	539	635	866	1,065	1,033	1,165	1,602

(GWEC, Various years)

Tracking progress towards sustainable energy for all (SE4All)

National access to electricity in Cape Verde stands at 70.6 per cent : 46.8 per cent in rural areas and 84.4 per cent in urban areas (World Bank, 2016) (Table 4 and Figure 4). Access to modern fuels is 33 and 88 per cent in rural and urban areas, respectively (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Cape Verde economy was 3.5 MJ per US dollar (2005 dollars at PPP) in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was 11.77 (World Bank, 2015).

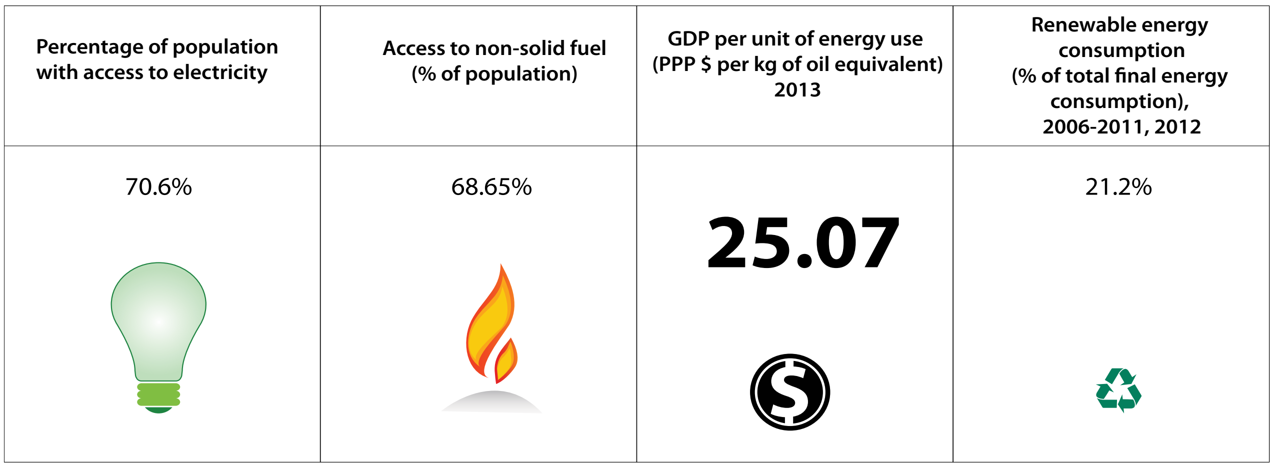
The share of renewable energy in the total final energy consumption (TFEC) is very low. In 2000, it was 1.7 per cent of total final energy consumption, increasing to 18.2 per cent in 2012. Traditional solid biofuels form the biggest share of renewable sources at 17.5 per cent of TFEC in 2012, while wind contributed 0.7 per cent . Renewable sources contributed 5.5 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 4: Cape Verde's Progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	58	59	67	70.6		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	46	59	67	68.65		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption		1.7	1.5	18.2		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	19.5		26.61 (2007)			
	Level of primary energy intensity(MJ/$2005 PPP)	4.8		2.8	3.5	3.28	3.49

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators



Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Cape Verde's energy-related Intended Nationally Determined Contributions (INDCs) targets stated in September 2015 are shown in Table 5. The government is aiming for a Low Carbon Development Strategy.

Table 5: Cape Verde's Key aspects/key mitigation measures to meet its energy Intended Nationally Determine Contributions (INDCs)

INDC
*Enhance smart-grid installation for the country's nine independent networks with state-of-the-art power conditioning, production and distribution control;
*Built-up of energy storage facilities (including through batteries and flywheels);
*Design renewable micro-grids;
*Design individual energy systems (home solar systems); and
*Systematically deploy solar-water-heaters across all islands.
*Find ways to reduce the proportion of technical and non-technical losses in energy distribution from about 25 per cent in 2010 to less than 8 per cent by 2030 or before;
*Improve energy efficiency of large consumers, with particular focus on hotels, hospitals and public administration offices by 2030 or before, including through mandatory installation of solar-water-heater components;
*Achieve 30 per cent of efficiency improvement in the use of electric power (15 per cent residential, 15 per cent commercial);
*Improve by at least 10 per cent fuel-usage across sectors and modes of application (except butane usage) by 2030 or before;
*Improve energy performance of the building envelop and implement a green building code, with the goal to cover all new (public or private) buildings by 2030 or before;
*Enhance energy efficiency of street lighting and creating energy rating labels for domestic appliances and air conditioners by 2030 or before;
*Further promote the use of smaller distributed energy solutions (e.g. solar pumps) for water pumping, distribution and irrigation;
*Promote the built-up of a comprehensive network of energy services companies (ESCOs) and clean-energy business incubators.

Table 6: Cape Verde's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• The Ministry of Tourism, Industry and Energy (MTIE) • Directorate General of Energy • Economic Regulatory Agency (ARE) • National Water and Electricity Company (ELECTRA) • Renewable Energy Research Group (NER)
Presence of a Functional Energy Regulator	Economic Regulatory Agency (ARE)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Electricity production is liberalised
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	• Empresa Nacional de Combustíveis (ENACOL) • Shell Cape Verde
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Renewable Energy Master Plan • Sectoral Renewable Energy Plan • National Energy Policy of 2008 • National Energy Plan for 2003-2012 • Energy Security Fund • ECOWAS Regional Renewable Energy Policy
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	• Decree-Law (DL) No.26/2003 creating Economic Regulator Agency (ERA) • DL No. 14/2006 (which revises the DL No. 54/99 sets the foundation for the electricity system in Cape Verde. • Decree-law No.30/2006 on Independent Producer licensing • Ordinance No.18/2006 on Power Producers Guarantees • Ordinance No.21/2006 on tariff and payment procedure of the fees for Independent Producers • DL No. 41/2006 defining the Electric Energy Crisis and specifying corrective measures • DL No. 4/VII/2007 (in Art. 54) allows for free customs duties on imports of equipment and accessories for renewable energy • DL No.1/2011 on Promotion and Incentive for the Use of Renewable Energy

This table was prepared with material from (REEEP, 2012); (UNIDO and ECREEE, Undated) and (Fonseca, 2014)

Institutional and Legal Framework

The Ministry of Tourism, Industry and Energy (MTIE) is in charge of the energy sector (Table 6). The energy regulator is Economic Regulatory Authority (ARE). ELECTRA (Empresa de Electricidad e Agua) is the national power utility company, the sole generator, transmitter and distributor of electric energy. On a regional level, the country is a member of the West African Power Pool. The legal framework is provided by the Decree-Law No. 14/2006 (which revises the DL No. 54/99) that sets the foundation for the electricity system in Cape Verde. The main sector policy is the National Energy Policy of 2008. There is also a National Energy Plan for 2003-2012.

Central African Republic

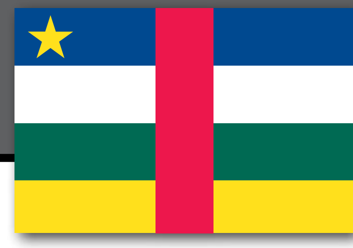


Figure 1: Energy profile of the Central African Republic

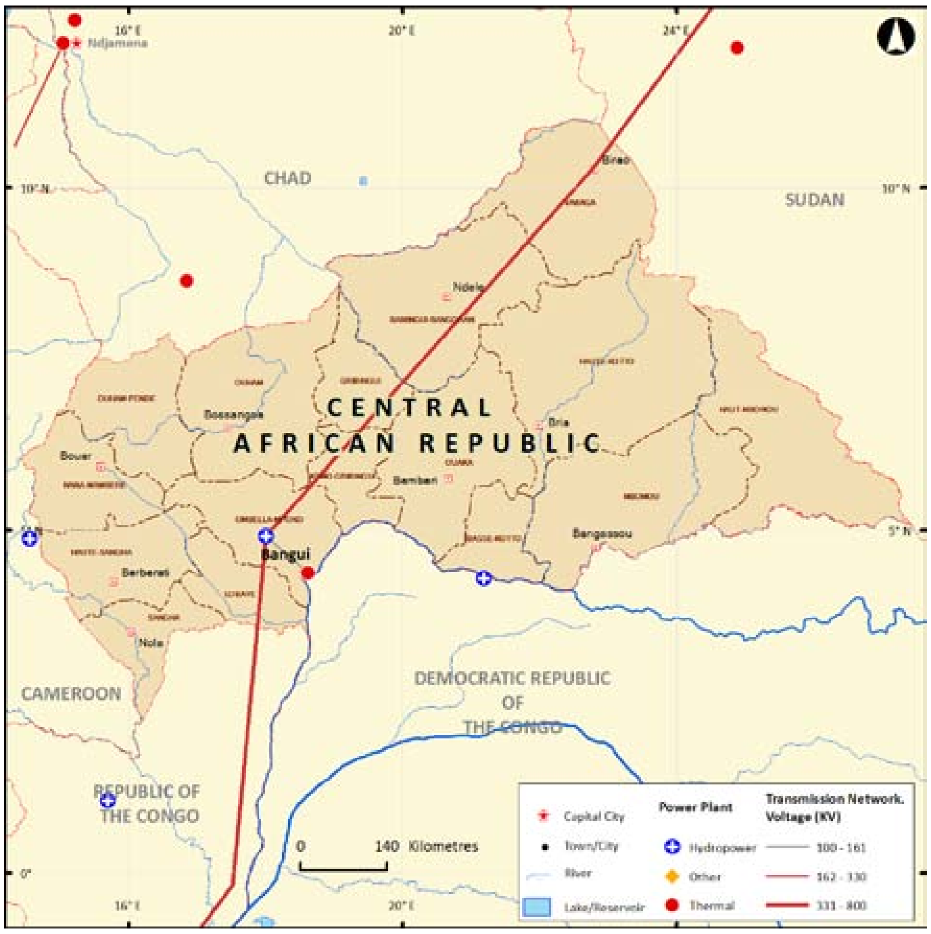
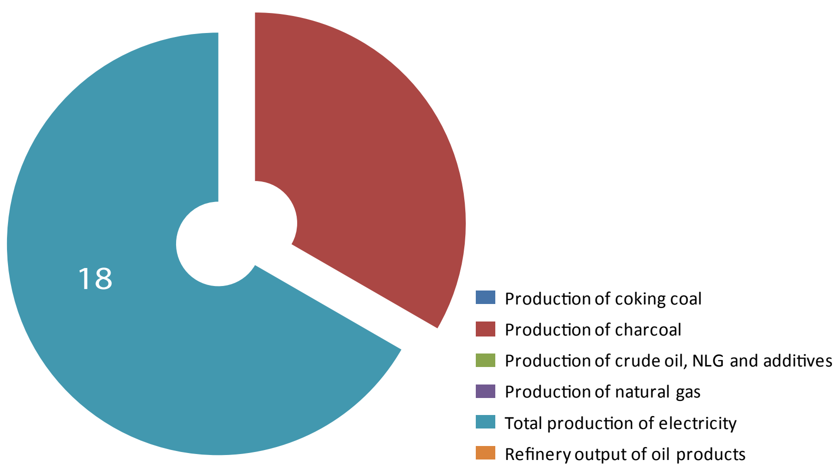
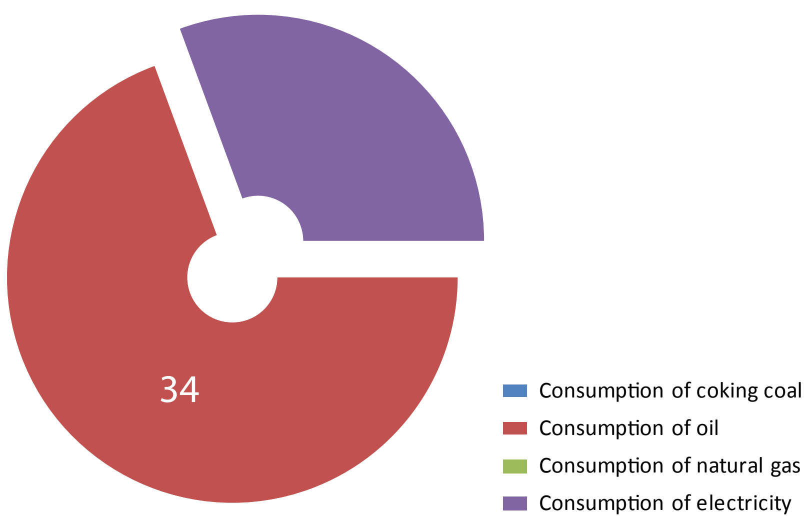


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

The Central African Republic had a population of 4.7 million people in 2013 (Table 1) (World Bank, 2015). Electricity production in 2015 was 18 ktoe with 88.8 per cent of it generated from hydro. Final electricity consumption in 2015 was 15 ktoe (AFREC, 2015). Table 2 shows the main energy statistics. Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Central African Republic's key indicators

Key indicators	Amount
Population (million)	4.71
GDP (billion 2005 USD)	1.07
CO_2 emission (Mt of CO_2)	0.3

Source: (World Bank, 2015)

Energy Resources

Biomass

Estimates indicate that 50 per cent of the country is forested and of this, 10 per cent is currently being used to supply energy needs. Against this background, the biomass intensity is currently deemed to be sustainable (REEEP, 2012).

Hydropower

The Central African Republic has great hydroelectric power, estimated at 2,000 MW (MMEH, 2013). Existing power stations include the Boali I (8.75 MW), Boali II (10 MW) and Boali III (10 MW). Other large hydropower installations are the 300 MW Palambo project, north of Bangui. There is also potential for small hydropower in Baboua, Bambari, Bangassou, Berbérati, Bocaranga, Bossangoa, Bouar, Bria, Carnot, Kaga-Bandoro, Kembe, Mbaîki, Ndélé, Paoua and Sibut (REEEP, 2012).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	4	4	141	9
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	2	2	2	2
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	7	12	12	16
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	9	14	14	18
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	0	43	43	34
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	8	7	13	15
Consumption of oil in industry	0	4	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	3	3	2
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	27
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	0	40	0	28
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Oil and natural gas

The country does not currently produce either petroleum or natural gas and petroleum needs are met through imports of refined products. Most of the population depends on traditional biomass to meet their energy needs. Energy self-sufficiency for the country stood at approximately 91 per cent in 2008 (REEEP, 2012).

Peat

The country has 100 km^2 of peatland (WEC, 2013).

Wind

Wind speeds above 5 m/s exist implying the potential for wind energy. But so far, wind power use is still largely uncharted (REEEP, 2012).

Geothermal

No study has currently been undertaken to determine the geothermal potential of the Republic (REEEP, 2012) been favourable findings of a high-temperature reservoir with a possible 3 MW of geothermal capacity (REEEP, 2012).

Solar

The average horizontal irradiation, which reaches 6.0 kWh/m^2/day in some areas, makes solar power a viable option. Global irradiance ranges from 2,000 to 2,400 kWh/m^2. Potential applications are in pumping for water supply, telecommunication systems, household lamps, radios, televisions, telephone recharging and small computing equipment (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

Access to electricity in the Central African Republic is one of the lowest in Africa, with access for 8.2 per cent and 14.8 per cent of rural and urban people respectively (Table 3 and Figure 4) (World Bank, 2016). A number of reasons conspire to explain the sector's slow growth, including low population density, the country's large size, years of social unreset and weak institutions in the energy sector.

Access to modern fuels is also low. In 2012, only 2 per cent of the rural population was using non-solid fuels and 3 per cent in urban areas had access to modern fuels (World Bank, 2015).

The Central African Republic's economy energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 7.2 MJ per US dollar (2005 dollars at PPP) in 2012, down from 13.8 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010 and 2012 was -0.42 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) increased from 81.0 to 94.0 per cent between 2010 and 2012. Traditional solid biofuels form the biggest share of renewable sources at 37.8 per cent of TFEC in 2012, while modern solid biofuels contributed 53.4 per cent and hydro only 2.8 per cent. Renewable sources contributed a 74.1 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Central African Republic's progress towards achieving SDG7– Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	3	6	10	10.8		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	3	3.22		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	93.9	86.0	81.0	94.0		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)	13.8		7.2	7.2	7.10	7.16

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
10.8%	3.22%	NA	78.37%

Table 4: Central African Republic's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Implement the National programme for advanced conversion of wood.
*Implement the National programme for reforestation and rehabilitation of post-exploitation areas.
*Build a photovoltaic solar power plant at Bangui.
*Develop a 180 MW Dimoli hydroelectric plant (integration project).
*Develop the 72 MW Lobaye hydroelectric plant.
*Develop the 60 KW La Kotto hydroelectric plant.
*Develop the Mobaye hydroelectric plant (integration project).
*Implement the National Rural Electrification Programme.
*Build a sluice dam along the Ubangi at Zinga.
*Implement improved cook stoves programme.
*Implement the National Biofuels Programme.
*Implement the Programme for the reduction of short-lived climate pollutants.
*Ensure the promotion of energy saving light bulbs.

Source: (ROC, 2015)

Table 5: Central African Republic's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Mines, Energy and Hydraulics • Rural Electrification Agency
Presence of a Functional Energy Regulator	• Autonomous Agency for the Regulation of the Electricity Sector (ARSEC)
	• Autonomous Agency Rural Electrification (ACER)
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Central African Power Pool (CAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	State owned vertically integrated Energie Centrafricaine (ENERCA)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	• Central African Oil Products Storage Company (SOCASP) • Oil Product Price Stabilization and Regulation Agency (ASRP)
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	National Energy Policy
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Order No. 05.001 of 1 January 2005 - the Electricity Code • Decree No. 05.272 of 11 September 2005 stipulates the roles of ARSEC • Decree No. 05.273 of 11 September 2005 operationalises ACER • Decree No. 10.092 of March 18, 2010 legalising the energy policy

This table was prepared with material from (MMEH, 2013); (REEEP, 2012) and (WTO, 2013)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

In September 2015, the country submitted its Intended Nationally Determined Contributions (INDCs). The INDCs guide the country on a sustainable, low-carbon development pathway while strengthening the resilience of the agriculture, food security, natural resources, health and infrastructure sectors against the impacts of climate change. Table 4 shows those related to energy.

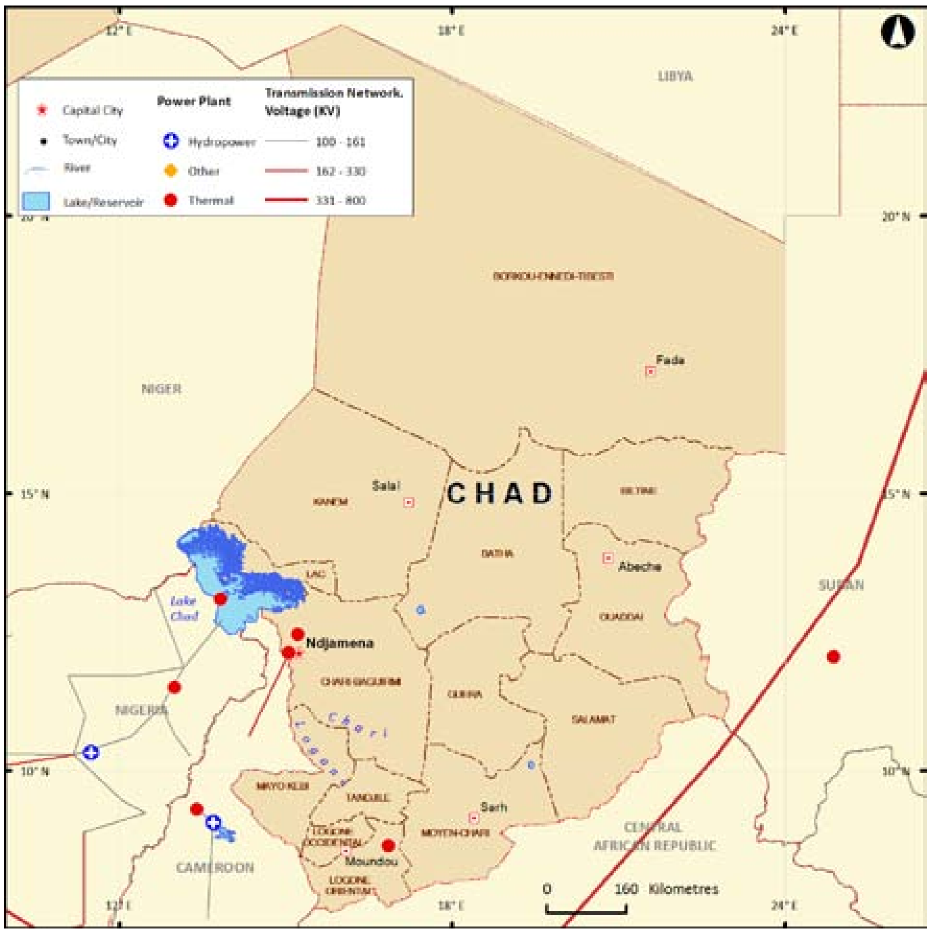
Institutional and Legal Framework

The Ministry of Mining, Energy and Hydraulics is in charge of the energy sector. The energy regulator is the Autonomous Agency for the Regulation of the Electricity Sector (ARSEC). The state-owned vertically integrated ENERCA (Énergie Centrafricaine) produces, distributes and sells electricity. On a regional level, the country is a member of the Central Africa Power Pool (CAPP). The legal framework is provided by the Order No. 05.001 of 1 January 2005 - the Electricity Code (Table 5).

The Energy Policy 2004 guides the sector and is keen on developing renewable energies as one of the strategies to address poverty and to encourage a low carbon development pathway through reducing emissions by 5 per cent compared to the business-as-usual reference level of 5,498.3 kt eq-CO_2 of avoided emissions at the 2030 horizon.

Chad

Figure 1: Energy profile of Chad



Energy Consumption and Production

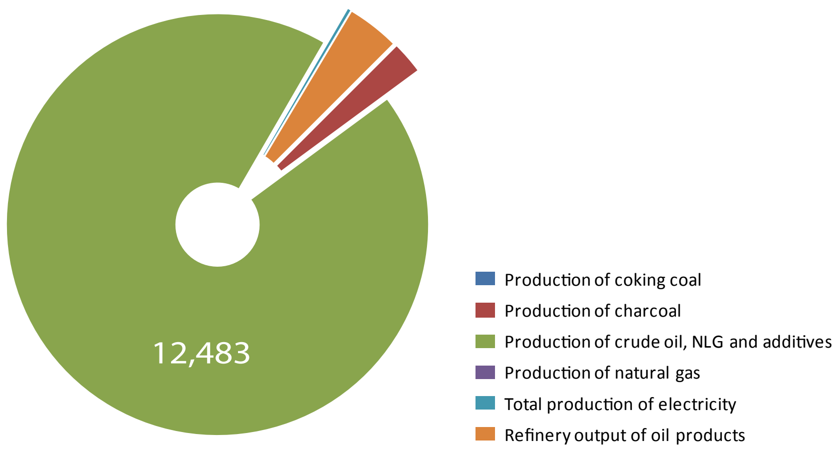
In 2013, Chad had a population of 13.14 million (Table 1). Although crude oil has become the country's primary source of export earnings, energy access for the population is very low. Electricity production in 2015 was 28 ktoe with 96.4 per cent of it generated from fossil fuels. Final electricity consumption in 2015 was 20 ktoe (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3 while key energy statistics are shown in Table 2.

Table 1: Chad's key indicators

Key indicators	Amount
Population (million)	13.14
GDP (billion 2005 USD)	9.70
CO_2 emission (Mt of CO_2)	0.53

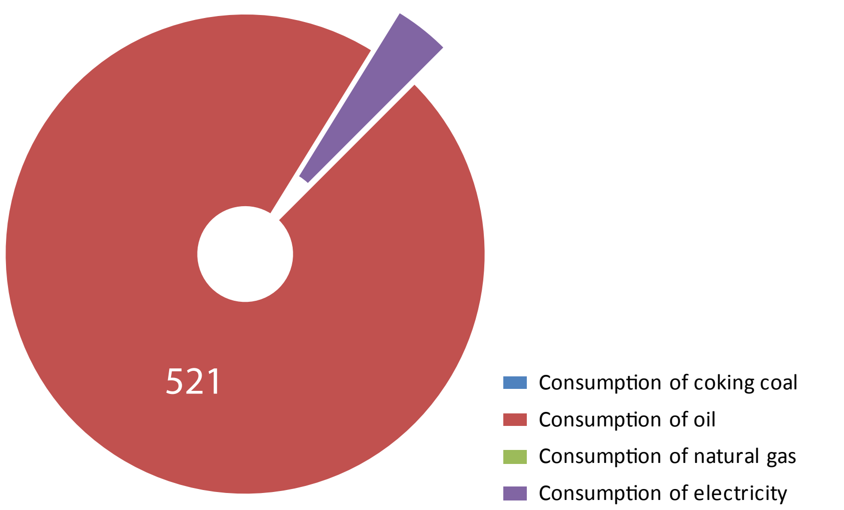
Source: (World Bank, 2015)

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Resources

Oil

Chad has the 10th largest oil reserves in Africa, estimated at 1.5 billion barrels of oil in 2013 (Table 3) (EIA, 2013). Chad started commercial oil production in 2003, when the 1,070 km Chad-Cameroon pipeline (CCP) was finished, allowing exports from the oil fields in the Doba Basin of southern Chad

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Oil well, Chad

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	412	497	296	319
Production of crude oil, NLG and additives	-	8164	5721	12483
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	8	9	9	27
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	-
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	8	9	9	28
Refinery output of oil products	-	-	0	525
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	72	126	252	521
Final consumption of natural gas	0	1	0	0
Final consumption of electricity	7	7	8	20
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-8206	-5871	-11814
Net imports of oil product	72	126	252	28
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

through Cameroon to a new terminal at Kribi at the Atlantic coast. The 20,000 bbl/d N'Djamena refinery began supplying the local market with petroleum products in 2011. Output peaked at around 170 kb/d in 2004, but stood at 130 kb/d in 2013 (OECD/IEA, 2014). Chad exports more than 85 per cent of her oil production via the Chad-Cameroon Pipeline (WEC, 2013).

Natural gas

There are no known reserves of natural gas.

Peat

There are 10 km^2 of peatland (WEC, 2013).

Wind

Chad is thought to have large on-shore wind potential (Buys, Deichmann, Meisner, Ton-That, & Wheeler, 2007). This is unusual for a land-locked country, but in this case, Chad's topography gives rise to high-speed winds at certain high altitudes, thus enabling the potential for wind energy generation (Mukasa, Mutambatsere, Arvani, & Triki , 2013)

Solar

There is also the potential for solar energy generation in Chad, especially in the north. The private sector is just beginning to get involved. For example, Starsol Solar PV has invested in a plant near N'Djamena to generate about 40 MW.

Table 3: Chad oil resources and reserves, (billion barrels)

Region	Proven reserves end 2013	Ultimately recoverable resources	Cumulative production end 2013	Remaining recoverable resources	Remaining per cent of ultimately recoverable resources
Sub Saharan Africa	65	258	55	203	79
Central Africa	7	47	10	37	78
Chad	1.5	3.4	0.5	2.9	84

Source: (OECD/IEA, 2014)

Tracking progress towards sustainable energy for all (SE4All)

Chad has one of the lowest electrification rates in Africa, as shown in Table 4 and Figure 4. In 1990, there were no electricity connections; by 2012, 6.4 per cent of the population had access. When disaggregated by location, 3.1 per cent of rural areas were electrified compared with 18.3 per cent of urban areas (World Bank, 2016). Access to non-solid fuels is also very low, with only 4.79 per cent using modern fuels —2 per cent in rural areas and 10 per cent in urban areas (World Bank, 2016).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Chad economy was 3.6 MJ per US dollar (2005 dollars at PPP) in 2012, down only slightly from 3.6 MJ per US dollar in 2010. The compound annual growth rate (CAGR) between 2010 and 2012 was -2.26 (World Bank, 2015).

Renewables almost totally dominate the energy mix, with a 90.4 per cent share in the total final energy consumption (TFEC), which decreased slightly from 94.5 to 93.5 per cent between 2010 and 2012. Traditional solid biofuels form the biggest share of renewable sources at 89.1 per cent of TFEC in 2012, while the modern solid biofuels contributed just 1.3 per cent (World Bank, 2015).

Table 4: Chad's progress towards achieving SDG7– Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	0	2	4	6.4		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	5	5	4.79		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	95.1	97.9	92.3	90.4		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	-	-	-	-		
	Level of primary energy intensity(MJ/$2005 PPP)	7.9		3.7	3.6	3.80	3.56

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
6.4%	4.79%	**NA**	90.61%

Magharebia / Foter / CC BY

Table 5: Chad's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Develop renewable energies for the agriculture and pastoral sectors
*Execute the project of Interconnection of Chad-Cameroon power grids to supply Chad with hydro-generated energy of 500 GWh
*Increase the production of solar energy to 200 GWh/year, i.e. : 140 MW/year
*Increase the production of wind energy up to 50 GWh/year
*Execute the construction of a national 225 KV line to interconnect all cities
*Build cross-country power grid (between adjacent cities)
*Promote the use of butane gas and efficient domestic energy

Source: (ROC, 2015)

Table 6: Chad's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Petroleum • Agency for Renewable Energy Development (ADER)
Presence of a Functional Energy Regulator	Electric Energy Authority
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	• Société Nationale d'Electicité (SNE) • Société des Hydrocarbures du Tchad • National Commission for the Negotiation of Petroleum Agreements (CNRCP)
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Central Africa Power Pool (CAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Société des Hydrocarbures du Tchad (Chad Hydrocarbons Company) was created in 2006 (for exploration, production and marketing of hydrocarbons and petroleum products, and the negotiation of oil contracts).
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Major players include ExxonMobil, Chevron, Petronas, Total, Shell, and Perenco.
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	Energy Master Plan
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	Act No. 014/PR/99 establishes the regulatory authority

This table was prepared with material from (MMEH, 2013); (REEEP, 2012) and (WTO, 2013)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Chad has published its INDC targets, which include activities to improve environmental management through tree planting and pursuing a low carbon development pathway to reduce greenhouse gas emissions and contribute to addressing climate change. The activities are all targeted on moving away from an oil-based economy to one based on more sustainable models of renewable energy. The targets are highlighted in Table 5.

Institutional and Legal Framework

The Ministry of Energy and Petroleum is in charge of the energy sector. The energy regulator is the Electric Energy Authority. The Société Nationale d'Electicité (SNE) is the sole generator, transmitter and distributor of electric energy. On a regional level, the country is a member of the Central African Power Pool. The legal framework is provided by Act No. 014/PR/99 (Table 6).

The energy sector is guided by a strategic framework on the improved management and governance of the energy sector. It aims to meet the energy needs of the population and expand access for industrial and agricultural production.

Comoros

Figure 1: Energy profile of Comoros

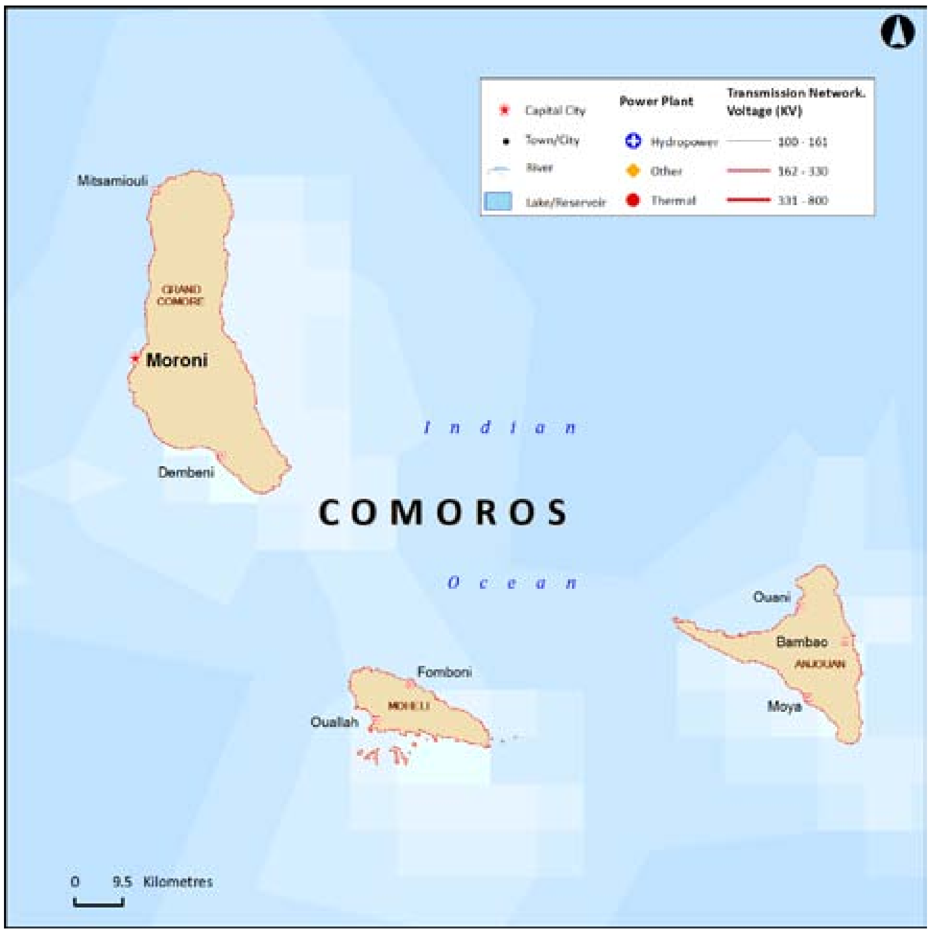
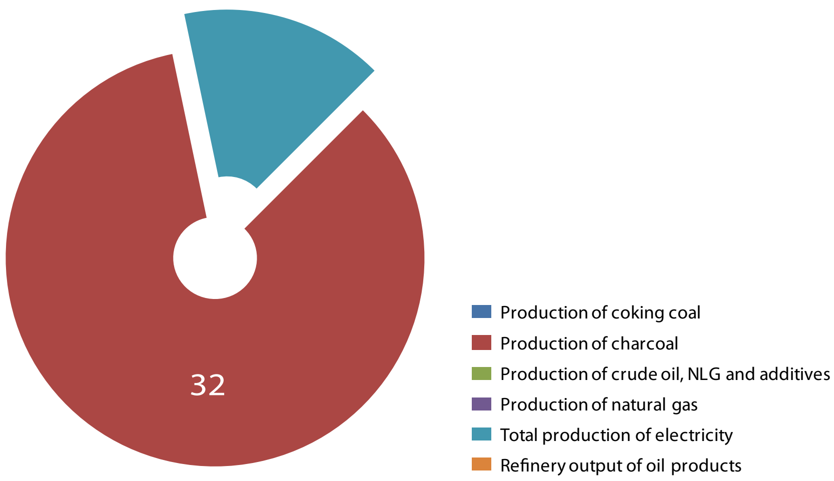
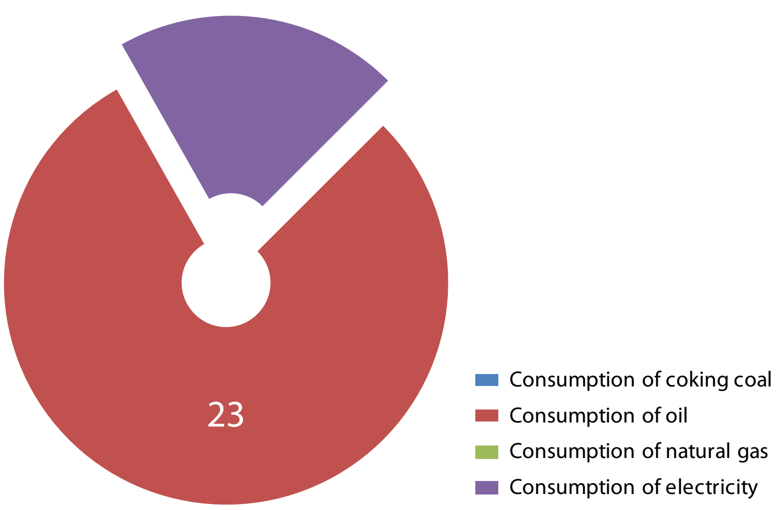


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, the population of the Comoros was 13.1 million people (Table 1) (World Bank, 2016). Electricity production in 2015 was 6 ktoe, with all of it generated from fossil fuels. Final electricity consumption in the same year was 6 ktoe (AFREC, 2015). Table 2 shows the main energy statistics. Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Comoros's key indicators

Key indicators	Amount
Population (million)	13.1
GDP (billion 2005 USD)	0.46
CO_2 emission (Mt of CO_2)	157.6

Source: (World Bank, 2015)

Energy Resources

Biomass

Biomass (wood and charcoal) is used to provide about 70 per cent of energy use in the Comoros. Other plants being explored for generating biomass energy include oilseed plants, such as coconut, sesame, peanut and *Jatropha curcas* (REEEP, 2012).

Hydropower

Although there is some hydroelectric potential, the islands have only about 1 MW of installed hydroelectric capacity (REEEP, 2012). More study is required to fully assess the country's available potential. There have been calls to create a national hydrographic and bathymetric service in the past (REEEP, 2012).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	0	32
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	2	4	3	6
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	0	0	0	0
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	2	5	3	6
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	35	38	44	23
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	2	4	3	6
Consumption of oil in industry	0	0	0	3
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	13
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	32	38	44	36
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

-   : Data not applicable
0   : Data not available
(P): Projected

(AFREC, 2015)

Oil and natural gas

The country has no known oil or gas reserves and hence has no upstream sector.

Wind

The potential for wind power in the Comoros is low. Measurements indicate that wind speeds rarely go above 3 m/s, the average required to drive a wind generator. For instance, two wind turbines set up in Ngazidja in 1985 (one on the eastern coast at Mtsangadju ya Dimani and the other on the northern coast at Wella) to drive groundwater pumps have not provided the volumes of water originally estimated (REEEP, 2012).

Geothermal

The potential for the Comoros to meet all its energy demands from geothermal sources is high. The key indicator of a potentially exploitable geothermal system on Grande Comore is the presence of a rift system associated with the active volcano. This geological structure along with other measurements, including surface thermal discharges and a geophysical survey, suggest that an active geothermal system is present. Currently the three islands: Grand Comore, Moheli and Anjouan, are being mapped by the Australian Sinclair Knight Merz (SKM) and New Zealand-based Gafo Energy. If successful, Gafo will operate the power installations. Recent analysis by engineers from KenGen, the Kenyan national utility, indicate that both the Karthala and La Grille volcanoes on Grand Comore have great geothermal potential, with reservoir temperatures taken at both sites of up to 300°C, at depths of 2,000 m and deeper (REEEP, 2012). But more data is required to determine the dimensions of both the geothermal reservoir and the heat source and the potential to develop it for power generation (Houmadi & Chaheire, 2015).

Solar

Solar has great potential on these islands since they experience an average of 5.0 kWp/m^2 or 2,880 hrs/yr of sunshine. There are a number of solar installations at domestic and commercial levels. For instance, the World Bank supported a local energy company called ENERCOM to implement about 100 installations on the three islands. There are also a number of hotels implementing solar as a means of reducing their ecological footprint (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

Just less than 70 per cent of the population of the Comoros has access to electricity: 61.4 per cent in rural areas and 85.1 per cent in urban areas (Table 3 and Figure 4). There are also access disparities between the three islands. For instance, the electrification rate on Grande Comore is 53.6 per cent , while on Mohéli it is 28.4 per cent and on Anjouan 22.6 per cent (REEEP, 2012). About a quarter of the population uses modern fuels, and of these, 10 per cent are in rural areas and 54 per cent in urban areas (World Bank, 2015); (World Bank, 2016).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the economy of the Comoros was 4.0 MJ per US dollar (2005 dollars at PPP) in 1990, increasing to 6.1 MJ per US dollar in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was 3.29 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) has been increasing from a low of 1.0 in 1990 to 46.1 in 2012. Hydropower forms the biggest share of renewable sources at 0.5 per cent of TFEC in 2012. Renewable sources contributed 11.5 per cent share of electricity generation in 2012 (World Bank, 2015).

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Electricity production is expensive as almost three quarters of the cost goes to diesel fuel. The total installed capacity is 22.6 MW and

Table 3: Comoros's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	42	45	52	69.3		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	12	21	25	25.52		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	1.0	1.0	1.3	46.1		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	36.9					
	Level of primary energy intensity(MJ/$2005 PPP)	4.0		5.8	6.1	6.10	6.14

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

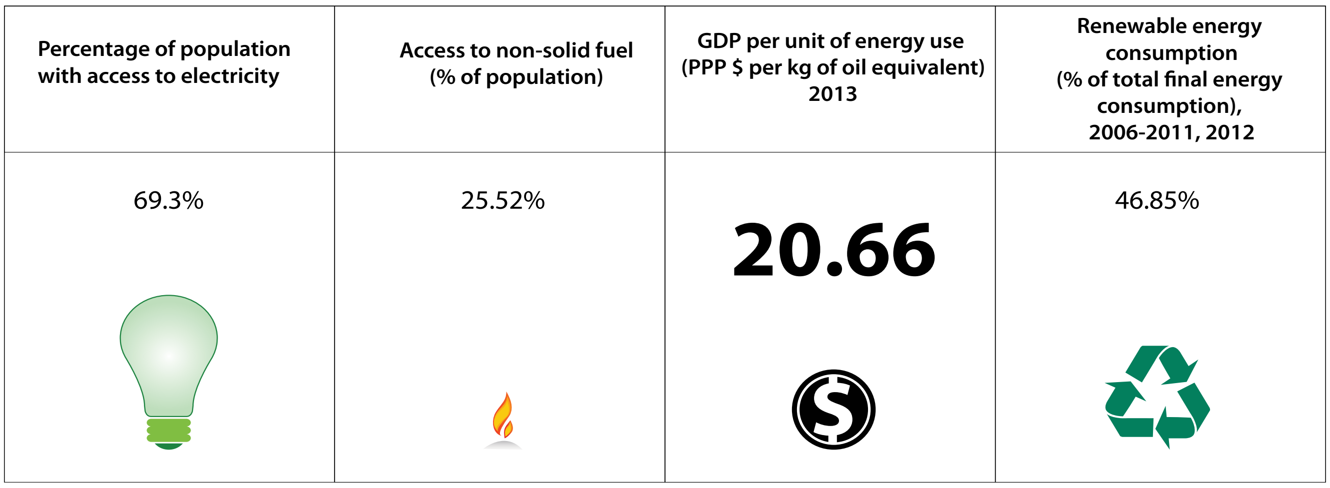


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Table 4: Comoros's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Reduce losses on the electricity distribution grid.
*Rehabilitate power plants.
Increase solar energy generation.
*Increase hydro generation potential.
*Produce geothermal energy.
*Promote LPG use in lieu of kerosene and fuel wood.
*Promote the use of improved cooking stoves under the framework of reduced fuel wood use plan.

Source: (ROC, 2015)

Table 5: Comoros's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Planning • Société Comorriene des Hydrocarbures
Presence of a Functional Energy Regulator	
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	• Société Comorriene des Hydrocarbures • Gestion de l'Eau et de l'Electricité aux Comores (MAMWE) • Electricité d'Anjouan (EDA)
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Gestion de l'Eau et de l'Electricité aux Comores (MAMWE) is vertically integrated
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Comor Hydrocarbures is state owned and has monopoly over oil and gas imports
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Document de politique de l'energie électrique et des produits pétroliers de l'Union des Comores • Poverty Reduction and Growth Strategy Paper (PRGSP) • Renewable Energy Policy 2008 • Strategy and Energy Action Plan 2013 • National Energy Sector Strategy 2012
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Petroleum Code 2012 • Constitution of 2009

This table was prepared with material from (REEEP, 2012); (UOC, undated) and (World Bank, 2013)

the effective capacity is 13 MW. The monthly consumption on Grande Comore only is 3,782.7 KWh. These high costs make the possibility of switching or incorporating more renewable into the energy mix very attractive (Houmadi & Chaheire, 2015). The development of alternative renewable energy is fundamental to the Intended Nationally Determined Contributions articulated by the Comoros in 2015 (Table 4).

Institutional and Legal Framework

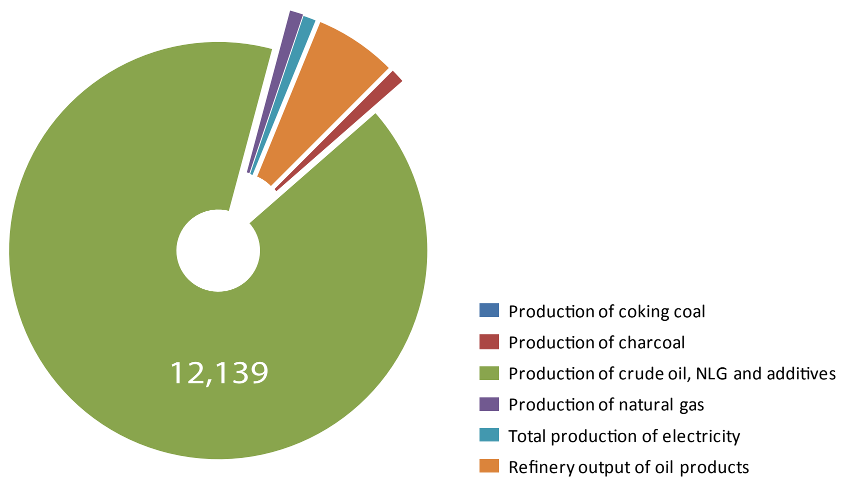
There is no government ministry in charge of the energy sector; however the Ministry of Planning monitors the hydrocarbons sector. The *Gestion de l'Eau et de l'Electricité aux Comores* (MAMWE) is the state-owned utility, in charge of the generation and distribution of electricity on the islands of Grand Comore and Moheli. Electricité d'Anjouan (EDA) is responsible for electricity generation and distribution Anjouan island. Both companies also regulate the energy industry on their respective islands. The Comoros does not participate in any regional power pools. The legal framework is guided by the 2009 Constitution and the Petroleum Code 2012 (Table 5).

The main sector policy is the National Energy Sector Strategy of 2012; along with the Poverty Reduction and Growth Strategy Paper (PRGSP), both set ambitious targets for access to energy and electricity.

Cote d'Ivoire

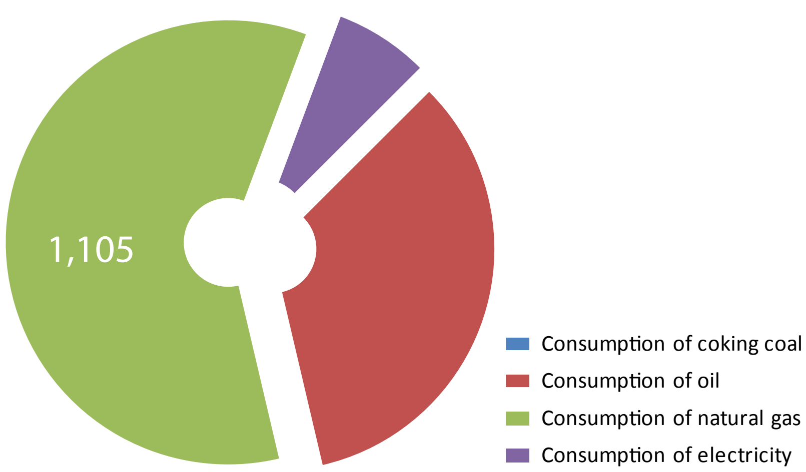
Figure 1: Energy profile of Côte d'Ivoire

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Côte d'Ivoire had a population of 20.32 million (Table 1) (IEA, 2016). Energy is a growth industry in Côte d'Ivoire. The country is an important supplier of energy to the region due to the excess electricity it generates, and its reserves of natural gas and recent offshore finds of oil and natural gas. Electricity production in 2015 was 648 ktoe with 66.5 per cent produced from fossil fuels and 31 per cent from hydro sources. Final consumption of electricity in the same year was 774 ktoe with industry consuming 19.2 per cent and transport consuming 99 per cent of electricity produced (Table 2) (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Côte d'Ivoire's key indicators

Key indicators	Amoun
Population (million)	20.32
GDP (billion 2005 USD)	21.93
CO_2 emission (Mt of CO_2)	8.68

Source: (World Bank, 2015)

Energy Resources

Biomass

As with most African countries, biomass is the most common energy source and it provides about 75 per cent of energy requirements, especially for domestic purposes and for small businesses. Fuel wood is mainly obtained from natural forests, savannah woodlands, bushland and tree plantations, among others. Forested land covers 32.7 per cent of the country (World Bank, 2015d), an area of about 6.38 million hectares. Agro-industrial residues, crops and plantations represent a readily available form of renewable energy and are already being used in some agro-businesses and sawmills (REEEP, 2012).

Biogas from household waste is being experimented with in Abidjan. The production of bioethanol using feedstock from maize, sugarcane and sweet sorghum is also being explored. It is estimated that in the northern part of Côte d'Ivoire, about 120 ktoe per year is available from bagasse (the fibrous byproducts of extracting sugarcane or sorghum juice) (REEEP, 2012).

Hydropower

Hydro and thermal generating plants provide all of Côte d'Ivoire's electricity, with hydro accounting for less than 50 per cent of the power generated.

By the end of 2011, there was 606 MW of installed hydropower capacity. Buyo, Kossou and Taabo are the main dams in Côte d'Ivoire with 165,174 and 210 MW of generating capacity, respectively. There are four other large sites that are still undeveloped. Their capacities range from 4 to 288 MW and there are various other small potential hydro sites that could also be developed (REEEP, 2012). In general, Côte d'Ivoire has a theoretical capacity of 46 TWh/annum with a technically exploitable potential of about 12.4 TWh (REEEP, 2012).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	108	126	132	144
Production of crude oil, NLG and additives	12 757	11 294	14 264	12 139
Production of natural gas	0	50	94	138
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	0	6	31	51
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	26	31	37	81
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	26	37	67	132
Refinery output of oil products	399	431	657	847
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	213	311	522	630
Final consumption of natural gas	0	112	870	1 105
Final consumption of electricity	33	50	52	127
Consumption of oil in industry	16	12	34	56
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	12	23	21	27
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	156	281	452	534
Consumption of electricity in transport	0	0	0	0
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-12 047	-11 294	-13 428	-11 680
Net imports of oil product	-465	-488	-215	-147
Net imports of natural gas	0	0	0	0
Net imports of electricity	23	36	24	5

(AFREC, 2015)

\- : Data not applicable
0 : Data not available
(P): Projected

Oil and natural gas

Production of offshore oil started in 1980 and by the end of 2011, oil production was estimated at 11,720 thousand barrels (WEC, 2013). Most (86 per cent) of the oil and gas wells are located in shallow marine areas, 7 per cent are in deep offshore wells and 7 per cent are onshore. The proven petroleum reserves in 2005 were 100 million barrels.

Natural gas was initially discovered in Côte d'Ivoire in the 1980s, but development only started in 2005. The proven recoverable reserves at the end of 2011 was 28.3 bcm and production was 1.6 bcm (WEC, 2013).

Peat

The area of peatland is 725 km^2 (WEC, 2013).

Wind

The only available data on wind is compiled by the *Société d'Exploitation et de Développement Aéroportuaire, Aéronautique et Météorologique* (SODEXAM) for civil aviation purposes. Along the coast, San Pedro in the west and Korhogo in the north have wind velocities above 6 m/s, while Bouake in the central region and Tabou on the western coast have wind speeds higher than 4 m/s.

Geothermal

The geological conditions point to some limited potential for geothermal energy, but no study has yet been undertaken (REEEP, 2012).

Solar

There is moderate potential for solar energy, ranging between 2.0 and 4.5 kWh/m^2/day with a daily sunshine duration of 6 hours (REEEP, 2012). Many educational and health facilities in urban areas use solar for water heating. It is estimated that about 2 kW is needed to heat 150 litres of water. In rural areas, solar could help reduce or replace the amount of firewood used for water heating (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

In Côte d'Ivoire, 55.8 per cent of the population has access to electricity: 29 per cent of rural areas are electrified compared with 88.1 per cent of urban areas (Table 3 and Figure 4) (World Bank, 2015); (World Bank, 2016). Access to modern fuels is low. In 2012, only 19.12 per cent were using non-solid fuels; 2 per cent of these are in rural areas and 35 per cent in urban areas (World Bank, 2015); (World Bank, 2016). The strategic plan 2013-2030 for the development of the electricity sector in Côte d'Ivoire aims to expand electricity production capacity, upgrade the way electricity is distributed throughout the country, enhance the use of more renewable energy sources and increase hydroelectric and thermal electricity generation. For instance, a new 275 MW dam is being built at Soubre and the CIRPEL and AZITO thermal power plants are being expanded.

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 9.7 MJ per US dollar (2005 dollars at PPP) in 2012, up from 4.9 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010 and 2012 was 9.56 (World Bank, 2015)

The share of renewable energy in the total final energy consumption (TFEC) has been declining from 80.2 per cent in 1990 to 74.4 in 2012. Traditional solid biofuels form the biggest share of renewable sources at 65.3 per cent of TFEC in 2012, while modern solid biofuels contributed 7.6 per cent and hydro only 1.5 per cent (World Bank, 2015). Renewable sources contributed 26.4 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Côte d'Ivoire's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	2010	2011
Ensure universal access to modern energy, including electricity and cooking	Access to electricity (% of population)	58.9	
	% of population with primary reliance on non-solid fuels		
Double the rate of improvement of energy efficiency	GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	5.6	4.7
Double the share of renewable energy in the global energy mix	Percentage of total final consumption of energy from renewable sources		

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
55.8%	19.12%	**5.0**	74.4%

Kossou Dam, general view of water inlets, Côte d'Ivoire

Table 4: Cote d'Ivoire's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Mines, Petroleum and Energy
Presence of a Functional Energy Regulator	National Authority for the Regulation of the Electricity Sector (ANARE)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	Compangnie Ivoirienne d'Electriciti (CIE)
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West African Power Pool (WAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Énergie Électrique de Côte d'Ivoire (EECI)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Petroci Holding, with three subsidiaries: Petroci Exploration-Production which handles upstream gas and oil activities; Petroci Gaz, which is responsible for the natural gas sector; and Petroci Industries-Services which manages all other related services.
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	IPPs include Azito Énergie, Compagnie Ivoirienne de Production d'Électricité (CIPREL), Aggreko and the natural gas producers (AFREN, Foxtrot, Canadian Natural Resources)
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Master Plan 2013-2030 • Strategic Action Plan developed by the Ministry of Petroleum and Energy of Côte d'Ivoire.
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	Electricity Code Law No. 2014-132 of 2014

This table was compiled with material from (REEEP, 2012)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

The government is conscious of its international obligations and in September 2015, submitted its Intended Nationally Determined Contributions (INDC) (Table 4). The INDC focuses on improving the share of renewables in the energy mix.

Institutional and Legal Framework

The Ministry of Mines, Petroleum and Energy is in charge of the energy sector. The energy regulator is the National Authority for the Regulation of the Electricity Sector (ANARE). The Energie Electrique de Côte d'Ivoire (EECI) is the sole generator, transmitter and distributor of electric energy. On a regional level, the country is a member of the West African Power Pool. The legal framework is provided by the Electricity Code No. 2014-132 of 2014. The Energy Master Plan 2013-2030 guides the development of the sector (Table 4).

Selling coal by the road, Cote d'Ivoire

Democratic Republic of the Congo

Figure 1: Energy profile of the Democratic Republic of the Congo

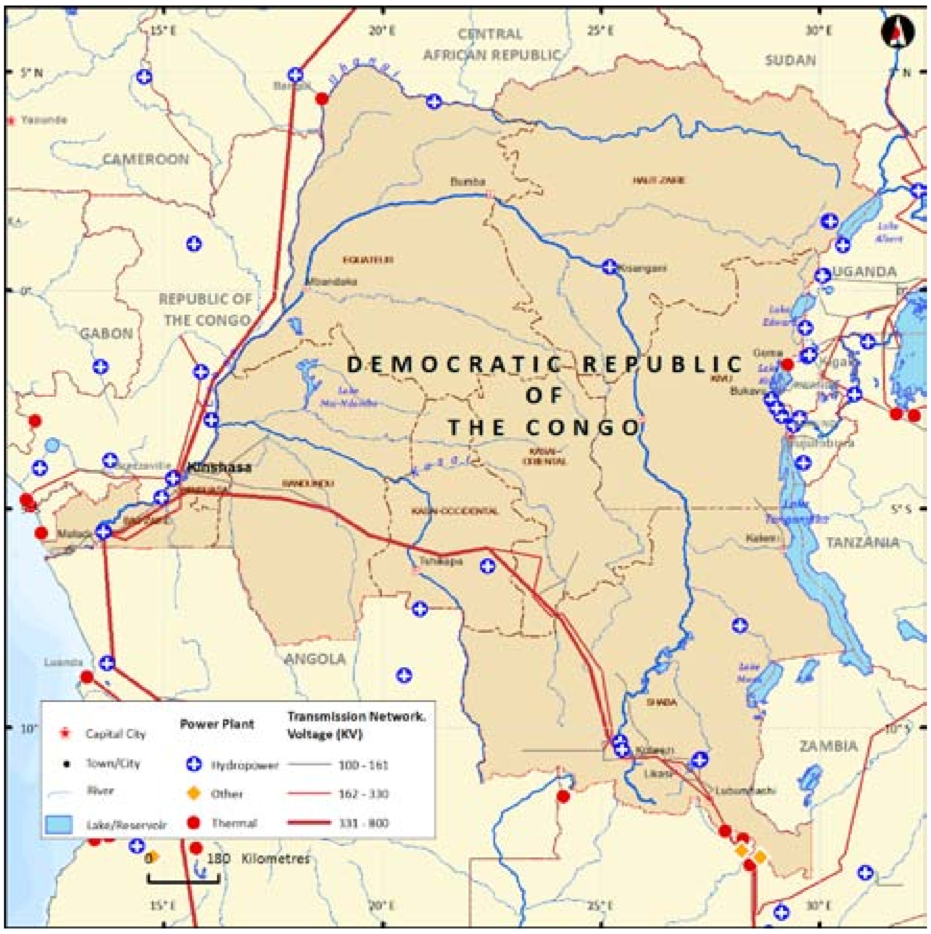
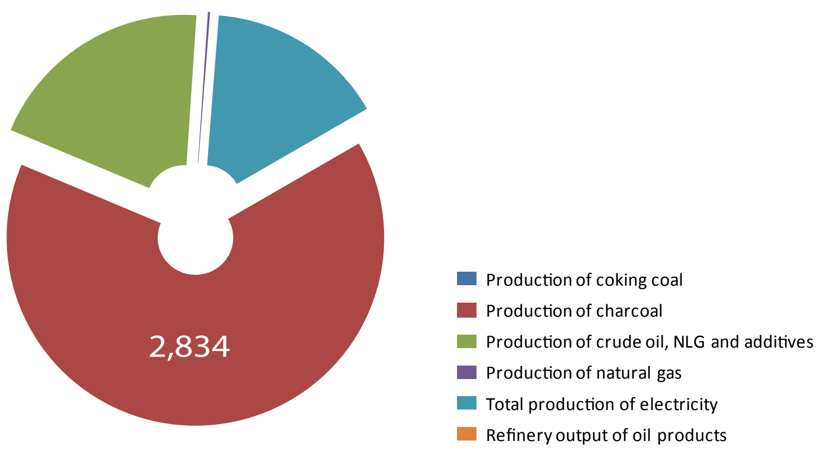
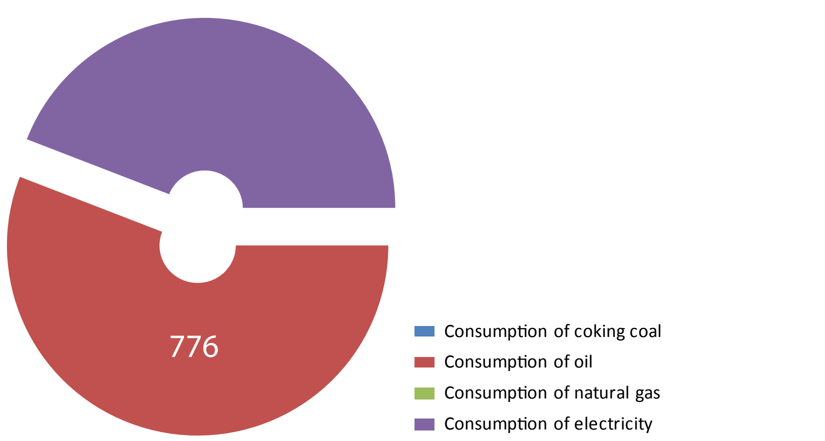


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, the DRC had a population of 67.51 million people (Table 1). Electricity production in 2015 was 676 ktoe with 99.7 per cent of it produced from hydro sources. Final consumption of electricity in the same year was 613 ktoe (Table 2) (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: The Democratic Republic of the Congo's key indicators

Key indicators	Amount
Population (million)	67.51
GDP (billion 2005 USD)	19.46
CO_2 emission (Mt of CO_2)	2.63

Source: (World Bank, 2015)

Energy Resources

Biomass

The DRC has around 125 million hectares of forest, representing 67.7 per cent of the country's land base (World Bank, 2015d). Most of the primary energy consumption is supplied by wood from these forests. There is also potential for biogas from plant and animal wastes. However, there are some barriers to development, including the high cost of digesters in relation to average incomes and the lack of training of users and maintenance staff.

Hydropower

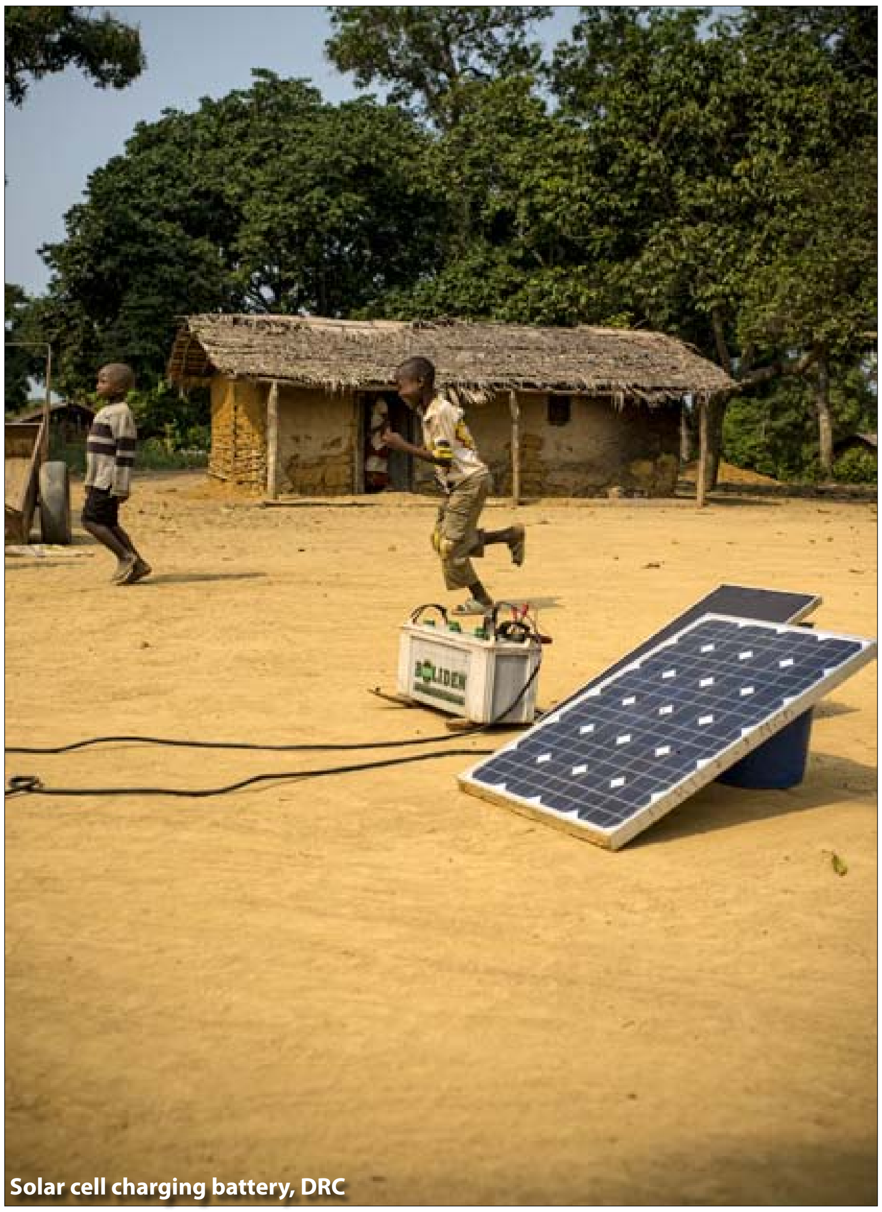
The DRC has huge hydropower resources, estimated at 774 GWh, the highest in Africa. It is estimated that if developed, this resource has the potential to create revenues for the country of over 6 per cent of GDP. The current level of exploitation is about 3 per cent of the country's economically exploitable capability and hydro provides almost all the country's electricity. The national electricity organization has 17 hydro plants with a total rated capacity of 2,410 MW. The two largest are Inga 1 (351 MW) and Inga 2 (1,424 MW) with new plants Inga 3 (4,320 MW) and Inga 4 in the planning phase (WEC, 2013).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	54	67	0	0
Production of charcoal	208	452	535	2,834
Production of crude oil, NLG and additives	1,092	1,185	1,076	864
Production of natural gas	0	0	8	8
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	2	2	1	1
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	516	636	653	674
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	518	638	653	676
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	0	0	0	0
Final consumption of oil	692	1,135	619	776
Final consumption of natural gas	0	0	0	0
Final consumption of electricity	390	403	581	613
Consumption of oil in industry	14	42	44	48
Consumption of natural gas in industry	0	0	0	0
Consumption of electricity in industry	163	266	341	401
Consumption of coking coal in industry	0	0	0	0
Consumption of oil in transport	251	352	525	716
Consumption of electricity in transport	0	0	0	0
Net imports of coking coal	0	0	0	0
Net imports of crude oil, NGL, Etc.	-1,107	-1,185	-1,039	-1,055
Net imports of oil product	367	525	714	926
Net imports of natural gas	0	0	0	0
Net imports of electricity	-390	-474	-65	0

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)



Solar cell charging battery, DRC

The massive Grand Inga (40,000 MW) is also planned and through interconnections between power pools, it should promote greater energy trade. Grand Inga plans to supply the following power pools: the South African Power Pool (SAPP), West African Power Pool (WAPP), East African Power Pool (EAPP), Central Africa Power Pool (CAPP) and the *Comité Maghrébin de l'Electricité* (COMELEC) (WEC, 2013).

Oil and natural gas

By the end of 2011, the DRC was estimated to have proven recoverable oil reserves of 1,600 million barrels and production figures at the end of the same year were 8.06 million barrels. Although the DRC has huge oil reserves, there is no oil refinery and all refined petroleum products have to be imported. The eastern part of the country suffers from untimely supply making the costs rise steeply. Data from 2008 showed that the DRC had natural gas reserves of 991.1 million m^3. Proven natural gas recoverable reserves at the end 2011 were 0.1 bcm (WEC, 2013). There was no production, consumption, importation or exportation of natural gas.

Coal

The recoverable coal reserves were estimated at 88 million tonnes by the end of 2011. These reserves are of the bituminous type including anthracite (WEC, 2013).

Wind

Nationwide wind speeds tend to be low, averaging 1.4 m/s. However, in Ugoma, wind speeds of up to 6.6 m/s have been measured. It is estimated that the potential for wind energy is about 77,380 MW, but it is uncertain how much of this is commercially viable (REEEP, 2012).

Geothermal

The eastern part of the DRC where volcanoes and active geothermal sites exist presents huge potential for the exploitation of geothermal energy. The temperatures in hot springs range from 35 to 90°C, with flow rate averages ranging from 11 to 162 litres/sec. The sector is undeveloped.

Solar

High insolation values ranging from 3.25 and 6.0 kWh/m^2/day make the DRC ideally positioned to exploit this resource. Currently, there are over 800 solar systems, with a total power of 83 kW. These are situated in: Equateur (167), Katanga (159), Nord-Kivu (170), the two Kasai provinces (170) and Bas-Congo (170). The Caritas network system has 148 installations with a total capacity of 6.31 kW.

Tracking progress towards sustainable energy for all (SE4All)

Article 48 of the 2006 Constitution provides for the right of access to electricity. Despite this, the electrification rate is very low. In 2012, it was only 16.4 per cent (World Bank, 2016). Table 3 and Figure 4 shows that the proportion of people in rural areas with access to electricity is 5.8 per cent while 36.3 per cent of urban areas are electrified (World Bank, 2016). But there are access deficiencies. For instance, the number of power outages experienced translates into lower rates of electrification due to widespread restrictions in hours of service, voltage fluctuations and impromptu blackouts. For example, Kinshasa is estimated to have an electrification rate of 90 per cent , but although they are connected to the grid, 21 per cent of households receive less than four hours of electricity supply daily, translating into a much lower average electrification rate (World Bank, 2015).

Access to modern fuels is very low. In 2012, only 2 per cent of people in rural DRC were using non-solid fuels and 11 per cent of urban areas (World Bank, 2015).

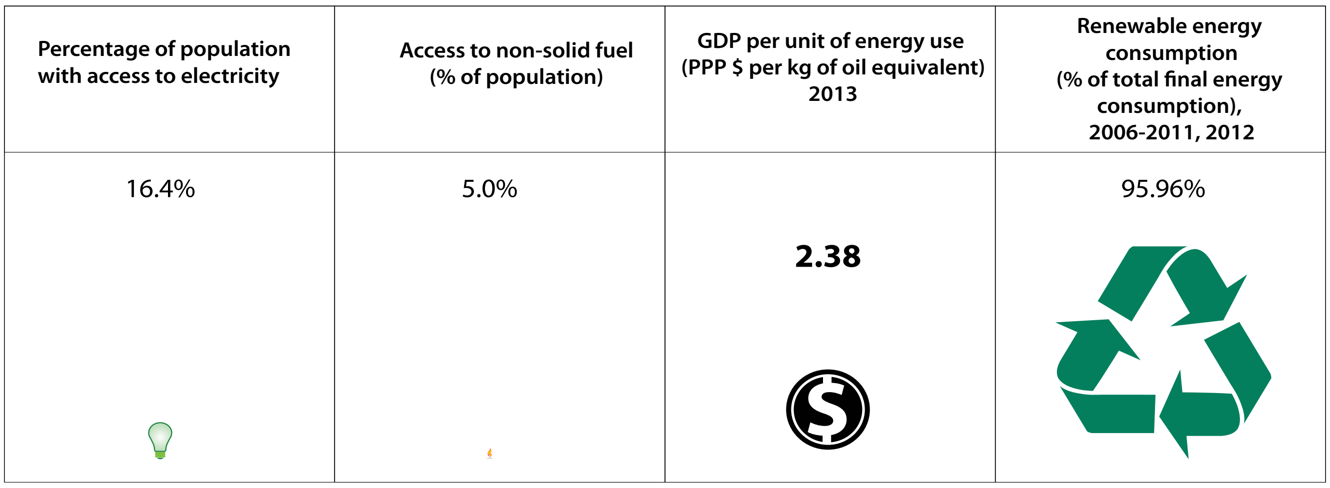
The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the economy was 19.1 MJ per US dollar (2005 dollars at PPP) in 2012, down from 21.2 MJ per US dollar in 2010. The compound annual growth rate (CAGR) between 2010 and 2012 was -4.34 (World Bank, 2015).

Table 3: DRC's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	6	7	15	16.4		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	3	5	5		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	92.0	97.2	96.2	95.96		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			1.7	1.7 (2011)		
	Level of primary energy intensity(MJ/$2005 PPP)	11.2	-	21.2	19.1	21.04	19.13

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators




Community farming in DRC

Table 4: DRC's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy • National Society of Electricity (SNEL) • Rural electrification • National Energy Commission (NCE) • National Renewable Energies Service (SENEN) • Ministry of Public Health
Presence of a Functional Energy Regulator	Electricity Regulation Authority (ARE)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	• Société nationale d'électricité (SNEL) - Public company responsible for production, transport, and distribution of electricity • La Congolaise des Hydrocarbures (Cohydro) • Services des Enterprises Pétrolières Congolaises (SEP-CONGO)
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	• South African Power Pool (SAPP) • Central African Power Pool (CAAP) • East African Power Pool (EAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	State owned SNEL is a vertically-integrated monopoly electricity production and distribution utility
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Perenco (UK), Teikoku Oil (Japan), Cohydro, Tullow Oil (UK), Heritage Oil (Canada), Surestream Petroleum (UK), Energulf Resources (US), ENI (Italy), and SOCO (UK)
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	National Electrification Fund Energy Sector Policy Letter 2009
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	Act number 14/011 of 17 June 2014 to govern the electricity sector Law No. 11/009 of Jul y2011 is the law on the fundamental principles relating to environmental protection Ordinance-Act No 70-033 of 1970 established state electricity company SNEL Act No 08/007 of 2008 privatized SNEL

This table was compiled with material from (REEEP, 2012)

The share of renewable energy in the total final energy consumption (TFEC) has remained over 90 per cent since 1990 and contributed 99.6 per cent share of electricity generation in 2012. Traditional solid biofuels form the biggest share of renewable sources at 73.6 per cent of TFEC in 2012, while the modern solid biofuels contributed 19.3 per cent and hydro only 3.1 per cent (World Bank, 2015).

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

The energy-related Intended Nationally Determined Contributions (INDC) published in August 2015 were to raise the population access rate to electricity, which is currently very low: 15 per cent at the national level (1 per cent in rural areas, 30 per cent in urban areas) whereas the average in sub-Saharan Africa is about 24.6 per cent (RDC, 2015). The rate in 2012 was 16.4 per cent (World Bank, 2016).

Institutional and Legal Framework

The Ministry of Mines, Energy and Hydrocarbons is in charge of the energy sector. The energy regulator is the Electricity Regulation Authority (ARE) (Table 4). The Société National d'Electricité (SNEL) is the sole generator, transmitter and distributor of electric energy. On a regional level, the country participates in the Central African Power Pool, Eastern Africa Power Pool and the Southern Africa Power Pool. The legal framework is provided by Act number 14/011 of 17 June 2014 governing the electricity sector. The main sector policy is the Energy Sector Policy Letter 2009.

Djibouti

Figure 1: Energy profile of Djibouti

Energy Consumption and Production

Djibouti is a small country with a population of 860,000 people (Table 1). The electricity sector in Djibouti has not seen much progress for several decades and the electrification rate is just over 50 per cent (World Bank, 2016). The equipment is old and inefficient so peak production capacity is considerably lower than installed capacity. Most demand is from the city of Djibouti and it has been growing at a high of 5 per cent a year. Forecasts put the maximum energy demand for 2025 at 810 GWh/yr (REEEP, 2012). There have been power interconnections with Ethiopia in recent years, and this has accounted for about 46 per cent of the country's guaranteed electricity production (REEEP, 2012). According to the power sharing agreement, Djibouti only receives surplus energy when Ethiopia has an excess (AfDB, 2013).

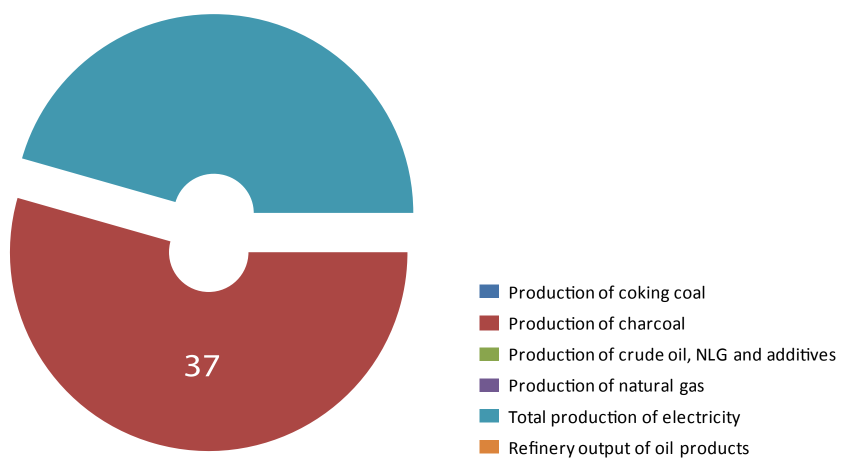
Total electricity production in 2015 was 31 ktoe and final consumption of electricity in the same year was 29 ktoe (Table 2) (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Djibouti's key indicators

Key indicators	Amount
Population (million)	0.86
GDP (billion 2005 USD)	1.03
CO_2 emission (Mt of CO_2)	0.47

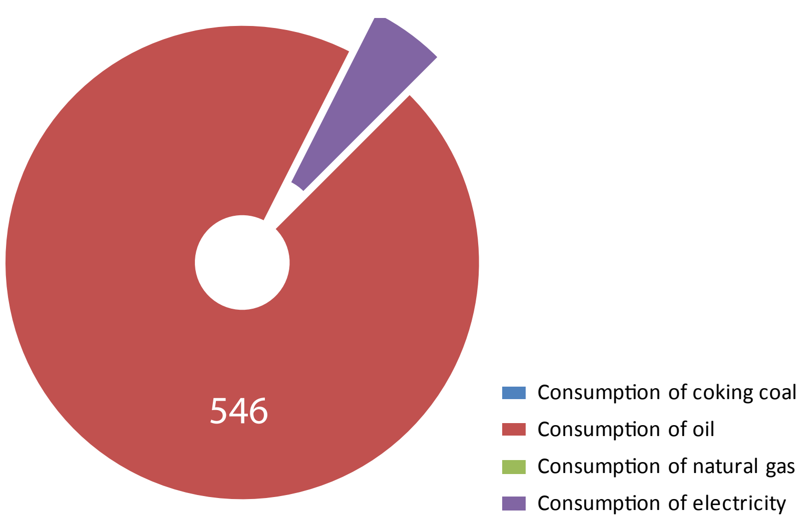
Source: (World Bank, 2015)

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

©World Bank

Djibouti geothermal project area

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	0	37
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	15	21	28	31
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	-
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	15	21	28	31
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	562	587	405	546
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	14	19	26	29
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	563	592	406	468
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

\- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Energy Resources

Biomass

There is limited potential for biomass for energy since the country is a semi-desert. However, formal studies need to be carried out on the country's biomass potential (REEEP, 2012).

Hydropower

Djibouti has no hydroelectric potential (REEEP, 2012).

Oil and natural gas

Djibouti has no indigenous sources of oil, natural gas, hydropower or coal.

Coal

Djibouti has no indigenous sources of oil, natural gas, hydropower or coal.

Wind

According to research in the 1980s, average wind speeds across the country are a maximum of 4 m/s highlighting moderate prospects for wind energy. Further studies in 2002 suggested that Goubet near the Gulf of Tadjourah ha the potential for a 50 MW wind farm and that Gali Maab Wein and Bada also have significant wind potential (REEEP, 2012). More recently, Qatar Petroleum International has been carrying out a feasibility study for a 60 MW wind power plant near Lake Assal.

Geothermal

The Lake Assal region has been found to have geothermal potential and the government is on course to build a 30 MW geothermal power plant there. Studies to identify other potential resources are also ongoing (REEEP, 2012

Solar

There is high potential for solar energy exploitation as daily insolation levels range between 5.5 and 6.5 kWh/m^2 in all areas of the country; the government intends to use this to ensure economic development. Djibouti has a target to extend electricity to 30 per cent of the rural population by 2017 using solar PV (REEEP, 2012). Plans are also in place to use solar energy to power a desalination plant to supply the city of Djibouti. It is estimated that about 40,000 m^3/day of salt water will be treated using a hybrid Concentrated Solar Power (CSP) and Reverse Osmosis (RO) plant.

Tracking progress towards sustainable energy for all (SE4All)

Of the population in Djibouti, 53.3 per cent has access to electricity; 13 per cent of rural areas are electrified, with this amount increasing to 65.2 per cent in urban areas (Table 3 and Figure 4) (World Bank, 2016). Access to modern fuels is much higher. In 2012, 13 per cent of people in rural Djibouti were using modern fuels compared with 84 per cent of those in urban areas (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Djiboutian economy was 3.5 MJ per US dollar (2005 dollars at PPP) in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was -24.66 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) was 34.8 per cent in 2012. Traditional biofuels formed 34.5 per cent of TFEC. The proportion of renewable sources as a share of electricity capacity was 0.8 per cent in 2012 (World Bank, 2015).

Table 3: Djibouti's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	43	46	50	53.3		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	79	84	84	84.27		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption				34.8		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	13.8	-	13.64 (2007)	-		
	Level of primary energy intensity(MJ/$2005 PPP)	4.8		6.1	3.5	3.77	3.48

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
53.3%	84.27%	**12.85**	34.44%

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Djibouti is considered very vulnerable to the impacts of climate change and thus is keen to participate in activities to reduce or reverse climate change. The country has committed to reducing its GHG emissions by 40 per cent by the year 2030, which translates to about 2 Mt of CO_2e (ROD, 2015). The energy-related Intended Nationally Determined Contributions (INDCs) are shown in Table 4.

Table 4: Djibouti's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Install 60 MW onshore wind turbines in Goubet by 2025
*Install three solar power plants in Petit Bara, Ali Sabieh and Goubet, with an estimated photovoltaic potential of 250 MW by 2025
*Exploit geothermal energy, whose potential is estimated at 1,200 MW in the region around Lake Assal, Lake Abbé and northern Goubet. The power plants are scheduled to be commissioned in 2030
*Implement energy efficiency project on 10 buildings
*Implement energy saving plan in public buildings
*Study construction of two additional very high voltage lines with a combined capacity of 250 MW in order to import electricity from Ethiopia
*Investigate rehabilitation of 3,000 existing buildings (accommodation and service buildings) each year to improve their thermal performance by means of insulation
*Raise awareness on the use of energy saving lighting equipment (low energy bulbs) in residential areas
*Perform a diagnostic review of the lighting and air conditioning systems used in different administrative buildings
*Improve energy efficiency capacity of the old Cité Ministérielle building and install a photovoltaic solar park on the roof
* Study tidal power plant - Combined production plant for electricity using household waste. Projected potential of 10 MW
*Study additional onshore wind turbines - Djibouti's total wind power potential is estimated at 390 MW. Installation of 11 onshore wind turbines in Goubet to produce 30 MW
*Accelerate air conditioners replacement - Incentives for households to replace their air conditioners at the end of their life cycles with more efficient units. An average of approximately 3,000 annually is projected
*Accelerate refrigerators replacement - Incentives for households to replace their refrigerators at the end of their life cycles by more efficient (Class A) units. An average of approximately 4,500 is projected annually
*Investigate "Green Mosques" – Implement energy efficiency and effectiveness solutions in the country's mosques

Source: (ROC, 2015)

Table 5: Djibouti's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Natural Resources • International Hydrocarbon Company • Électricité de Djibouti (EDD) • Directorate for Rural Electrification in the Agence Djiboutienne de Developpement Sociale (ADDS) • Djiboutian Agency for Energy Management • The Geothermal Energy Development Office • National Energy Commission
Presence of a Functional Energy Regulator	Ministry of Energy and Natural Resources
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	East African Power Pool (EAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Imports are dominated by Shell, Total and Oil Libya.
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	Ethiopian Electric Power Corporation and EDD have a joint PPA.
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Strategy and Action Plan for the electricity sector • Djibouti National Energy Master Plan • Renewable Energy Fund
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	• Decree 83-071/ PWEDD of 2 February, 1983 establishing the EDD • Presidential Decree 11 2009-0218/MERN October 2009 established the National Energy Commission • Law 32/AN/13/7ème L January 20, 2014 established the Geothermal energy Development Office • Electricity law is under preparation

This table was prepared with material from (MMEH, 2013); (REEEP, 2012) and (WTO, 2013)

Institutional and Legal Framework

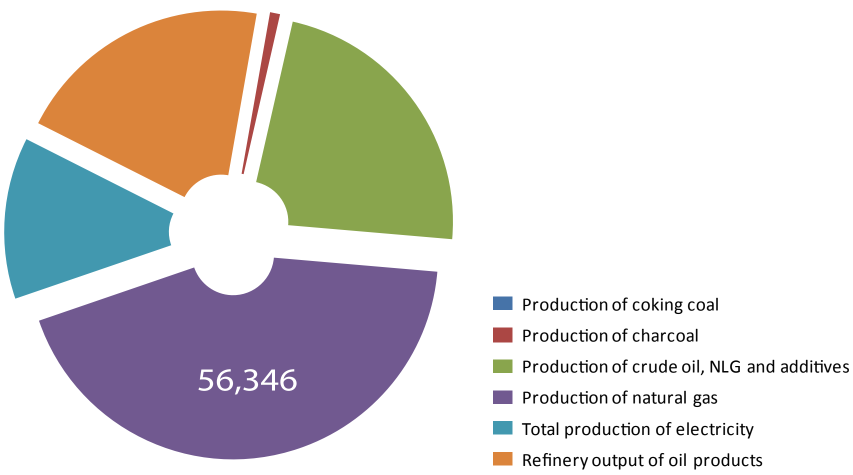
The Ministry of Energy and Natural Resources is in charge of the energy sector and is also the sector regulator (Table 5). The Électricité de Djibouti (EDD) is the sole generator, transmitter and distributor of electric energy. On a regional level, the country is a member of the East African Power Pool. An Electricity Law is under preparation. The Djibouti National Energy Master Plan and the National Strategy and Action Plan for the electricity sector guide developments in the sector.

Street in Djibouti City, Djibouti

Eygpt

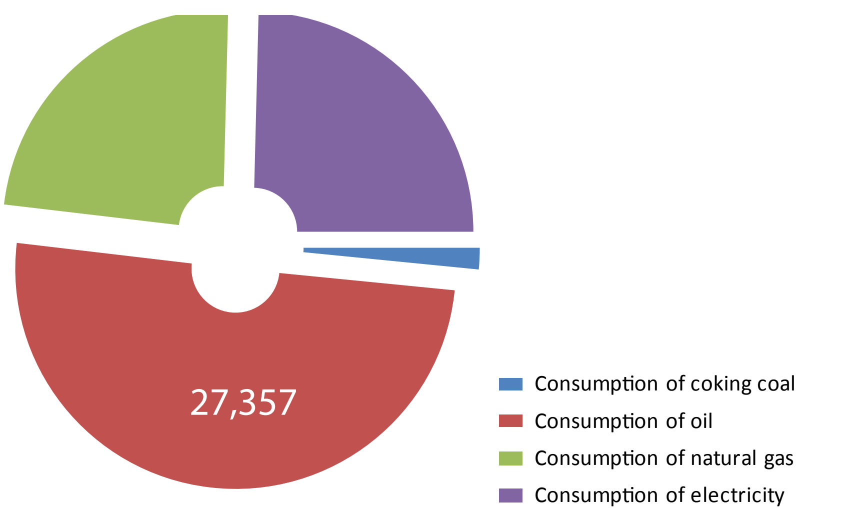
Figure 1: Energy profile of Egypt

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Egypt has a large population, which was 82.06 million in 2013 (Table 1). In 2015, the total production of electricity was 16,504 ktoe of which 90.7 per cent is from fossil fuels. Final consumption of electricity in the same year was 13,385 ktoe. Consumption by industry was 2.4 per cent (AFREC, 2015) (Table 2). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Egypt's key indicators

Key indicators	Amount
Population (2013 million)	82.06
GDP (billion 2005 USD)	128.55
CO2 emission (Mt of CO2)	184.32

Source: (World Bank, 2015)

Energy Resources

Hydropower

Most hydropower in Egypt is produced by the large dam projects on the Nile: the High Dam, Aswan I and Aswan II. In 2013, 13.7 billion kilowatt-hours (KWh) of electricity was generated accounting for 9 per cent of total country power generation (EIA, 2015).

