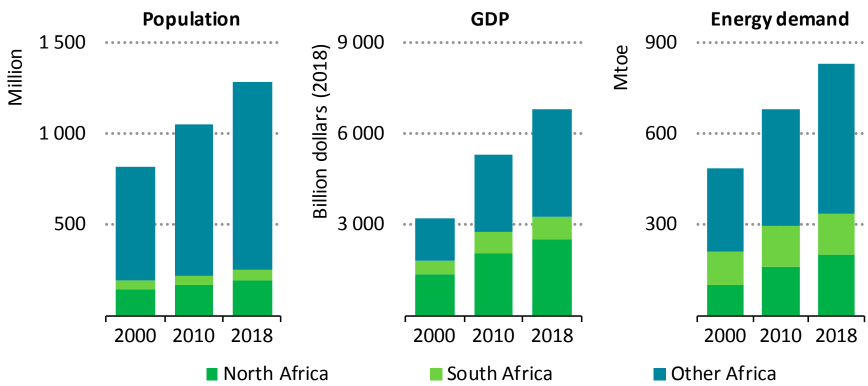
Africa today

Viewing Africa through a new lens?

SUMMARY

- The pace of change in Africa's energy sector has quickened, imparting to the continent a growing sense of confidence despite many setbacks. Africa's economy is also on an upward trajectory, with gross domestic product (GDP) likely to rise by around 4% this year. East Africa looks to be the fastest-expanding region today, led by Rwanda, Ethiopia, Kenya, and Tanzania. The way in which the energy sector develops will have a crucial influence on Africa's future.

Figure 8.1 ▷ Selected indicators for Africa, 2000, 2010, 2018



Africa's urban population is expanding fast while energy services and GDP struggle to keep pace

Note: GDP = Gross domestic product in PPP terms, $2018.

- The number of people gaining access to electricity in Africa doubled from 9 million a year between 2000 and 2013 to 20 million people between 2014 and 2018, outpacing population growth. As a result, the number of people without access to electricity, which peaked at 610 million in 2013, declined slowly to around 595 million in 2018. Recent progress has been led by Kenya, Ethiopia and Tanzania, which accounted for more than 50% of those gaining access. However, sub-Saharan Africa's electrification rate of 45% in 2018 remains very low compared with other parts of the world.
- Since 2015, only seven million people have gained access to clean cooking in sub-Saharan Africa, meaning that the number of people without access increased to over 900 million in 2018 as population growth outpaced provision efforts. Progress has been strongest in parts of West Africa such as Côte d'Ivoire and Ghana which

have promoted liquefied petroleum gas (LPG). However, the problem remains acute and Sub-Saharan Africa is one of the only regions worldwide where the number of people without access to clean cooking continues to increase.

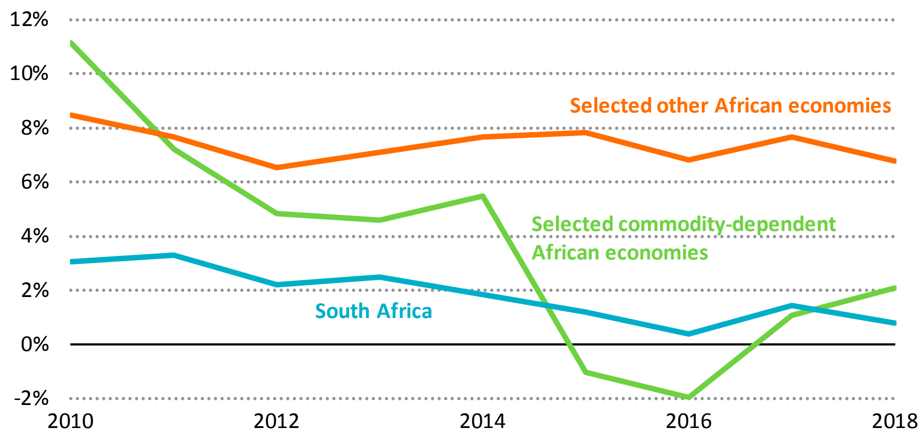
- Energy demand in Africa has been driven by the growing needs of North Africa, Nigeria and South Africa. There are also very strong regional variations. Countries such as Democratic Republic of the Congo (DR Congo), Africa's fourth most populous country, and Mozambique have seen their primary energy demand increase by over 50% between 2010 to 2018, whereas others such as Côte d'Ivoire and Ghana have witnessed only a gradual increase in energy demand (or even a decline).
- With a fifth of the world's population, Africa accounts for only 6% of global energy demand and little more than 3% of electricity demand. Average energy consumption per capita in most African countries is well below the world average and largely comparable to that of India. Bioenergy is the largest source of energy in Africa today, meeting 45% of primary energy demand and over half of final energy consumption.
- Africa has plentiful renewable energy resources and its economic potential is substantially larger than the current and projected power consumption of the continent. Bioenergy, hydropower, solar and wind power account for the bulk of the resources. East Africa also has rich geothermal resources. To date, limited use has been made of this vast potential: Africa has only 50 gigawatts (GW) of renewable capacity, mostly hydropower (36 GW). But this is changing: utility-scale projects have entered service in Egypt, Ethiopia, Kenya, Morocco and South Africa. Meanwhile, mini-grids, micro-grids and solar home systems are anchoring efforts to bring modern energy services and new sources of productive employment to remote populations, facilitated by digital technologies and payment tools.
- The future of natural gas in Africa is at an important juncture. Since 2010, there have been major gas discoveries in every part of the continent: immense finds in East Africa (Mozambique and Tanzania) were followed by more in Egypt, West Africa (Mauritania and Senegal) and South Africa. While Africa accounts for 6% of global gas production today, over 40% of global gas discoveries between 2011 and 2018 were in Africa. These resources offer new opportunities for Africa's energy and industrial development. The prospects for gas, however, hinge upon well-articulated strategies to bring the discoveries into production and build infrastructure to deliver gas to consumers at competitive prices.
- Africa is home to many of the minerals essential to the energy industry, for example, DR Congo accounts for almost two-thirds of global cobalt production. The continent also produces a large share of key minerals such as platinum (cars and fuel cells), chromium (wind turbines) and manganese (batteries), which will play a major role in powering the global energy transitions.