Oil

The proven oil reserves in Egypt are the sixth largest in Africa and more than 50 per cent are located offshore in the Western Desert and the Gulf of Suez region (WEC, 2013). By 2014, proven oil reserves were estimated

Cairo at night

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	20	14	12	0
Production of charcoal	0	0	1,000	1,030
Production of crude oil, NLG and additives	35,293	29,226	26,410	29,608
Production of natural gas	18,555	35,901	57,629	56,346
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	5,302	8,211	11,354	14,970
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	1,260	1,087	1,122	1,097
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	12	47	147	438
Total production of electricity	6,575	9,346	12,622	16,504
Refinery output of oil products	26,105	34,318	28,082	26,404
Final Consumption of coking coal	453	755	511	855
Final consumption of oil	20,285	23,562	28,323	27,357
Final consumption of natural gas	7,015	8,829	12,171	12,795
Final consumption of electricity	5,627	7,801	11,215	13,385
Consumption of oil in industry	5,461	5,548	5,231	3,697
Consumption of natural gas in industry	2,072	5,567	5,970	6,958
Consumption of electricity in industry	2,111	2,812	3,500	3,314
Consumption of coking coal in industry	453	203	203	189
Consumption of oil in transport	9,060	9,374	13,758	15,060
Consumption of electricity in transport	0	0	0	29
Net imports of coking coal	720	945	504	496
Net imports of crude oil, NGL, Etc.	-7,379	2,892	-3,969	-6,110
Net imports of oil product	-692	-6,737	4,567	7,546
Net imports of natural gas	0	-14,049	-11,776	-5,874
Net imports of electricity	14	-67	-137	-34

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

at 4 billion barrels (EIA, 2015), but the country is facing challenges meeting local demand in the face of declining domestic production. Egypt is a member of Organization of Arab Petroleum Exporting Countries (OAPEC). Domestic oil consumption has grown by over 30 per cent over the last decade, from 550,000 bbl/d in 2000 to 815,000 bbl/d in 2011 (WEC, 2013).

Natural gas

Proven recoverable reserves by December 2011 amounted to 2,186 bcm and production is 61.3 bcm (WEC, 2013).

Coal

By the end of 2011, Egypt had proven reserves of 16 million tonnes of bituminous coal, including anthracite (WEC, 2013).

Wind

The coastal area around the Red Sea has high potential for wind energy, recording wind speeds of 7-10 m/s (GWEC, 2014). By the end of 2013, 550 MW of wind power was installed, which increased to 610 MW in 2014; there is a target to reach 7,200 MW by 2020 (representing 12 per cent of national electric capacity installed and contributing to the country's 20 per cent renewable electricity target by 2020) (Table 3) (GWEC, 2014).

Table 3: Installed wind power capacity in Egypt, (MW)

Region	Year							
	End 2007	End 2008	End 2009	End 2010	End 2011	End 2012	End 2013	End 2014
Egypt		365	430	550	550	550	550	610
Africa	539	635	866	1,065	1,033	1,165	1,602	2,535

Source: (OECD/IEA, 2014)

Nuclear

Egypt established a Nuclear Power Plants Authority (NPPA) in 1976, and in 1983 the El Dabaa site on the Mediterranean coast was selected for development of nuclear power. However, these plans were frozen after the Chernobyl accident. In 2006, there were indications of a revival of the civilian nuclear power programme, with a commitment to build a 1,000 MW nuclear power station at El Dabaa at an estimated cost of US$1.5 bn. In March 2008, Egypt signed an agreement with Russia on the peaceful uses of nuclear energy.

Solar

Solar opportunities are good in Egypt, with 140 MW already in operation (NBI, 2013). Many of the installed photovoltaic systems are used in remote areas for water pumping, desalination, rural clinics, telecommunications, and so on.

Tracking progress towards sustainable energy for all (SE4All)

Egypt is one of the top 10 countries worldwide that has made the most progress in providing electricity to its population. According to the World Bank (2013), about 1.3 million Egyptians acquired access to electricity in the last two decades (1990-2010). As shown in Table 4 and Figure 4, by 2010, 100 per cent of the population (both urban and rural) had access to electricity and 99.99 per cent to non-solid fuels (World Bank, 2015).

Egypt's energy intensity increased at a compound annual growth rate (CAGR) of -0.41 per cent over the 20 years between 1990 and 2010 and at 1.62 per cent over the tracking period 2010-2012 (World Bank, 2015). The energy intensity of the Egyptian economy (the ratio of the quantity of energy consumption per unit of economic output) between 2010 and 2012 increased from 3.7 to 3.8 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

A National Energy Conservation plan is being implemented; activities include increasing the use of compact fluorescent lamps, improving energy efficiency in street lighting and public buildings, and scaling up solar water heating. The Credit Guarantee Company (CGC) is operating an energy efficiency program for small and medium enterprises. On the supply side, the main effort is on improving the use of fossil fuels through the increased use of combined cycle gas turbine power plants and supercritical technology for steam power plants.

Egypt has adopted a National Energy Efficiency Action Plan (NEEAP) (2012-2015) with cumulative energy efficiency targets of 5 per cent . There is an Energy Efficiency (EE) unit at the Council of Ministers secretariat, which is the mandated entity for developing and implementing this plan. However, there is no designated energy efficiency agency and no general legal framework for EE measures.

The share of renewable energy in the total final energy consumption declined from 8.5 per cent in 1990 to 5.5 per cent in 2012 (World Bank, 2015); (World Bank, 2016). The New National Renewable Energy Strategy adopted in February 2008 aims to achieve a generation of 20 per cent of the country's electricity from renewable resources by 2020.

Table 4: Egypt's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	96	98	100	100		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	88	97	100	99.99		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	8.6	8.2	6.1	5.5		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	10.5		11.3	10.9		11.36 (2013)
	Level of primary energy intensity(MJ/$2005 PPP)	4.0		3.7	3.8	3.79	3.80

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

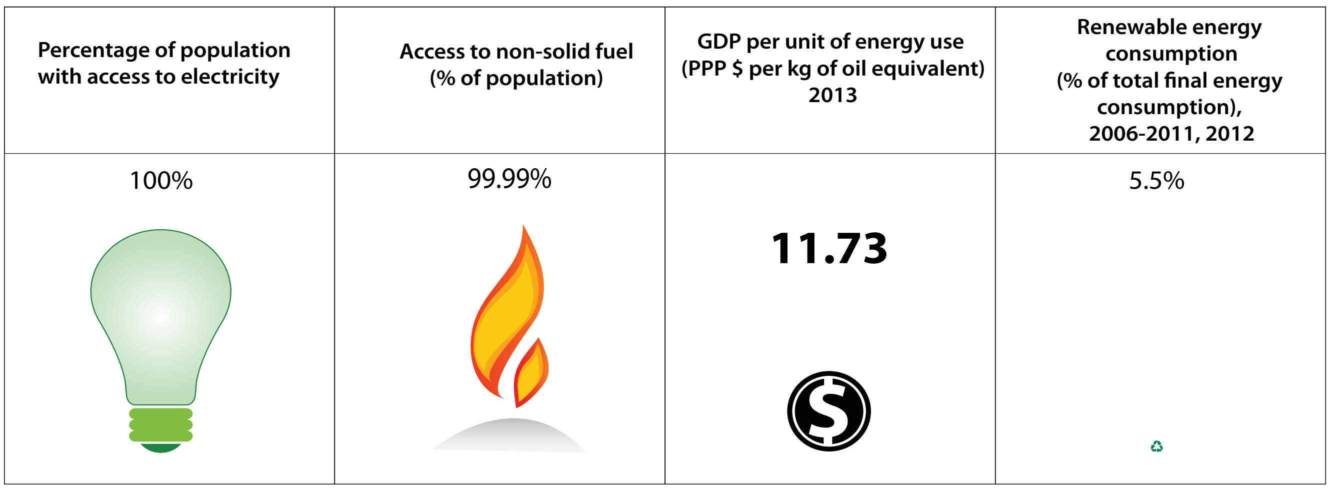


Table 5: Egypt's key aspects/key mitigation measures to meet its energy related Intended Nationally Determined Contributions (INDCs)

INDC
*Conduct comprehensive studies to assess the impact of climate change on the energy sector, propose appropriate adaptation measures, and estimate the economic cost of those proposed adaptation measures. In addition, these studies should determine the safe locations for the construction of power generation projects
* Build institutional and technical capacities of different units in the energy sector regarding climate change issues
*Support research and technological development to enable the electricity sector to deal properly with climate change

Source: (ROC, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Egypt is keen to contribute to global efforts to address climate change, as rising temperatures are likely to negatively impact the energy and other productive sectors, such as agriculture and tourism. The energy-related Intended Nationally Determined Contributions (INDC) articulated by the government are highlighted in Table 5.

Table 6: Egypt's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Electricity and Energy (MOEE) manages the General Plan of the Energy Generation, Transmission and Distribution; • Ministry of Petroleum (MOP) regulates the petroleum subsector. • Egyptian Electricity Holding Company (EEHC); • Rural Electrification Authority (REA); • Hydro Power Plants Authority (HPPA); • Atomic Energy Authority (AEA); • Nuclear Power Plants Authority (NPPA); • Nuclear Materials Authority (NMA); • New and Renewable Energy Authority (NREA).
Presence of a Functional Energy Regulator	Electric Utilities and Consumer Protection Regulatory Agency (EEUCPRA) - established by Presidential Decree No. 339/2000 – and under the supervision of the MOEE.
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	Egyptian Electricity Holding Company (EEHC), owned by government with 16 affiliated companies (six production; nine distribution; and the Egyptian Electricity Transmission Company).
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	East African Power Pool (joined in 2005 and temporarily left in 2016 pending resolution of issues regarding utilization of the Nile River waters.
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	EEHC owns over 90 per cent of Egypt's generating capacity. Transmission and distribution are a monopoly under the EEHC umbrella.
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Egyptian General Petroleum Corporation (EGPC) is the state entity charged with managing upstream activities – including the infrastructure, licensing and production of oil and gas. International and foreign national oil companies play a significant role in Egypt's upstream sector on a production-sharing basis with the EGPC. The energy sector consists of three holding companies in addition to the EGPC and the Egyptian Mineral Resource Authority (EMRA). These include: the Egyptian Natural Gas Holding Company (EGAS); the Egyptian Petrochemicals Holding Company (ECHEM); and Ganoub El Wadi Petroleum Holding Company (GANOPE).
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	Feed-in Tariffs for Smaller RE Projects, including solar.
Presence Functional IPPs and their contribution	PowerTech of Malaysia.
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Strategy for the Development of Energy Conservation Measures and Renewable Energy Application 1982. • Renewable Energy Strategy of 2008 set a 20 per cent target of total electrical energy mix from renewable energy by 2020. This target is expected to be met largely by scaling-up of wind power. The Government also made a policy proposal to establish a dedicated transmission body for solar energy, the Solar Energy Trader (SET).
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Law No. 1103/1974 – on re-organization of the Ministry of Electricity and Energy (MOEE); • Law No. 63/1974 – concerning establishing the institutions of the electricity body; • Law No. 12/1976 – on establishing the Egyptian Electric Utility; • Law No.100/1996 – on amendment of Law No. 12/1976 – related to establishing the Egyptian Electricity body; • Law No. 18/1998 – on some provisions of electricity distribution companies, power plants and the transmission grid; • Egyptian Electricity Holding Company Decree No. 86/2005 – concerning the commercial status of electricity distribution companies; • Prime Minister's Decree No. 1795/2008 – to amend the price of natural gas and electricity to the intensive industrial companies; and • the Prime Minister's Decree No. 2130/ 2010 – regarding amendment of the law on selling electricity to some of the industrial companies.

This table was prepared with material from (MMEH, 2013); (REEEP, 2012) and (WTO, 2013)

Institutional and Legal Framework

The Ministry of Electricity and Energy (MOEE) is in charge of the energy sector (Table 6). The energy regulator is the Egyptian Electric Utilities and Consumer Protection Regulatory Agency (EgyptERA). The state owned Egyptian Electricity Holding Company (EEHC) dominates the electricity sector. It has 16 affiliated companies (six productions; nine distributions; and the Egyptian Electricity Transmission Company). On a regional level, the country used to be a member of the East African Power Pool, but pulled out in early 2016. The legal framework is provided by the new Egyptian Electricity Law, issued by law no. 87 in 2015.

The main objectives of the Energy Policy Strategy include energy security, meeting domestic demand and developing available energy resources.

Equatorial Guinea

Figure 1: Energy profile of Equatorial Guinea

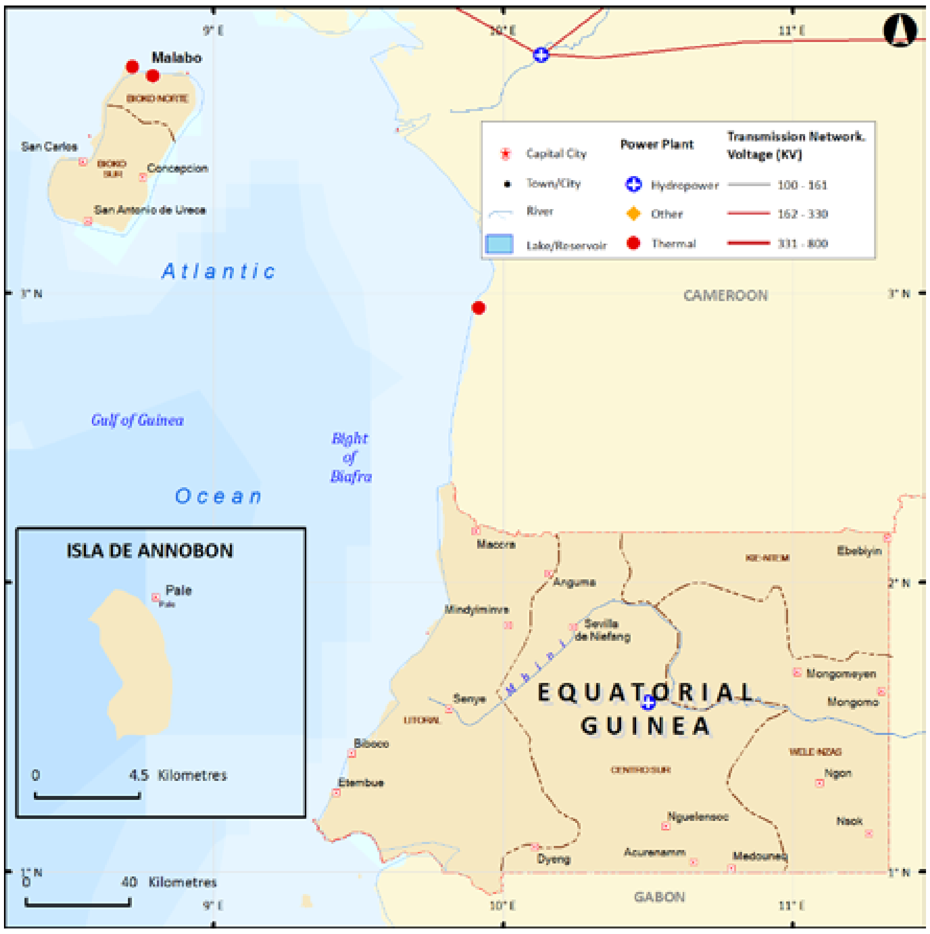
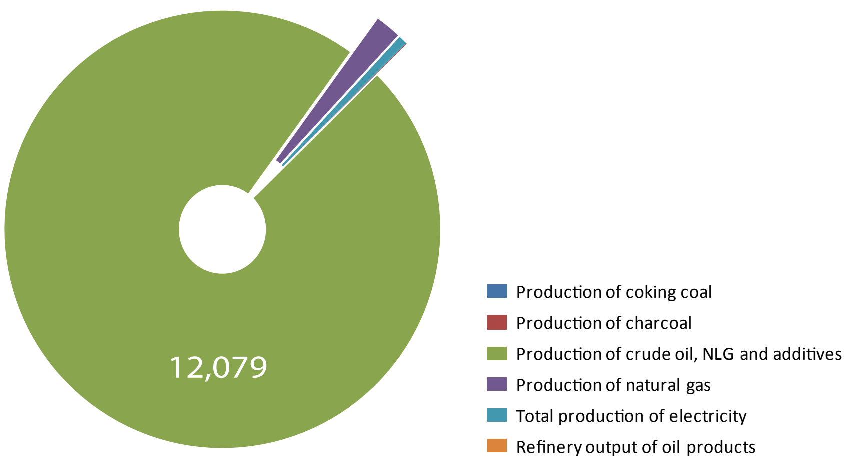
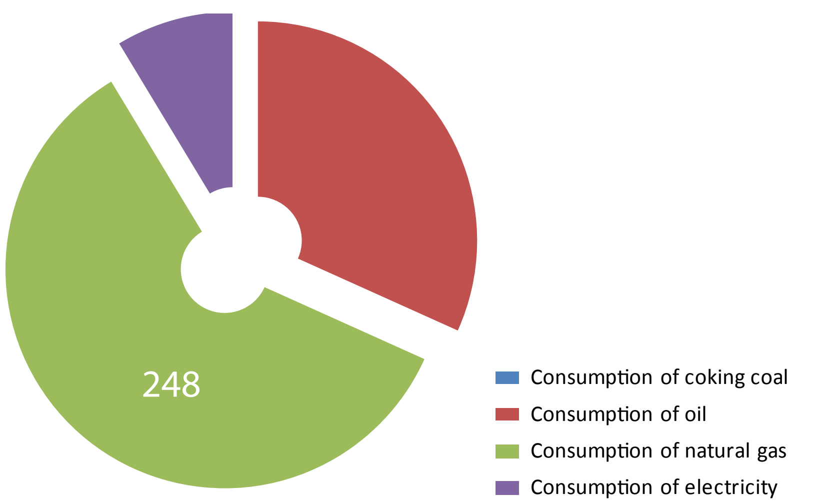


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Equatorial Guinea had a population of 790,000 people in 2013 (Table 1) (IEA, 2016). Total electricity production in 2015 was 82 ktoe with 57.3 per cent generated from hydro and 41.4 per cent generated from fossil fuels (IEA, 2016). Electricity consumption in 2015 was 36 ktoe. Table 2 shows the main energy statistics. Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Equatorial Guinea's key indicators

Key indicators	Amount
Population (million)	0.79
GDP (billion 2005 USD)	9.29
CO_2 emission (Mt of CO_2)	6.68

Source: (World Bank, 2015)

Energy Resources

Biomass

The biomass potential is over 400 tonnes/ha (REEEP, undated). Forest biomass covers 57.1 per cent of the land area (World Bank, 2015). Sixty per cent of the population lives in rural areas and since only about 43 per cent these areas are electrified, it is likely that almost 50 per cent use biomass to provide their domestic energy requirements.

Hydropower

The hydropower industry is quite underdeveloped, with only 1 MW of installed capacity in 2011 (WEC, 2013); (REEEP, undated). Hydropower potential is estimated at 2,600 MW; about 50 per cent of this is viable for commercial exploitation.

Oil and natural gas

The proven recoverable oil reserves by the end of 2011 were 1,100 million barrels and oil production at the end of the same year was 91,625 thousand barrels (WEC, 2013). Oil is the country's most important export with exports of crude oil amounting to 318,120 barrels per day (WEC, 2013).

By the end of 2011, proven recoverable resources of natural gas were 36.8 bcm (1,299.6 bcf) and natural gas production was 36.8 bcm (WEC, 2013). The natural gas reserves are located off Bioko Island and are mainly in the Zafiro and Alba oil and gas fields. The Alba field was discovered in 1984 and

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	7	7
Production of crude oil, NLG and additives	5,477	16,731	14,387	12,079
Production of natural gas	1	43	216	237
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	3	7	34	34
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	0	1	1	47
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	4	7	35	82
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	77	54	269	132
Final consumption of natural gas	1	43	216	248
Final consumption of electricity	3	7	8	36
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	0	0	0	0
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-5,606	-16,731	-14,901	-13,878
Net imports of oil product	77	54	229	269
Net imports of natural gas	0	0	0	0
Net imports of electricity	0	0	0	0

\- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Zafiro began production in 1996. Oil production originates almost entirely from the Zafiro, Ceiba, and Okume fields. Condensate production comes from the Alba field (WEC, 2013).

Wind

Wind speeds averaging 6 m/s at heights of 80 m have been measured in the southern area of the mainland. But there are currently no wind power projects in the country (REEEP, undated).

Geothermal

Bioko Island is of volcanic origin (REEEP, undated).

Solar

The heavy forest and biomass cover across the country means that average daily horizontal irradiation is 2.0-2.5 kWh/m^2/day, which is too low for large-scale power generation. But there are opportunities for smaller-scale exploitation, such as to heat water (REEEP, undated).

Oil platform, Equatorial Guinea

Tracking progress towards sustainable energy for all (SE4All)

The national electrification rate in 2012 was 66 per cent ; 43 per cent of rural areas are electrified and 93.1 per cent of urban areas (Table 3) (World Bank, 2016). The electricity sector is a major focus of the national development strategy. The Action Plan for 2020 commits to providing the country and its population with basic needs for development. The country's "Electricity for All" statement aims to establish an efficient and reliable electricity system.

Fifty-five per cent of the national population uses modern fuels (Table 3 and Figure 4). When disaggregated by location, only 25 per cent of the rural population uses non-solid fuels compared to 91 per cent in urban areas (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 5.8 MJ per US dollar (2005 dollars at PPP) in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was 4.74 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) has been decreasing steadily since 1990. In 2012, renewables accounted for 29.2 per cent of the final energy mix. Traditional solid biofuels form the biggest share of renewable sources at 29.0 per cent of TFEC in 2012, while hydro

Table 3: Equatorial Guinea's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	57	61	65	66		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	28	43	53	55.06		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	82.0	53.2	15.4	29.2		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	-	-	-	-		
	Level of primary energy intensity(MJ/$2005 PPP)	15.4		5.3	5.8	5.71	5.77

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

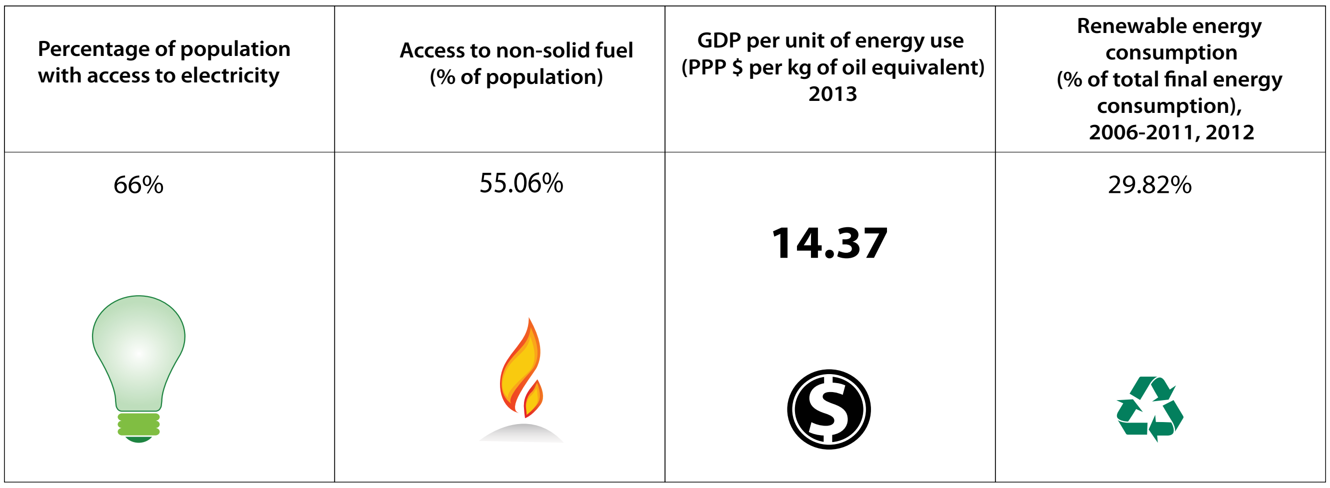


Table 4: Equatorial Guinea's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Develop and adopt a Law on Energy
*Harnessing the hydroelectric potential of the Wele River for the electrification of the entire Continental Region of the country
*Reform and renovate hydroelectric plants of Musola (0.4-0.5 MW) and Riaba (3.8 MW) for the electrification of the entire Bioko Island and Bikomo in the Continental Region (3.2 MW)
*Consider wind, solar and/or tidal options for remote islands of the country (Annobón, Corisco, and others).

Source: (ROC, 2015)

Malabo, Equitorial Guinea

Table 5: Equatorial Guinea's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	The Ministry of Mines, Industry and Energy
Presence of a Functional Energy Regulator	Electricity Energy Regulatory Agency
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	National oil company is GEPetrol
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Central African Power Pool (CAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Electricity productions are SEGESA Holdings, SEGESA Generation, SEGESA Transmission and SEGESA Commercial. SEGESA holdings and SEGESA generation can both generate electricity
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	Legislation is being proposed to allow IPPs to operate
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	National energy policy is confined to the Hydrocarbons Law
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	• Fundamental Law • Hydrocarbons Law No. 8/2006 • Petroleum Regulations issued under the Hydrocarbons law • Decree Law No. 1/1986 and Decree Law No. 4/2004 on taxation of petroleum-related activities • Decree number 03/2002 of 21 May sets the tariffs for the production of electricity • Regulation 02/24 that sets the conditions for approval of priority national and transboundary projects • Law Decree 20/2005 that allows for the transformation of the electricity sector

This table was compiled with material from (REEEP, 2012), (Colón & Gerena, 2014) and (Lexadin, 2010)

contributed only 0.8 per cent . Renewable sources contributed 6.3 per cent share of electricity generation in 2012 (World Bank, 2015).

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

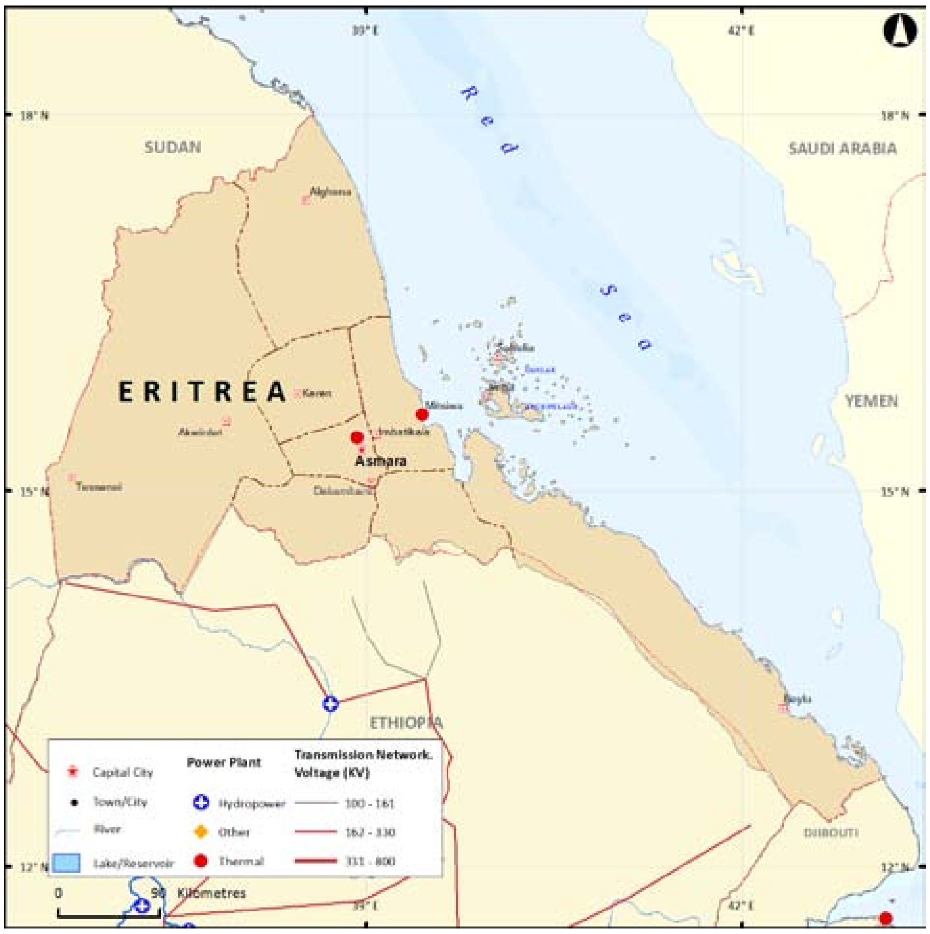
The energy-related Intended Nationally Determined Contributions (INDC) were articulated by the government in 2015 and aim to enhance the exploitation of renewable forms of energy. They are highlighted in Table 4.

Institutional and Legal Framework

The Ministry of Mines, Industry and Energy is in charge of the energy sector (Table 5). The energy regulator is the Electricity Energy Regulatory Agency. The Electricity sector is managed by *Sociedad de Electricidad de Guinea Ecuatorial* (SEGESA), which has a number of subsidiaries: SEGESA Generation, SEGESA Transmission and SEGESA Commercial. On a regional level, the country is a member of the Central Africa Power Pool. The legal framework is provided by the Fundamental Law, which contains some provisions on energy. The main sector policy is contained in the Hydrocarbons Law.

Eritrea

Figure 1: Energy profile of Eritrea



Energy Consumption and Production

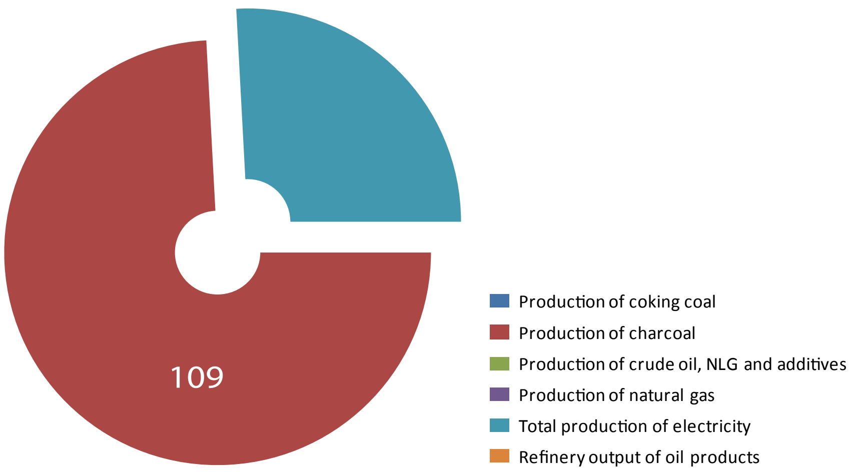
Eritrea's population was 6.33 million in 2013 (Table 1) (IEA, 2016). Table 2 shows that total production of electricity was 38 ktoe in 2015 with 97.3 per cent generated from fossil fuels. Final consumption of electricity is 33 ktoe with 9 per cent of this consumed in industry (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Eritrea's key indicators

Key indicators	Amount
Population (million)	6.33
GDP (billion 2005 USD)	1.25
CO_2 emission (Mt of CO_2)	0.55

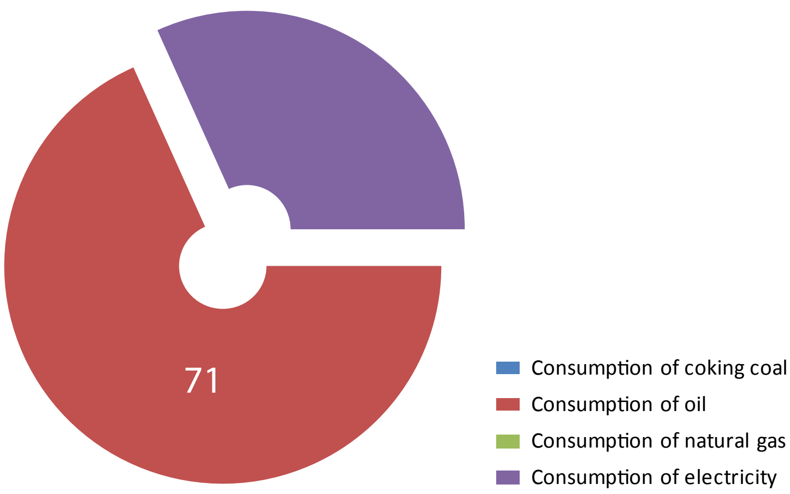
Source: (World Bank, 2015)

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Resources

Biomass

The use of combustible renewables and waste biomass (including dung, crop residues and wood) makes up about 78.25 per cent of total energy consumption. With most of the rural population (88 per cent) lacking access to electricity, biomass is an alternative energy source (World Bank, 2015). The following are the potential sources of modern biomass energy use in certain areas in Eritrea:

- The Alighider Farm Estate has the potential to supply raw materials (cotton and sorghum stalks, elephant grass and banana leaves, among others) for briquette production for at least 15 plants, each with a capacity of 4,000 tons per year. Briquettes can replace fuel wood and charcoal. Agricultural waste could generate electricity thermally;
- Biogas plants could be installed in the Elabered Agro-industry and other smaller dairy farms;
- Biogas could be generated from cacti;
- Energy recovery from municipal solid and liquid wastes is possible;
- Energy crops, such as Salicornia (being developed by SeaWater Farms, a biofuels company), could generate electricity for local uses or for the central grid (REEEP, 2012).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	13	84	99	109
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	18	25	27	37
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	-
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	18	25	27	38
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	161	158	39	71
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	15	21	23	33
Consumption of oil in industry	17	28	8	8
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	6	5	6	6
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	73	66	44	48
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	206	228	158	163
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Hydropower

Ninety per cent of Eritrea receives only 450 mm of rain a year and evapotranspiration rates are very high. This has implications on river flows. Despite this, there is a small hydropower potential in the country: three river systems, the Barka, Mereb-Gash and the Setit, have hydropower potential of about 16,890 GWh altogther. Of this, about 33 per cent can be harnessed (Yohannes, 2008).

Oil and natural gas

Eritrea does not have oil resources, although oil exploration has taken place. There is a refinery that was closed down in 1997 due to high operational costs. It has the capacity to refine 18,000 bbl/d of crude oil (REEEP, undated).

Wind

There is the potential to exploit wind energy, especially along the coastline as far as 200 km north of Aseb. For example, average wind speeds of 9.5 m/s at a height of 10 m have been measured around Aseb Airport (Rosen, Van Buskirk, & Garbesi, 1999).

Geothermal

The area south of Massawa near the Mount Alid volcanic area is thought to be viable for geothermal resources (RECIPES, 2006), but more information is still required.

Solar

Solar energy is currently being used mainly in public buildings. However, there is the potential to extend this use to crop driers, refrigeration, water heating and tobacco curing, among others. Average insolation is between 5.0 and 6.55 kWh/m^2/day (REEEP, undated).

Tracking progress towards sustainable energy for all (SE4All)

The national electrification rate in Eritrea is quite low, at 36.1 per cent in 2012 (Table 3 and Figure 4) (World Bank, 2016). All (100 per cent) urban areas have access to electricity compared to 12 per cent of rural areas. Of the rural population, only 13 per cent have access to modern fuels while the proportion is 66 per cent in urban areas (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 4.6 MJ per US dollar (2005 dollars at PPP) in 2012, down from 5.0 MJ per US dollar in 2010. The compound annual growth rate (CAGR) between 2010 and 2012 was -4.08 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) was 80.4 per cent in 2012. Traditional solid biofuels form the biggest share of renewable sources at 76.7 per cent of TFEC in 2012, while modern solid biofuels contributed only 3.8 per cent (World Bank, 2015). Renewable sources contributed 0.6 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Eritrea's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	23	32	33	36.1		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	16	28	35	36.13		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	88.3	71.2	77.2	80.42		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			8.4	8.82 (2011)		
	Level of primary energy intensity(MJ/$2005 PPP)			5.0	4.6	4.75	4.61

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
36.1%	36.13%	**8.82**	80.42%

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

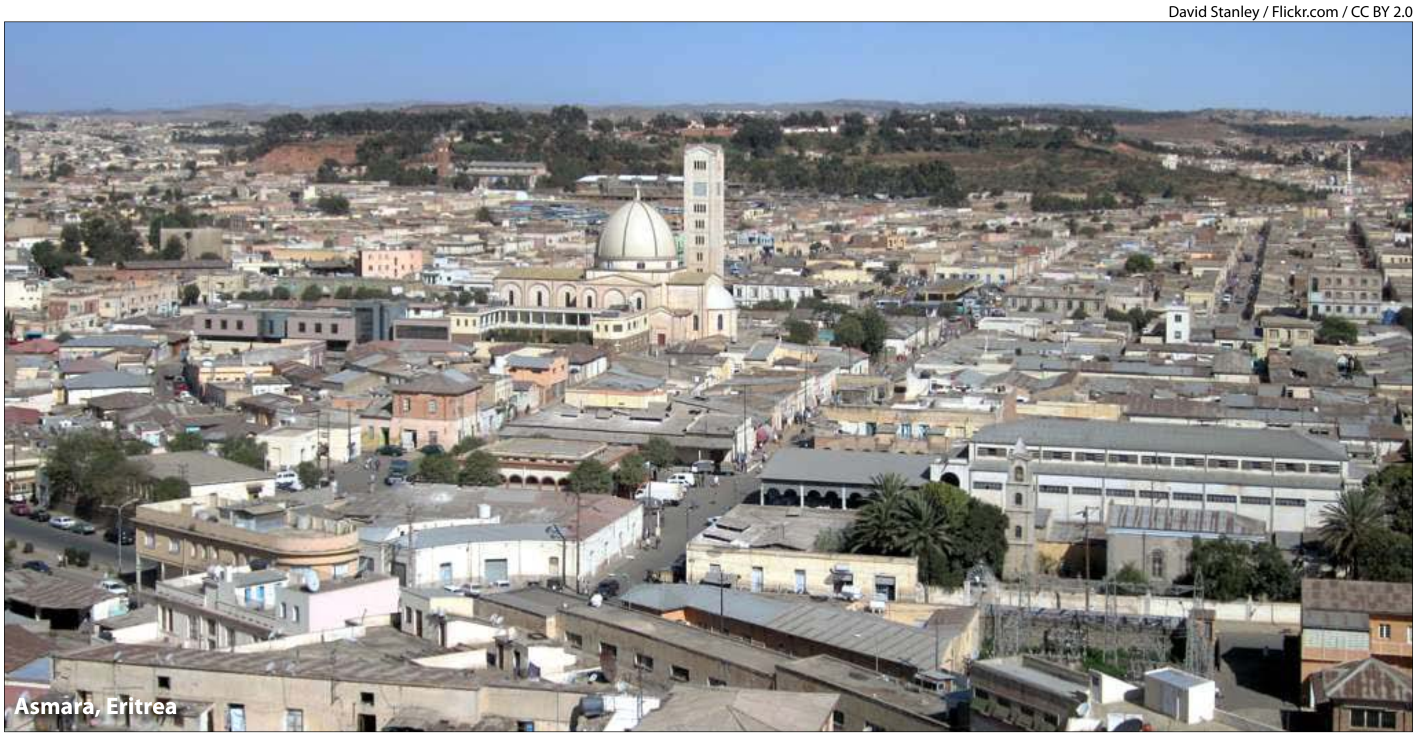
The country's energy-related Intended Nationally Determined Contributions (INDC) aim to reduce emissions by improving energy security and access and enhancing energy conservation as shown in Table 4 (SOE, 2015).

Table 4: Eritrea's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*raise the share of electricity generation from renewable energy to 70% of the total electricity generation mix (wind, solar and geothermal).
*reduce transmission and distribution losses at least by 50%.
*enhance energy conservation by introducing rail transportation to cover about 400km for mass transportation of freight with estimated cost of about USD 1billion and uses of big buses for passenger transport to a long distance.

Source: SOE, 2015

David Stanley / Flickr.com / CC BY 2.0



Asmara, Eritrea

Table 5: Eritrea's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Mines • Renewable Energy Centre
Presence of a Functional Energy Regulator	Department of Energy
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	Eritrean Electricity Authority
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Electricity sector is vertically integrated
Oil market unbundled.	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Eritrea Petroleum Corporation (EPC)
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Policy 2009 • Rural Electrification Programme • Energy development initiatives in its long-term program, up to 2015 • National Power Development Master Plan (under development)
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Proclamation No. 141/2004 on promoting efficiency, safety, environmental protection and private sector involvement • Proclamation number 142/2004 reforming the electricity sector

This table was compiled with material from (REEEP, 2012), (Colón & Gerena, 2014) and (Lexadin, 2010)

Institutional and Legal Framework

The Ministry of Energy and Mines is in charge of the energy sector. The functions of a regulator are currently undertaken by the Department of Energy. The Eritrean Electricity Corporation (EEC) is the sole generator, transmitter and distributor of electric energy. Eritrea is a member country of the East African Power Pool, but currently participates very little. The legal framework is provided by Proclamation number 142/2004 that reformed the electricity sector and allowed for more private sector participation.

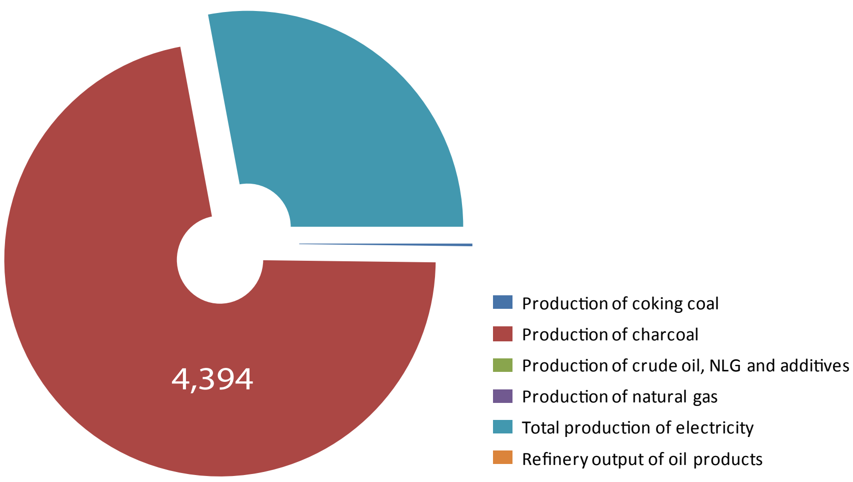
The main sector policy is the Energy Policy 2009 (Table 5). Most of Eritrea's energy is generated from thermal yet the country has plenty of renewable energy potential. The Energy Policy aims to increase the use of renewables in its energy mix so as to reduce dependency on fossil fuels and lower greenhouse gas emissions.

Camels with firewood, Eritrea

Ethiopia

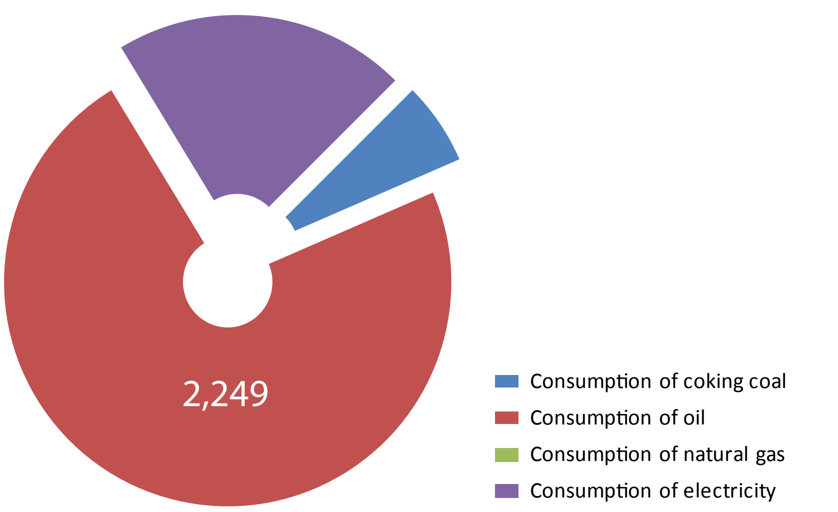
Figure 1: Energy profile of Ethiopia

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Ethiopia's population in 2013 was 94.1 million (Table 1) (IEA, 2016). Total production of electricity in 2015 was 1,708 ktoe with 82.7 per cent produced from hydro, 2.8 per cent from fossil fuels and 2.7 per cent from geothermal sources (Table 2). Final consumption of electricity was 654 ktoe in the same year (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Ethiopia's key indicators

Key indicators	Amount
Population (million)	94.10
GDP (billion 2005 USD)	27.74
CO_2 emission (Mt of CO_2)	8.50

Source: (World Bank, 2015)

Energy Resources

Biomass

Ethiopia has a huge biomass energy potential with estimates putting the national woody biomass stock at 1,149 million tonnes with annual yields of 50 million tonnes in the year 2000. Biomass distribution across the country is uneven, with the northern highlands and eastern lowlands having low biomass cover. Population growth is putting pressure on these resources.

Agro-processing industries, such as processing sugar-cane bagasse, cotton stalk, coffee hull and oil- seed shells, present an opportunity for biomass energy. But currently, there are no grid-connected biomass power plants. Municipal waste and biofuels have been underutilized, although the current Growth and Transformation Plan seeks to address this by stepping up the dissemination of domestic biogas plants, vegetable oil stoves and improved stoves (REEEP, 2014).

Hydropower

There are enormous resources for hydro generation; the gross theoretical potential (650 TWh/yr) is second only to that of the Democratic Republic of the Congo (WEC, 2013). Despite this, only about 3 per cent of the country's hydropower potential is being exploited (REEEP, 2014). Currently, domestic demand is insufficient to justify its full development. Neighbouring countries of Kenya and Sudan, however, could benefit from the electricity provided by hydropower development in Ethiopia (WEC, 2013).

Some of the hydroelectric projects include Tekeze (300 MW in 2009), Gibe II (420 MW in 2010), Tana Beles (460 MW in 2010) and Amerti Nesha (97 MW in 2011). Additionally, four more projects (Gibe III, Ashegoda expansion, Adama II and the Grand Ethiopian Renaissance Dam) are under construction. However, these developments are constrained by the inadequate power transmission system (REEEP, 2014).

Oil and natural gas

Ethiopia has few proven hydrocarbon reserves, although there is potential for oil and gas exploration. By the end of 2011, the proved recoverable reserves of natural gas were 25 bcm (WEC, 2013). There is no in-country refinery so all petroleum products are imported.

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	0	0	0	12
Production of charcoal	686	778	3 530	4 394
Production of crude oil, NLG and additives	0	0	5	0
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	26
Production of electricity from fossil fuels	2	4	3	48
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	154	245	420	1413
Production of geothermal electricity	0	0	2	47
Production of electricity from solar, wind, Etc.	0	0	0	173
Total production of electricity	156	249	424	1 708
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	0	0	26	184
Final consumption of oil	1,099	1,692	1,911	2,249
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	121	207	385	654
Consumption of oil in industry	294	411	587	804
Consumption of natural gas in industry	0	0	0	0
Consumption of electricity in industry	47	85	120	149
Consumption of coking coal in industry	0	0	26	184
Consumption of oil in transport	642	1 050	1,333	997
Consumption of electricity in transport	0	0	0	0
Net imports of coking coal	0	0	13	168
Net imports of crude oil, NGL, Etc.	0	0	0	0
Net imports of oil product	1,064	1,518	2,313	2,563
Net imports of natural gas	-	-	-	-
Net imports of electricity	0	0	0	-34

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

Peat

There are about 200 km^2 of peatlands (WEC, 2013).

Coal

Ethiopia is known to have some coal deposits in the Dilbi-Moye basin in the southwest of the country. Deposits are estimated at 14,016,730 tonnes (MME, 2009). Other areas with coal deposits include the Geba basin (250,000,000 tonnes), Chilga basin (19,000,000 tonnes) and Chida Waka (9.38 million tonnes) (MME, 2009).

Wind

Ethiopia has one of the most ample wind resources in Eastern Africa, with velocities ranging from 7 to 9 m/s. At the end of 2013, 171 MW of wind energy was installed (GWEC, Various years). It installed another 90 MW in 2013 (Table 3), in line with the government's very ambitious plans for build-out of up to 7 GW by 2030 (GWEC, Various years).

Two wind farms are in operation: the 51 MW Adama I wind farm, which began production in 2011, with a second phase (150 MW) under construction; and the 120 MW Ashegoda wind farm, which came on line at the end of 2013. The Ethiopian government is keen to use renewables to mitigate the seasonal availability of hydropower. To that end, a solar and wind power master plan has also been prepared.

Table 3: Installed wind power capacity in Ethiopia, (MW)

	End 2007	End 2008	End 2009	End 2010	End 2011	End 2012	End 2013
Ethiopia						81	171

Source: (GWEC, Various years)

Geothermal

By the end of 2011, the installed capacity of electricity from geothermal sources was 7.3 MW and the annual output was 10.0 GWh (WEC, 2013). The Ethiopian Rift Valley and the Afar depression have considerable geothermal resources and are thought to be able to generate more than 5,000 MWe of electricity. A 7.3 MWe geothermal pilot power plant has been installed at Aluto Langano Geothermal plant and is generating 4 MWe; there are plans to expand this project to 70 MWe. Other promising sites include Teo, Danab, Kone and others (REEEP, 2014). Ethiopia is also pursuing a $4 billion private sector investment to develop its geothermal power resources and produce 1,000 MW from steam (REEEP, 2014).

Solar

Ethiopia has great potential for solar energy as it receives a solar irradiation of 5,000-7,000 Wh/m^2 depending on the locale and the season. The solar radiation averages 5.2 kWh/m^2/day. The values vary with the seasons, ranging from 4.55 to 5.55 kWh/m^2/day, and over space, ranging from 4.25 kWh/m^2/day in the extreme western lowlands to 6.25 kWh/m^2/day in Adigrat area (REEEP, 2014). Installed solar capacity in 2011 was 5 MW (WEC, 2013).

Tracking progress towards sustainable energy for all (SE4All)

Ethiopia is one of the top 20 countries with a deficit in access to electricity, with 63.9 million people without access to electricity in 2010 and 81.1 million people lacking access to non-solid fuels (Table 4 and Figure 4) (World Bank, 2013). The vast majority of the Ethiopian population (83.2 per cent as of 2010) lives in rural areas, where modern energy services are rarely available. But there has been some progress. The World Bank (2016) indicates that by 2012, 7.6 per cent of the rural population had access to electricity while the urban population had reached 100 per cent . Access to modern fuels is low. In 2012, only 2.19 per cent of Ethiopians were using non-solid fuels; 2 per cent of these are in rural areas and 18 per cent in urban Ethiopia (World Bank, 2016).

The Ethiopian economy energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 17.0 MJ per US dollar (2005 dollars at PPP) in 2012, down from 28.6 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010 and 2012 was -4.34 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) was 94.49 per cent in 2012 (World Bank, 2016). Traditional solid biofuels form the biggest share of renewable sources at 92.6 per cent of TFEC in 2012, while modern solid biofuels contributed only 0.8 per cent and hydro 1.1 per cent (World Bank, 2015). Renewable

Table 4: Ethiopia's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	10	13	23	26.6		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	4	6	3	2.19		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	95.6	94.3	94.5	93.5		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			2.8	3.1 (2011)		2.62 (2013)
	Level of primary energy intensity(MJ/$2005 PPP)	28.6	18.6		17.0	17.69	17.04

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
26.6%	2.19%	2.11	94.49%

Table 5: Ethiopia's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Expand electric power generation from renewable energy.
*Leapfrog to modern and energy efficient technologies in transport, industry and building sectors.
*Expand electric power generation from geothermal, wind and solar sources to minimize the adverse effects of droughts on predominantly hydroelectric energy sector.
*Build additional dams and power stations to further develop energy generation potential from the same river flow as well as develop new dam sites on parallel rivers in order to maintain the baseline hydropower electricity generation capacity to levels attainable under a 'no-climate change' scenario.

Source: (ROC, 2015)

John Savage / Flickr.com / CC BY-ND

Addis Ababa, Ethiopia

Table 6: Ethiopia's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Water, Irrigation and Energy (MWIE) • Ministry of Mines Rural Electrification Executive Secretariat (REES) • Regional Energy Agencies • Ethiopian Rural Energy Development and Promotion Centre (EREDPC)
Presence of a Functional Energy Regulator	• Ethiopian Energy Authority (EEA)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	• East African Power Pool (EAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	• Ethiopian Electric Utility (EEU) • Ethiopian Electric Power (EEP)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	• Ministry of Mines is in charge of upstream hydrocarbon and geothermal resources exploration
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	• Feed-in tariff legislation (still a Bill)
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Energy Policy 1994 • Ethiopian Electric Power Strategy • Rural Electrification Fund • Off-grid Rural Electrification Master Plan • Alternative Energy Development and Promotion Programme
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Electricity Proclamation No. 86/1997 of June 1997 established the EAA • Proclamation number 691/ 2010 establishing the Ministry of Water and Energy (MWE) • Electricity Operations Regulations (49/1999) • Letter of power sector policy (2003) • Investment proclamation (280/2004) encouraging IPP • Electricity Feed-in-Tariff Bill, 2012

This table is compiled with material from (REEEP, 2014) and (Rai, Kaur, Fikreyesus, & Kallore, 2013)

sources contributed a 99.4 per cent share of electricity generation in 2012 (World Bank, 2015). Even in urban areas, half of households rely on traditional biomass (wood, dung and agricultural residues) for cooking, and in rural areas, virtually all do (except for 0.2 per cent who use kerosene and 1.2 per cent who use charcoal). While many nations in sub-Saharan Africa face similar challenges, Ethiopia ranks particularly low in terms of energy progress, with an EDI of 0.017 and a ranking of 62 out of 64, according to the IEA's 2011 Energy Development Index (EDI). Ethiopia has made big strides in recent years, however, with 48.3 per cent of towns and villages connected to the grid as of July 2012, according to the Ethiopia Electric Power Corporation.

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

By 2030, Ethiopia hopes to limit its net greenhouse gas emissions to 145 Mt CO_2e or lower as part of its contribution to the fight against climate change. The country has articulated its INDC in line with national energy and development policies as highlighted in Table 5.

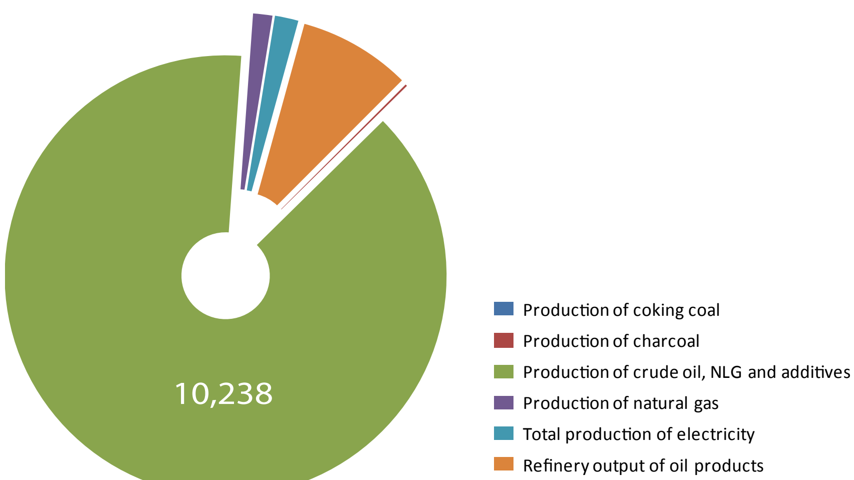
Institutional and Legal Framework

The Ministry of Water, Irrigation and Energy (MWIE) is in charge of the energy sector. The energy regulator is Ethiopian Energy Authority (EEA) (Table 6). The Ethiopian Electric Power is charged with generation and transmission of electricity while the Ethiopian Electric Utility handles distribution and sales. On a regional level, the country is a member of East African Power Pool. The legal framework is provided by the Electricity Proclamation No. 86/1997. The main sector policy is the National Energy Policy 1994. Although it gives high priority to the development of hydropower, it also provides for a more diverse energy mix.

Gabon

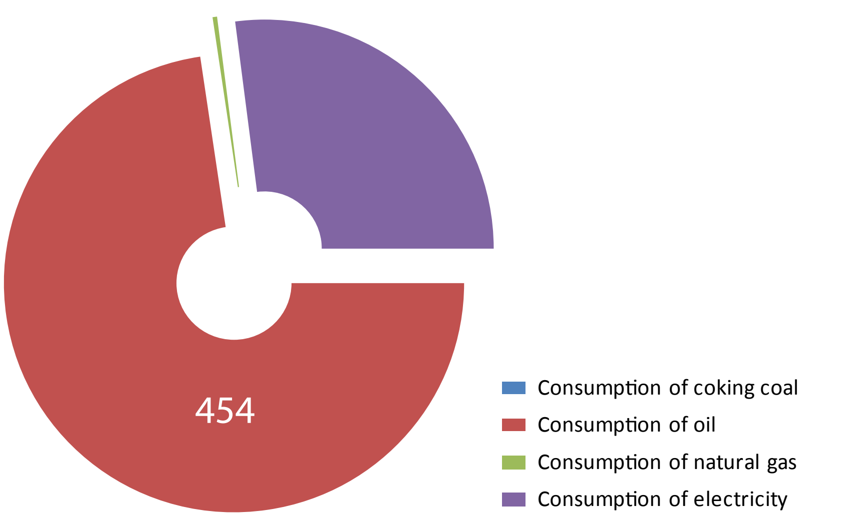
Figure 1: Energy profile of Gabon

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Gabon had a population of 1.67 million in 2013 (Table 1). In 2015, total electricity produced was 199 ktoe with 51.7 per cent produced from hydro and 48.2 per cent from fossil fuels (Table 2). Final consumption of electricity in 2015 was 169 ktoe (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Gabon's key indicators

Key indicators	Amount
Population (million)	1.67
GDP (billion 2005 USD)	11.60
CO_2 emission (Mt of CO_2)	2.83

Source: (World Bank, 2015)

Energy Resources

Biomass

Gabon's forests cover a huge portion of the land area and supply an equally large proportion of the country's energy needs (IEA, 2016). Biomass is the predominant energy source used by 80 per cent of the domestic sector (REEEP, 2012). The country has collaborative ventures at international and regional levels for sustainable forest management and energy use through the Central African Forest Initiative and the International Centre for Carbon Sequestration and Biomass Energy. As the formal wood sector grows, there is also potential to use waste from the timber industry to produce energy.

Hydropower

The topography and high precipitation combine to provide ideal conditions for the generation of electricity from hydro sources. The technically exploitable hydropower by 2011 was 6,000 MW of which only 3 per cent has been exploited (WEC, 2013). The existing power stations include the the Petite Poubara and Grand Poubara dams on Gabon's main waterway – River Ogooué; and two others on the Mbei river the Kinguélé and Tchimbélé dams. The sector is expanding with more projects planned on the Okano, Ngounié and Ouue rivers, totalling 502 MW.

Oil and natural gas

Gabon has extensive proven recoverable oil reserves, estimated at 3,700 million barrels at the end of 2011. These reserves are the fifth largest in sub-Saharan Africa after Nigeria, Angola, Sudan, South Sudan and Uganda. It ranks third largest oil producer in sub-Saharan Africa, after Nigeria and Angola. The oil production figure at the end of 2011 was 91,625 thousand barrels (WEC, 2013). The oil fields are located both on- and offshore and mainly around the Port-Gentil area. Oil production has been declining from a peak of 370,000 in 1997 to 239,000 bbl/d in 2013. Oil consumption is 20 bbl/day (WEC, 2013). There are also natural gas resources with proven reserves at the end of 2011 estimated at 29.0 bcm and production of 8 bcm (WEC, 2013).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	15	16
Production of crude oil, NLG and additives	12,885	12,419	11,552	10,238
Production of natural gas	75	94	167	164
Production of electricity from biofuels and waste	1	1	1	1
Production of electricity from fossil fuels	28	48	74	96
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	70	70	78	103
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	99	119	153	199
Refinery output of oil products	601	708	967	952
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	376	456	495	454
Final consumption of natural gas	1	2	2	2
Final consumption of electricity	93	111	137	169
Consumption of oil in industry	165	172	243	225
Consumption of natural gas in industry	1	2	2	2
Consumption of electricity in industry	23	27	35	37
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	101	116	157	146
Consumption of electricity in transport	0	0	1	1
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-12,234	-11,739	-10,519	-9,725
Net imports of oil product	-203	-241	-468	-421
Net imports of natural gas	0	0	0	0
Net imports of electricity	0	0	0	0

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Wind

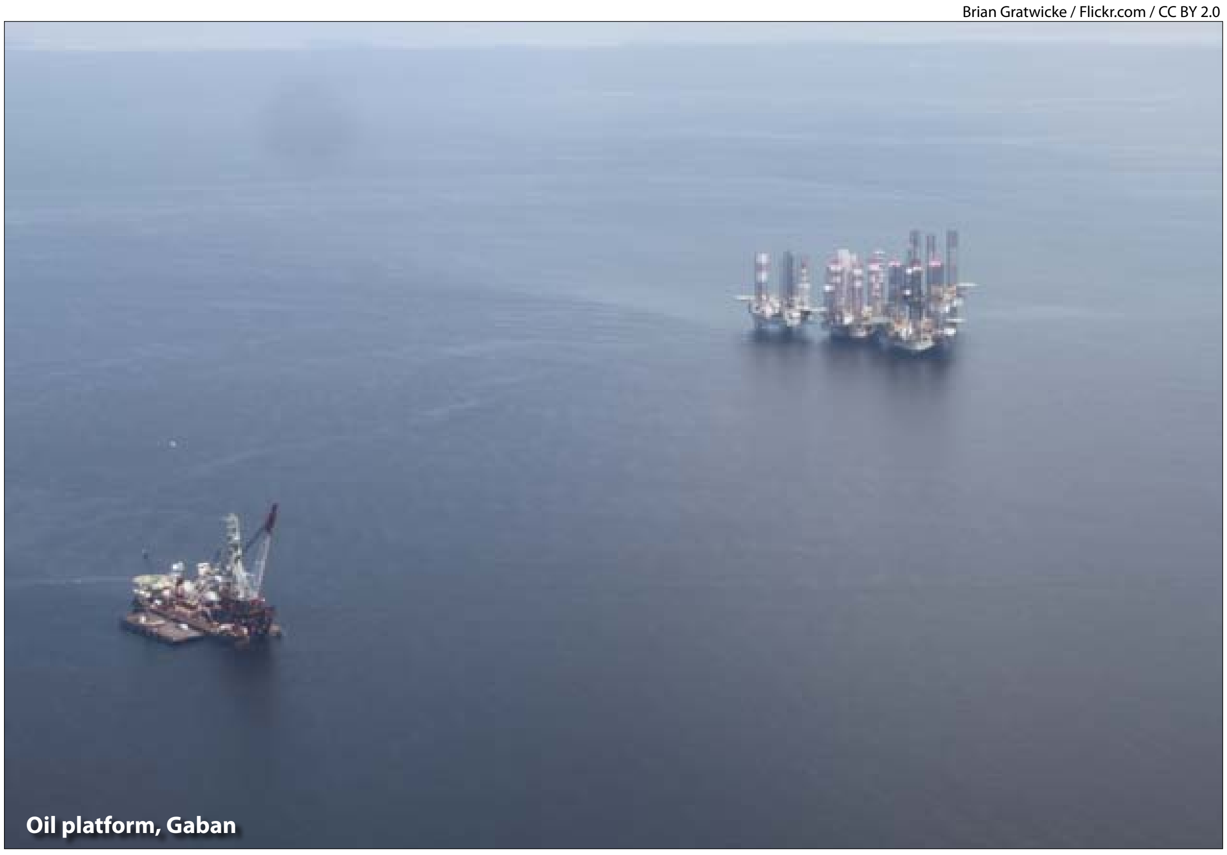
The heavily forested nature of the country reduces the production of wind energy in the interior, but there may be potential along the coast, especially around Pointe Denis and Loango National Park. Average wind speeds of up to 6 m/s have been recorded in parts of the country (REEEP, 2012).

Geothermal

This is an unexploited area.

Solar

There are about 300 sunshine days a year, translating into an average daily solar insolation of around 4 kWh/m^2. Gabon is heavily forested, which presents challenges in connecting communities to the electricity grid, so stand-alone solar systems are ideal to power smaller villages. So far, an €18 million scheme to provide solar to homes, schools and shops is being implemented (REEEP, 2012).



Oil platform, Gaban

Tracking progress towards sustainable energy for all (SE4All)

National access to electricity is relatively high at 89.3 per cent in 2012 (Table 3 and Figure 4) (World Bank, 2016). However, the rate of urbanization far outstrips that of electrification and as a result load shedding is common, negatively impacting the economy. Rural electrification stands at 44.9 per cent while it is 98.1 per cent in urban areas. National access to modern fuels is almost 80 per cent . But this masks local disparities. In rural areas, access to non-solid fuels is only 31 per cent compared to 89 per cent in urban areas (World Bank, 2015); (World Bank, 2016). The 2010-2020 electricity plan aims to make Gabon a sustainable energy platform using an energy mix of biomass, gas and hydro in line with the Gabon Emergent policy. The policy also aims to increase regional cooperation through transmission and energy distribution within the region. To that end, a national transmission network will be constructed between 2010 and 2018 and it will have a national load-dispatching centre (IEEJ, 2013).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 3.1 MJ per US dollar (2005 dollars at PPP) in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was -3.80 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) was 69.6 per cent . Traditional solid biofuels form the biggest share of renewable sources at 53.4 per cent of TFEC in 2012, while the modern solid biofuels contributed

Table 3: Gabon's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 per cent of population with access to electricity	73	74	82	89.3		
	7.1.2 per cent of population with primary reliance on non-solid fuels	45	63	76	78.68		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption		78.3	74.5	63.0	69.57	
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	-	-	12.5	13.2 (2011)		
	Level of primary energy intensity(MJ/$2005 PPP)	2.7	-	3.4	3.1	3.27	3.15

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

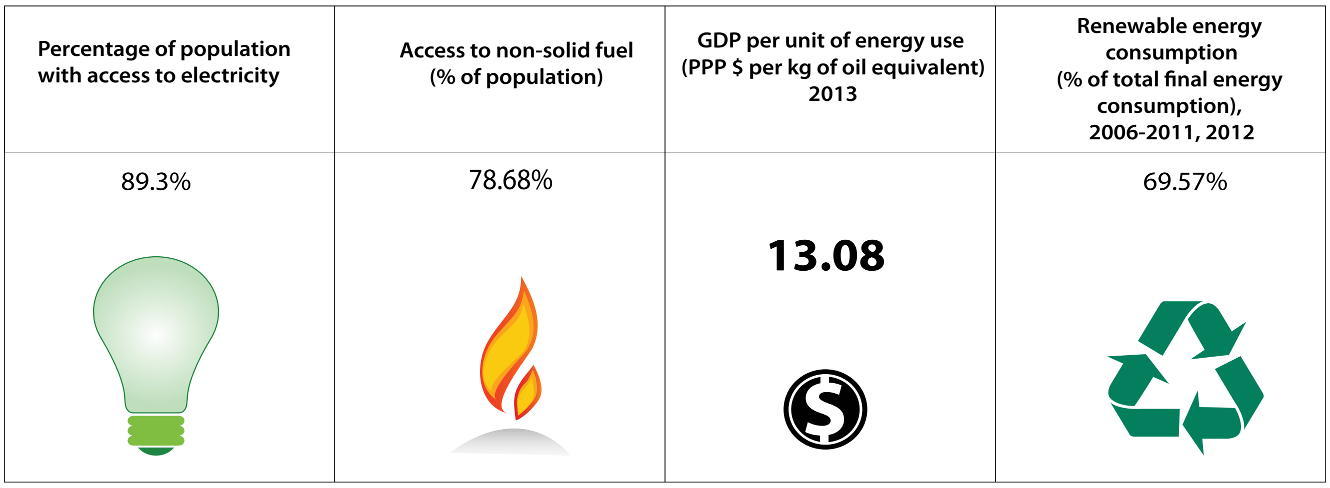


Table 4: Gabon's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions INDCs

INDC
*Develop accrued energy efficiency of the economy.
*Develop decarbonized means of production.
*Continue to improve energy efficiency on this basis, with a goal of attaining 4,000 GWh of consumed electricity toward horizon 2025.
*Put in place an ambitious plan to develop hydroelectricity with the goal of reaching 85 per cent of total electricity generation from hydroelectric plants and 20 per cent from gas plants by 2025.
*Decrease GHGs emissions by 9,000 GgCO2 over 2010-2025 period, being 31 per cent related to the trend-based scenario (48 per cent in 2025).
*Export up to 5,000 GWh of electricity over the same period of 2010-2025.
*Develop a solar electrification plan for remote villages. This plan will allow improving energy access in rural areas without having to use fossil fuel.

Source: (ROC, 2015)

Table 5: Gabon's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Mines, Petroleum and Hydrocarbons; and • Ministry of Energy and Hydraulic Resources
Presence of a Functional Energy Regulator	• Water and Energy Sector Regulatory Agency 2010.
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	• Central Africa Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	• Société d'Electricité et d'Eaux du Gabon (SEEG) is state owned and vertically integrated
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	• The Gabon Oil Company, formed in 2011 by Presidential Decree, operates two fields Obangue and Remboue in partnership with international companies.
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• The Energy Policy 2006 • Industrialization Policy • Gabon Emergent policy
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	• Plans to update the oil and gas law • Exploration and Production Contract (ESPC) established by Law No. 14/82 in January 1983 • Mining Code was established by Law No. 15/62 (1962) • Decree No. 981/PR (1970) and modified under Ordinance 45/73 (1973)

This table is compiled with material from (REEEP, 2014) and (Rai, Kaur, Fikreyesus, & Kallore, 2013)

31.0 per cent and hydro 3.2 per cent (World Bank, 2015). Renewable sources contributed a 41.7 per cent share of electricity generation in 2012 (World Bank, 2015) and the country target is 70 per cent by 2020 (REN21, 2014). Gabon aims to have 80 per cent of energy provided by renewables by 2020.

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Gabon has committed to contributing to addressing the problem of climate change. The country articulated its Intended Nationally Determined Contributions (INDC) in 2015. The energy-related commitments are given in Table 4.

Institutional and Legal Framework

Two ministries — the Ministry of Mines, Petroleum and Hydrocarbons and the Ministry of Energy and Hydraulic Resources — have joint responsibility for the energy sector (Table 5). The energy regulator is the Water and Energy Sector Regulatory Agency 2010. The *Société d'Electricité et d'Eaux du Gabon* (SEEG) is the sole generator, transmitter and distributor of electric energy. On a regional level, the country is a member of the Central Africa Power Pool. The main sector policy is the Energy Policy 2006.

Gambia

Figure 1: Energy profile of Gambia

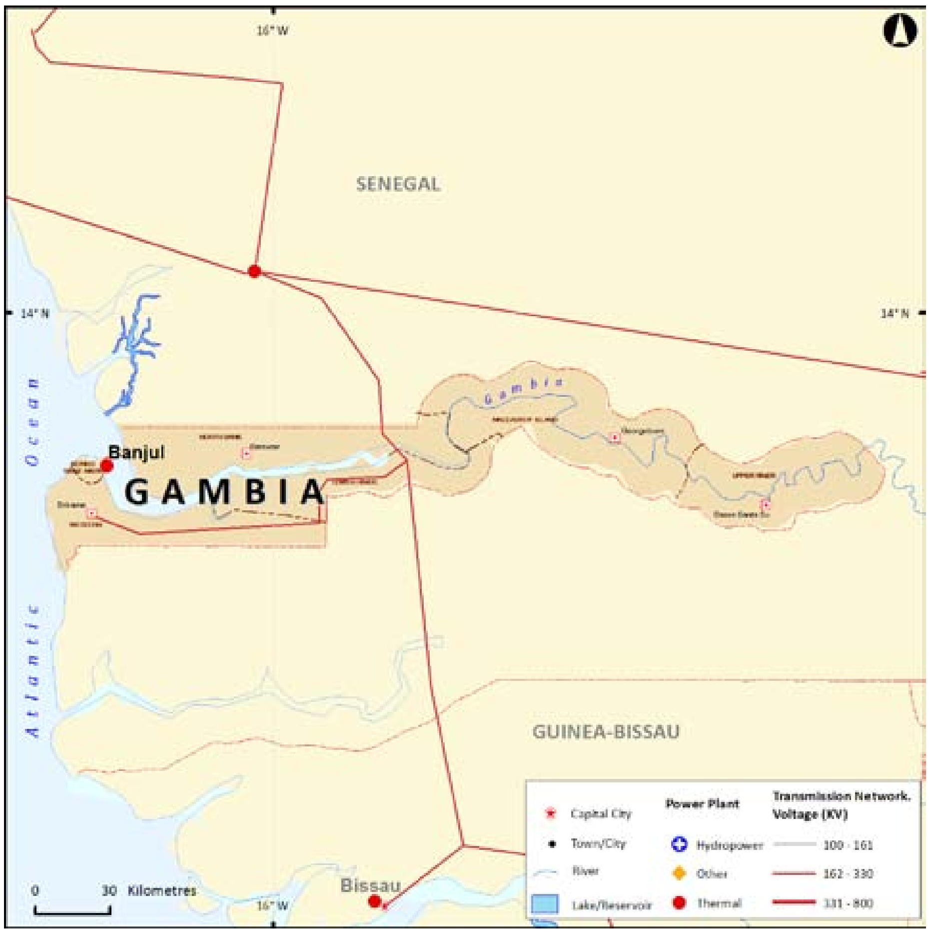
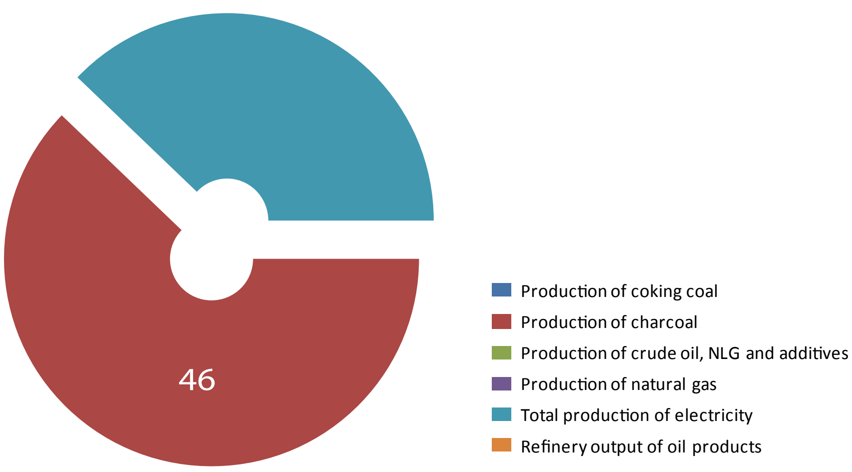
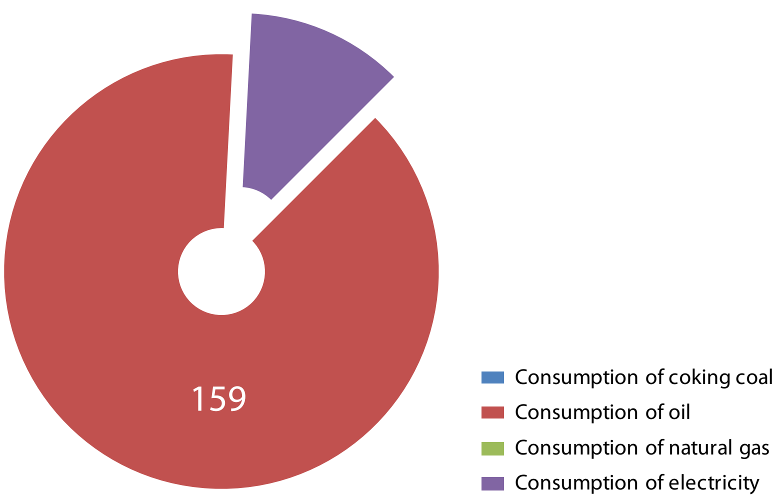


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Gambia's population was 1.86 million (Table 1). Total production of electricity in 2015 was 28 ktoe with 96.4 per cent produced from fossil fuels (Table 2). In 2015, final consumption of electricity was 21 ktoe (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Gambia's key indicators

Key indicators	Amount
Population (million)	1.86
GDP (billion 2005 USD)	58.7
CO_2 emission (Mt of CO_2)	0.42

Source: (World Bank, 2015)

Energy Resources

Biomass

Electricity supply is erratic and so households rely on biomass for over 90 per cent of their energy needs (REEEP, 2012). Alternative fuels are gaining in popularity. Energy crops include the Jatropha plant which is being used a source of biofuels and Miscanthus (Elephant grass). Waste to energy ventures are also being promoted such as the use of groundnut shell briquettes and a waste to energy plant developed as a Public Private Partnerships (PPP) between National Water Electricity Company and Naanovo Energy Gambia Ltd (REEEP, 2012). Fuel efficient cookstoves that use less woodfuel and lower emissions are also being promoted.

Hydropower

Gambia has no hydroelectricity generating potential. However, is working with Guinea, Guinea-Bissau and Senegal, through their regional institution the Gambia River Basin Development Organisation (OMVG) to improve energy supply and security in the member states. Joint current projects include the Kaleta project (240 MW) on the Konkoure River in Guinea and Sambangalou project (128 MW) in Senegal (REEEP, 2012). Three smaller ones totalling 195 MW on Rivers Gambia, Corubal and Tomine are in the prefeasibility stage.

Oil and natural gas

Although offshore exploration activities are ongoing, Gambia does not have any known oil deposits. As such it relies on imports to meets its petroleum needs. Net imports of oil have been increasing from 92 ktoe in 2000 to 177 ktoe in 2015 (AFREC, 2015). About 15 per cent of electricity was produced from fossil fuels in 2015 (AFREC 2015)

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	0	46
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	10	16	17	27
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	-
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	10	16	18	28
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	90	104	170	159
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	9	15	20	21
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	9	15	20	20
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	92	106	172	177
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

\- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Peat

The country has 100 km^2 of peatlands (WEC, 2013).

Wind

The country's coastal areas offer the most realistic options for wind energy; one analysis indicates wind speeds of 5.5 m/s at a height of 50 m on the coast and 3m/s inland (Ceesay, 2012). Wind energy is currently used for water pumping. In 2009, a 150 kVA wind project was being implemented by an Independent Power Producer (IPP) in Batakunku Village, in Kombo South district. It provides electricity for the community and the excess is channeled to the transmission network. GAMWIND another IPP, is operating a 900 kW wind park that is also tied to the grid (REEEP, 2012).

Geothermal

Gambia does not as yet have any known potential sources of geothermal energy. Geological surveys though have found heat reserves in the deeper rock layers which may point to some potential.

Solar

Gambia receives 2,500 sunshine hours per annum which translates to a solar irradiance of over 4.5 kW/m^2/day (REEEP, 2012). Solar energy is already being harvested and used for the traditional applications of lighting, refrigeration, heating and pumping of water and electricity for communication equipment, among others. A number of these installations were financed by the Regional Solar Programme of the Permanent Interstates Committee for Drought Control in the Sahel (CILSS) (REEEP, 2012). There has not been much investment in solar power generation since then (World Bank, 2013).

Cooking over a wood burning fire, Gambia

Tracking progress towards sustainable energy for all (SE4All)

The Gambia has overall low electrification rates: in rural areas, 25.7 per cent of the population has access to electricity and in urban areas the proportion is 41 per cent (Table 3). The national electrification rate is 34.5 per cent (World Bank, 2016). In 2012, only 2 per cent of rural areas had access to modern fuels and 5.02 per cent has such access in urban areas. Banjul, the capital, has the highest electrification rate while the least electrified are the North Bank and Central River areas (REEEP, 2012). There have been initiatives to improve the extent of electrification, but progress is slow. A 6.2 MW capacity project started in 2000 had only achieved 2.2 MW of capacity by 2009 (REEEP, 2012).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 5.5 per US dollar (2005 dollars at PPP) in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was -1.27 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) was 49.7 per cent in 2012. Traditional solid biofuels form the biggest share of renewable sources at 49.7 per cent of TFEC in 2012 (World Bank, 2015).

Table 3: Gambia's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	18	34	31	34.5		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	4	5	5.02		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	58.9	50.3	41.0	49.7		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	22.5		17.57 (2007)			
	Level of primary energy intensity(MJ/$2005 PPP)	5.8		5.7	5.5	5.7	5.53

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
34.5%	5.02%	16.55	48.83%

Table 4: Gambia's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Reduce transmission losses by refurbishing and upgrading the national grid (from 33Kv to 132Kv) to reduce losses. Reduction GgCO_2e in 2025 = 98.7
* Install solar PV, wind power and hydroelectric power plants. Reduction GgCO_2e in 2025 =78.5
*Substitute incandescent light bulbs and raise awareness in the residential sector. Reduction GgCO_2e in 2025 = 42.9
*Install solar water heating facilities on public buildings and support them for hotels and the residential sector. Reduction GgCO_2e in 2025 = 19. 3
*Promote energy saving appliances and additional hydroelectric, solar PV and wind power capacities. GgCO_2e in 2025 = 121.7
* Reduce firewood and charcoal consumption and the overuse of forest resources. GgCO_2e in 2025 = 287.6
* Reduce fuel consumption through efficiency standards. GgCO_2e in 2025 = 114.0
*Remove methane emissions from landfills. GgCO_2e in 2025 = 237.0
*Reduce methane emissions from anaerobic decomposing of organic matter by composting and reducing waste generation by recycling. GgCO_2e in 2025 = 2.7

Source: (ROC, 2015)

Table 5: Gambia's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Department of State for Petroleum, Energy and Mineral Resources (DoSPEMR) • National Water and Electricity Company (NAWEC) • Ministry of Petroleum & Mineral Resources •
Presence of a Functional Energy Regulator	Public Utilities Regulatory Authority (PURA)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	• West African Power Pool (WAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	• Department of State for Finance and Economic Affairs plays a major role in the downstream sector • Gambia National Petroleum Company • Ministry of Petroleum & Mineral Resources • Private companies involved in downstream sector: Galp Energia Gambia Ltd, Total Ltd, Elton Oil Ltd and Castle Oil Ltd
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	IPPs include: • Global Electric Company with a power plant in Brikama Kabafita, with a total installed capacity of 25MW • GAMWIND operating the first large scale (900kW) grid-tied wind park.
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Energy Policy and Action Plan 2014-2018 • National Energy Efficiency Action Plan 2015-2020/2030 • National Investment Program on Access to Energy in The Gambia (2013-2020) • National Energy Policy 2005 • Vision 2020 • Poverty Reduction Strategy Paper (PRSP).
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	• Petroleum Act (2004) • Renewable Energy Act (2013) • Electricity Act

This table was compiled with material from (REEEP, 2012) and (ROG, 2013)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Although data for 2010 indicates that Gambia represents less than 0.01 per cent of global emissions, the government is still keen to do its part in reducing global climate change. The energy-related Intended Nationally Determined Contributions (INDC) are given in Table 4.

Institutional and Legal Framework

The Department of State for Petroleum, Energy and Mineral Resources (DoSPEMR) is in charge of the energy sector (Table 5). The energy regulator is the Public Utilities Regulatory Authority (PURA). The National Water and Electricity Company (NAWEC) is the sole generator, transmitter and distributor of electric energy. On a regional level, the country is a member of the West African Power Pool (WAPP). The legal framework is provided by the Electricity Act. The main sector policy is the National Energy Policy 2005.

Ghana

Figure 1: Energy profile of Ghana

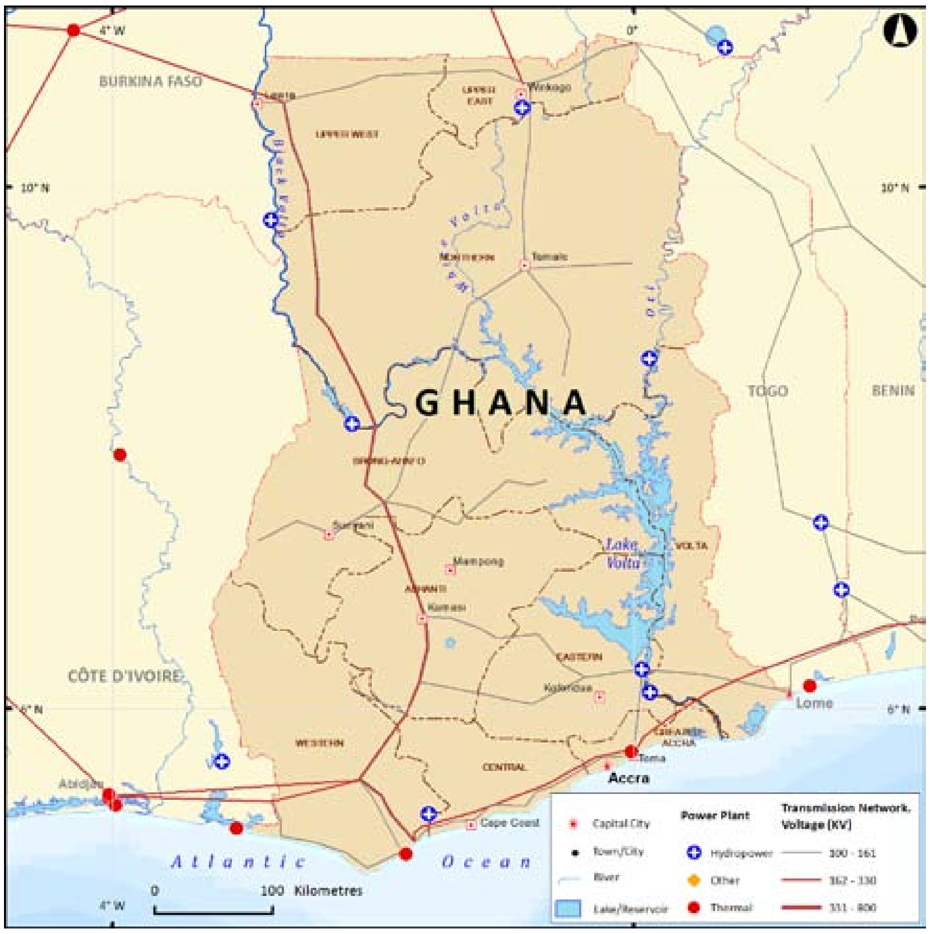
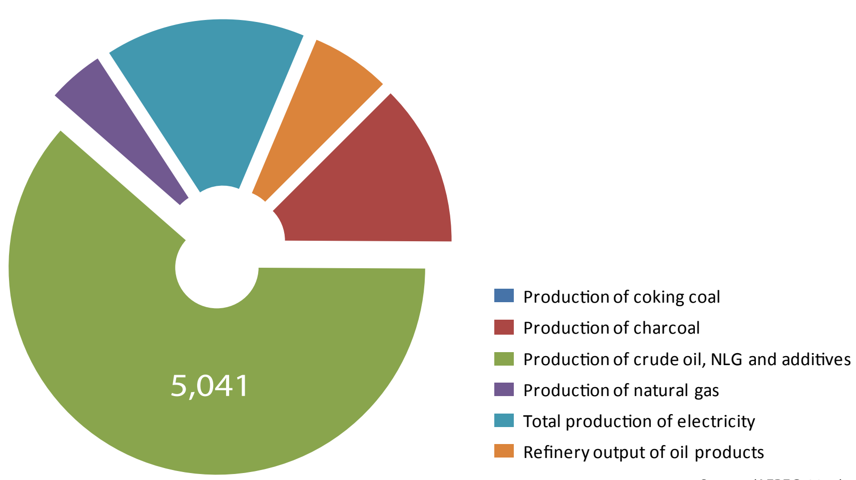
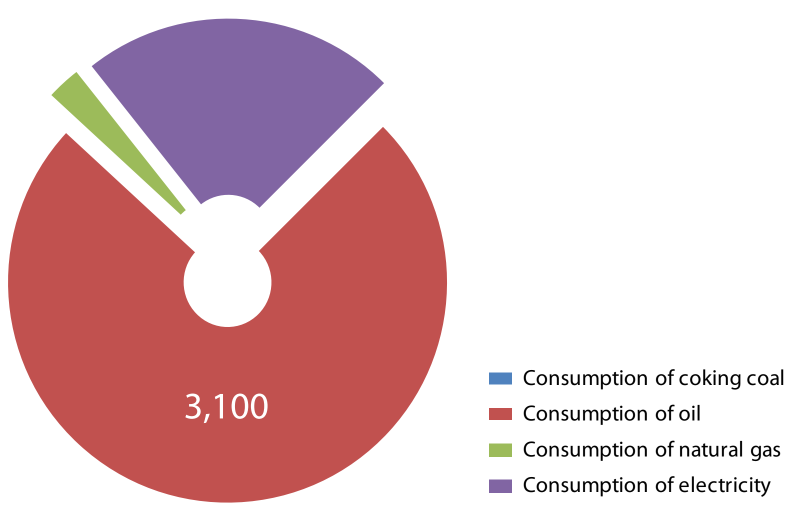


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Ghana's population in 2013 was 25.91 million (Table 1). Total production of electricity in 2015 was 1,275 ktoe with 41.6 per cent produced from fossil fuels and 46.9 per cent from hydro sources (Table 2). The final consumption of electricity in 2015 was 975 ktoe (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Ghana's key indicators

Key indicators	Amount
Population (million)	25.91
GDP (billion 2005 USD)	19.93
CO_2 emission (Mt of CO_2)	13.65

Source: (World Bank, 2015)

Energy Resources

Biomass

Biomass is the main source of energy both in terms of endowment and consumption, with demand for fuelwood and charcoal growing at about 3 per cent per year (MOE, 2010). Biomass resources cover about 20.8 million hectares and supply approximately 60 per cent of total energy used in Ghana (MOE, 2010).