8.1 Context

8.1.1 Economic growth and industrialisation

Africa has experienced relatively low gross domestic product (GDP) growth since 2010, an average of 3.1% per year compared with a global average of 3.5% per year. GDP per capita in the continent is less than a third of the global average and in sub-Saharan Africa as low as a fifth of the global average. Two countries, Nigeria (17%) and South Africa (12%) account for a large portion of Africa's economic activity. Recent growth in some countries has been significantly influenced by their dependence on commodities. The greater this reliance, the more severe the impact of the 2014 commodity price decline; and the greater the fall, the more challenging the recovery (Figure 8.2). While countries such as Ethiopia, Kenya and Rwanda have successfully boosted growth through public investment and a growing services sector (AUC/OECD, 2018), Nigeria is only slowly pulling out of the recession that was triggered by a combination of lower oil prices and production outages associated with conflict (IEA, 2018a).

Figure 8.2 ▷ Annual GDP growth rates in selected African economies



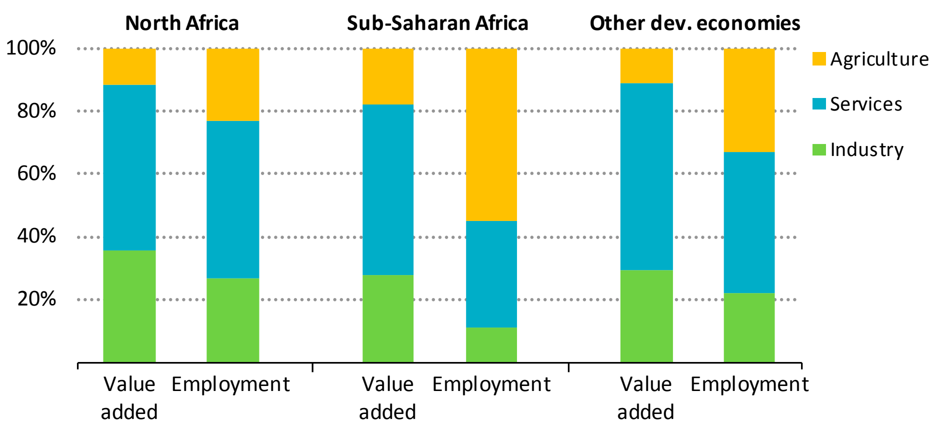
Commodity-dependent economies in sub-Saharan Africa have yet to recover fully from the commodity price fall in 2014

Note: Selected commodity-dependent economies are Algeria, Angola and Nigeria; Selected other African economies are Ethiopia, Kenya, Rwanda and Senegal.

Despite this, the overall sub-Saharan economy has expanded by more than one-third since 2010, reaching more than $4.3 trillion in 2018. Growth in Nigeria and South Africa has slowed, but GDP elsewhere is now growing at the fastest pace since 2013. GDP growth for the continent as a whole is forecast to accelerate to 4% in 2019, up from an estimated 3.3% in 2018, making it the second fastest-growing region in the world, after Asia. Some countries are growing much faster than this average. In Ghana for example, the International Monetary Fund estimates that GDP will rise by almost 9% in 2019, double the pace of emerging economies as a whole, and well ahead of world growth (IMF, 2019). Ethiopia, Côte d'Ivoire, Rwanda, Senegal and Tanzania all feature on the African Development Bank Group's list of the ten fastest-growing economies for 2018 (AfDB, 2019). Foreign direct investment (FDI) into Africa rose by 11% to $46 billion in 2018, reversing declines in 2016 and 2017 while FDI into sub-Saharan Africa increased by 13% to $32 billion (UNCTAD, 2019).

North Africa and South Africa are relatively industrialised, but other sub-Saharan African countries represent only a small share of global industrial production, and industry is hampered in many countries by unreliable electricity supply and high energy costs. The contribution of different sectors to GDP and employment varies significantly between individual economies, but for sub-Saharan Africa as a whole the relatively low share of employment in industrial sectors stands out. By contrast, services contribute 55% to the economy and a third of employment, while agriculture accounts for only 18% of GDP but well over half of employment (Figure 8.3).

Figure 8.3 ▷ Shares of value added and employment by sector in North Africa and sub-Saharan Africa, 2018



Agriculture accounts for a very large share of employment in sub-Saharan Africa even when compared to other developing economies

Incomes and personal wealth vary greatly across Africa, but sub-Saharan Africa is home to some of the world's poorest people. While global poverty rates have been reduced by more than half since 2000, and good progress is being made in many African countries such as DR Congo, Ethiopia and Nigeria, more than 40% of the population in sub-Saharan Africa continues to live below the poverty line on an income of less than $1.90 a day (UN, 2019a). Sub-Saharan Africa also remains one of the most unequal regions in the world. Half of the twenty most unequal countries in the world (measured by the Gini co-efficient) are in sub-Saharan Africa (UNDP, 2017). Average per capita incomes across sub-Saharan Africa range from over $10 000 in Mauritius and South Africa to less than $500 in the Central

African Republic, Madagascar and Niger. In 2018, average per capita GDP in sub-Saharan Africa was around $4 000 ($2018 at power purchasing parity) compared to about $3 700 in 2010. This represents an average annual increase of around 1% a year over the period. This compares with an average annual GDP per capita increase of 2.3% worldwide and 5.5% in developing Asia over the same period. The small size of the annual increase of per capita GDP in sub-Saharan Africa may seem hard to square with its faster GDP growth rate: the reason for the difference is that the population of sub-Saharan Africa grew rapidly over the period.

8.1.2 Demographics and urbanisation

In 2000, Africa's population of 817 million accounted for just over 13% of the world's 6.1 billion people. By 2018, this share had increased to around 17%, as Africa's population expanded at more than twice the global rate to reach almost 1.3 billion, of which almost 85% or 1.1 billion live in sub-Saharan Africa. Eleven countries account for almost two-thirds of sub-Saharan Africa's population today (Figure 8.4). The average age of the population of Africa is very young: in 2017, the median age was 17 while children under age 15 accounted for 41% of the population and 42% of the population of sub-Saharan Africa (UNDESA, 2019).

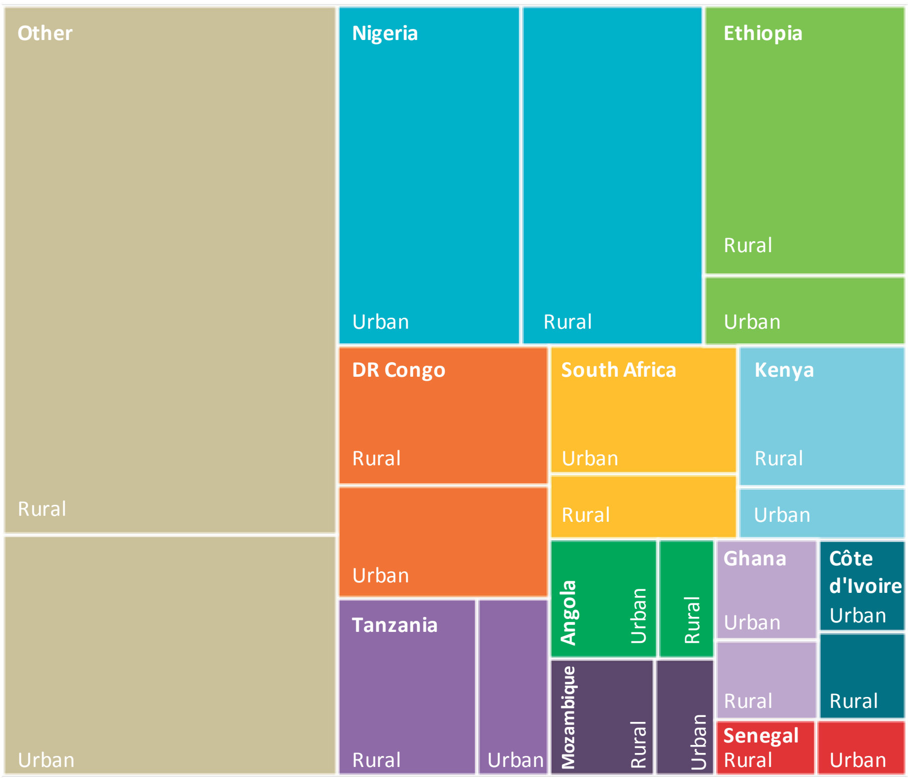
Almost 60% of Africa's population lives in rural areas although an increasing share is moving to the expanding urban areas. Africa already has two megacities in sub-Saharan Africa (Kinshasa and Lagos) and another in North Africa (Cairo). There are another five large cities on the continent with a population of between five and ten million each: Alexandria, Dar es Salaam, Johannesburg, Khartoum and Luanda (UNDESA, 2018).[1] Of these, Dar es Salaam and Luanda are likely to become sub-Saharan Africa's next megacities. The implications of an increasingly urban population for the energy sector are profound. In general, urban residents tend to consume more energy than those in rural areas, in large part because of differences in income levels. Smart urban planning and sustainable development offer a huge opportunity to shape patterns of future energy use. However, there are also likely to be major challenges arising from further strains on air quality, housing, transport, public utilities and sanitation (see Chapter 10).