Ghana has much fertile land for growing food as well as crops that can be made into different sorts of solid and liquid biofuels. The two main biofuels on the market are biodiesel and ethanol. The Energy Sector Strategy and Development Plan (2010) aims to sustain the supply and efficient use of wood-fuels while making sure that their use does not contribute to deforestation.

Hydropower

Ghana has generous water resources that have the potential to provide 2,420 MW of hydroelectricity (REEEP, 2014). Existing dams include the 912 MW Akosombo plant, Kpong (140 MW) and Bui (400 MW) plants all on the Volta river. Ghana is exploring opportunities for alternative energy sources as its reliance on hydroelectricity makes it particularly vulnerable to impacts of climate change.

Oil and natural gas

The proven recoverable oil reserves at the end of 2011 were 15 million barrels. Oil production in 2011 was 26,388 thousand barrels. At that time, proven recoverable reserves of gas were 22.7 bcm (WEC, 2013). Ghana produces 140-200 million cubic feet of natural gas per day. But since December 2012, delays in the construction of a gas refinery at Sekondi-Takoradi have constrained production. In 2011, the crude oil industry accounted for about 6 per cent of the Ghanaian economy (WEC, 2013). .

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	1,150	1,343	1,664	1,033
Production of crude oil, NLG and additives	0	0	169	5,041
Production of natural gas	0	0	53	358
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	53	100	273	531
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	568	458	595	740
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	4
Total production of electricity	621	558	868	1,275
Refinery output of oil products	1,032	1,546	949	506
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	1,582	1,935	2,423	3,100
Final consumption of natural gas	0	0	112	103
Final consumption of electricity	522	515	591	965
Consumption of oil in industry	271	330	489	625
Consumption of natural gas in industry	0	0	0	0
Consumption of electricity in industry	346	393	271	344
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	1,022	1,254	1,633	2,135
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	1,200	1,837	1,497	-2,702
Net imports of oil product	819	580	1,595	2,048
Net imports of natural gas	0	0	394	403
Net imports of electricity	41	15	-80	-45

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Peat

Areas of peatland are equivalent to 59 km^2 (WEC, 2013).

Wind

Ghana has wind data for quite a number of years now, albeit scattered and inconsistent, and the indications are that there is good potential for exploitation of wind as a source of energy. However due diligence on the technical and financial viability for development at a large scale needs to be done before any serious investments can be undertaken (REEEP, 2014). Wind speeds vary across the country with the highest measured along the Ghana-Togo border in the Volta region where average wind speeds of over 9 m/s at 50 m have been recorded. Along the eastern coastline wind speeds range from 6.2-7.1 m/s at 50 m and patches towards the north have recorded speeds of between 7.8-8.4 m/s at 50 m (Osei, Ribeiro and Kwofi, 2011). The National Energy Policy, 2010 sites wind energy as a priority area for development and efforts are ongoing in this area. For instance, under its Renewable Energy Development Plan, the Volta River Authority is currently implementing feasibility studies for generating 150 MW of wind energy.

Geothermal

Ghana has no known geothermal resource.

Solar

Ghana's potential for solar energy generation is high with the data indicating solar radiation levels are about 4-6 kWh/m^2 providing great opportunities for exploitation. Ghana is currently implementing a 155 MW photovoltaic solar energy plant, the Nzema project, to provide electricity to over 100,000 households. This will increase the country's electricity generating capacity by 6 per cent. There is also a pilot program to replace kerosene lanterns with solar lanterns in remote off-grid communities so as to reduce the national kerosene subsidy. Ghanaians use kerosene as their main source of lighting. The government plans to use this potential to support rural electrification Brong Ahafo (central Ghana) and in the Greater Accra and Volta regions in south-eastern parts of the country.

Tracking progress towards sustainable energy for all (SE4All)

In 2012, the national electrification rate was 64.1 per cent . However, the difference in access rate between the richest 60 per cent and the poorest 40 per cent of the population was more than 40 percentage points. The gap between urban and rural areas is also large. The rate of access to electricity in Ghana is 41 per cent and 85 per cent in rural and urban areas, respectively. The National Electrification Scheme has been critical in extending electricity supply. Access to modern fuels is low. In 2012, only 16.78 per cent of Ghanaians were using non-solid fuels; 4 per cent of these are from rural areas and 29 per cent are in urban Ghana (Table 3 and Figure 4) (World Bank, 2015). A majority of Ghanaians use solid fuels for cooking. However, these are associated with indoor air pollution from burning of woodfuel and deforestation causing major health and environmental impacts. The government policy is therefore encouraging the use of LPG, mainly in urban areas, and the use of improved (energy efficient and smokeless) cook stoves in rural areas.

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Ghanaian economy was 4.6 MJ per US dollar (2005 dollars at PPP) in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was -6.51 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) almost halved, dropping from 80.6 to 49.5 per cent between 1990 and 2012. Traditional solid biofuels form the biggest share of renewable sources at 33.1 per cent of TFEC in

Table 3: Ghana's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	31	45	61	64.1		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	8	15	17		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	80.6	74.7	66.5	49.5		49.49 (2012)
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			7.5	8.1 (2011)		
	Level of primary energy intensity(MJ/$2005 PPP)	8.0		5.2	4.6	4.69	4.56

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

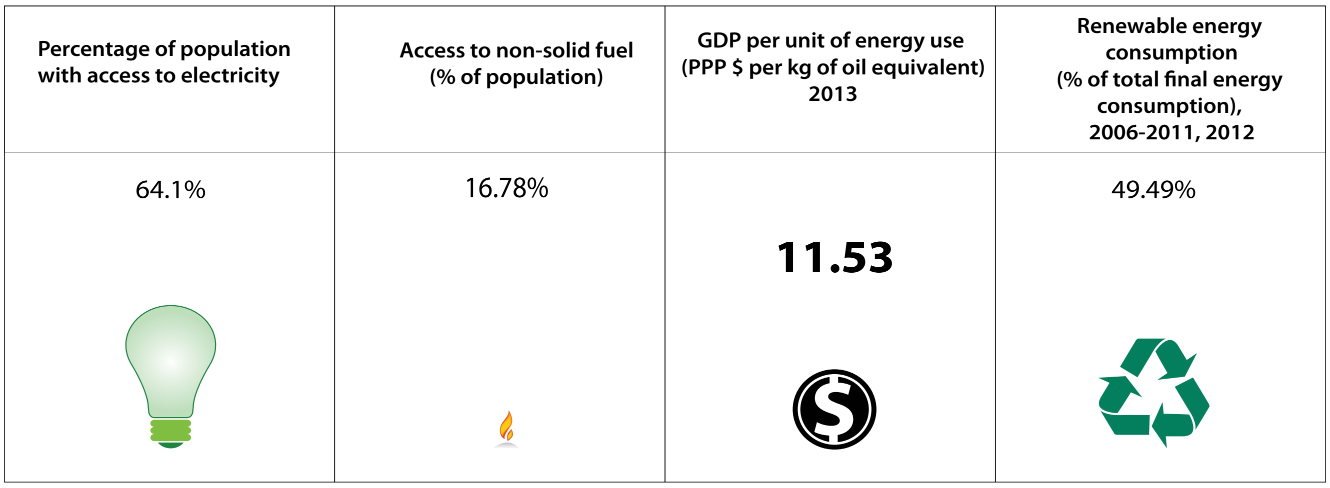


Table 4: Ghana's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Scale up renewable energy penetration by 10 per cent by 2030/5
*Promote clean rural households lighting/1
*Expand the adoption of market-based cleaner cooking solutions/2
*Double energy efficiency improvement to 20 per cent in power plants/1
*Scale up renewable energy penetration by 10 per cent by 2030
-Increase small-medium hydro installed capacity up to 150-300 MW
-Attain utility scale wind power capacity up to 50-150 MW
-Establish 55 solar mini-grids with an average capacity of 100 kW which translates to 10 MW
-Scale up the 200,000 solar home systems for lighting in urban and selected non-electrified rural households
*Promote clean rural households lighting
-Increase solar lantern replacement in rural non-electrified households to 2 million
*Expand the adoption of market-based cleaner cooking solutions
-Scale up adoption of LPG use from 5.5 per cent to 50 per cent in peri-urban and rural households by 2030.
-Scale up access and adoption of 2 million efficient cook stoves up to 2030
*Double energy efficiency improvement to 20 per cent in power plants
-Scale up 120 MSCF12 natural gas replacement of light crude oil for electricity generation in thermal plants.

Source: (ROC, 2015)

Table 5: Ghana's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Petroleum • Environmental Protection Agency (EPA) • Ghana Energy Foundation • Ghana Investment Promotion Centre (GIPC) • Public Utility Regulatory Commission (PURC)
Presence of a Functional Energy Regulator	Energy Commission
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	Ghana National Petroleum Corporation (GNPC)
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West Africa Power Pool (WAPP).
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Volta River Authority (VRA) unbundled in 2005. • VRA - electricity generation • Ghana Grid Company Limited (GridCo) - electricity transmission • Northern Electricity Department (NED) - sole electricity distributor to the north • Electricity Company of Ghana (ECG) – electricity distributor to the south.
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Petroleum Commission (upstream)
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	CenPower/Kpone IPP produces 348 MW.
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Energy Policy • National Electrification Scheme (NES) • National Renewable Energy Policy • Policy Framework for Street Lighting in Ghana (2011)
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Energy Commission Act • Volta River Development Act (1961 • Public Utilities and Regulatory Commission Act, 1997 (Act 538); and • Renewable Energy Act, 2011 (Act 832) • National Petroleum Authority Act, 2005 (Act 691) • Petroleum Exploration and Production Bill 2016 • Petroleum Revenue Management Act 2011

This table was compiled with material from (REEEP, 2014) and (IRENA, 2015)

2012, while the modern solid biofuels contributed 9.1 per cent and hydro 7.3 per cent (World Bank, 2015). Renewable sources contributed 67.1 per cent of the share of electricity generation in 2012 (World Bank, 2015).

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

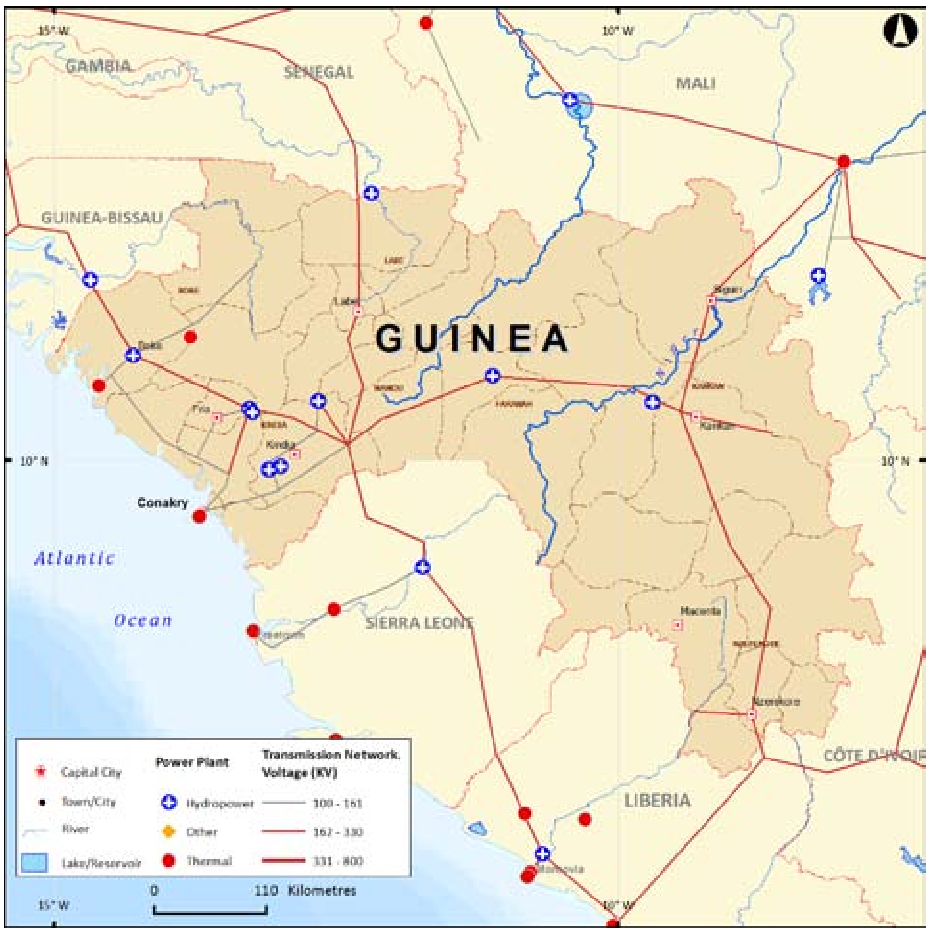
Ghana is keen to contribute to efforts to reduce the impacts of climate change. The actions identified in Ghana's INDC are designed to help attain low carbon climate resilience through effective adaptation and reduction of emissions of greenhouse gas (GHG) in the different sectors. The energy-related Intended Nationally Determined Contributions (INDC) are given in Table 4.

Institutional and Legal Framework

The Ministry of Energy and Petroleum is in charge of the energy sector (Table 5). The energy regulator is the Energy Commission. The electricity sector is unbundled with the Volta River Authority (VRA) generating electricity, the Ghana Grid Company Limited (GridCo) transmitting it and two companies — the Electricity Company of Ghana (ECG) and the Northern Electricity Distribution Company (NED Co) — distributing the electricity to the southern and northern parts of the country, respectively. On a regional level, the country is a member of the West African Power Pool. The Energy Policy 2010 guides the sector.

Guinea

Figure 1: Energy profile of Guinea



Energy Consumption and Production

Guinea had a poulation of 11.94 in 2013 (Table 1) (World Bank, 2016). In 2015, total production of electricity was 109 ktoe with 43.1 per cent produced from fossil fuels and 55.9 per cent from hydro sources (Table 2). Final consumption of electricity is 95 ktoe (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Guinea's key indicators

Key indicators	Amount
Population (million)	11.94
GDP (billion 2005 USD)	3.61
CO_2 emission (Mt of CO_2)	2.59

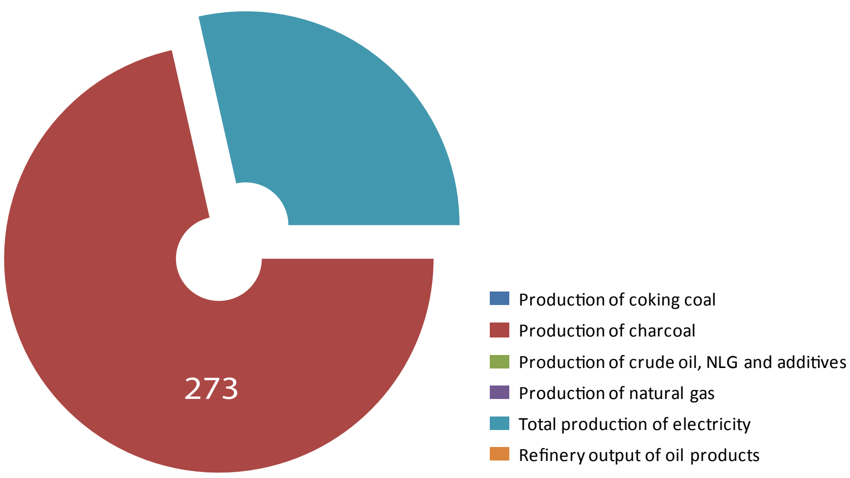
Source: (World Bank, 2015)

Energy Resources

Biomass

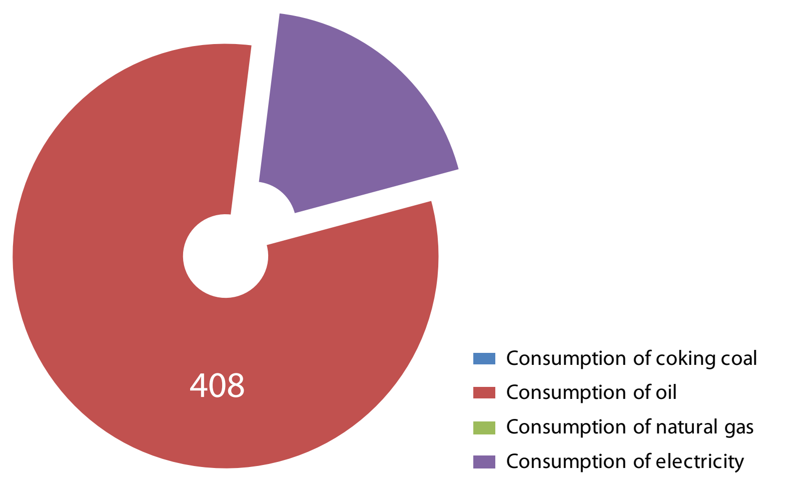
There is a dearth of information on the actual volume of Guinea's biomass potential with some estimates averaging 8.5 to 14 million m^3 in accessible biomass volume (REEEP, 2012). However, like in other African nations, wood and charcoal play a big part in the country's energy balance. In 2015, production of charcoal amounted to 273 ktoe (AFREC, 2015).

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Solar panels power refrigerators for vaccines

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	0	273
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	29	34	39	47
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	35	42	45	61
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	64	76	83	109
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	412	439	456	408
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	59	70	77	95
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	4	35
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	412	442	469	499
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Hydropower

Guinea has considerable potential for hydropower generation, with the gross theoretical capability estimated at 26,000 GWh/year, 40 per cent of which lies in the Konkoure River basin (REEEP, 2012). There is thus the option of substituting expensive thermal generation with relatively cleaner hydroelectricity (WEC, 2013). However, this will require much support and investment commitment from the government. The installed hydroelectric capacity in 2011 was 75 MW, with a further 80 MW under construction (WEC, 2013). The coastal region holds most (46 per cent) of the hydro-generation potential followed by the mountainous area near the Fouta-Djalon which have a potential of 43 per cent (WEC, 2013).

Oil and natural gas

At the end of 2011, the estimated recoverable oil reserves were 1,700 and million barrels of oil.

Peat

There are 1,952 km^2 of peatland (WEC, 2013).

Tidal power

In 2013, the Wave Electricity Renewable Power Ocean (WERPO) company of Israel signed an MOU with the government to build a 100 MW tidal power plant in Conakry (Energy Mix Report, 2013).

Wind

Data is limited as to wind power potential, but it is suggested that the mean wind speeds ialong the coast and in the central part of the country are between 2 to 4 m/s annually. This may be too low for large-scale wind power production, but could be used for smaller applications such as water pumps (REEEP, 2012).

Geothermal

No study has been done to assess the geothermal potential of Guinea (REEEP, 2012).

Solar

There is a dearth of information on the potential of solar power in Guinea. However, REEEP (2012) indicates a mean annual insolation of just under 5 kWh/ m^2/day and sunshine duration averaging 2,700 hours a year, indicating commercial viability. By 2015, the production of electricity from solar and wind was estimated at 1 ktoe (AFREC, 2015).

Tracking progress towards sustainable energy for all (SE4All)

There are a number of challenges in the sector, including unending load shedding, inadequate distribution networks, with a loss rate of 49 per cent , and poor management of the national electricity company; these have conspired to leave Guinea with a very low national electrification rate of 26.2 per cent (Table 3) (World Bank, 2016). Access to electricity in rural areas is only 2.9 per cent compared to 74.2 per cent in urban areas (World Bank, 2016). In fact, many of the micro-hydro dams located outside the capital city that were built before 1960 are only operational due to the ingenuity of local engineers. Access to modern fuels is low with most households using firewood and charcoal for cooking (REEEP, 2012). In 2012, only 2 per cent of people in rural areas were using non-solid fuels and just 3 per cent in urban areas (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 15.1 MJ per US dollar (2005 dollars at PPP) in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was -0.24 (World Bank, 2015).

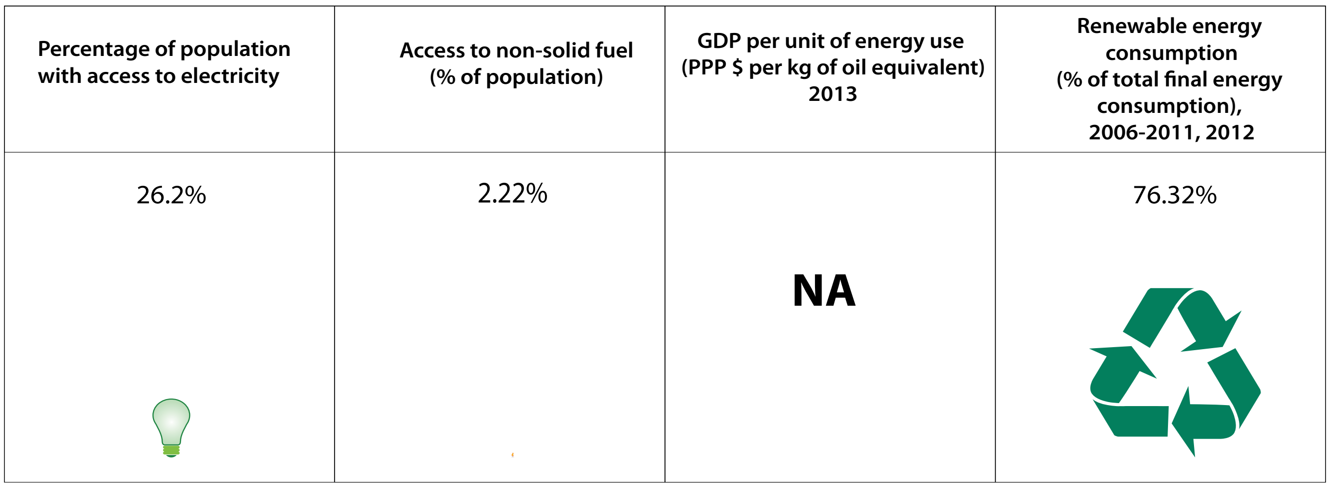
The share of renewable energy in the total final energy consumption (TFEC) decreased slightly from 92.6 to 74.1 per cent between 1990 and 2012. Traditional solid biofuels form the biggest share of renewable sources at 72.8 per cent of TFEC in 2012, while modern solid biofuels contributed only 0.5 per cent and hydro 0.8 per cent . Renewable sources contributed 28.4 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Guinea's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	14	16	20	26.2		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	2	2.22		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	92.6	89.6	88.9	74.1		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						11.16 (2013)
	Level of primary energy intensity(MJ/$2005 PPP)	14.4		15.2	15.1	12.00	11.92

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators



Magharebia / Foter / CC BY

Table 4: Guinea's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Produce 30 per cent of energy (excluding wood-energy) from renewable energy sources.
*Commission hydro-power stations producing 1,650 MW (127 MW in 2011).
*Install an additional 47 MW (3 MW in 2011) of solar and wind power.
*Increase the supply of biofuels and other modern energies (40k toe of butane and biogas, 3000 kWc of biofuels).
*Support the dissemination of technologies and practices that are energy- efficient or use alternatives to wood-energy and charcoal.
* Reduce final demand for firewood and charcoal by 50 per cent per capita (in urban and rural areas) as compared to 2011.
*Improve the energy performance of the Guinean economy.
*Improve electricity yields by 50 per cent in relation to the baseline situation (2011).
*Reduce specific consumption of the transport, residential and public administration sectors by improving the quality of the transport fleet; promoting public transport; disseminating solar streetlamps and low-energy lamps and electrical appliances; and implementing efficiency standards in building design.

Sources: (World Bank, 2015); (World Bank, 2016)

Table 5: Guinea's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Energy and Hydraulics (MEH)
Presence of a Functional Energy Regulator	Electricity Sector Regulatory Body 2005
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West African Power Pool (WAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Electricity Corporation of Guinea (EDG)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Ministry of Mines and Geology
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	National Directorate of Energy (Ministry of Energy and Hydraulics)
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy policy 2008 • Electrification Master Plan • Electricity Sector Efficiency Improvement Project
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Petroleum Code has been introduced by the Law L/2014 /N°034/AN dated 23December 2014 • Electricity production laws of 1993 • Law L/98/012 of 1st June 1998.

This table was compiled with material from (REEEP, 2012)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Guinea is rich in natural resources that make it a carbon sink. But these same resources are under threat from climate change. The government aims to protect these resources while at the same time helping to reduce its contribution to global climate change. To that end, the Intended Nationally Determined Contributions (INDCs) were articulated. Those related to energy are shown in Table 4.

Institutional and Legal Framework

The Ministry of Energy and Hydraulics (MEH) is in charge of the energy sector while the National Directorate of Energy defines policy (Table 5). The energy regulator is the Electricity Sector Regulatory Body 2005. The Electricity Corporation of Guinea (EDG) is the sole generator, transmitter and distributor of electric energy. On a regional level, the country is a member of West African Power Pool. The legal framework is provided by the electricity production laws of 1993 and by Law L/98/012 of 1st June 1998. The main sector policy is the Energy Policy 2008.

Guinea Bissau

Figure 1: Energy profile of Guinea Bissau

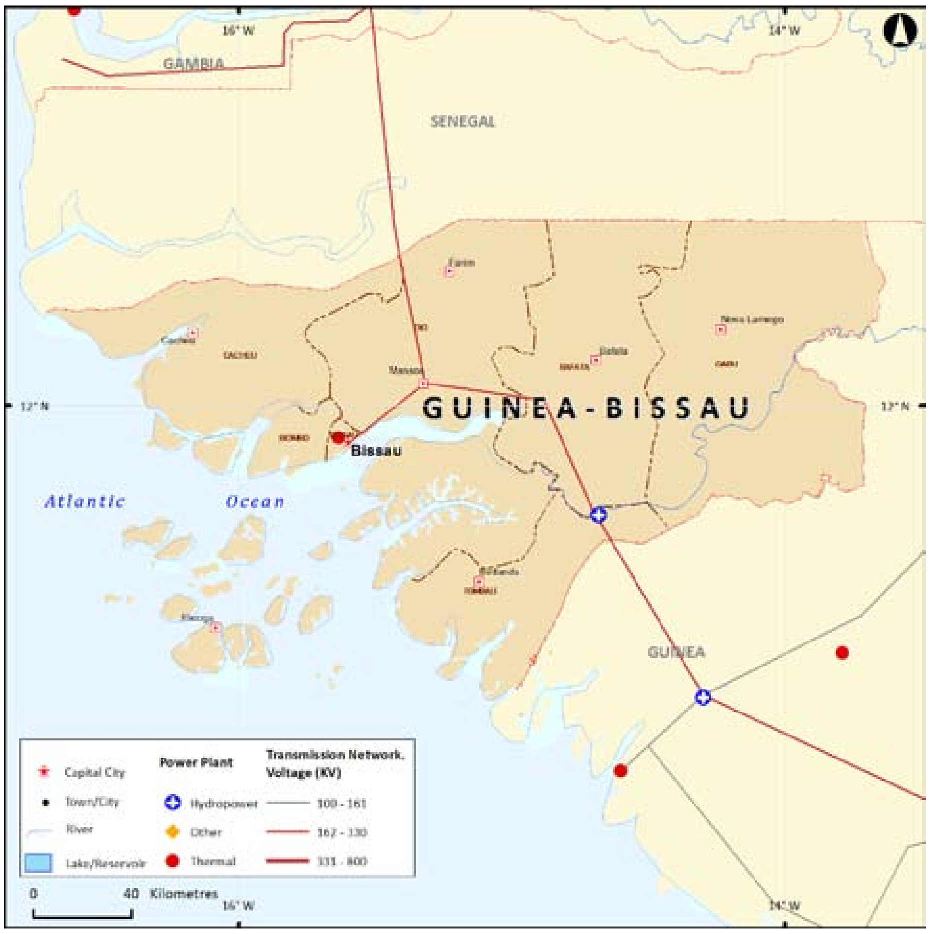
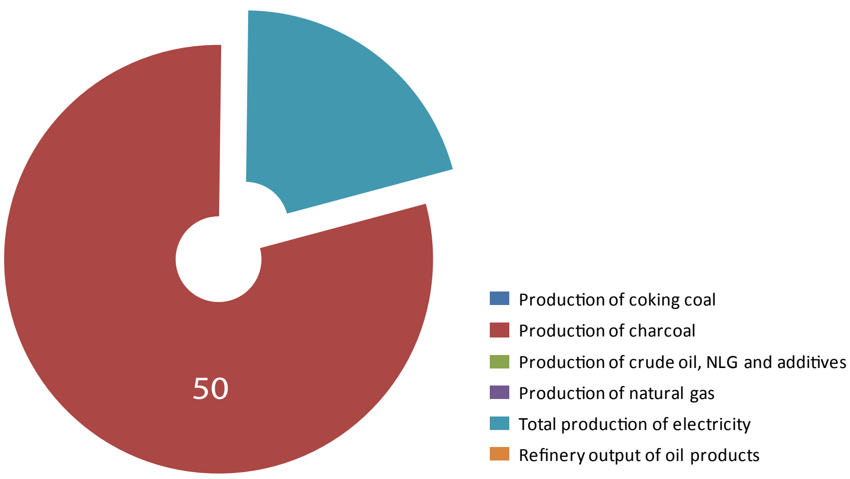
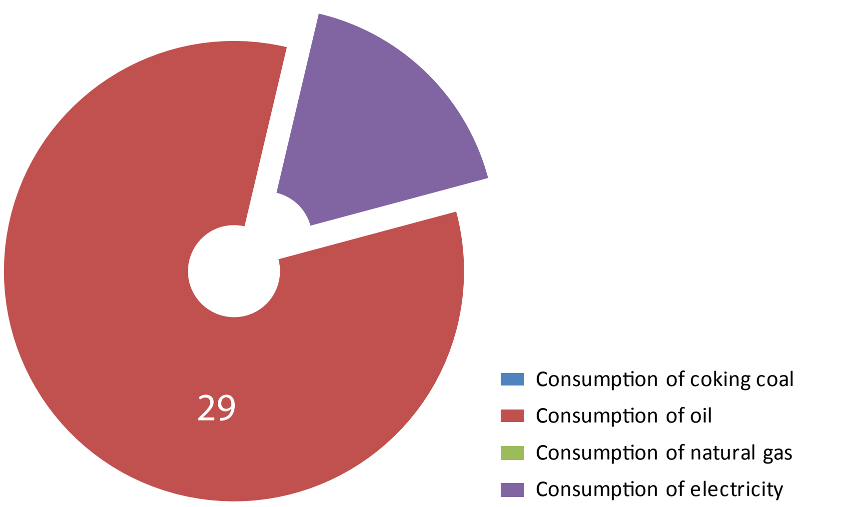


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Guinea Bissau has a population of 1.75 million (Table 1). Total production of electricity in 2015 was 13 ktoe with all of it produced from fossil fuels (Table 2). Final consumption of electricity in the same year was 6 ktoe (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: Guinea Bissau's key indicators

Key indicators	Amount
Population (million)	1.75
GDP (billion 2005 USD)	0.83
CO_2 emission (Mt of CO_2)	0.24

Source: (World Bank, 2015)

Energy Resources

Biomass

Fuelwood supplies about 90 per cent of the energy consumed in Guinea-Bissau. The country has about 2 million ha of forest. The yearly consumption of wood for energy is about 1.29 per cent of the available biomass resource, which is about 48.3 million m^3 translating into a deforestation rate of 30,000 to 60,000 ha/year (AfDB, 2015) (REEEP, 2012). Charcoal production doubled from 21 ktoe in 2010 to 50 ktoe in 2015 (AFREC, 2015). There is potential for the production of biofuels from jatropha plantations and the agro-industrial waste from cashew nut cultivation (REEEP, 2012).

Hydropower

The transboundary Geba River and its main tributary the Rio Corubal are estimated to have a hydropower potential of approximately 184 MW (REEEP, 2012). But by 2015 hydroelectricity was not still not an important source of energy.

Tidal

The coast of Guinea-Bissau, with its deeply indented coastline, experiences high tidal range values making this a commercially viable energy resource. The highest mean annual tidal amplitude of 3.4 m was recorded at Porto Gole, on the banks of Rio Geba and could generate 50 MW of electricity (REEEP, 2012); (DICAT, undated). In 2015, a 500 MW tidal energy plant joint venture was announced between the government and the Israeli Wave Electricity Renewable Power Ocean (WERPO).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	13	14	21	50
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	2	5	6	13
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	-
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	2	5	6	13
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	33	128	133	29
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	1	5	5	6
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	17	0	0	21
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	37	128	133	47
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

Wind

According to REEEP (2012), typical wind speeds range from 2.5 to 7 m/s along the coast and some islands. However, there are no plans to exploit this resource (REEEP, 2012).

Geothermal

There is no geothermal energy use in the country (REEEP, 2012).

Solar

Solar energy use is minimal despite the country receiving over 4.5 kWh of solar radiation and about 3,000 sunshine hours per annum (REEEP, 2012). The legal framework in support of extending renewable energies is weak, but there are plans to increase solar use by about 2 per cent of total energy consumption by 2015 (REEEP, 2012).

Solar panels on roof, Guinea Bissau

Tracking progress towards sustainable energy for all (SE4All)

By 2012, 61 per cent of the country was electrified, but the gap between rural and urban areas is stark (Table 3). Only a small proportion of the population outside the capital has access to public electricity supply and this occurs only part of the time. Rural areas have 21.5 per cent coverage of electricity compared to 100 per cent of urban areas (World Bank, 2015); (World Bank, 2016). Despite the full access to electricity in urban areas, power is only available 70 per cent of the time (REEEP, 2012). The challenges include electricity losses due to aging equipment, illegal connections and irregular billing. The African Development Bank (AfDB) is supporting a programme to strengthen the electricity distribution network by rehabilitating some of the infrastructure, connecting new subscribers and improving the management and governance of the National Electricity and Water Corporation (EAGB). This should add 27.5 MW by 2018 while support from the West African Development Bank should add 10 MW by 2017 (AfDB, 2015).

Access to modern fuels is low. In 2012, only 2 per cent of people in rural Guinea-Bissau were using non-solid fuels; in urban areas, the proportion is slightly higher at 4 per cent (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) averaged 15 MJ per US dollar (2005 dollars at PPP) from 1990 to 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was -0.24 (World Bank, 2015).

Table 3: Guinea Bissau's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	51	54	57	60.6		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	2	2		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	70.8	50.1	37.4	88.5		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	21.3					
	Level of primary energy intensity(MJ/$2005 PPP)	14.4		15.2	15.1	14.64	15.10

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

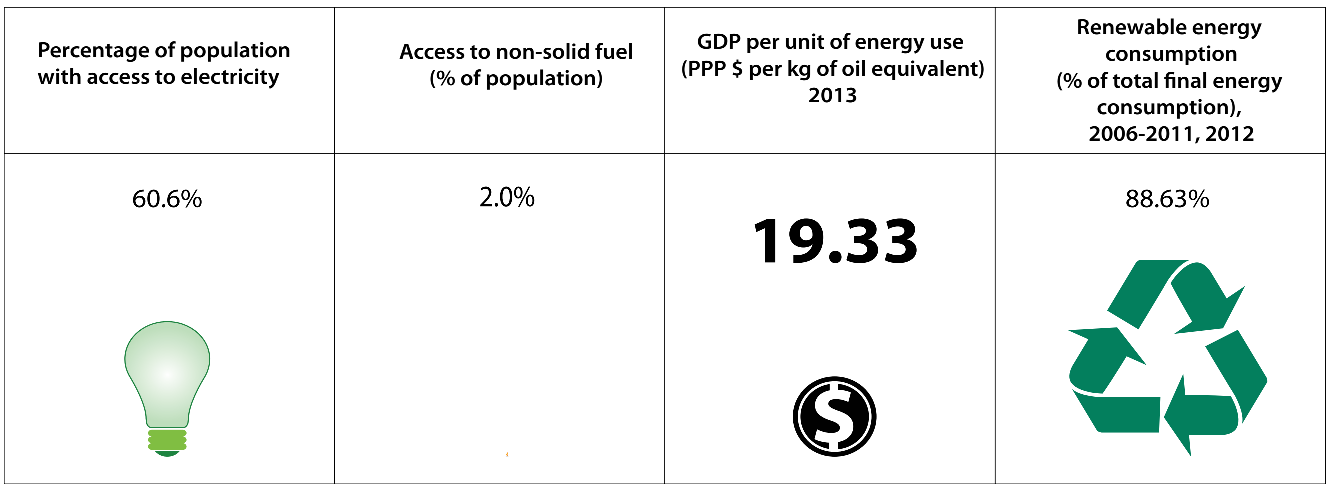


Table 4: Guinea Bissau's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Attain 80 per cent renewable energy in the national energy mix by 2030;
*Improve energy efficiency by reducing energy losses up to 10 per cent in the 2030 time span;
*Reach 80 per cent of universal access to electricity by 2030.

Source: (ROC, 2015)

The share of renewable energy in the total final energy consumption (TFEC) has been changing drastically over the years, settling at 88.5 per cent in 2012 (World Bank, 2015). With the output gap in electricity supply, the dependence on traditional biofuels is high, forming an 80.8 per cent share of renewable sources; this threatens the national forest resource. It is estimated that 8.1 per cent of forested area was lost between 1990 and 2005 (REEEP, 2012). Modern solid biofuels contributed only a 7.7 per cent share of renewable sources in 2012 (World Bank, 2015).

Table 5: Guinea Bissau's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Industry • General Directorate for Energy (DGE) • State Secretariat of Energy and Natural Resources
Presence of a Functional Energy Regulator	Ministry of Energy and Industry
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West African Power Pool (WAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	National Electricity and Water Corporation (EAGB)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Ministry of Energy and Industry
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	PetroGuin (national oil company)
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Master Plan for the Development of the Energy Sector 1980 • National Energy Policy 1995 • Draft Renewable Policy 2004
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	

This table was compiled with information from (REEEP, 2012) and (AfDB, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Guinea Bissau is concerned about climate change because it is vulnerable to the consequences, even though its low greenhouse gas (GHG) emissions make the country a GHG sink. Hence, it articulated its INDCs in 2015 and those related to energy are shown in Table 4.

Institutional and Legal Framework

The Ministry of Energy and Industry is in charge of both implementing policies in the energy sector and regulating them (Table 5). The National Electricity and Water Corporation (EAGB) manages the electricity sector in Guinea Bissau. On a regional level, the country is a member of the West African Power Pool. The main sector policy is the National Energy Policy 1995, and more recently, the Energy Master Plan of 2013.

Kenya

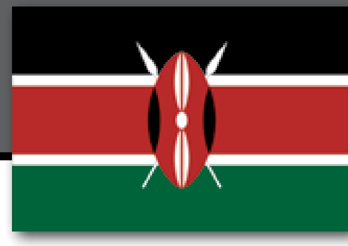


Figure 1: Energy profile of Kenya

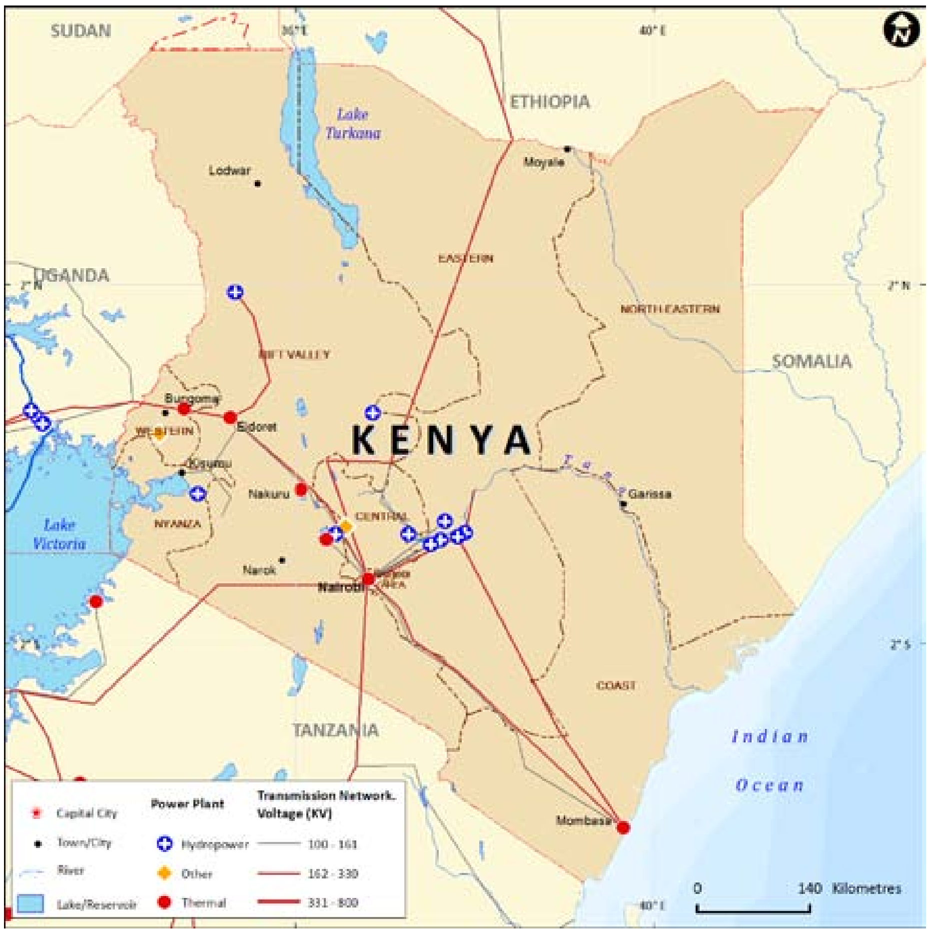
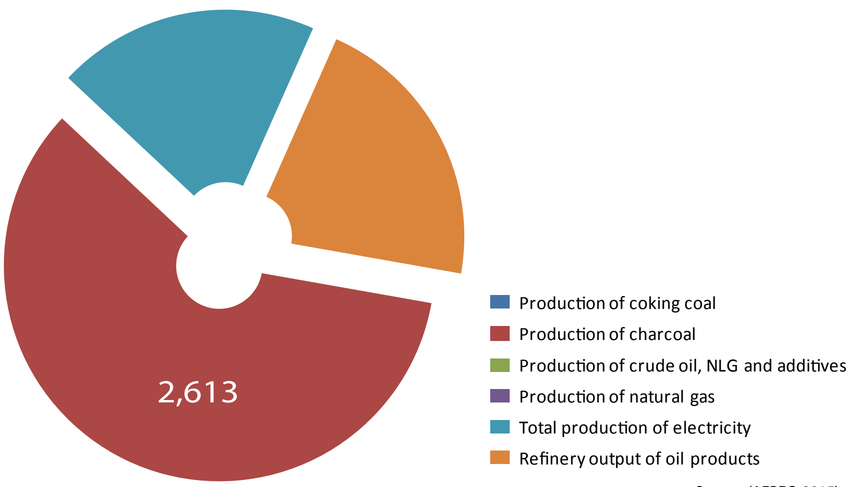
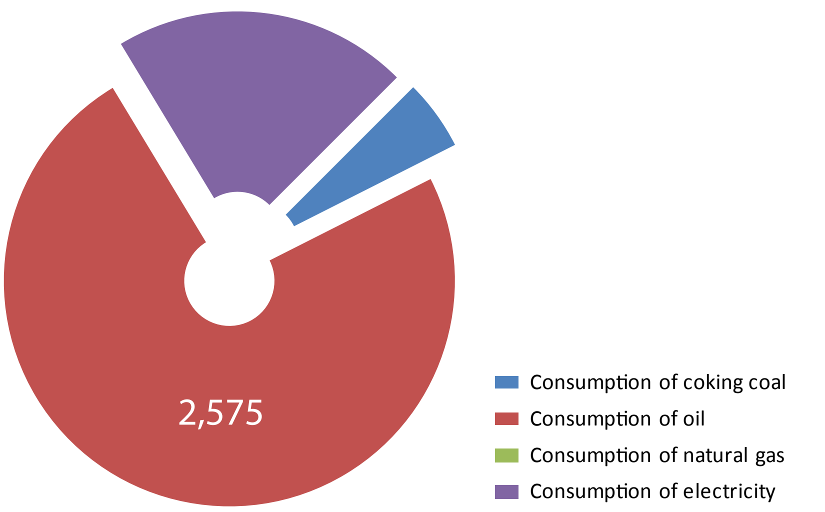


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Kenya had a population of 43.69 million (Table 1). Electricity production in 2015 was 869 ktoe with 36.4 per cent of it generated from fossil fuels, 26.6 per cent from hydro and 32.4 per cent from geothermal sources. Final consumption of electricity in the same year was 738 ktoe (AFREC, 2015). Table 2 shows the key energy statistics for the country. Key energy consumption and production statistics are shown in Figure 2 and 3.

Table 1: Kenya's key indicators

Key indicators	Amount
Population (million)	43.69
GDP (billion 2005 USD)	28.05
CO_2 emission (Mt of CO_2)	11.70

Source: (World Bank, 2015)

Energy Resources

Hydropower

In 2005, hydroelectricity production was 50.3 per cent of total electricity production decreasing to 26.7 per cent in 2015 (AFREC, 2015). Hydropower generation has been unstable lately due to the unpredictability of the water resource. During periods of drought, the government is forced to purchase expensive and polluting fossil fuels. For instance, the suppressed long rains in 2014 led to a 19.5 per cent decline in hydro generation. The catchment of the Mau forest complex has a potential hydropower generation capacity of about 535 MW (UNEP, 2009). Protecting forests or "water towers" has thus become a central point in ensuring a sustainable energy supply.

Transportation in rural Kenya

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	1,112	2,012	2,287	2,613
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	19	28	27	20
Production of electricity from fossil fuels	183	152	197	317
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	114	260	292	232
Production of geothermal electricity	37	76	125	282
Production of electricity from solar, wind, Etc.	0	0	2	17
Total production of electricity	353	516	642	869
Refinery output of oil products	1,994	1,615	1,617	932
Final Consumption of coking coal	34	55	137	176
Final consumption of oil	1,910	2,314	2,830	2,575
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	276	424	544	738
Consumption of oil in industry	283	354	887	809
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	169	269	312	309
Consumption of coking coal in industry	34	55	137	189
Consumption of oil in transport	1,169	1,557	1,560	1,463
Consumption of electricity in transport	0	0	0	0
Net imports of coking coal	34	55	137	179
Net imports of crude oil, NGL, Etc.	2,290	1,657	1,449	857
Net imports of oil product	763	1,484	2,316	3,190
Net imports of natural gas	-	-	-	-
Net imports of electricity	17	-1	1	1

-   : Data not applicable
0   : Data not available
(P): Projected

(AFREC, 2015)

Peat

The area of land covered with peat is about 2,440 km^2 (WEC, 2013).

Wind

The existing highland and mountainous areas, the Rift Valley and other geographical features have combined to create ideal conditions for the high wind speeds required for commercial wind energy generation. The Kenya Renewable Energy Association indicates high wind speeds of above 9 m/s at 50 m high in the northwest while areas along the Indian Ocean average above 5 m/s at 50 m high (KEREA, 2016). The windiest places are the edges of the Rift Valley, Marsabit and Turkana districts. In 2015, the country had 17 ktoe of solar and wind energy installed (AFREC, 2015). Existing projects include the Ngong Wind Power plant in Kajiado county with 5.1 MW, the 60 MW Kinangop Wind Park in Nyandarua county and the 300 MW Lake Turkana Wind Power Project (LTWP) in Marsabit county (KEREA, 2016). The LTWP project should contribute the equivalent of over 20 per cent of the current installed electricity generating capacity to the national grid (AfDB, 2014).

Geothermal

Kenya is one of the few countries in Africa that has seriously invested in its geothermal potential. As a result, electricity from geothermal sources plays an important role in the total energy mix. There is 169 MWe of installed capacity and the annual output is 1,430 GWh (WEC, 2013). Production of geothermal electricity increased from 37 ktoe in 2005 to 282 ktoe in 2015 (AFREC, 2015). Potential geothermal sites are found at Arus-Bogoria, Badlands, Barrier, Eburru, Emuruangogolak, Korosi, Lake Baringo, Lake Magadi, Longonot, Menengai, Olkaria, Suswa, PakaSilali and Namarunu. The Olkaria site is operational with Olkaria I having an installed capacity of 45 MWe, Olkaria II with 70 MWe and Oklaria III with 48 MWe (WEC, 2013). and there is another planned 2.5 MWe power station at the Eburru site (WEC, 2013).

Solar

Solar insolation rates in Kenya are over 4 kWh/m^2 (REEEP, 2014) suitable for solar PV commercialization. The government, through the Ministry of Energy and Petroleum, has been very supportive of solar energy development. As a result, the solar PV market is very vibrant. By the 2013/14 financial year, almost 1,000 institutions, including health centres, dispensaries and administrative units, had Solar PV systems installed at a total cost of KSh 3.2 billion. The accumulated cost of installing Solar PV systems in Arid and Semi Arid Lands (ASAL) counties of the northeastern and eastern regions was KSh 1.98 billion at the end of 2013/14 (KNBS, 2014). Solar energy facilitates lighting, drying, irrigation and solar water heating. The solar water heating sector is growing by 20 per cent per annum (KEREA, 2016). Solar Water Heating Regulations have been in place since 2012 to guide the sector.

Tracking progress towards sustainable energy for all (SE4All)

Electricity access in Kenya is low but there are plans to address this deficit. In 2010, 31.2 million or 23 per cent of people in Kenya had no access to electricity and 32.6 million had no access to non-solid fuels. Segregating by location, 6.7 per cent of people in rural Kenya had access to electricity compared to 58.2 per cent in urban areas in 2012 (World Bank, 2015); (World Bank, 2016). Kenya's Rural Electrification Fund charges all electricity consumers 5 per cent of the value of their monthly electricity consumption towards electrification (KNBS, 2014).

Access to non-solid fuels was 16.16 per cent in 2012 with 3 per cent and 49 per cent with access to non-solid fuels in rural and urban areas, respectively (World Bank, 2015); (World Bank, 2016). The second Medium Term Plan also intends to increase installed capacity for electricity generation by 5,538 MW in 2017 (GOK, 2013). This translates into increased rural and urban access rates of 50 per cent and a reduction in the cost of electricity by 50 per cent by 2018.

Between the 1990-2000 and 2000-2010 period, energy intensity decreased from a compound annual growth rate (CAGR) of 0.14 per cent to -2.54 per cent . The energy intensity of the Kenyan economy (the ratio of the quantity of energy consumption per unit of economic output) decreased from 9.7 MJ in 2010 to 9.3 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) averaged 78.53 per cent in 2012 and 77.12 per cent between 2006 and 2011. By 2010, Kenya had 320,000 solar home systems installed (World Bank, 2015). The share of renewable energy in the electricity generated is 75.2 per cent . Vision 2030 aims to modernize the energy infrastructure network and to increase the share of energy

Table 3: Kenya's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	11	15	23	23		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	19	20	17	16		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	77.7	81.8	77.1	78.5		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	5.2		5.2	5.4 (2011)		5.59 (2013)
	Level of primary energy intensity(MJ/$2005 PPP)	9.5		9.7	9.3	9.56	9.26

Sources: (World Bank, 2015); (World Bank, 2016)

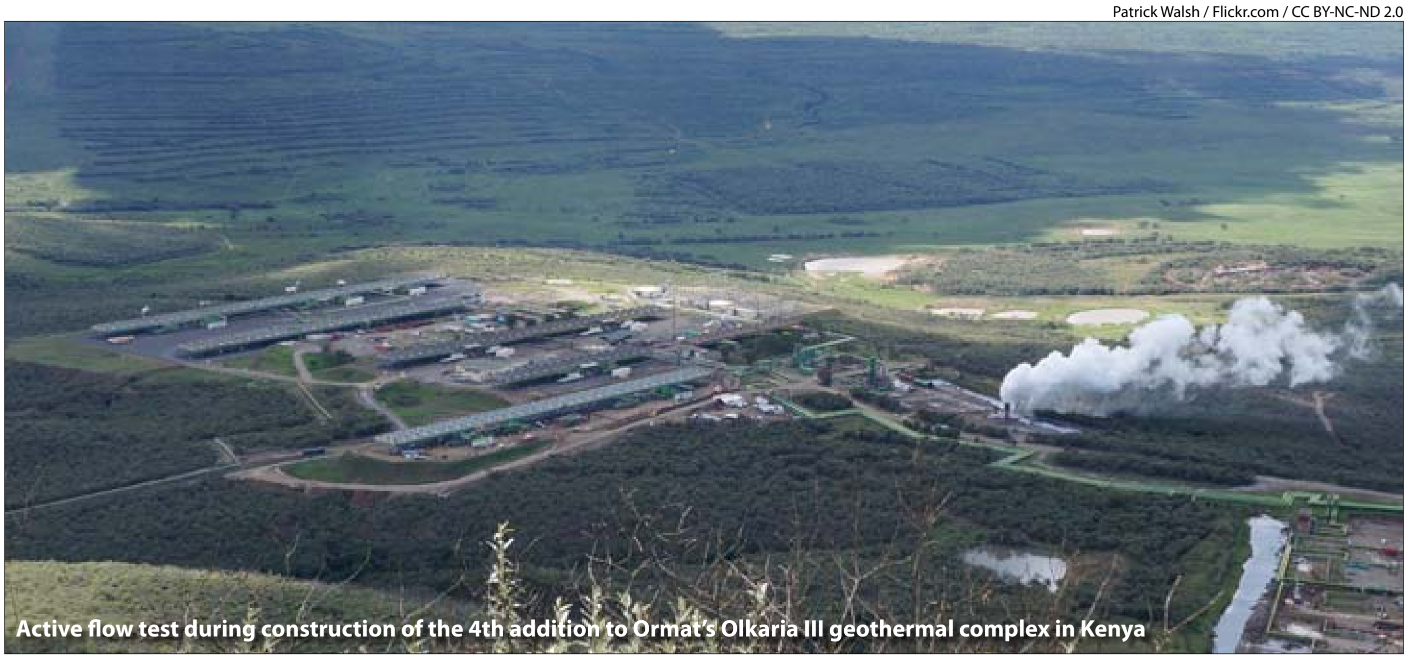
Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
23%	16.17%	**5.77**	78.53%

Table 4: Kenya's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Expand energy production through geothermal, solar and wind sources, as well as other renewable and clean energy options.
*Enhance energy and resource efficiency across the different sectors.
*Progress towards achieving a tree cover of at least 10 per cent of the land area of Kenya.
*Adopt clean energy technologies to reduce over reliance on wood fuels.
*Develop low carbon and efficient transportation systems.

Source: (MENR, 2015)



Active flow test during construction of the 4th addition to Ormat's Olkaria III geothermal complex in Kenya

Table 5: Kenya's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Petroleum (MOEP) • Rural Electrification Authority (REA) • Geothermal Development Company (GDC)
Presence of a Functional Energy Regulator	Energy Regulatory Commission
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	East African Power Pool (EAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	• Kenya Generating Company (KENGEN) • Kenya Power and Lighting Company (KPLC) • Kenya Transmission Company (KETRACO)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	• National Oil Corporation of Kenya (State owned) involved in all aspects of the petroleum supply chain – covering the upstream oil and gas exploration, midstream petroleum infrastructure development; and downstream marketing of petroleum products. • Kenya Pipeline Company (KPC) Limited
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	Yes
Presence Functional IPPs and their contribution	• Iberafrica Power (E.A.) Company Limited • Tsavo Power Company Limited • Mumias Sugar Company Limited • Orpower 4 Inc • Rabai Power Company Limited • Imenti Tea Factory Company Limited • Gikira Hydro • Thika Power Limited • Gulf Power Limited • IberAfrica, Tsavo, Or-power, Rabai, Imenti, and Mumias together account for about 26 per cent of the country's installed capacity from thermal, geothermal and bagasse
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Sessional Paper No. 4, 2004 on Energy • Feed-in-Tariffs (FiT) Policy • Least Cost Power Development Plan (LCPDP) 2011-2030 • National Energy and Petroleum Policy 2015 • Draft Electricity Grid Code 2016 • National Petroleum Sector Master Plan
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Energy Act of 2006 • Energy Bill 2015 • Petroleum (Exploration, Development and Production) Bill, 2015 • Energy (Local Content) Regulations, 2014 • Energy (Energy Management) Regulations, 2012 • Petroleum Exploration, Development and Production (Local Content) Regulations, 2014

This table was compiled with information from (REEEP, 2015)

generated from renewable energy sources. The objective is to increase access to energy and ensure an affordable and reliable supply.

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

The energy-related Intended Nationally Determined Contributions (INDCs), highlighted in Table 4, aim to operationalize Kenya's climate change, environmental and natural resources management policies through actions in clean energy development and energy efficiency, among others.

Institutional and Legal Framework

The Ministry of Energy and Petroleum is in charge of the energy sector (Table 5). The energy regulator is the Energy Regulatory Commission. The Kenya Generating Company (KENGEN), Kenya Power and Lighting Company (KPLC) and the Kenya Transmission Company (KETRACO) are in charge of the different elements of electricity. On a regional level, the country is a member of the East African Power Pool. The legal framework is provided by the Energy Act No. 12 of 2006 and the soon-to-be approved Energy Bill 2015. The main sector policy is the Sessional Paper No. 4, 2004 on Energy (MOE, 2008) and the newly passed National Energy and Petroleum Policy 2015.

Lesotho

Figure 1: Energy profile of Lesotho

Energy Consumption and Production

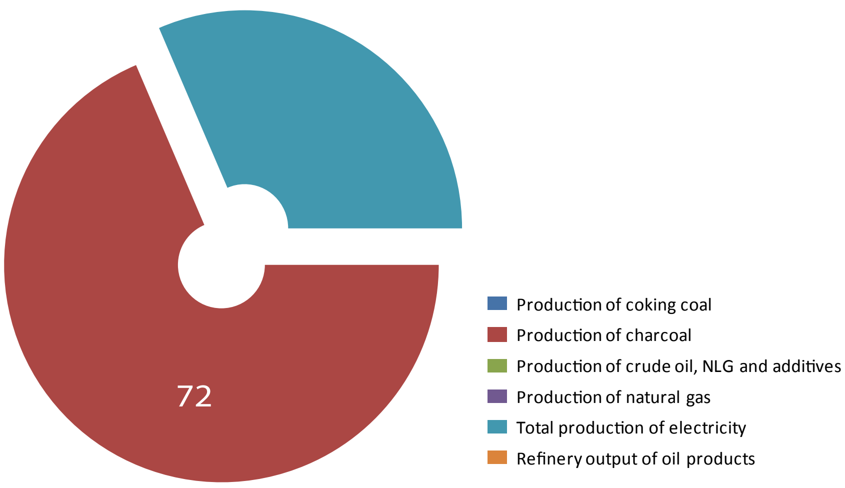
In 2013, the population of Lesotho was 2.08 million (Table 1). In 2015, total electricity produced was 33 ktoe and all of it came from hydro sources (Table 2). Final consumption of electricity in the same year was 44 ktoe (AFREC, 2015). Figures 2 and 3 show the main energy statistics.

Table 1:Lesotho's key indicator

Key indicators	Amount
Population (million)	2.08
GDP (billion 2005 USD)	2.01
CO_2 emission (Mt of CO_2)	2.20

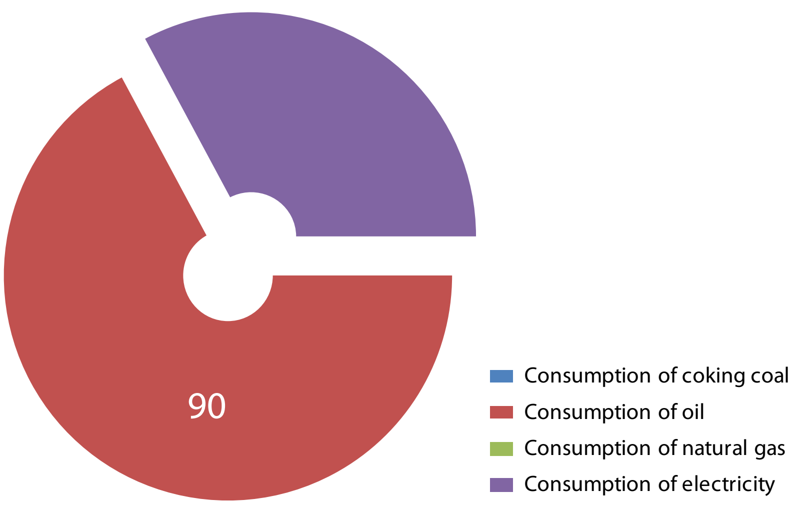
Source: (World Bank, 2015)

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Resources

Biomass

Lesotho, as is the case with many other African countries, relies heavily on biomass to supply domestic energy needs for the predominantly rural population. Further, since it does not produce any crude oil, there is an over dependence on imported fossil fuels. As a result its economy is vulnerable to fluctuating oil import prices (REEEP, 2012).

Hydropower

Hydroelectric power exists in abundance and contributes most of the country's electricity needs. The combined generation from the four small hydropower stations owned by the Lesotho Electricity Company is 3.25 MW. The Muela hydropower plant has a maximum nominal generating capacity of 72 MW. However, in periods of national maximum demand, the generation capacity may be stretched (flat-out) to just over 80 MW. On the other hand, economic growth and increased access has meant that during peak times, especially in the winter months, demand can be as high as 120 MW (REEEP, 2012).

Renewable energy output from the Lesotho Highlands Power Project (LHPP) will be 6,000 MW from wind and 4,000 MW from hydro sources. This is equivalent to about 5 per cent of neighbouring South Africa's electricity needs. It is estimated that Lesotho's hydro generation potential is approximately 450 MW (REEEP, 2012). The Muela Hydropower Station has a combined generation capacity of 72 MW (often exceeded at a full capacity of 80 MW) with each of its three turbines generating 24 MW. This beneficial bi-product of the LHPP generally meets Lesotho's electricity requirements (LHWP 2009); when national demand exceeds the 72 MW operating limit, electricity often needs to be purchased from Eskom to compensate. The currently volatile energy supply situation in South Africa has on occasion affected Eskom's ability to honour export agreements, and there are times when Lesotho is unable to import the necessary electricity to refill its own supply.

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	867	72
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	0	0	0	0
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	25	30	60	33
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	25	30	60	33
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	70	75	186	90
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	24	29	26	44
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	70	75	186	176
Net imports of natural gas	-	-	-	-
Net imports of electricity	1	1	10	19

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

The second phase of the Lesotho Highlands Water Project (LHWP) will build a hydropower station with an installed capacity of between 1,000 MW and 1,200 MW and is proposed to be operational in 2018. About 200 MW of this will supply Lesotho's power needs, with the remaining power transmitted to South Africa.

In 2015, energy generated by the Lesotho Highlands Development Authority was 532,190 MWh from the Mohale dam (LHDA, 2016a); exports to South Africa in the same year were 4,408 MWh (LHDA, 2016b).

Oil and natural gas

Lesotho does not have any natural gas, oil or coal reserves. Net imports of oil product in 2015 amounted 176 ktoe (AFREC, 2015).

Peat

The country has 100 km^2 of peatlands (WEC, 2013).

Wind

With less than 20 per cent of the country lying below 1,800 m above sea level, there are technically a huge number potential sites where wind power can be generated. Currently, three sites being investigated—near Katse Dam, Mohale Dam and Mphaki in the south of Lesotho (REEEP, 2012). A wind farm at Letseng in the Maluti-Drakensberg area proposed by a South African-Lesotho joint venture is on course for development despite concerns regarding the conflict between vulture conservation and the wind energy industry. This location is important for the ecology of the Bearded and Cape Vultures as it contains some of their breeding and foraging grounds and bird collisions with wind turbines is an emerging ecological issue.

Solar

The implementation of solar in Lesotho is being championed by the Lesotho Solar Energy Society (LESES). Installers and dealers are registered with the LESES and this enables the implementation and enforcement of regulations and standards (REEEP, 2012). Renewables are a priority in the Energy Policy 2015-2025. Specific targets include promoting solar in the design of new buildings and phasing out energy intensive items in old buildings such as electrical geysers and replacing them with solar water heating. The Rural Electrification Master Plan aims to increase access to electricity by encouraging the uptake of solar.

Tracking progress towards sustainable energy for all (SE4All)

Lesotho has one of the lowest electrification rates in Africa. In 2010, only 17 per cent of the population had access to electricity increasing to 20.6 per cent in 2012 (Table 3). Most access is concentrated in the urban and growth centers where transmission and distribution infrastructure services are relatively well developed. About 10.2 per cent of the area serviced by the grid is defined as rural, increasing to 47 per cent in the urban areas (World Bank, 2015); (World Bank, 2016).

Most households generally use a combination of energy sources for cooking that can be categorized as follows: traditional (such as dung, agricultural residues and fuel wood); intermediate (such as coal and kerosene); or modern (such as liquefied petroleum gas (LPG) and electricity). Electricity is mainly used for lighting (REEEP, 2012). Access to non-solid fuels in 2012 was 38.02 per cent with 19 per cent in rural areas and 93 per cent in urban areas (World Bank, 2015).

Lesotho's energy intensity increased at a compound annual growth rate (CAGR) of 2.64 over the 20 years between 1990 and 2010; and at -2.81 CAGR from 2010 to 2012. The rate of increase during the period 2000-2010 was 4.89 per cent compared to 0.44 per cent between 1990 and 2000 (World Bank, 2015).

Between 2010 and 2012, the economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) increased from 11.6 MJ to 11.0 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

The share of renewable energy in total final energy consumption (TFEC) decreased from 100 to 40.5 per cent between 2010 and 2012. Traditional biofuels form the biggest share of renewable sources at 35.2

Table 3: Lesotho's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	6	5	17	21		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	36	39	38	38.02		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption		100.0	100.0	40.5		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)				200.37 (2007)		
	Level of primary energy intensity(MJ/$2005 PPP)	6.9		11.6	11.0	11.07	10.96

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

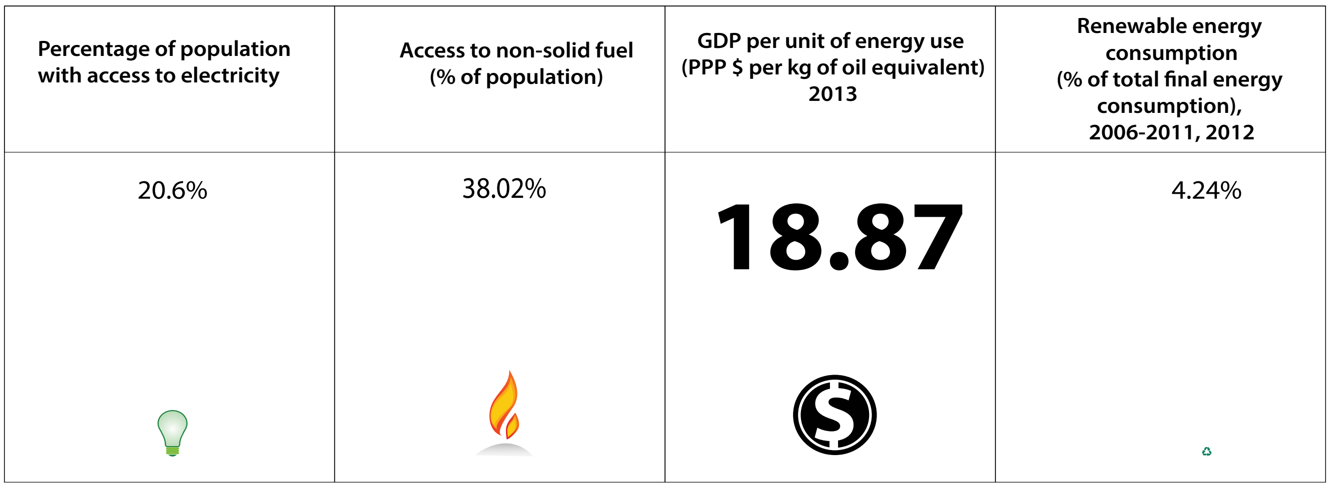


Table 4: Lesotho's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Continue the development of hydropower resources, particularly in terms of advancing technical design and sourcing funding for development of identified sites.
*Design and implement demand-side management techniques to encourage better use of existing distribution infrastructure, and reduce peak demands.
*Promote renewable energy.
*Improve distribution efficiency of the power system through measures that reduce transmission and distribution losses.
*Continue to develop and promote uptake of renewable sources of energy, particularly wind and solar (where feasible).
*Develop a low-energy investment plan.
*Improve energy efficiency by 20 per cent by 2020.
*Increase electricity coverage /access to 35 per cent of households in 2015, 50 per cent in 2020 and 80 per cent by 2030.
*Reduce, paraffin consumption from 30, 434 kilolitres (2014) to 25,000 kilolitres in 2020, with a GHG saving of 12 Gg CO2 eq and 20,000 kilolitres in 2030 with a GHG saving 24 Gg CO2 eq in the BAU.
*Adopt potential reduction of transmission and distribution losses from 2015 until 2030 by 0.5 per cent per annum (total of 7.5 per cent).
*Increase renewable energy sources by 200 MW by 2020: 4 0MW from solar (2017/2018); 35 MW from wind (2017); and 125 MW from hydropower (2025).

Source: (MEM, 2015)

Table 5: Lesotho's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Energy Affairs - technical
Ministry of Natural Resources - policy	
Presence of a Functional Energy Regulator	Lesotho Electricity Authority
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Southern Africa Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	• Lesotho Electricity Generation Authority (LEGA) • Lesotho Highlands Development Authority • Lesotho Electricity Company (LEC) • Lesotho Electrification Unit (LEU)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	BP, Total, Chevron, Shell and Engen
Presence of Functional (Feed in Tariffs) FIT systems	No
Presence Functional IPPs and their contribution	PowerNET Developments (Pty) Ltd
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Policy 2015-2025 • National Rural Electrification Fund (NREF)
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Lesotho Electricity Authority Act of 2002 • Lesotho Electricity Authority Amendment Act 2011 • Lesotho Highlands Development Authority (Amendment) Act 2000

This table was compiled with material from (REEEP, 2012), (LEWA, 2016) and (Tsehlo, 2012)

per cent of TFEC in 2012 (World Bank, 2015). Renewable sources contributed 100 per cent of the share of electricity capacity in 2012 (World Bank, 2015).

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Under the Lesotho Energy Policy 2015 and Draft Lesotho Renewable Energy Policy 2013, the government's long-term plan is to increase energy efficiency and use more climate friendly technologies to supply energy. This vision is reflected in the energy-related Intended Nationally Determined Contributions (INDC), which are highlighted in Table 4.

Institutional and Legal Framework

The Ministry of Energy Affairs is in charge of the energy sector. The energy regulator is Lesotho Electricity Authority. Lesotho Electricity Company (LEC) is the monopoly transmitter, distributor and supplier of electricity, while the Lesotho Highlands Development Authority (LHDA) is the main generator of electricity from the Muela Hydro Power Station. On a regional level, Lesotho is a member of the Southern Africa Power Pool. The legal framework is provided by the Lesotho Electricity Authority Act of 2002 (Table 5).

The main sector policy is the 2015-2025 Energy Policy. It aims to increase energy access by increasing reliability and affordability. Ultimately this will improve livelihoods, promote economic growth and investment, ensure energy security and contribute to environmental protection including climate change (KOL, Undated).

Liberia

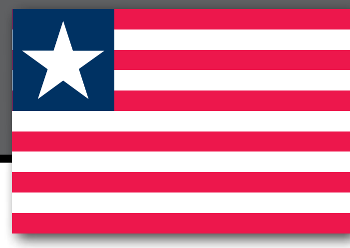
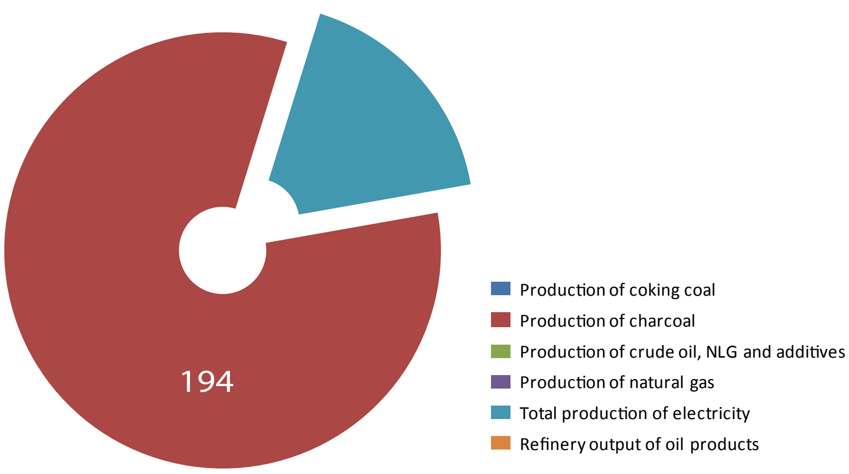


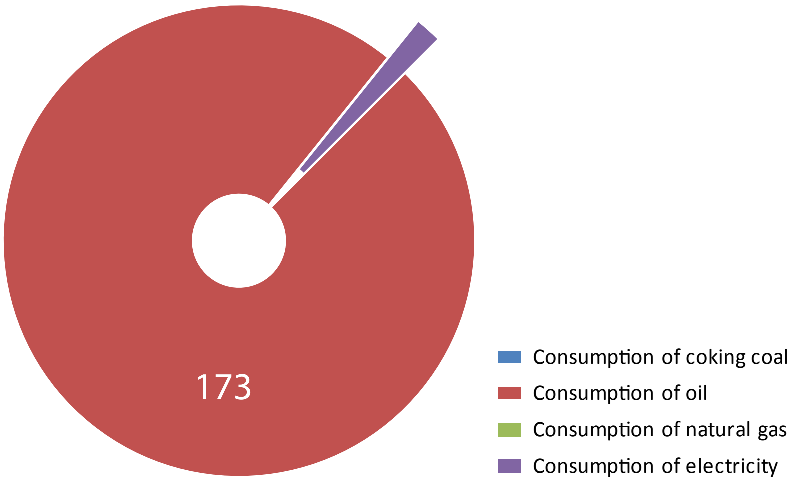
Figure 1: Energy profile of Liberia

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

By 2013, Liberia had a population of 4.29 million (Table 1). In 2015, Liberia produced 41 ktoe of electricity of which 53.6 per cent was from hydro, 24.3 per cent from fossil fuels and 21.4 per cent from biofuels and waste. Final consumption of electricity in the same year was 3 ktoe (AFREC, 2015). Table 2 and Figures 2 and 3 shows the main energy statistics.

Table 1: Liberia's key indicator

Key indicators	Amount
Population (million)	4.29
GDP (billion 2005 USD)	975.31
CO_2 emission (Mt of CO_2)	0.89

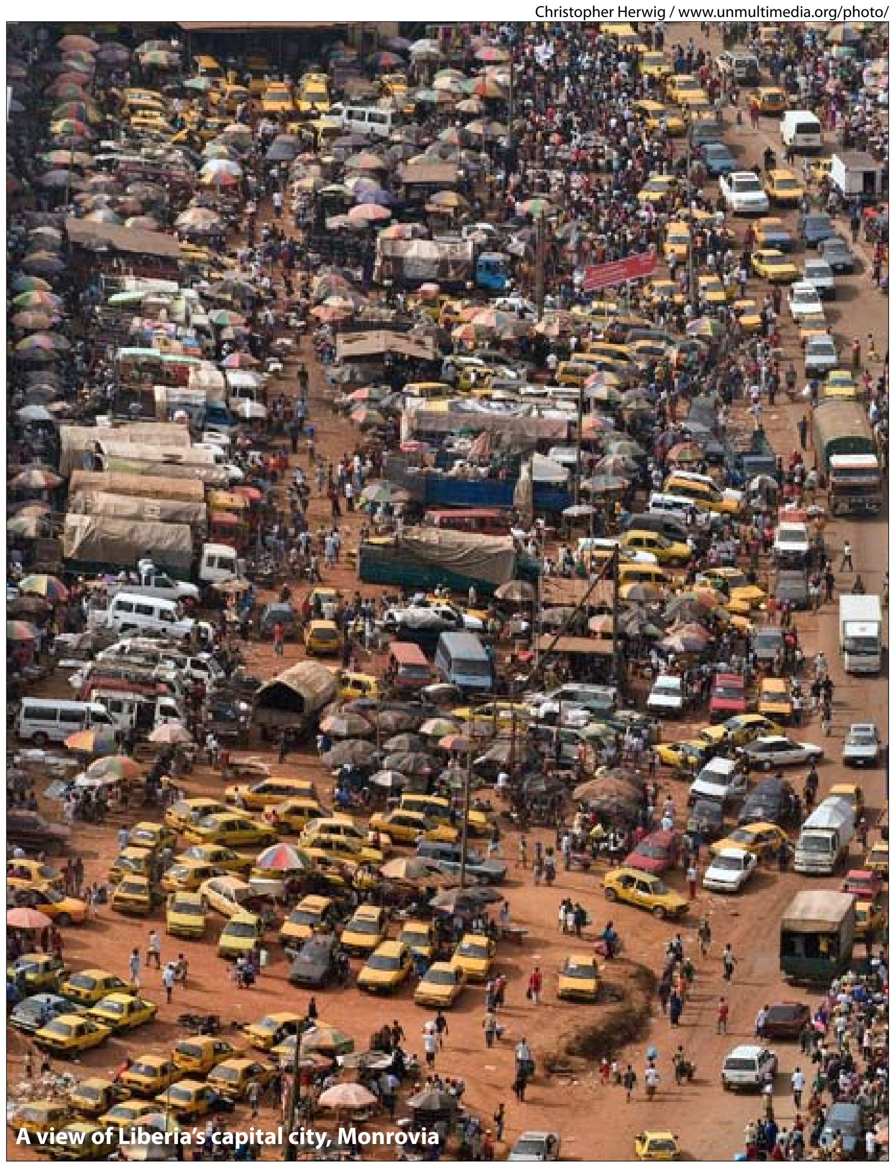
Source: (World Bank, 2015)

Energy Resources

Biomass

The civil war devastated a lot of Liberia's energy infrastructure necessitating the re-establishment of energy services once peace was restored (REEEP,

Christopher Herwig / www.unmultimedia.org/photo/



A view of Liberia's capital city, Monrovia

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	2,236	194
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	9
Production of electricity from fossil fuels	3	3	3	10
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	22
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	3	3	3	41
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	147	178	183	173
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	25	25	27	3
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	148	180	184	192
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

2012). Biomass energy is used for cooking and heating with the majority of the low-income population using it. The higher income households in the urban areas use electricity and liquified petroleum gas (REEEP, 2012). Apart from the traditional wood fuels, there is also potential to use agricultural waste from coconuts, oil palm, wheat and rice. According to REEEP (2012), the energy potential from agricultural waste and future waste streams from the forest industry is 6,000 GWh/year and 15,000 GWh/year respectively.

Hydropower

Liberia has a hydroelectricity potential of 1,000 MW which could be dammed from a selection of rivers that drain about 63 per cent of the country's water (REEEP, 2012). Of Liberia's many rivers there are six large ones from which hydroelectricity generation is a possibility – the Cavalla, Cestos, Lofa, Mano, Saint John and the Saint Paul rivers (REEEP, 2012). Developing hydropower has been particularly challenging due to financial and capacity constraints. There is potential for energy trade through the West African Power Pool.

Wind

Liberia generally lies in a low wind region so potential for wind energy exploitation may be low. However, it is likely that the highland and coastal areas may have some good prospects (REEEP, 2012).

Geothermal

This sector has not been assessed (REEEP, 2012).

Solar

In terms of solar energy assessments, Liberia is seriously lacking in data. However, interpolations suggest solar insolation of between 4.0 and 6.0 kWh/m^2/day (REEEP, 2012). The solar resource is already being utilized and the country has an estimated installed capacity of about 100 kW (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

The national rate of electrification in Liberia is 9.8 per cent with 1.2 per cent in rural areas and 18.9 per cent in urban areas (Table 3 and Figure 4) (World Bank, 2016). Access to non-solid fuels in 2012 was 2 per cent with 19 per cent in rural areas and 93 per cent in urban areas (World Bank, 2015).

Liberia's energy intensity increased at a compound annual growth rate (CAGR) of 2.64 over the 20 years between 1990 and 2010 and at -2.81 CAGR from 2010 to 2012. The rate of increase during the period 2000-2010 was -2.61 per cent compared to -0.22 per cent between 1990 and 2000 (World Bank, 2015b).

Between 2010 and 2012, the Liberian economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) increased from 30.5 MJ to 27.5 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

The share of renewable energy in total final energy consumption (TFEC) decreased from 92.5 to 84.4 per cent between 2010 and 2012. Traditional biofuels form the biggest share of renewable sources at 84.4 per cent of TFEC in 2012 (World Bank, 2015).

Table 3: Liberia's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	0	1	4	10		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	2	2		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	95.4	90.5	92.5	84.4		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)	40.7		30.5	27.5	6.46	6.42

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
9.8%	2.0%	NA	89.39%

Table 4: Liberia's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Reduce GHGs by at least 10 per cent by 2030.
*Improve energy efficiency by at least 20 per cent by 2030.
*Raise share of renewable energy to at least 30 per cent of electricity production and 10 per cent of overall energy consumption by 2030.
*Replace cooking stoves with low thermal efficiency (5-10 per cent) with the higher efficiency (40 per cent) stoves.
*Strengthen the implementation and coordination mechanisms to improve climate change mitigation actions.
*Implement quantitative and qualitative research and improve systematic priority sequencing between National Energy Policy, Low Carbon Economy, and National Vision 2030 developmental goals.
*Strengthen institutional and individual capacity in renewable energy technology and management.
*Implement and strengthen policy that promotes private investment in renewable energy (hydro, biomass and solar etc.).
*Rehabilitate existing hydropower plants and build new hydropower plants to increase hydropower production capacity.
*Produce and distribute 280,543 energy saving cook stoves that use fuel wood and 308,004 energy saving cook stoves that use charcoal by 2030.
*Implement large-scale biomass projects to generate about 30 MW by 2030.
*Protect water catchments around hydropower sources such as the St. Paul River Basin.
*Strengthen the transmission and distribution infrastructure for public utilities to ensure climate resilience (i.e. flooding).

Source: (MEM, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Liberia is active in global climate change initiatives and articulated its Intended Nationally Determined Contributions (INDC) in September 2015 (ROL, 2015). Those related to energy aim to place the country firmly on a carbon neutral pathway and are highlighted in Table 4.

Table 5: Liberia's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Lands, Mines and Energy Rural and Renewable Energy Agency (RREA)
Presence of a Functional Energy Regulator	Energy Regulatory Board (ERB) National Commission on Electricity
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	Liberia Electricity Company (LEC) 1973
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West African Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Liberia National Oil Corporation (LNOC) 2002
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Liberia National Oil Corporation (LNOC) Liberia Petroleum Refining Corporation (1978)
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Energy Policy 2009 • Renewable Energy and Energy Efficiency Policy and Action Plan 2007 • Rural Energy Master Plan • Rural Energy Fund (REFUND) • Liberia National Petroleum Policy 2012
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• 2015 Electricity law of Liberia • Public Utilities Authority Law 1973 • National Oil Company Act 2000 • Petroleum Law 2002

This table was compiled with material from (REEEP, 2012)

Institutional and Legal Framework

The Ministry of Lands, Mines and Energy is in charge of the energy sector. The energy regulator is the Energy Regulatory Board (ERB). The Liberia Electricity Company (LEC) is in charge of generation, transmission and distribution of electricity. On a regional level, it is a member of the West African Power Pool. The legal framework is provided by the 2015 Electricity Law of Liberia. The main sector policy is the 2009 National Energy Policy (Table 5).

Solar power panels generate energy for a newly renovated local administrative building, Liberia

Libya

Figure 1: Energy profile of Libya

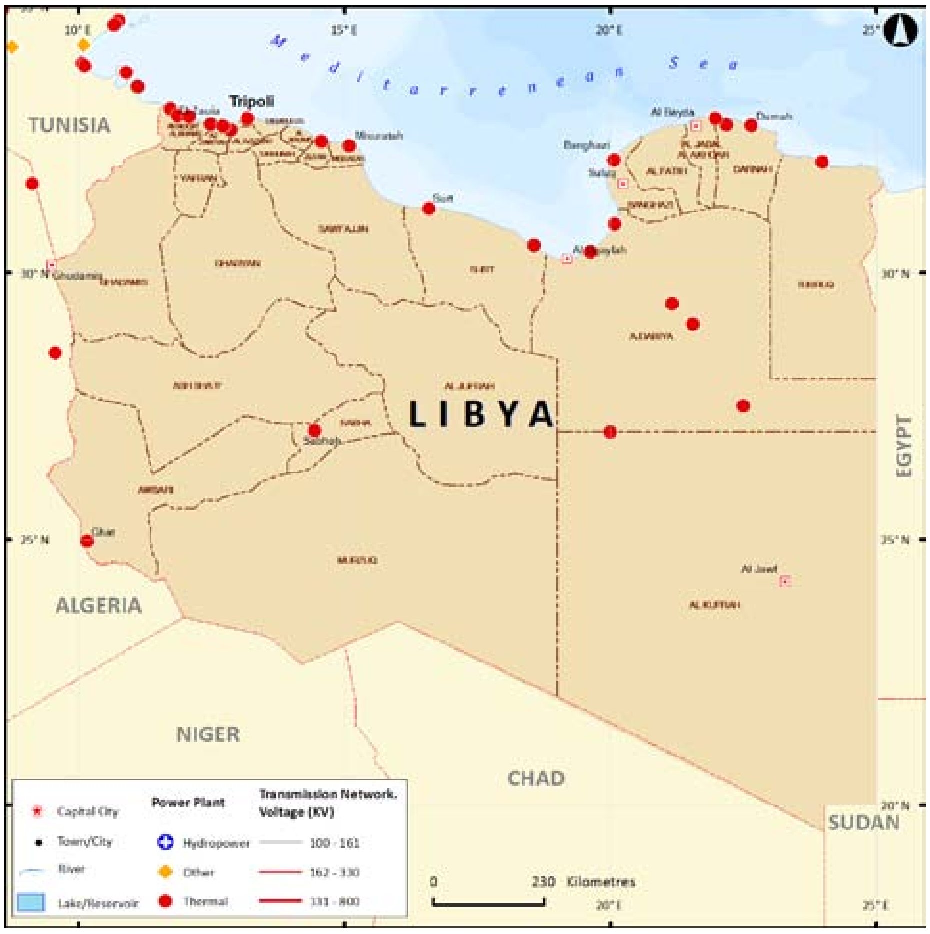
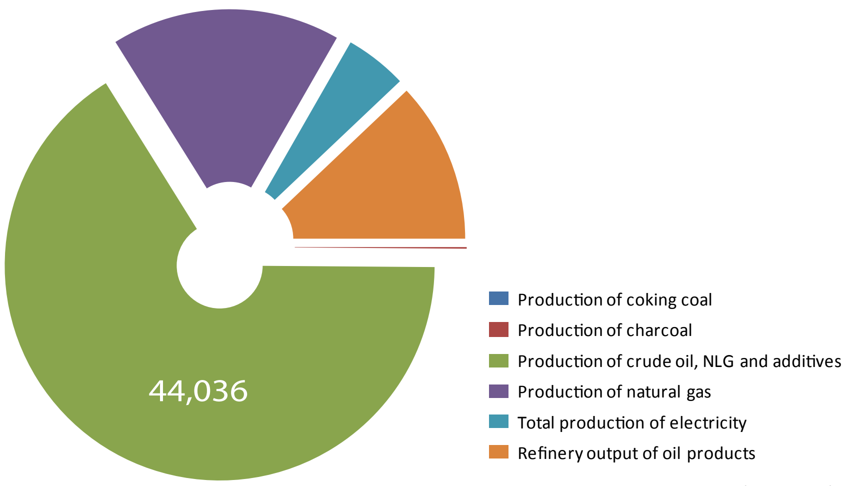
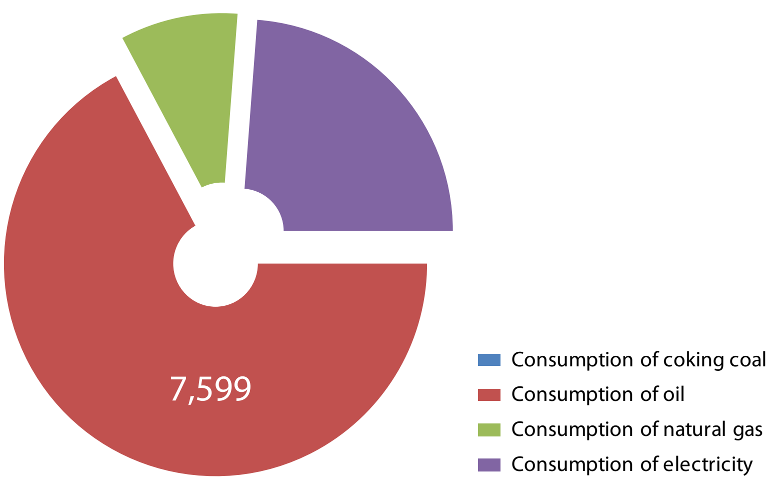


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Libya had a population of 6.2 million and in 2015, the total amount of electricity produced was 3,105 ktoe of which 99.9 per cent was from fossil fuels (Tables 1 and 2). In the same year, final consumption of electricity was 2,690 ktoe (AFREC, 2015). Figures 2 and 3 highlight the key energy statistics.