The gender equality landscape in African countries is complex and sometimes contradictory, presenting both challenges and opportunities for the future. Nearly one-in-four households in Africa are headed by a woman: those in Southern Africa are most likely to be headed by a woman, while households in West African countries are least likely to be headed by a woman (Van de Valle, 2015). The percentage of women elected to parliament in many African countries, (e.g. Rwanda, Namibia, South Africa and Senegal) is among the highest in the world (IPU, 2019). Countries such as Mauritius, Seychelles and South Africa have female literacy rates on par with or exceeding those in many developing and emerging

[1] Large cities are generally defined as having between five and ten million inhabitants and megacities as having ten million or more inhabitants.

economies. Conversely, sub-Saharan Africa contains nine of the ten countries with the lowest levels of female literacy in the world. The complicated gender terrain in sub-Saharan Africa, evidenced by the existence of high levels of disparity between different groups of women as well as between regions and countries, has important implications for access to energy and for socio-economic development.

Figure 8.4 ▷ Share of urban/rural population in sub-Saharan Africa, 2018

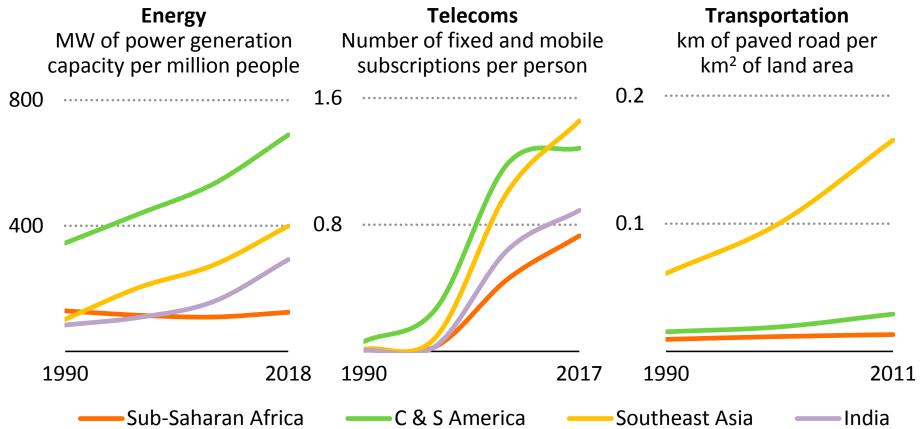


Eleven countries account for almost two-thirds of sub-Saharan Africa's 1.1 billion people today

8.1.3 Infrastructure and investment

Infrastructure is an essential building block for economic development and quality of life, but Africa, especially sub-Saharan Africa, lags behind other developing economies in virtually all aspects of infrastructure quality. Over the past three decades, the level of per capita power generation capacity in sub-Saharan Africa has remained flat, whereas in India and Southeast Asia (which had less generation capacity per capita than sub-Saharan Africa in 1990) it has grown fourfold. Sub-Saharan Africa has made relatively good progress on telecommunications infrastructure, but still compares unfavourably with other developing economies. Paved road network density has remained unchanged over the past three decades despite the growth in population and trade, owing mainly to continued under-investment in road expansion, maintenance and rehabilitation (Figure 8.5).

Figure 8.5 ▷ Infrastructure quality developments in selected regions



Slow infrastructure development in sub-Saharan Africa shows a stark contrast with progress in other developing economies

Note: C&S America = Central and South America; MW = megawatt.

Sources: International Telecommunications Union Statistics; World Bank World Development Indicators Database.

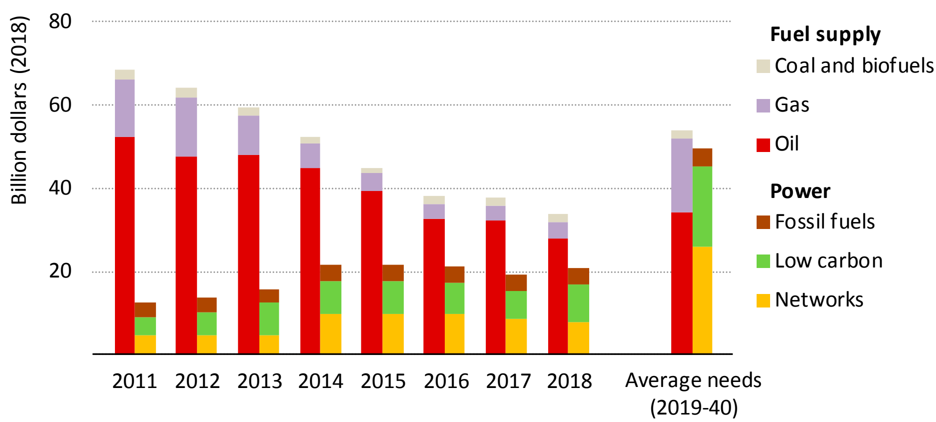
Making up the deficit of energy infrastructure in Africa will require a massive ramp-up in investment, but actual spending trends have been moving in the opposite direction. Energy supply investment in sub-Saharan Africa has dropped by over 30% since 2011[2], and oil and gas investments have more than halved because of low oil prices and investor concerns about regulation and security in major producing countries. Power supply investment registered strong growth until 2014, but has since stalled. The one bright spot has been rising investment in solar photovoltaics (PV), which is set to surpass that in hydropower for the first time in 2019, according to early data. Nonetheless, levels of spending still fall significantly short of what would be needed in the Stated Policies Scenario, particularly in the power sector (Figure 8.6).

Attracting capital for oil and gas projects in sub-Saharan Africa has generally been hampered by uncertainties around fiscal and regulatory frameworks - the design of local content rules has been a particular source of contention (Box 8.1). Moreover, difficulties in reaching agreement on contractual terms have often led to reliance in practice on a

[2] Energy supply investment includes capital spent on building infrastructure for fuel supply (extraction, processing and transportation of oil, gas, coal and biofuel) and power supply (generation, networks and storage).

handful of large companies that have the capacity to bear the risks. As a result, investment in oil and gas in sub-Saharan Africa has largely been driven by international oil companies. This contrasts with the prevailing trend in many other resource-rich countries where domestic companies, and in particular national oil companies (NOCs) take the lead. In those cases where sub-Saharan countries have established a NOC, they have generally not been effective in accelerating resource developments in the country due to their limited financial capacity and lack of technical expertise in handling complex projects (see Chapter 11). The lack of a competitive service industry is another constraint that has weighed on development costs. The limited attractiveness of the domestic market also means that most spending in oil and gas has been directed at export-oriented projects (e.g. upstream and liquefied natural gas) rather than projects geared towards domestic markets (e.g. gas pipeline, refineries).

Figure 8.6 ▷ Historical energy supply investment and average by sector in sub-Saharan Africa in the Stated Policies Scenario



Investments in fuel supply would need to increase by 60% from today's levels to meet needs; investments in power would need to grow by two-and-a-half times through to 2040

Investment in power infrastructure in sub-Saharan Africa has mainly been financed by state budgets with substantial contributions from international donors. Public and international development finance collectively accounted for over 90% of the capital committed to power infrastructure in 2017 (ICA, 2017). While public sources of finance have an important role to play, they are unlikely to be sufficient to address the significant investment gaps that exist, and need to be supplemented by private sector financing. Africa has so far had limited success in mobilising private finance. Between 2013 and the first-half of 2018, power sector investment based on private participation in infrastructure (PPI) models in sub-Saharan Africa amounted to around $4.5 billion per year on average, less than 10% of the annual needs between today and 2040. Most of the region's PPI investment has gone to a handful of countries with South Africa alone accounting for more than half.

Ultimately whether projects can attract financing depends on whether developers and investors believe that they will deliver adequate returns and the timely repayment of debt to lenders. This requires a sound investment framework (e.g. tariff schemes, institutional and regulatory structures) as well as a robust contracting framework (e.g. offtake agreements and financing structures) to manage risks around future cash flows (see Chapter 10). The role of public and development finance is also important: these sources can not only provide necessary capital, but also encourage private sector investment through targeted interventions such as risk sharing, liquidity support and take-out financing. Outside South Africa, public and development finance has not been very effective in catalysing private capital, suggesting that much more needs to be done to plug the investment gaps in power and energy infrastructure (see Chapter 12).