Table 1: Libya's key indicators

Key indicators	Amount
Population (million)	6.20
GDP (billion 2005 USD)	37.99
CO_2 emission (Mt of CO_2)	43.23

Source: (World Bank, 2015)

Energy Resources

Biomass

Libya's biomass potential of 2 TWh/year is currently not an important energy source and is thought to be only suitable for domestic consumption (REEEP, 2012).

Hydropower

The lack of resources for hydropower seriously hinders the development of this sector, and it is likely to remain like this for the near future (REEEP, 2012).

Oil and natural gas

Libya is a net exporter of energy sources by a large amount, but imports petroleum products, amounting to 3,208 ktoe, due to inadequate refining capability. Total crude oil exports in 2013 were 48,307 increasing to 66,325 ktoe in 2015 (AFREC, 2015). Natural gas exports in the same period were 9,328 and 6,067 ktoe respectively (AFREC, 2015). Electricity produced from petroleum in 2015 was 3,103 ktoe (AFREC, 2015). The crude oil reserves in Libya are the largest in Africa, however the security situation is having impacts on the sector.

Wind

In Africa, high quality wind resources are confined to a few areas. Somalia has the highest onshore potential of any country, followed by Sudan, Libya, Mauritania, Egypt, Madagascar and Kenya (Mukasa, Mutambatsere,

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	77	79
Production of crude oil, NLG and additives	63,884	77,528	73,240	44,036
Production of natural gas	5,337	10,619	14,340	11,450
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	1,316	1,935	2,816	3,103
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	-
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	2
Total production of electricity	1,316	1,935	2,816	3,105
Refinery output of oil products	15,128	15,877	19,478	8,053
Final Consumption of coking coal	0	0	0	0
Final consumption of oil	6,137	6,394	8,759	7,599
Final consumption of natural gas	2,388	3,228	1,971	1,015
Final consumption of electricity	1,051	1,679	2,442	2,690
Consumption of oil in industry	1,467	1,494	2,296	1,896
Consumption of natural gas in industry	1,027	984	421	204
Consumption of electricity in industry	263	273	179	124
Consumption of coking coal in industry	0	0	0	0
Consumption of oil in transport	3,845	3,974	5,770	5,204
Consumption of electricity in transport	0	0	0	0
Net imports of coking coal	0	0	0	0
Net imports of crude oil, NGL, Etc.	-46,518	-60,360	-48,307	-66,325
Net imports of oil product	-4,636	-4,889	-1,455	3,208
Net imports of natural gas	-726	-4,901	-9,328	-6,067
Net imports of electricity	0	0	-7	4

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Arvani, & Triki , 2013). According to (Gatnash, 2012), average wind speeds of 5.3-6.2 m/s have been recorded at 40 m altitude. These speeds are suitable for the small-scale development of wind energy if commercial viability is difficult. It is likely that inland, wind speeds could be higher.

Tidal energy

Given that Libya has a coastline of 1,770 km, there is likely to be potential for the development of tidal energy but comprehensive studies to determine this need to be carried out (Gatnash, 2012).

Geothermal

The geothermal energy sector has some potential especially in the area of indoor cooling, along the lines of similar systems in Palestine. This would greatly reduce energy consumption contributing to environmental sustainability reducing home energy usage by much. The sector could benefit from more in depth studies to determine viability. However according to (REEEP, 2012) Underground Thermal Energy Storage (UTES), in which surplus heat is stored in pipes in the ground during the warmer months to be extracted during the cooler winter seasons is being looked at as an option. Furthermore, near Waddan City, new technology may make it possible to use the existing low-temperature geothermal source for power generation (REEEP, 2012).

However according to (REEEP, 2012) Underground Thermal Energy Storage (UTES), in which surplus heat is stored in pipes in the ground during the warmer months to be extracted during the cooler winter seasons is being looked at as an option. Furthermore, near Waddan City, new technology may make it possible to use the existing low-temperature geothermal source for power generation (REEEP, 2012).

Solar

Libya has expansive areas of unencumbered desert land that could lend itself to the development of solar energy. Daily solar radiation has been measured at 7.5 kWh/m^2 (REEEP, 2012). By 2015, there was 2 ktoe of solar and wind energy installed in the country (AFREC, 2015).

Tracking progress towards sustainable energy for all (SE4All)

By 2010, 100 per cent of Libya had access to electricity in both rural and urban areas (Table 3 and Figure 4) (World Bank, 2015). By 2012, 99.99 per cent of the population also has access to non-solid fuels (World Bank, 2015) (World Bank, 2016).

Between the 1990-2000 and 2000-2010 period, the 2000, the energy intensity decreased from a compound annual growth rate (CAGR) of -3.10 per cent to -1.67 per cent respectively. Over the tracking period 2010-2012 it returned to 3.70 per cent . The energy intensity of the Libya economy (the ratio of the quantity of energy consumption per unit of economic output) increased from 4.7 MJ in 2010 to 5.1 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

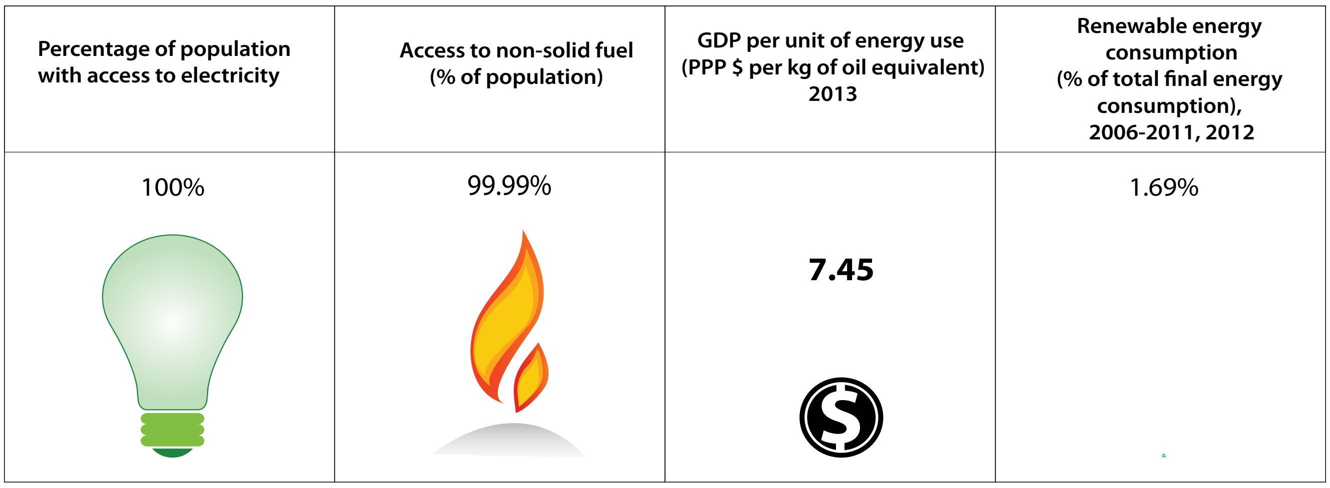
The share of renewable energy in the total final energy consumption has been declining. In 1990, it was 3.1 per cent decreasing to 1.69 per cent in 2012 (World Bank, 2015) (World Bank, 2016).

Table 3: Libya's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	97	100	100	100		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	90	99	100	99.99		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	3.1	2.1	2.1	1.7	2.26	1.69
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			11.2	13.3 (2011)		
	Level of primary energy intensity(MJ/$2005 PPP)			4.7	5.1		

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators



Tarek Siala / Flickr.com / CC BY 2.0

Tripoli at night

Table 4: Libya's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Electricity and Renewable Energy • Energy Council • Atomic Authority • Solar Energy Research Centre management, • Renewable Energy Authority of Libya (REAOL) 2007 • Centre for Solar Energy Studies (CSES)
Presence of a Functional Energy Regulator	None
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	State-owned General Electricity Company of Libya (GECOL)
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Comite Maghrebin De L'electricite (COMELEC) Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	• National Oil Corporation (NOC)
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Renewable energy roadmap to 2030 • National Energy Efficiency Action Plan (NEEAP)
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Prime Ministerial Decision of 8 September 2009 establishing Energy Council • Draft Electricity Bill

This table was compiled with material from (REEEP, 2012)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

The country has not defined its energy-related Intended Nationally Determined Contributions (INDC).

Institutional and Legal Framework

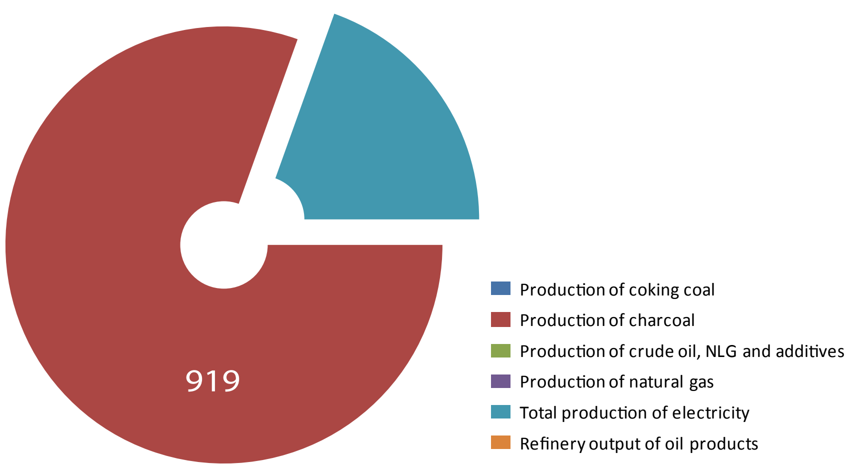
The Energy Council is in charge of the energy sector; and there is also a Ministry of Electricity and Renewable Energy which regulates and controls the electricity sector. The vertically structured General Electricity Company of Libya (GECOL) is in charge of generation, transmission and distribution of electricity; and it also works closely with the Renewable Energy Authority of Libya (REAOL). However, coordination between the two is weak (MOF, 2014). On a regional level, the country is a member of Comite Maghrebin De L'electricite (COMELEC) Power Pool. The legal framework is provided by the Draft Electricity Bill (Table 4).

International Space Station photo of Tripoli, Libya at night

Madagascar

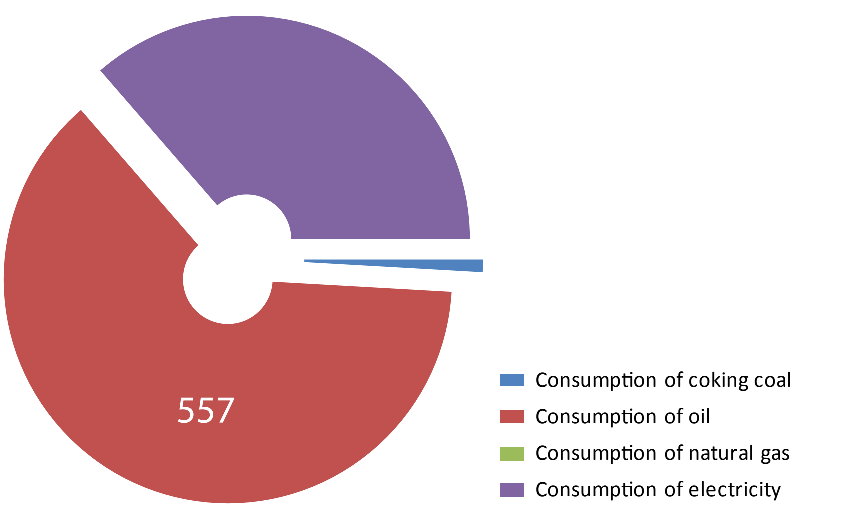
Figure 1: Energy profile of Madagascar

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Madagascar's population in 2013 was 22.92 million (Table 1) (World Bank, 2015). Electricity produced in 2015 was 223 ktoe of which 61.8 per cent came from fossil fuels and 36.3 per cent from hydro sources (Table 2). Final consumption of electricity in the same year was 323 ktoe (AFREC, 2015). Key energy statistics are highlighted in Figures 2 and 3.

Table 1: Madagascar's key indicators

Key indicators	Amount
Population (million)	22.92
GDP (billion 2005 USD)	6.21
CO_2 emission (Mt of CO_2)	2.44

Source: (World Bank, 2015)

Energy Resources

Biomass

The rural areas predominantly use firewood and charcoal as fuel sources. However, this has impacts on indoor air quality and the health of residents. In 2015 charcoal production amounted to 919 ktoe (AFREC, 2015). There is potential for energy from biofuels using agricultural waste from the sugar sector. Jatropha is also being cultivated for its oil which is used variously in the biofuels industry.

Hydropower

Only 1.9 per cent of Madagascar's hydroelectric power potential has currently been used (REEEP, 2012). In 2015, the country currently produced a total of 223 ktoe of electricity out of which 81 ktoe is from hydropower (AFREC, 2015).

Oil and natural gas

Madagascar imported 735 ktoe of oil products in 2015. In 2010, 41 ktoe of electricity was produced from fossil fuels increasing to 138 ktoe in 2015 (AFREC, 2015). Paraffin is used by 85 per cent of the population in the countryside for lighting (REEEP, 2012).

Wind

This island has several areas considered suitable for wind energy generation. Average wind speeds measured at 80 m range from above 7.5 m/s in the north and south; and above 5.5 m/s in the east and west. In 2015, 4 ktoe of electricity was generated from solar and wind (AFREC, 2015). Most of this is being used to extend rural electrification (REEEP, 2012).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	8	0	0	0
Production of charcoal	244	333	453	919
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	21	29	41	138
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	46	56	61	81
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	1	4
Total production of electricity	67	85	103	223
Refinery output of oil products	400	403	0	0
Final Consumption of coking coal	6	6	6	8
Final consumption of oil	469	839	615	557
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	53	64	73	323
Consumption of oil in industry	82	91	91	43
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	24	27	22	21
Consumption of coking coal in industry	9	6	6	6
Consumption of oil in transport	344	349	349	438
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	1	9	8	8
Net imports of crude oil, NGL, Etc.	363	375	0	0
Net imports of oil product	270	449	608	735
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Geothermal

Hot springs and dormant volcanoes are some of the indications that geothermal energy potential may exist. It is thought to be a medium-temperature geothermal system with about 350 MW of energy (REEEP, 2012).

Solar

Solar insolation in Madagascar has been measured at 5.5 kWh/m²/day (REEEP, 2012). The sector is quite developed and it is used to power a variety of items from public buildings to rural electrification including solar cooking and lighting (REEEP, 2012).

Planting firewood trees, Madagascar

Tracking progress towards sustainable energy for all (SE4All)

Madagascar has a low electrification rate, averaging 15.4 per cent nationally, 8.1 per cent in rural areas and 60.7 per cent in urban areas in 2012 (World Bank, 2015); (World Bank, 2016). Access to non-solid fuels in 2012 was 2 per cent in both rural and urban areas and also at the national level (Table 3 and Figure 4) (World Bank, 2015).

Madagascar's energy intensity increased at a compound annual growth rate (CAGR) of 0.89 over the 20 years between 1990 and 2010; and at 0.76 CAGR from 2010 to 2012. Between 2010 and 2012, the Madagascar economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) increased from 6.3 MJ to 6.4 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

The share of renewable energy in total final energy consumption (TFEC) decreased from 86.4 to 78.4 per cent between 1990 and 2012. Traditional biofuels form the biggest share of renewable sources at 43.7 per cent of TFEC in 2012, followed by modern solid biofuels at 33.1 per cent and hydro at 1.5 per cent (World Bank, 2015). Renewable sources contributed 30.3 per cent of the share of electricity capacity in 2012 (World Bank, 2015).

Table 3: Madagascar's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	9	11	14	15.4		
	7.1.2 per cent of population with primary reliance on non-solid fuels	2	2	2	2		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	86.4	78.5	82.8	78.4		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)	5.3		6.3	6.4	6.46	6.42

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
15.4%	2.0%	NA	78.85%

Table 4: Madagascar's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Facilitate access to energy by strengthening existing systems and by promoting renewable and alternative energies;
*Rehabilitate energy producing network and plant stations;
*Reinforce renewable energy (hydraulic and solar) from the current level of 35 per cent to 79 per cent);
*Improve energy efficiency;
*Develop rural electrification programme;
*Disseminate improved stoves (by 2030: 50 per cent of households adopting improved stoves).

Source: (MEM, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Madagascar aims to reduce its greenhouse gas emissions by about 30 $MtCO_2$ compared to the Business-as-Usual scenario (ROM, 2015). Actions to accomplish this are articulated in its INDC. Those related to energy are listed in Table 4.

Table 5: Madagascar's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy • Agency for the Development of Rural Electrification (ADER)
Presence of a Functional Energy Regulator	Board of Electricity Regulation (ORE) 2004
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	JIRAMA (Jiro sy Rano Malagasy – Malgache Power and Water)
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Belongs to SADC but not to the SAPP
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Office Malgache des Hydrocarbures (OMH) (Malagasy Hydrocarbons Board)
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	No
Presence Functional IPPs and their contribution	Association des Opérateurs Professionnels en Electrification de Madagascar (AOPEM) Hydelec Madagascar S.A. ENELEC Madagascar Électricité de Madagascar (EDM)
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	National Electricity Fund (FNE) 2002 No specific renewable energy policy
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	Law No. 98-032 on energy in 1999

This table was compiled with material from (REEEP, 2012)

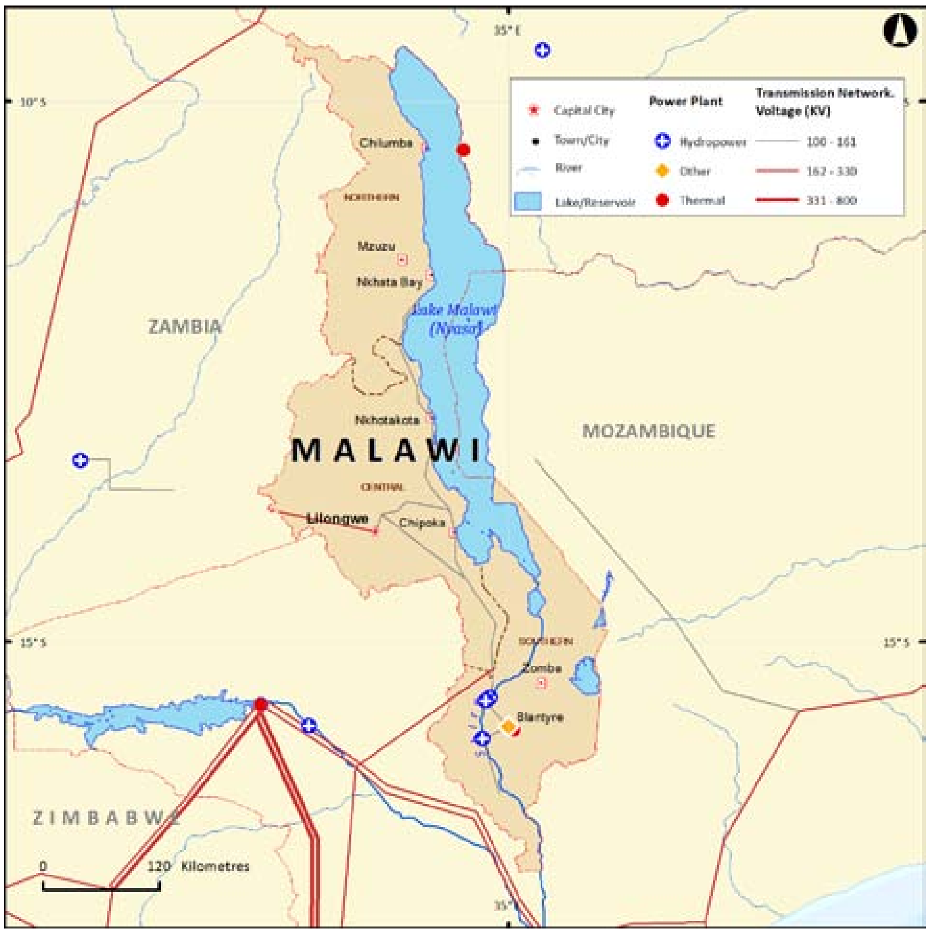
Institutional and Legal Framework

The Ministry of Energy is in charge of the energy sector. The energy regulator is the *Office pour la Regulation de l'Electrification* (ORE), which was created in 2004. The JIRAMA (*Jiro sy Rano Malagasy* – Malgache Power and Water) is in charge of generation, transmission and distribution of electricity (Table 5). On a regional level, Madagascar is a member of the Southern Africa Development Corporation, but not yet a member of the Southern Africa Power Pool (SAPP). The legal framework is provided by the Law No. 98-032 on energy of 1999. A policy and national energy strategy is being developed with plans to reform the electricity sector.

Diesel and gas stocked in barrels. Gas is brought to the island in barrels, Madagascar

Malawi

Figure 1: Energy profile of Malawi



Energy Consumption and Production

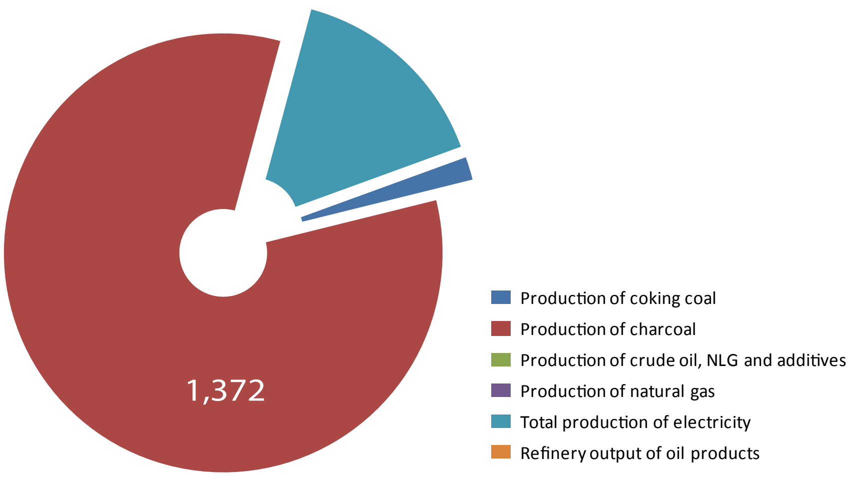
By 2013, the population of Malawi was 16.19 million (Table 1). In 2015, total electricity produced was 252 ktoe of which 98.4 per cent came from hydro sources (Table 2). In the same year, the final consumption of electricity was 148 ktoe (AFREC, 2015). Figures 2 and 3 show the main energy statistics.

Table 1: Malawi's key indicators

Key indicators	Amount
Population (million)	16.19
GDP (billion 2005 USD)	4.33
CO_2 emission (Mt of CO_2)	1.21

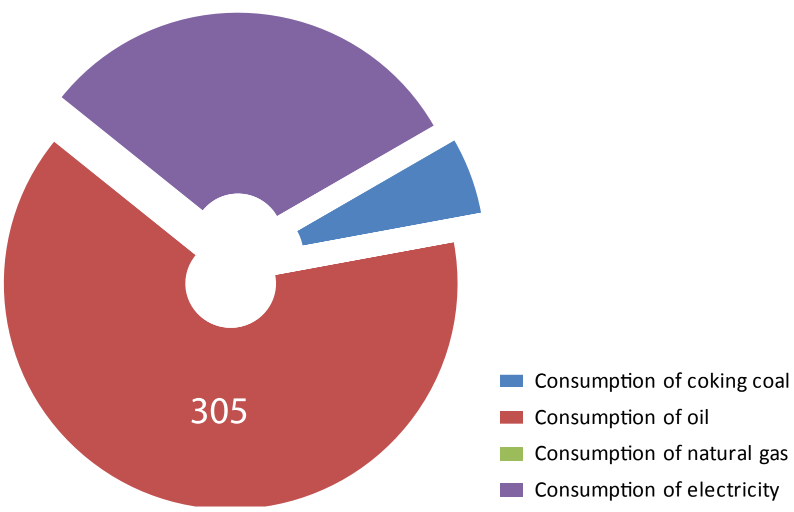
Source: (World Bank, 2015)

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Resources

Biomass

Nine out of 10 people use some form of biomass as a source of energy, and this translates to about 88.5 per cent of the total energy needs. In urban and rural areas, 43.4 and 41.8 per cent of people use charcoal and firewood for cooking, respectively (Gamula, Hui, & Peng, 2013). The high usage of biomass by the growing population is a major driver behind loss in forest cover. Government programs to improve efficiency in the sector are on-going. These include technologies options such as improved cook-stoves and the use of substitute fuels implemented by various government initiatives such as the National Sustainable and Renewable Energy Programme (NSREP) (REEEP, 2012).

Hydropower

By 2011, installed capacity was 300 MW (WEC, 2013).

Oil and natural gas

Malawi is not an oil producing country and imports almost all its refined oil products. In 2015, final consumption of oil was 305 ktoe and imports of oil products was 391 ktoe. Fossil fuels were used to produce 1 ktoe of electricity in 2015 down from 18 ktoe in 2010 (AFREC, 2015).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	44	26	40	28
Production of charcoal	1,711	1,511	1,374	1,372
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	16	18	18	1
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	88	112	149	248
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	3
Total production of electricity	104	130	167	252
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	48	42	37	26
Final consumption of oil	264	340	304	305
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	96	121	158	148
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	0	0	0	0
Consumption of electricity in industry	-	-	-	-
Consumption of coking coal in industry	0	0	0	0
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-10	12	0	0
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	264	340	351	391
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Peat

Malawi has 492 km^2 of peatlands (WEC, 2013).

Coal

Malawi starting mining coal over three decades ago and has a total of four coal fields. The proven recoverable reserves of coal in 2011 was 2 million tonnes of sub-bituminous

coal; in 2011, coal production was 0.1 million tonnes (WEC, 2013). Production from the two active fields in Rumphi district does not meet the required local industrial volumes, so imports from Mozambique make up the deficit (Gamula, Hui, & Peng, 2013).

Wind

Malawi's lakeshore areas provide the windy conditions ideal for generating energy from this resource. Mean wind speeds are above 5 m/s for most of the year (Gamula, Hui, & Peng, 2013) and it is estimated that with serious investment Malawi has the potential to meets its energy demand from wind in less than 15 years (REEEP, 2012).

Nuclear

Malawi produces 1.2 per cent of global uranium production used for generating nuclear power (IEA, 2014). There are two known deposits in northern Malawi — 63,000 tonnes of proven reserves at Kayerekera in Karonga district and another still being analysed at Illomba in Chitipa district (Gamula, Hui, & Peng, 2013). The uranium mines are self-sufficient in energy supplied by thermal generators on site. The government has long-term plans to invest in nuclear power (Gamula, Hui, & Peng, 2013).

Solar

Solar energy levels range from 900 W/m^2 to 1,200 W/m2 depending on the time of the year (Gamula, Hui, & Peng, 2013). If implemented it is reliable and can be deployed for domestic use, irrigation and small businesses.

Tracking progress towards sustainable energy for all (SE4All)

Malawi is one of 20 countries worldwide that account for 83 per cent of the global energy-access deficit; it also has one of the lowest electrification rates (Table 3 and Figure 4) (World Bank, 2015). The national electrification rate was 9.8 per cent in 2012, with access proportions of 2.0 per cent in rural areas and 37.1 per cent in urban areas (World Bank, 2015); (World Bank, 2016). Government is implementing a rural electrification programme, but it will take time before national grid connections reach the currently unconnected population. National access to non-solid fuels in 2012 was 3.09 per cent, with 2 per cent in rural areas and 11 per cent in urban areas (World Bank, 2015).

Malawi's energy intensity increased at a compound annual growth rate (CAGR) of -1.57 per cent over the 20 years between 1990 and 2010 and at -1.42 per cent CAGR from 2010 to 2012. Between 2010 and 2012, the Malawi economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) decreased from 10.5 MJ to 10.2 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

The share of renewable energy in total final energy consumption (TFEC) decreased from 86.4 to 78.4 per cent between 1990 and 2012. In 2012, modern solid biofuels formed the biggest share of renewable sources at 36.61 per cent , followed by traditional biofuels at 35.1 per cent of TFEC, hydro at 6.9 per cent and liquid biofuels at 0.1 per cent . Renewable sources contributed 99.3 per cent of the share of electricity capacity and 57.4 per cent of the electricity generated in 2012 (World Bank, 2015).

Table 3: Malawi's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	3	5	9	9.8		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	3	3		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	86.1	76.9	81.3	78.7		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)	14.3		10.5	10.2	10.13	10.16

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
9.8%	3.09%	NA	79.24%

Table 4: Malawi's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Produce 2000 solar water heaters (SWH)
*Increase SWH from 2,000 to 20,000 by 2030
*Install 20,000 solar PV systems
*Increase solar PV from 20,000 to 50,000 by 2030
*Produce 2 million litres of bio-diesel/year
*Increase biodiesel production from 2 to 20 million/year
*Produce 18 million litres of ethanol/year
*Increase ethanol production from 18 to 40 million litres per year
*Increase the number of passengers using mass transport by 1 per cent
*Increase the number of passengers using mass transport by 30
*Producing 351 MW of hydroelectricity
*Increase generation of hydroelectric power (HEP) by 800 MW by 2025
*Distribute energy saving cook stoves to 400,000 households
*Increase the number of households adopting energy saving stoves to 2 million by 2030

Source: (MEM, 2015)

Table 5: Malawi's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry Of Natural Resources and Environmental Affairs • Rural Electrification Management Committee
Presence of a Functional Energy Regulator	• Malawi Energy Regulatory Authority
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	• Southern Africa Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	• Electricity Supply Corporation of Malawi (ESCOM) Limited
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	• Ministry of Natural Resources and Environmental Affairs
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Energy Policy 2003 • Rural Electrification Fund;
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Act 20, the Energy Regulation Act • Act 21, the Rural Electrification Act • Act 22, the Electricity Act • Act 23, the Liquid Fuels and Gas (Production and Supply) Act

This table was compiled with material from (REEEP, 2012) and (Gamula, Hui, & Peng, 2013)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Malawi was keen to participate in global initiatives to combat climate change, especially since its economy is agro-based and climate-sensitive. The country's energy-related Intended Nationally Determined Contributions (INDC) are found in Table 4.

Institutional and Legal Framework

The Ministry of Natural Resources, Energy and Environment is in charge of the energy sector (Table 5). The energy regulator is the Malawi Energy Regulatory Authority. The Electricity Supply Corporation of Malawi (ESCOM) Limited is a publicly owned company and the only electrical power supplier. On a regional level, Malawi is a member of the Southern Africa Power Pool. The legal framework is provided by the Act 22, the Electricity Act. The main sector policy is the Energy Policy 2003, which aims to stimulate economic development and rural transformation by improving energy sector governance, including mitigating the environmental, safety and health impacts of energy production and utilization.

Mali

Figure 1: Energy profile of Mali

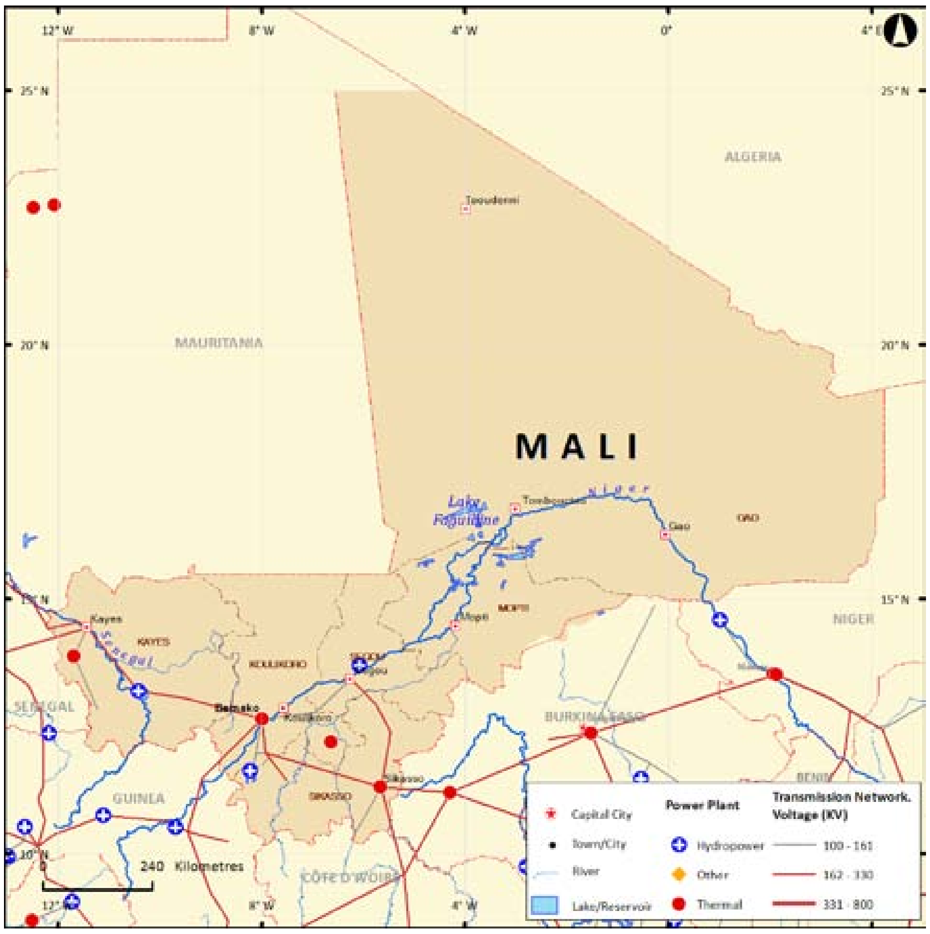
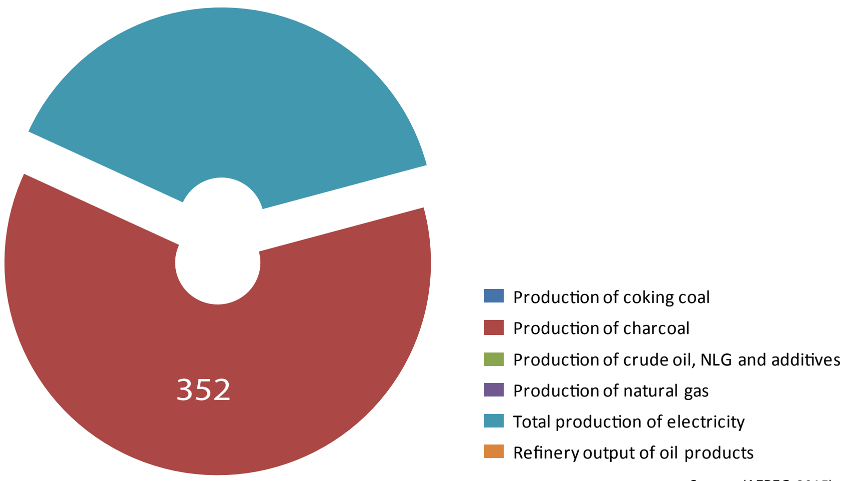
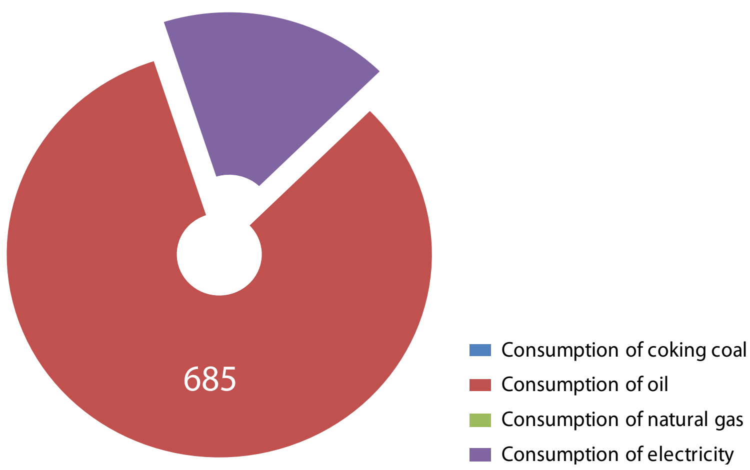


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Mali's population in 2013 was 16.59 million, as shown in Table 1 (World Bank, 2016). In 2015, total electricity produced was 225 ktoe, of which 58.2 per cent came from fossil fuels, 38.6 per cent from hydro and 2.6 per cent from biofuels and waste (Table 2). Final consumption of electricity in 2015 was 145 ktoe (AFREC, 2015).

Table 1: Mali's key indicators

Key indicators	Amount
Population (million)	16.59
GDP (billion 2005 USD)	7.28
CO_2 emission (Mt of CO_2)	1.25

Source: (World Bank, 2015)

Energy Resources

Biomass

Mali has extensive biomass resources including forests which are under pressure to provide fuel wood to satisfy the domestic energy requirements of the growing population. Eighty per cent of national energy supply is provided by biomass and this contributes to the deforestation rate of 4,000 km^2 every year (REEEP, 2012). Electricity demand is growing at 10 per cent per year. Other forms of biomass that could be used for energy provision include biofuels from jatropha plantations and agricultural waste such as rice straw, bagasse from sugarcane and cotton stalks. In 2015, production of electricity from biofuels and wastes amounted to 6 ktoe (AFREC, 2015).

A pile of chopped fuelwood in Mali

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	210	232	316	352
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	4	4	4	6
Production of electricity from fossil fuels	44	49	81	131
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	21	55	60	87
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	70	109	145	225
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	189	245	563	685
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	60	97	123	145
Consumption of oil in industry	1	2	1	19
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	35	53	55	57
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	179	222	534	638
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	492	559	792	871
Net imports of natural gas	-	-	-	-
Net imports of electricity	0	0	0	1

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Hydropower

Mali's hydropower potential is just over 1,000 MW mainly from the Niger and Senegal Rivers. So far, only 22 per cent of this potential has been exploited (REEEP, 2012). Existing power plants include the Sélingué on the Sankarani river, an offshoot of River Niger, and the Manantali, Gouina and Félou plants on the Senegal River. Under the auspices of the Organization for the Development of the Senegal River, the Manantali dam provides electricity for Mali, Senegal and Mauritania. There are also numerous sites suitable for small hydro plants (REEEP, 2012).

Wind

The wind energy potential varies over the country from speeds as low as 3 m/s (not ideal for wind power generation) to 7 m/s (REEEP, 2012). A wind resource mapping exercise was recently completed for Mali (FRSE, 2016).

Solar

Measurements of solar radiation are over 5 kWh/m^2/day and in 2015, about 1 ktoe of electricity generated was from solar or wind (REEEP, 2012), (AFREC, 2015). The uptake of solar PV systems has been increasing, especially with the recent declines in prices as more PV-generated electricity becomes available. The recent mapping of potential solar resources will support decision making for investment in solar energy (FRSE, 2016).

Tracking progress towards sustainable energy for all (SE4All)

The national electrification rate of Mali was 25.6 per cent in 2012 (Table 3 and Figure 4). In rural areas, this falls to 11.9 per cent while in urban areas it is 50.4 per cent (World Bank, 2015); (World Bank, 2016). Grid extension into rural areas is limited and the size, economic situation and sparseness of the population means it is unlikely to occur at any meaningful scale in the near future. What little rural electrification exists is provided by mini-grids or individual systems. National access to non-solid fuels in 2012 was 2 per cent , with 2 per cent in rural areas and 3 per cent in urban areas (World Bank, 2015).

Mali's energy intensity increased at a compound annual growth rate (CAGR) of -2.31 per cent over the 20 years between 1990 and 2010 and at 0.75 per cent CAGR from 2010 to 2012. Between 2010 and 2012, the Mali economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) increased from 3.2 MJ to 3.3 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

The share of renewable energy in total final energy consumption (TFEC) decreased from 91.6 to 83.54 per cent between 1990 and 2012. In 2012, traditional solid biofuels formed the biggest share of renewable sources at 78.9 per cent, followed by hydro at 3.1 per cent of TFEC and modern biofuels at 1.5 per cent (World Bank, 2015). Renewable sources contributed 51.6 per cent of the share of electricity capacity and 28.2 per cent of the electricity generated in 2012 (World Bank, 2015).

Table 3: Mali's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	12	17	17	25.6		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	2	2		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	91.6	88.9	88.3	83.5		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)	5.2		3.2	3.3	3.20	3.29

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

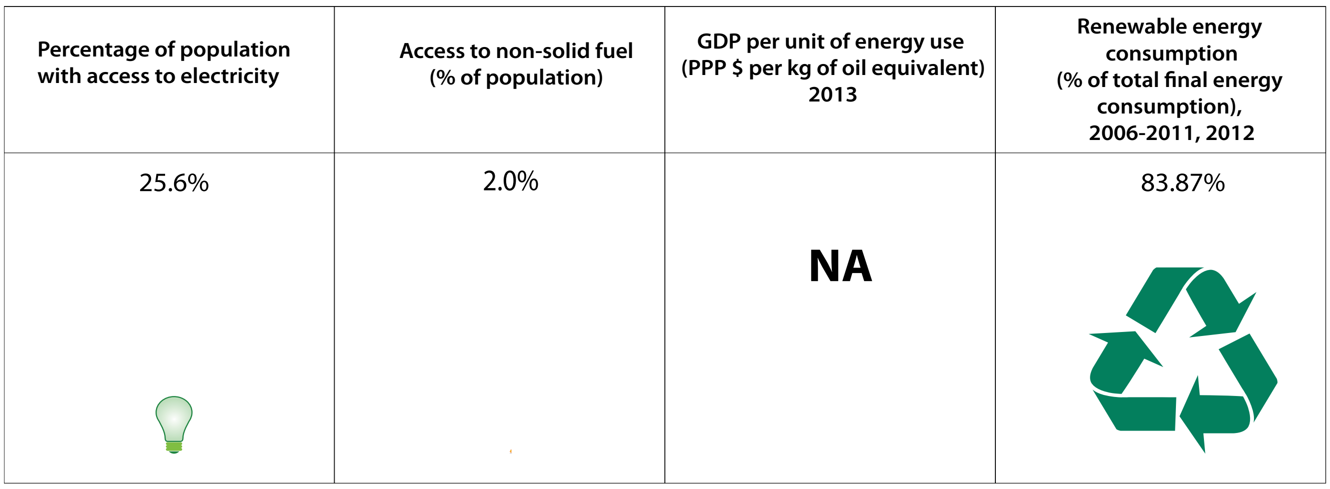


Table 4: Mali's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Implement a large scale renewable energy recovery plan (SREP) for a total budget of US $258 million.
*Execute the Manantali II project for a total cost of US $150 million between 2016 and 2021.
*Implement the rural electrification project using renewable energies between 2015 and 2020 for a total cost of US $7.2 million.
*Build the Kénié hydroelectric power plant between 2015 and 2020 for a total budget of US $165 million.

Source: (MEM, 2015)

Table 5: Mali's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Water • Rural Electrification and Domestic Energy Agency (AMADER) • National Research Center for Solar and Renewable Energy (CNESOLER) • National Agency for the Development of Biofuels (ANADEB)
Presence of a Functional Energy Regulator	Electricity and Water Regulatory Commission (CREE)
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West African Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Vertically Energie du Mali SA (EDM)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	National Office of Petroleum Products (ONAP)
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	Scatec Solar ASA
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Energy Policy 2006 • National Strategy for the Development of Renewable Energy 2006 • National Energy Sector Policy Letter 2009 • Rural Electrification Framework • National Strategy for the Development of Biofuels 2008
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	ECOWAS Protocol on Energy 2003

This table was compiled with material from (REEEP, 2012), (MEW, 2011) and (Toure, 2011)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Mali articulated its Intended Nationally Determined Contributions (INDC) in 2015, as it is a keen participant in global climate deliberations. Those related to energy are highlighted in Table 4.

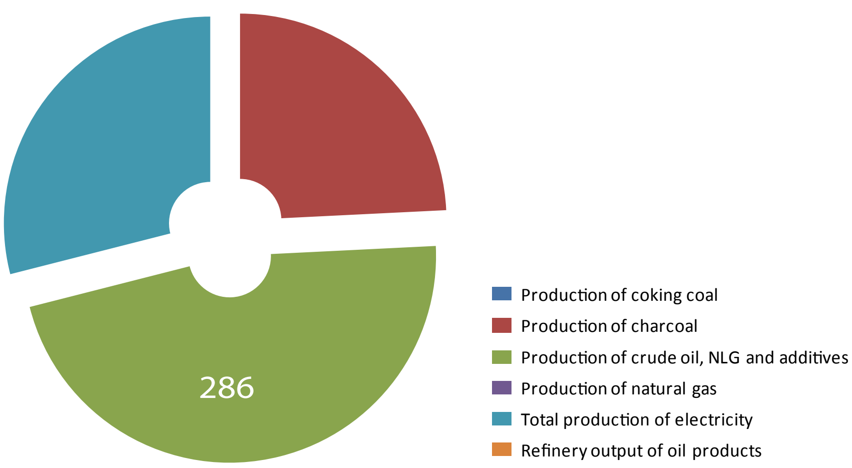
Institutional and Legal Framework

The Ministry of Energy and Water is in charge of the energy sector (Table 5). The energy regulator is the Electricity and Water Regulatory Commission (CREE). Energie du Mali SA (EDM) provides electricity services with the support of local private energy companies, the Rural Electrification and Domestic Energy Agency (AMADER) and the Rural Electrification Fund. On a regional level, Mali is a member of West African Power Pool. The legal framework is provided by the ECOWAS Protocol on Energy 2003, which Mali has ratified. The main sector policy is the National Energy Policy 2006, which aims to meet the energy needs of the populace while ensuring the protection of people, infrastructure and the environment against the risks of inappropriate energy services.

Mauritania

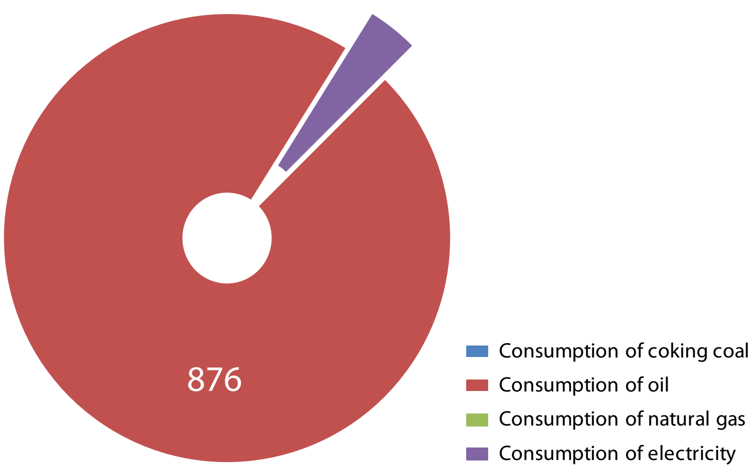
Figure 1: Energy profile of Mauritania

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

The population of Mauritania in 2013 was 3.87 million, as shown in Table 1 (World Bank, 2016). In 2015, total production of electricity was 177 ktoe, of which 80.7 per cent came from fossil fuels, 12.4 per cent from hydro and 6.7 per cent from solar and wind (Table 2). Final consumption of electricity in 2015 was 33 ktoe. Figures 2 and 3 show the main energy statistics.

Table 1: Mauritania's key indicators

Key indicators	Amount
Population (million)	3.87
GDP (billion 2005 USD)	3.27
CO_2 emission (Mt of CO_2)	2.31

Source: (World Bank, 2015)

Energy Resources

Biomass

Biomass provides about 60 per cent of Mauritania's energy mix (REEEP, 2012). In 2015, production of charcoal was 148 ktoe (AFREC, 2015). There are opportunities to generate electricity from agricultural residue including rice husks and straw, jatropha and charcoal made from the invasive weed Typha (REEEP, 2012). There is an estimated energy potential of 3.7 GWh from 556,000 tonnes of crop waste (REEEP, 2012).

Hydropower

Electricity from hydro sources comes from energy interconnections with the Senegal River Basin Development Organisation (OMVS). In-country the installed capacity and production in 2011 was 30 MW (WEC, 2013).

Oil and natural gas

Oil supplies 95 per cent of the country's commercial energy needs with the main fuel product being liquefied petroleum gas (LPG). Mauritania, Senegal and Cape Verde combine to represent 90 per cent of the regional trade in natural gas (REEEP, 2012). Production of natural gas at the end of 2011 was 28 bcm (988.8 bcf) (WEC, 2013).

Oil production figures in 2011 were 1,300 thousand tonnes (9.5 million barrels). Offshore oil reserves have been estimated at 1 billion barrels. Production of electricity from fossil fuels in 2015 143 ktoe compared with total electricity production of 177 ktoe (AFREC, 2015).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	0	148
Production of crude oil, NLG and additives	-	-	366	286
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	17	39	50	143
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	3	4	10	22
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	12
Total production of electricity	20	43	60	177
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	0	459	650	876
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	18	40	56	33
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-343	-201
Net imports of oil product	149	1185	718	930
Net imports of natural gas	-	-	-	-
Net imports of electricity	0	0	0	0

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

Peat

There is 60 km^2 of peatlands in the country (Blyth, 2014); (WEC, 2013)

Wind

Mauritania has registered the highest wind speeds on the continent and has an estimated available wind energy of 7,644 kW/m^2 per year (REEEP, 2012) indicating good potential for commercialization. In 2015, the electricity utility SOMELEC commissioned a wind plant in Nouakchott with the potential to generate 30 MW of power.

Geothermal

Studies need to be undertaken, but so far indications are that the country has low geothermal potential (REEEP, 2012).

Solar

High levels of solar irradiation and availability of land present Mauritania with ideal conditions for solar energy generation (REEEP, 2012). Already a 15 MW solar power plant in Nouakchott run by SOMELEC, the electricity utility, has improved the country's carbon footprint by displacing more than 20,000 tonnes of CO2 per annum(Masdar Clean Energy, 2016). In 2015, 12 ktoe of electricity was produced from solar or wind (AFREC, 2015) and there are plans for further investment in the sector.

Tracking progress towards sustainable energy for all (SE4All)

The national electrification rate of Mauritania was 21.8 per cent in 2012 (Table 3 and Figure 4). In rural areas, this falls to 4.4 per cent while in urban areas, it is 46.0 per cent (World Bank, 2015); (World Bank, 2016). National access to non-solid fuels in 2012 was 42.05 per cent . Disaggregated by location, it was 20 per cent in rural areas and 66 per cent in urban areas (World Bank, 2015).

Mauritania's energy intensity increased at a compound annual growth rate (CAGR) of -6.81 per cent over the 20 years between 1990 and 2010 and at 28.07 per cent CAGR from 2010 to 2012. Between 2010 and 2012, the Mauritanian economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) increased from 4.8 MJ to 7.8 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

The share of renewable energy in total final energy consumption (TFEC) decreased from 40.9 to 33.2 per cent between 1990 and 2012. In 2012, traditional solid biofuels formed the biggest share of renewable sources at 32.2 per cent (World Bank, 2015). Renewable sources contributed 33.1 per cent of the share of electricity capacity in 2012 (World Bank, 2015).

Table 3: Mauritania's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 per cent of population with access to electricity	12	15	18	21.8		
	7.1.2 per cent of population with primary reliance on non-solid fuels	18	32	40	42		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	40.9	42.6	35.1	32.2		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)	19.5		4.8	7.8	7.68	7.81

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
21.8%	42.05%	NA	33.28%

Women installing solar panels, Mauritania

Table 4: Mauritania's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Petroleum, Energy and Mines (MPEM) • Directorate General of Hydrocarbons (DGH) • l'Agence de Développement et d'Electrification • Rurale et l'Agence de Promotion de l'Accès Universel aux Services
Presence of a Functional Energy Regulator	Autorité de Régulation
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	A member of Comite Maghrebin De L'electricite (COMELEC) Power Pool , but not active in the network.
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Mauritanian Electricity Company (SOMELEC) 2001
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Hardman Petroleum (France) Dana Petroleum (UK) Woodside Petroleum (Australia) British Borneo Oil and Gas (Malta)
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Downstream activities are co-ordinated by both government-owned companies such as the Société Mauritanienne de Commercialisation de Produits Pétroliers (SMCPP) and the Societe Nationale Industrielle et Miniere of Mauritania (SNIM), as well as private companies such as Elf and Mobil.
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	Mauritania Strategy of Renewable Energy 2014
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Decree No. 2001-065 of June 18th, 2001 creating the National Renewable Energy Agency (ADER) • Law 2001-18, establishing the Multisectoral Regulation Authority (ARM) that regulates the water, electricity, telecommunications and postal services • Electrical Code 2001(??)

This table was compiled with material from (REEEP, 2012) and (IRENA, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

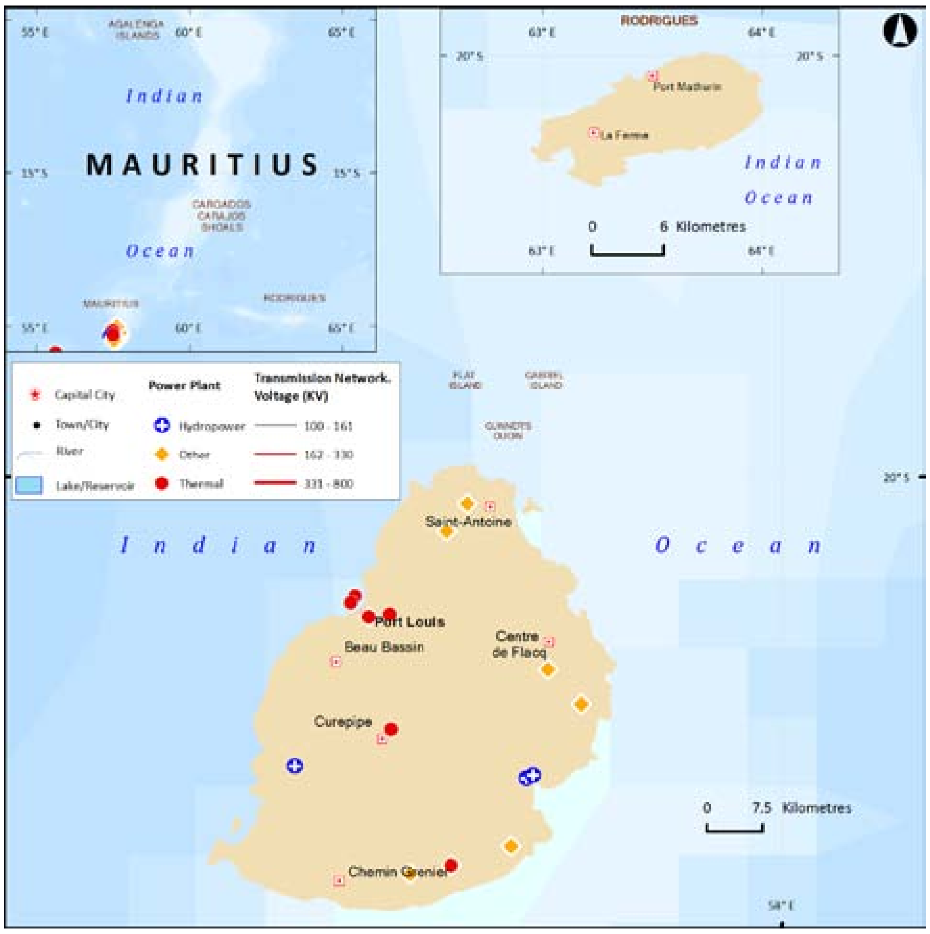
The energy-related Intended Nationally Determined Contributions (INDC) were formulated in September 2015 and aim to reduce greenhouse gas emissions by 22.3 per cent in 2030 or by 4.2 million tonnes of carbon dioxide equivalent ($MtCO_2e$).

Institutional and Legal Framework

The *Ministère du Pétrole de l'Energie et des Mines* is in charge of the energy sector (Table 4). The energy regulator is the *Autorité de Régulation*. The state owned Société Mauritaneinne d'Electricité is in charge of the electricity sector. On a regional level, Mauritania is an active member of the Maghreb Committee for Electricity (COMELEC), via the national utility SOMELEC. It is not interconnected to the COMELEC Power Pool, although a connection is planned from Nouadhibou. The legal framework is provided by the Electrical Code 2001.

Mauritius

Figure 1: Energy profile of Mauritius



Energy Consumption and Production

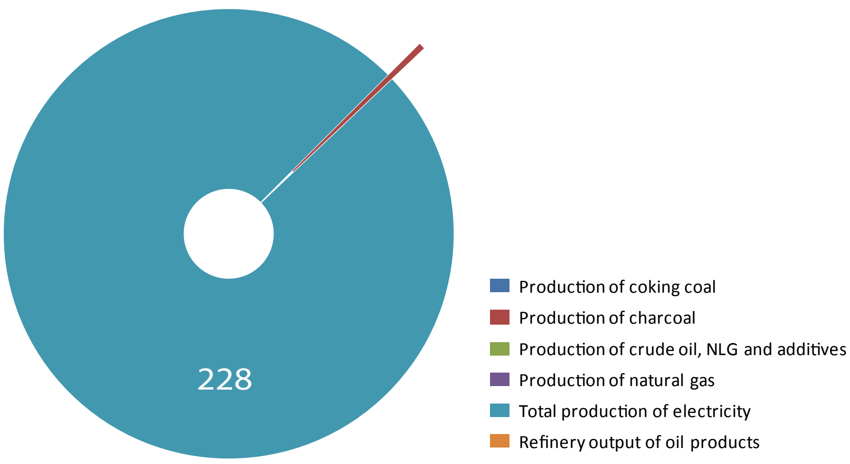
In 2013, the population of Mauritius was 1.26 million (Table 1). In 2015, total production of electricity was 228 ktoe, of which 92.1 per cent came from fossil fuels, 26.3 per cent from biofuels and waste and 3.9 per cent from hydro sources (Table 2). Final consumption of electricity in the same year was 210 ktoe (AFREC, 2015). Figures 2 and 3 show the main energy statistics.

Table 1: Mauritius"s key indicators

Key indicators	Amount
Population (million)	1.26
GDP (billion 2005 USD)	8.66
CO_2 emission (Mt of CO_2)	3.83

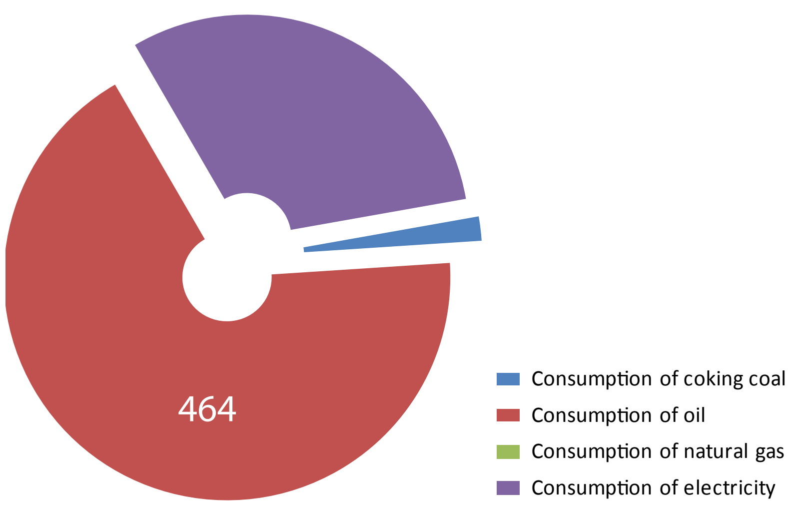
Source: (World Bank, 2015)

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Resources

Biomass

There is ample opportunity to generate electricity using biomass from agricultural waste. For instance, in 2013 there was an annual technical generation potential of 1,000 GWh of electricity from bagasse (solid waste left after sugar cane juice has been extracted) and other agricultural residue (REEEP, 2012).

Anna Frodesiak / Wikipedia / CC CC0

Bagasse, a by-product of the cane sugar industry, is used to produce energy in Mauritius

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	1	1	1
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	35	37	47	60
Production of electricity from fossil fuels	101	138	175	157
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	8	10	9	9
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	2
Total production of electricity	145	185	231	228
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	14	21	13	12
Final consumption of oil	997	1098	445	464
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	134	172	215	210
Consumption of oil in industry	0	0	97	84
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	80	78
Consumption of coking coal in industry	0	0	13	13
Consumption of oil in transport	0	0	293	319
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	114	194	337	377
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	974	1,100	1,094	1,069
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Hydropower

Electricity generated from hydro sources amounted to 9 ktoe in 2015 and any future expansion will probably be through micro (5-100 kW) or pico hydro (less than 5kW) plants to a total of 10 MW (REEEP, 2012).

Oil and natural gas

Mauritius imports petroleum products to meet its energy requirements, as it has no oil or gas (REEEP, 2012).

Wind

The potential for wind energy has allowed Mauritius to set a target in its Long-term Energy Strategy 2009-2025 to source 35 per cent of its electricity from renewables by 2025, with wind supplying 8 per cent of total generation. The country has an inland technical wind-power potential of between 60 and 140 MW and almost twice that potential offshore (REEEP, 2012). The government also aims to improve the knowledge base guiding decision makers implementing wind energy by producing a wind atlas.

Solar

Solar resources are substantial, with an average solar radiation of 5.4 kWh/m^2/day (REEEP, 2012). In 2015, 2 ktoe of electricity was generated from wind or solar (AFREC, 2015). The Mauritius Sustainable Island Fund, launched in 2008, is promoting energy efficiency through introducing household usage of solar for water heating and lighting. The government has also been considering augmenting grid supply through solar generation (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

By 2012, the whole of Mauritius had access to electricity (Table 3 and Figure 4) (World Bank, 2016). National access to non-solid fuels in 2012 was 99.26 per cent (World Bank, 2015).

Mauritius's energy intensity increased at a compound annual growth rate (CAGR) of -1.19 per cent over the 20 years between 1990 and 2010 and at -1.98 per cent CAGR from 2010 to 2012. Between 2010 and 2012, the Mauritian economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) increased from 6.5 MJ to 6.2 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

The share of renewable energy in total final energy consumption (TFEC) decreased from 91.6 to 83.54 per cent between 1990 and 2012. In 2012, traditional solid biofuels formed the biggest share of renewable sources at 1.3 per cent , followed by modern biofuels at 15.1 per cent of TFEC and hydro at 1.3 per cent (World Bank, 2015). Renewable sources contributed 24.5 per cent of the share of electricity capacity and 22.2 per cent of the electricity generated in 2012 (World Bank, 2015).

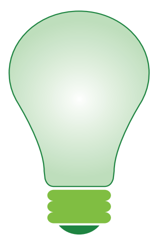
Table 3: Mauritius's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	97	99	100	100		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	83	93	98	99.26		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	51.9	14.6	6.9	34.0		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)				15.66 (2013)		
	Level of primary energy intensity(MJ/$2005 PPP)	8.2		6.5	6.2	6.28	6.20

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
100%	99.26%	**16.18**	3.36%



Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Mauritius is already facing environmental challenges, such as changes in rainfall patterns, and this is likely to impact the agricultural and natural resources sectors

Table 4: Mauritius's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Expand solar, wind and biomass energy production and other renewable energy sources.
*Adopt sustainable consumption and production in all sectors of the economy.
*Gradually shift towards the use of cleaner energy technologies, such as LNG, among others.
*Modernize the national electricity grid through the use of smart technologies, which is a prerequisite to accelerate the uptake of renewable energy.
*Increase efficient use of energy through the deployment of appropriate technologies in all sectors of the economy and awareness raising on energy conservation.
*Adopt sustainable transportation, including promotion of energy efficient mass transportation systems based on hybrid technologies and cleaner energy sources.
*Implement sustainable and integrated waste management, including waste to energy.
*Implement a sustained tree planting programme within the context of the cleaner, greener and safer initiative.

Source: (MEM, 2015)

Table 5: Mauritius's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Energy and Public Utilities
Presence of a Functional Energy Regulator	Central Electricity Board (CEB)
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	A member of SADC, but does no participate in the Southern Africa Power Pool.
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Central Electricity Board
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	State Trading Corporation (STC) imports all petroleum products which are then distributed by Shell, Esso, Caltex and Total.
Presence of Functional (Feed in Tariffs) FIT systems	Yes being developed
Presence Functional IPPs and their contribution	Compagnie Thermique de Savannah (CTSav) 74 MW Compagnie Thermique Du Sud (CTDS) Central Thermique de Belle Vue (CTBV) FUEL Steam and Power Generation Company (FSPG) Consolidated Energy Limited (CEL)
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Outline of the Energy Policy 2007-2025 in 2007 • Long Term Energy Strategy 2009-2025 in 2008 • Integrated Electricity Plan (IEP) 2003-2012
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Electricity Act of 1939 (amended 1991) • Utility Regulatory Authority Act 2005 • Grid Code 2009 • Maurice Ile Durable (MID) Levy 2008 • Energy Efficiency Act 2011 • Central Electricity Board Act 1964 • Petroleum Act of 1970 (amended 1991)

This table was compiled with material from (REEEP, 2012) and (AFD, 2012)

adversely. To play its role in mitigating climate change, the country articulated its Intended Nationally Determined Contributions in 2015. The energy-related INDCs are listed in Table 4.

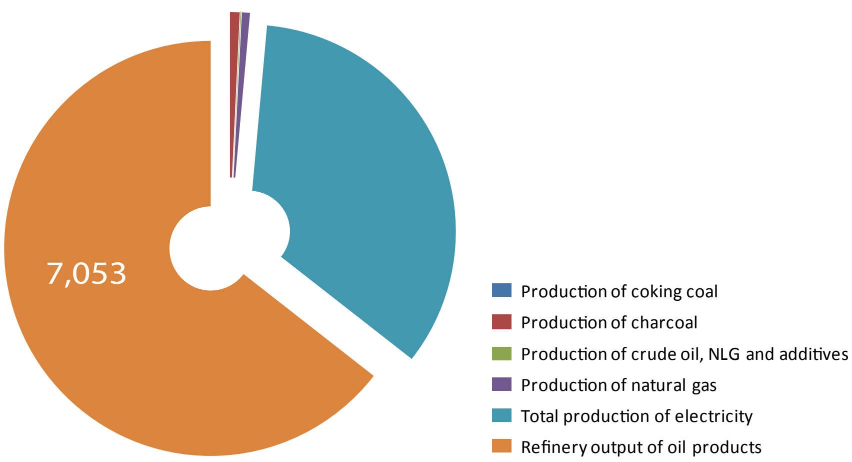
Institutional and Legal Framework

The Ministry of Energy and Public Utilities is in charge of the energy sector (Table 5). The Central Electricity Board (CEB) is the generator and supplier of electricity and also acts as the current electricity regulator. On a regional level, Mauritius is a member of the Southern Africa Development Corporation, but does not participate in the Southern Africa Power Pool. The legal framework is provided by the Electricity Act of 1939 (amended in 1991). The Long Term Energy Strategy 2009-2025 aims to increase the renewable energy share to 35 per cent by 2025, with the application of technologies to harness available renewable energy resources.

Morocco

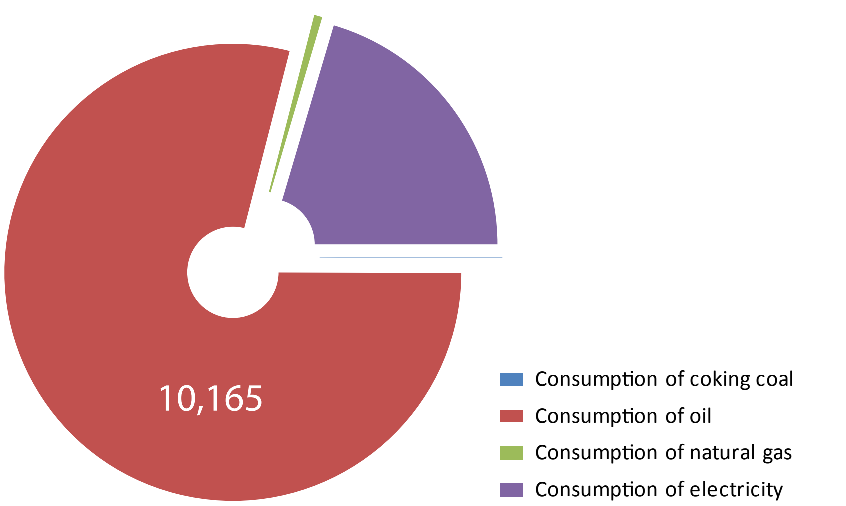
Figure 1: Energy profile of Morocco

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Morocco had a population of 33.01 million in 2013 (Table 1). In 2015, total electricity production was 3,733 ktoe, with 86.1 per cent from fossil fuels, 8.09 per cent from hydro and 5.7 per cent from solar and wind. Final electricity consumption was 2,630 ktoe (AFREC, 2015) as shown in Table 2. Between 2000 and 2015, Morocco's consumption of electricity almost doubled. This is likely partly due to a focus on energy-intensive sectors, such as construction and chemicals, among others. Figures 2 and 3 show the key energy statistics.

Table 1: Morocco's key indicators

Key indicators	Amount
Population (million)	33.01
GDP (billion 2005 USD)	84.97
CO_2 emission (Mt of CO_2)	50.34

Source: (World Bank, 2015)

Energy Resources

Biomass

It is primarily in Morocco's rural areas where traditional biomass is still used for cooking and other domestic purposes. The annual consumption of wood is estimated at 30,000 ha while land under forest is about 9 million ha (REEEP, 2014). Production of charcoal increased from 78 to 82 ktoe between 2010 and 2015 respectively (AFREC, 2015). There is research on-going into biogas from landfill waste and the use of biomass to replace oil in thermal generators.

Hydropower

Generation of electricity from hydro-sources increased by 2.3 per cent to 302 ktoe between 2010 and 2015 (AFREC, 2015). Hydro-electricity has been the main source of the available renewable energy options to the electricity grid making up 8 per cent of total electricity generated in 2015. However, the contribution of hydro-electricity to the grid has been fluctuating. For instance in 2005 hydro contributed 6 per cent of total electricity generated increasing to 14.5 per cent 2010 (AFREC, 2015). This could partly be the influence of climate change. Future developments are looking at micro-hydro power (plants generating between 5 and 100 kW of electricity).

Oil and natural gas

Morocco produced only 6 ktoe of crude oil in 2015, yet net imports of crude oil were 6,705 ktoe, net imports of oil product was 6,275 ktoe and net imports of natural gas was 1,086 ktoe in the same year (AFREC, 2015). The share of oil in electricity generation was 86.1 per cent in 2015 highlighting how central oil is to the Moroccan economy. Shale oil deposits by 2011 were estimated at over 53 billion barrels (WEC, 2013), with the most important deposits at Timahdit in the Middle Atlas Mountains and Tarfaya in the southwest. The government aims to develop this resource so as to reduce its over-dependence on oil and gas from other Arab countries.

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015,P
Produc tion of coking coal	35	7	0	0
Production of charcoal	11	12	78	82
Production of crude oil, NLG and additives	12	7	9	6
Production of natural gas	42	43	49	69
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	1,150	1,807	1,681	3,216
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	62	123	295	302
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	6	18	57	215
Total production of electricity	1,217	1,947	2,032	3,733
Refinery output of oil products	6,600	6,790	6,596	7,053
Final Consumption of coking coal	409	466	12	6
Final consumption of oil	5,716	7,176	9,549	10,165
Final consumption of natural gas	42	43	50	74
Final consumption of electricity	1,348	1,668	2,145	2,630
Consumption of oil in industry	977	1,139	1,104	996
Consumption of natural gas in industry	42	429	49	79
Consumption of electricity in industry	520	615	775	1,014
Consumption of coking coal in industry	409	466	12	6
Consumption of oil in transport	2,568	3,201	4,275	4,459
Consumption of electricity in transport	18	25	24	28
Net imports of coking coal	2,024	3,449	2,157	3,191
Net imports of crude oil, NGL, Etc.	6,400	6,514	5,737	6,705
Net imports of oil product	33	1,627	6,341	6,275
Net imports of natural gas	0	0	583	1,086
Net imports of electricity	200	69	339	422

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Peat

There is 10 km^2 of peatland (WEC, 2013).

Coal

The proven recoverable reserves of coal by the end of 2011 was 82 million tonnes (WEC, 2013).

Wind

Wind energy is a growth industry in Morocco as the resource potential is high, estimated at 25,000 MW (REEEP, 2014). The north and southwestern coasts of Africa are considered most attractive regions for wind energy generation (WEC, 2013). By the end of 2013, there was 487 MW of installed wind energy (GWEC, Various years) and the government is planning to augment this to 2,000 MW by 2020 (OECD/IEA, 2014). This additional capacity will be installed using a variety of financing options (GWEC, 2009).

Table 3: Installed wind power capacity in Morocco, (MW)

	End 2007	End 2008	End 2009	End 2010	End 2011	End 2012	End 2013
Morocco	124	134	253	286	291	291	487
Africa	539	635	866	1 065	1 033	1 165	1 602

Source: (GWEC, Various years)

Nuclear

Morocco is interested in utilizing nuclear energy to diversify energy supply. The National Centre for Energy Sciences and Nuclear Technologies (CNESTEN) was established over 30 years ago to drive research in that area (OECD/IEA, 2014).

Geothermal

According to AFREC (2015), by 2015 geothermal energy was not part of Morocco's energy mix. However, there are hot natural springs in the northeast. These visible features of geothermal activity may be an indicator of potential energy that could be tapped (REEEP, 2014).

Solar

Morocco has ample resources for solar energy generation with irradiation appraised at over 2,300 kWh/m^2/yr (REEEP, 2014). The government is investing heavily in developing its solar potential with a target of having installed capacity from solar of 2 GW by 2020 (OECD/IEA, 2014). The institutional framework for solar includes the Moroccan Agency for Solar Energy set up in 2010 and the Institute for Research into Renewable and Solar Energies established in 2011 and they are already having an impact. For instance, production of electricity from solar and wind increased almost four-fold between 2010 and 2015 to 215 ktoe (AFREC, 2015). There are solar plants at Ain Beni Mathar (20 MW) and 160 MW at Ouarzazate (OECD/IEA, 2014).

Tracking progress towards sustainable energy for all (SE4All)

By 2012, the whole of Morocco had access to electricity (Table 4 and Figure 4) (World Bank, 2016). National access to non-solid fuels in 2012 was 97.10 per cent . Disaggregated by location, it was 85 per cent in rural areas and 100 per cent in urban areas (World Bank, 2015).

Morocco's energy intensity increased at a compound annual growth rate (CAGR) of 0.42 per cent over the 20 years between 1990 and 2010 and at 1.48 per cent CAGR from 2010 to 2012. Between 2010 and 2012, the Moroccan economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) increased from 3.4 MJ to 3.5 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

Morocco's success at increasing access to electricity lies in pursuing an off-grid renewable energy electrification model at village scale (Benkhadra, 2011). This project which started in 1995 is being led by the government utility ONEE in collaboration with PPPs and so far, 1.9 million households have electricity (OECD/IEA, 2014). The share of renewable energy in total final energy consumption (TFEC) decreased from 91.6 to 83.54 per cent between 1990 and 2012. In 2012, modern biofuels formed the biggest share of renewable sources at 5.2 per cent , followed by traditional solid biofuels at 4.6 per cent of TFEC, hydro at 1.0 per cent and wind 0.5 per cent (World Bank, 2015). Renewable sources contributed 25.9 per cent of the share of electricity capacity and 8.6 per cent of the electricity generated in 2012 (World Bank, 2015).

Table 4: Morocco's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	49	71	99	100		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	81	91	96	97		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	8.5	6.7	7.2	11.3		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)				12.74 (2013)		
	Level of primary energy intensity(MJ/$2005 PPP)	3.1		3.4	3.5	3.49	3.51

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

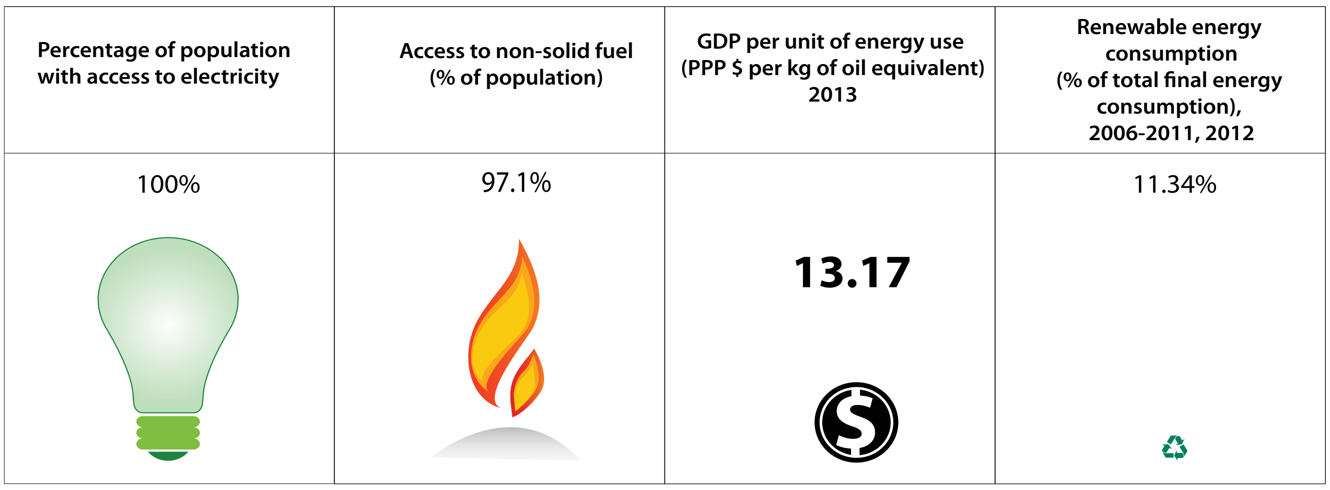


Table 5: Morocco's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Reach over 50 per cent of installed electricity production capacity from renewable sources by 2025.
*Reduce energy consumption by 15 per cent by 2030.
*Substantially reduce fossil fuel subsidies, building on reforms already undertaken in recent years.
*Substantially increase the use of natural gas, through infrastructure projects allowing liquefied natural gas (LNG) imports.
*Provide 42 per cent of the installed electrical power from renewable sources, of which 14 per cent is from solar energy, 14 per cent is from wind energy and 14 per cent is from hydraulic energy by 2020.
*Achieve 12 per cent energy savings by 2020 and 15 per cent by 2030, based on current trends.
*Reduce energy consumption in buildings, industry and transport by 12 per cent by 2020 and 15 per cent by 2030. The breakdown of expected savings per sector is 48 per cent for industry, 23 per cent for transport, 19 per cent for residential and 10 per cent for services.
*Install an additional capacity of 3,900 MW of combined-cycle technology running on imported natural gas by 2030.
*Supply major industries with imported and re-gasified natural gas through pipelines.

Source: (MEM, 2015)

Table 6: Morocco's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy, Mining, Water and Environment (MEMEE) • Agency for the Development of Renewable Energy and Energy Efficiency • Moroccan Agency for Solar Energy • Office of Hydrocarbons and Mining (ONHYM)
Presence of a Functional Energy Regulator	National Authority for Electricity Regulation
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	ONEE (Office National de l'Electricité et de l'Eau Potable)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	No
Presence Functional IPPs and their contribution	• Jorf Lasfar Electric Company JLEC (coal power plant with 6 units of 350 MW capacity each) • Energie Electrique de Tahadart (400 MW NGCC power plant) • Compagnie Eolienne du Detroit (Wind park)
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	National Energy Strategy 2009 Energy Development Fund 2009
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Law No.13-09 Renewable Energy Law • Law No.16-09 creating the National Agency for the Promotion of Renewable Energy and Energy Conservation (ADEREE) • Law No. 57-09 creating the Moroccan Agency for Solar Energy (MASEN) • Bill No. 48-15 on regulation of the electricity sector adopted in September 2015 • Law No.47-09 relating to energy efficiency • Draft law on Public-Private Partnerships (PPPs) • Law No. 16-08, 40-09 and 54-14 dealing with the Office National de l'Eau et de l'Eau Potable (ONEE)

This table was compiled with material from (REEEP, 2014) and (OECD/IEA, 2014)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Morocco's vision is to make the country more resilient to climate change while making the transition to a low carbon economy. Many of the activities to achieve this vision will be undertaken by transforming the energy sector. The main targets are to reduce dependence on energy imports while meeting the internal growing demand for energy. By June 2015, the government had stated its energy-related Intended Nationally Determined Contributions (INDC). These are highlighted in Table 5.

Institutional and Legal Framework

The Ministry of Energy, Mining, Water and Environment (MEMEE) is in charge of the energy sector (Table 6). A bill to approve an energy regulator was passed in September 2015. The ONEE (*Office National de l'Electricité et de l'Eau Potable*) is the sole generator, transmitter and distributor of electric energy. On a regional level, the country is a member of Maghreb Electricity Committee (COMELEC) Power Pool. The legal framework is provided by Law N° 16-08, 40-09 and 54-14 dealing with the ONEE.

The National Energy Strategy 2009 is the main sector policy. The challenges of this policy are the high-energy import dependency that negatively affects the country's balance of trade and the energy bill, which makes up 12 per cent of GDP (Zejli, 2015). Over 91 per cent of energy supplied comes from abroad (OECD/IEA, 2014). Addressing these issues through investing in more renewables will help to reduce GHG emissions in the energy sector.

Mozambique

Figure 1: Energy profile of Mozambique

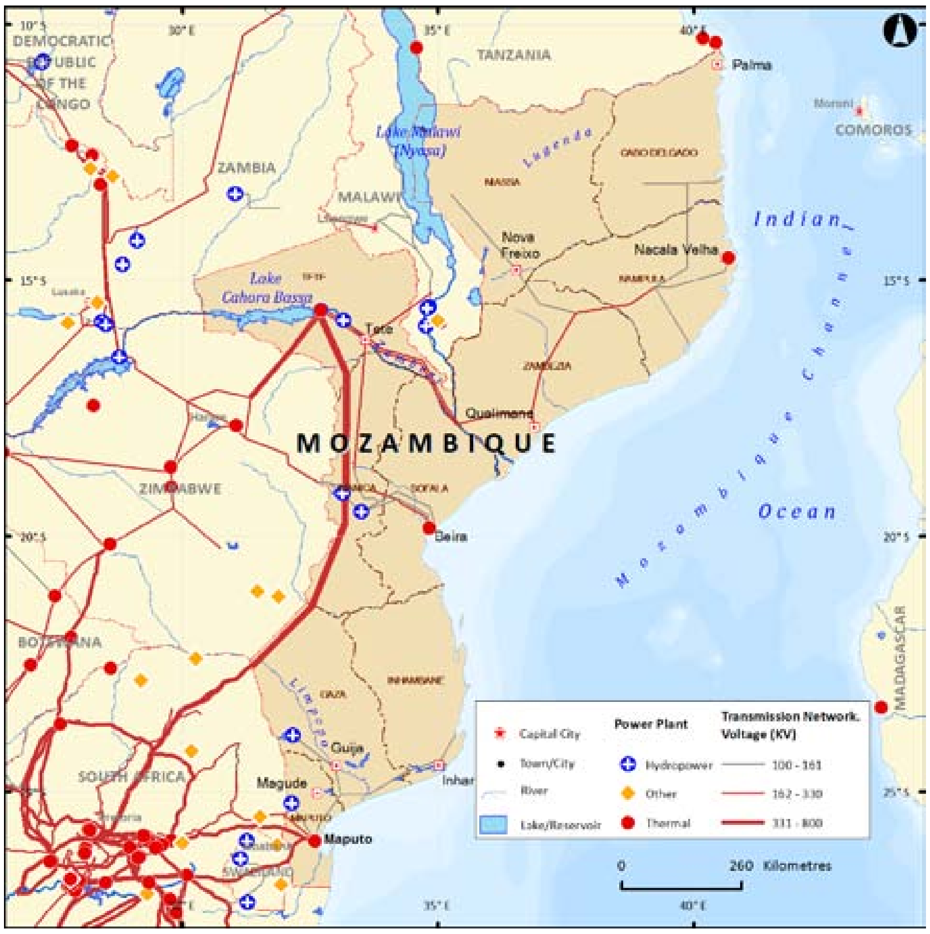
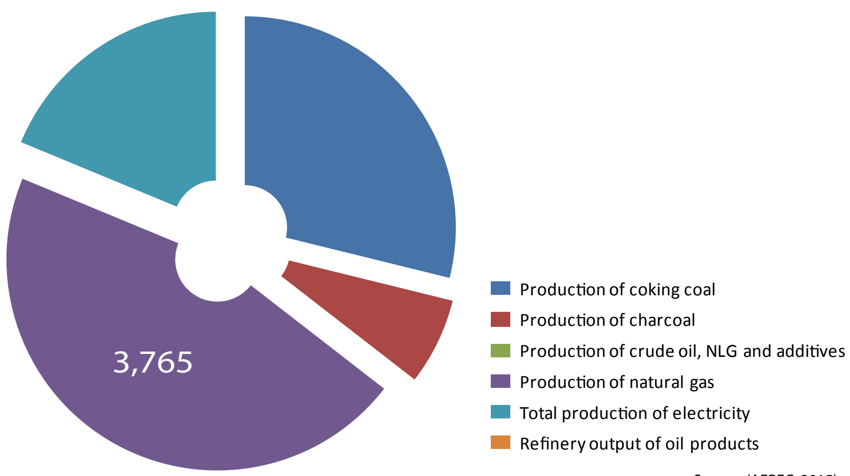
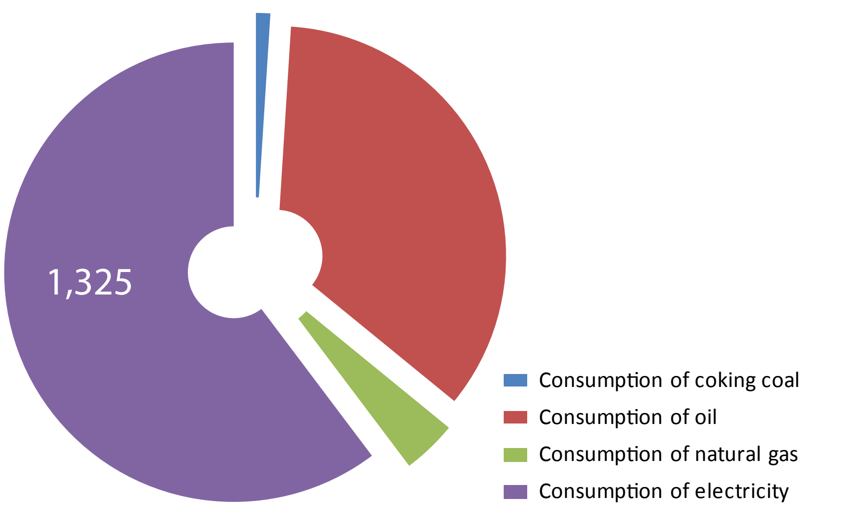


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Mozambique had a population of 25.83 million (Table 1). In 2015, total electricity production was 1,543 ktoe, of which most (98.9 per cent) came from hydro sources (Table 2). Final electricity consumption in the same year was 1,325 ktoe (AFREC, 2015). Figures 2 and 3 show the main energy statistics.