Box 8.1 ▷ Governance and policy frameworks

Good governance is closely correlated with faster growth, higher investment and faster poverty reduction. The World Bank Governance Indicators show that there was little to no progress in institutional quality across sub-Saharan Africa from 2000 to 2015 (World Bank, 2018). Progress was however recorded in many countries on perceived corruption. Côte d'Ivoire and Senegal, for example, are among the countries that improved their position on the Corruption Perceptions Index while, Angola, Nigeria, Botswana, South Africa and Kenya all displayed some promising developments (Transparency International, 2019).

Stable and effective governance and regulatory frameworks are crucial for increasing competition and attracting investments in the energy sector, and weak governance and regulatory frameworks at national and sub-national levels continue to impede performance in the energy sector. A key issue is the need for transparent and responsible management of hydrocarbon revenues (discussed in more detail in Chapter 11).

8.2 Access to modern energy

Access to modern energy is a central pillar of efforts to reduce poverty and support economic growth in sub-Saharan Africa. Modern household energy services have two components: first, access to clean cooking facilities, where progress remains slow, with around 900 million people without access today; second, access to electricity, where there has been strong progress in several countries over the past decade but almost 600 million people in sub-Saharan Africa remain without access today (Box 8.2). Beyond households, gaining access to modern energy services is also essential for businesses, farmers and community buildings.

Box 8.2 ⊳ Defining and tracking household energy access

The IEA defines a household as having energy access when it has reliable and affordable access to both clean cooking facilities and electricity, which is enough to supply a basic bundle of energy services initially, and with the level of service capable of growing over time (IEA, 2019a).[3] We consider that this basic bundle of electricity services should encompass, at a minimum, several lightbulbs, phone charging, a radio and potentially a fan or television. Access to clean cooking facilities means access to (and primary use of) modern fuels and technologies, including natural gas, liquefied petroleum gas (LPG), electricity, bioethanol and biogas, or improved biomass cookstoves which deliver significant improvements[4] compared with basic biomass cookstoves and three-stone fires traditionally used in some developing countries. This definition of energy access serves as a benchmark to measure progress towards Sustainable Development Goal (SDG) 7.1 and as a benchmark for our forward-looking analysis.

The *World Energy Outlook (WEO)* electricity and clean cooking access databases are updated annually. They contain the most recent country-level data on the share of national, urban and rural households with electricity and clean cooking access for the 2000-18 period. The Access to Electricity Database sources data, where possible, from government-reported values for household electrification.[5] It takes into account connections to the main grid, and where available access through decentralised systems able to supply the basic energy services mentioned above. Despite their development benefits, "pico solar" products, mainly solar lanterns which may include mobile phone chargers, are considered to be below the minimum threshold to count as having access.

Access to electricity is considered to be binary (a household either has or does not have access) as the availability and quality of reported data limits the capacity to describe the level of service, reliability and affordability.[6] Within these limits, this special focus

[3] A full description of the *World Energy Outlook* energy access methodology can be found at www.iea.org/energyaccess/methodology.

[4] Most improved cookstoves currently in use have not been found to significantly improve household air pollution and thus are not considered as access to clean cooking. For our projections, only the most improved biomass cookstoves that deliver significant improvements are considered as contributing to energy access.

[5] The IEA Electricity Access Database, based on administrative data reported by ministries, differs from the World Bank Global Electrification Database, which derives estimates from household surveys. The IEA administrative data on electrification provides information from the perspective of supply-side data on utility connections and decentralised systems distributions, which in particular have the advantage of being updated annually. More information on the differences between databases can be found in the *Tracking SDG 7 Report*, which the IEA chaired in 2019, as one of the United Nations-appointed co-custodians of SDG 7 (IEA, IRENA, UNSD, WB, WHO, 2019).

[6] The World Bank's Energy Sector Management Assistance Program is undertaking surveys in several countries to measure energy access according to the "Multi-Tier Framework", a methodology that measures multiple attributes of the supply and use of electricity and cooking fuels; this initiative is helpful to map the current levels of access to affordable, reliable and modern energy, though assessment difficulties are likely to remain on a large scale.

integrates comprehensive analyses on the reliability of power systems, the level of energy demand from households, and the affordability of energy services, which are all important in ensuring that access to modern energy services delivers social and economic benefits (see section 8.3.3, and Chapters 9 and 10).

The Access to Clean Cooking Database comes from IEA analysis based on the Household Energy Database 2018, collected by the World Health Organization, which compiles data on reliance on primary cooking fuels at urban and rural level using national surveys. This is complemented by IEA's *World Energy Balances*, which contain data on residential energy consumption, as well as government sources of data.