Table 1: Mozambique's key indicators

Key indicators	Amount
Population (million)l	25.83
GDP (billion 2005 USD)	11.19
CO_2 emission (Mt of CO_2)	2.95

Source: (World Bank, 2015)

Energy Resources

Biomass and biofuel

Over 78 per cent of households use biomass to supply their domestic energy needs (REEEP, 2012). The use of wood fuels for energy contributes to indoor air pollution and deforestation affecting human and environmental health. There is the opportunity to use agricultural waste, such as bagasse from the sugar industry or copra wastes from the coconut industry, to generate energy (REEEP, 2012). In 2015, 15 ktoe of electricity was produced from biofuels and waste (AFREC, 2015).

Hydropower

Mozambique has a large potential for hydroelectricity, with installed capacity and production in 2011 of 107 MW (WEC, 2013). The hydropower generation potential is 15,000 MW per year and currently only 14 per cent of this has been developed (REEEP, 2012). Production of electricity from hydro-sources has been steadily increasing from 760 ktoe in 2000 to 1,527 ktoe in 2015 (AFREC, 2015). Interconnections with the South African Power Pool (SAPP) provide opportunities for energy trade.

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	9	2	20	2,374
Production of charcoal	249	297	335	547
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	1	2,075	2,967	3,765
Production of electricity from biofuels and waste	0	0	0	15
Production of electricity from fossil fuels	1	2	2	0
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	760	1,140	1,431	1,527
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	761	1,142	1,432	1,543
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	3	0	5	22
Final consumption of oil	434	499	693	767
Final consumption of natural gas	0	17	70	84
Final consumption of electricity	180	786	917	1,325
Consumption of oil in industry	29	76	97	116
Consumption of natural gas in industry	0	17	70	78
Consumption of electricity in industry	38	669	737	742
Consumption of coking coal in industry	0	0	3	24
Consumption of oil in transport	305	479	534	613
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-12	-11	-14	-1,744
Net imports of crude oil, NGL, Etc.	781	-20	-28	-32
Net imports of oil product	437	502	735	833
Net imports of natural gas	0	-2,055	-2,838	-3,507
Net imports of electricity	-558	-207	-305	-137

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

Oil and natural gas

In 2011, there were 127 bcm of proved recoverable natural gas reserves (WEC, 2013).

Peat

There is 575 km^2 of peatland (WEC, 2013).

Coal

Although Mozambique has some coal reserves (140 million TJ) these are not currently being fully exploited (Table 3) (WEC, 2013).

Table 3: Mozambique's coal reserves and production

Country	Coal reserves	Production
Mozambique	212	
Rest of region	357	2
Africa total	31 617	255.4

Source: (WEC, 2013)

Wind

There is a dearth of data to support wind energy exploitation. To that end measurements are being taken and will culminate in the production of a national wind power potential map (REEEP, 2012).

Solar

Mozambique's solar potential is largely unexploited but has been used to extend rural electrification through isolated systems. The incident solar radiation per year across the country is just under 1.5 million GWh (REEEP, 2012). Production of electricity from solar and wind was 1 ktoe in 2015 (AFREC, 2015).

Tracking progress towards sustainable energy for all (SE4All)

Mozambique has a very low electrification rate, but has been working to address this. By 2012, the national access was 20.2 per cent , with 5.4 per cent in rural areas and 54.5 per cent in urban areas (Table 4 and Figure 4). National access to non-solid fuels in 2012 was 3.80 per cent (World Bank, 2016). Disaggregated by location it was 2 per cent in rural areas and 10 per cent in urban areas (World Bank, 2015).

Mozambique's energy intensity changed at a compound annual growth rate (CAGR) of -3.76 per cent over the 20 years between 1990 and 2010 and at -4.28 per cent CAGR from 2010 to 2012. Between 2010 and 2012, the Mozambiquan economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) decreased from 19.5 MJ to 17.9 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

The share of renewable energy in total final energy consumption (TFEC) decreased from 93.1 to 88.4 per cent between 1990 and 2012. In 2012, traditional biofuels formed the biggest share of renewable sources at 66.7 per cent , followed by hydro at 12.5 per cent and modern solid biofuels at 9.1 per cent of TFEC (World Bank, 2015). Renewable sources contributed 89.8 per cent of the share of electricity capacity and 99.9 per cent of the electricity generated in 2012 (World Bank, 2015).

Table 4: Mozambique's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	6	7	15	20.2		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	4	3.80		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	93.1	92.5	89.6	88.4		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			2.3	2.3 (2011)		2.54 (2013)
	Level of primary energy intensity(MJ/$2005 PPP)	42.1		19.5	17.9	18.9	17.91

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
20.2%	3.8%	2.62	88.44%

Table 5: Mozambique's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Implement National Climate Change Adaptation and Mitigation Strategy (NCCAMS) (2013 to 2030)
*Implement the Energy Strategy (which needs to be updated and approved by 2016)
*Implement Biofuel Policy and Strategy
*Implement New and Renewable Energy Development Strategy (2011 to 2025)
*Adopt Conservation and Sustainable Use of the Energy from Biomass Energy Strategy (2014 to 2025)
*Adopt the Master Plan for Natural Gas (2014 to 2030)
*Implement Renewable Energy Feed-in Tariff Regulation (REFIT)
*Implement the Mozambique's Integrated Urban Solid Waste Management Strategy (2013 – 2025)
*Create and launch the Renewable Energy Atlas for Mozambique
*Build and manage two solid waste landfills for the recovery of methane
*Implement the Project of Urban Mobility in the Municipality of Maputo

Source: (MEM, 2015)

Table 6: Mozambique's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Energy
Fundo Nacional de Energia (FUNAE) 1997 for rural electrification	
National Directorate of New and Renewable Energy (DNEE)	
Presence of a Functional Energy Regulator	National Energy Council (CNELEC) 2004
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	Electricidade de Mocambique (EDM)
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Southern Africa Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Empresa Nacional de Hidrocarbonetos de Mocambique (ENH)
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	National Directorate of Fuel (Direcção Nacional de Combustíveis)
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	Hidroelectrica de Cahora Bassa (HCB) (but government owns 82 per cent of it)
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Policy (1998) • Energy Sector Strategy (2000) • Electricity Master Plan for Development of the National Grid 2005-2019
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Ministerial Law No. 20/97, which is the Organic Act for the National Directorate for Electrical Energy (DNEE) • Electricity Law (No. 21/97)

This table was compiled with material from (REEEP, 2012) and (Hivos and Practical Action, Undated)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Mozambique is vulnerable to the impacts of climate change and is already been subject to significant natural disasters. For example, it is estimated that the impacts of natural disasters between 1980 and 2003 cost about US$1.74 billion (ROM, 2015). The government aims to increase community and economic resilience to climate risks and promote low-carbon development and a green economy. To that end, the government formulated its Intended Nationally Determined Contributions (INDC). Those related to energy are listed in Table 5.

Institutional and Legal Framework

The Ministry of Energy is in charge of energy sector policy issues while the National Directorate for Electrical Energy (DNEE) is in charge of technical issues. The energy regulator is the National Electricity Council (CNELEC) created in 2004. The *Electricidade de Mocambique* (EDM) is the sole generator, transmitter and distributor of electric energy. On a regional level, the country is a member of Southern Africa Power Pool. The legal framework is provided by the Electricity Law (No. 21/97). The main sector policy is the Energy Policy (1998), which is clear on the need for energy security and efficiency (Table 6).

Namibia

Figure 1: Energy profile of Namibia

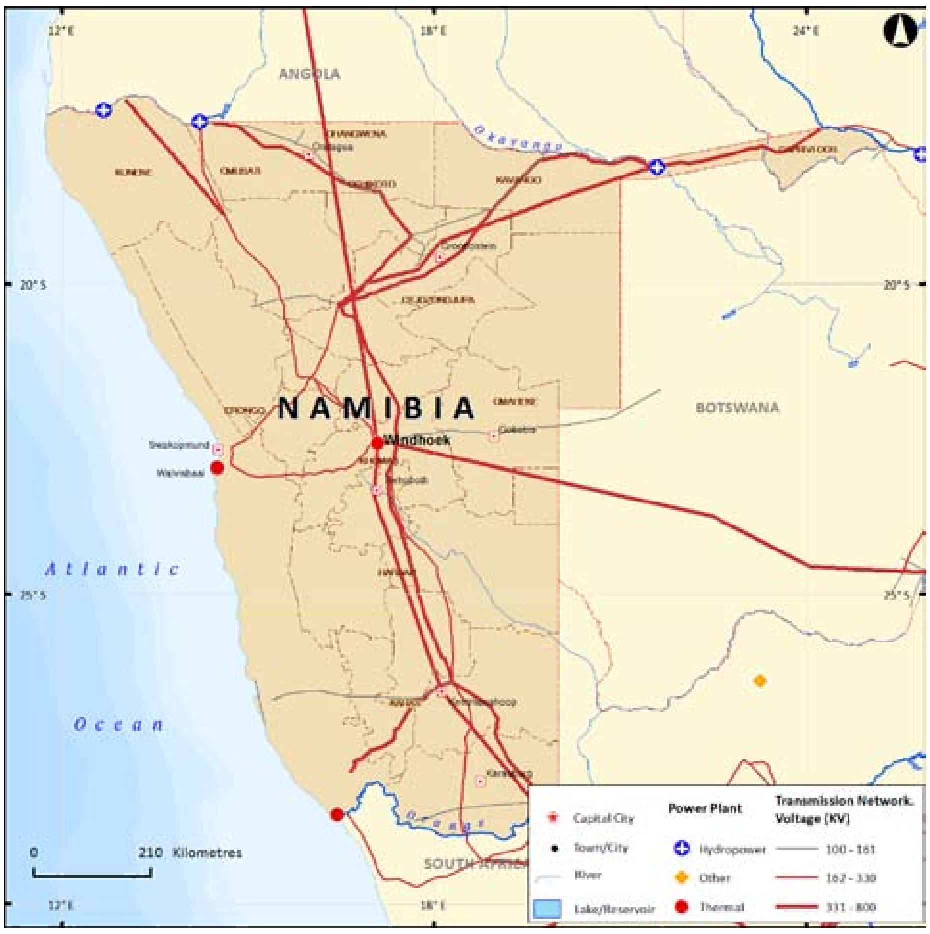
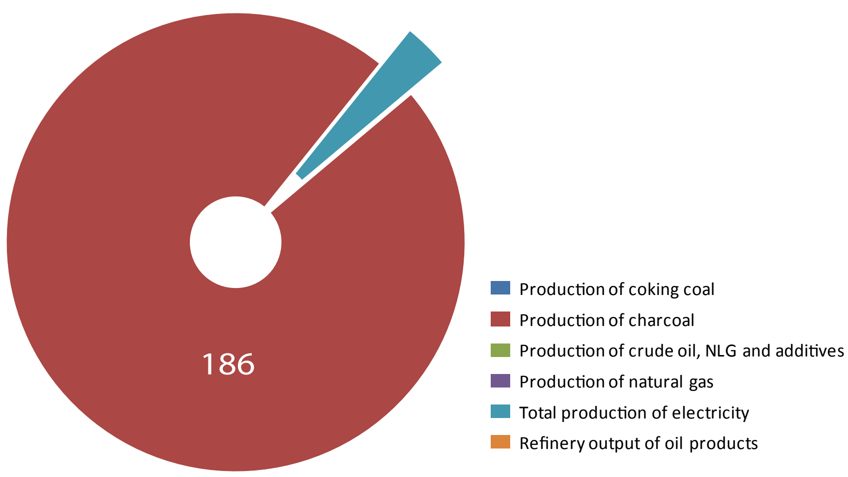
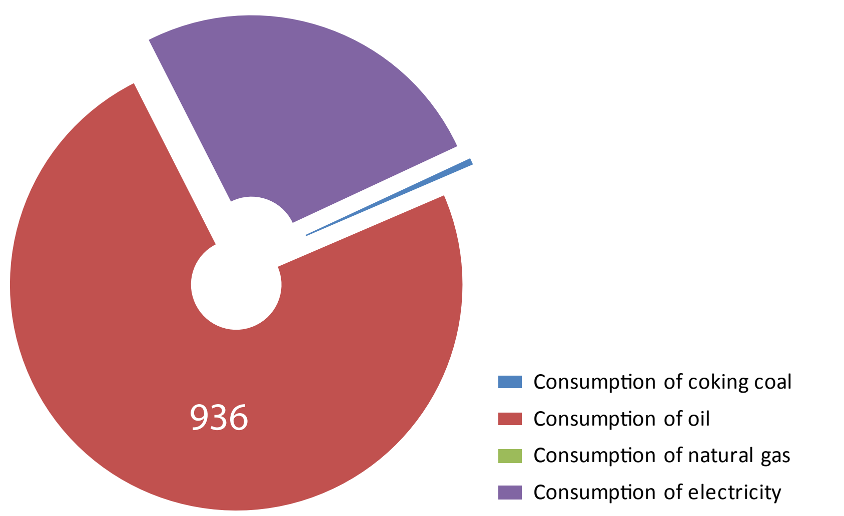


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Namibia had a population of 2.3 million (Table 1). In 2014, total production of electricity was 132 ktoe of which 93.9 per cent came from hydro sources. Final electricity consumption in 2014 was 320 ktoe increasing to 323 ktoe in 2015 as shown in Table 2 (AFREC, 2015). Figures 2 and 3 show the key energy statistics for the country.

Table 1: Namibia's key indicators

Key indicators	Amount
Population (million)	2.30
GDP (billion 2005 USD)	10.52
CO_2 emission (Mt of CO_2)	3.43

Source: (World Bank, 2015)

Energy Resources

Biomass

Biomass energy is not a major part of the energy mix in Namibia (IEA, 2014). Environmental change in the Namibian landscape is providing opportunity for biomass energy generation from the so-called invader bush. Over 26 million hectares have been encroached upon by unwanted woody species effectively taking land out of cultivation and pasture and impacting livelihoods (REEEP, 2014). Utilizing the woody biomass for energy was devised as a means of upscaling the debushing of the infested land. The literature indicates that the affected land could generate about 1,100 TWh of electricity with regrowth thought to provide sustainable feedstock (REEEP, 2014). Nampower, the public utility, is exploring PPP models to finance several of these decentralised bush-to-electricity projects. Other plants that could provide biofuel include jatropha which was identified in the Namibian National Bio-Oil Energy Roadmap.

Hydropower

A vibrant hydropower sector depends on an abundant supply of running water and plentiful rainfall to sustain the resource. Namibia is very dry and has only two permanent rivers — the Kunene and Orange rivers on its northern and southern borders respectively, both draining into the Atlantic. But the fact that they are shared resources means that any efforts to develop

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	121	152	180	186
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	1
Production of electricity from fossil fuels	3	4	5	4
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	119	143	106	126
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	122	147	111	6
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	2	11	18	6
Final consumption of oil	573	837	897	936
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	205	248	289	323
Consumption of oil in industry	60	76	89	95
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	48	0	69	67
Consumption of coking coal in industry	0	0	0	0
Consumption of oil in transport	365	529	499	512
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	2	2	18	5
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	580	844	976	1 004
Net imports of natural gas	-	-	-	-
Net imports of electricity	106	128	194	205

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

their hydropower potential are subject to lengthy bilateral negotiations. According to the World Energy Council (WEC, 2013), the hydropower potential of Namibia is unknown. Namibia's main source of electricity generation is the 330 MW Ruacana Hydroelectric Power Station (Leskela, 2012). In 2015, about 125 ktoe of electricity from hydro was produced (AFREC, 2015). Other projects in the pipeline include the Epupa dam, the Baynes hydro project and various small hydro (REEEP, 2014).

Oil and natural gas

The proven recoverable reserve of natural gas at the end of 2011 was 62.3 bcm (2,199.8 bcf) (WEC, 2013). It is thought that there is some offshore potential as well. Natural gas has not been well developed because of a lack of gas production and transport infrastructure, but this may change going forward (WEC, 2013).

Peat

There are 10 km^2 of peatland (WEC, 2013).

Wind

Namibia has huge wind resources with Lüderitz and Walvis Bay with wind speeds of 7 m/s or higher (REEEP, 2014). The SAPP has estimated the Namibian potential for wind at 27.201 MW and 36 TWh per year with a relative land use of 824,268 km^2. According to REEEP (2014), there is one 22 kW wind turbine feeding into the grid in Erongo Region.

Nuclear

Uranium is mined in 20 countries and half the world's production of uranium comes from just six, of which Namibia is one. In sub-Saharan Africa, Namibia, Niger and South Africa are among the ten-largest uranium resource-holders in the world (WEC, 2013). Namibia provides 8.2 per cent of global production and the government is interested in including nuclear power in its energy mix. However, this will require large investments in terms of financial resources and the building of technical, regulatory and infrastructural capacity.

Geothermal

Although hot springs are present in Windhoek, Rehoboth and in Kunene region, there is no evidence that definitely points to geothermal potential in this country. More research is needed.

Solar

Namibia has an excellent solar potential since the average high direct insolation is 2,200 kWh/m^2/yr (REEEP, 2014). The areas with the highest potential are in the northern and southern parts of the country and also in the west. Solar in Namibia is primarily used for water pumping and for rural electrification to power radios, lighting, TVs and fans. IPPs are venturing into the sector. In 2015, there was no large commercial solar PV plant in Namibia (REEEP, 2014). Advances are being made in the sector, however. For instance, an Independent Power Producer (Innosun Energy Holdings) opened a 4.5 MW solar plant in Omaruru in 2015 and there are plans to build a concentrating solar thermal power plant by 2017 (Rämä, Pursiheimo, Lindroos, & Ko, 2013).

Tracking progress towards sustainable energy for all (SE4All)

Just under half of all Namibians have access to electricity. Household electrification in urban areas in 2012 was 94.1 per cent whereas for rural households it reached 14.6 per cent (Table 3 and Figure 4) (World Bank, 2016). Access to modern fuels is low with 14 per cent of rural Namibians and 83 per cent of those in urban areas using non-solid fuels (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the economy was 3.3 MJ per US dollar (2005 dollars at PPP) in 2012, down from 3.5 MJ per US dollar in 2010. The compound annual growth rate (CAGR) between 2010-2012 was -2.60 (World Bank, 2015).

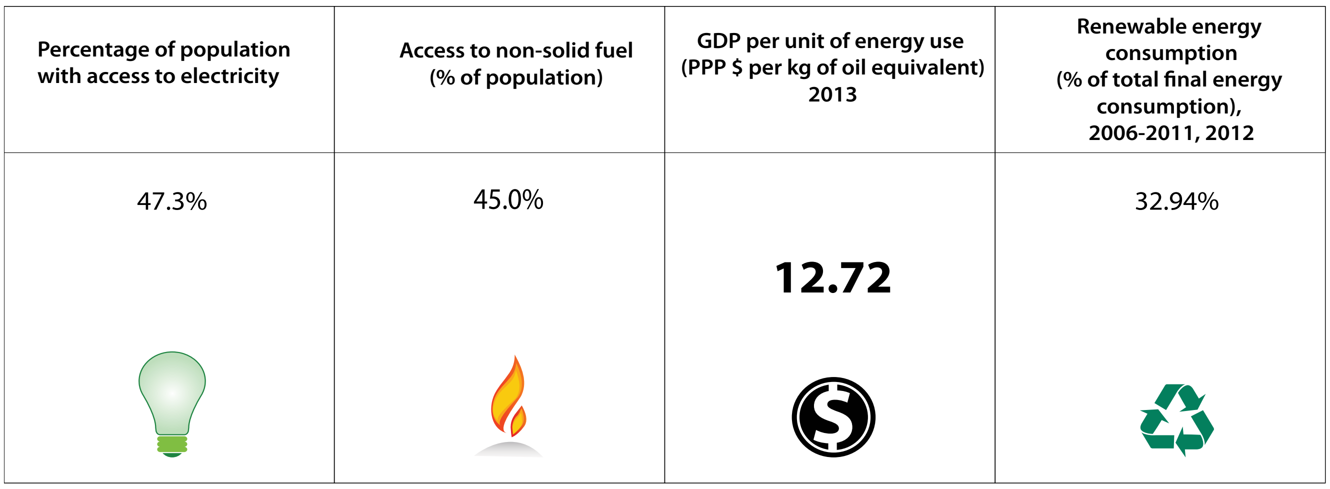
The share of renewable energy in the total final energy consumption (TFEC) increased slightly from 30.2 per cent in 2010 to 32.9 per cent in 2012. Traditional solid biofuels form the biggest share of renewable sources at 13.2 per cent of TFEC in 2012, while hydro contributed 19.6 per cent and solar only 0.1 per cent . Renewable sources contributed a 97.8 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Namibia's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	26	37	44	47.3		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	26	37	44	45		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	38.9	38.2	30.2	32.94		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			11.8	12.2 (2011)	12.32 (2013)	
	Level of primary energy intensity(MJ/$2005 PPP)			3.5	3.3	3.32	3.27

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators



Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

By 2030, Namibia aims to have reduced its GHG emissions by about 89 per cent compared to the BAU scenario (RON, 2015). Some of the activities will involve the energy sector. Table 4 highlights the energy-related Intended Nationally Determined Contributions (INDCs).

Table 4: Namibia's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Increase share of renewable energy (hydro, solar, wind and biomass) in electricity production from 33 per cent in 2010 to about 70 per cent in 2030.
*Implement an energy efficiency programme to reduce consumption by about 10 per cent in 2030.
*Commission a mass transport system in the city of Windhoek to reduce the number of cars (taxis and private) by about 40 per cent.
*Implement a car pooling system to reduce fossil fuel consumption.
*Improve freight transportation through bulking to reduce the number of light load vehicles by about 20 per cent.
These measures are expected to result in a reduction of some 1,300 Gg CO_2-eq.
*Increase share of renewables in electricity production from 33 per cent to 70 per cent. GHG amount = 740; per cent BAU scenario in 2030 = 3.3.
*Increase energy efficiency and demand side management (DSM). GHG amount = 51; per cent BAU scenario in 2030 = 0.2.
*Mass transport in Windhoek, car and freight pooling. GHG amount = 510; per cent BAU scenario in 2030 = 2.3.

Source: (MEM, 2015)

Table 5: Namibia's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• National Petroleum Corporation of Namibia (NAMCOR) • Renewable Energy and Energy Efficiency Institute (REEEI) • National Planning Commission (NPC).
Presence of a Functional Energy Regulator	Electricity Control Board (ECB)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Southern Africa Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	NamPower, the national electricity utility, is a state-owned company with a mandate to generate, trade, transmit, import, export and distribute electricity.
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	National Petroleum Corporation of Namibia (NAMCOR)
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	Renewable Energy Feed in Tariff (REFIT) interim program
Presence Functional IPPs and their contribution	NNOSUN-OMBURU SOLAR PV PLANT (4.5 MW)
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Policy, Regulatory Framework and Energy Future of Namibia 2011 to 2013 • White Paper on Energy Policy of 1998
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Electricity Act 2 of 2000 • Electricity Act, 4 of 2007

This table was compiled with material from (REEEP, 2014) and (Rämä, Pursiheimo, Lindroos, & Ko, 2013)

Institutional and Legal Framework

The Ministry of Mines and Energy is in charge of the energy sector (Table 5). The energy regulator is the Electricity Control Board. Nampower has the mandate to generate, trade, transmit, import, export and distribute electricity. On a regional level, Namibia is a member of Southern Africa Power Pool. The main sector policy is the 1998 White Paper on Energy Policy. The legal framework is provided by the Electricity Act of 2002.

Taken near Ruacana-Dam, Namibia

Niger

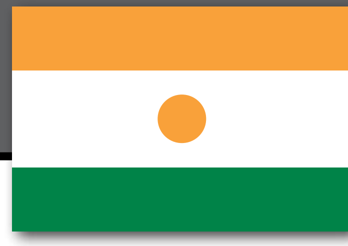


Figure 1: Energy profile of Niger

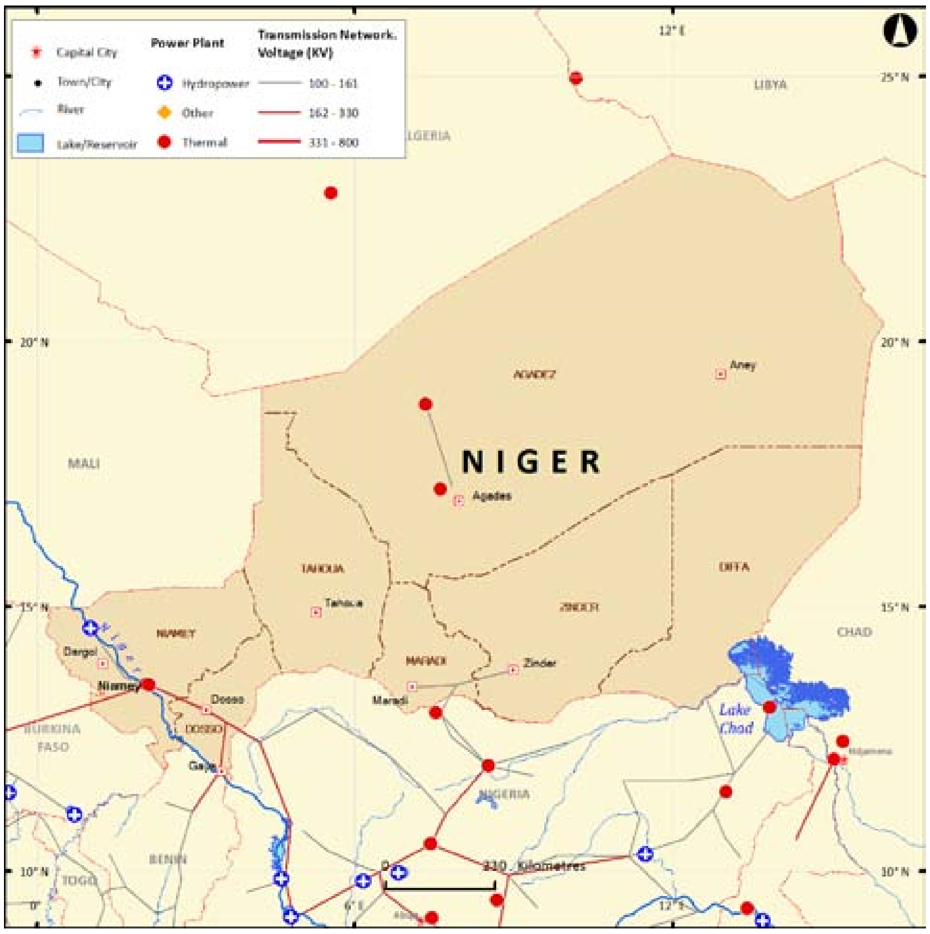
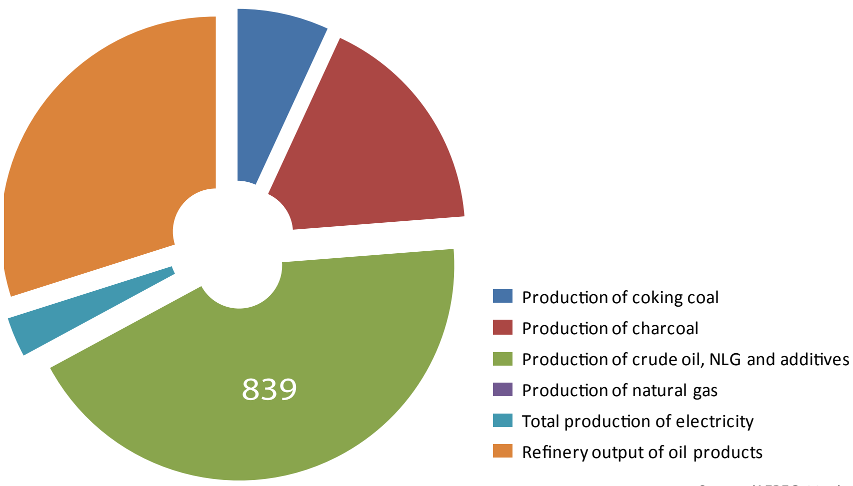
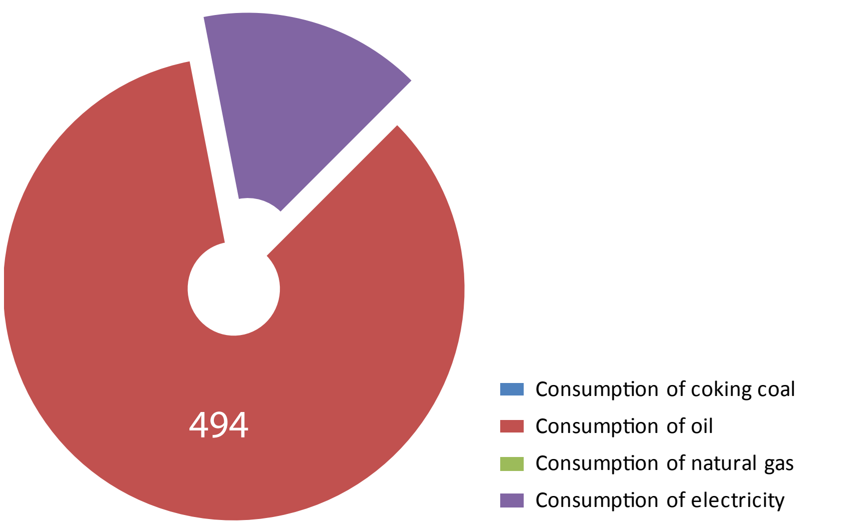


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

As shown in Table 1, Niger had a population of 17.83 million in 2013. In 2015, total production of electricity was 58 ktoe, with all of it produced from fossil fuels (Table 2). Final consumption of electricity in the same year was 91 ktoe (AFREC, 2015). Figures 2 and 3 show the main energy statistics

Table 1: Niger's key indicators

Key indicators	Amount
Population (million)	17.83
GDP (billion 2005 USD)	5.18
CO_2 emission (Mt of CO_2)	1.85

Source: (World Bank, 2015)

Energy Resources

Biomass

There is huge potential for harnessing energy from biomass in this country. It is estimated that the current forest stock stands at about 9.9 million ha and there is also potential from agricultural (crop and animal) waste. Biogas is only at the experimental stage (REEEP, 2012).

Hydropower

The Niger River has about 270 MW of undeveloped hydroelectric potential. Current projects include the 125 MW Kandadji project, 200 km upstream from Niamey, the capital, as well as two smaller dams at Gambou (122 MW) and Dyodyonga (26 MW). Small hydroelectric sites in the country have the potential to produce nearly 8 GWh per year, most notably Sirba and Gouroub Dargol (REEEP, 2012).

Oil

There have been recent discoveries of oil and gas. Oil production started in 2011 in a joint venture with the Chinese National Petroleum Corporation (CNPC). A new refinery with a 20,000 bbl/day capacity has also been built (IRENA, 2013).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	81	93	126	133
Production of charcoal	210	232	316	327
Production of crude oil, NLG and additives	0	0	0	839
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	18	20	21	58
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	-
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	18	20	21	58
Refinery output of oil products	0	0	0	579
Final Consumption of coking coal	0	103	101	0
Final consumption of oil	153	175	257	494
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	28	37	72	91
Consumption of oil in industry	13	19	50	97
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	12	15	14	21
Consumption of coking coal in industry	0	0	0	0
Consumption of oil in transport	125	139	221	347
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	0	0	0	0
Net imports of crude oil, NGL, Etc.	0	0	0	0
Net imports of oil product	178	194	306	-55
Net imports of natural gas	-	-	-	-
Net imports of electricity	18	29	56	55

\- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Wind

In the north, average wind speeds of 5 m/s have been measured, tapering off to about 2.5 m/s in the south. These figures indicate a moderate potential for wind energy exploitation. Currently, about 30 small-scale installations are used for water pumping purposes (REEEP, 2012).

Nuclear

Uranium is mined in 20 countries and half the world's production of uranium comes from just six countries, of which Niger is one. In sub-Saharan Africa, Namibia, Niger and South Africa are among the ten-largest uranium resource-holders in the world (WEC, 2013). Niger provides 7.7 per cent of global production.

Geothermal

Although many geological studies have been undertaken for oil in this country, so far none has been done to assess the geothermal potential (REEEP, 2012). .

Solar

Niger receives between 7 and 10 hours of sunshine per day with an average solar energy potential of 5-7 kWh/m^2/day. In the 1960s, Niger was one of the first countries in the world to consider renewable energy technologies to solve its energy needs. It set up the National Solar Energy Centre (*Centre National d'Énergie Solaire* – CNES), which was originally founded to undertake applied research in various aspects of renewable energies.

Tracking progress towards sustainable energy for all (SE4All)

By 2012, only 14 per cent of Niger was electrified (Table 3 and Figure 4) (World Bank, 2016). In urban areas, 62 per cent of people had access to electricity but in rural areas, only 5 per cent . National access to non-solid fuels in 2012 was only 3 per cent . Disaggregated by location, it was 2 per cent in rural areas and 7 per cent in urban areas (World Bank, 2015).

Niger's energy intensity increased at a compound annual growth rate (CAGR) of -2.60 per cent over the 20 years between 1990 and 2010 and at 0.60 per cent CAGR from 2010 to 2012. Between 2010 and 2012, the Niger economy's energy intensity (the ratio of the quantity of energy consumption per unit of economic output) increased from 6.2 MJ to 6.3 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

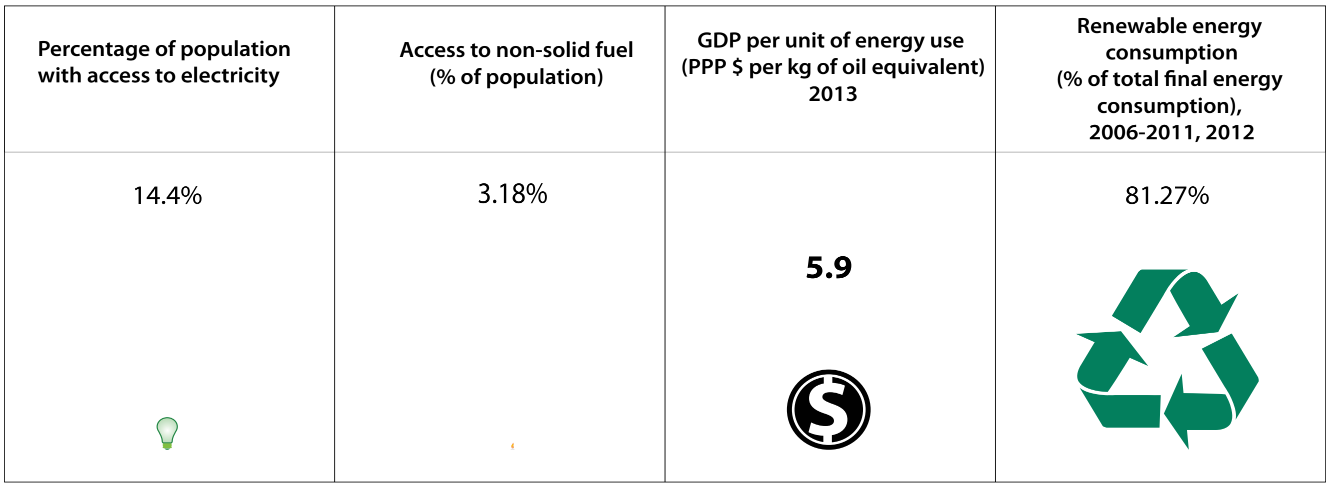
The share of renewable energy in total final energy consumption (TFEC) decreased from 91.6 to 83.54 per cent between 1990 and 2012. In 2012, traditional solid biofuels formed the biggest share of renewable sources at 78.0 per cent, followed by modern biofuels at 1.7 per cent of TFEC (World Bank, 2015).

Table 3: Niger's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	6	7	9	14		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	3	3		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	86.8	93.9	73.7	79.7		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)				5.7 (2013)		
	Level of primary energy intensity(MJ/$2005 PPP)	10.6		6.2	6.3		

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators



Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

The country has committed to implementing activities to reduce emissions and contribute to controlling climate change. The Intended Nationally Determined Contributions (INDC) related to energy were prepared in October 2015 and are listed in Table 4.

Table 4: Niger's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Implement the management of residential sub-sector through rural electrification and the conservation and replacement of wood energy.
*Implement a management plan of the transportation and residential sub-sectors, and promote rural electrification.
*Adopt plans for wood energy saving and reduction of specific consumption in transportation.
*Implement a management plan for the sector concerned with the demand for, transformation and dissemination of renewable energies; improve the energy efficiency of the sectors.
*Promote solar photovoltaic for pumping and electrification.
Conditional technologies
*Exploit solar photovoltaic and thermal energy and wind energy sources.
*Build a nuclear power plant and a gas power plant and develop hydroelectricity programme.
* Save wood use in cooking, adopt energy efficiency programme, promote the use of biogas, and promote the construction of frame-free buildings.

Source: (MEM, 2015)

Table 5: Niger's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Energy and Petroleum
Presence of a Functional Energy Regulator	Autorité de Régulation Multisectorielle (ARM) the Multi-Sector Regulatory Authority,
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	• Chinese National Petroleum Corporation (CNPC) • Société de Raffinage de Zinder (SORAZ) or Zinder Refining Company established in 2010, refines crude oil produced in Niger
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Société nigérienne des produits pétroliers (SONIDEP), Tamoil, Mobil and Total Société nigérienne des hydrocarbures (SONIHY) and the Niger gas companies NIGERGAZ and SONIGAZ import gas
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Policy Statement 2004
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Act 98-017 establishing National Centre for Solar Energy in 1998 • Electricity Code was enshrined into law through Decree no. 2003-2004

This table was compiled with material from (REEEP, 2012) and (IRENA, 2013)

Institutional and Legal Framework

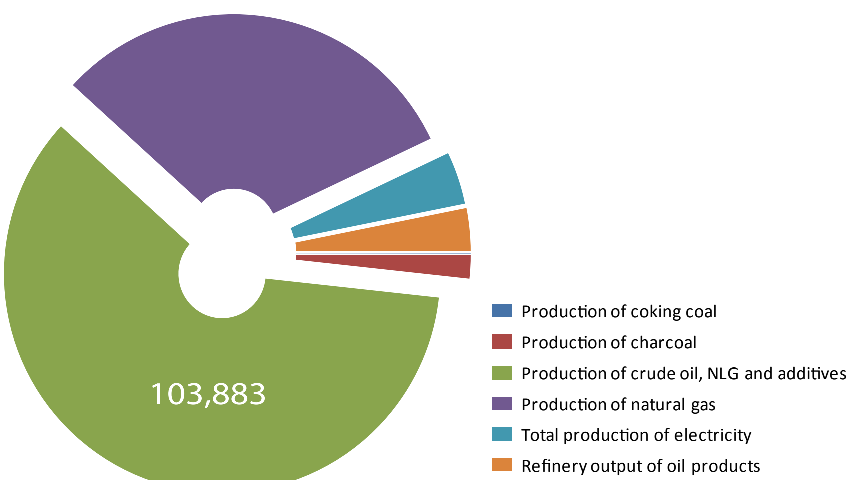
The Ministry of Energy and Petroleum is in charge of the energy sector. The *Société Nigérienne d'Electricité* (NIGELEC) is responsible for electricity production, transmission and distribution. The sector regulator is the Autorité de Régulation Multisectorielle (ARM) (Table 5). On a regional level, Niger is a member of the West African Power Pool. The legal framework is provided by the Electricity Act of 1939 (amended in 1991).

Niger relies heavily on imported electricity from Nigeria. Challenges in Nigeria coupled with growing energy demand in Niger is leading to frequent shortages and blackouts, limiting socioeconomic growth. Niger aims to diversify its energy supply base, particularly focusing on renewable energy resources. The 2004 Energy Policy Statement has been strengthened by other strategies including the National Renewable Energies Strategy, National Strategy for Access to Modern Energy Services, National Strategy for Domestic Energies and the Strategy for Rural Development; all aim to enhance renewable energy while protecting the environment.

Nigeria

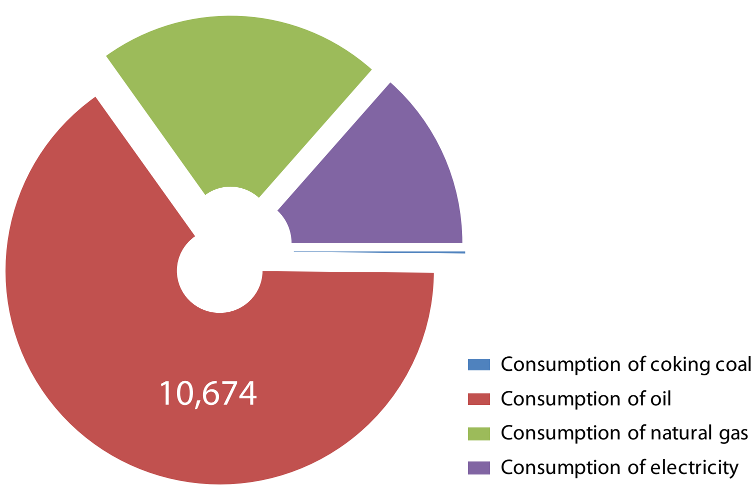
Figure 1: Energy profile of Nigeria

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Nigeria had a population of 174 million (Table 1). In 2015, total electricity produced was 6,738 ktoe, of which 91.5 per cent came from fossil fuels and 8.3 per cent from hydro sources. Final electricity consumed was 2,218 ktoe (AFREC, 2015) as shown in Table 2. Figures 2 and 3 highlight the key energy statistics.

Table 1: Nigeria's key indicators

Key indicators	Amount
Population (million)	174
GDP (billion 2005 USD)	183.31
CO_2 emission (Mt of CO_2)	61.00

Source: (World Bank, 2015)

Energy Resources

Biomass

Worldwide, Nigeria is the third largest producer of bioenergy, after China and India, respectively. In 2010, the share of bioenergy of total primary energy supply was over 80 per cent (WEC, 2013). In 2011, Nigeria was among the largest woodfuel producers, along with India, China, Brazil and Ethiopia.

Oil and natural gas

Nigeria's proven recoverable reserves at the end of 2011 was 37,200 million barrels while oil production at the end of the same period was 881,066 thousand barrels (WEC, 2013). It has ail reserves of about 35 billion barrels (5.6×109 m^3) and gas reserves of about 5 trillion cubic metres, ranking it 10th and 9th in the world, respectively.

Nigeria has the second largest proven oil reserves in Africa, after those of Libya. The oil fields are located in the south, specifically in the Niger delta and offshore in the Gulf of Guinea. Current exploration activities are mostly focused in the deep and ultra-deep offshore, with some activities in the Chad basin, located in the northeast of the country. Nigeria has been a member of OPEC since 1971. Most of the oil is exported to North America and Western Europe and the bulk of the refined product requirements are imported.

Security is an issue in this sector and is curtailing oil exploration projects. For instance, in 2011, only three exploratory wells were drilled compared with more than 20 in 2005. This has affected the government's expected ability to increase proven oil reserves to 40 billion barrels over the next few years.

Nigeria (and Algeria) are the main gas producers in Africa and production is expected to double between now and 2030, increasing to about 400 bcm per annum. Proved recoverable reserves of natural gas in Nigeria at the end of 2011 were 5,110 bcm; current production, at 29 bcm, is estimated to last more than 100 years (WEC, 2013). Gas in Nigeria is supplied to industrial users in and around Lagos. The Escravos pipeline is the main conduit through which gas originating in the Niger Delta passes as it is supplied to a variety of industrial users in and around the Lagos region. Other major industrial clients use this gas in captive power plants, such as Guinness's Ogba and Benin breweries.

Nigeria had an estimated 180 trillion cubic feet (Tcf) of proved natural gas reserves at the end of 2011, according to the OGJ, making Nigeria's the world's ninth largest natural gas reserve.

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	2	5	19	25
Production of charcoal	896	1,559	2,228	2,975
Production of crude oil, NLG and additives	107,708	120,930	121,377	103,883
Production of natural gas	11,733	19,963	29,863	53,830
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	782	1,340	1,698	6,169
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	484	684	543	562
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	8
Total production of electricity	1,266	2,024	2,240	6,738
Refinery output of oil products	4,668	9,020	5,083	5,496
Final Consumption of coking coal	31	4	19	25
Final consumption of oil	9,849	11,147	11,387	10,674
Final consumption of natural gas	1,077	3,126	1,346	3,512
Final consumption of electricity	783	1,539	1,859	2,218
Consumption of oil in industry	705	551	341	424
Consumption of natural gas in industry	1,117	1,452	1,346	3,502
Consumption of electricity in industry	164	192	298	366
Consumption of coking coal in industry	7	4	19	25
Consumption of oil in transport	7,198	8,809	886	8,555
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	0	0	0	0
Net imports of crude oil, NGL, Etc.	-103,151	-111,422	-109,292	-104,343
Net imports of oil product	6,885	4,424	8,312	7,766
Net imports of natural gas	-5,094	-11,337	19,728	-22,771
Net imports of electricity	-2	0	0	0

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

Table 3: Nigeria's coal reserves and production (million tonnes)

Country	Coal reserves	Production
Nigeria	190	
Rest of region	357	2
Africa total	31,617	255.4

Source: (GWEC, Various years)

Coal

By the end of 2011, Nigeria had 21 million tonnes of proved recoverable bituminous coal reserves, including anthracite (Table 3) (WEC, 2013). It is among the top 5 countries in Africa, by reserves. The others are South Africa, Zimbabwe, Mozambique and Tanzania.

Wind

Wind is not a major source of energy in Nigeria. In 2011, Nigeria had only 2 MW of installed capacity (WEC, 2013).

Nuclear

Nigeria plans to have about 1,000 MWe of nuclear power installed by 2017 and 4,000 MWe by 2027. In 2009, cooperation agreements were signed with Russia on the peaceful use of nuclear energy, including the construction of nuclear power plants (WEC, 2013). Two sites have been proposed to host 4,000 MW nuclear power projects: Geregu in Kogi State and Itu in Akwa Ibom State (ECN, 2012). The Nigerian Atomic Energy Commission (NAEC) is to conduct standard surveys, including Environmental Impact Assessments (EIA), detailed evaluations and characterization. In addition, the government will enact a comprehensive nuclear law, create an independent nuclear power regulatory body with clear authority and functions separated from promotional bodies and functions and ensure waste and fuel-cycle management. A draft strategy for the safe and sustainable management of radioactive waste and spent nuclear fuel has also been prepared. It includes an option for use when repatriation of spent fuel is not possible (ECN, 2012).

Geothermal

The literature indicates that more studies are necessary, but current indications point to the potential for geothermal energy (Zira, 2013). The normal geothermal gradient of the earth is between 2-30c/100m and a geothermal gradient above this range is considered to be a good site for geothermal systems. According to research findings, the geothermal gradient in the Niger Delta ranges from 1.3 to 5.50c/100m. The geothermal gradient of the Anambra Basin ranges from 2.5 to 4.90c /100m (Avbovbo, 1978 in (Zira, 2013)). A similar study of the geothermal gradient of the Bida Basin shows that it ranges from 2 to 2.50c/100m. The Borno Basin temperature gradient ranges from 1.1 to 5.90c/100m. Finally, a study on the Sokoto Basin has revealed that its geothermal gradient ranges from 0.9 to 7.60c/100m (Ewa and Schoeneich, 2010 in (Zira, 2013). Areas of geothermal anomalies with gradients above 5°C/100m are likely to be potential areas for prospecting. There are also hot and warm springs, which occur in Akiri in Benue State, Wikki in Yankari Game Reserve in Bauchi State and Ruwan Zafi in Adamawa State located in Lamurde, for example.

Solar

Nigeria is in the process of engaging with the private sector to set up renewable energy projects, especially in the field of solar energy. For example, discussions are taking place to set up a total of 1 GW solar power capacity across the country. Nigeria has signed agreements with three companies: Solius NGPC, Peoples Home Association and Solar Force Nigeria Limited. They will include large utility-scale power projects and distributed power projects. Nigeria is estimated to have 20 MW of solar energy installed (REN21, 2014).

Tracking progress towards sustainable energy for all (SE4All)

Some 75 million people in Nigeria, mostly in rural areas, have no access to electricity (Table 4 and Figure 4). By 2012, 34.4 per cent of the rural population had access to electricity, compared with 83.6 per cent in urban areas. Only a quarter of the population (24.85 per cent) or about 127 million people have access to modern fuels and there are disparities between rural and urban access: only 11 per cent in rural areas and 55 per cent in urban areas (World Bank, 2016); (World Bank, 2015).

The Nigerian economy energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 6.3 MJ per US dollar (2005 dollars at PPP) in 2012, down from 9.6 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010 and 2012 was 0.95 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) has been almost constant since the 1990s at around 88 per cent . Traditional solid biofuels form the biggest share of renewable sources at 77.1 per cent of TFEC in 2012, while the modern solid biofuels contributed 9 per cent and hydro only 0.4 per cent . Renewable sources contributed a 19.7 per cent share of electricity generation in 2012.

Table 4: Nigeria's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 per cent of population with access to electricity	42	45	48	55.6		
	7.1.2 per cent of population with primary reliance on non-solid fuels	23	26	25	25		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	88.4	86.9	88.8	88.5		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			7.1	7.2 (2011)		
	Level of primary energy intensity(MJ/$2005 PPP)	9.6		6.2	6.3	6.20	6.27

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
55.6%	24.85%	7.28	86.47%

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Nigeria's Intended Nationally Determined Contributions (INDCs) aim to ensure economic and social development by growing the economy at 5 per cent a year, improving the standard of living and ensuring access to electricity for all (FRON, 2015). Table 5 shows the energy-related INDCs.

Table 5: Nigeria's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
* Work towards ending gas flaring by 2030.
* Work towards off - grid solar PV of 13GW (13,000 MW) .
* Promote the use of efficient gas generators.
* Increase energy efficiency by 2 per cent per year (30 per cent by 2030).
* Promote transport shift from private cars to public buses.
* Improve and modernize electricity grid.
*Implement economy-wide energy efficiency.
*Build efficient gas power stations.
*Work toward ending of gas flaring.
*Adopt and disseminate a climate smart agriculture.
*Reduce transmission losses.
*Promote use of renewable energy.
*Improve energy efficiency by 20 percent, generate 13 GW of renewable electricity provided to rural communities currently off-grid, and end gas flaring.

Source: (MEM, 2015)

Table 6: Nigeria's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Federal Ministry of Power (FMOP) • Department of Petroleum Resources within the Ministry of Petroleum Resources. • Energy Commission of Nigeria (ECN) was established in 1989 • Rural Electrification Agency (REA) established by the EPSR Act (2005) • Presidential Taskforce on Power (PTFP) established in 2010 • Nigerian Nuclear Regulatory Authority (NNRA), 1995
Presence of a Functional Energy Regulator	Nigerian Electricity Regulatory Commission (NERC), 2005
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	Nigerian National Petroleum Corporation (NNPC), 1977, is an integrated Oil and Gas company
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West African Power Pool (WAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Unbundled – 17 unbundled business units under the Power Holding Company of Nigeria (PHCN): • Distribution (11 companies): Abuja Electricity Distribution Company plc , Benin Electricity Distribution Company plc, Eko Electricity Distribution Company plc, Enugu Electricity Distribution Company plc, Ibadan Electricity Distribution Company plc, Ikeja Electricity Distribution Company plc, Jos Electricity Distribution Company plc, Kano Electricity Distribution Company plc, Kaduna Electricity Distribution Company plc, Port Harcourt Electricity Distribution Company plc, and Yola Electricity Distribution Company plc • Generation (6 companies): Afam Power plc, Egbin Power plc, Kainji Hydro-Electric plc, Sapele Power plc, Shiroro Hydro-Electric plc, and Ughelli Power plc • Transmission (1 company): Transmission Company of Nigeria
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	Three large-scale IPPs produce approximately 25 per cent of Nigeria's electric power
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Electric Power Policy (NEPP), 2001 • National Integrated Power Project (NIPP) – established in 2004 • Energizing Access to Sustainable Energy (EASE) • Roadmap for Power Sector Reform (RPSR), 2013
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Electric Power Sector Reform Act (EPSR), 2005 (Act No. 6 of 2005) • Energy Commission of Nigeria Act (Cap 109 LFN of 1990 • Nuclear Safety and Radiation Protection Act (1995) • Electricity Industry (Enforcement) Regulations (2014) • Draft Regulations for Investment in Electricity Networks in Nigeria (2014)

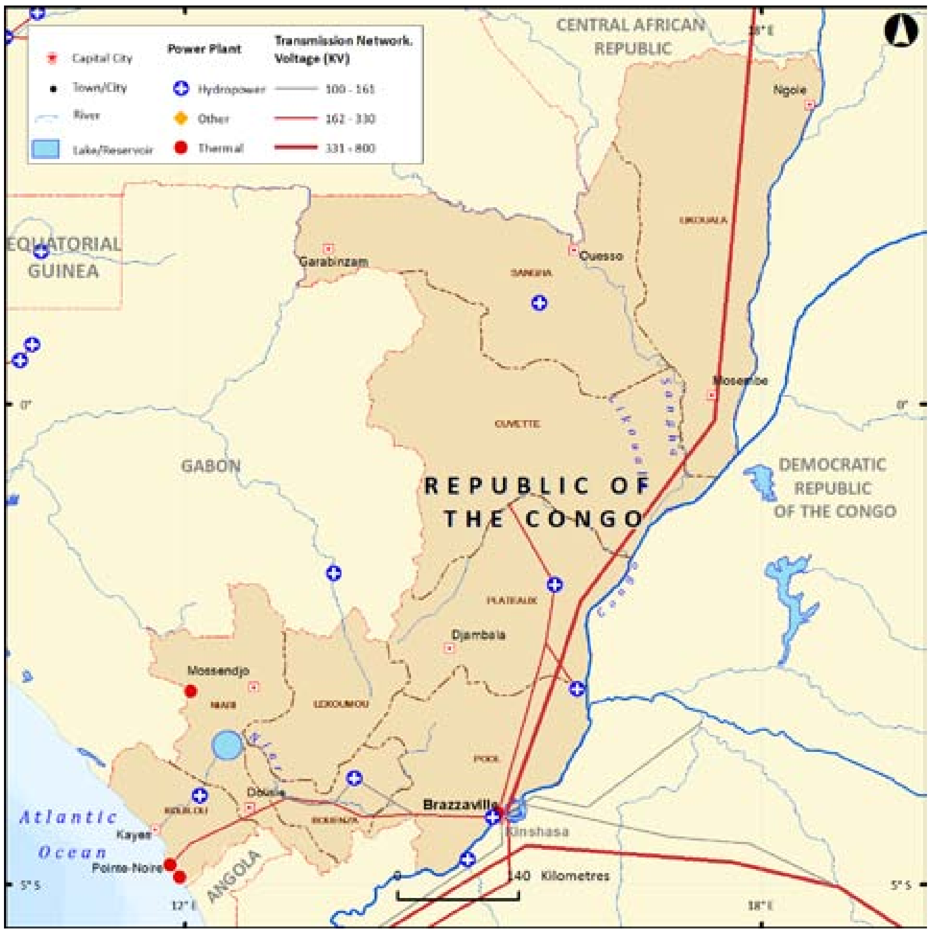
This table was compiled with material from (REEEP, 2014) and (Usman & Abbasoglu, 2014)

Institutional and Legal Framework

The Federal Ministry of Power (FMOP) is in charge of the energy sector. The energy regulator is the Nigerian Electricity Regulatory Commission (NERC) set up in 2005. Under the Power Holding Company of Nigeria (PHCN) there are 11 distribution, 6 generation and 1 transmission companies. They manage the electricity supply in each state or region of the country. At a regional level, the country is a member of the West African Power Pool. The legal framework is provided by the Electric Power Sector Reform Act (EPSR), 2005 (Act No. 6 of 2005). The main sector policy is the National Electric Power Policy (NEPP), 2001 (Table 6).

Republic of the Congo

Figure 1: Energy profile of the Republic of the Congo



Energy Consumption and Production

The Republic of the Congo had a population of 4.45 million people in 2013 (Table 1). In the same year, it produced a total of 14,977 ktoe of energy. The Republic of the Congo's primary energy supply was 14.98 Mtoe in 2013 (IEA, 2016). Industry consumed 2 per cent , transport 22.9 per cent and other sectors (residential, agriculture, commercial and other unspecified sectors), 50.7 per cent . Electric power consumption was 0.23 MWh per capita in 2013 (IEA, 2016).

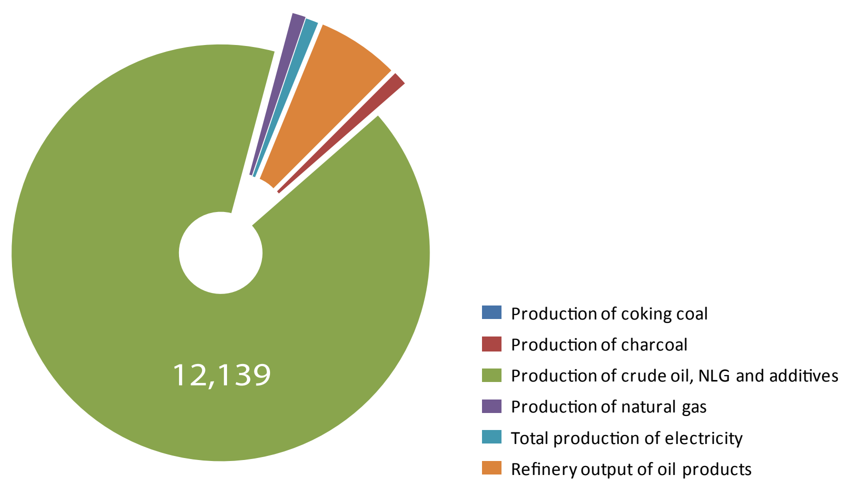
Electricity production in 2015 was 132 ktoe with 61 per cent from hydro and 38.6 per cent from fossil fuel sources (Table 2). Final electricity consumption in the same year was 127 ktoe with 21.2 per cent consumed by industry (AFREC, 2015). Key consumption and production statistics are shown in Figures 2 and 3.

Table 1: The Republic of the Congo's key indicators

Key indicators	Amount
Population (million)	4.45
GDP (billion 2005 USD)	8.72
CO_2 emission (Mt of CO_2)	2.34

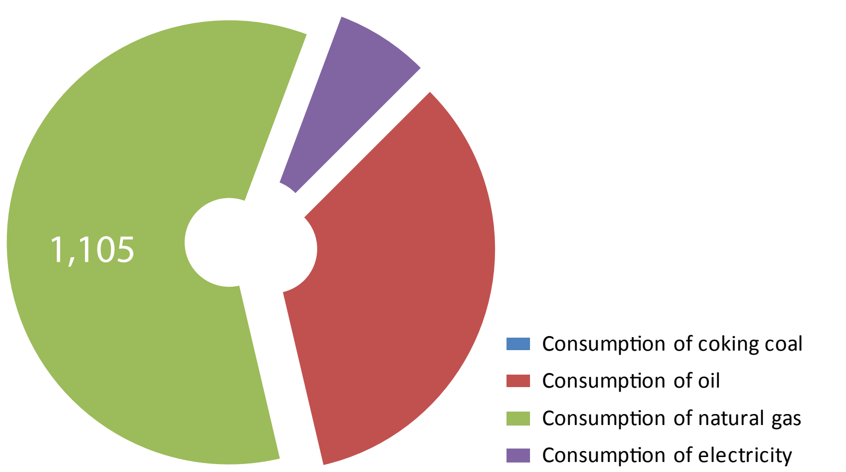
Source: (World Bank, 2015)

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Resources

Biomass

Wood and charcoal are the main sources of energy, mainly for cooking and especially in rural areas. Significant biomass energy potential exists in the country and there is much forestry for wood energy. Other potential exists in the form of palm oil for biodiesel. About 12 million acres of land with biomass potential for energy has been identified (REEEP, 2012).

Hydropower

Hydropower installed capacity in 2011 was 89 MW and accounted for 78 per cent of total net electricity generation (WEC, 2013). Although this country has huge potential for hydropower generation, estimated at 2,500 MW, less than 5 per cent has been developed. There are currently three hydroelectric dams: Imboulou (120 MW), Moukoukoulou (74 MW) and Djoué (15 MW). The government is looking for investors to participate in the planned Sounda Gorge dam, with an estimated capacity of 1,200 MW (REEEP, 2012).

Oil and natural gas

Up to 80 per cent of government revenues and 90 per cent of exports come from the oil sector. The proven recoverable reserves of oil at the end of 2011 were 1,600 million barrels, the 5th largest proven reserves in sub-Saharan Africa. Production figures at the end of the same time period were estimated at 111.4 million barrels (WEC, 2013). Congo is a mature oil producer, and recent offshore discoveries in 2008 boosted oil output. The country is currently the 7th largest oil producer in sub-Saharan Africa; it is expected to become the 3rd largest in Africa by 2017 when recent potential oil finds (the Moho Nord project) come on stream (Martin, Toothill, & Moussavou, Hunting the Pre-Salt, 2009).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	108	126	132	144
Production of crude oil, NLG and additives	12 757	11 294	14 264	12 139
Production of natural gas	0	50	94	138
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	0	6	31	51
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	26	31	37	81
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	26	37	67	132
Refinery output of oil products	399	431	657	847
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	213	311	522	630
Final consumption of natural gas	0	112	870	1 105
Final consumption of electricity	33	50	52	127
Consumption of oil in industry	16	12	34	56
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	12	23	21	27
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	156	281	452	534
Consumption of electricity in transport	0	0	0	0
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-12 047	-11 294	-13 428	-11 680
Net imports of oil product	-465	-488	-215	-147
Net imports of natural gas	0	0	0	0
Net imports of electricity	23	36	24	5

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Natural gas

The production of natural gas in 2011 was 90.6 bcm (WEC, 2013). Congo holds the 5th largest proven natural gas reserves in sub-Saharan Africa but lack of sufficient infrastructure has led to only 15 per cent being monetized. Sixty-eight per cent was reinjected to boost oil production and the remaining 17 per cent was flared or vented, since the costly infrastructure (pipelines, power plants and other infrastructure) are wanting. However, flaring has environmental concerns due to the emissions created and from the economic wastage of an energy resource. Two constructed gas-fired electric power stations have had the twin purpose of increasing the electricity capacity and reducing gas flaring — the Centrale Electrique du Congo (CEC), at 300 MW, and Centrale Électrique de Djeno (CED), with 50 MW (WEC, 2013).

Oil sands

Studies have indicated the possibility of large oil sands deposits. These are unusual petroleum deposits of bitumen also known as tar sands. Exploration is on-going. In the Congo Basin, there are two main tar sands bitumen deposits covering a combined area of about 1,800 km^2 with between 500 million and 2.5 billion bbl recoverable (TarSandsWorld, 2014). After Madagascar, Congo is the second country in Africa that may begin commercial production from oil sands before the decade ends.

Recent indications point to pre-salt oil deposits in shallow waters just off the coastline. The resources are estimated at 1.2 billion bbl of oil and about 1.0 trillion cu ft of gas (Koning, 2014).

Peat

The area of peat land is 6,220 square kilometres (WEC, 2013).

Wind

There are some areas in the north and south where wind speeds of between 5.5 to 6.0 m/s have been identified as possible locations for wind power generation (REEEP, 2012). But on the whole, wind energy technologies are in their infancy and the installed capacity is minimal.

Geothermal

Currently, no geothermal resources have been identified in the country, and no major studies into the potential resource have been conducted (REEEP, 2012).

Solar

Average insolation ranges between 2.0 and 3.0 kWh/m^2/day (REEEP, 2012). The potential for solar in Djiri is currently being explored by the *Programme National de Développement des Energies Nouvelles et Renouvelables* (ENR). However, exploitation of this resource will be hindered by the heavily forested nature of this country.

Tracking progress towards sustainable energy for all (SE4All)

The electricity sector is grossly inadequate with research from 2008 indicating that the existing infrastructure is insufficient to serve the growing population (Balkiabiya, 2008). This shortcoming affects transmission and distribution such that even by rehabilitating strategic infrastructure such as the Imboulou dam, problems still remain (Koua & Pr Yang, 2015). Since 2010, investment in gas-fired power stations has helped to increase electricity capacity in Point-Noire, but there is still a reliance on electricity imports from the neighbouring Democratic Republic of the Congo (DRC) to meet growing power demand in urban areas.

Despite the rich energy resources, less than half of the population of the Republic of the Congo has access to electricity; only 11.7 per cent of rural and 58.9 per cent of urban areas are electrified (World Bank, 2016) (Table 3 and Figure 4). This is due to a severe deficiency in electricity infrastructure as a result of the civil war. Until the distribution network is improved, biomass will remain the major fuel, especially in the countryside. Only a quarter of the population uses modern fuels. This figure is very low in the rural areas (5 per cent) but higher in urban areas (36 per cent) (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the economy was 2.9 MJ per US dollar (2005 dollars at PPP) in 2012, down only slightly from 2.6 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010 and 2012 was 2.29 (World Bank, 2015).

Table 3: The Republic of the Congo's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000		2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	24	21	37	41.6		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	3	15	23	24.83		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	66.7	72.7	50.6	48.19		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			15.1	14.2		
	Level of primary energy intensity(MJ/$2005 PPP)	2.6		2.8	2.9	-	-

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
41.6%	24.83%	**10.69**	48.19%

Magharebia / Foter / CC BY

Table 4: The Republic of the Congo's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
Increase the electricity share in its energy mix with a target of about 4,000 GWh of consumed electricity toward 2025 horizon.
Develop a solar electrification plan for remote villages (Congo Energy Strategy 2015-2025).

Source: (ROC, 2015)

jbdodane / Flickr.com / CC BY-NC 2.0

Eni Mboundi oil field, Republic of Congo

Table 5: The Republic of the Congo's Institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Mines, Energy, and Water Resources • Societe Nationale des Petroles du Congo (SNPC) • National Agency for Rural Electrification (ANER)
Presence of a Functional Energy Regulator	Regulatory Agency for the Electricity Sector (ARSEL)
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Central Africa Power Pool (CAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	State owned National Electricity Company (SNE)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	• Société Nationale des Pétroles du Congo (SNPC) • Gaz-Congo, Elf and Agi (LNG) • Eni
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Perenco, Murphy Oil, Africa O&G, Prestoil, Chevron, and SOCO Internationals.
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/ grid codes & oil codes (5 max or yes/no) most critical ones	• Law No 14-2003 of April 10, 2003 on the Electricity Code • Law No 17-2003 of April 10, 2003 creating the development funds for electricity sector (FDSEL) • Law No 16-2003 of April 10, 2003 creating the regulatory agency for electricity sector (ARSEL) • Law No 15-2003 of April 10, 2003 creating the National Agency for Rural Electrification (ANER); • Decree No 2010-241 of March 16, 2010 on the organization of the Ministry of Energy and Hydraulics

This table was compiled with material from (REEEP, 2012)

The Republic of the Congo also has extensive hydropower potential, but most of it remains untapped. The share of renewable energy in the total final energy consumption (TFEC) has been on the decline after a small spike to 72.7 per cent in 2000 before falling to just under 50 per cent in 2012.

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

By 2000, hydrocarbons represented almost a quarter of direct emissions, leaving much room for emissions-reduction measures (ROC, 2015). The Republic of the Congo aims to do this partly by developing more of its rich hydro-electricity resources with the objective of increasing the share of electricity from hydro sources to 85 percent by 2025 (ROC, 2015). The energy-related INDC statements are listed in Table 4.

Institutional and Legal Framework

The Ministry of Energy and Hydraulics is in charge of the energy sector (Table 5). The energy regulator is Regulatory Agency for the Electricity Sector (ARSEL). The state owned *Société National d'Electricité* (SNE) is responsible for electricity generation and supply. On a regional level, the country is a member of the Central African Power Pool. The legal framework is provided by the Law No 14-2003 of April 10, 2003 on the Electricity Code.

Rwanda

Figure 1: Energy profile of Rwanda

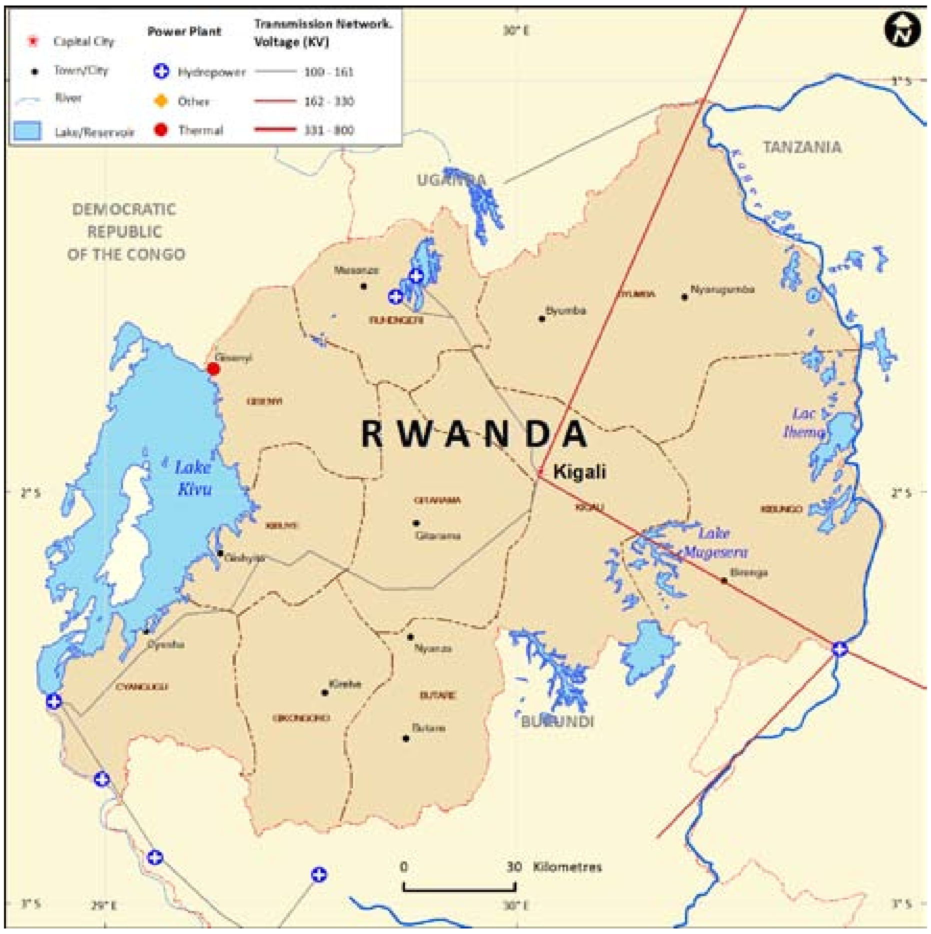
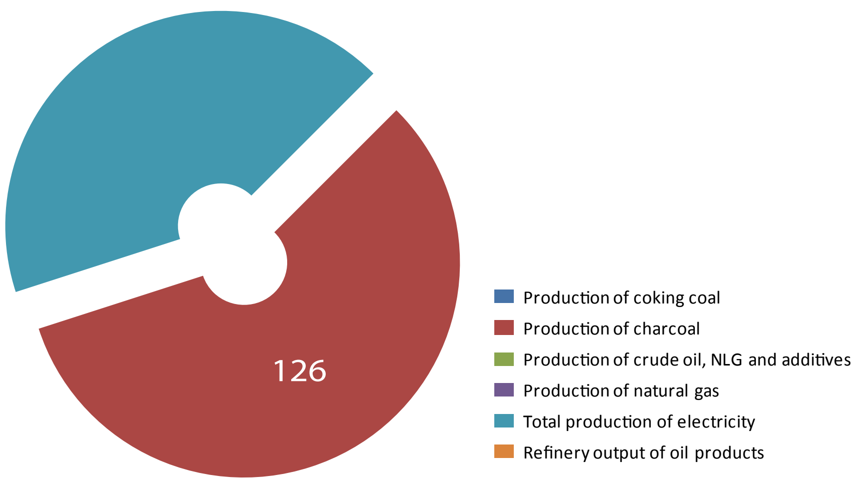
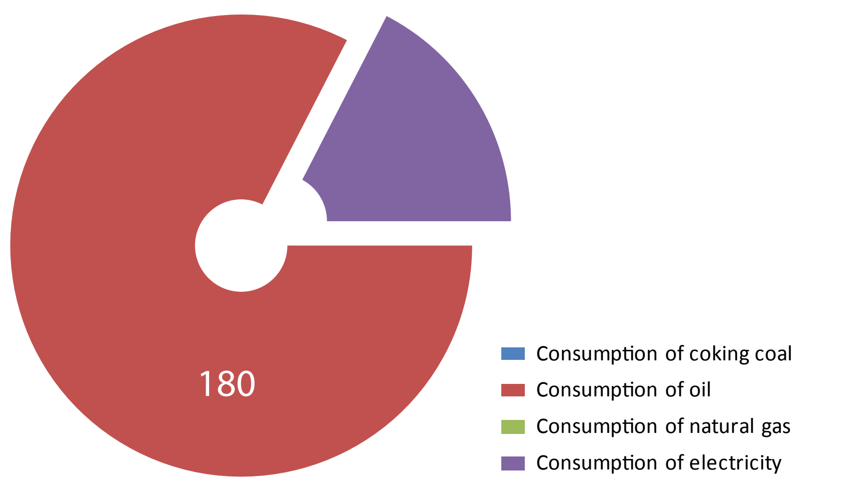


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Rwanda's population in 2013 was 11.08 million (Table 1) (World Bank, 2016). In 2015, total electricity produced was 93 ktoe, of which 51.6 per cent came from fossil fuels, 19.3 per cent from hydro and 27.9 per cent from solar and wind (Table 2). Final electricity consumption in 2015 was 38 ktoe (AFREC, 2015). Figures 2 and 3 highlight key production and consumption statistics.

Table 1: Rwanda's key indicators

Key indicators	Amount
Population (million)	11.08
GDP (billion 2005 USD)	4.72
CO_2 emission (Mt of CO_2)	0.06

Source: (World Bank, 2015)

Energy Resources

Hydropower

There is roughly 313 MW of hydropower potential in Rwanda (AfDB, 2013). Small and medium-size hydropower projects are located in sites such as Gihira, Gisenyi, Mukungwa, Ntaruka, Nyabarongo and Rukarara, with numerous other mini- and micro-hydro sites around the country. Small and medium-size hydropower stations presently provide 39.7 MW of operational capacity and an additional 77.2 MW of potential capacity. Mini- and micro-hydro provide 4.5 MW of operational capacity, with an additional 8 MW of potential capacity. The Rusizi River (shared with DRC) and the Rusumo Falls (shared with Tanzania) are potential sources of hydropower. The various phases of Rusizi are providing 161 MW in total and the Rusumo Falls is thought to be able to provide 20.5 MW of electricity when developed (AfDB, 2013).

Geothermal and methane

There is a 700 MW potential of geothermal energy, of which 490 MW are considered an economic resource (AfDB, 2013). The main fields are Karisimbi with 160 MW, Gisenyi with 150 MW, Kinigi with 120 MW and Bugarama with 60 MW. Karisimbi has an estimated resource size of 320 MW with currently assessed potential production capacity of 160 MW. There are plans to expand the installed geothermal generation capacity to 310 MW of power by 2017 (AfDB, 2013).

The methane resource in Lake Kivu is approximately 55 bcm. Potential power production capacity is estimated at 700 MW to be shared with DRC. Rwanda's share is 350 MW (AfDB, 2013).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	144	121	124	126
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	0	4	15	48
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	9	6	9	18
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	26
Total production of electricity	10	10	24	93
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	260	276	265	180
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	17	17	28	38
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	0	0
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	260	281	266	224
Net imports of natural gas	-	-	-	-
Net imports of electricity	8	8	5	7

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

Solar and wind

Rwanda's wind potential is currently being mapped, but the resource is presently used only in small, localized instances. The country is a moderate source of solar energy with an average solar irradiation of 5.5 kWh/m^2/day. The 250 kW Kigali solar project feeds into the national grid (REEEP, 2012).

Peat

Rwanda has 40,000 ha of peat bogs with an estimated power production capacity of 300 MW. Peat sites have been identified in Akanyaru, Bahimba, Bisika, Cyato, Cyabararika, Gasaka, Gihitasi, Gishoma, Kageyo, Kaguhu, Nyirabirande, Mashoza, Mashya, Murago, Nyabigongo, Rwuya, Rwabusoro, Rucahabi and Rugeramigozi (AfDB, 2013).

Geothermal

Although many geological studies have been undertaken for oil in this country, so far none has been done to assess the geothermal potential (REEEP, 2012). .

Biomass

Rwanda's energy mix is dominated by biomass, which accounts for about 85 per cent of primary energy use. Although the dependency on biomass has dropped from 95 per cent to 85 per cent in the last 20 years, the ratio is still considered too high and harmful to forest resources (AfDB, 2013).

Tracking progress towards sustainable energy for all (SE4All)

Only 6 per cent of the population had access to electricity in the year 2000, increasing to 18 per cent in 2012 (Table 3). This increased access occurred even though during that period of time, Rwanda's population grew from approximately 8.4 million to 11.4 million. The electrification gap between rural and urban areas is substantial, with only 7.7 per cent of rural areas being electrified compared to 61.5 per cent of urban areas (World Bank, 2016). Access to modern fuels has remained low for several decades, with only 2 per cent of Rwandese currently having access to modern fuels (World Bank, 2015).

The energy intensity of the Rwandese economy (the ratio of the quantity of energy consumption per unit of economic output) was 7.3 MJ per US dollar (2005 dollars at PPP) in 2010, increasing to 5.6 MJ per US dollar in 2012. This has economic implications because the unit of energy required to produce a unit of GDP has increased, in essence decreasing the energy efficiency of the country. The compound annual growth rate (CAGR) between 2010 and 2012 was -12.45 (World Bank, 2015).

The proportion of renewable energy in the total final energy consumption (TFEC) was 86.3 per cent in 2012 and it generated 42.3 per cent of electricity (World Bank, 2015). Most (75.3 per cent) of the renewable energy consumed is in the form of traditional biofuels. Rwanda's energy goals stated in Vision 2020 are to reduce biomass energy from 86.3 per cent to 50 per cent by 2020, expand access to electricity to 70 per cent by 2017 and have 100 per cent of public institutions connected by 2017. The current 2012 level of electricity production from renewables is set to increase as 20 mini- hydropower projects totalling 9 MW were to

Table 3: Rwanda's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	2	6	11	18		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	2	2		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	84.4	89.4	87.9	86.3		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)	5.7		7.3	5.6	5.99	5.61

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
18%	2.0%	**NA**	86.75%

Table 4: Rwanda's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Promote a low carbon energy mix
*Establish a new grid connected to renewable electricity generation capacity in the form of large-scale hydro power plants and solar PV power plants
*Install sustainable small scale energy sources
*Install solar PV mini-grids in rural communities.
*Adopt energy efficiency and demand side management
*Increase energy efficiency through demand-side measures and grid-loss reduction
*Promote environmentally sustainable use of biomass fuels

Source: (MEM, 2015)

Table 5: Rwanda's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Infrastructure (MINIFRA) Ministry of Forestry and Mines Rwanda Development Board (RDB)
Presence of a Functional Energy Regulator	Rwanda Utilities Regulatory Authority (RURA)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	ELECTROGAZ Rwanda Energy Corporation (RECO)
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	East African Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Rwanda Energy Group (REG Limited) and subsidiaries - the Energy Utility Corporation Limited (EUCL) and the Energy Development Corporation Limited (EDCL)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	• Controlled by the Ministry of Commerce and Consumption – which is responsible for formulating and managing the pricing policy of petroleum products – with downstream oil imports coming through Kenya and Tanzania. • Distribution and marketing of fuel products is carried out by Enterprise Rwandaise de Petrole (ERP); Societe Generale de Petrole (SGP); Rwanda Petrolgaz; Engen; and Shell.
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	Yes
Presence Functional IPPs and their contribution	Private-sector power generation is in its infancy but the GoR is keen to increase the market share of IPPs.
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	Economic Development and Poverty Reduction Strategy (EDPRS) Energy Policy 2008 National Energy Strategy (2008-2020) Electricity Access Roll-out Program (EARP) Biomass Energy Strategy Analysis 2009
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	• Electricity Law No. 21/2011 • Law No. 39/2001 creating Rwanda Utilities Regulatory Authority and replaced by Law Nº 09/2013 of 01/03/2013 • Decree No. 18/76 of April 1976 establishing ELECTROGAZ • Law of January 31, 2014 establishing Rwanda Energy Group (REG Limited) and its two subsidiaries • Draft Gas Law and Regulations for methane projects

This table was compiled with material from (REEEP, 2012), (RURA, 2012), (RURA, 2001) and (ROR, 2014)

be completed by 2014-2015, and a 12-17 MW Nyabarongo II medium hydropower as well as the145MW Ruzizi III regional hydropower are under way (MININFRA, 2015). There are also plans to increase the number of solar projects implemented.

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Rwanda's high population density, over-reliance on rain-fed agriculture and increasing incidents of natural disasters such as floods and landslides makes it very vulnerable to climate change. Rwanda's Intended Nationally Determined Contributions (INDCs) are based on its National Strategy for Climate Change and Low Carbon Development (GOR, 2015). Table 4 lists Rwanda's actions to support the energy-related INDCs.

Institutional and Legal Framework

The Ministry of Infrastructure (MININFRA) is in charge of energy infrastructure (Table 5). The energy regulator is Rwanda Utilities Regulatory Authority (RURA). Rwanda Energy Group Limited was created with two subsidiaries: the Energy Utility Corporation Limited (EUCL) and the Energy Development Corporation Limited (EDCL). The EUCL handles generation, transmission and distribution of electricity to end-users. At the regional level, the country is a member of the East African Power Pool. The legal framework is provided by the Electricity Law No. 21/2011.

The main sector policy is the Energy Policy 2008 and the National Energy Strategy (2008-2020) facilitates implementation. A major focus is to diversify energy sources by developing available domestic sources of energy and phasing out fossil-fuels.

São Tomé and Príncipe

Figure 1: Energy profile of São Tomé and Príncipe

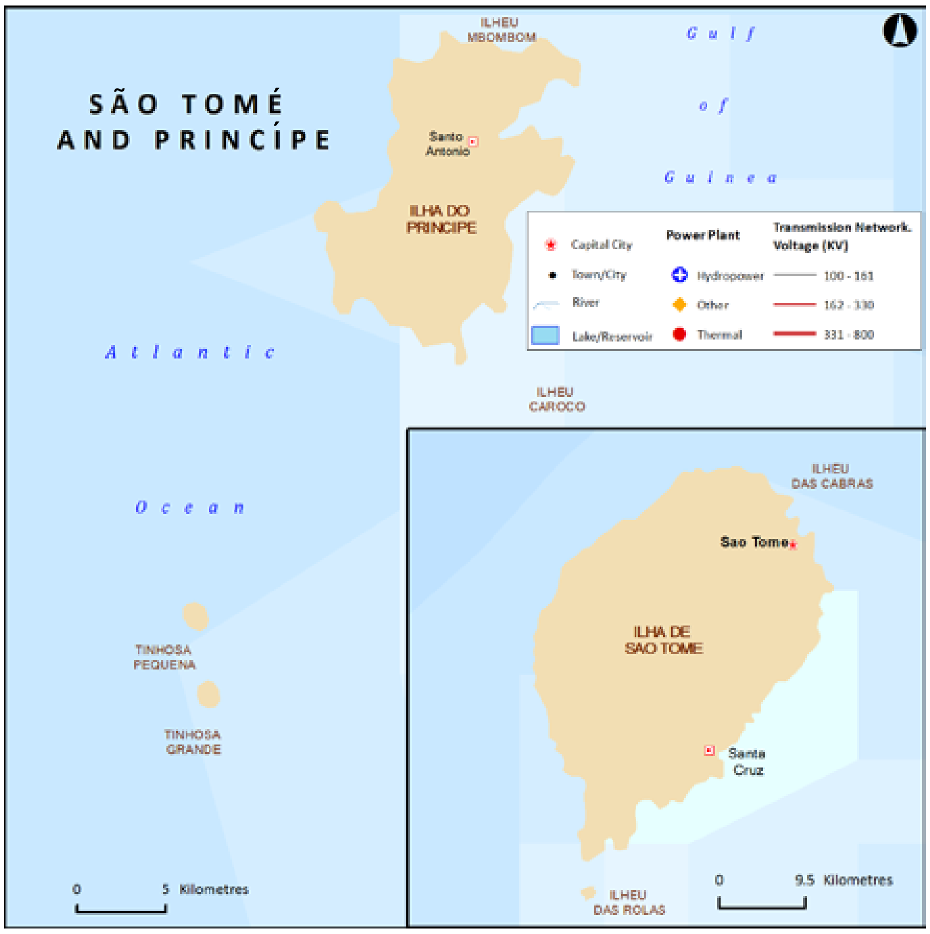
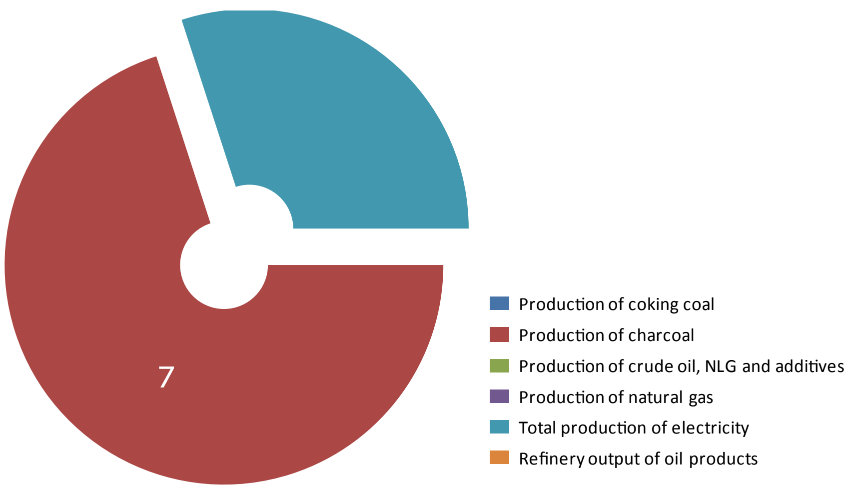
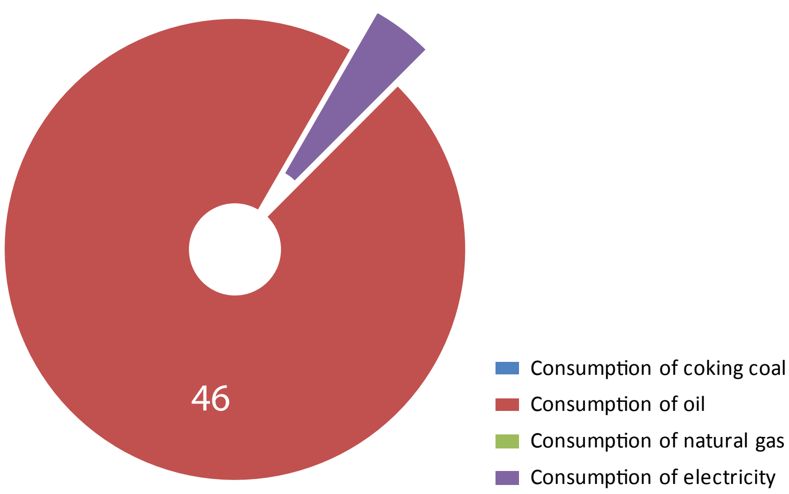


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

São Tomé and Príncipe had a population of 0.18 million in 2013 as shown in Table 1. In 2015, total electricity produced was 3 ktoe, of which 66.6 per cent came from fossil fuels and 33.3 per cent from hydro sources (Table 2). Final electricity consumed was 2 ktoe (AFREC, 2015). Figures 2 and 3 show the main energy statistics

Table 1: São Tomé and Príncipe's key indicators

Key indicators	Amount
Population (million)	0.18
GDP (billion 2005 USD)	0.19
CO_2 emission (Mt of CO_2)	0.10

Source: (World Bank, 2015)

Energy Resources

Biomass

In 2012, 40 per cent of the population did not have access to electricity. The energy need is met by biomass (firewood and charcoal), which is used heavily for cooking purposes. About 30 GWh/year is generated from biomass use (REEEP, 2012).