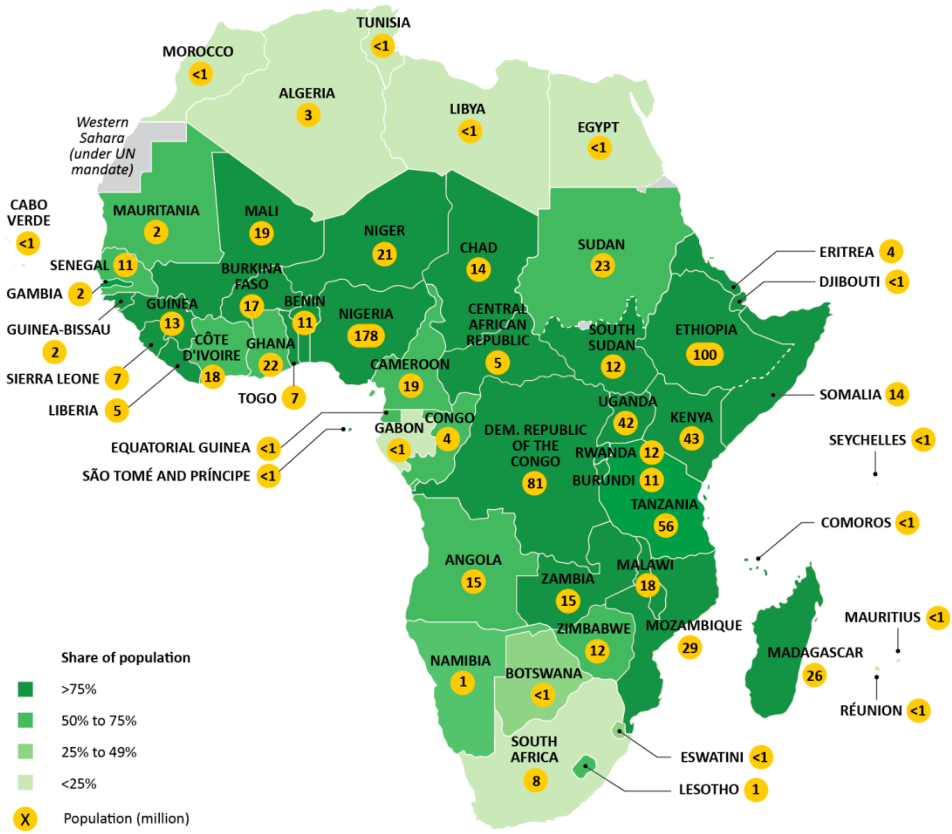
8.2.1 Clean cooking

Lack of access to clean cooking remains very acute in sub-Saharan Africa with access increasing only slightly from 15% in 2015 to 17% in 2018 (Figure 8.7). Progress has been registered in a handful of countries: West Africa has made the fastest progress since 2010, with almost 3 million people gaining access each year, followed by East Africa with nearly 1.5 million people per year. The number of people without access exceeded 900 million in 2018 as population growth outpaced efforts to provide access. Sub-Saharan Africa is the only region where the number of those without access continues to rise significantly, highlighting the urgent need for action. Almost 500 000 premature deaths per year are related to household air pollution from the lack of access to clean cooking facilities, with women and children the worst affected. Lack of access to clean fuels is also one of the most significant contributors in low-income countries to women's workloads, and poses a barrier to the economic advancement of women. It leads to women collecting and carrying loads of wood that weigh as much as 25-50 kilogrammes, which can also damage their health (UNEP, 2017).

Forest degradation, sometimes leading to deforestation, is another serious consequence of the unsustainable harvesting of fuelwood, mainly driven by inefficient charcoal production for cities (see Chapter 9). The forest area per capita in the sub-Saharan African region, a rough proxy for biomass potential available for consumption, is declining at an annual average rate of about 3%, almost double the rate seen in other developing regions. Biomass consumption outstrips the sustainable potential by the largest margin in Nigeria and Kenya. It is estimated that 27-34% of wood-fuel harvesting in tropical regions is unsustainable (FAO, 2018). Deforestation and the resultant shortage of fuel affect millions of people, especially women and children, who bear most of the responsibility for gathering firewood and cooking.

The shares of cooking fuels in sub-Saharan Africa (excluding South Africa) have remained relatively stable in recent years (Figure 8.8). Solid biomass – including fuelwood, charcoal and dung – is the most widely used fuel across the region (Box 8.3). Several governments, including Ghana, Cameroon and Kenya, are promoting LPG as a better alternative, largely in