Hydropower

Although there are indications of the potential for small hydropower, research is needed to confirm economic viability. Feasibility studies by the Municipal Water and Electricity Company (EMAE) have highlighted 14 potential sites (REEEP, 2012). Existing power plants are located on the Contadores and Guégue rivers.

Oil and natural gas

There has been some successful offshore exploration for oil in the zone between Nigeria and São Tomé and Príncipe and oil is expected to flow as of 2016 (REEEP, 2012). The Joint Development Zone established in 2001 for joint exploration of the oil resources of Nigeria and São Tomé and Príncipe is based on a 60:40 ratio of benefit sharing, respectively. However, as a result of this emphasis on oil, there has been little research in alternative energy sources in the country (Liu, Masera, & Esser, 2013).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	7	7
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	1	1	2	2
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	1	0	0	1
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	1	1	2	3
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	20	26	35	46
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	2	3	2	2
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	17	27	44	52
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

Wind

The potential for wind is inadequate for exploitation (REEEP, 2012).

Geothermal

The island is geographically located on the Cameroon volcanic mountain line and this could indicate some geothermal potential. However there has been no study to determine this potential (REEEP, 2012)

Solar

Average daily insolation is 5.2 kWh/m², which implies good potential for solar energy development. However, there is little development of the sector. Currently, there is minimal use of solar PV in schools and other public buildings (REEEP, 2012).

Ponta Figo Hike Hydropower Station 1, Sao Tome

Tracking progress towards sustainable energy for all (SE4All)

By 2012, electricity coverage extended to only 60.5 per cent of the population and supply is unreliable (Table 3) (World Bank, 2016). Domestic energy requirements are met by kerosene and candles for lighting and biomass for cooking. Coverage of electricity distribution lines is mainly in the northwestern part of the country, towards the capital city. By 2012, 68.3 per cent of urban areas had access to electricity and 47 per cent of rural areas (World Bank, 2015); (World Bank, 2016).

Access to modern fuels is low. In 2012, only 28.77 per cent were using non-solid fuels; 16 per cent of these are from rural areas and 42 per cent in urban areas (World Bank, 2015). About 85 per cent of households use firewood or coal for cooking (REEEP, 2012).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 5.7 MJ per US dollar (2005 dollars at PPP) in 2012, down only slightly from 6.1 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010 and 2012 was -1.35 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) has been declining steadily from 62.2 in 1990 to 42.4 in 2012. Traditional solid biofuels form the biggest share of renewable sources at 41.6 per cent of TFEC in 2012, while hydro contributed only 0.8 per cent (World Bank, 2015). Renewable sources contributed 6.4 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: São Tomé and Príncipe's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	50	53	57	60.5		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	8	20	27	28.77		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	62.2	35.7	35.4	42.4		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			9.15 (2007)			
	Level of primary energy intensity(MJ/$2005 PPP)	6.1		5.8	5.7	5.7	5.68

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
60.5%	28.77%	**8.62**	43.22%

Table 4: São Tomé and Príncipe's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Build Isolated Mini Power plant (1 MW);
*Build Hydro Power plant connected to the main network (9 MW);
*Install Photovoltaic solar panels (12 MW);
*Build Mini-hydro Power plant connected to the main grid (4 MW).

Source: (MEM, 2015)

Table 5: São Tomé and Príncipe's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Natural Resources, Energy and Environment • National Petroleum Council
Presence of a Functional Energy Regulator	No dedicated regulator
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Central Africa Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Empresa de Agua e Electricidade (Water and Electricity Company)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	National Petroleum Agency (ANP)
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	• Empresa Nacional de Combustíveis e • Óleos (National Oil Company) • National State Oil Company (Petrogas)
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	Hidroeléctrica STP Ltda (5MW)
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Decreto-Lei No 14/2005 creating AGER • Decreto-Lei No 40/2008 EMAE statute • Law 3/2004 and Decree 14/2005 establishing General regulation Authority • Electricity sector bill (Ante-projecto de Lei de Bases do Sector Eléctrico) • General Law on Petroleum Exploration and Exploitation of August 2000 • Decree No 3/2004 creates the National Petroleum Council. • Law No 5/2004 of June 2004 creates the National Petroleum Agency (ANP). • Oil Revenue Management Law (ORML) of December 2004

This table was compiled with material from (REEEP, 2012)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

São Tomé and Príncipe are already feeling the impacts of climate change and are keen to reduce these effects through adaptation. The government articulated its Intended Nationally Determined Contributions (INDCs) in 2015 and the energy-related INDCs are listed in Table 4.

Institutional and Legal Framework

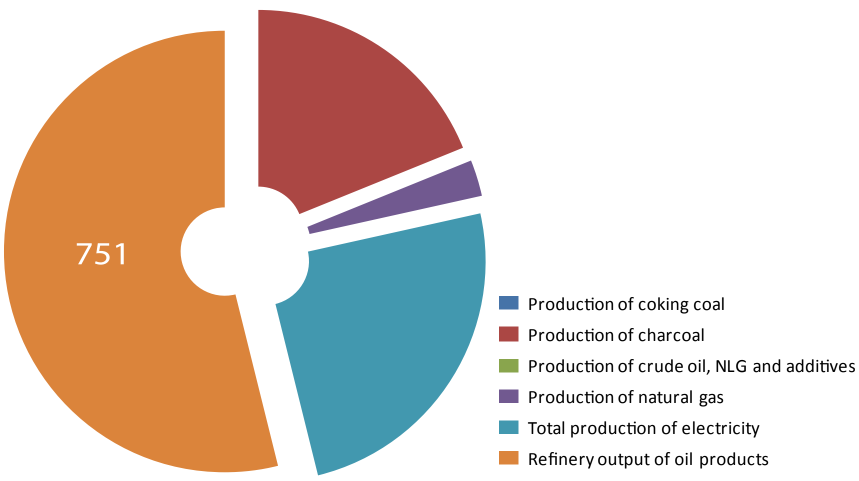
The Ministry of Natural Resources, Energy, and Environment is in charge of the energy sector (Table 5). There is no dedicated energy regulator, although the General Regulation Authority (*Autoridade Geral de Regulação* (AGER)) that was created to regulate the infrastructure sector is expected to assume responsibility for regulating the energy sector in the future. The *Empresa de Água e Electricidade* (EMAE) — the Water and Electricity Company — is the state-owned monopoly that manages water and electricity supply. On a regional level, São Tomé and Príncipe is a member of Central Africa Power Pool. It is also a member of the Association of Energy Regulators of the Portuguese Speaking Countries (RELOP) established in 2008.

The main sector policy is the government's 2007 Program of Action that prioritizes energy. But the Electricity Sector Reform Commission is spearheading reforms in the sector.

Senegal

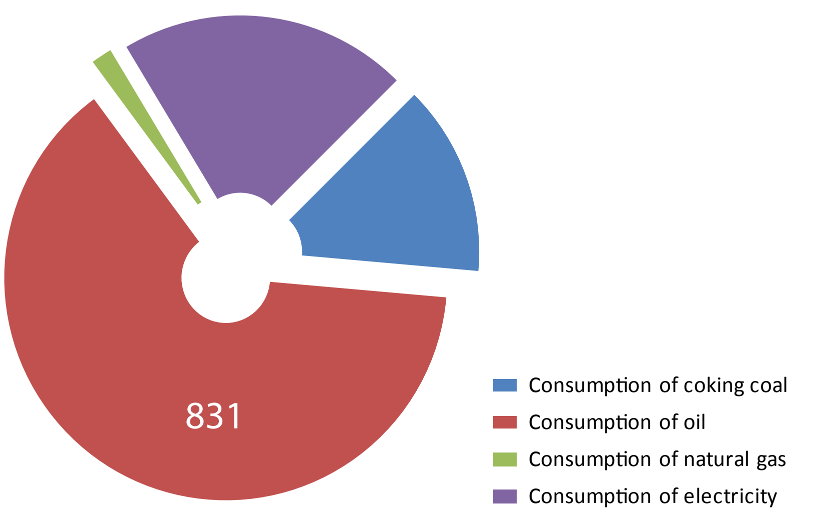
Figure 1: Energy profile of Senegal

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Senegal had a population of 14.13 million (Table 1). In 2015, total electricity produced was 343 ktoe, with 88.9 per cent from fossil fuels and 9 per cent from solar and wind. Final electricity consumed was 276 ktoe, as shown in Table 2 (AFREC, 2015). Figures 2 and 3 highlight the key energy statistics.

Table 1: Senegal's key indicators

Key indicators	Amount
Population (million)	14.13
GDP (billion 2005 USD)	11.25
CO_2 emission (Mt of CO_2)	6.00

Source: (IEA, 2016)

Energy Resources

Biomass

Biomass (firewood and charcoal) is the main energy source used by households, providing more than half of the national energy balance (REEEP, 2014). Charcoal production in 2015 amounted to 263 ktoe (AFREC, 2015). There is potential for the development of solid biomass from agricultural waste and crop residues and liquid biofuels in the country. In 2010, the production of electricity from biofuels and waste was 4 ktoe and this increased to 5 ktoe in 2015 (AFREC, 2015). The National Bioenergy Strategy 2006 aims to use plant species such as Jatropha for biofuel production. The target was 1,134 million litres of refined biodiesel from 2012 (Dafrallah, 2009). The government is also interested in producing biogas from from fermenting organic waste.

Hydropower

The Manantali hydroelectricity plant built along the Senegal River is located in Mali, but supplies electricity to Senegal as well as Mauritania. The dam is managed by the Senegal River Basin Development Authority and has a potential of 200 MW (REEEP, 2014). In 2015, the amount of electricity that came from hydro sources was 31 ktoe making up about 9 per cent of total electricity produced in the country (AFREC, 2015).

Oil and natural gas

Senegal imported 655 ktoe of oil in 2015 and used 305 ktoe of it to produce electricity (AFREC, 2015). Lately, there have been some finds of oil in the

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	296	335	424	263
Production of crude oil, NLG and additives	1	0	0	0
Production of natural gas	1	15	22	37
Production of electricity from biofuels and waste	4	4	4	5
Production of electricity from fossil fuels	127	164	234	305
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	0	23	22	31
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	2
Total production of electricity	131	191	261	343
Refinery output of oil products	884	874	564	751
Final Consumption of coking coal	0	78	147	182
Final consumption of oil	901	1,004	882	831
Final consumption of natural gas	1	15	22	20
Final consumption of electricity	113	158	221	276
Consumption of oil in industry	157	139	79	95
Consumption of natural gas in industry	0	0	0	0
Consumption of electricity in industry	29	35	60	63
Consumption of coking coal in industry	0	78	147	182
Consumption of oil in transport	608	697	645	618
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	0	78	135	199
Net imports of crude oil, NGL, Etc.	855	925	612	655
Net imports of oil product	437	583	1,204	1,099
Net imports of natural gas	0	0	0	0
Net imports of electricity	17	23	22	24

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Senegal basin and the Senegal Guinea Bissau Joint Development Zone. Oil mining activities are known to affect biodiversity and habitats. In particular, one of the blocks — the Sangomar Deep — is located near the Saloum Delta National Park. This area is habitat to sea birds including the Royal Tern (*Thalasseus maximus*), among others (Veen, Dallmeijer, & Diagana, 2008).

Peat

There are about 36 km^2 of peatland (WEC, 2013).

Coal

Currently, all coal for electricity generation is imported, although there are plans to introduce greater electricity production from coal through IPP investments (REEEP, 2014).

Wind

Wind speeds from a low of 3.7 m/s up to a high of 6.1 m/s have been measured along the 250 km coast between Dakar and Saint Louis (REEEP, 2014). Towards the interior, the wind speeds are low and can only support the smaller traditional wind energy systems.

Geothermal

The potential provided by this sector needs more research.

Solar

Senegal can successfully exploit commercial level solar PV power projects as measurements of the Direct Normal Solar Irradiation over most of the country is over 1,800 kWh/ m^2/year (REEEP, 2014). It is one of a handful of countries in Africa that has piloted green mini-grids and is now ready to roll them out for country-wide implementation (World Bank, 2015).

Tracking progress towards sustainable energy for all (SE4All)

The electrification rate for Senegal in 2012 was 56.5 per cent , more than double the rate in 1990 (Table 3 and Figure 4). In rural areas, 26.6 per cent had access to electricity and in urban areas, this figure rose to 87.8 per cent . Access to modern fuels in 2012 was 8 per cent in rural areas and 69 per cent in urban areas (World Bank, 2015); (World Bank, 2016).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Senegalese economy was 5.8.0 MJ per US dollar (2005 dollars at PPP) in 2012, up slightly from 5.1 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010-2012 was -0.25 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) increased slightly from 42.5 per cent in 2010 to 51.4 in 2012. Traditional solid biofuels form the biggest share of renewable sources at 49.2 per cent of TFEC in 2012, while the modern solid biofuels contributed 1.4 per cent and hydro 0.7 per cent . Renewable sources contributed a 9.8 per cent share of electricity generation in 2012 (World Bank, 2015); (World Bank, 2016).

Table 3: Senegal's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	26	37	57	56.5		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	32	38	39	39.27		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	55.6	47.7	42.5	51.4		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			8.2	8.2		
	Level of primary energy intensity(MJ/$2005 PPP)	5.1		5.8	5.8		

Sources: (World Bank, 2015); (World Bank, 2016)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Senegal is keen to contribute to reducing global GHG emissions and has articulated its Intended Nationally Determined Contributions (INDCs). Those related to energy are listed in Table 4.

Table 4: Senegal's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Build Solar PV power plants of aggregated total capacity of 160 MW
*Build wind power plants of aggregated total capacity of 150 MW
*Build hydraulic power plants of aggregated total capacity of 144 MW/522 GWh
*Implement rural electrification programme (PNUER) . - 392 villages to be electrified with mini-grid using solar or hybrid (diesel/solar)
*Install 27,500 household bio digesters
*Produce and disseminate 4.6 million improved cooking woodstoves
*Produce and disseminate 3.8 million of improved cooking stoves for charcoal
*Commission wind power plants for a total cumulated capacity of 200 MW
*Commission Solar PV power plants for a total cumulated capacity of 200 MW
*Commission biomass power plants for a total cumulated capacity of 50 MW
*Commission Concentrated Solar Power CSP power plants for a total cumulated capacity of 50 MW
*Add Hydraulic 200 GWh to the existing grid
*Replace the Jindal 320 MW coal power plant with two combined- cycle LNG (CCGN) power plants of 400 MW (2020: 200 MW and 2028: 200 MW)
*Electrify 500 villages using solar (mini-grid) under the universal access to electricity program
*Build and disseminate 7.6 million of improved cooking woodstoves, 6.8 million of improved cooking stoves using charcoal, and 49,000 household bio digesters
*Manufacture typha-based thermal insulation materials in Senegal and adoption of Nubian vault technique in rural habitat and community infrastructure construction
* Run pilot phase to promote facilities of cold storage for food.
*Make energy audits for heavy industries compulsory
*Conduct energy supply studies for new installations (75 studies/year)
*Run pilot program for capacity building in environmental knowledge
*Implement waste recovery/recycling program in the agriculture and food processing industry (biogas)
*Implement efficient lighting program (distribute/sell 3 million LED bulbs)
*Implement energy efficiency programme in tertiary buildings and in the administration
*Promote high-performing facilities of cold storage for food: the plan is to replace up to 95 per cent of existing non-efficient equipment fleet
*Energy efficiency and public lighting (replacing 75,000 street lamps)
* Implement capacity building in environmental knowledge for companies (aiming at 50 companies per year, with financial incentives)
*Implement agriculture and food-processing waste recovery/recycling plan: recycle/recover 4 million GJ of agricultural biomass through co/tri-generation (115 MW)
*Implement energy efficiency program in the cement industry
*Substitute 40 per cent of the coal destined for electricity auto-generation by natural gas

Source: (ROS, 2015)

Institutional and Legal Framework

The Ministry of Energy is in charge of the energy sector. The energy regulator is the Electricity Sector Regulating Committee (CRSE).

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
56.5%	39.27%	**8.68**	51.36%

Table 5: Senegal's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Energy National Agency for Renewable Energies (ANER) Ministry of Renewable Energies Senegalese Rural Electrification Agency (ASER) National Agency for Solar Energy (ANDES) 2010
Presence of a Functional Energy Regulator	Commission de Régulation du Secteur de l'Electricité (CRSE)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	Société Nationale d'Electricité du Sénégal (SENELEC) has the monopoly for transmission and distribution of electricity.
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West African Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	Feed-in tariff scheme provided in the Renewable Energy Law (No. 2010-21)
Presence Functional IPPs and their contribution	IPPs produce about 50 per cent of power and sell exclusively to SENELEC.
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Policy (Letter of Development Policy for the Energy Sector) adopted in 2012 • National Bioenergy Strategy 2006
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Electricity Law (98-29), 1998 established the Commission for the Regulation of Electricity • Renewable Energy Law (No. 2010-21) provides for regulation of the sector allowing for a feed-in tariff scheme and tax incentives for development • Law 2010-22 Regulating the Biofuels Industry • Decree No. 2013-684 on the establishment, organization and functioning of the National Agency for Renewable Energies • Decree 1577 Regulating the Inter-Ministerial Committee on Renewable Energy • Decree No. 2008-38 on the powers of the Minister of Biofuels, Renewable Energies and Scientific Research

This table was compiled with material from (Nachmany, et al., 2015), (IRENA, 2012) and (REEEP, 2014)

The Société Nationale d'Electricité du Sénégal (SENELEC) has the monopoly for transmission and distribution of electricity. On a regional level, the country is a member of the West African Power Pool. The legal framework is provided by the Electricity Law (98-29) of 1998, which also established the Commission for the Regulation of Electricity. The main sector policy is the Energy Policy (Letter of Development Policy for the Energy Sector), adopted in 2012 (Table 5).

Seychelles

Figure 1: Energy profile of Seychelles

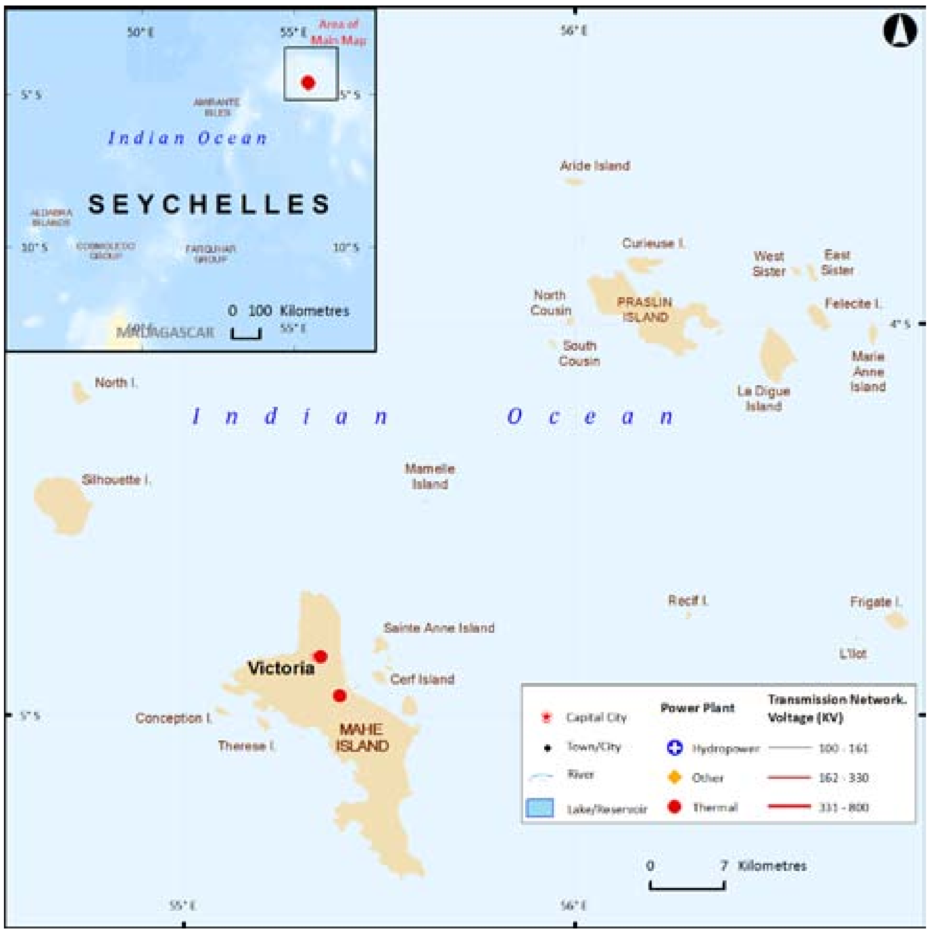
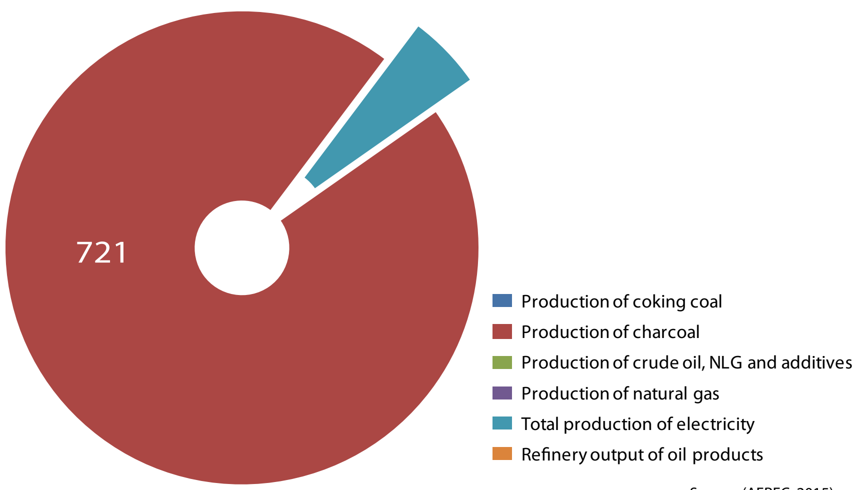
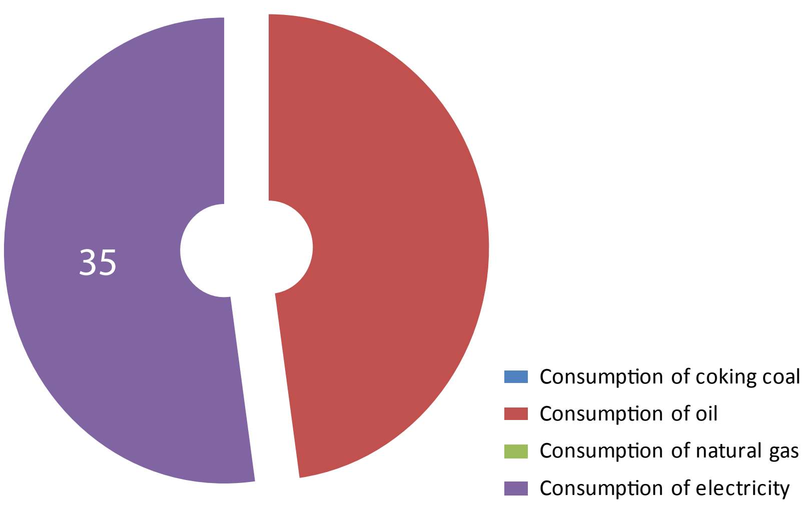


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013 the population of the Seychelles was 0.08 million people as shown in Table 1. In 2015, total electricity production was 38 ktoe, with 94.7 per cent from fossil fuel sources (Table 2). Final electricity consumed in the same year was 35 ktoe (AFREC, 2015). Figures 2 and 3 show the key energy statistics.

Table 1: Seychelles' key indicators

Key indicators	Amount
Population (million)	0.08
GDP (billion 2005 USD)	1.38*
CO_2 emission (Mt of CO_2)	0.59

Source: (World Bank, 2015) *(IndexMundi, 2015)

Energy Resources

Biomass

Although there is a dearth of data, there is some evidence of the potential for biomass energy development, especially in the waste-to-energy sector. For example, the landfill at Providence on Mahe receives 35,000 tonnes of waste a year, which has the equivalent of roughly 8,000 tonnes of oil and could thus be a source of energy (Vreden, Wigan, Kruze, Dyhr-Mikkelsen, & Lindboe, 2010). Crop waste and residue from agricultural processes could also be used for energy generation. Although there has been some interest from various IPPs, comprehensive appraisals still need to be undertaken to establish commercial viability (REEEP, 2012).

Hydropower

There is no capacity for hydropower generation (REEEP, 2012).

Oil and natural gas

Final consumption of oil was 32 ktoe in 2015 and 36 ktoe of oil was used to generate electricity (AFREC, 2015). The Seychellois economy depends to a great deal on oil imports to meet national needs. A total of 323 ktoe of oil products were imported in 2015.

Wind

Measurements of wind are between 6.9 and 7.5 m/s at 80 m – suitable for commercial electricity generation. A largescale wind project — the 6 MW Port Victoria wind Power Project — has been built by MASDAR Clean Energy. It provides 7GWh of electricity per year (REEEP, 2012).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	721	721
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	1
Production of electricity from fossil fuels	15	19	24	36
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	-
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	15	19	24	38
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	192	287	317	32
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	14	17	23	35
Consumption of oil in industry	0	0	0	1
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	9
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	29
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	192	287	317	323
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

Geothermal

This still needs to be studied further (REEEP, 2012).

Solar

The mean irradiance has been measured at 5.8 kWh/m^2/day and presents ideal opportunity for generating solar electricity (REEEP, 2012). The Seychelles Energy Commission has established standards and regulations to guide all stakeholders in the sector so as to ensure standardization in the importation and installation of PV systems that complement the electricity network (SEC, 2014).

Wind turbines, Seychelles

Tracking progress towards sustainable energy for all (SE4All)

The data indicates that access to electricity in the Seychelles is 100 per cent , but there is a significant disparity between rural and urban areas, with the former having an electrification rate of 17.3 per cent and urban areas with 100 per cent . Access to modern fuels is high with 99.78 per cent of the population using non-solid fuels in 2012 (World Bank, 2016).

The economy energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 4.5 MJ per US dollar (2005 dollars at PPP) in 2012, up from 1.8 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010 and 2012 was -10.84 (World Bank, 2015).

Seychelles is almost completely dependent on oil for energy including the production of electricity; thus, the share of renewable energy in the total final energy consumption is almost nothing (SEC, 2014). For example, in 2012, the share of renewable energy in the total final energy consumption was 0.5 per cent . Traditional solid biofuels formed 0.5 per cent of TFEC in 2012 (World Bank, 2015).

Table 3: Seychelles' progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	97	99	100	100		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	78	91	99	99.78		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption			8.7 (2007)	0.5		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)	1.8		5.7	4.5	4.82	4.53

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

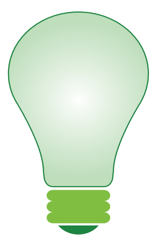
Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
100% 	99.78% 	**8.19**	0.51%

Table 4: Seychelles' key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Build Isolated Mini Power plant (1 MW);
*Build Hydro Power plant connected to the main network (9 MW);
*Install Photovoltaic solar panels (12 MW);
*Build Mini-hydro Power plant connected to the main grid (4 MW).

Source: (MEM, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Like all small island states, the Seychelles is particularly vulnerable to the impacts of climate change and climate variability. It is prioritizing adaptation to climate change. The government has submitted its energy-related Intended Nationally Determined Contributions (INDCs). Those relevant to energy are listed in Table 4.

Table 5: Seychelles institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Home Affairs, Environment, Transport and Energy
Presence of a Functional Energy Regulator	Seychelles Energy Commission
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Public Utility Company (PUC)
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Seychelles Petroleum Company
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	Energy Policy 2010-2030
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Public Utility Company Act 1985 • Seychelles Energy Commission Act No. 5 of 2010 • The Public Utilities Corporation Act (1985) • Seychelles Energy Commission Act (2010) • Energy Regulatory Act 2012

This table was compiled with material from (REEEP, 2012) and (Vreden, Wigan, Kruze, Dyhr-Mikkelsen, & Lindboe, 2010)

Institutional and Legal Framework

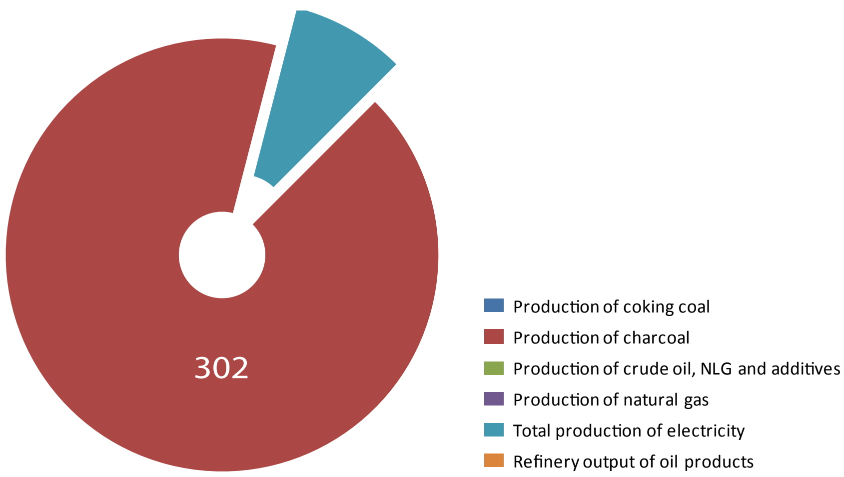
The Ministry of Home Affairs, Environment, Transport and Energy is in charge of the energy sector (Table 5). The energy regulator is the Seychelles Energy Commission. The Public Utilities Company (PUC) is the sole generator, transmitter and distributor of electric energy. On a regional level, the Seychelles is a member of the Southern Africa Development Corporation (SADC), but it is not a member of the Southern Africa Power Pool. The legal framework is provided by the Public Utilities Corporation Act (1985). The main sector policy is the Seychelles Energy Policy 2010-2030. It calls for a review of the legal framework governing the energy sector and has special emphasis on renewable energy, energy efficiency and energy conservation.

Windmills rise above the New Port on Victoria's Inner Harbour on Mahe Island, Seychelles

Sierra Leone

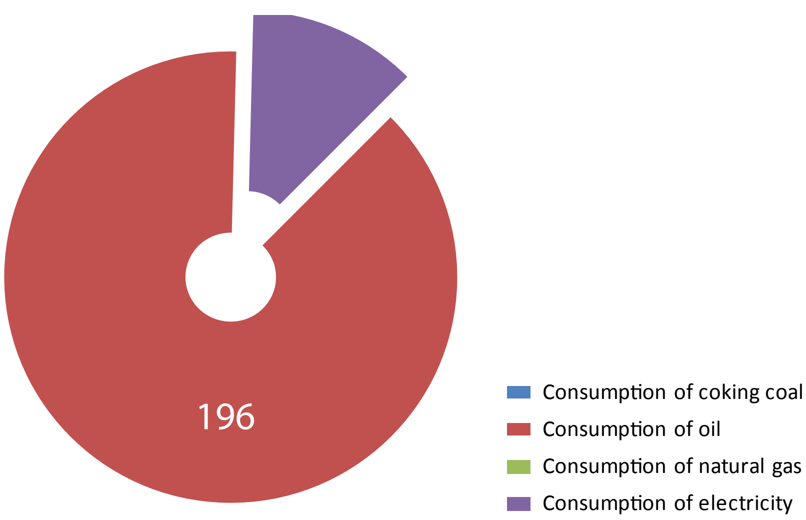
Figure 1: Energy profile of Sierra Leone

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Sierra Leone had a population of 6.17 million as shown in Table 1. In 2015, total production of electricity was 28 ktoe of which 46.4 came from fossil fuels and 42.8 per cent from hydro sources. Final electricity consumption was 27 ktoe (Table 2) (AFREC, 2015). Key energy indicators are shown in Figures 2 and 3.

Table 1: Sierra Leone's key indicators

Key indicators	Amount
Population (million)	6.17
GDP (billion 2005 USD)	3.12
CO_2 emission (Mt of CO_2)	0.89

Source: (World Bank, 2015)

Energy Resources

Biomass

In common with many African countries, biomass plays a big role in the energy mix representing over 80 per cent of the total energy consumed in Sierra Leone (UNDP, 2012). Biomass potential is high and includes fuelwood from forests, crop waste and agricultural residue with an estimated total generation potential of 2,706 GWh (REEEP, 2012). There is also potential for about 32 MW of biofuels from sugarcane ethanol some of which could be supplied to the national grid (REEEP, 2012).

Hydropower

According to (REEEP, 2012) the hydropower potential in the country is just over 1,500 MW. Located on the Seli River, the Bumbuna is the largest hydropower plant generating up to 50 MW of electricity. In 2015, almost half (28 ktoe) of the electricity generated was from hydro sources and this placed the country at the mercy of changes in the climate regime (AFREC, 2015). For instance, the generating capacity of the Bumbuna hydroelectricity station typically decreases by 64 per cent during the dry season from its normal 50 MW during the rains (REEEP, 2012). There are plans to expand the Bumbuna Plant to 275 MW (REEEP, 2012). The government is considering investing in hydro at the following sites: Betmai III, Bekongor III, Kambatibo and Yiben I and II (REEEP, 2012). There are also many sites for the development of small and mini hydro.

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	281	302
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	1
Production of electricity from fossil fuels	6	5	4	13
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	1	2	22	12
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	2
Total production of electricity	8	7	26	28
Refinery output of oil products	247	326	0	0
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	125	281	200	196
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	7	6	12	27
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	125	285	218	305
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Oil and natural gas

After biomass, oil is the next biggest energy source at 13 per cent (UNDP, 2012). Petroleum products are mainly used for electricity power generation and transport. In 2015, 13 ktoe of fossil fuels was used in the production of electricity a three-fold increase from 10 years previously (AFREC, 2015). Although some offshore discoveries were made in 2009 and 2010, the sector is still in the exploratory phase (UNDP, 2012). Domestic needs are met through importation of refined petroleum products. Importation of oil products has doubled over the last decade. For instance, in 2000, 125 ktoe of oil products were imported compared to 305 ktoe in 2015 (AFREC, 2015). Final consumption of oil in 2015 was 196 ktoe, down from a high of 281 ktoe in 2005 (AFREC, 2015).

Wind

Wind energy has not really been exploited in this country as there is a dearth of data on wind speeds and. The existing data indicates means of between 3 and 5 m/s and it is thought that speeds of 12 m/s are also likely in some places (UNDP, 2012, REEEP 2012). However, investments in wind energy systems can only be done on the back of scientific studies in this area. These are urgently called for as it might also be possible to invest in new technology options that may allow for the generation of electricity in low wind areas (REEEP, 2012).

Geothermal

There appears to be no potential for geothermal energy in this country (REEEP, 2012).

Solar

Solar is a potential growth industry in Sierra Leone with the installed capacity currently estimated at 25 MW (REEEP, 2012). There are also some upcoming investments such as the US $28.9 million street lighting project that is ongoing in Freetown and other major towns across the country (UNDP, 2012); and a US $18 million Solar Park Freetown Project that will generate about 6 MW of power. These are possible because solar radiation in the country averages between 1,460-2,200 kWh/m which is deemed suitable for exploitation (UNDP, 2012) (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

The national electrification rate for Sierra Leone was 14.2 per cent in 2012 (Table 3 and Figure 4). Access to electricity in rural areas is 1.2 per cent and in urban areas is 46.5 per cent (World Bank, 2016). The electricity sector is hindered by inadequate and aging transmission and distribution networks and damage suffered during the war, although much is being done to rehabilitate it. The current electricity system covers mainly the western region of the country with most consumption happening in the capital city of Freetown (UNDP, 2012).

Access to modern fuels is low. In 2012, only 2 per cent of the population was using non-solid fuels down from 6 per cent in 1990. In the rural and urban areas, and the percentage is the same for both rural and urban areas (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 8.0 MJ per US dollar (2005 dollars at PPP) in 2012, down from 11.7 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010 and 2012 was -6.94 (World Bank, 2015).

The share of renewable energy in the total final energy consumption was 80.4 per cent in 2012. Traditional solid biofuels form the biggest share of renewable sources at 56.3 per cent of TFEC in 2012, while the modern solid biofuels contributed 22.9 per cent and hydro 1.2 per cent only. Renewable sources contributed 36.0 per cent share of electricity generation in 2012) (World Bank, 2015).

Table 3: Sierra Leone's' progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	6	9	12	14.2		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	6	6	2	2		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	95.6	90.6	71.2	80.4		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)	11.7		9.2	8.0	9.06	7.98

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
14.2%	2.0%	NA	80.35%

Table 4: Sierra Leone's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Expand clean energy utilization (e.g. solar, mini-hydroelectric power, LPG, biomass stoves etc.).
*Develop energy efficiency programmes through sensitization and awareness raising campaigns, promote sustainable production of charcoal and reduce dependence on firewood.
*Develop alternative energy sources such as bio-fuels from sugarcane, corn, rice husk, etc.
*Develop agricultural and urban waste incineration programmes for energy production.
*Promote energy efficiency, enhanced management and expansion of the energy mix through uptake of renewable energy sources (Solar, Wind, Hydro, and Biomass) particularly in the rural areas of Sierra Leone.

Source: (MEM, 2015)

Table 5: Sierra Leone's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy • National Power Authority • Petroleum Directorate
Presence of a Functional Energy Regulator	Electricity and Water Regulatory Commission
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West African Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Sector unbundled: • Electricity Generation and Transmission Company • Electricity Distribution and Supply Authority • Energy Asset Unit
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Energy Policy 2009 • National energy strategic plan 2010-2025 • Petroleum Policy 2010
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Electricity and Water Regulatory Commission Act 2011 • National Electricity Act of 2011 • National Power Authority Act of 1982 Petroleum (Exploration and Production) Act 2011

This table was compiled with material from (REEEP, 2012), (AJME, 2011) and (UNDP, 2012))

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Sierra Leone is the third most vulnerable country after Bangladesh and Guinea Bissau to the negative impacts of climate change (GOSL, 2015). Over dependence on rain-fed agriculture and natural resource-based livelihoods places the population at high risk. The government articulated its Intended Nationally Determined Contributions (INDCs) in 2015. Those related to energy are listed in Table 4.

Institutional and Legal Framework

The Ministry of Energy is in charge of the energy sector (Table 5). The energy regulator is Electricity and Water Regulatory Commission. The electricity sector is unbundled with three companies as follows: the Electricity Generation and Transmission Company, the Electricity Distribution and Supply Authority, and the Energy Asset Unit. On a regional level, the country is a member of West African Power Pool. The legal framework is provided by the National Electricity Act of 2011.

The main sector policy is the National Energy Policy 2009 and it is guided by a strategic plan 2010-2025

Somalia

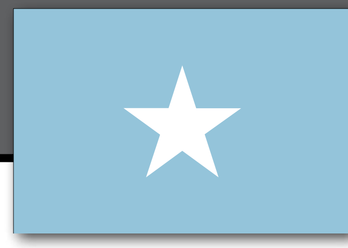


Figure 1: Energy profile of Somalia

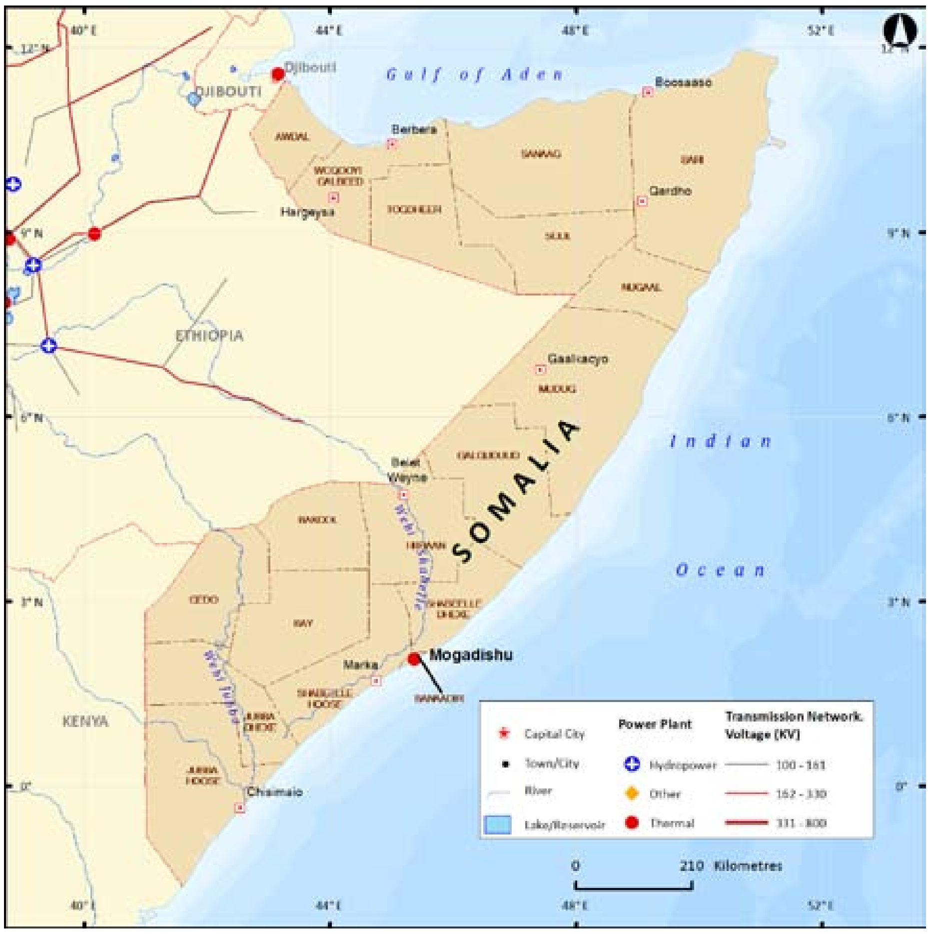
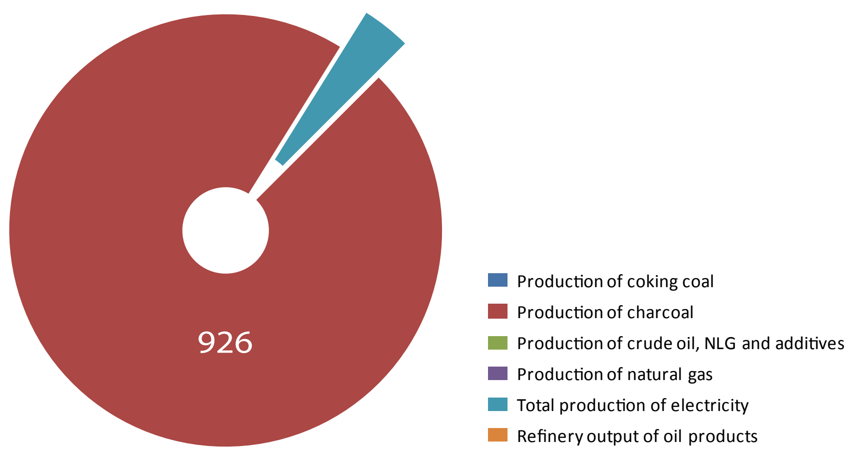
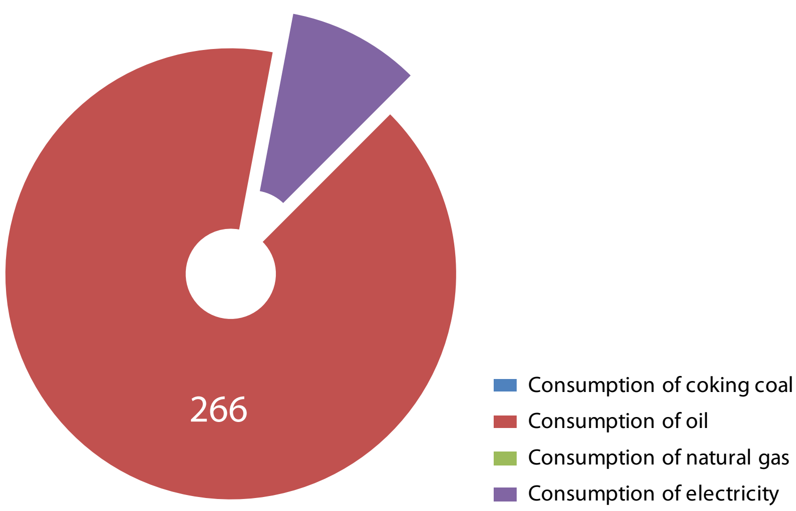


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

The population of Somalia in 2013 was 6.17 million people (Table 1). Total electricity produced in 2015 was 35 ktoe, with 97.1 per cent produced from fossil fuels. Final electricity consumption in 2015 was 28 ktoe (AFREC, 2015). Table 2 shows the energy statistics of Somalia.

Table 1: Somalia's' key indicators

Key indicators	Amount
Population (million)	6.17
GDP (billion 2005 USD)	3.12
CO_2 emission (Mt of CO_2)	0.89

Source: (World Bank, 2015)

Energy Resources

Biomass

Charcoal is a major economic industry in Somalia. It provides both income and the population's energy needs. About 97 per cent of urban households depend on charcoal while rural households rely on firewood as their main source of energy (AfDB, 2013). In the five years from 2010, the amount of charcoal produced almost doubled from 523 to 926 ktoe in 2015 (AFREC, 2015). This is putting massive pressure on the forest resource, contributing to desertification and the destruction of grazing and arable land. For instance, forest cover in 1985 was about 60 per cent of the land area but by 2001, this had declined to about 10 per cent of land area or about 6.5 million ha (REEEP, 2012). There is urgent need for alternative sources of fuel and proposals have indicated biofuels from crop and animal wastes and marine biomass (REEEP, 2012). In addition, improved technologies for sustainable sustainable charcoal production should be made (REEEP, 2012).

Hydropower

The deployment of hydroelectricity has been seriously hampered by the security situation in this country. Currently only 2.85 per cent of total electricity is generated from hydropower (AFREC, 2015). The in-country potential for hydropower is estimated at between 100 and 120 MW of which only 4 per cent has been exploited on the Juba river (REEEP, 2012).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	0	0	523	926
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	20	23	27	34
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	0	0	0	1
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	20	23	27	35
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	241	244	271	266
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	19	22	25	28
Consumption of oil in industry	0	0	0	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	0	0
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	0
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	241	239	150	131
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

A dam at Bardhere, in southern Somalia, has also been planned. Other challenges to the sector include the seasonality of the rivers.

Oil and natural gas

Somalia's geology, and proximity to traditional oil producers in the Middle East, indicates the potential existence of oil reserves (AfDB, 2013). So far, however, the situation has not been conducive to exploration activities. There are indications that the Dharoor field in Bari province, Puntland has about 1.2 billion barrels of oil with the potential of almost ten times that in deposits and additional potential for off-shore oil and natural gas production in the Indian Ocean and the Red Sea (Balthasar, 2014). Somalia depends on imported petroleum for electricity production and in 2015 97 per cent of the electricity was produced by oil amounting to 34 ktoe (AFREC, 2015). Net imports of oil in 2015 were 131 ktoe (AFREC, 2015). The one refinery stopped operations in 1991 when the political situation deteriorated (REEEP, 2012).

Wind

The extensive coastline with the presence of attractive offshore winds lends itself particularly to the generation of wind energy. Measurements of wind speeds have ranged from a low of 3 m/s to a high of 11.4 m/s (FGS, 2015). Wind energy has been exploited for over 70 years primarily for water pumping. REEEP (2012) estimates that about half the land area has suitable wind speeds for power generation and this could help alleviate some of the existing pressures on forests for biomass energy and replace some of the diesel electricity generators thus contributing to emissions reduction (REEEP, 2012).

Geothermal

The signs for geothermal potential are poor (REEEP, 2012).

Solar

There is some potential to use the abundant solar energy resources and indeed it is already being exploited. The most common uses include lighting, cooking and water pumping and heating in both public and private buildings. Somalia receives an average solar insolation of between 5 and 7 kWh/ m^2/day translating into a total energy capacity of 2,163 million MWh/year (REEEP, 2012) (FGS, 2015).

Tracking progress towards sustainable energy for all (SE4All)

The three ‘semi-autonomous’ regions of Somalia (Somaliland, Puntland and South-Central Somalia) each have their own separate electricity network. Most of these networks are run by the private sector and based on thermal generation. The country has a national level electrification rate of 32.7 per cent ; 17.3 per cent of rural areas have access to electricity and in urban areas, it is 57.7 per cent (Table 3) (World Bank, 2016). In Puntland, only the main towns like Bosaso have electricity, while in South-Central Somalia, two-thirds of households in Mogadishu and under almost a quarter of households in Merka have access to electricity for lighting (REEEP, 2012).

In the absence of adequate electricity supply, firewood and charcoal remain the main sources of energy. As a result actual consumption of energy is low in comparison with other countries ranging from 20 to 50 kWh/per day per person for cooking and lighting homes and streets (Afgarshe, 2015). Access to modern fuels in 2012 was 4.58 per cent ; only 4 per cent and 5 per cent of rural and urban areas, respectively, use non-solid fuels (World Bank, 2015); (World Bank, 2016).

The share of renewable energy in the total final energy consumption (TFEC) has remained high over the years. In 1990, it was 100 per cent of the energy mix, declining to 94.3 per cent in 2012. Traditional solid biofuels form the biggest share of renewable sources at 65.8 per cent of TFEC in 2012, while modern solid biofuels contributed 28.6 per cent (World Bank, 2015).

Table 3: Somalia’s progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	22	26	29	32.7		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	4	4.58		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	100.0	96.3	94.8	94.3		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)					54.93	54.69

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
32.7% 	4.58%	NA	94.2% 

Table 4: Somalia’s key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Accelerate diffusion of energy efficient cook - stoves for reduction in charcoal consumption
*Promote sustainable and efficient production of charcoal (green charcoal) for local consumption
*Manage energy Plantations sustainably to meet the local demand of charcoal and fuel wood
*Establish Liquefied Petroleum Gas (LPG) market and accelerate diffusion to shift from charcoal to LPG in main urban centers
*Introduce biogas as an alternative source of energy in areas with heavy loads of biodegradable feedstock
*Establish of solar energy market and accelerate diffusion of solar energy equipment to reduce local charcoal production

Source: (MEM, 2015)

Table 5: Somalia's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	In Somaliland: • Ministry of Mining, Energy and Water Resources • Somaliland Energy Commission • Transitional Federal Government: There are Energy Authorities in Puntland and Somaliland.
Presence of a Functional Energy Regulator	
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	• Electricity is supplied by government agencies in the regions of Puntland and Somaliland. • Puntland Electric Energy Authority owns the Bosasso, Ghardo and Garowe power stations.
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	Somaliland Electrical Energy Act of 2013

This table was compiled with material from (REEEP, 2012) and (Vreden, Wigan, Kruze, Dyhr-Mikkelsen, & Lindboe, 2010)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Thermal energy is a major source of electricity and the utilization of renewable energy resources such as solar, hydroelectric and wind are opportunities that could be used to reduce contributions to global climate change. Somalia has articulated its energy-related Intended Nationally Determined Contributions (INDC) in line with international requirements. Those related to energy are listed in Table 4.

Institutional and Legal Framework

Somalia has great potential for developing energy from various resources. However, the long period of civil strife has led to serious deficiencies in energy infrastructure development. The Ministry of Energy and Water is in charge of the energy sector. There is no legal framework governing the entire territory although some regions have developed energy sector laws, such as the Somaliland Electrical Energy Act of 2013 that could provide guidelines for Puntland and South Central Somalia (Table 5).

South Africa

Figure 1: Energy profile of South Africa

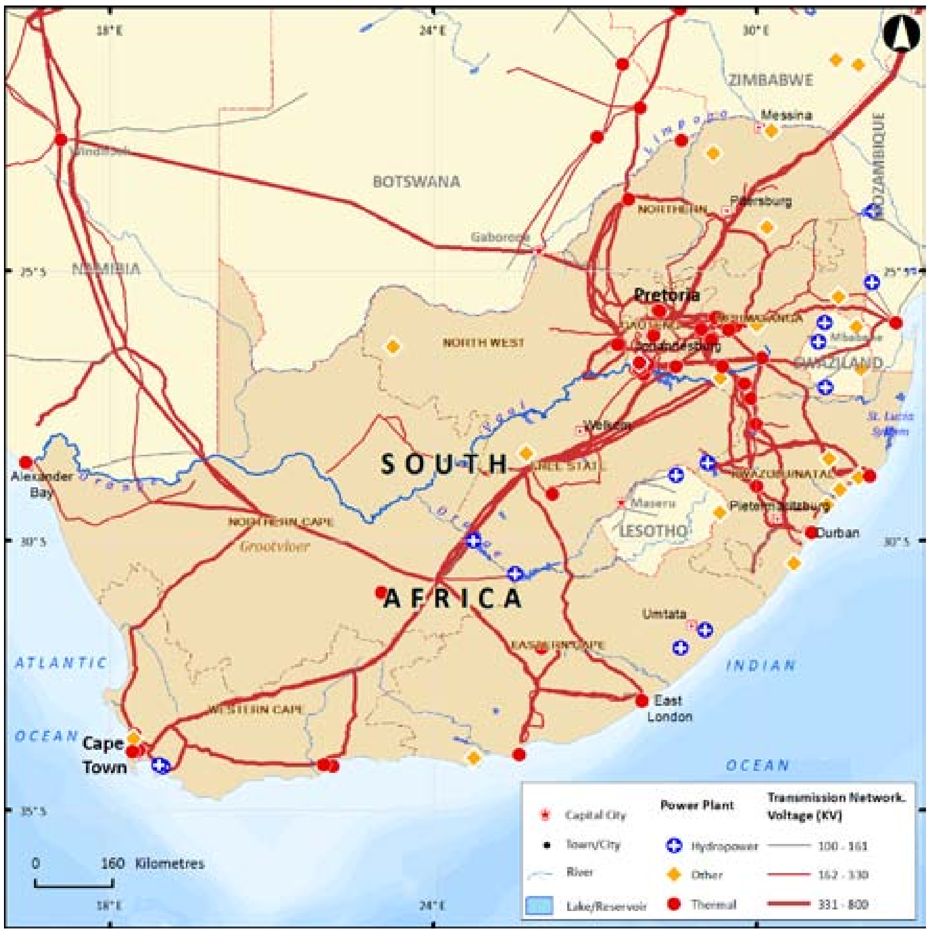
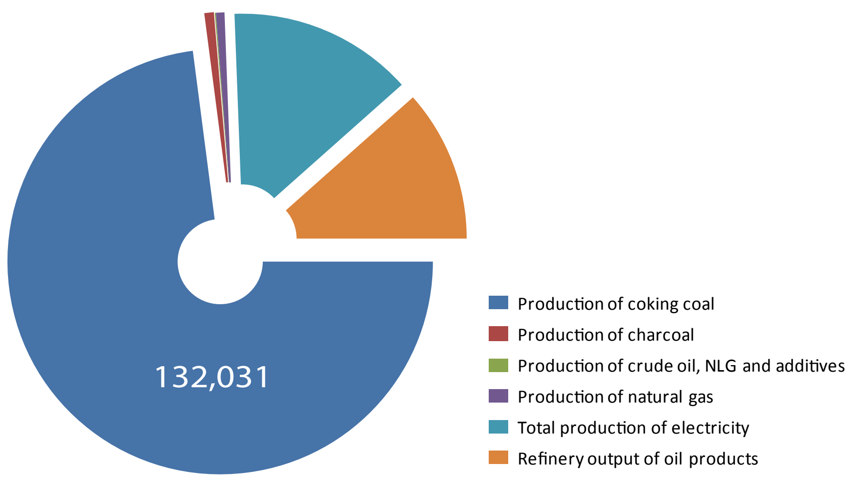
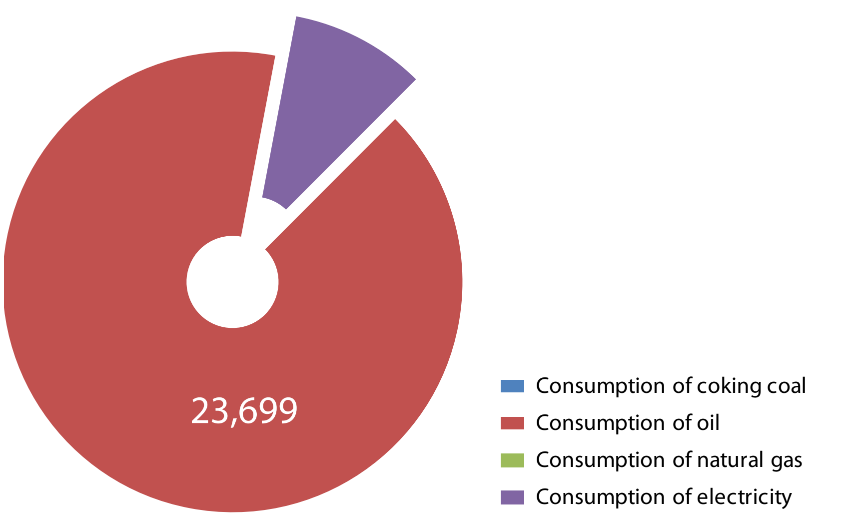


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

South Africa's population in 2013 was 53.16 million, as shown in Table 1. In 2015, total electricity produced was 25,399 ktoe, of which 90 per cent was produced from fossil fuels, 4.8 per cent from nuclear and 4.3 per cent from hydro. Final electricity consumption was 20,877 ktoe in the same year (Table 2) (AFREC, 2015). Figures 2 and 3 show the key energy statistics

Table 1: South Africa's' key indicators

Key indicators	Amount
Population (million)	53.16
GDP (billion 2005 USD)	323.75
CO_2 emission (Mt of CO_2)	420.40

Source: (World Bank, 2015)

Energy Resources

Biomass

The use of biomass in electricity production is currently minimal, despite its actual potential A futuristic outlook points to between 9 to 16 per cent of the total energy demand being met by biomass. The feedstock for this could potentially be agricultural waste including bagasse, forestry residues and other bio-energy crops such as jatropha (REEEP, 2014). There have been investments in biogas at a domestic and municipal level. For instance, in Durban, the third most populous town in the country, two waste-to-energy projects from landfill sites have been built (REEEP, 2014).

Hydropower

There is potential to increase electricity supply by expanding hydropower generation. There has been a preference for pumped storage hydropower plants with electricity being generated from the following plants: Lima (1,500 MW), Ingula (1,332 MW), Drakensberg (1,000 MW) and the Palmiet (200 MW) (WEC, 2013). Typically, South Africa is a dry country with most of the rivers suitable for hydroelectricity generation located in the eastern part of the country. It is estimated that there could be up to 8,000 potential sites for the generation of micro hydropower (each between 5 and 100 kW) in the Eastern Cape and KwaZulu Natal provinces, but river seasonality in the face of climate change may place some barriers in developing this potential. In 2015, out of a total 25,399 ktoe of electricity produced, 1,114 ktoe of electricity was produced from hydro sources (AFREC, 2015).

Oil and natural gas

Oil production figures at the end of 2011 were 700 thousand tonnes (or 5,131 thousand barrels); 27.1 bcm of natural gas was also produced (WEC, 2013).

Peat

There is about 300 km^2 of peatland (WEC, 2013).

Coal

In 2011, South Africa had 30.2 billion tonnes of proven reserves of coal (bituminous, including anthracite) and produces about 0.25 billion tonnes of coal (WEC, 2013). It holds 95 per cent of Africa's total coal reserves and the ninth biggest recoverable coal reserves in the world (US Energy Information

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	114,541	125,161	130,138	132,031
Production of charcoal	1,064	1,159	1,251	1,304
Production of crude oil, NLG and additives	253	4113	173	156
Production of natural gas	1,553	2,572	1,401	1,170
Production of electricity from biofuels and waste	26	23	24	136
Production of electricity from fossil fuels	16,631	17,767	19,566	22,862
Production of nuclear electricity	1,119	971	1,101	1,221
Production of hydro electricity	314	503	438	1,114
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	48	92	65
Total production of electricity	18,090	19,312	21,221	25,399
Refinery output of oil products	25,387	27,859	21,948	20,943
Final Consumption of coking coal	12,098	12,856	9,807	10,546
Final consumption of oil	15,944	36,265	22,934	23,699
Final consumption of natural gas	1,544	2,058	1,928	1,847
Final consumption of electricity	15,307	18,550	20,005	20,877
Consumption of oil in industry	1,464	1,377	1,446	1,731
Consumption of natural gas in industry	0	0	1,927	1,862
Consumption of electricity in industry	8,336	9,719	10,356	9,584
Consumption of coking coal in industry	9,893	7,357	8,026	5,835
Consumption of oil in transport	11,440	14,022	15,572	15,087
Consumption of electricity in transport	463	477	309	312
Net imports of coking coal	-35,716	-36,499	-33,921	-34,439
Net imports of crude oil, NGL, Etc.	17,109	16,904	17,981	19,577
Net imports of oil product	-5,894	-7,336	4,435	3,988
Net imports of natural gas	0	2,055	2,904	3,732
Net imports of electricity	61	-201	-213	-457

(AFREC, 2015)

- : Data not applicable
0 : Data not available
(P): Projected

Administration, 2013). South Africa obtains 92.7 per cent of its electricity from coal; and given the very high carbon content of coal makes the country a chief emitter of greenhouse gases. For example, emissions of carbon dioxide in 2011 were 420.4 mt of CO2 (IEA, 2016). This makes South Africa the leading emitter of carbon dioxide in Africa and number 14 in the world (US Energy Information Administration, 2013). More than 25 per cent of the coal produced is exported. Eskom, the electricity utility, consumes about two-thirds of coal consumed in the country (WEC, 2013).

The three main areas where coal is found in South Africa as cited directly in WEC (2013) include:

- The shale Volksrust Formation in central and northern Mpumalanga province;
- The sandy Vryheid Formation of the northern part of the main Karoo basin and by far the most commercially important deposits; and
- The Molteno Formation, limited to the northeastern Cape.

Coal to liquids

Coal liquefaction is a process by which coal is used as the feed stock to produce an alternative petroleum fuel allowing coal to be substituted for oil. South Africa has been producing coal-derived fuels for over 60 years and daily production now stands at about 160,000 bbl (WEC, 2013). These fuels are used in motorized vehicles and commercial jets among others. About a third of the country's petrol and diesel needs are produced from local coal. Coal is a contentious fuel with air pollution and its impacts on health driving the process for the development and use of clean cooking fuels and replace traditional biomass or solid fuels with liquefied petroleum gas (LPG). Emerging coal technologies such as the production of dimethylether (DME) are gaining prominence as it can be used as a domestic fuel allowing the country to be free of the price volatility of crude oil (WEC, 2013).

Underground coal gasification

Sasol and Eskom have been conducting trials of Underground Coal Gasification (UCG) facilities for some time (WEC, 2013). UCG is a method of transforming coal that is still in the ground (especially that which is difficult or uneconomical to extract) into a combustible gas that can be used for as a synthetic natural gas or diesel fuel.

Wind

Wind energy industry in South Africa has been growing by leaps and bounds facilitated by the ample wind speeds that allow for electricity generation. In mountain areas wind speeds average 8 m/s at 10 m while at the coast it is about half that amount at the same height (REEEP, 2014). There are a number of operational wind farms and in 2014, wind power increased to 570 MW from a low of 10 MW in 2013 (GWEC, 2014). Given the country's struggles to meet growing energy demand in recent years, wind is a central part of the energy strategy going forward. The Integrated Resource Plan for Electricity aims to have 8.4 GW installed by 2030 with about 75 per cent of this online by 2025. Already 562 MW is under construction (GWEC, 2014).

Nuclear

The first commercial nuclear power reactor became operational in 1984 and the government is committed to developing a further 9,600 MWe in the next ten years, despite financial challenges. The Koeberg Nuclear Plant located near Cape Town generated about 12.7 TWh or about 5.3 per cent of total generated power in 2008. The plant, which is owned and operated by Eskom, the power utility, has two 900 MWe Pressurized Water Reactor (PWR) units that were commissioned in 1984-1985. In the May 2011 budget speech, the energy minister reaffirmed that by 2030, 22 per cent of new generating capacity would be nuclear and 14 per cent coal-fired. The budget also provided R586 million ($85 million) for the Nuclear Energy Corporation of South Africa (NECSA) for nuclear energy research and development (WEC, 2013).

Geothermal

The dominance of cheap coal in the energy sector has meant that there is currently no large-scale geothermal production in the country

Solar

South Africa has good solar resources with direct normal irradiance averages of over 7.0 kWh/m^2/day in many areas of the country (REEEP, 2014). Recently, the sector has received a boost with Eskom promoting the use of solar-powered geysers for domestic hot-water needs (REEEP, 2014).

Tracking progress towards sustainable energy for all (SE4All)

Access to electricity in South Africa was 85.4 per cent in 2012 (Table 3 and Figure 4) (World Bank, 2016). There is a disparity between rural and urban dwellers, with 66.9 per cent of those in rural areas having electricity compared with 96.6 per cent in urban areas (World Bank, 2015). The government aims to reach 97 per cent electrification — defined as universal access — by 2025 through a mix of on- and off-grid technologies (mainly solar home systems). Access to modern fuels was 86.7 per cent in 2012. In rural areas, 67 per cent use non-solid fuels compared with 96 per cent in urban areas (World Bank, 2016). In absolute terms, there was an increase in the population with access to non-solid fuels of 2.4 million (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the South African economy was 9.3 MJ per US dollar (2005 dollars at PPP) in 2012, down from 10.1 MJ per US dollar in 2010. The compound annual growth rate (CAGR) between 2010-2012 was -3.85 compared to -0.39 over the 20-year period 1990-2010. South Africa has an Energy Efficiency Plan, which had set a target of energy efficiency improvement of 12 per cent by 2015 (World Bank, 2015). A number of procedures and regulation plans are in place to ensure this, including the following:

- Minimum energy performance standards for appliances, equipment and lighting;
- The South African National Standards (SANS) 204 Energy Efficiency in Buildings, released for final comment in March 2011;
- The voluntary Energy Efficiency and Energy Demand Management Flagship Programme.

Table 3: South Africa's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	65	66	83	85.4		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	60	75	85	86.7		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	16.6	18.2	18.7	16.9		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			4.3	4.5 (2011)		4.69
	Level of primary energy intensity(MJ/$2005 PPP)	10.9		10.1	9.3	9.67	9.31

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

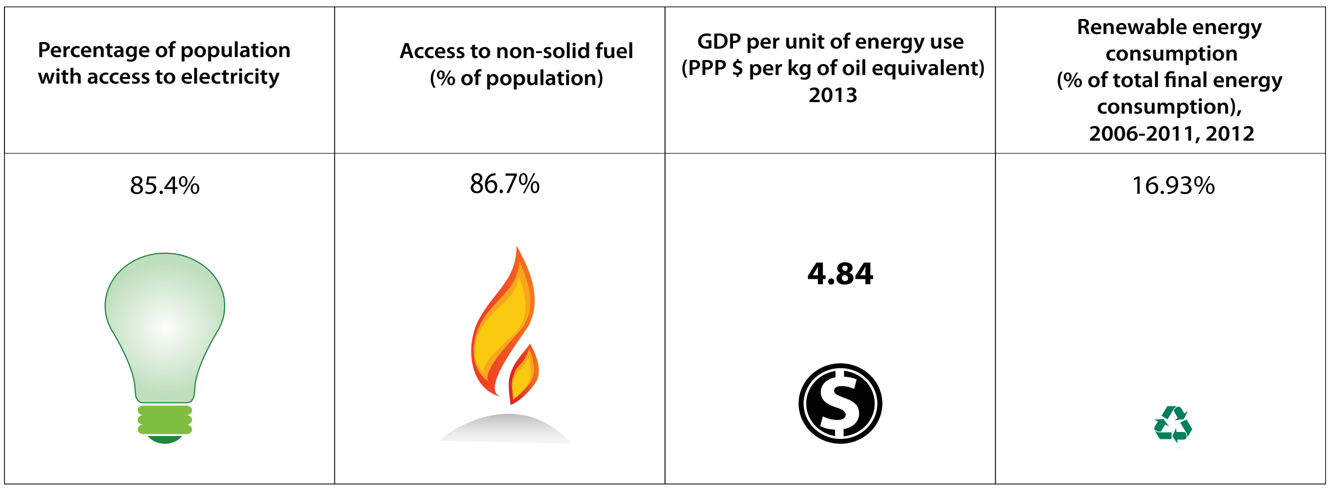


Table 4: South Africa's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Establish a Renewable Energy Independent Power Producer Procurement Programme (REI4P).
*Implement approved 79 renewable energy IPP (Independent Power Producer) projects for a total capacity of 5,243 MW, with private investment totaling ZAR 192 billion (approx. US $16 billion).
*Consider a package of projects totaling 6,300 MW in the public transport infrastructure.
*Support catalytic and demonstrative green economy initiatives.

Source: (MEM, 2015)

The share of renewable energy in the total final energy consumption (TFEC) in 2012 was 16.9 per cent , similar to the share in 1990. In 2010, the share of renewable energy in the TFEC was 18.7 per cent . Traditional solid biofuels form the biggest share of renewable sources at 13.7 per cent of TFEC in 2012. Renewable sources contributed only 1 per cent share of electricity generation in 2012.

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

South Africa plays an active role in the global initiatives on climate change and is committed to addressing climate change based on science and equity. The government has articulated the Intended Nationally Determined Contributions (INDC). Those related to energy are listed in Table 4.

Table 5: South Africa's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Department of Energy (DOE) • South African Nuclear Energy Corporation SOC Limited (NECSA) • National Radioactive Waste Disposal Institute (NRWDI) • Central Energy Fund (CEF) Group of companies under CEF (Proprietary) Limited • South African National Energy Development Institute (SANEDI)
Presence of a Functional Energy Regulator	• National Energy Regulator of South Africa (NERSA) • National Nuclear Regulator (NNR) • National Gas Regulator
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	ESKOM has monopoly of the power market but does not have exclusive generation rights in South Africa
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Southern African Power Pool (SAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Vertically integrated. But distribution activities were unbundled from ESKOM in 2003 and Regional Electricity Distributors (REDs) created operating under the Electricity Distribution Industry Holding Company (EDIH). However from 2010, the DOE took over the EDIH's mandate.
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	• Petroleum, Oil and Gas Corporation of South Africa (PetroSA), state-owned national oil and gas company, and has the monopoly in the oil, fuels and natural gas sectors (liquid fuels and gas market) • SASOL , private fuels and chemicals company, also operates Gas-to-Liquid facilities. • SASOL has the monopoly on the Coal-to-Liquid sector in South Africa.
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	Renewable Energy Independent Power Producer Programme (REIPPP)
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Department of Energy Strategic Plan 2015 – 2020) • White Paper on the Energy Policy 1998 • Integrated Energy Plan (IEP) 2003 • White Paper on Renewable Energy 2003 • Energy Efficiency Strategy 2005 • Biofuels Industrial Strategy 2007 • National Response to South Africa's Electricity Shortage 2008 • Renewable Energy Policy Roadmaps • Integrated Resource Plan (IRP) (2010-2030) 2011
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• National Energy Regulator Act, 2004 (Act No.40 of 2004) • Electricity Regulation Act, 2006 (Act No. 4 of 2006) • National Energy Act, 2008 (Act No. 34 of 2008) • Petroleum Products Act, 1977 (Act No. 120 of 1977 • Central Energy Fund Act, 1977 (Act No. 38 of 1977) • Nuclear Energy Act, 1999 (Act No. 46 of 1999) • National Nuclear Regulator Act, 1999 (Act No. 47 of 1999) • Petroleum Pipelines Act, 2003 (Act No. 60 of 2003) • Petroleum Pipelines Levies Act, 2004 (Act No. 28 of 2004) • Gas Act, 2001 (Act No. 48 of 2001) • Gas Regulator Levies Act, 2002 (Act No. 75 of 2002)

This table was compiled with material from (REEEP, 2012) and (Vreden, Wigan, Kruze, Dyhr-Mikkelsen, & Lindboe, 2010)

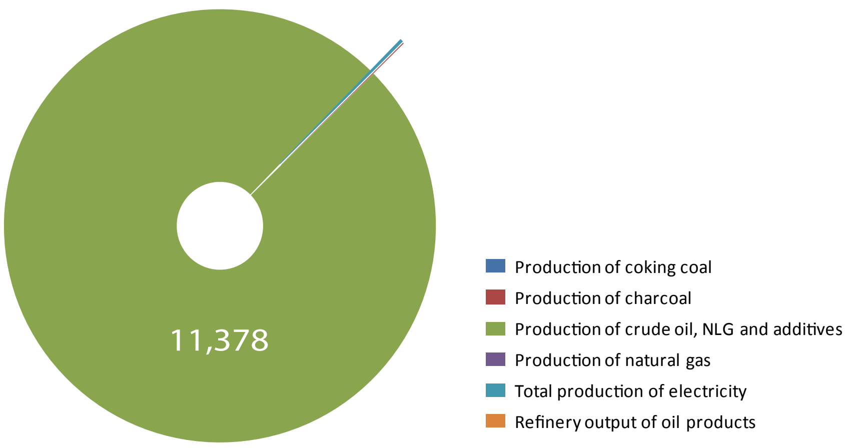
Institutional and Legal Framework

The South African Department of Energy (DOE) is in charge of the energy sector. The energy regulator is the National Energy Regulator of South Africa (NERSA). Eskom has monopoly of the power market but does not have exclusive generation rights. On a regional level, the country is a member of the Southern Africa Power Pool. The legal framework is provided by the National Energy Act, 2008. The Integrated Energy Plan (IEP) and the 2011 Integrated Resource Plan (IRP) will address the issue of clean energy, energy efficiency and energy security (Table 5).

South Sudan

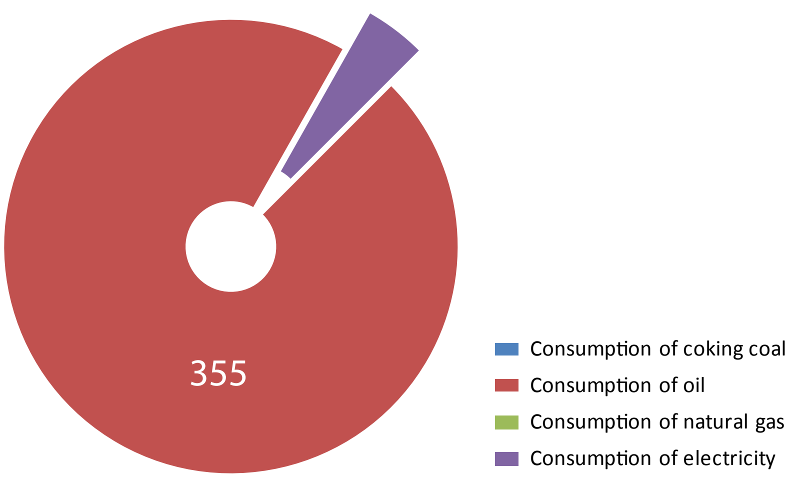
Figure 1: Energy profile of South Sudan

Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

The total population of South Sudan in 2013 was 11.3 million people (Table 1). Total production of electricity in 2015 was 28 ktoe, with 92.8 per cent from fossil fuels and 7.1 per cent from hydro sources. Final electricity consumption in 2015 was 16 ktoe (Table 2) (AFREC, 2015). Figures 2 and 3 show the energy production and consumption statistics.

Table 1: South Sudan's key indicators

Key indicators	Amount
Population	11.30
GDP (billion 2005 USD)	10.95
CO_2 emission (Mt of CO_2)	1.47

Source: (World Bank, 2015)

Energy Resources

The power infrastructure in the country is under-developed following long years of civil strife.

Biomass

The electricity sector is so undeveloped that about 70 per cent of South Sudan's populace depend on traditional biomass fuels such as woodfuel, charcoal, crop residue and animal dung to provide their cooking and heating energy needs (REEEP, 2012). In 2015, 8 ktoe of charcoal were produced (AFREC, 2015). The country is rich in forest and other woody biomass with just over 70 million hectares existing. The allowable cut is estimated at 29.3 million cubic metres but allowances need to made for changes in demand in light of population growth (REEEP, 2012).

Hydropower

As the River Nile flows through South Sudan, it presents many opportunities for hydropower generation from large plants to small hydro. Existing plants include: Fula (1,080 MW), Bedden (720 MW), Lekki (420 MW), Shukoli (250 MW) and Juba barrage (120 MW) (ROSS, 2014). The government is also investing in small hydro as a more efficient means of enabling access to electricity to the many communities scattered around the country. Small hydro plants may generate up to 40 MW of electricity and so far about 18 potential locations have been identified (ROSS, 2014). The Fula Small Hydropower plant is currently being developed and it is estimated that it will be able to provide Juba between 40 and 60 MW of power (AfDB, 2013).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	-	-	-	8
Production of crude oil, NLG and additives	-	-	-	11,378
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	-	-	-	-
Production of electricity from fossil fuels	-	-	-	26
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	-	-	-	2
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	-	-	-	-
Total production of electricity	-	-	-	28
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	-	-	-	355
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	-	-	-	16
Consumption of oil in industry	-	-	-	0
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	-	-	-	-
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	-	-	-	328
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	0
Net imports of oil product	-	-	-	456
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

\- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Oil and natural gas

South Sudan became independent in 2011 and this was a turning point in its history as an oil producing country. The oil infrastructure and refining capacity is all located in the Republic of Sudan in the north and political instability has greatly affected the mining and export of the petroleum resource. Oil is the cornerstone of the South Sudanese economy earning about 60 per cent of GDP in 2010 down from 98 per cent in 2008, and this has had significant impacts at the national level (AfDB, 2013) (REEEP, 2012). The data indicates that 11,378 ktoe of crude oil in 2015 (AFREC, 2015) and the proven reserves by the beginning of 2014 were 3.5 billion barrels of oil (US Energy Information Administration, 2014).

With the splitting of the two countries most of the oil producing blocks are located in South Sudan — about 70 per cent of the deposits (US Energy Administration, 2014). There are also some deposits in Abeyi, a disputed area on their common border (AfDB, 2013). South Sudan

The natural gas industry is underdeveloped and any gas that is produced along with the oil is flared or re-injected (WEC, 2013).

Wind

The potential for wind energy lies in rural electrification where distributed systems can easily be utilized. According to REEEP (2012) the wind power density is between 285 and 380 W/m^2 which implies good resources for wind power generation. There will be need to attract private investment to develop this sector (REEEP, 2012).

Geothermal

The location of South Sudan in the vicinity of the East African Rift System is a high indicator of geothermal potential which the government would be keen to exploit. The country has partnered with the Kenyan Geothermal Development Company (GDC) to carry out an assessment of its geothermal resource (REEEP, 2012).

Solar

South Sudan has about 8 hours of sunshine per day with a solar potential 436 W/m^2/year (REEEP, 2012). This can be successfully used to support electrification in the rural areas. Currently, solar energy is being used to supply more than 40,000 households to power a variety of devices that run on solar power such as electricity lighting, phone charging and radios. There are plans to increase the use of the country's high potential for solar energy to meet energy demand.

Tracking progress towards sustainable energy for all (SE4All)

The energy situation is a direct reflection of the state of conflict from which this country has recently emerged. It has rich hydropower potential, but most of electricity is generated from thermal sources and the supply is limited to a few towns. The existing electricity network is a trio of decentralised plants that transmit power to Juba (the capital), Malakal (capital of Eastern Nile State) and Wau (capital of Wau State). Electrification rates in South Sudan are the lowest in Africa. Local statistics indicate that South Sudan's Electricity Corporation has an installed capacity of 25 MW with approximately 15,000 consumers having access to an electricity network (ROSS, 2014). The World Bank (2015) indicates that only 5.1 per cent of people countrywide have access to electricity, with 3 per cent in rural areas and 12 per cent in urban areas (Table 3 and Figure 4). The Infrastructure Action Plan aims to expand generation capacity from the present 50 MW to about 580 MW by 2025 (AfDB, 2013).

Biomass meets the majority of the country's energy needs and indeed access to modern fuels is very low. In 2012, only 2 per cent of South Sudanese in both rural and urban areas were using non-solid fuels (World Bank, 2016). But under the Intended Nationally Determined Contributions (INDCs), South Sudan has indicated its intentions to increase the efficiency of biomass use, especially fuelwood and charcoal in the traditional energy sector.

There are no data on energy intensity or on the share of renewable energy in total final energy consumption.

Table 3: South Sudan's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	0	0	2	5.1		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	2	2		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption						
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)						

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
5.1%	**NA**	**NA**	**NA**

Table 4: South Sudan'skey aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Increase the use of clean and carbon-neutral energy.
*Construction of a hydroelectricity plant at the Fulla rapids.
*Increase the use of the country's high potential for solar and wind energy to meet energy demand.
*Increase the efficiency of biomass use (particularly fuel wood and charcoal) in the traditional energy sector.
*Increase efficiency of electricity usage in the formal energy sector and ensuring the best use of hydropower by a careful management of the water resources.

Source: (MEM, 2015)

Table 5: South Sudan's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Electricity and Dams (MoED) • Ministry of Petroleum and Mining (MoPM) • Planned reforms: Electricity Regulatory Agency, Petroleum Regulatory Agency and a Rural Electrification Agency are also proposed.
Presence of a Functional Energy Regulator	South Sudan Electricity Regulation Authority
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	East African Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	South Sudan Electricity Corporation (SSEC) is in charge of generation and transmission and sale of electricity to distributors.
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	The National Petroleum and Gas Corporation (NPGC) is the main policymaking and supervisory body in the upstream, midstream, and downstream segments of the hydrocarbon sector and is authorized to approve petroleum agreements on the government's behalf.
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	The Nile Petroleum Corporation (Nilepet), the national oil company is active in oil and gas exploration and production as a minority shareholder with foreign oil companies due to limited technical expertise and financial resource.
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Electricity Sector Policy 2007 • Draft South Sudan Petroleum Policy Paper (December 2010)
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Council of Ministers Order No.30/2006 • National Electricity Bill 2015 • Petroleum Act 2012

This table was prepared with material from (REEEP, 2012) and (ROSS, 2014)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

South Sudan's vulnerability to the impacts of climate change is compounded by the range of developmental challenges resulting from over half a century of conflict. However, the country is committed to its international obligations and published its Intended Nationally Determined Contributions (INDC). Those related to energy are listed in Table 4.

Institutional and Legal Framework

The Ministry of Electricity and Dams is in charge of the energy sector (Table 5). The energy regulator is the South Sudan Electricity Regulation Authority. The South Sudan Electricity Corporation (SSEC) is in charge of generation and transmission and the sale of electricity to distributors. On a regional level, the country is a targeted member of the Eastern Africa Power Pool. The legal framework is provided by the National Electricity Bill 2015, which has just been approved by Parliament. The main sector policy is the 2007 National Electricity Sector Policy. Much of the energy infrastructure in South Sudan is wanting and the government intends to develop clean energy options as much as possible.

Sudan

Figure 1: Energy profile of Sudan

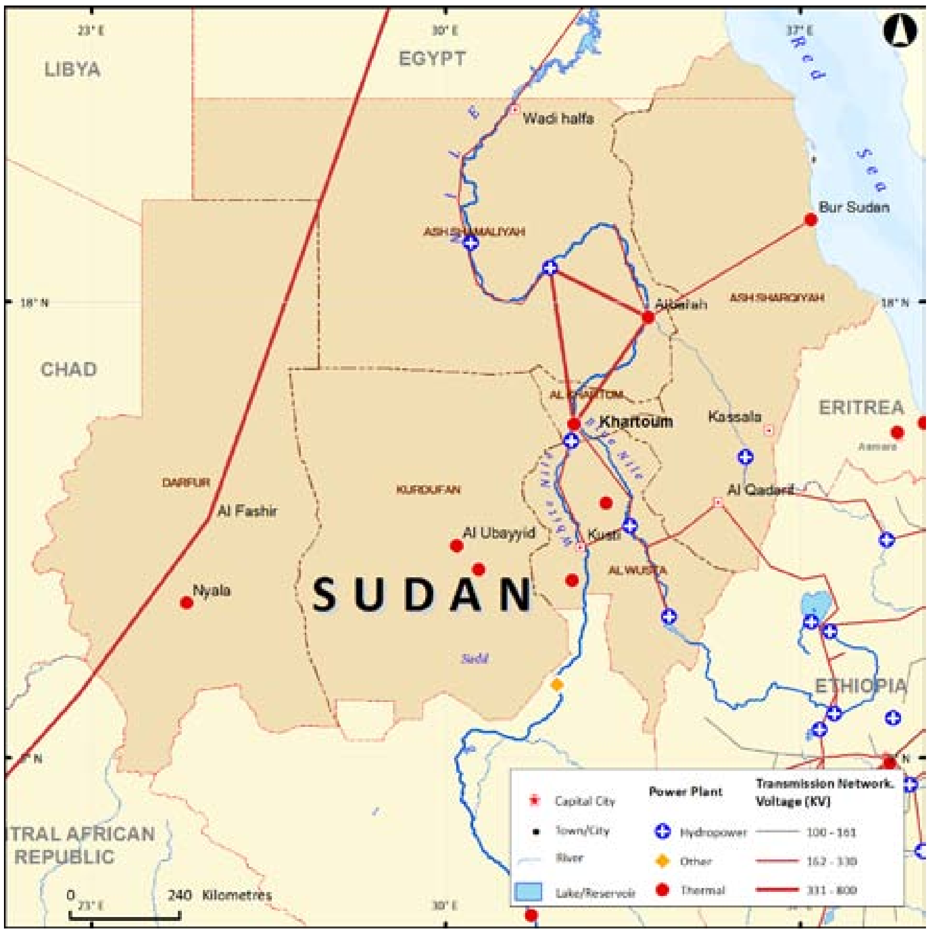
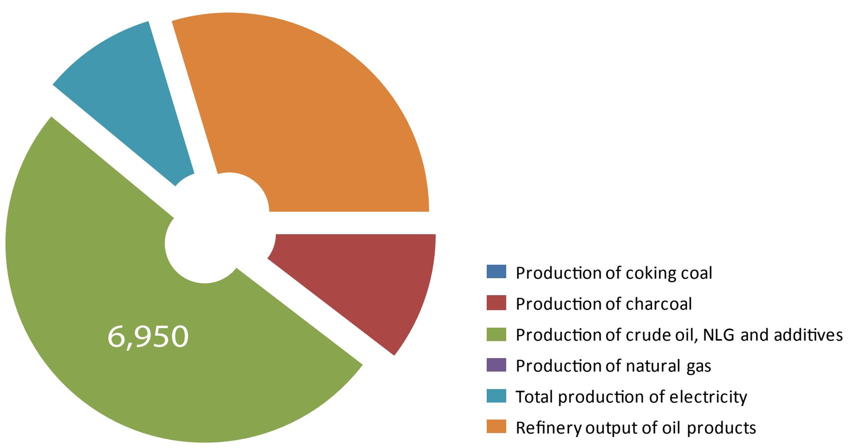
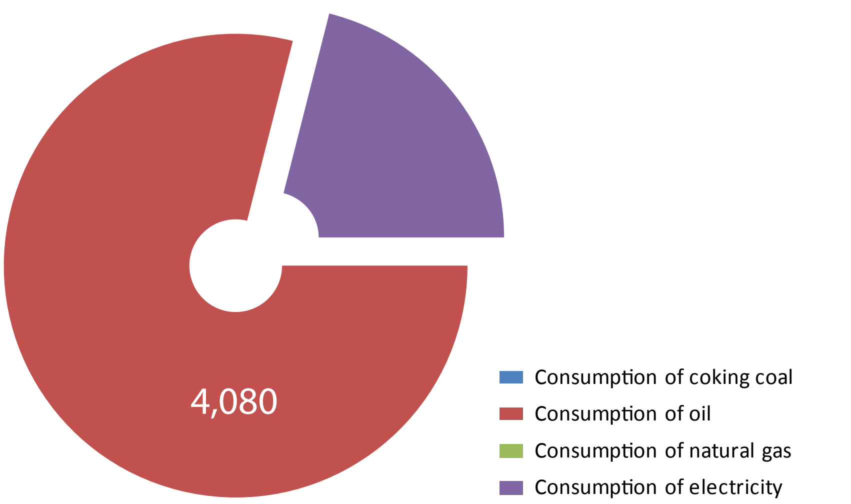


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Sudan's population in 2013 was 37.96 million, as shown in Table 1. Total electricity produced in 2015 was 1,281 ktoe, with 64.9 per cent produced from hydro, 33.6 per cent from fossil fuels and 1.32 per cent from biofuels and waste. Final electricity consumption in 2015 was 1,087 ktoe (Table 2) (AFREC, 2015). Figures 2 and 3 show the energy statistics.

Table 1: Sudan's key indicators

Key indicators	Amount
Population (million)	37.96
GDP (billion 2005 USD)	29.27
CO_2 emission (Mt of CO_2)	13.58

Source: (World Bank, 2015)

Energy Resources

Biomass

Traditional biomass provides most of the energy needs of the local population especially those who live in the countryside with no access to electricity. Fuelwood and charcoal provide about 75 per cent of energy needs (USAID, 2012). Charcoal produced in 2015 amounted to 1,431 ktoe (AFREC, 2015). The alternative biomass fuel sector is a growth industry with some sugar industries already using bagasse for cogeneration to supply their energy needs. Installed cogeneration capacity is just over 56 MW REEEP (2012). In terms of biofuels, the alien invasive Mesquite shrub (Prosopsis spp), agricultural wastes and livestock dung are both potential feedstocks. There are plans to use the alien invasive Mesquite shrub as a biofuel for domestic energy. In 2009, a bio-ethanol plant was established (REEEP, 2012) and in 2013 regulations to guide the biofuels industry were proposed.

Hydropower

Total potential for hydropower in the country is estimated at 4,860 MW (REEEP, 2012) and in 2015 electricity from hydropower amounted to 832 ktoe about 65 per cent of total electricity produced (AFREC, 2015). Electricity is generated from an array of power plants around the country including Merowe in the north, Upper Atbara and Seteit in the east, Sennar and the Roseires in the south, among others. The capacity of Merowe hydropower plant is 1,250 MW (REEEP, 2012). There is also potential for small hydro from various sites around the country.

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	1,711	1,511	1,368	1,431
Production of crude oil, NLG and additives	8,380	13,700	21,555	6,950
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	44	44	44	17
Production of electricity from fossil fuels	119	203	112	431
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	102	95	533	832
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	265	342	689	1,281
Refinery output of oil products	1,962	3,506	4,883	4,075
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	1,358	2,526	4,480	4,080
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	135	215	520	1,087
Consumption of oil in industry	207	286	1,206	777
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	29	36	76	100
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	1,001	2,017	2,789	2,802
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-6,184	-4,876	-6,822	-931
Net imports of oil product	515	640	409	860
Net imports of natural gas	-	-	-	-
Net imports of electricity	-	-	-	-

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Oil and natural gas

As in the case of South Sudan, oil plays a major role in the economy of the Republic of Sudan. In 2005, production of oil was 13,700 ktoe increasing to 21,555 in 2010. In 2015, however production had declined to a mere 6,950 ktoe (AFREC, 2015). This can be attributed to the fact that after 2011, most of the oil producing blocks were located in the newly independent South Sudan; and the Republic of Sudan remained with the oil infrastructure including pipelines and refineries. Most of the oil producing areas are on, or near, the border with South Sudan. Net imports of oil increased from 409 ktoe in 2010 to 860 ktoe in 2015 (AFREC, 2015). The government recently opened exploration bids for some new blocks hoping that new finds will help boost the oil sector (EOE, 2013). In 2015, 33.6 per cent of electricity produced was from fossil fuels (AFREC, 2015.

Wind

Although the use of wind energy is not widespread there is potential for rural electrification especially through off-grid solutions. This would strengthen energy security and enhance access to electricity. The Northeast Trade winds blow over the Red Sea in northern Sudan with speeds to a high of 6 m/s (REEEP, 2012). Current small-scale uses of wind energy include phone charging, domestic water pumping, and irrigation. But the government is keen to upscale generation of on-grid electricity from wind. Omene Energy, an IPP, is currently developing 500 MW of wind power along the Red Sea coast (REEEP, 2012) (Omer, undated).

Geothermal

There is about 400 MW of potential geothermal energy in Sudan (REEEP, 2012). Geothermal potential is located in different regions around the country. For instance, in the Darfur region the Jabel Marra volcano and the Tagbo and Beidob hills have registered good measurements; while further north towards the Red Sea there is geothermal activity near the Bayud volcano. Although there is currently no electricity from geothermal sources, the government is looking to neighbouring Kenya which has much experience in exploiting geothermal energy for guidance in this area (REEEP, 2012).

Solar

In 2015 electricity generated from solar and wind was only 1 ktoe (AFREC, 2015). However, there is potential for solar energy use to increase. The mean solar insolation in the country is 6.1 kWh/m2/day, which implies good potential for solar energy (REEEP, 2015). Solar is used in a variety of settings to provide energy for water pumping in agriculture, lighting and others in a variety of rural and peri-urban settings (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

The national electrification rate in Sudan is 32.6 per cent (Table 3 and Figure 4) (World Bank, 2016). In rural areas, 17.8 per cent have access to electricity, while in urban areas, the rate is higher at 62.1 per cent (World Bank, 2016). In 2010, Sudan had an electricity access deficit of 30.9 million people (World Bank, 2013a).

In 2012, only 27.9 per cent of the Sudanese people were using non-solid fuels; 16 per cent of these were in rural areas and 42 per cent in urban areas (World Bank, 2016); (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Sudanese economy was 5.3 MJ per US dollar (2005 dollars at PPP) in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was 7.13 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) decreased slightly to 64 per cent in 2012 from 66.6 per cent in 2010. Traditional solid biofuels form the biggest share of renewable sources at 41.2 per cent of TFEC in 2012, while modern solid biofuels contributed 18.7 per cent and hydro only 4.1 per cent (World Bank, 2015). Renewable sources contributed 70.1 per cent share of electricity generation in 2012 (World Bank, 2015). The government plans to integrate renewable energy in the power system of the Sudan, with a target of 20 per cent by 2030.

Table 3: Sudan's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	23	25	29	32.6		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	8	25	27.9		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	73.3	81.6	66.6	63.97		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						10.27 (2013)
	Level of primary energy intensity(MJ/$2005 PPP)	9.3		4.6	5.3	4.76	5.29

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
32.6%	27.9%	**10.61**	63.97%

Table 4: Sudan's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Integrate renewable energy in the power system of the Sudan with a target of 20 per cent by 2030 including Wind energy – 1,000 MW (grid connected);
Solar PV energy – 1,000 MW (on- and off-grid); Solar CSP technology - 100 MW (grid connected);
*Waste to Energy: -80 MW (grid connected); Biomass Potential - 80 MW (grid connected); Small Hydro Plants - 50 MW (grid connected).

Source: (MEM, 2015)

Oil installation on the road from Bentiu to Yida

Table 5: Sudan's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Mining • Ministry of Petroleum (MOP)
Presence of a Functional Energy Regulator	Electricity Regulatory Authority (ERA)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	The National Electricity Corporation (NEC) was the sole generator, transmitter and distributor of electric energy in Sudan. It was been unbundled in 2010 into the following companies: • Merowe Dam Electricity Company Ltd • Sudanese Hydropower Generation Company Ltd • Sudanese Thermal Power Generation Company Ltd • Sudanese Transmission Lines Company Ltd • Sudanese Electricity Distribution Company Ltd
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Sudanese Petroleum Cooperation (SPC)
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Strategic Plan for Sudan 2007-2011 • Sudan Renewable Energy Master Plan 2005
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Petroleum Wealth Act, 1998 • Regulations for Protection of the Environment in the Petroleum Industry 2001

This table was compiled with material from (REEEP, 2012)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Sudan aims to follow a low carbon development pathway in the three sectors of energy, forestry and waste, in line with national development priorities. The Intended Nationally Determined Contributions (INDC) were articulated in November 2015 and those related to energy are listed in Table 4.

Institutional and Legal Framework

The Ministry of Energy and Mining and the Ministry of Petroleum are in charge of the energy sector (Table 5). There are three energy regulators for electricity, oil and mining, as follows: Electricity Regulatory Authority (ERA), Sudanese Petroleum Cooperation (SPC) and Public Geological Research Authority (PRA), respectively. The National Electricity Corporation (NEC) is the sole generator, transmitter and distributor of electric energy in Sudan. On a regional level, Sudan is a member of greater East African Power Pool. The main sector policy is the National Strategic Plan for Sudan 2007-2011 and there is a Sudan Renewable Energy Master Plan 2005. The legal framework is provided by the Petroleum Wealth Act 1998, the Regulations for the Protection of the environment in the Petroleum Industry 2001 and subsequent amendments.

Swaziland

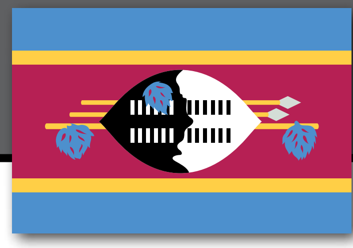


Figure 1: Energy profile of Swaziland

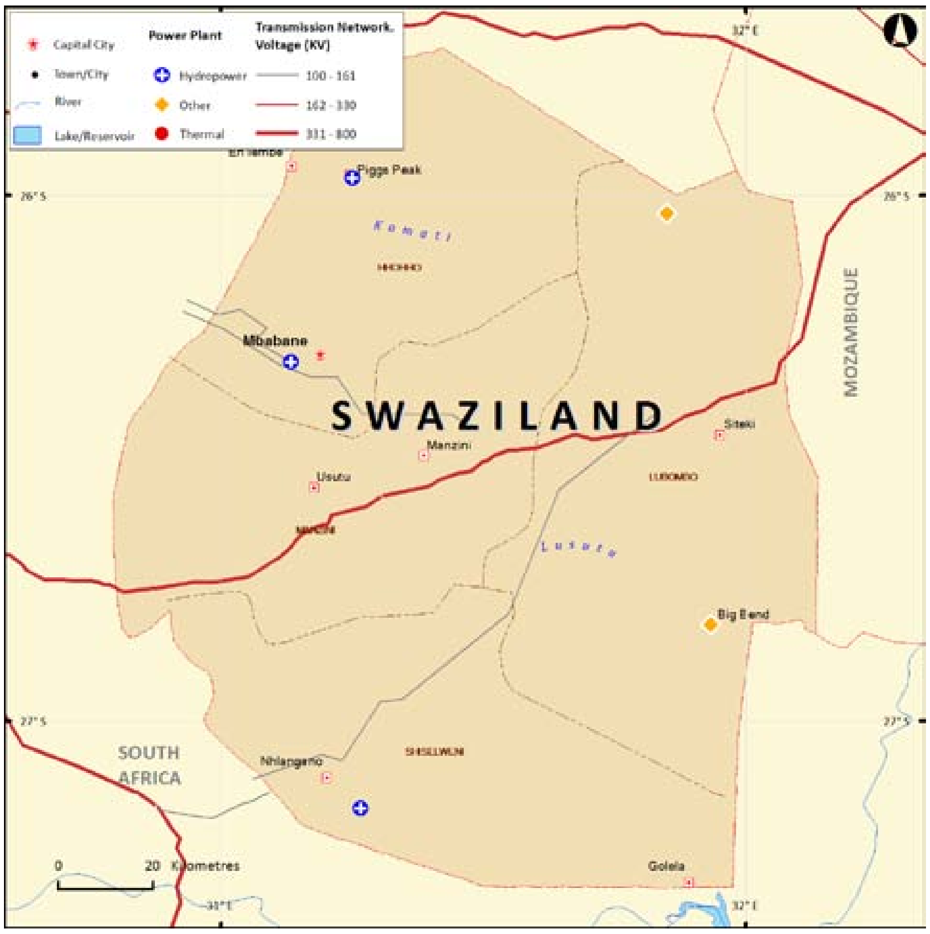
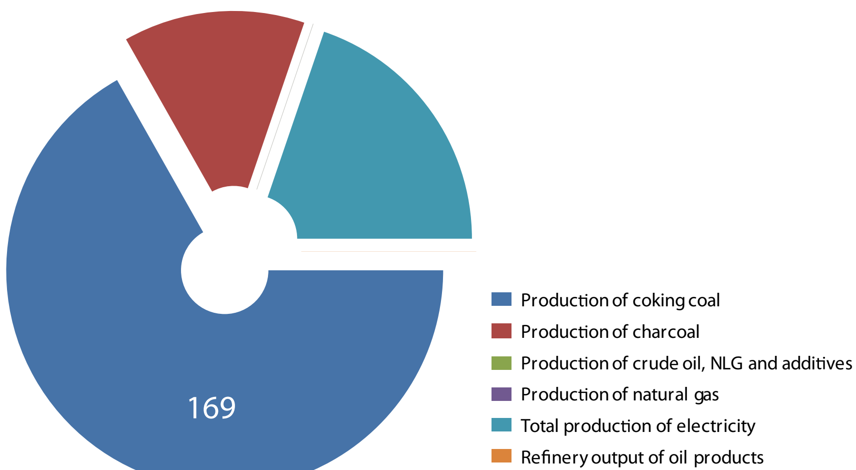
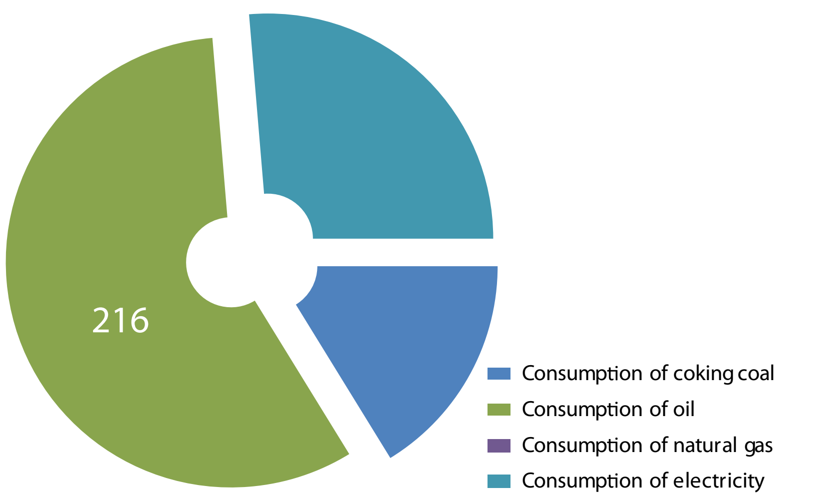


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Swaziland had a population of 1.25 million (Table 1). Electricity production in 2015 was 50 ktoe while final consumption of electricity was 99 ktoe, as shown in Table 2.

Table 1: Swaziland's key indicators

Key indicators	Amount
Population (million)	1.25
GDP (billion 2005 USD)	3.12
CO_2 emission (Mt of CO_2)	1.04

Source: (World Bank, 2015)

Energy Resources

Biomass

Swaziland has high levels of poverty, and biomass meets 90 per cent of domestic energy needs (IRENA, 2014). It is also an important energy source for industry through cogeneration. For instance sugar industry uses bagasse as feedstock to produce electricity and they have an installed capacity of 105 MW (IRENA, 2014) (REEEP, 2012). In 2010, traditional woody biomass contributed approximately 66 per cent of the national energy demand (IRENA, 2014). Wood-fuel production and charcoal production increased by 25 per cent and 50 per cent respectively between 2002 and 2012 (IRENA, 2014). In 2015, charcoal production amounted to 34 ktoe (AFREC, 2015). This has put the forests under severe pressure. Forests and woodlands cover about 625,400 ha, with 74 per cent being indigenous species (REEEP, 2012).

Increased efficiency in biomass usage, such as fuel-efficient cookstoves, is needed to protect the forests. With electricity imports from South Africa becoming increasingly difficult cogeneration is an option that should be exploited.

Table 2: Total energy statistics (ktoe)

Category / Catégorie	2000	2005	2010	2015 P
Production of coking coal	183	135	179	169
Production of charcoal	0	0	721	34
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	9	4
Production of electricity from fossil fuels	22	20	22	27
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	17	14	25	18
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	39	34	56	50
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	103	54	128	61
Final consumption of oil	177	177	239	216
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	90	106	113	99
Consumption of oil in industry	0	0	1	1
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	0	0	113	115
Consumption of coking coal in industry	0	0	17	16
Consumption of oil in transport	0	0	137	143
Consumption of electricity in transport	0	0	34	34
Net imports of coking coal	-178	-230	-246	-187
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	177	177	202	297
Net imports of natural gas	-	-	-	-
Net imports of electricity	53	75	78	41

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Hydropower

Electricity produced from hydropower in 2015 was 18 ktoe in 2015; and although this was down from 25 ktoe in 2010, hydro is still an important part of the energy mix in Swaziland (AFREC, 2015). The hydroelectricity power stations operated by the Swaziland Electricity Company (SEC) have an installed capacity of 61 MW equivalent to about 15 per cent of the total energy demand (WEC, 2013). The actual generation in 2011 was 69 GWh per annum (WEC. 2013).

Swaziland has 60.4 MW of small hydro in operation and the government is looking to develop more sites to augment supply. These include a total of 945 kW on the Mpuluzi, Lusushwana and Usutu Rivers (IRENA, 2014). Independent Power Producer are also engaged in the Swaziland energy sector.

Oil and natural gas

There are no known reserves of oil so all petroleum products are imported. Net imports have increased over the years from 177 ktoe in 2000 to 297 ktoe in 2015 (AFREC, 2015). In addition 54 per cent of electricity produced in 2015 was from fossil fuels (AFREC, 2015).

Coal

Coal is mainly used in the sugar industry for cogeneration.

Wind

The government has been looking into the possibility of exploiting wind to for rural electrification as part of its efforts to increase the share of renewables in the energy mix (REEEP, 2012). Average wind speeds of 4 m/s have been measured (REEEP, 2012).

Geothermal

The presence of hotsprings could be an indicator of geothermal energy, but research is needed to study this further (REEEP, 2012).

Solar

More research is needed in this area, but the data indicates Global Horizontal Irradiance figures of between 4 to 6 kWh/m^2/ day (REEEP, 2012). There are variations in solar intensity between the summer and winter months (IRENA, 2014). Solar is currently being used on a small-scale level in the country side. Efforts to upscale solar might not be feasible due to the large land requirement to host the solar panels. About 149 kW of solar PV has been installed in Bulembu, the Mbabane blood bank, the Luyengo campus of the University of Swaziland among others (IRENA, 2014).

Tracking progress towards sustainable energy for all (SE4All)

Swaziland had a national electrification rate of 42 per cent in 2012 (Table 3 and Figure 4). All the urban areas are fully electrified (100 per cent access) while only 24.5 per cent of rural areas have access to electricity (World Bank, 2016). The approach to rural electrification has mainly been through grid extension. Currently the electricity grid covers 70 per cent of the country (IRENA, 2014). Nationally, access to modern fuels is low, with only 38.37 per cent of the population using non-solid fuels; 20 per cent are in rural areas and 87 per cent in urban areas (World Bank, 2015).

In 2010, Swaziland had one of the highest energy intensities (the ratio of the quantity of energy consumption per unit of economic output) globally. In 2012, the energy intensity was 7.8 MJ per US dollar (2005 dollars at PPP). The compound annual growth rate (CAGR) between 2010 and 2012 was 1.10 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) in 2012 was 39.9 per cent . Traditional solid biofuels form the biggest share of renewable sources at 24.4 per cent of TFEC in 2012, while modern solid biofuels contributed 8.5 per cent and hydro 7.0 per cent . Renewable sources contributed a 40.3 per cent share of electricity capacity in 2012 (World Bank, 2015).

Table 3: Swaziland's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	29	32	35	42		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	26	34	38	38.37		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	84.3	46.8	35.7	39.9		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	13.5		20.45 (2007)			
	Level of primary energy intensity(MJ/$2005 PPP)	4.7		7.7	7.8	7.91	7.83

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
42%	38.37%	19.27	39.47%

Table 4: Swaziland's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Double the share of renewable energy in the national energy mix by 2030, relative to 2010 levels
*Implement small scale, decentralized renewable energy technologies to improve energy access in rural areas. This will also reduce the unsustainable wood harvesting practices that are currently undertaken
*Increase the use of grid-connected renewable technologies with fuel sources such as waste, solar, bagasse (from the sugar industry) and wood chips.

Source: (MEM, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Climate change is a national development priority and the country has published its Intended Nationally Determined Contributions as required by global obligations. The energy-related INDCs reiterate many of the country's policy objectives and are listed in Table 4.

Table 5: Swaziland's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Natural Resources and Energy
Presence of a Functional Energy Regulator	Energy Regulatory Authority
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Swaziland Electricity Company
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Policy 2003 • National Energy Policy Implementation Strategy 2009 • Swaziland Utilization of Renewable Energy Action Plan, 1997 • National Biofuels Development Strategy and Action Plan • Public Private Partnership policy 2013 • Renewable Energy Independent Power Producers Policy (REIPPP) (under development)
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/ no) most critical ones	• Electricity Act 2007 • Energy Regulatory Authority Act, 2007 • Petroleum Bill • IRENA Statute, 2011

This table was compiled with material from (REEEP, 2012) and (IRENA, 2014)

Institutional and Legal Framework

The Ministry of Natural Resources and Energy sets the policy framework for the country (Table 5). The sector regulator is the Energy Regulatory Authority. Swaziland Electricity Company handles generation, transmission and distribution. The Electricity Act 2007 is the main law regulating the electricity supply sector. Swaziland is a member of the Southern Africa Power Pool (SAPP). The Energy Policy was developed in 2003 to address energy issues in light of the national development plan, with renewable and energy from alternative sources a cornerstone of the policy.

Komati River Maguga Dam, Swaziland

Tanzania

Figure 1: Energy profile of Tanzania

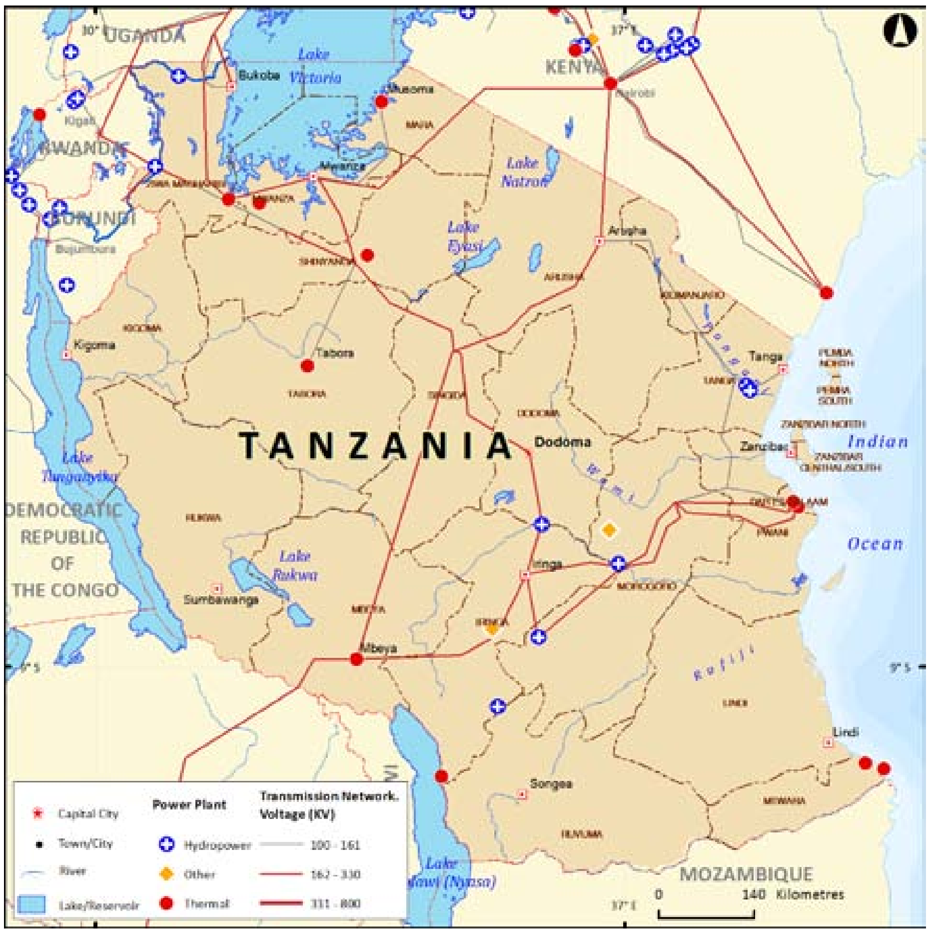
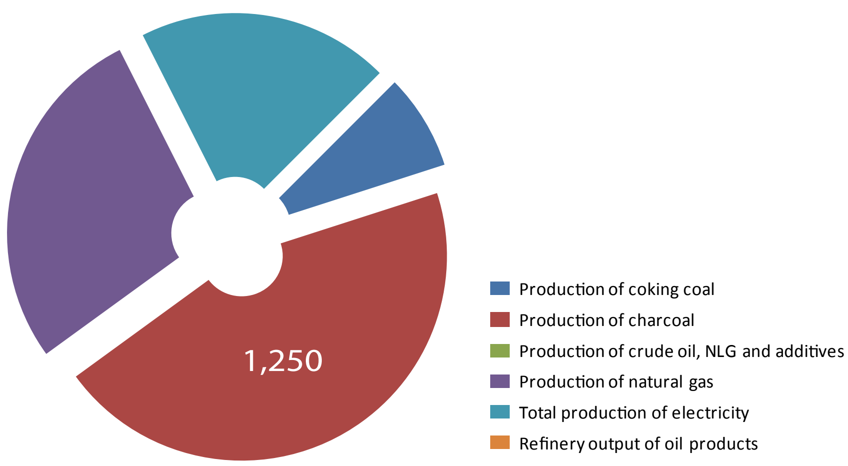
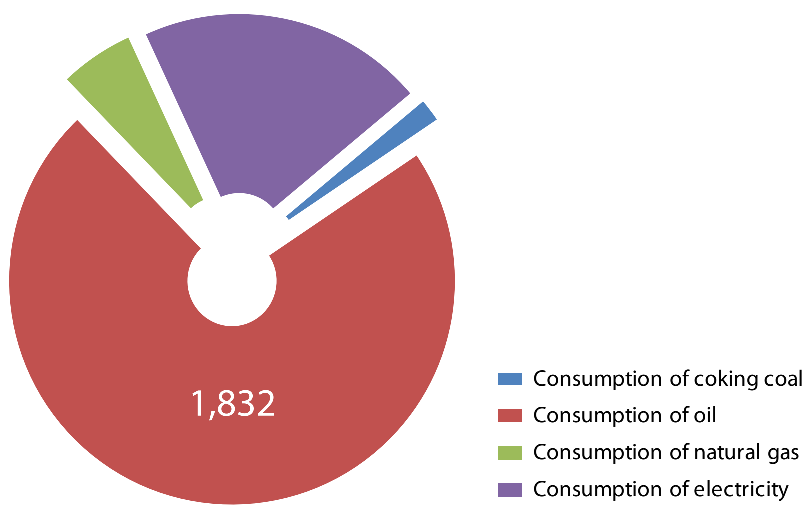


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Tanzania had a population of 49.25 million (Table 1). Total electricity production in 2015 was 555 ktoe, with 70.9 per cent from fossil fuels and 27.2 per cent from hydro sources, as shown in Table 2. Final consumption of electricity was 526 ktoe in 2015 (AFREC, 2015). Figures 2 and 3 show the main energy statistics.

Table 1:Tanzania's key indicators

Key indicators	Amount
Population (million)	49.25
GDP (billion 2005 USD)	23.30
CO_2 emission (Mt of CO_2)	9.70

Source: (IEA, 2016)

Energy Resources

Biomass

Only 10 per cent of total energy consumption is provided by petroleum and hydroelectricity with the balance coming from biomass (REEEP, 2014). These proportions are a direct indicator of the country's level of development. Tanzania has a forested area of about 35.5 million hectares and this feeds a huge commercial charcoal industry placing the forests under growing pressure (REEEP, 2014). Commercial firewood and charcoal are both big revenue earners especially in the rural areas and demand has grown over the past 15 years. For instance, in 2000, the production of charcoal was 699 ktoe increasing to 1,154 in 2010 and 1,250 in 2015 (AFREC, 2015). In 2012, demand for charcoal outside the urban domestic sector was about 300,000 tonnes of charcoal (Camco Clean Energy (Tanzania) Ltd , 2014).

Hydropower

Tanzania's hydropower potential is estimated at 4.7 GW, but so far only 705 MW of the potential installed capacity has been developed (REEEP, 2014). Of the 555 ktoe of electricity produced in 2015, 151 ktoe was produced from hydro sources in the same year (AFREC, 2015). The installed capacity in 2011 was 561 MW with most of this power is generated at Mtera and Kidatu dams on the Great Ruaha River in south-central Tanzania (WEC, 2013). Other power stations include Kihansi, Pangani, Hale and Nyumba ya Mungu with installed capacities of 180, 68, 21 and 8 MW respectively.

Planned developments include Ruhudji (360 MW) on the Ruhudji River in the south, Rumakali (220 MW) on the Rumakali River that drains into Lake Nyasa, and Stieglers Gorge (2,100 MW) on River Rufiji (REEEP, 2014).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	44	42	54	210
Production of charcoal	699	1,066	1,154	1,250
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	0	127	715	766
Production of electricity from biofuels and waste	0	0	0	9
Production of electricity from fossil fuels	29	108	218	394
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	184	153	219	151
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	213	261	437	555
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	25	6	0	41
Final consumption of oil	693	705	1,453	1,832
Final consumption of natural gas	0	127	111	135
Final consumption of electricity	170	202	293	526
Consumption of oil in industry	114	94	67	89
Consumption of natural gas in industry	0	127	111	151
Consumption of electricity in industry	33	62	89	95
Consumption of coking coal in industry	25	6	0	41
Consumption of oil in transport	460	851	1,106	1,565
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	757	1,275	1,652	2,371
Net imports of natural gas	-	-	-	-
Net imports of electricity	5	12	5	5

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Oil and natural gas

Total production of electricity in 2015 was 555 ktoe. The electricity produced from fossil fuels in the same year was 394 ktoe or 70.9 per cent (AFREC, 2015). Net imports of petroleum products increased from 1,652 ktoe in 2010 to 2,371 ktoe in 2015 (AFREC, 2015). Development of natural gas for electricity is ongoing at the Songo Songo and

Mnazi Bay gas fields. Two other fields, Mkuranga and Kiliwani, are under appraisal. The proven recoverable reserves of natural gas at the end of 2011 were 6.5 bcm (WEC, 2013); by 2013, the total natural gas reserves discovered amounted to 46.5 trillion cubic feet, of which about 8 trillion cubic feet were in onshore fields (URT, 2014).

Petroleum exploration activities have led to the following gas discoveries listed verbatim from (URT, 2014):

- Songo Songo in Kilwa District, Lindi
- Mnazi Bay in Mtwara
- Mkuranga, coast region
- Kiliwani/East Songo Songo area
- Deep-sea Blocks 1, 3 and 4 by Ophir/BG southeast of Mafia Island and east of Mnazi Bay (some fields under exploration and partly under appraisal)
- Deep-sea Block 2 east of Lindi town by Statoil/ExxonMobil (some fields under exploration and partly under appraisal)
- Ntorya in Mtwara by Ndovu Resources/Aminex (planned for appraisal).

Wind

Tanzania is estimated to have good wind power potential, but research is still being carried out. The Indian Ocean coastline and areas in the Rift Valley shows promising wind speeds.

The government plans to build a 50 MW wind farm at Singida in the central part of the country (GWEC, 2014). In support of the renewable energy sector, work started on a new renewable energy policy in 2014, including a feed-in tariff for wind power and other renewable energy sources (GWEC, 2014).

Geothermal

Tanzania's location in the Rift Valley suggests a high potential for geothermal power generation; surveys indicate a potential of 450 MWe (Mnjokava, 2012). Investigations of hot springs in Rufigi district, Morogoro and Mara regions are promising (Mnjokava, 2012). But environmental issues need to be considered since geothermal exploitation might affect groundwater flows.

Solar

Tanzania is seeking to utilize its solar power beyond the traditional lighting and phone charging functions, by investigating large PV projects. The mean solar energy density is about 4.5kW/m^2/day (REEEP, 2014).

Tracking progress towards sustainable energy for all (SE4All)

Tanzania's national electrification rate lies at just 15.3 per cent — with less than 4 per cent in rural areas and 46.4 per cent in urban areas (World Bank, 2016). Energy demand is growing at the rate of 9-10 per cent each year (Muema & Shabbir, 2011). By 2012, only 4.24 per cent of Tanzanians had access to modern fuels, with 2 per cent in rural areas and 15 per cent in urban Tanzania (Table 4 and Figure 4) (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Tanzanian economy was 12.1 MJ per US dollar (2005 dollars at PPP) in 2012, showing almost no change from the 12.6 MJ per US dollar in 2010. The compound annual growth rate (CAGR) between 2010 and 2012 was -1.90 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) was 88.2 per cent in 2012. Traditional solid biofuels form the biggest share of renewable sources at 68.4 per cent of TFEC in 2012, while modern solid biofuels contributed 19.2 per cent and hydro only 0.6 per cent (World Bank, 2015).

Table 3:Tanzania's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 per cent of population with access to electricity	7	9	15	15.3		
	7.1.2 per cent of population with primary reliance on non-solid fuels	2	5	4	4.24		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	94.8	94.3	90.7	88.17		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			4.7	4.9 (2011)	4.83 (2013)	
	Level of primary energy intensity(MJ/$2005 PPP)	16.0		12.6	12.1	12.29	

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
15.3%	4.24%	**4.99**	88.17%

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Tanzania aims to put its economy on a climate resilient development pathway and its Intended Nationally Determined Contributions (INDCs) articulates actions to that end. Those related to energy are listed in Table 4.

Table 4: Tanzania's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Explore and invest in energy diversification system.
*Promote the use of energy efficient technologies and behavior.
*Enhance integrated basin catchment and upstream land management for hydro sources.
*Enhance the use of renewable energy potential across the country (hydro, solar, wind, biomass and geothermal).

Source: (MEM, 2015)

Table 5: Tanzania's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Energy and Minerals • Ministry for Petroleum Affairs • Rural Energy Agency
Presence of a Functional Energy Regulator	
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	• East African Power Pool (EAPP) • Southern Africa Power Pool (SAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	Tanzania Petroleum Development Corporation (TPDC)
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	• Energy and Water Utilities Regulatory Authority (EWURA) • Petroleum Importation Coordinator Ltd.
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• The draft National Energy Policy of 2015 • Petroleum Policy 2015 • Natural Gas Policy 2015 • Local Content Policy 2014 • Rural Energy Fund
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	Electricity Act (2008) Petroleum (Exploration and Production) Act 1980 Petroleum Act 2008 Rural Energy Act 2005

This table was compiled with material from (REEEP, 2014) and (URT, 2014)

Institutional and Legal Framework

The Ministry of Energy and Minerals is in charge of laying the policy foundation for the country (Table 5). In the upstream petroleum sector, the Ministry for Petroleum Affairs regulates the Tanzania Petroleum Development Corporation (TPDC), while in the downstream sector, regulatory oversight is provided by the Energy and Water Utilities Regulatory Authority (EWURA) as well as the Petroleum Importation Coordinator Ltd. The main law is the Electricity Act (2008). In 2015, a National Energy Policy was drafted, which proposes improving energy security and efficiency and the legal framework and unbundling the energy sector, among other actions (GWEC, 2014).

A boy stands under an electricity pylon in rural Tanzania

Togo

Figure 1: Energy profile of Togo

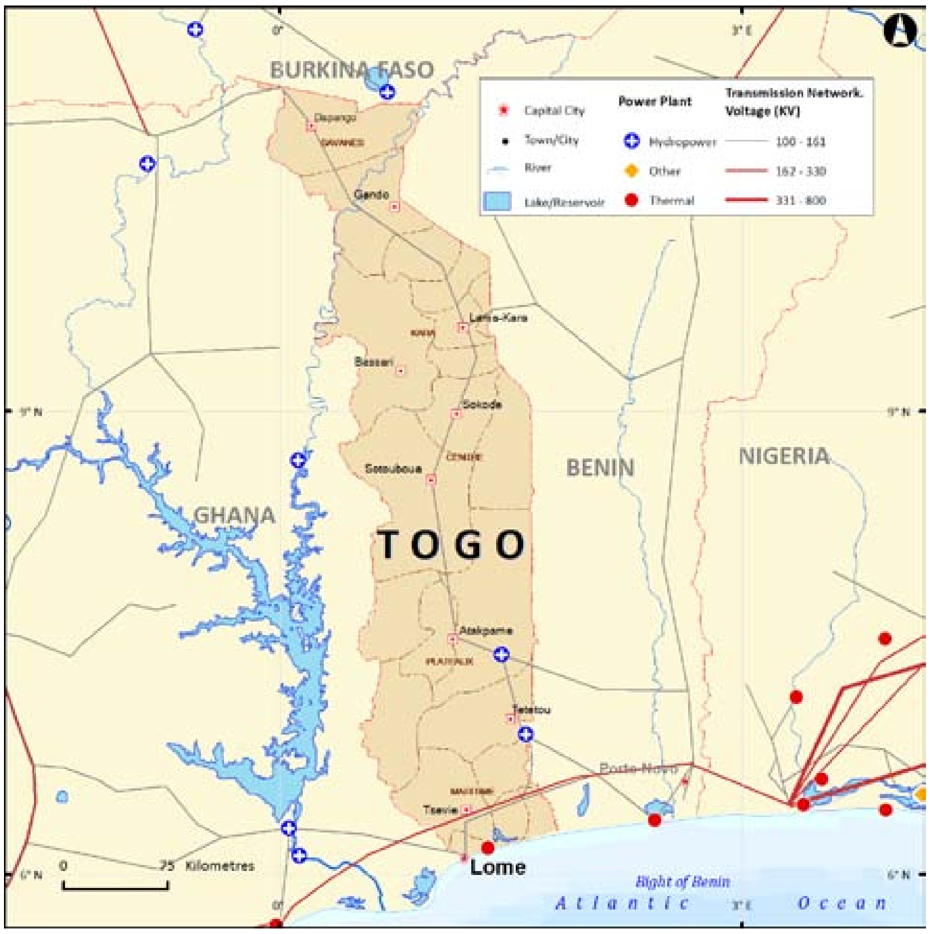
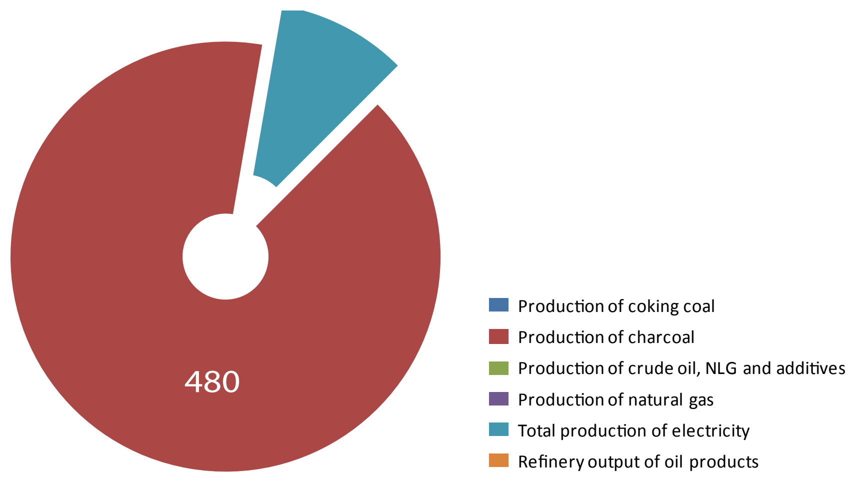
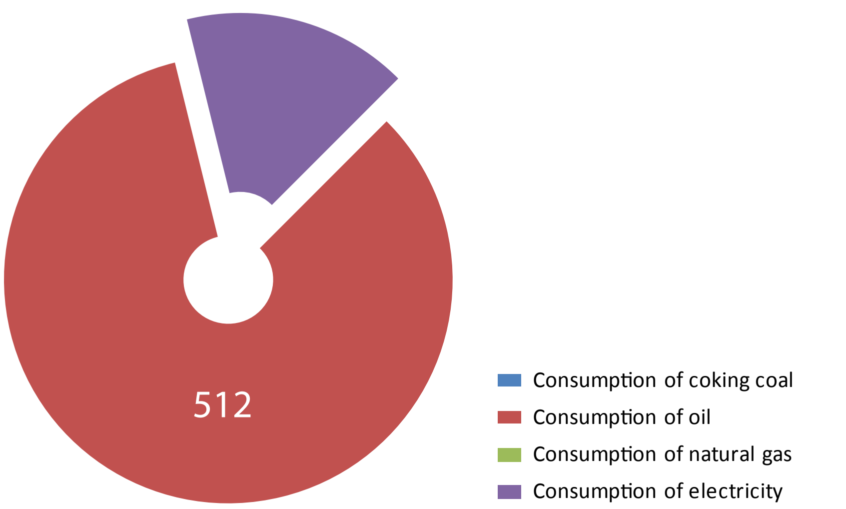


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Togo had a population of 6.82 million (Table 1). Total electricity production in 2015 was 52 ktoe, with 71.1 per cent from fossil fuels and 23 per cent from hydro sources. Final consumption of electricity was 52 ktoe in 2015 as shown in Table 2 (AFREC, 2015). Figures 2 and 3 show the main energy statistics.

Table 1: Togo's key indicators

Key indicators	Amount
Population (million)	6.82
GDP (billion 2005 USD)	2.89
CO_2 emission (Mt of CO_2)	1.67

Source: (World Bank, 2015)

Energy Resources

Biomass

Traditional biomass is an important energy source in Togo with the biomass potential estimated at 2,600 ktoe (REEEP, 2012). Charcoal production has been increasing over the years from 330 ktoe in 2000 to 480 ktoe in 2015 (AFREC, 2015). There is some biogas used but more investment is needed to expand its usage.

Nangbeto Hydroelectric Power Plant Togo

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	330	374	416	480
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	1
Production of electricity from fossil fuels	6	10	3	37
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	9	6	8	12
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	2
Total production of electricity	15	16	11	52
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	0	0	0	0
Final consumption of oil	288	342	641	512
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	40	52	58	100
Consumption of oil in industry	86	30	77	49
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	11	16	18	19
Consumption of coking coal in industry	0	0	0	0
Consumption of oil in transport	152	222	508	411
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	60	0	0	0
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	325	349	715	564
Net imports of natural gas	-	-	-	-
Net imports of electricity	32	44	61	57

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Hydropower

Togo had 66 MW of hydro-electric capacity installed in 2011 (WEC, 2013). Despite this and the potential for mini- and micro-hydroplants, on River Mono (eastern Togo) and River Oti (a transboundary river), the sector is undeveloped. The combined production capacity on these two rivers is about 224 MW (REEEP, 2012). Just 23 per cent of Togo's electricity comes from hydro-electricity (AFREC, 2015).

Oil and natural gas

Togo has no hydrocarbon deposits and all petroleum products are imported. In 2015, this amounted to 564 ktoe of oil products (AFREC, 2015).

Peat

There is about 10 km^2 of peatland (WEC, 2013).

Wind

There is much potential to exploit wind energy in Togo as the wind speeds recorded are fairly good. For instance, some of the coastal areas have recorded mean wind speeds between 5 m/s and as high as 6 m/s (REEEP, 2012) (MEF, 2014). The government has initiated a project to build a wind farm on 4,000 ha in a swamp near River Zio. Environmental issues regarding energy developments in wetlands will have be seriously considered. The farm will connect to the grid and provide between 5-7 per cent of the country's electricity on completion. A similar farm was developed in Cape Verde — the Cabeolica wind project in Cape Verde.

Geothermal

There has been no in-depth study to investigate potential in this sector (REEEP, 2012).

Solar

Togo still has a nascent solar industry despite the potential for solar energy. To date, solar has been used for off-grid services in rural areas such as water heating, telecommunications, school systems and other small-scale applications. The solar radiation is about 4.5 kWh/m^2/day (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

The national electrification rate is very low at 31.5 per cent , with 8.9 per cent electrification in rural areas and 67.6 per cent in urban areas (World Bank, 2016). Access to modern fuels is equally low. Electricity demand is growing at an annual rate of 8 per cent and will double over the next 10 years (Table 3). An additional 200 MW is needed to meet this demand (MEF, 2014). In 2012, only 4.75 per cent of the Togolese were using non-solid fuels; 2 per cent of these are in rural areas and 9 per cent in urban areas (World Bank, 2016); (World Bank, 2015).

Togo is among the countries with one of the highest energy intensities. The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Togolese economy was 15.0 MJ per US dollar (2005 dollars at PPP) in 2012, down slightly from 16.6 MJ per US dollar in 2010. The compound annual growth rate (CAGR) between 2010 and 2012 was -5.00 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) in 2012 was 72.7 per cent . Traditional solid biofuels form the biggest share of renewable sources at 60.3 per cent of TFEC in 2012, while modern solid biofuels contributed 3.9 per cent and hydro 3.4 per cent . Renewable sources contributed a 84.7 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Togo's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	10	17	28	31		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	2	4	4.75		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	78.7	77.1	76.1	72.7		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			2.9	3.0 (2011)		
	Level of primary energy intensity(MJ/$2005 PPP)	10.3		16.6	15.0		

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

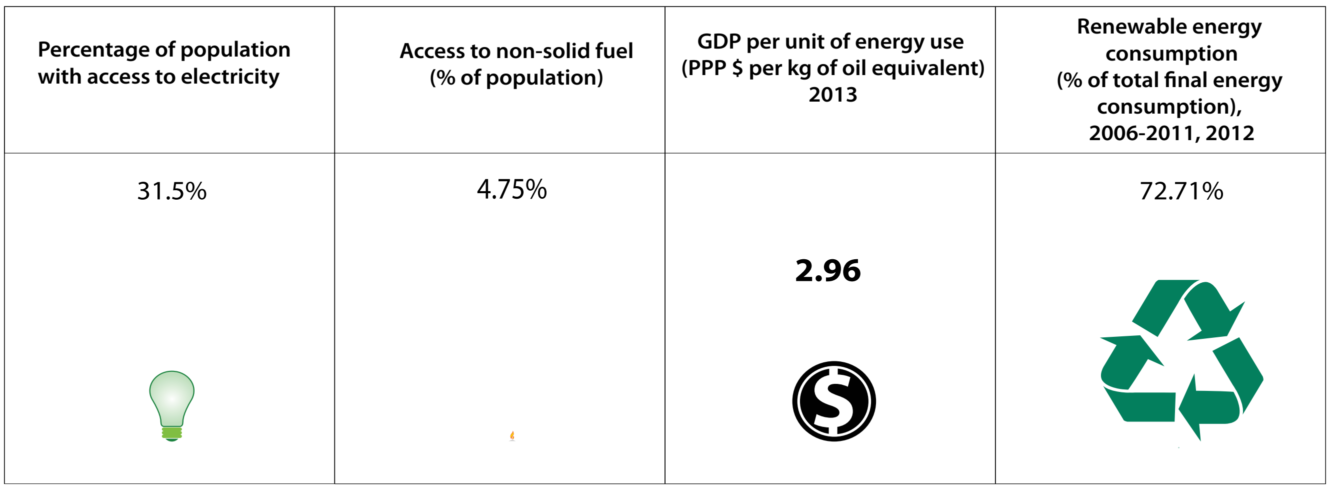


Table 4: Togo's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Produce and popularize energy-efficient stoves using wood, charcoal and gas among all of the country's social strata (a process that will need to begin with subsidies or appropriate tax benefits)
*Promote renewable energies (thermal, solar photovoltaic, micro-hydraulic, wind, etc.) by facilitating access to those technologies and training the populations on how to use and manage them
*Develop renewable energies (target of 4 per cent of the energy mix): promotion of bio-fuels and reclamation of degraded land; training and seeking out technical and financial partners for the production of new and renewable energies; tax remission on imports of solar and other renewable energies' equipment
*Implement a sustainable management of traditional energy sources (firewood and charcoal)
*Implement electricity-saving strategies
*Develop mini hybrid networks for rural electrification
*Promote low-carbon transport modes
*Promote new, clean technologies in the building sector

Source: (MEM, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Although Togo is a negligible emitter of greenhouse gases, it is subject to the impacts of global climate change. To that end, Togo

Table 5: Togo's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• Ministry of Mines and Energy • Proposal to establish a Rural Electrification Agency
Presence of a Functional Energy Regulator	Regulatory Authority for Electricity Sector (ARSE)
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	West African Power Pool (WAPP)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	Electricity Energy Company of Togo (CEET) is in charge of transmission and distribution of electricity Communaute Electrique du Benin (CEB), ddevelops generation and transmission infrastructure for Benin and Togo
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	Contour Global
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Policy and Strategy 2012 • Togo development strategy SCAPE 2013-2017 on renewable energy
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Agreement on the International Code of Benin-Togo Electricity 2003; • Law No. 2000-012 of 2000 on the electricity sector; • Decree No. 2000-089/PR of 2000 establishing the modalities for conducting activities regulated by law No. 2000-012; • Decree No. 2000-090/PR of 8 November 2000 on the organization and functioning of the Regulatory Authority for Electricity Sector.

This table was compiled with material from (REEEP, 2012) and (MEF, 2014)

has fulfilled its international commitments and published its Intended Nationally Determined Contributions (INDC). These are in line with its national development policy. The energy related INDCs are listed in Table 4.

Institutional and Legal Framework

The Ministry of Mines and Energy is in charge of the energy sector (Table 5). The Regulatory Authority for Electricity Sector (ARSE) is involved in project evaluation and selection, ensures compliance with electrical safety and technical standards and arbitrates disputes. The Benin Electricity Community (CEB), a binational entity, is in charge of importation and transportation for both Benin and Togo; it also concludes energy or electricity transit agreements and develops master plans for the generation and transmission of electricity. The Electricity Energy Company of Togo (CEET), a state owned company, is in charge of electricity transmission and distribution. At the regional level, Togo is a member of West African Power Pool.

The legal framework is provided by the Agreement on the International Code of Benin-Togo Electricity of 2003 and Law No. 2000-012 of 2000 on the electricity sector. Togo's Energy Policy and Strategy 2012 emphasizes a diversification of the energy mix with a focus on rural electrification; it also encourages the participation of the private sector and improvements in energy data and energy efficiency.

Tunisia

Figure 1: Energy profile of Tunisia

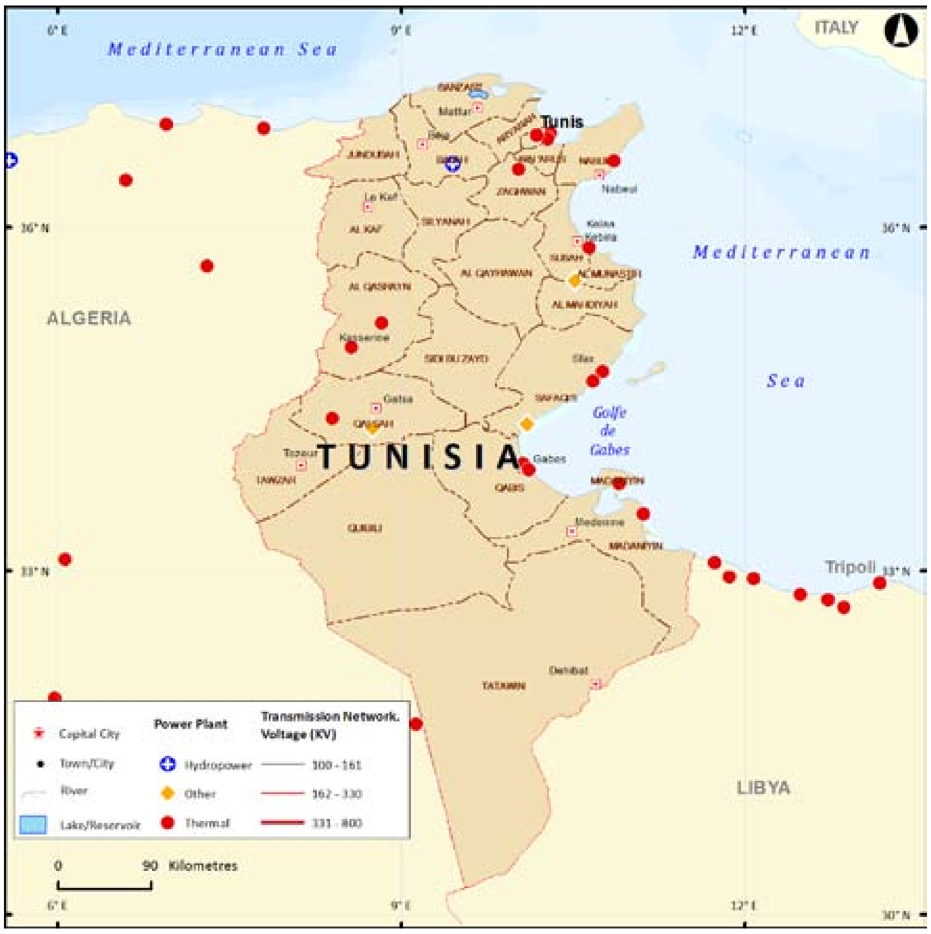
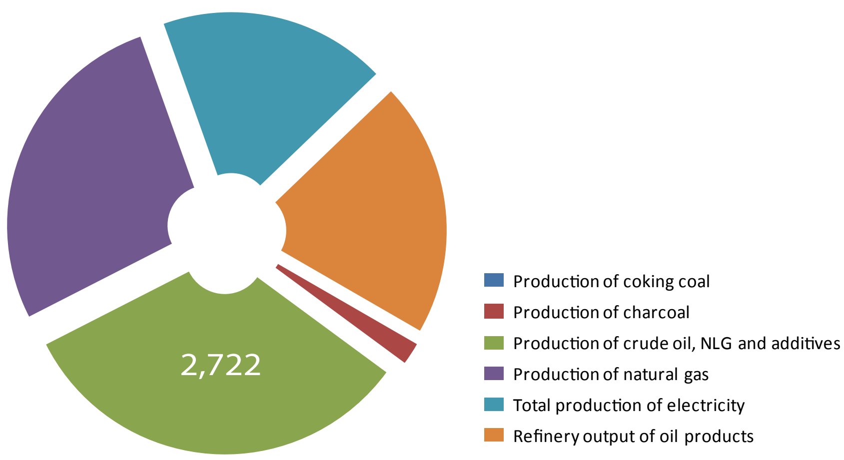
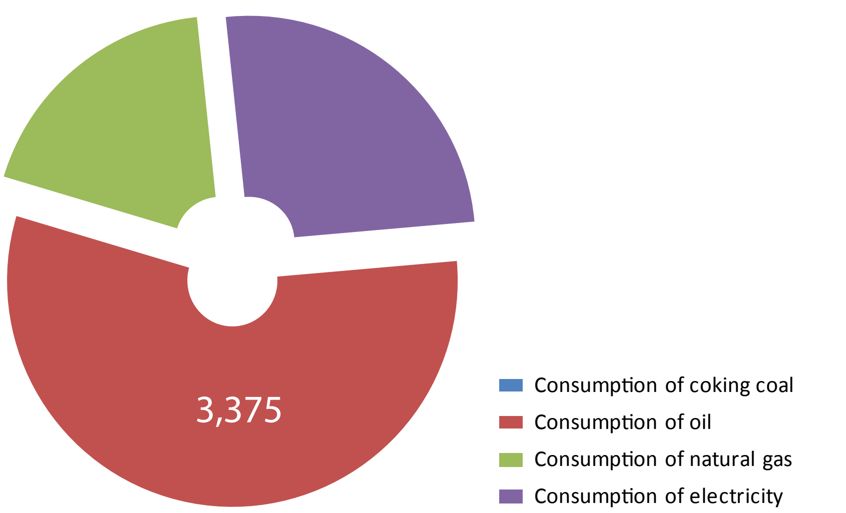


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Tunisia had a population of 10.89 million (Table 1). Total electricity production in 2015 was 1,523 ktoe, with 97 per cent from fossil fuels and 2.6 per cent from solar and wind energy. Final electricity production was 1,523 ktoe, as shown in Table 2 (AFREC, 2015). Figures 2 and 3 show the main energy statistics.

Table 1: Tunisia's key indicators

Key indicators	Amount
Population (million)	10.89
GDP (billion 2005 USD)	43.34
CO_2 emission (Mt of CO_2)	23.65

Source: (World Bank, 2015)

Energy Resources

Biomass

There is minimal use of traditional biomass fuels in Tunisia as almost the entire country has access to electricity and to non-solid fuels for cooking. Only 0.93 per cent of the rural population and 0.01 per cent of the urban population use wood or charcoal for cooking (World Bank, 2015). The production of charcoal has remained almost stable over the last decade averaging 150 ktoe over the last decade (AFREC, 2015). Wood is frequently used in the tabouna or traditional bread oven. There were efforts to improve improve fuel efficiency and reduce emissions through an improved lid design.

Other biomass energy projects include waste to energy project such as biomass gasification using poultry waste and a 10 MW waste-to-electricity project at the Jebel

Chakir landfill in the capital Tunis (REEEP, 2012). Feedstock for these waste-to-energy projects come from organic waste as listed in REEEP (2012):

- 2.2 million tonnes of household waste;
- 2.2 million tonnes from farms and agro-industry;
- 1 million tonnes from olive oil processing;
- 400,000 tonnes from poultry droppings; and
- 200,000 tonnes from waste-water treatment.

Hydropower

In 2015, the total electricity produced was 1,535 ktoe and only 5 ktoe of that was produced from hydro sources (AFREC, 2015). The installed hydropower capacity at the end of 2011 was 70 MW (WEC, 2013). Hydro electricity is not an important part of the energy mix, however government is in the process of developing more hydropower by building small and mini-hydro dams where feasible (REEEP, 2012).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	121	152	148	149
Production of crude oil, NLG and additives	3,445	3,201	3,453	2,722
Production of natural gas	2,095	2,323	2,980	2,276
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	861	1,102	1,368	1,490
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	6	12	4	5
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	2	4	12	40
Total production of electricity	868	1,118	1,421	1,535
Refinery output of oil products	1,635	1,569	255	1,725
Final Consumption of coking coal	66	0	0	0
Final consumption of oil	3,625	3,816	3,849	3,375
Final consumption of natural gas	641	844	1,228	1,128
Final consumption of electricity	779	966	1,165	1,523
Consumption of oil in industry	1,000	948	1,054	746
Consumption of natural gas in industry	476	593	880	1,019
Consumption of electricity in industry	397	407	440	414
Consumption of coking coal in industry	0	0	0	0
Consumption of oil in transport	1,561	1,667	1,921	1,726
Consumption of electricity in transport	9	3	26	10
Net imports of coking coal	0	0	0	0
Net imports of crude oil, NGL, Etc.	-1,623	-1,621	-3,457	-3,497
Net imports of oil product	2,568	3,080	3,806	2,959
Net imports of natural gas	1,736	1,861	2,231	2,666
Net imports of electricity	0	-3	2	-3

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Oil and natural gas

The proven oil recoverable reserves at the end of 2011 were 55 million tonnes (400 million barrels) and oil production figures were 3,700 thousand tonnes (72,121 thousand barrels). In 2011, the proven recoverable reserves of natural gas were 65.1 bcm (2,300.1 bcf) (WEC, 2013).

Peat

Tunisia has 1 km^2 of peatland (WEC, 2013).

Wind

According to the Wind Atlas for Tunisia published in 2009, several sites have been identified with good potential for wind power, with average wind speeds of between 5.9 to 6.73 m/s at 80 m (GIZ, 2013). Some of the potential sites include Zaghouan, Kasserine, Kebili and Nabeul, among others (GIZ, 2013) and when developed could eventually generate up to 1,000 MW of electricity (REEEP, 2013).

The gross wind energy potential in Tunisia is estimated at more than 8,000 MW (GIZ, 2013). By the end of 2013, wind power accounted for 245 MW (GWEC, Various years).

Geothermal

The southern part of the country, specifically, Kebili, Gabes and Tozeur regions, is rich in hot springs which are a good indicator of geothermal activity. The geothermal resources originate from the extensive Continental Intercalaire aquifer covering an area of 1 million km^2 and spreading into the neighbouring countries of Libya and Algeria. The aquifer is about 2.8 km deep and temperatures range from 30 to 80°C (REEEP, 2012), (Mohammed, 2015). The huge thermal resources amounting to about 1.1 billion m3 have been extensively used for heating greenhouses, irrigation and for recreational thermal baths (Mohammed, 2015). Although the proportions vary from region to region, agriculture utilizes the biggest share at 76 per cent followed by the drinking water and tourism sectors at 19 and 5 per cent respectively (Mohammed, 2015).

Solar

Tunisia has massive potential for solar energy and although it is currently under utilizing this potential, things are changing with the government paying more attention to this energy resource. The 2010-2016 Tunisian Solar Plan aims to increase the use of renewables in the energy mix by increasing the use of solar energy; and this is expected to result in national energy savings of 660 ktoe per annum (REEEP, 2012). The mean daily insolation was measured at 5.0-5.5 kWh/m^2 (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

By 2010, 100 per cent of Tunisian's had access to electricity in both rural and urban areas (World Bank, 2015). In addition, 99.96 per cent of the population also has access to non-solid fuels (World Bank, 2016). The high connection rate is the result of constant efforts by the government over the past 30 years (Table 3 and Figure 4).

Between the 1990-2000 and 2000-2010 period, energy intensity decreased from a compound annual growth rate (CAGR) of -0.73 per cent to -1.13 per cent . Over the tracking period 2010-2012, it further decreased to -2.77 per cent . The energy intensity of the Tunisian economy (the ratio of the quantity of energy consumption per unit of economic output) decreased from 3.9 MJ in 2010 to 3.6 MJ per US dollar (2005 dollars at PPP) (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) has been declining. In 1990, it was 14.5 per cent , decreasing to 13.05 per cent in 2012 (World Bank, 2015); (World Bank, 2016). Traditional biofuels such as woody biomass formed the biggest share of renewable sources at 12.1 per cent of TFEC in 2012, with modern biofuels and hydropower forming 0.2 and 0.1 per cent , respectively (World Bank, 2015). Renewable sources contributed only a 1.7 per cent share of electricity generation in 2012 (World Bank, 2013); (World Bank, 2015).

Table 3: Tunisia's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	93	95	100	100		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	84	94	100	99.96		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	14.5	14.2	14.6	13.05		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			11.4	11.5 (2011)	11.22 (2013)	
	Level of primary energy intensity(MJ/$2005 PPP)	4.6		3.9	3.6	3.64	3.64

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
100%	99.96%	11.59	13.05%

Table 4: Tunisia's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
* Intensify the promotion of energy efficiency in all consumer sectors and for all energy usages.
*Achieve an installed renewable energy capacity of 3,815 MW in 2030, including 1,755 MW for wind power, 1,610 MW for solar photovoltaic (PV) and 450 MW for concentrated solar power (CSP).
*Triple the solar water heater distribution rate, which will exceed 220 m^2 of collectors per 1,000 inhabitants in 2030, compared to 73 in 2015.

Source: (MEM, 2015)

Road side petrol station, Djerba, Tunisia

Carsten ten Brink/Flickr.com/CC BY-NC-ND 2.0

Table 5: Tunisia's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Industry and Energy (TMIE).
Presence of a Functional Energy Regulator	National Agency for Energy Conservation
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Comite Maghrebin de L'electricite (COMELEC)
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	(Société Tunisienne de l'Electricité et du Gaz, Tunisian Company for Electricity and Gas is the sole organization responsible for transmission and distribution and retains control of the existing power generation facilities
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	State owned Entreprise Tunisienne des Activités Pétrolières, Tunisian Refining Industry Company created in 1972 plans oil and gas explorations and manage national gas and petroleum wealth
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	(Société Nationale de Distribution des Pétroles, National Company of Oil Distribution shares the oil distribution market with some private companies (s.a. Total, Shell, BP, etc.)
Presence of Functional (Feed in Tariffs) FIT systems	To be determined by Minister of Industry
Presence Functional IPPs and their contribution	Carthage Power Company produces 10 per cent of electricity consumed (86 per cent by STEG)
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	Energy management programme 2008-2011
Energy Transition Fund	
Renewable Energy and Energy Efficiency Plan 2008	
National Fund for Energy Efficiency Subsidies	
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Energy Sector is Law No. 2004-72 of 2004 on the rational use of energy • Law No. 62-8 of 1962 that established the Société Tunisienne d'Electricité et du Gaz (STEG) • Law N° 2005-106 that created the National Energy Fund • Act 2009-7 of 2009 amending the 2004 Law on Energy Conservation to allow IPPs • Renewable energy law 2015

This table was compiled with material from (REEEP, undated) and (GIZ, 2013)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Tunisia aims to lower its carbon intensity by 41 per cent by 2030 compared to the 2010 base year. To do so, it proposes reducing its greenhouse gas emissions across all sectors. The country has published its Intended Nationally Determined Contributions (INDC). Those related to energy are listed in Table 5.

Institutional and Legal Framework

The Ministry of Industry and Energy is in charge of the energy sector (Table 5). The energy regulator is the National Agency for Energy Management. The state-owned Tunisian Company of Electricity and Gas (STEG) is the sole generator, transmitter and distributor of electric energy. On a regional level, Tunisia is a member of Comite Maghrebin de L'electricite (COMELEC), the power pool of the Magreb region. There are also interconnections with the European Electricity Grid to export up to 1,000 MW (800 MW gas and 200 MW Renewable Energy (RE)).

Article 44 of the new Tunisian Constitution of 2014 commits the government to "provide the means necessary to guarantee a healthy and balanced environment and contribute to the climate's integrity" (GOT, 2015). The energy sector is central to the policy of addressing climate change.

Uganda

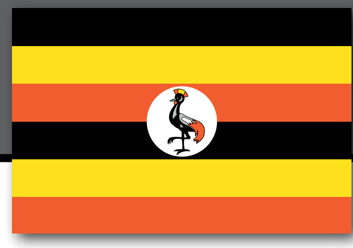


Figure 1: Energy profile of Uganda

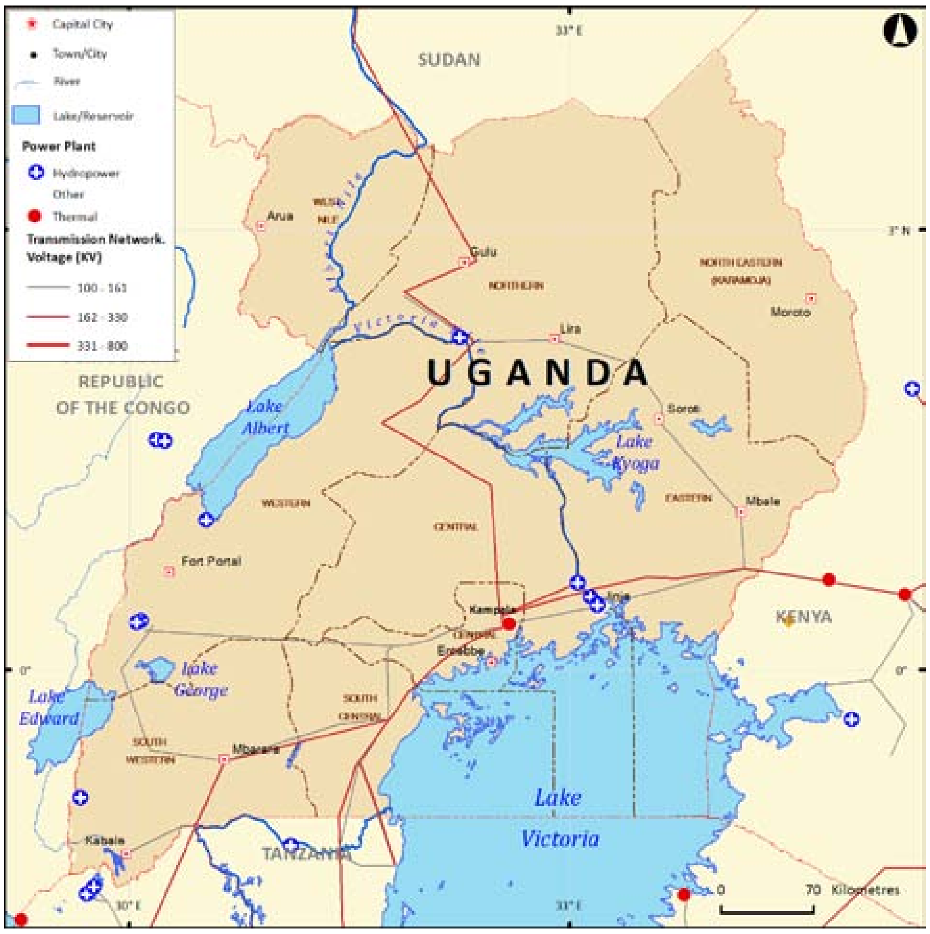
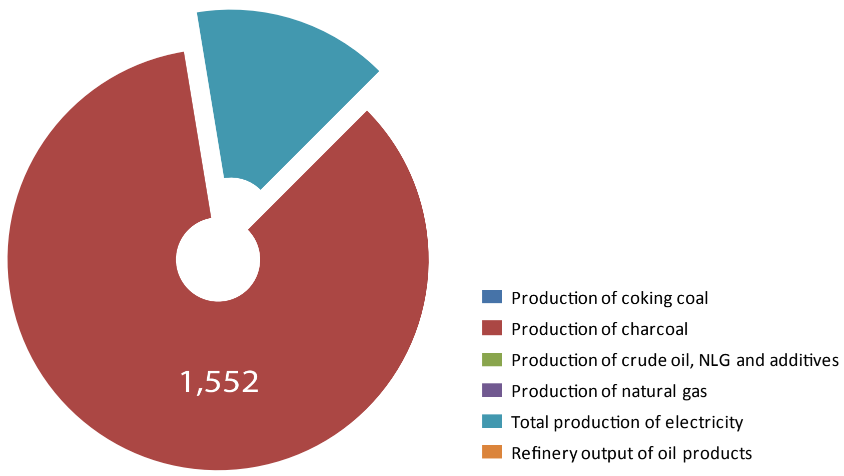
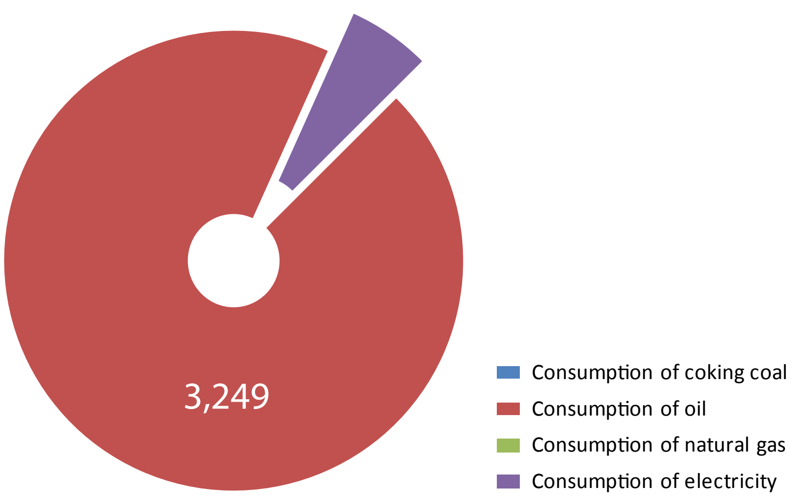


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Uganda had a population of 36.52 million (Table 1). Total electricity production in 2015 was 276 ktoe with 74.6 per cent produced from hydro, 19 per cent from fossil fuels and 5.4 per cent from biofuels and waste. Final electricity consumption in the same year was 200 ktoe (AFREC, 2015). Table 2 shows the main energy statistics. Figures 2 and 3 show energy production and consumption.

Table 1: Uganda's key indicators

Key indicators	Amount
Population (million)	36.52
GDP (billion 2005 USD)	15.69
CO_2 emission (Mt of CO_2)	3.79

Source: (World Bank, 2015)

Energy Resources

Biomass

Biomass is the most used energy source in the country with demand averaging 44 million tonnes per year supplied by a combination of fuel wood, agricultural wastes and charcoal (MEMD, 2013). Most of this energy is used at the household level (74 per cent) followed by industry, commercial and institutional use at 18, 5 and 3 per cent respectively (MEMD, 2013). Fuel wood is the most highly consumed primary fuel with annual consumption of about 28 million tonnes, but tree biomass which is the most commonly used form, can only supply 26 million tonnes on a sustainable basis. This unmet need creates undue pressures on the country's biomass resources.

The production of charcoal has been increasing from 245 ktoe in 2000, to 405 in 2005, 506 in 2010 to a high of 1,552 ktoe in 2015 (AFREC, 2015). The conversion of wood into charcoal is highly inefficient and it is estimated that 16 million tonnes of wood are converted into 1.8 million tonnes of charcoal every year (MEMD, 2013). The sugar industry consumes a significant amount of biomass in form of bagasse. Industry is increasingly switching from heavy furnace oil to biomass waste such as coffee or rice husks for their thermal energy requirements. The Biomass Energy Strategy addresses issues of efficiency and technology transfer for sustainable biomass management.

Hydropower

Along the Nile River, the hydropower potential is about 2,000 MW. So far 380 MW at Nalubaale and Kiira and 250 MW at Bujagali have been developed (Tumwesigye, Twebaze, Mukuregye, & Muyambi, 2011). The literature indicates that the 500 m drop of the Nile between Lake Victoria and Lake Albert represents approximately 4,000 MW of energy (NBI, 2013). Additional potential exists on smaller rivers in the upstream catchments such as Semliki (18 MW) (NPA, 2015).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	-	-	-	-
Production of charcoal	245	405	506	1,552
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	9	15
Production of electricity from fossil fuels	1	5	71	53
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	133	158	128	206
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	2
Total production of electricity	134	164	207	276
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	-	-	-	-
Final consumption of oil	417	548	482	3,249
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	6	8	12	200
Consumption of oil in industry	48	100	110	439
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	2	4	7	109
Consumption of coking coal in industry	-	-	-	-
Consumption of oil in transport	0	0	0	2,150
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-	-	-	-
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	438	576	506	3,173
Net imports of natural gas	-	-	-	-
Net imports of electricity	-2	0	-4	-9

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Other projects underway include Isimba Power station (183 MW) Karuma Power Station (600 MW). Mini hydropower plants already connected to the national electricity grid include Nyagak I (3.5 MW), Kabalega (9 MW), Kanungu (6.6 MW), Bugoye (13 MW), Mubuku I (5 MW), Mubuku III (10 MW) and Mpanga (18 MW).

Oil and natural gas

Although oil has been discovered, Uganda is not yet an oil producer, so there are currently no exports of oil. However, oil consumption in 2014 amount to 14,000 bbl/year (IndexMundi, 2015).

Commercially viable deposits of oil in the around Lake Albert in western Uganda were confirmed in 2006. Deposits are estimated at 6.5 billion barrels of oil equivalent and production is expected to start in 2018 (NPA, 2015). Full exploitation of the deposits might require the construction of an export pipeline to the Indian Ocean coast, although other possibilities are being examined.

The Petroleum (Refining, Gas conversion, Transmission and Midstream Storage) Act 2013, the Petroleum (Exploration, Development and Production) Act 2013 and the Public Finance Management Act 2015 have been passed strengthening the legal and policy foundation for the sector. The National Oil Company and Petroleum Authority are also being set up. Land acquisition for the proposed Oil Refinery at Kabaale in Hoima is almost complete. It is expected to be built on a Public-Private-Partnership arrangement. A crude oil pipeline to the Indian Ocean and petroleum products pipelines are also to be built (MFPED, 2015).

Wind

Wind is an underexploited energy source possibly because of a dearth of wind data. Wind speeds thought to be commercially viable are found in Tororo (eastern Uganda), Pader (West Nile) and Nakapiripirit (northeastern Uganda). Average wind speeds are in the region of 7-9 m/s at a height of 80 m (Alobo, 2013).

Geothermal

There is a Geothermal Development Plan 2003-2008 for the sector and the Ministry is planning to develop a Geothermal Policy and a Geothermal Act. Three sites have so far been licensed to private developers (3-year exploration license based on the Mining Act of 2003). Countrywide geothermal surveys have been undertaken and currently detailed work is underway at Kibiro (Hoima), Panyimur (Nebbi), Buranga (Bundibugyo) and Katwe (Kasese).

Solar

Average solar radiation is between 5 and 6 kWh/m^2/day with insolation highest in the drier northeastern regions, and lower in the mountains in the east and south-west (REEEP, 2012). Solar energy is underutilized in the country although this is slowly changing. The use of solar PV started in the 1980s and has been utilized for lighting, vaccine refrigeration in health centres, communications and signalling for the railways and for telecommunication. In 2014, two 10 MW solar power stations (Tororo Solar Power Station and Soroti Solar Power Station) in the east of Uganda were licensed by the Electricity Regulatory Authority (ERA) and should be online soon (ERA, 2016).

Tracking progress towards sustainable energy for all (SE4All)

Uganda has one of the lowest electrification rates with only 18.2 per cent of people with access to electricity in 2012 and only 8.1 per cent in rural areas and 71 per cent in urban areas (Table 3) (World Bank, 2015) (World Bank, 2016a). The energy access deficit was estimated as 28.5 million people (World Bank, 2013). There have been efforts at addressing this deficit such as the Rural Electrification Strategy and Plan 2001-2010; the Rural and Urban Poor Electricity Access Programme 2001; and the Energy for Rural Transformation programme 2002-2013.

Access to modern fuels is low with only 2.56 per cent of Ugandans using non-solid fuels; 2 per cent of these are from the rural areas and 10 per cent in urban areas in 2012 (World Bank, 2015) (World Bank, 2016). To that end a Modern Energy Service Programme, 2011 is being implemented and will involve the promotion of renewable-energy-based technology for households, institutions, commercial buildings and small-scale industries.

Uganda was among the top 20 countries worldwide with the highest energy intensity level in 2010. The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) in 2012 was 9.1 MJ per US dollar (2005 dollars at PPP). The compound annual growth rate (CAGR) between 2010 and 2012 was -2.76 (World Bank, 2015).

The share of renewable energy in the total final energy consumption decreased slightly from 96.1 to 90 per cent between 1990 and 2012. Traditional solid biofuels form the biggest share of renewable sources at 86.2 per cent of TFEC in 2012, while the modern solid biofuels contributed 2.7 per cent and hydro 1.1 per cent only. Renewable sources contributed 42.9 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Uganda's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	7	9	15	18.2		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	3	3	2.56		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	96.1	94.6	88.8	90.0		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)						
	Level of primary energy intensity(MJ/$2005 PPP)	24.4		9.7	9.1	9.23	9.14

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
18.2%	2.56%	NA	90.33%

Table 4: Uganda's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Increasing the efficiency in the use of biomass in the traditional energy sector
*Promoting renewable energy and other energy sources Increasing the efficiency in the modern energy sector, mainly of electricity
*Ensuring the best use of hydropower by careful management of the water resources

Source: (MEM, 2015)

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Solar panel charging in Uganda

Table 5: Uganda's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Energy and Mineral Development Petroleum Authority National Oil Company Rural Electrification Agency 2003
Presence of a Functional Energy Regulator	Electricity Regulatory Authority 2000
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	East African Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	
Presence of Functional (Feed in Tariffs) FIT systems	Energy policy regularly publishes a standardised Power Purchase Agreement (PPA) with feed-in-tariffs
Presence Functional IPPs and their contribution	
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• Energy Policy of 2002 • Oil and Gas Policy 2008 • Renewable Energy Policy 2007 • Electricity Sector Strategic Plan 2014/15-2023/24 • Rural Electrification Master Plan • Rural Electrification Fund • Rural Electrification Strategy and Plan 2013-2022 • Strategic Plan for the Uganda Power Sector, 1997
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• The Electricity Act 1999 • Petroleum Act of 1964 • Petroleum (Exploration and Production) Act of 1985 • Petroleum (Exploration and Production) (Conduct of Exploration Operations) Regulations of 1993 • Petroleum (Exploration, Development, Production and Value Addition) Bill, 2010 • Energy Efficiency and Conservation Bill

This table was compiled with material from (REEEP, 2012).

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Uganda's energy-related Intended Nationally Determined Contributions (INDC) published in October 2015 aims to reduce emissions by increasing the amount of renewable energy capacity by at least 1,100 MW compared to business-as-usual by 2030 (GOU, 2015). Activities to achieve this are listed in Table 4.

Institutional and Legal Framework

The Ministry of Energy and Mineral Development is in charge of the energy sector (Table 5). The Uganda Electricity Generating Company, Uganda Electricity Transmission Company, Uganda Electricity Distribution Company are the companies with responsibility for generating, transmitting and distributing electric energy, respectively. On a regional level, Uganda is a member of the East African Power Pool. The main sector policy is Energy Policy 2002. The legal framework is provided by the Electricity Act 1999 establishes the Electricity Regulatory Authority and sets the foundation for the entire energy generation lifecycle from transmission to use. The Petroleum (Exploration, Development, Production and Value Addition) Bill, 2010 will operationalise the Oil and Gas Policy 2008.

An Energy Efficiency and Conservation Bill is also in development. It will legislate towards better energy management in industries, households, commercial and institutional buildings; and to promote energy efficiency in the mining, transport and agriculture sectors contributing to climate change conservation.

Zambia

Figure 1: Energy profile of Zambia

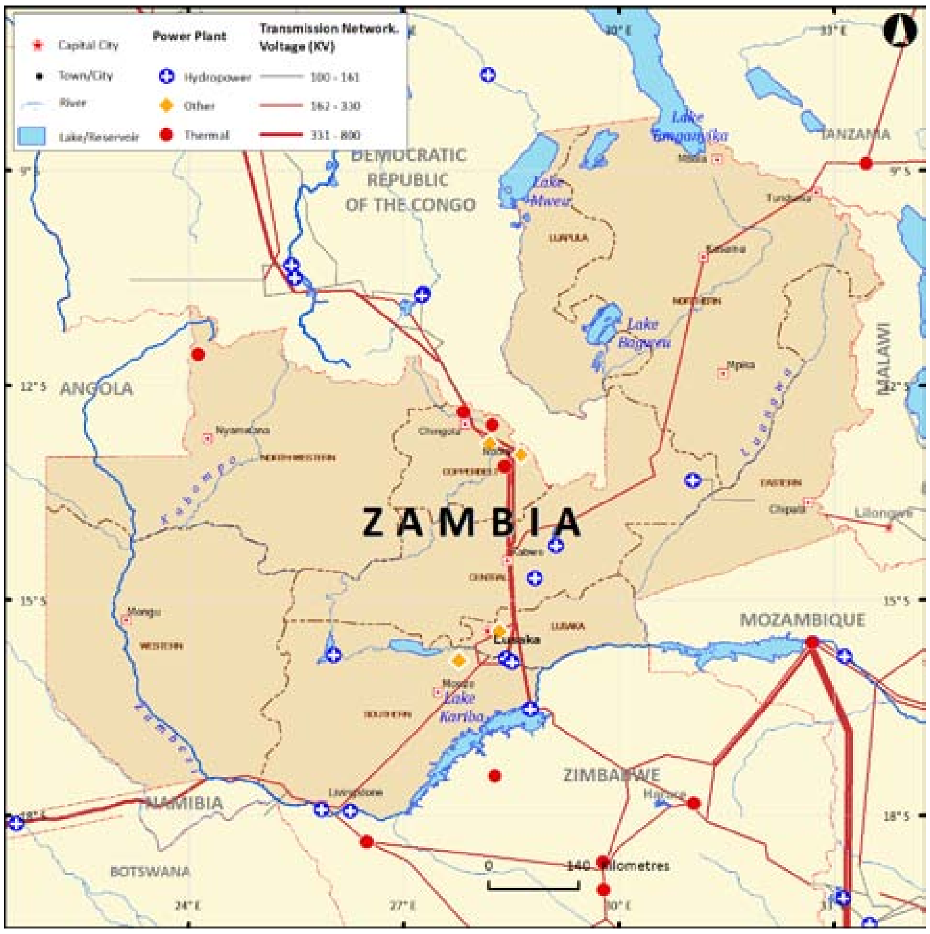
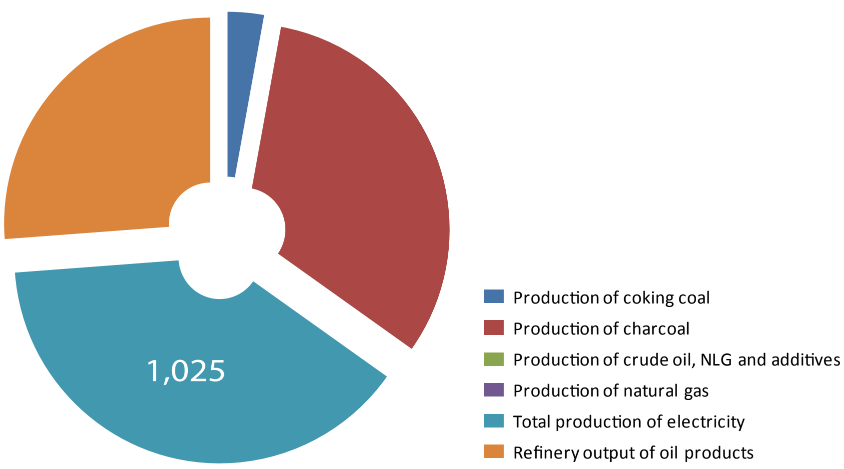
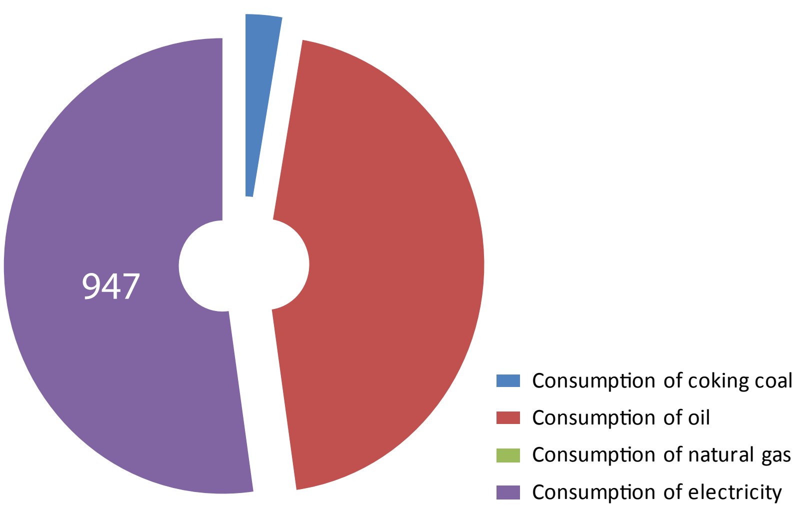


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

In 2013, Zambia had a population of 14.54 million (Table 1). Total electricity production in 2015 was 1,025 ktoe, with 93.3 per cent from hydro and 6.5 per cent from fossil fuels. Final electricity consumption in the same year was 97 ktoe, as shown in Table 2 (AFREC, 2015). Figures 2 and 3 show the main energy statistics.

Table 1: Zambia's key indicators

Key indicators	Amount
Population (million)	14.54
GDP (billion 2005 USD)	15.32
CO_2 emission (Mt of CO_2)	3.44

Source: (IEA, 2016)

Energy Resources

Biomass

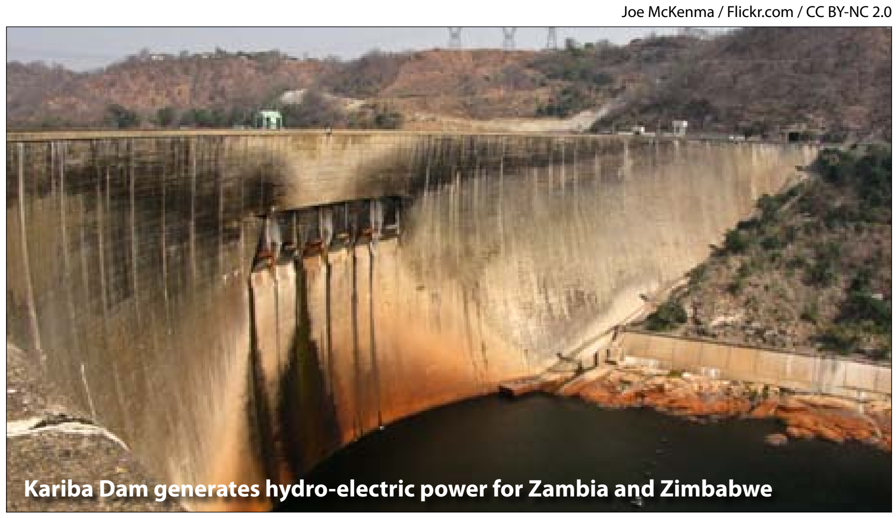
It is estimated that 95 per cent of energy used by Zambian households in the countryside is derived from woody biomass and charcoal (REEEP, 2012). Charcoal production in 2010 was 742 ktoe increasing to 842 ktoe in 2015 (AFREC, 2015). Although forest cover is vast (about 66 per cent of Zambia's total land area), it is being lost due to demand for energy from the growing population. This pressure on the forest resource is one of the drivers behind investing in alternative fuels such as biogas and biofuels. Possible feedstock for biofuels in Zambia include Jatropha, cottonseed, soy seed and sunflower.

The country has set up the legal framework for the biofuels sector including the the development of standards for biodiesel and bioethanol; and a code of conduct for blending of biofuels (REEEP, 2012). The National Energy Policy is promoting gel fuel made from sugar molasses as an alternative energy to wood fuel use. Initially, ethanol is made and then it is mixed with the gel to obtain the alternative fuel, but the limitation is in accessing the ethanol.

Hydropower

Only a third of Zambia's large hydroelectric power potential of 6,000 MW has been utilized (REEEP, 2012). In 2015, Zambia produced 957 ktoe

Joe McKenma / Flickr.com / CC BY-NC 2.0



Kariba Dam generates hydro-electric power for Zambia and Zimbabwe

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	87	84	1	75
Production of charcoal	596	655	742	842
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	0	0	0
Production of electricity from fossil fuels	4	5	3	67
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	669	764	969	957
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	0
Total production of electricity	673	769	972	1,025
Refinery output of oil products	23	554	647	689
Final Consumption of coking coal	60	76	1	49
Final consumption of oil	392	608	551	816
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	569	712	684	947
Consumption of oil in industry	130	199	270	383
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	357	479	351	344
Consumption of coking coal in industry	56	61	1	49
Consumption of oil in transport	221	350	223	297
Consumption of electricity in transport	1	1	2	2
Net imports of coking coal	-3	-6	0	0
Net imports of crude oil, NGL, Etc.	26	544	584	710
Net imports of oil product	213	176	176	193
Net imports of natural gas	-	-	-	-
Net imports of electricity	-65	-21	-47	-48

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

of hydroelectricity out of a total electricity production of 1,025 (AFREC, 2015). The major generating stations are Kafue Gorge Power Station with 990 MW capacity and the 720 MW Kariba North Bank plant and the Victoria Falls Power Station with 108 MW capacity (WEC 2013). Sites yet to be developed include Kafue Gorge Lower (750 MW), Itezhi Tezhi (120 MW), Kalungwishi (210 MW), Mambilima, Batoka Gorge (1,800 MW), Devil's Gorge and Kabompo, among others (REEEP, 2012).

There is great potential for mini hydro, which the Zambia Electricity Supply Corporation (ZESCO) is planning to develop.

Oil and natural gas

Zambia has a thriving downstream sector even though it has no oil or gas reserves (REEEP, 2012). The refinery at Ndola is operated by BP (REEEP, 2012). In 2000 refinery outputs of oil were 23 ktoe increasing to 554 ktoe in 2000 and 647 and 689 ktoe in 2010 and 2015 respectively (AFREC, 2015).

Peat

The area of peatland is 12,201 km^2 (WEC, 2013).

Coal

In 2011, there were 10 million tonnes of proved recoverable reserves of coal (bituminous, including anthracite) and coal production was estimated at 0.2 million tonnes (WEC, 2013).

Wind

Wind speeds are low only suitable for off-grid low grade activities such as generating electricity at remote sites to support domestic cooking and heating (REEEP, 2012). However, there is little growth in this area so far.

Geothermal

The Zambian Geological Survey (ZGS) has been carrying out surveys on geothermal areas since the 1950s; more recently, the Kenyan electricity generation utility, KENGEN, has been involved. The country has over 80 hot springs, with many considered promising (REEEP, 2012).

Solar

Data from AFREC (2015) indicates no production of electricity from the available solar resource by 2015. And although the mean solar insolation of 5.5 kWh/m^2/day can support rural electrification, progress is really slow (REEEP, 2012).

Tracking progress towards sustainable energy for all (SE4All)

The national electrification rate is 22.1 per cent (Table 3 and Figure 4). Access to electricity in urban areas is still quite low at 47 per cent with rural electrification at only 5.8 per cent (World Bank, 2016). Zambia's Vision 2030 aims to achieve 51 per cent rural energy access and 90 per cent urban access by 2030. Access to modern fuels is low. In 2012, 42 per cent of people in urban areas and 3 per cent in rural areas were using non-solid fuels (World Bank, 2015); at the national level, the rate was 17.32 per cent (World Bank, 2016).

The Zambian economy energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 9.0 MJ per US dollar (2005 dollars at PPP) in 2012, down from 11.5 MJ per US dollar in 1990. The compound annual growth rate (CAGR) between 2010 and 2012 was -2.17 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) increased slightly from 82.9 in 1990 to 88.2 in 2012. Traditional solid biofuels form the biggest share of renewable sources at 66.4 per cent of TFEC in 2012, while modern solid biofuels contributed 11.7 per cent and hydro 10.0 per cent. Renewable sources contributed a 99.7 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Zambia's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	13	17	19	22.1		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	4	13	17	17.32		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	82.9	89.9	90.7	88.15		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			5.7	5.7 (2011)	5.74 (2013)	
	Level of primary energy intensity(MJ/$2005 PPP)	11.5		9.4	9.0	9.20	9.03

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
22.1%	17.32%	**5.93**	88.15%

Table 4: Zambia's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Implement fuel switch (diesel/heavy fuel oil (HFO) to biodiesel)
*Implement fuel switch (coal to biomass)
*Switch from existing isolated diesel to mini-hydro; introduce and increase blending of bio-fuels with fossil fuels and where possible substitution with bio-fuels
*Expand off-grid renewable energy to non-electrified rural areas, in addition to solar photovoltaic and wind
*Expand on-grid program to support economic growth and grid extension through inter-basin water transfer
*Extend grid to non-electrified rural areas

Source: (MEM, 2015)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Zambia published its Intended Nationally Determined Contributions (INDC) in September 2015. Zambia intends to reduce its CO_2 equivalent emissions by implementing programs in various sectors, including energy, forestry, agriculture, water, Town and Country Planning, sanitation and transport. Those related to energy are listed in Table 4.

Table 5: Zambia's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	• The Ministry of Mines, Energy and Water Development • Rural Electrification Authority
Presence of a Functional Energy Regulator	
Ownership of sectoral resources and markets (Electricity/ power market; liquid fuels and gas market)	
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Southern Africa Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	ZESCO Limited is owned by the government was formerly called the Zambia Electricity Supply Corporation Limited
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	Tazama Pipelines Limited, a joint venture between the Tanzanian and Zambian governments imports crude oil. It is refined at the Indeni Refinery in Ndola the Copper belt province, a 50-50 joint venture between the Zambian government and Total Outre Mer.
Presence of Functional (Feed in Tariffs) FIT systems	Renewable Energy Feed-In Tariff (REFiT) Regulatory Framework and the REFiT Pricing Methodology
Presence Functional IPPs and their contribution	• Lunsemfwa Hydropower Company Limited 56 MW) • Ndola Energy Company Limited (50 MW) • Zengamina Power Limited (0.75 MW).
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	• National Energy Policy 2007 • Rural Electrification Master Plan 2008-2030
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Energy Regulation Act Cap 436 1995 • Electricity Act • Electricity Amendment Act • Energy Regulation Act • Petroleum Act • Petroleum Production and Exploration Act • Rural Electrification Act

This table was compiled with material from (REEEP, 2012) and (World Bank, 2013)

Institutional and Legal Framework

The Ministry of Mines, Energy and Water Development is in charge of the energy sector (Table 5). The energy regulator the is Energy Regulatory Board. ZESCO Limited is the sole generator, transmitter and distributor of electric energy. At the regional level, Zambia is a member of the Southern Africa Power Pool. The main sector policy is the National Energy Policy 2007, while the legal framework is provided by the Energy Regulation Act Cap 436 of 1995.

The solar panels installed in the village of Mpanta, Zambia

Zimbabwe

Figure 1: Energy profile of Zimbabwe

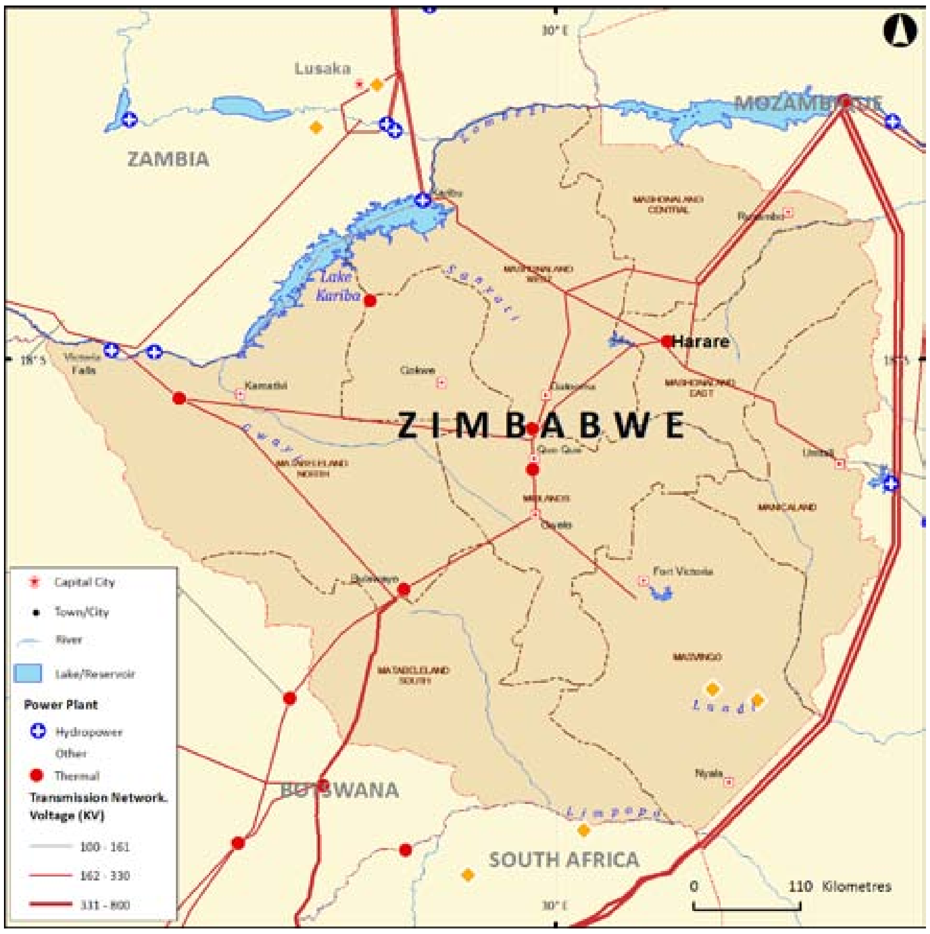
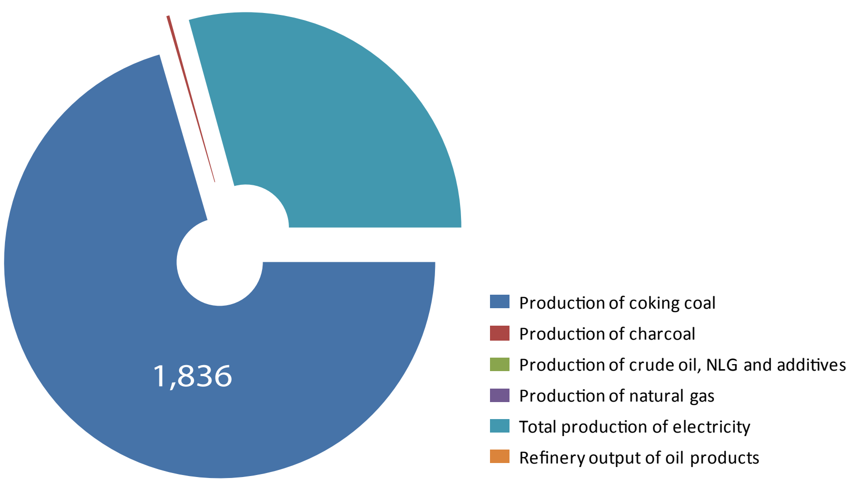
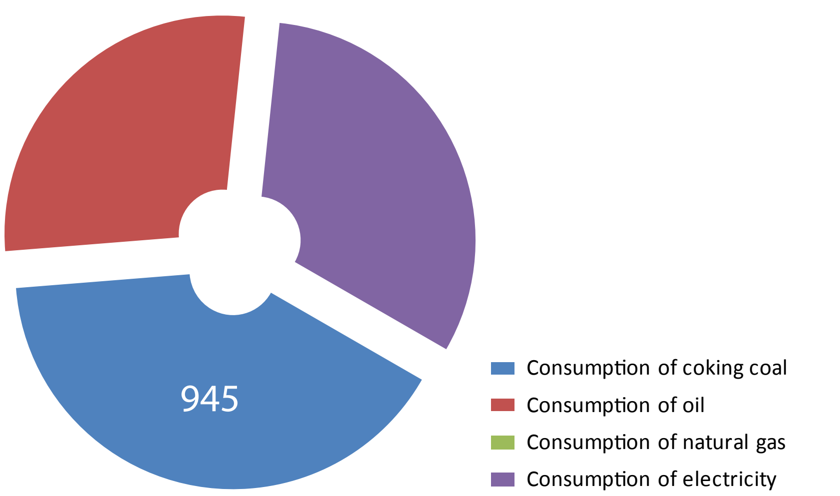


Figure 2: Total energy production, (ktoe)



Source: (AFREC, 2015)

Figure 3: Total energy consumption, (ktoe)



Source: (AFREC, 2015)

Energy Consumption and Production

Zimbabwe's population in 2013 was 14.15 million people, as shown in Table 1. Total production of electricity in 2015 was 762 ktoe, with 32.9 per cent from fossil fuels and 66.2 per cent from hydro sources (Table 2). The final consumption of electricity in 2015 was 761 ktoe (AFREC, 2015). Figures 2 and 3 show the main energy statistics.

Table 1: Zimbabwe"s key indicators

Key indicators	Amount
Population (million)	14.15
GDP (billion 2005 USD)	6.73
CO_2 emission (Mt of CO_2)	13.46

Source: (IEA, 2016)

Energy Resources

Biomass

In Zimbabwe, fuelwood is an important source of domestic energy for up to 90 per cent of people in the countryside (REEEP, 2012), with demand exceeding supply in some of the heavily populated provinces, such as Manicaland and Mashonaland East among others (MEPD, undated). Demand exceeds the sustainable output of forests by a factor of one and a half (MEPD, undated). The declining forest stock has impacts on food and energy security.

The biofuels industry has much potential. The two sugarcane mills in the southern part of Zimbabwe use over 1.3 million tonnes of bagasse to generate electricity used by the sugar factories (Blyth, 2014); (REEEP, 2012). The Chisumbanje Ethanol Project in Manicaland province has a capacity to generate up to 18 MW of electricity (REEEP, 2012). There is also potential for power generation from wood waste from the wood industry. Plantation timber is expected to generate 140,000 tones of biomass waste per year from 2015 (REEEP, 2012).

Hydropower

According to WEC (2013), the installed capacity of hydropower in Zimbabwe by 2011 was 754 MW. In 2015, 504 ktoe of hydroelectricity was produced out of a total of 762 ktoe of electricity produced (AFREC, 2015). The potential for small hydro power is 120 MW (REEEp, 2012) with some already connected to the grid such as the grid-connected 750 kW privately owned Rusitu Mini hydro plant on the Nyahode river and the 30 MW Gairezi plant located in Nyange district in the east of the country (REEEP, 2012).

Table 2: Total energy statistics (ktoe)

Category	2000	2005	2010	2015 P
Production of coking coal	429	1,850	1,575	1,836
Production of charcoal	10	11	7	6
Production of crude oil, NLG and additives	-	-	-	-
Production of natural gas	-	-	-	-
Production of electricity from biofuels and waste	0	13	6	6
Production of electricity from fossil fuels	321	371	180	251
Production of nuclear electricity	-	-	-	-
Production of hydro electricity	280	499	516	504
Production of geothermal electricity	-	-	-	-
Production of electricity from solar, wind, Etc.	0	0	0	1
Total production of electricity	602	883	702	762
Refinery output of oil products	-	-	-	-
Final Consumption of coking coal	754	729	766	945
Final consumption of oil	1,151	1,051	587	653
Final consumption of natural gas	-	-	-	-
Final consumption of electricity	917	1,075	1,081	741
Consumption of oil in industry	91	69	62	65
Consumption of natural gas in industry	-	-	-	-
Consumption of electricity in industry	457	399	268	263
Consumption of coking coal in industry	519	272	314	269
Consumption of oil in transport	598	409	364	413
Consumption of electricity in transport	-	-	-	-
Net imports of coking coal	-115	-102	-103	-66
Net imports of crude oil, NGL, Etc.	-	-	-	-
Net imports of oil product	1,034	1,055	627	684
Net imports of natural gas	-	-	-	-
Net imports of electricity	440	256	63	46

- : Data not applicable
0 : Data not available
(P): Projected

(AFREC, 2015)

Oil and natural gas

With no oil resources of its own, Zimbabwe is completely dependent on imports for this source of energy (REEEP, 2012). Net imports of oil product in 2015 was 684 ktoe (AFREC, 2015).

Peat

There are 1,400 km^2 of peatland (WEC, 2013).

Coal

According to WEC (2013), the proven recoverable reserves of coal at the end of 2011 were 0.5 billion tonnes of bituminous, including anthracite coal. In 2011, 2.7 million tonnes of bituminous coal were produced (WEC, 2013). Coal is important in the production of electricity in Zimbabwe. The coal-fuelled Hwange Thermal Plant has a potential of 750 MW but is only producing 29.3 per cent of that capacity (REEEP, 2012).

Wind

Generally speaking, the relatively low wind speeds of about 3.5 m/s constrain Zimbabwes efforts at developing wind energy. However, in some areas such as the Eastern highlands, a 300 km stretch of mountains, and in Bulawayo speeds of between 4 and 6 m/s have been recorded (REEEP, 2012). This resource is currently only used for off-grid purposes.

Geothermal

Zimbabwe's location close to the Great Rift Valley points to the potential presence of geothermal energy. However much more research into this area needs to be undertaken (REEEP, 2012).

Solar

Average solar insolation is 5.7 kWh/ m^2/day (REEEP, 2012), making the solar PV sector a potential growth industry, but one that has not been exploited much. It is estimated that although solar PV has a technical potential of over 300 MW, but only 3 MW is so far being put to use (REEEP, 2012). Much of the solar power is being used in rural areas in schools, hospitals and homes. Exploiting this potential could do much to extend access to electricity to the local populace and contribute to emissions reduction in Zimbabwe.

Tracking progress towards sustainable energy for all (SE4All)

Electric power in Zimbabwe is generated from the Kariba, Hwange, Harare, Bulawayo, Munyati and Harare power stations and other IPPs but it is not sufficient to meet current demand, creating a net deficit of electricity supply (MEPD, 2009). By 2012, national access to electricity stood at 40.5 per cent (Table 3). However, when disaggregated by location, 16.1 per cent of rural areas were electrified compared to 78.5 per cent of urban areas (Table 3 and Figure 4) (World Bank, 2016). Access to modern fuels is low at only 29.65 per cent (World Bank, 2016). In 2012, only 6 per cent of Zimbabweans in rural areas were using non-solid fuels and 80 per cent in urban areas (World Bank, 2015).

The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) of the Zimbabwean economy was 17.5 MJ per US dollar (2005 dollars at PPP) in 2012, down from 19.6 MJ per US dollar in 2010. The compound annual growth rate (CAGR) between 2010 and 2012 was -5.52 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) decreased slightly from 80.8 per cent in 2010 to 75.6 per cent in 2012. Traditional solid biofuels form the biggest share of renewable sources at 66 per cent of TFEC in 2012, while modern solid biofuels contributed only 5 per cent and hydro 4.6 per cent . Renewable sources contributed a 60 per cent share of electricity generation in 2012 (World Bank, 2015).

Table 3: Zimbabwe's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	28	34	37	40.5		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	33	34	30	30		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	64.1	70.2	80.8	75.6		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)			2.2	2.3 (2011)	2.22 (2013)	
	Level of primary energy intensity(MJ/$2005 PPP)	14.7		19.6	17.5	18.00	17.53

Sources: (World Bank, 2015); (World Bank, 2016)

Figure 4: SDG indicators

Percentage of population with access to electricity	Access to non-solid fuel (% of population)	GDP per unit of energy use (PPP $ per kg of oil equivalent) 2013	Renewable energy consumption (% of total final energy consumption), 2006-2011, 2012
40.5	29.65%	**2.29**	75.6%

Table 4: Zimbabwe's key aspects/key mitigation measures to meet its energy Intended Nationally Determined Contributions (INDCs)

INDC
*Promote ethanol blending being avoided emissions of 202 $GgCO_2e$ by 2030 for an indicative cost of US $100 million;
*Promote and disseminate solar water heaters to avoid 179 $GgCO_2e$ by 2030, for an indicative cost of US $1.230 billion;
*Improve energy efficiency to avoid 1, 278 $GgCO_2eq$ by 2030, for an indicative cost US $60 million;
*Increase hydro in our energy mix to avoid 15,316 $GgCO_2eq$ by 2030 for an indicative cost of US $5 billion;
*Refurbish and electrify the rail system to avoid 341 $GgCO_2eq$ by 2030 for an indicative cost of US $7.246 billion;
*Build coal-bed methane (CBM) power plant for an indicative cost of US $1 billion;
*Install solar powered off-grids of 3,000 MW and 8 Integrated Waste Management units for an indicative cost of US $500 million;
*Upgrade thermal power station technologies for an indicative cost of US $5 billion;
*Review and improve the transport system for an indicative cost of US $37 billion;
*Adopt sustainable energy alternatives of curing tobacco for an indicative cost of US $1.05 billion.

Source: (MEM, 2015)

Table 5: Zimbabwe's institutional and legal framework

Basic Elements	Response
Presence of an Enabling Institutional Framework for sustainable energy development and services (Max 5 institutions) most critical ones	Ministry of Energy and Power Development Rural Electrification Agency The Zimbabwe Electricity Regulatory Commission (ZERC, www.zerc.co.zw) is a statutory body established under the Electricity Act, (Chapter 13:19) No. 4 of 2002, as amended by the Electricity Amendment Act No. 3 of 2003. It became operational in August 2003. The Petroleum Act, passed in 2006, provided for the establishment of the
Presence of a Functional Energy Regulator	Energy Sector Regulatory Board Zimbabwe Energy Regulatory Authority
Ownership of sectoral resources and markets (Electricity/power market; liquid fuels and gas market)	Petroleum Regulatory Authority (PRA), to licence and regulate the petroleum industry, to promote the development of efficient procurement, sales and distribution of petroleum products, and to safeguard the interests of consumers of petroleum products. The PRA also has an advisory role to the Minister. The PRA is still to be established National Oil Company of Zimbabwe (NOCZIM) has been unbundled into the National Oil Infrastructure Company (NOIC) and Petrotrade to enhance sector efficiency.
Level of participation in regional energy infrastructure (Power Pools) and institutional arrangements	Southern Africa Power Pool
Environment for Private Sector Participation	
Whether the Power Utility(ies) is/are vertically integrated or there is unbundling (list the Companies)	State owned ZESA Holdings and subsidiaries: Zimbabwe Power Company and Zimbabwe Electricity Transmission and Distribution Company.
Where oil and gas production exists, whether upstream services and operations are privatized or state-owned, or a mixture (extent) e.g., licensed private exploration and development companies)	
Extent to which Downstream services and operations are privatized or state-owned, or a mixture (extent)	The petroleum sub-sector has been liberalized. The National Oil Company of Zimbabwe (NOCZIM) has been unbundled into the National Oil Infrastructure Company (NOIC) and Petrotrade.
Presence of Functional (Feed in Tariffs) FIT systems	
Presence Functional IPPs and their contribution	Rusitu Power Corporation
Legal, Policy and Strategy Frameworks	
Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	The National Energy Policy 2012
Renewable Energy Policy (draft)	
Independent Power Producers Policy (draft)	
Current enabling laws/pieces of legislation (including: RE; EE; private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Energy Regulatory Authority Act [Chapter 13:23] of 2011 • Rural Electrification Act 2002 • Rural Electrification Fund Act (Chapter 13:20) of 2002 • Electricity Regulatory Bill

This table was compiled with material from (REEEP, undated)

Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement

Zimbabwe aims to build resilience to climate change while pursuing its sustainable development agenda. The country articulated its Intended Nationally Determined Contributions (INDC) in September 2015. Those related to energy are listed in Table 4.

Institutional and Legal Framework

The Ministry of Energy and Power Development is in charge of energy policy. The energy sector regulator is the Zimbabwe Energy Regulatory Authority. The state owned ZESA Holdings and subsidiaries, the Zimbabwe Power Company and Zimbabwe Electricity Transmission and Distribution Company handle the generation, transmission and distribution of electric energy. On a regional level, Zimbabwe is a member of the Southern Africa Power Pool. The legal framework is provided by the Energy Regulatory Act of 2011. The Zimbabwe Energy Council is the local representative of the World Energy Council.

The main sector policy is the National Energy Policy 2012. It aims to provide access to electricity for the whole country and to develop alternative sources of electricity as well. A main focus is to explore regional cooperation to develop large hydropower dams and also for oil and gas opportunities. In the medium term, it aims to develop coal and coal-bed methane to contribute to power generation.

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Active Power: The component of electric power that performs work, typically measured in kilowatts (kW) or megawatts (MW); also known as "real power." The terms "active" or "real" are used to modify the base term "power" to differentiate it from Reactive power.

Acute Lower Respiratory Infections (ALRI): From an epidemiological point of view, acute lower respiratory infections usually include acute bronchitis and bronchiolitis, influenza and pneumonia.

Alternate Current (AC): An electric current that reverses its direction at regularly recurring intervals.

Apparent Power: The product of the voltage (in volts) and the current (in amperes). It comprises both active and reactive power. It is measured in "volt-amperes" and often expressed in "kilovolt-amperes" (kVA) or "megavolt-amperes" (MVA).

Associated-dissolved natural gas: Natural gas that occurs in crude oil reservoirs either as free gas (associated) or as gas in solution with crude oil (dissolved gas); see also Natural gas.

Backup power: Electric energy supplied by a utility to replace power and energy lost during an unscheduled equipment outage.

Biofuels: Liquid fuels and blending components produced from biomass feedstocks, used primarily for transportation.

Biofuels and Waste: Solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Biofuels are defined as any plant matter used directly as fuel or converted into fuels (e.g., charcoal) or electricity and/or heat. Included here are wood, vegetal waste (including wood waste and crops used for energy production), ethanol, animal materials/wastes and sulphite lyes.

Biomass: (for electricity generation rather than cooking): The burning of organic matter. This category of 'Other Renewables' includes waste-to-power projects.

Biomass: Organic non-fossil material of biological origin constituting a renewable energy source.

Carbon Capture and Storage (CCS): A family of technologies and techniques that enable the capture of CO_2 from fuel combustion or industrial processes, the transport of CO_2 via ships or pipelines, and its storage underground, in depleted oil and gas fields and deep saline formations.

Capacity Factor (CF): The ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period.

Chronic Obstructive Pulmonary Disease (COPD): A progressive disease that makes it hard to breathe. "Progressive" means the disease gets worse over time.

Coal: A readily combustible black or brownish-black rock whose composition, including inherent moisture, consists of more than 50 per cent by weight and more than 70 per cent by volume of carbonaceous material. It is formed from plant remains that have been compacted, hardened, chemically altered, and metamorphosed by heat and pressure over geologic time.

Coal/peat: All coal primary (including hard coal and lignite) and derived fuels (including patent fuel, coke oven coke, gas coke, BKB, gas works gas, coke oven gas, blast furnace gas and other recovered gases). Peat is also included in this category.

Coke (coal): A solid carbonaceous residue derived from low-ash, low-sulfur bituminous coal from which the volatile constituents are driven off by baking in an oven at temperatures as high as 2,000 degrees Fahrenheit so that the fixed carbon and residual ash are fused together. Coke is used as a fuel and as a reducing agent in smelting iron ore in a blast furnace. Coke from coal is grey, hard, and porous and has a heating value of 24.8 million Btu per tonne.

Coking coal: Bituminous coal suitable for making coke.

Cold-bed methane (CBM): Also known as coalbed gas, coal seam gas (CSG), or coal-mine methane (CMM) is a form of natural gas extracted from coal beds. In recent decades it has become an important source of energy in the United States, Canada, Australia, and other countries.

Compact Fluorescent Lamp (CFL): A fluorescent lamp produces light differently from incandescent bulbs. In a CFL, an electric current is driven through a tube containing argon and a small amount of mercury vapour. This generates invisible ultraviolet light that excites a fluorescent coating (called phosphor) on the inside of the tube, which then emits visible light. CFLs need a little more energy when they are first turned on, but once the electricity starts moving, CFLs use about 70% less energy than incandescent bulbs. A CFL's ballast helps "kick start" the CFL and then regulates the current once the electricity starts flowing.

Compound annual growth rate (CAGR): The mean annual growth rate of an investment over a specified period of time longer than one year. To calculate compound annual growth rate, divide the value of an investment at the end of the period in question by its value at the beginning of that period, raise the result to the power of one divided by the period length, and subtract one from the subsequent result.

Compressed natural gas (CNG): Natural gas compressed to a pressure at or above 200-248 bar (i.e., 2900-3600 pounds per square inch) and stored in high-pressure containers. It is used as a fuel for natural gas-powered vehicles.

Compressed natural gas vehicle (CNGV): A vehicle that uses compressed natural gas as fuel.

Concentrated Solar Power (CSP): A solar energy conversion system characterized by the optical concentration of solar rays through an arrangement of mirrors to generate a high temperature onto a small area. It may also refer to a system that focuses solar rays on a photovoltaic cell to increase conversion efficiency.

Conventional oil and natural gas production: Crude oil and natural gas that is produced by a well drilled into a geologic formation in which the reservoir and fluid characteristics permit the oil and natural gas to readily flow to the wellbore.

Cost-based rates (electric): A ratemaking concept used for the design and development of rate schedules to ensure that the filed rate schedules recover only the cost of providing the service.

Crude oil: A mixture of hydrocarbons that exists in liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities. Depending upon the characteristics of the crude stream, it may also include 1. Small amounts of hydrocarbons that exist in gaseous phase in natural underground reservoirs but are liquid at atmospheric pressure after being recovered from oil well (casing head) gas in lease separators and are subsequently comingled with the crude stream without being separately measured. Lease condensate recovered as a liquid from natural gas wells in lease or field separation facilities and later mixed into the crude stream is also included; 2. Small amounts of nonhydrocarbons produced with the oil, such as sulfur and various metals; 3. Drip gases, and liquid hydrocarbons produced from tar sands, oil sands, gilsonite,and oil shale.

Dam: A physical barrier constructed across a river or waterway to control the flow of or raise the level of water. The purpose of construction may be for flood control, irrigation needs, hydroelectric power production, and/or recreation usage.

Day ahead or hour ahead markets: Forward markets where electricity quantities and market clearing prices are calculated individually for each hour of the day on the basis of participant bids for energy sales and purchases.

Demand Side Management (DSM): A utility action that reduces or curtails end-use equipment or processes. DSM is often used in order to reduce customer load during peak demand and/or in times of supply constraint. DSM includes programs that are focused, deep, and immediate such as the brief curtailment of energy-intensive processes used by a utility's most demanding industrial customers, and programs that are broad, shallow, and less immediate such as the promotion of energy-efficient equipment in residential and commercial sectors.

Diesel fuel: A fuel composed of distillates obtained in petroleum refining operation or blends of such distillates with residual oil used in motor vehicles. The boiling point and specific gravity are higher for diesel fuels than for gasoline.

Direct Current (DC): A type of electricity transmission and distribution by which electricity flows in one direction through the conductor, usually relatively low voltage and high current (such as from a battery). To be used for typical 120 volt or 220 volt household appliances, DC must be converted to alternating current (AC).

Economically recoverable resources: The portion of technically recoverable resources that can be profitably produced.

Electric energy: The ability of an electric current to produce work, heat, light, or other forms of energy. It is measured in kilowatt hours.

Electric power: The rate at which electric energy is transferred. Electric power is measured by capacity and is commonly expressed in megawatts (MW).

Electric power grid: A system of synchronized power providers and consumers connected by transmission and distribution lines and operated by one or more control centers. In the continental United States, the electric power grid consists of three systems: the Eastern Interconnect, the Western Interconnect, and the Texas Interconnect. In Alaska and Hawaii, several systems encompass areas smaller than the State (e.g., the interconnect serving Anchorage, Fairbanks, and the Kenai Peninsula; individual islands).

Electric Vehicle (EV): A vehicle that operates solely on electricity. It is propelled by one or more electric motors powered by rechargeable battery packs.

Electricity: A form of energy characterized by the presence and motion of elementary charged particles generated by friction, induction, or chemical change.

Electricity demand: The rate at which energy is delivered to loads and scheduling points by generation, transmission, and distribution facilities.

Electricity plants: Plants which are designed to produce electricity only. If one or more units of the plant is a Combined Heat and Power (CHP) unit (and the inputs and outputs cannot be distinguished on a unit basis) then the whole plant is designated as a CHP plant. Both main activity producers and auto producer plants are included here. Customs clearance has taken place.

Emissions: Anthropogenic releases of gases to the atmosphere. In the context of global climate change, they consist of radiatively important greenhouse gases (e.g., the release of carbon dioxide during fuel combustion).

Energy: The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks. Electrical energy is usually measured in kilowatthours, while heat energy is usually measured in British thermal units (Btu).

Energy consumption: The use of energy as a source of heat or power or as a raw material input to a manufacturing process.

Energy consumption per capita: Represents total primary energy supply (TPES) divided by the population of the country.

Energy demand: The requirement for energy as an input to provide products and/or services.

Energy Efficiency (EE): A ratio of service provided to energy input (e.g., lumens to watts in the case of light bulbs). Services provided can include buildings-sector end uses such as lighting, refrigeration, and heating; industrial processes; or vehicle transportation. Unlike conservation, which involves some reduction of service, energy efficiency provides energy reductions without sacrifice of service. May also refer to the use of technology to reduce the energy needed for a given purpose or service.

Energy intensity: Measures the amount of energy (Total Primary Energy Supply, or TPES, in tonnes of oil equivalent, or toe) a country needs to generate a unit of gross domestic product (GDP).

Energy source: Any substance or natural phenomenon that can be consumed or transformed to supply heat or power. Examples include petroleum, coal, natural gas, nuclear, biomass, electricity, wind, sunlight, geothermal, water movement, and hydrogen in fuel cells.

Feed-in Tariff (FIT): A policy mechanism used to encourage deployment of renewable electricity technologies. A FIT program typically guarantees that customers who own a FIT-eligible renewable electricity generation facility, such as a roof-top solar photovoltaic system, will receive a set price from their utility for all of the electricity they generate and provide to the grid. A FIT is a performance-based incentive rather than an investment-based incentive, and in that respect is more similar to production tax credits and the renewable energy credits of an RPS market than to investment tax credits or other investment subsidies.

Flare: A tall stack equipped with burners used as a safety device at wellheads, refining facilities, gas processing plants, and chemical plants. Flares are used for the combustion and disposal of combustible gases. The gases are piped to a remote, usually elevated, location and burned in an open flame in the open air using a specially designed burner tip, auxiliary fuel, and steam or air. Combustible gases are flared most often due to emergency relief, overpressure, process upsets, startups, shutdowns, and other operational safety reasons. Natural gas that is uneconomical for sale is also flared. Often natural gas is flared as a result of the unavailability of a method for transporting such gas to markets.

Fossil fuel: An energy source formed in the Earth's crust from decayed organic material. The common fossil fuels are petroleum, coal, and natural gas.

Four stroke engine (4T): An engine that requires four strokes of the piston to complete a power cycle.

Fracking or hydraulic fracturing: The pumping of pressurized water and chemicals underground to release gas trapped in rock formations.

Fractionation: The process by which saturated hydrocarbons are removed from natural gas and separated into distinct products, or "fractions," such as propane, butane, and ethane.

Fuel: Any material substance that can be consumed to supply heat or power. Included are petroleum, coal, and natural gas (the fossil fuels), and other consumable materials, such as uranium, biomass, and hydrogen.

Fuel cell: A device capable of generating an electrical current by converting the chemical energy of a fuel (e.g., hydrogen) directly into electrical energy. Fuel cells differ from conventional electrical cells in that the active materials such as fuel and oxygen are not contained within the cell but are supplied from outside. It does not contain an intermediate heat cycle, as do most other electrical generation techniques.

Fuel oil: A liquid petroleum product less volatile than gasoline, used as an energy source. Fuel oil includes distillate fuel oil (No. 1, No. 2, and No. 4), and residual fuel oil (No. 5 and No.6).

Fuel wood: Wood and wood products possibly including scrub and branches, etc., bought or gathered and used by direct combustion.

Gas: A non-solid, non-liquid combustible energy source that includes natural gas, coke-oven gas, blast-furnace gas, and refinery gas.

Generation: The process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, expressed in kilowatthours.

Generation company: An entity that owns or operates generating plants. The generation company may own the generation plants or interact with the short-term market on behalf of plant owners.

Generating facility: An existing or planned location or site at which electricity is or will be produced.

Generating station: A station that consists of electric generators and auxiliary equipment for converting mechanical, chemical, or nuclear energy into electric energy.

Generating unit: Any combination of physically connected generators, reactors, boilers, combustion turbines, and other prime movers operated together to produce electric power.

Generator capacity: The maximum output, commonly expressed in megawatts (MW), that generating equipment can supply to system load, adjusted for ambient conditions.

Geothermal energy: Hot water or steam extracted from geothermal reservoirs in the earth's crust. Water or steam extracted from geothermal reservoirs can be used for geothermal heat pumps.

Greenhouse effect: The result of water vapour, carbon dioxide, and other atmospheric gases trapping radiant (infrared) energy, thereby keeping the earth's surface warmer than it would otherwise be. Greenhouse gases within the lower levels of the atmosphere trap this radiation, which would otherwise escape into space, and subsequent re-radiation of some of this energy back to the Earth maintains higher surface temperatures than would occur if the gases were absent.

Greenhouse gases (GHG): Those gases, such as water vapour, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride, that are transparent to solar (short-wave) radiation but opaque to long-wave (infrared) radiation, thus preventing long-wave radiant energy from leaving Earth's atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface.

Grid: The layout of an electrical distribution system.

Gross domestic product (GDP): The monetary value of all the finished goods and services produced within a country's borders in a specific time period. Though GDP is usually calculated on an annual basis, it can be calculated on a quarterly basis as well. GDP includes all private and public consumption, government outlays, investments and exports minus imports that occur within a defined territory. Put simply, GDP is a broad measurement of a nation's overall economic activity.

Gross energy intensity: Total consumption of a particular energy source(s) or fuel(s) by a group of buildings, divided by the total floor space of those buildings, including buildings and floor space where the energy source or fuel is not used, i.e., the ratio of consumption to gross floor space.

Hard coal: Comprises anthracite coking coal and other bituminous coal.

Heavy Fuel Oil (HFO): Also known as "residual fuel oil", is based on the high viscosity, tar-like mass, which remains after the distillation and subsequent cracking of crude oil in order to produce lighter hydrocarbon products, such as petrol , distillate diesel fuels and heating oil or feedstocks for lubricants. The main components are alkanes, cycloalkanes and different carbon hydrides. The boiling range is between 300°C and ~700°C. Due to its semi-fluid consistence, HFO has to be preheated to make it combustible in engines. RMA, RMB, RMD, RME, RMG or RMK are the international trade names.

High Voltage (HV): Having or using a very powerful flow of electricity; transmission lines are operated at relatively high voltages varying from 69 kV up to 765 kV, and are capable of transmitting large quantities of electricity over long distances.

High Speed Rail (HSR): A type of passenger rail transport that operates significantly faster than the normal speed of rail traffic. Specific definitions by the European Union include 200 km/h (120 mph) for upgraded track and 250 km/h (160 mph) or faster for new track. There are a number of different definitions for high-speed rail in use worldwide and there is no single standard.

Hydroelectric power (HEP): The use of flowing water to produce electrical energy.

Hydropower: Includes micro-hydro and pumped storage projects unless otherwise stated.

Integrated Solar Combined Cycle (ISCC): A hybrid technology in which a solar thermal field is integrated within a combined cycle plant. In ISCC plants, solar energy is used as an auxiliary heat supply, supporting the steam cycle, which results in increased generation capacity or a reduction of fossil fuel use.

International Aviation Bunkers: Deliveries of aviation fuels to aircraft for international aviation. Fuels used by airlines for their road vehicles are excluded. The domestic/International split should be determined on the basis of departure and landing locations and not by the nationality of the airline; for many countries this incorrectly excludes fuel used by domestically owned carriers for their international departures.

International Marine Bunkers: Those quantities delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and in coastal waters. Consumption by ships engaged in domestic navigation is excluded. The domestic/International split is determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship. Consumption by fishing vessels and by military forces is also excluded.

Landfill Gas (LFG): Gas that is generated by decomposition of organic material at landfill disposal sites. The average composition of landfill gas is approximately 50 per cent methane and 50 per cent carbon dioxide and water vapour by volume. The methane percentage, however, can vary from 40 to 60 per cent, depending on several factors including waste composition (e.g. carbohydrate and cellulose content). The methane in landfill gas may be vented, flared, combusted to generate electricity or useful thermal energy on-site, or injected into a pipeline for combustion off-site.

Life Cycle Analysis (LCA): Also called Life Cycle Assessment (LCA), is a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle. The International Organisation for Standardisation (ISO), a world-wide federation of national standards bodies, has standardised this framework within the series ISO 14040 on LCA.

Light Emitting Diode (LED): A two-lead semiconductor light source. It is a p–n junction diode, which emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the colour of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

Liquefied natural gas (LNG): Natural gas (primarily methane) that has been liquefied by reducing its temperature to -260 degrees Fahrenheit at atmospheric pressure.

Liquefied Petroleum Gases (LPG): A group of hydrocarbon gases, primarily propane, normal butane, and isobutane, derived from crude oil refining or natural gas processing. These gases may be marketed individually or mixed. They can be liquefied through pressurization (without requiring cryogenic refrigeration) for convenience of transportation or storage. Excludes ethane and olefins.

Liquefied Refinery Gases (LRG): Hydrocarbon gas liquids produced in refineries from processing of crude oil and unfinished oils. They are retained in the liquid state through pressurization and/or refrigeration. The reported categories include ethane, propane, normal butane, isobutane, and refinery olefins (ethylene, propylene, butylene, and isobutylene).

Load (electric): An end-use device or customer that receives power from the electric system.

Losses: Includes losses in energy distribution, transmission and transport.

Methane (CH_4): A colourless, flammable, odorless hydrocarbon gas which is the major component of natural gas. It is also an important source of hydrogen in various industrial processes. Methane is a greenhouse gas.

Municipal waste: Any organic matter, including sewage, sewage sludge, and industrial or commercial waste, and mixtures of such matter and inorganic refuse from any publicly or privately operated municipal waste collection or similar disposal system, or from similar waste flows (other than such flows which constitute agricultural wastes or residues, or wood wastes or residues from wood harvesting activities or production of forest products).

Natural gas: A gaseous mixture of hydrocarbon compounds, the primary one being methane. Natural gas includes both "associated" and "non-associated" gas.

Natural Gas Combined Cycle (NGCC): An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines, here natural gas. The exiting heat is routed to a conventional boiler or to a heat recovery steam generator for utilization by a steam turbine in the production of electricity. This process increases the efficiency of the electric generating unit.

Net electricity consumption: Consumption of electricity computed as generation, plus imports, minus exports, minus transmission and distribution losses.

Nonassociated natural gas: Natural gas that is not in contact with significant quantities of crude oil in the reservoir.

Nuclear electric power (nuclear power): Electricity generated by the use of the thermal energy released from the fission of nuclear fuel in a reactor.

Nuclear fuel: Fissionable materials that have been enriched to such a composition that, when placed in a nuclear reactor, will support a self-sustaining fission chain reaction, producing heat in a controlled manner for process use.

Nuclear reactor: An apparatus in which a nuclear fission chain reaction can be initiated, controlled, and sustained at a specific rate. A reactor includes fuel (fissionable material), moderating material to control the rate of fission, a heavy-walled pressure vessel to house reactor components, shielding to protect personnel, a system to conduct heat away from the reactor, and instrumentation for monitoring and controlling the reactor's systems.

Off peak: Period of relatively low system demand. These periods often occur in daily, weekly, and seasonal patterns; these off-peak periods differ for each individual electric utility.

Oil: A mixture of hydrocarbons usually existing in the liquid state in natural underground pools or reservoirs. Gas is often found in association with oil. See also Petroleum.

Oil Products: Comprises refinery gas, ethane, LPG, aviation gasoline, motor gasoline, jet fuels, kerosene, gas/diesel oil, fuel oil, naphtha, white spirit, lubricants, bitumen, paraffin waxes, petroleum coke and other oil products.

Oil shale: A sedimentary rock containing kerogen, a solid organic material.

Organic waste: Waste material of animal or plant origin.

Output: The amount of power or energy produced by a generating unit, station, or system.

Particulate Matter (PM): Also called particle pollution, the term refers to a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope. These particles come in many sizes and shapes and can be made up of hundreds of different chemicals. Some are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires. Most particles form in the atmosphere as a result of complex reactions of chemicals such as sulphur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries and automobiles.

Peak demand: The maximum load during a specified period of time.

Peat: Peat consists of partially decomposed plant debris. It is considered an early stage in the development of coal. Peat is distinguished from lignite by the presence of free cellulose and a high moisture content (exceeding 70 per cent). The heat content of air-dried peat (about 50 percent moisture) is about 9 million Btu per tonne.

Petroleum refinery: An installation that manufactures finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and alcohol.

Petroleum: A broadly defined class of liquid hydrocarbon mixtures. Included are crude oil, lease condensate, unfinished oils, refined products obtained from the processing of crude oil, and natural gas plant liquids. Note: Volumes of finished petroleum products include non-hydrocarbon compounds, such as additives and detergents, after they have been blended into the products.

Photovoltaic and solar thermal energy (as used at electric utilities): Energy radiated by the sun as electromagnetic waves (electromagnetic radiation) that is converted at electric utilities into electricity by means of solar (photovoltaic) cells or concentrating (focusing) collectors.

Photovoltaic cell (PVC): An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts and being capable of converting incident light directly into electricity (direct current).

Photovoltaic-powered drip irrigation (PVDI): Systems combine the efficiency of drip irrigation with the reliability of a solar-powered water pump.

Power: The rate of producing, transferring, or using energy, most commonly associated with electricity. Power is measured in watts and often expressed in kilowatts (kW) or megawatts (mW), also known as "real" or "active" power. See Active Power, Apparent Power, Reactive Power, Real Power.

Power (electrical): An electric measurement unit of power called a voltampere is equal to the product of 1 volt and 1 ampere. This is equivalent to 1 watt for a direct current system, and a unit of apparent power is separated into real and reactive power. Real power is the work-producing part of apparent power that measures the rate of supply of energy and is denoted as kilowatts (kW). Reactive power is the portion of apparent power that does no work and is referred to as kilovars; this type of power must be supplied to most types of magnetic equipment, such as motors, and is supplied by generator or by electrostatic equipment. Voltamperes are usually divided by 1,000 and called kilovoltamperes (kVA). Energy is denoted by the product of real power and the length of time utilized; this product is expressed as kilowatthours.

Power exchange: An entity providing a competitive spot market for electric power through day- and/or hour-ahead auction of generation and demand bids.

Power loss: The difference between electricity input and output as a result of an energy transfer between two points.

Power pool: An association of two or more interconnected electric systems having an agreement to coordinate operations and planning for improved reliability and efficiencies.

Power Purchase Agreement (PPA): Traditionally, a contract between a government agency and a private utilities company. The private company agrees to produce electricity, or some other power source, for the government agency over a long period of time. Most PPA partners are locked into contracts that last between 15 and 25 years, but they can otherwise vary dramatically in terms of commissioning process, curtailments, transmission issue resolution, credit, insurance and environmental regulations.

Pressurized Water Reactor (PWR): A nuclear reactor in which heat is transferred from the core to a heat exchanger via water kept under high pressure, so that high temperatures can be maintained in the primary system without boiling the water. Steam is generated in a secondary circuit.

Primary energy: Energy in the form that it is first accounted for in a statistical energy balance, before any transformation to secondary or tertiary forms of energy. For example, coal can be converted to synthetic gas, which can be converted to electricity; in this example, coal is primary energy, synthetic gas is secondary energy, and electricity is tertiary energy. See Primary energy production and Primary energy consumption.

Primary energy consumption: Consumption of primary energy. (Energy sources that are produced from other energy sources, e.g., coal coke from coal, are included in primary energy consumption only if their energy content has not already been included as part of the original energy source).

Primary energy consumption expenditures: Expenditures for energy consumed in each of the four major end-use sectors, excluding energy in the form of electricity, plus expenditures by the electric utilities sector for energy used to generate electricity. There are no fuel-associated expenditures for associated expenditures for hydroelectric power, geothermal energy, photovoltaic and solar energy, or wind energy. Also excluded are the quantifiable consumption expenditures that are an integral part of process fuel consumption.

Primary fuels: Fuels that can be used continuously. They can sustain the boiler sufficiently for the production of electricity.

Production: The production of primary energy, i.e., hard coal, lignite, peat, crude oil, NGLs, natural gas, biofuels and waste, nuclear, hydro, geothermal, solar and the heat from heat pumps that is extracted from the ambient environment production is calculated after removal of impurities (e.g., sulphur from natural gas).

Production capacity: The amount of product that can be produced from processing facilities.

Proved reserves: Volumes of oil and natural gas that geologic and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions.

Public utility: Enterprise providing essential public services, such as electric, gas, telephone, water, and sewer under legally established monopoly conditions.

Purchasing Power Parity (PPP): A theory in economics that approximates the total adjustment that must be made on the currency exchange rate between countries that allows the exchange to be equal to the purchasing power of each country's currency.

Reactive Power: The portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive power must be supplied to most types of magnetic equipment, such as motors and transformers. Reactive power is provided by generators, synchronous condensers, or electrostatic equipment such as capacitors and directly influences electric system voltage. It is a derived value equal to the vector difference between the apparent power and the real power. It is usually expressed as kilovolt-amperes reactive (KVAR) or megavolt-ampere reactive (MVAR).

Real Power: The component of electric power that performs work, typically measured in kilowatts (kW) or megawatts (MW)--sometimes referred to as Active Power. The terms "real" or "active" are often used to modify the base term "power" to differentiate it from Reactive Power and Apparent Power.

Refinery: An installation that manufactures finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and oxygenates.

Remaining oil and natural gas in-place (original oil and gas in -place minus cumulative production): The volume of oil and natural gas within a formation before the start of production is the original oil and gas in -place. As oil and natural gas are produced, the volumes that remain trapped within the rocks are the remaining oil and gas in-place, which has the largest volume and is the most uncertain of the four resource categories.

Renewable energy (RE): Energy derived from renewable sources.

Renewable energy resources: Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

Renewable fuels (other): Fuels and fuel blending components, except biomass-based diesel fuel, renewable diesel fuel, and fuel ethanol, produced from renewable biomass. Note: This category "other" pertains to the petroleum supply data system.

Shale Gas: Natural gas produced from wells that are open to shale formations. Shale is a fine-grained, sedimentary rock composed of mud from flakes of clay minerals and tiny fragments (silt-sized particles) of other materials. The shale acts as both the source and the reservoir for the natural gas. See natural gas.

Reserves-to-production ratio (R/P or R:P): A ratio indicating the remaining lifespan of a natural resource. This ratio is expressed in terms of years, and is used in forecasting the future availability of a resource to determine project life, income, employment, etc. While applicable to all natural resources, it is primarily used in the oil and gas industry.

Solar: A semantic covering any form of electricity generation which uses the sun as its sole energy source unless further specified.

Solar energy: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

Solar Home Systems (SHS): Stand-alone photovoltaic systems that offer a cost-effective mode of supplying amenity power for lighting and appliances to remote off-grid households. SHS usually operate at a rated voltage of 12 V direct current (DC) and provide power for low power DC appliances such as lights, radios and small TVs for about three to five hours a day. Furthermore they use appliances such as cables, switches, mounts, and structural parts and power conditioners / inverters, which change 12/ 24 V power to 240VAC power for larger appliances. SHS are best used with efficient appliances so as to limit the size of the array. A SHS typically includes one or more PV modules consisting of solar cells, a charge controller which distributes power and protects the batteries and appliances from damage and at least one battery to store energy for use when the sun is not shining.

Solar radiation: A general term for the visible and near visible (ultraviolet and near-infrared) electromagnetic radiation that is emitted by the sun. It has a spectral, or wavelength, distribution that corresponds to different energy levels; short wavelength radiation has a higher energy than long-wavelength radiation.

Solar thermal panels: A system that actively concentrates thermal energy from the sun by means of solar collector panels. The panels typically consist of fat, sun-oriented boxes with transparent covers, containing water tubes of air baffles under a blackened heat absorbent panel. The energy is usually used for space heating, water heating, and heating swimming pools.

Statistical differences: The sum of the unexplained statistical differences for individual fuels, as they appear in the basic energy statistics. It also includes the statistical differences that arise because of the variety of conversion factors in the coal/peat and oil columns.

Steam Coal: Steam coal comprises anthracite, other bituminous coal and sub-bituminous coal.

Stock Changes: The difference between opening stock levels on the first day of the year and closing levels on the last day of the year of stocks on national territory held by producers, importers, energy transformation industries and large consumers. A stock build is shown as a negative number, and a stock draw as a positive number.

Straight Vegetable Oil (SVO): Vegetable oil that is used directly as a fuel, in either modified or unmodified equipment.

Tar sands: Naturally occurring bitumen-impregnated sands that yield mixtures of liquid hydrocarbon and that require further processing other than mechanical blending before becoming finished petroleum products.

Technically recoverable resources: Includes all the oil and gas that can be produced based on current technology, industry practice, and geologic knowledge. As technology develops, as industry practices improve, and as the understanding of the geology increases, the estimated volumes of technically recoverable resources also expand.

Thermal: Fossil fuels such as petroleum products and coal when used for electricity.

Total final consumption (TFC): The sum of consumption by the different end-use sectors; backflows from the petrochemical industry are not included in final consumption.

Total Primary Energy Supply (TPES): Made up of production + imports – exports – international marine bunkers – international aviation bunkers ± stock changes. For the world total, international marine bunkers and international aviation bunkers are not subtracted from TPES.

Transfers: Both inter-product transfers, products transferred and recycled products.

Transmission (electric): An interconnected group of lines and associated equipment for the movement or transfer of electric energy between points of supply and points at which it is transformed for delivery to customers or is delivered to other electric systems.

Transmission line: A set of conductors, insulators, supporting structures, and associated equipment used to move large quantities of power at high voltage, usually over long distances between a generating or receiving point and major substations or delivery points.

Transport: Movement of natural, synthetic, and/or supplemental gas between points beyond the immediate vicinity of the field or plant from which produced except (1) for movements through well or field lines to a central point for delivery to a pipeline or processing plant within the same state or (2) movements from a city gate point of receipt to consumers.

Two stroke engine (2T): A type of internal combustion engine which completes a power cycle with two strokes (up and down movements) of the piston during only one crankshaft revolution.

Unconventional oil and natural gas: An umbrella term for oil and natural gas that is produced by means that do not meet the criteria for conventional production. What has qualified as "unconventional" at any particular time is a complex interactive function of resource characteristics, the available exploration and production technologies, the current economic environment, and the scale, frequency, and duration of production from the resource. Perceptions of these factors inevitably change over time and they often differ among users of the term. Sources of unconventional oil include synthetic oil, oil sands, and shale formations.

Undiscovered technically recoverable resources (UTRR): Oil and gas that may be produced as a consequence of natural pressure, artificial lift, pressure maintenance, or other secondary recovery methods, but without any consideration of economic viability. They are primarily located outside of known fields.

Uranium (U): A heavy, naturally radioactive, metallic element (atomic number 92). Its two principally occurring isotopes are uranium-235 and uranium-238. Uranium-235 is indispensable to the nuclear industry because it is the only isotope existing in nature, to any appreciable extent, that is fissionable by thermal neutrons. Uranium-238 is also important because it absorbs neutrons to produce a radioactive isotope that subsequently decays to the isotope plutonium-239, which also is fissionable by thermal neutrons.

Volt (V): The International System of Units (SI) measure of electric potential or electromotive force. A potential of one volt appears across a resistance of one ohm when a current of one ampere flows through that resistance. Reduced to SI base units, 1 V = 1kg times m^2 times s-3 times A-1(kilogram metre squared per second cubed per ampere).

Voltage: The difference in electrical potential between any two conductors or between a conductor and ground. It is a measure of the electric energy per electron that electrons can acquire and/or give up as they move between the two conductors.

Wind energy: Kinetic energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power generators.

Wind power plant: A group of wind turbines interconnected to a common utility system through a system of transformers, distribution lines, and (usually) one substation. Operation, control, and maintenance functions are often centralized through a network of computerized monitoring systems, supplemented by visual inspection.

Wind turbine: Wind energy conversion device that produces electricity; typically three blades rotating about a horizontal axis and positioned up-wind of the supporting tower.

(Compiled from web sites of Africa Energy Database 2015, International Energy Agency and United States Energy Information Agency and other sources)

ABERME	Benin Agency for Rural Electrification and Energy Control
ACEC	Africa Clean Energy Corridor
ACER	Autonomous Agency for Rural Electrification (CAR)
ADDS	Agence Djiboutienne de Développement Social or Djibouti Agency for Social Développent
ADER	Agency for Renewable Energy Development (Chad)
ADER	Agency for the Development of Rural Electrification (Madagascar)
ADER	National Renewable Energy Agency (Mauritania)
ADEREE	National Agency for the Promotion of Renewable Energy and Energy Conservation (Morocco)
AEA	Atomic Energy Authority (Egypt)
AEEP	Africa-EU Energy Partnership
AER	Rural Electrification Agency (Cameroon)
AfDB	African Development Bank
AFREC	African Energy Commission
AGER	Autoridade Geral de Regulação or General Regulatory Authority (São Tomé and Príncipe)
AICD	Africa Infrastructure Country Diagnostic
ALGPP	Aluto Langano Geothermal Pilot Plant
ALNAFT	National Agency for the Efficient Exploitation of Hydrocarbon Resources (Algeria)
AMADER	Rural Electrification and Domestic Energy Agency (Mali)
ANADEB	National Agency for the Development of Biofuels (Mali)
ANARE	National Authority for the Regulation of the Electricity Sector (Côte d'Ivoire)
ANDES	National Agency for Solar Energy (Senegal)
ANER	National Agency for Rural Electrification (Congo)
ANER	National Agency for Renewable Energies (Senegal)
ANP	National Petroleum Agency (São Tomé and Príncipe)
AOPEM	Association des Opérateurs Professionnels en Electrification de Madagascar or Madagascar Association of Professional Electrification Operators
APP	Africa Progress Panel
APRUE	L'Agence Nationale pour la Promotion et la Rationalisation de l'Utilisation de l'Energie or Agency for the Promotion and Rationalization of Energy Use
APSA	African Peace and Security Architecture
APV	Africa Power Vision
ARE	Economic Regulatory Authority (Cape Verde)
ARE	Electricity Regulation Authority (DRC)
AREA	Atomic Energy Regulatory Agency (Angola)
AREI	Africa Renewable Energy Initiative
ARM	Multisectoral Regulation Authority (Mauritania)
ARM	Autorité de Régulation Multisectorielle or Multisectoral Regulation Authority (Niger)
ARSE	Electricity Regulatory Authority (Burkina Faso)
ARSE	Regulatory Authority for the Electricity Sector (Togo)
ARSEC	Autonomous Agency for the Regulation of the Electricity Sector (Congo)
ARSEL	Agence de Régulation du Secteur de l'Electricité or Electricity Sector Regulatory Agency (Cameroon)
ARSEL	Regulatory Agency for the Electricity Sector (Congo)
ASAL	Arid and Semi Arid Lands (Kenya)
ASEA	Association des Sociétés d'Electricité d'Afrique or Association of Electricity Companies of Africa
ASER	Senegalese Rural Electrification Agency
ASRP	Oil Products Price Stabilization and Regulation Agency (Congo)
AU	Africa Union
AUC	African Union Commission
BEWRA	Botswana Energy and Water Regulatory Agency
BLM	U.S. Bureau of Land Management
BOTEC	Botswana Technology Centre
BPC	Botswana Power Corporation
CAPP	Central Africa Power Pool (See also PEAC)
CAR	Central African Republic
CBEND	Combating Bush Encroachment for Namibia's Development
CCP	Chad-Cameroon Pipeline
CDER	Centre de Développement des Energies Renouvelables or Centre for Renewable Energy Development
CDM	Clean Development Mechanism
CEB	Electricity Community of Benin
CEB	Central Electricity Board (Mauritius)
CEC	Centrale Electrique du Congo or Congo Power Plant
CED	Centrale Electrique de Djeno or Djeno Power Plant (Congo)
CEET	Electric Energy Company of Togo
CEF	Central Energy Fund (South Africa)
CenPower	CenPower Generation Company Ltd (Ghana)
CEPGL	Economic Community of the Great Lakes Countries
CFA	Franc of French-Speaking Countries of Africa
CGC	Credit Guarantee Company (Egypt)
CIE	Compangnie Ivoirienne d'Electricité or Electricity Public Utility Company of Côte d'Ivoire
CILSS	Permanent Interstates Committee for Drought Control in the Sahel
CIPREL	Compagnie Ivoirienne de Production d'Électricité or Electricity Production Company of Côte d'Ivoire
CNELEC	National Electricity Council (Mozambique)
CNES	Centre National d'Énergie Solaire or National Centre for Renewable Energy (Niger)
CNESOLER	National Research Center for Solar and Renewable Energy (Mali)
CNPC	Chinese National Petroleum Corporation (Niger)
CNRCP	National Commission for the Negotiation of Petroleum Agreements (Chad)
Cohydo	La Congolaise des Hydrocarbures or Hydrocabons Company of the DRC
COMELEC	Comité Maghrébin de l'Electricité or Electricity Committee of the Maghreb Region
COMESA	Common Market of Eastern and Southern Africa

CONTRELEC	Agency for the Control of Internal Electrical Installations (Benin)
COP	Conference of the Parties
CREE	Electricity and Water Regulatory Commission (Mali)
CREG	Algerian Electricity and Gas Regulation Commission
CRSE	Commission de Régulation du Secteur de l'Electricité or Electricity Sector Regulating Committee (Senegal)
CSES	Centre for Solar Energy Studies (Libya)
CSPH	Caisse de Stabilisation des Prix des Hydrocarbures or Office for Hydrocarbons Price Stabilization (Cameroon)
CTBV	Belle Vue Thermal Plant (Mauritius)
CTDS	Compagnie Thermique Du Sud or Thermal Energy Company of Southern Region (Mauritius)
CTL	Coal liquefaction (South Africa)
CTSav	Compagnie Thermique de Savanna or Savanna Thermal Energy Company (Mauritius)
CWIQ	Core Welfare Indicators Questionnaire
DGE	Directorate General for Energy (Benin) and (Guinea Bissau)
DGH	Directorate General of Hydrocarbons (Mauritania)
DICAT	Department of Civil, Environmental and Architectural Engineering (Guinea Bissau)
DL	Decree-law (Cape Verde)
DNEE	National Directorate for Electrical Energy (Mozambique)
DOE	South African Department of Energy
DoSPEMR	Department of State for Petroleum, Energy and Mineral Resources (Gambia)
DRC	Democratic Republic of the Congo
EAA	Eastern Africa Association
EAC	East African Community
EAGB	National Electricity and Water Corporation (Guinea Bissau)
EAPP	Eastern Africa Power Pool
EARP	Electricity Access Roll-out Program (Rwanda)
EARS	East Africa Rift System
EASE	Energizing Access to Sustainable Energy (Nigeria)
ECB	Electricity Control Board (Namibia)
ECCAS	Economic Commission for Central African States
ECG	Electricity Company of Ghana
ECHEM	Egyptian Petrochemicals Holding Company
ECN	Energy Commission of Nigeria
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency (Cape Verde)
EDA	Electricité d'Anjouan or Electricity Company of Anjouan (Comoros)
EDCL	Energy Development Corporation Limited (Rwanda)
EDD	Électricité de Djibouti or Electricity Pulic Utility Company of Djibouti
EDEL	Empresa de Distribuição de Electricidade, S.A., Luanda or Luanda Electricity Distribution Company
EDG	Electricity Public Utility Company of Guinea
EDI	Energy Development Index
EDIH	Electricity Distribution Industry Holding Company (South Africa)
EDM	Electricidade de Moçambique or Electricity Company of Mozambique
EDM	Energie du Mali SA or Energy Corporation of Mali
EDPRS	Economic Development and Poverty Reduction Strategy (Rwanda)
EEA	Ethiopian Energy Authority
EECI	Energie Electrique de Côte d'Ivoire or Electric Energy Company of Côte d'Ivoire
EEHC	Egyptian Electricity Holding Company
EEP	Ethiopian Electric Power
EEU	Ethiopian Electric Utility
EEUCPRA	Electric Utilities and Consumer Protection Regulatory Agency (Egypt)
EGAS	Egyptian Natural Gas Holding Company
EGL	L'Energie des pays des Grands Lacs or Energy Agency of the Great Lakes Countries
EGPC	Egyptian General Petroleum Corporation
EgyptERA	Egyptian Electric Utilities and Consumer Protection Regulatory Agency
EIA	U.S. Energy Information Administration
EICV	Integrated Household Living Conditions Survey (Rwanda)
EITI	Extractive Industry Transparency Initiative (São Tomé and Príncipe)
ELECTRA	Empresa de Electricidad e Agua or Electricity and Water Company (Cape Verde)
ELECTROGAZ	Electricity and Gas Company (Rwanda)
ELPS	Escravos-Lagos Pipeline System
EMAE	Empresa de Água e Electricidade or Water and Electricity Company (São Tomé and Príncipe)
EMRA	Egyptian Mineral Resource Authority
ENACOL	The Empresa Nacional de Combustíveis or National Fuels Company (Cape Verde)
ENE	Empresa Nacional de Electricidade or National Electricity Public Utility Company (Angola)
ENELEC	Private Electricity Production Company (Madagascar)
ENERCA	Énergie Centrafricaine or Energy Company of the CAR
ENERCOM	Solar Energy Company (Comoros)
ENH	Empresa Nacional de Hidrocarbonetos de Mocambique or National Hydrocabons Company of Mozambique
EPA	Environmental Protection Agency (Ghana)
EPC	Eritrea Petroleum Corporation
EPCV	Permanent Household Living Conditions Survey
EPSR	Electric Power Sector Reform (Nigeria)
ERA	Electricity Regulatory Authority (Sudan)
ERB	Energy Regulatory Board (Liberia)
EREDPC	Ethiopian Rural Energy Development and Promotion Centre
ERP	Enterprise Rwandaise de Petrole or Rwanda Oil Company
ESCO	Energy Services Company
ESCOM	Electricity Supply Corporation of Malawi Ltd
ESKOM	Electricity Public Utility Company (South Africa)
EUCL	Energy Utility Corporation Ltd (Rwanda)
EWURA	Energy and Water Utilities Regulatory Authority
FDSEL	Development funds for electricity sector (Congo)
FMOP	Federal Ministry of Power (Nigeria)
FNE	National Electricity Fund (Madagascar)
FNME	National Energy Efficiency Fund of Algeria
FUNAE	Fundo Nacional de Energia or National Funds for Energy (Mozambique)
Gafo	Gafo Energy NZ Ltd
GALSI	Gasdotto Algeria - Sardegna Italia

GAMEK	Gabinete de Aproveitamento do Médio Kwanza or Office for the Exploitation of Mid-Kwanza Region Water Resources (Angola)
GAMWIND	Gambian National Energy Company
GANOPE	Ganoub El Wadi Petroleum Holding Company (Egypt)
GDC	Geothermal Development Company (Kenya)
GECOL	General Electricity Company of Libya
GEM	Gazoduc Enrico Mattei
GENI	Global Energy Network Institute
GHI	Global Horizontal Irradiance
GIPC	Ghana Investment Promotion Centre
GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale ZusammenarbeitAssistance or German International Development Agency (Tunisia)
GNPC	Ghana National Petroleum Corporation
GOT	Government of Tunisia
GridCo	Ghana Grid Company Ltd
GRTE	Société Algérienne du Gestion du Réseau de Transport de L'Electricité or Algerian Company for the Management of Electricity Transmission Grid
GRTG	Société Algérienne du Gestion du Réseau de Transport du Gaz or Algerian Company for the Management of Gas Pipelines
GTP	Growth and Transformation Plan
GTZ	German Technical Cooperation Agency
GWEC	Global Wind Energy Council
HCB	Hidroelectrica de Cahora Bassa or Hydoelectric Power Plant of Cahora Bassa (Mozambique)
HPPA	Hydro Power Plants Authority (Egypt)
HYDELEC	Hydroelectricity Company (Madagascar)
IAEA	International Atomic Energy Agency
ICA	Infrastructure Consortium for Africa
IEA	International Energy Agency
IEP	Integrated Electricity Plan (Mauritius)
IEP	Integrated Energy Plan (South Africa)
IFC	International Finance Corporation
IMB	International Maritime Bureau
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IPPF	Infrastructure Project Preparation Facility
IRB	Independent Regulatory Board
IRENA	International Renewable Energy Agency
IRP	Integrated Resource Plan (South Africa)
IRSE	Instituto Regulador de Sector Eléctrico or Electricity Sector Regulatory Institute (Angola)
JDA	Joint Development Agency (São Tomé and Príncipe)
JDZ	Joint Development Zone (São Tomé and Príncipe)
JIRAMA	Jiro sy Rano Malagasy or Malagasy Power and Water (Madagascar)
JLEC	Jorf Lasfar Electric Company (Morocco)
JMC	Joint Ministerial Committee (São Tomé and Príncipe)
KenGen	Kenya Generating Company
KETRACO	Kenya Transmission Company
KfW	Kreditanstalt für Wiederaufbau or German Government-owned Development Bank
KPC	Kenya Pipeline Company
KPLC	Kenya Power and Lighting Company
Kpone	Kpone Independent Power Plant (Ghana)
KSh	Kenya Shilling
LCPDP	Least Cost Power Development Plan (Kenya)
LEC	Lesotho Electricity Company and/or Liberia Electricity Company
LEGA	Lesotho Electricity Generation Authority
LESES	Lesotho Solar Energy Society
LEU	Lesotho Electrification Unit
LHDA	Lesotho Highlands Development Authority
LNOC	Liberia National Oil Corporation
MAD	Moroccan Dirham
MAMWE	Gestion de l'Eau et de l'Electricité aux Comores or Water and Electricity Management in Comoros
MASEN	Moroccan Agency for Solar Energy
MEDELEC	Association of Electricity Companies of the Mediterranean Region
MEDRING	Mediterranean Electricity Ring
MEE	Ministry of Energy and Water (Benin)
MEH	Ministry of Energy and Hydraulics (Guinea)
MEMEE	Ministry of Energy, Mining, Water and Environment (Morocco)
MENA	Middle East and North African
MERN	Ministry of Energy in charge of Natural Resources (Djibouti)
MEWT	Ministry of Environment, Wildlife and Tourism (Botswana)
MICS	Multiple Indicators Cluster Survey
MID	Maurice Ile Durable or Mauritius Sustainable Island Programme
MINEA	Ministry of Energy and Water (Angola)
MINIFRA	Ministry of Infrastructure (Rwanda)
MME	Ministry of Mines and Energy (Namibia)
MMEWR	Ministry of Minerals, Energy and Water Resources (Botswana)
MoED	Ministry of Electricity and Dams (South Sudan)
MOEE/MoEE	Ministry of Electricity and Energy (Egypt)
MOEP	Ministry of Energy and Petroleum (Kenya)
MoESD	Ministry of Education and Skills Development (Botswana)
MOP	Ministry of Petroleum (Egypt)
MoPM	Ministry of Petroleum and Mining (South Sudan)
MPEM	Ministry of Petroleum, Energy and Mines (Mauritania)
MTIE	Ministry of Tourism, Industry and Energy (Cape Verde)
MWE	Ministry of Water and Energy (Ethiopia)
MWIE	Ministry of Water, Irrigation and Energy (Ethiopia)
NAEC	Nigerian Atomic Energy Commission
NAMCOR	National Petroleum Corporation of Namibia
NAPP	North Africa Power Pool
NAWEC	National Water and Electricity Company (Gambia)
NCCAMS	National Climate Change Adaptation and Mitigation Strategy (Mozambique)
NCE	National Energy Commission (DRC)
NDC	Nationally Determined Contributions
NEAL	New Energy Algeria
NEC	National Electricity Corporation (Sudan)
NECSA	Nuclear Energy Corporation of South Africa
NED	Northern Electricity Department (Ghana)
NEDCo	Northern Electricity Distribution Company (Ghana)
NEEAP	National Energy Efficiency Action Plan (Egypt) and (Libya)

NEPAD	New Partnership for Africa's Development
NEPP	National Electric Power Policy (Nigeria)
NER	Renewable Energy Research Group (Cape Verde)
NERC	Nigerian Electricity Regulatory Commission
NERSA	National Energy Regulator of South Africa
NG	National Geographic
NIGELEC	Société Nigérienne d'Electricité or Electricity Public Utility Company of Niger
NIGERGAZ	Gas Distribution Company of Niger
Nilepet	Nile Petroleum Corporation (South Sudan)
NIPP	National Integrated Power Project (Nigeria)
NMA	Nuclear Materials Authority (Egypt)
NNPC	Nigerian National Petroleum Corporation
NNR	National Nuclear Regulator (South Africa)
NNRA	Nigerian Nuclear Regulatory Authority
NOC	National Oil Corporation (Libya)
NOCZIM	National Oil Company of Zimbabwe
NOIC	National Oil Infrastructure Company (Zimbabwe)
NPC	National Planning Commission (Namibia)
NPCA	NEPAD Planning and Coordinating Agency
NPGC	National Petroleum and Gas (South Sudan)
NPP	Nuclear Power Programme (Nigeria)
NPPA	Nuclear Power Plants Authority (Egypt)
NREA	New and Renewable Energy Authority (Egypt)
NREF	National Rural Electrification Fund (Lesotho)
NRWDI	National Radioactive Waste Disposal Institute (South Africa)
O&GJ	Oil and Gas Journal
OAPEC	Organisation of Arab Petroleum Exporting Countries
OAU	Organization of African Union
OECD	Organisation for Economic Co-operation and Development
OMH	Office Malgache des Hydrocarbures or Malagasy Office for Hydrocarbons
OMVS	Senegal River Development Organisation (Mauritania)
ONAP	National Office of Petroleum Products (Mali)
ONATOUR	National Peat Office (Burundi)
ONEE	Office National de l'Electricité et de l'Eau Potable or Office for Electricity and Potable Water (Morocco)
ONHYM	Office of Hydrocarbons and Mining (Morocco)
ORE	Office pour la Régulation de l'Electrification or Board of Electricity Regulation (Madagascar)
PDSE	Energy Sector Development Plan (Cameroon)
PEAC/CAPP	Central Africa Power Pool (DRC)
PERG	Programme d'Electrification Rurale Globale or Programme for Global Rural Electrification (Morocco)
PetroGuin	National Oil company (Guinea Bissau)
PetroSA	Petroleum, Oil and Gas Corporation of South Africa
PHCN	Power Holding Company of Nigeria
PIDA	Programme for Infrastructure Development in Africa
PIRA	Public Utilities Regulatory Authority (Gambia)
plc	Public Limited Company
PNUER	Programme National d'Urgence d'Electrification Rurale or National Urgent Rural Electrification Programme (Senegal)
PRA	Public Geological Research Authority (Sudan)
PRA	Petroleum Regulatory Authority (Zimbabwe)
PRGSP	Poverty Reduction and Growth Strategy Paper (Comoros)
PRML	Oil Revenue Management Law (São Tomé and Príncipe)
PRSP	Poverty Reduction Strategy Papers (IMF)
PSMP	Power System Master Plan
PST	Tunisian Solar Plan
PUC	Public Utilities Company (Seychelles)
PURC	Public Utility Regulatory Commission (Ghana)
PWEDD	Decree by the Government of Djibouti defining the obligations and status of the Djibouti Electricity Company (EDD)
RCREEE	Regional Centre for Renewable Energy and Energy Efficiency
RDB	Rwanda Development Board
REA	Rural Electrification Authority (Egypt, Kenya and Nigeria)
REAOL	Renewable Energy Authority of Libya
REC	Regional Economic Community
RED	Regional Electricity Distributor (South Africa)
REEEI	Renewable Energy and Energy Efficiency Institute (Namibia)
REEEP	Renewable Energy and Energy Efficiency Partnership
REES	Ministry of Mines Rural Electrification Executive Secretariat (Ethiopia)
REFIT/REFiT	Renewable Energy Feed-in Tariff Regulation
REFUND	Rural Energy Fund (Liberia)
REG	Rwanda Energy Group Ltd
REGIDESO	Régie de Production et Distribution d'Eau et d'Electricité or Water and Electricity Production and Distribution Company (Burundi)
REI4P	Renewable Energy Independent Power Producer Procurement Programme (South Africa)
REIPPP	Renewable Energy Independent Power Producer Policy (Swaziland)
RELOP	Association of Energy Regulators of the Portuguese Speaking Countries (São Tomé and Príncipe)
REN	Renewable Energy Policy Network
RIIC	Rural Industries Innovation Centre (Botswana)
ROR	Republic of Rwanda
ROSS	Republic of South Sudan
RPSR	Roadmap for Power Sector Reform (Nigeria)
RREA	Rural and Renewable Energy Agency (Liberia)
RURA	Rwanda Utilities Regulatory Authority
SADC	Southern African Development Community
SANEDI	South African National Energy Development Institute
SANS 204	South African National Standard for Energy Efficiency in Buildings
SAPP	Southern Africa Power Pool
SASOL	International integrated chemicals and energy company
SBEE	Benin National Electricity Utility Company
SCAPE	Stratégie de Croissance Accélérée et de Promotion de l'Emploi or Strategy for Accelerated Growth and Promotion of Employment (Togo)
SDA	Société de Distribution de l'Electricité et du Gaz d'Alger or Electricity and Gas Distribution Company of Algiers
SDC	Société de Distribution de l'Electricité et du Gaz du Centre or Electricity and Gas Distribution Company of Central Algeria (Algeria)
SDE	Société de Distribution de l'Electricité et du Gaz de l'Est or Electricity and Gas Distribution Company of Eastern Region (Algeria)

SDG	Sustainable Development Goal
SDO	Société de Distribution de l'Electricité et du Gaz de l'Ouest or Electricity and Gas Distribution Company of Western Region (Algeria)
SE4ALL	Sustainable Energy for All
SEBEE	Société Béninoise d'Energie Electrique or Electricity Company of Benin (Benin)
SEC	US Securities and Exchange Commission
SEC	Swaziland Electricity Company
SEEG	Société d'Electricité et d'Eaux du Gabon or Electricity and Water Company of Gabon
SEGESA	Sociedad de Electricidad de Guinea Ecuatorial or Electricity Company of Equatorial Guinea
SENELEC	Société Nationale d'Electricité du Sénégal or National Electricity Public Utility Company of Senegal
SENEN	National Renewable Energies Service (DRC)
SEP-CONGO	Services des Enterprises Pétrolières Congolaises or Oil Companies Office of Congo
SERA	Swaziland Energy Regulatory Authority
SGP	Société Générale de Pétrole or Rwanda Petroleum Company
SIDS	Small Islands Developing States
SINELAC	Société Internationale d'Electricité des Pays des Grands Lacs or International Electricity Company of Great Lakes Countries
SKB	Shariket Kahraba Berrouaghia (Angola)
SKD	Shariket Kahraba Koudiet Eddraouche (Angola)
SKH	Shariket Kahraba Hadjret Ennouss (Angola)
SKM	Sinclair Knight Merz (Comoros)
SKS	Shariket Kahraba Skikda (Angola)
SKT	Shariket Kahraba Terga (Angola)
SME	Small and Medium Sized Enterprise
SNE	Société Nationale d'Electicité or National Electricity Company (Chad and Congo)
SNEL	Société National d'Electricité or National Electricity Company (DRC)
SNIM	Société Nationale Industrielle et Minière or National Company for Industry and Mines (Mauritania)
SNPC	Société Nationale des Pétroles du Congo or National Corporation of Congolese Oil Companies
SOCASP	Central African Oil Products Storage Company
SOCO	SOCO International plc.
SODEXAM	Société d'Exploitation et de Développement Aéroportuaire, Aéronautique et Météorologique or Company for Airports, Aerospace and Metreorological Operations and Development (Côte d'Ivoire)
SOFRECO	French Company specialized in Counseling and Technical Assistance in the fields of Sustainable Social and Economic Development
SOMELEC	Morocco Electricity Company
SONABEL	National Electricity Company of Burkina Faso
SONABHY	Société Nationale Burkinabé d'Hydrocarbures or Burkina Faso National Hydrocarbons Company
SONACOP	National Petroleum Products Commercialization Company (Benin)
SONARA	National Refining Company (Cameroon)
SONEL	Société Nationale d'Eléctricité or National Electricity Public Utility Company (Cameroon)
SONELGAZ	National Electricity and Gas Company (Algeria)
SONIDEP	Société Nigérienne des produits pétroliers or Niger National Company for Petroleum Products
SONIGAZ	Niger Gas Company
SONIHY	Société Nigérienne des Hydrocarbures or Niger Hydrocarbons Company
SORAZ	Société de Raffinage de Zinder or Zinder Refining Company (Niger)
SPC	Sudanese Petroleum Corporation
SPE	Société Algérienne de Production de l'Electricité or Algerian Company for Electricity Production
SREP	Large scale renewable energy recovery plan (Mali)
SSA	Sub-Saharan Africa
SSEC	South Sudan Electricity Corporation
STC	State Trading Corporation (Mauritius)
STEG	Tunisian Company of Electricity and Gas
STEM	Short Term Electricity Market
STI	Science, Technology, and Innovation
TANESCO	Tanzania Electricity Supply Company Ltd
TCRET	Test & Training Centre in Renewable Energy Technologies (Malawi)
TMIE	Ministry of Industry and Energy (Tunisia)
TPDC	Tanzania Petroleum Development Corporation
UAE	United Arab Emirates
UCG	Underground coal gasification (South Africa)
UK	United Kingdom
UMA	Union of Maghreb Arab
UNCTAD	United Nations Conference on Trade and Development
UN-DESA	United Nations-Division of Economic and Social Affairs
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Office
UNSD	United Nations Statistics Division
UNSTATS	United Nations Statistical Commission
UNU-IAS	United Nations University - Institute of Advanced Studies
UPDEA	Union of African Electricity Producers, Distributors and Conveyors
US	United States
VRA	Volta River Authority (Ghana)
WAGP	West African Gas Pipeline
WAPP	West Africa Power Pool
WEC	World Energy Council
WERPO	Wave Electricity Renewable Power Ocean (Guinea Bissau)
WHO	World Health Organization
ZAR	South African Rand
ZERC	Zimbabwe Electricity Regulatory Commission
ZERO	Zimbabwe Environmental Research Organization
ZESA	Zimbabwe Electricity Supply Authority
ZESCO	Zambia Electricity Supply Corporation

Conversion Table

To >	TJ	Gcal	Mtoe	MBtu	GWh
From v	**Multiply by:**				
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	10-7	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	10^{7}	1	3.968×10^{7}	11630
MBtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3412	1

Unit of Measure/Symbols

bbl	Barrel(s)
bbl/d	Barrel(s) per day
Bbl/sd	Barrel per stream day
bcf	Billion cubic feet
bcm	Billion cubic metres
CO_2e	CO_2 equivalent
EJ	Exajoule
Gcal	Gigacalorie
$GgCO_2$	Gigagrams (Gg) Carbon Dioxide (CO_2)
$Gg\text{-}CO_2e$	Gigagrams (Gg) Carbon Dioxide (CO_2) equivalent
GJ	Gigajoule
Gt	Gigaton
GW	Gigawatt (MW1,000) One billion watts or one thousand megawatts
GWe	Gigawatt electric = One billion watts of electric capacity
GWh	Gigawatt hour = One billion watthours
ha	Hectare
hp	Horsepower = A unit for measuring the rate of work (or power) equivalent to 33,000 foot-pounds per minute or 746 watts
J	Joule = A measure of energy, or the ability or capacity to do work
kb/cd	Thousand barrels per calendar day
kcal	Kilocalorie
kg	Kilogramme
kgU	Kilogramme of uranium
kJ	Kilojoule
kt	Kilotonne
ktoe	Kilotonne of oil equivalent
kV	Kilovolt
kV/m	Kilovolt per metre
kW	Kilowatt = One thousand watts
kWc	Kilowattcrete or kilowatt peak
kWe	Kilowatt-electric = One thousand watts of electric capacity
kWh	Kilowatt hour - a thousand watts of power produced or used for one hour, equivalent to 3.6 million joules (MJ). One kWh is equivalent to 3,412 Btu
MBtu	million British thermal units
MJ	Megajoule or million joules
MJ/$	Million joules/dollar
mmcfd	Million cubic feet per day
Mmscf	Million standard cubic feet
mmtpa	Million tonnes per annum
$MtCO_2e$	Million metric tonnes of carbon dioxide equivalent
Mtoe	Million tonnes of oil equivalent = equivalent to 41,868 MJ or 11,630 GWh
MW	Megawatt = One million watts of electricity
MWe	Megawatt electric = One million watts of electric capacity
MWh	Megawatt hour = One thousand kilowatt-hours or one million watt-hours
MWt	Megawatt thermal
PWh	Petawatt hour
t	Metric ton=tonne
tcf	Trillion cubic feet
tcm	Trillion cubic metres
$tCO_2eq.$	One tonne of carbon dioxide (CO_2)
TJ	Terajoule
toe	Tonne of oil equivalent
TW	Terrawatt
TWh	Terawatt hour = Energy unit in which electricity consumption is measured 1TWh = 1000GWh = 3,600 x 103 GJ
V	Volt = International System of Units (SI) measure of electric potential or electromotive force
W	Watt (Measure of electric power) = One watt is equal to 1 joule (J) per second
Wh	Watt hour

BACK OF COVER

Africa is rich in energy resources but still has limitations in its capability to exploit and use them. In many African countries, power is inaccessible, unaffordable and unreliable — about half the population still has no access to electricity. On the other hand, the continent has vast but virtually unexploited energy resources. This Atlas compiles and synthesizes data and information about Africa's energy potential and the pace of change in energy production and consumption. It presents the most recent available data in a format that is easily understandable to policy makers, investors and the public by using visually strong and imaginative maps, time-line graphs, charts and comparative satellite images. Its clear narrative illustrates the challenges and opportunities in meeting Sustainable Development (SDG) Goal 7: "*Ensure access to affordable, reliable, sustainable and modern energy for all*". Its unique features include an assessment of the environmental impacts of energy development; the links between energy and gender; integration of energy markets through five regional power pools; and energy profiles of each of the 54 African countries.