Figure 8.7 ⊳ Population without access to clean cooking in Africa, 2018



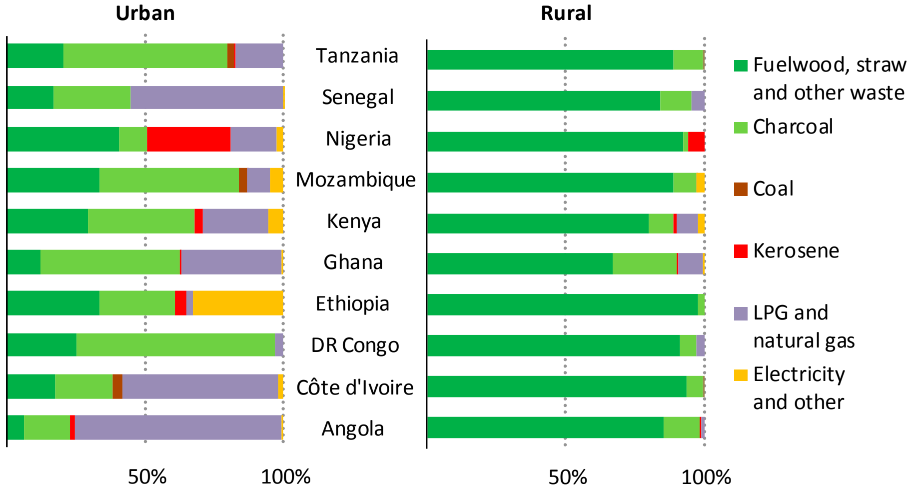
Around 900 million people are without access to clean cooking in Africa; in 32 countries more than 75% of the population is without access to clean cooking

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Sources: IEA analysis; World Health Organization (WHO) Household Energy Database.

urban areas. Ghana has been promoting LPG since 1989 and 24% of the population relied on LPG in 2018; as of December 2017, the government had distributed LPG cookstoves to 150 000 households in 108 districts under the LPG Promotion Programme launched in 2017. It intends to distribute them in all 217 districts of Ghana by 2020 (Asante, et al., 2018). In other countries, for example Nigeria, LPG uptake primarily displaces kerosene. Clean cooking has only increased by 0.7 percentage point since 2013 in rural sub-Saharan Africa, in part because supply chains for cleaner fuels lack the necessary scale to reach many rural communities.

Figure 8.8 ⊳ Main fuels used by households for cooking, 2018



Use of clean cooking fuels such as LPG continues to increase in urban areas, but reliance on traditional use of biomass still dominates in rural areas

Sources: IEA analysis; WHO Household Energy Database.

8

Box 8.3 ⊳ Traditional and modern uses of biomass

The various forms of bioenergy differ in terms of sustainability. Bioenergy feedstocks include different products and by-products from the agriculture, forestry and waste sectors (e.g. wood, charcoal, sugarcane, palm oil, animal waste) and there are many ways to use them to produce energy (heat, electricity and fuels).

In Africa, as well as developing Asia, solid biomass remains the largest source of energy used by households (in energy-equivalent terms) and is often burned as fuel in a traditional manner in inefficient and polluting cookstoves, using very basic technologies often with no chimney or one that operates poorly. This so-called "traditional use" of solid biomass is not sustainable and is associated with a range of damaging impacts to health and well-being. The volumes concerned are generally excluded when presenting shares of energy from renewable sources.

Solid biomass can also be used for cooking and heating in more advanced, efficient and less polluting stoves. It can likewise be used as a fuel in combined heat and power plants or transformed into processed solid biomass (pellets), liquid biofuels or biogas. These are classified as modern uses of bioenergy.

Bioenergy has the potential to contribute to the decarbonisation of the power, heat and transport sectors, bringing wider benefits in terms of rural development and diversification of energy supply. There are a number of potential concerns regarding sustainability that have to be considered when planning to use biomass, however, including deforestation, loss of biodiversity, lifecycle greenhouse-gas (GHG) emissions, land-use changes and air pollution linked to combustion. It is thus important that the potential benefits of using bioenergy are balanced against the sustainability considerations that are unique to each bioenergy supply chain application (see Chapter 9).

Several programmes support the diffusion of improved biomass cookstoves. Nonetheless, extensive analysis conducted by the IEA for *Energy Access Outlook 2017*, in collaboration with the International Institute for Applied Systems Analysis, showed that such programmes had limited success (IEA, 2017a). Improvements in pollutant levels from improved biomass cookstoves were often overstated, with virtually no biomass cookstoves on the market meeting WHO standards for exposure to household air pollution.

Conversely, while their reach has been limited to date, alternative biomass-based cooking fuels (such as bioethanol, biomass pellets, briquettes and biogas) are increasingly considered as viable alternatives to the unsustainable use of biomass. Where infrastructure and production can be efficiently developed, bioethanol in particular could prove to be not only safer but also cheaper than charcoal or kerosene. KOKO Networks, a company that focuses on promoting liquid bioethanol as a clean cooking fuel, recently launched 700 distribution points across Nairobi following a successful pilot project. Government support however will be essential to support production and distribution in many areas, especially in rural areas. In Ethiopia, for example, following initiatives such as Project Gaia, the government developed a National Biofuels Policy; promoting ethanol both for stoves and for blending with gasoline as a transport fuel, and production of ethanol now stands at around 40 million litres per year.

Very efficient electric cooking solutions are meanwhile increasing the attractiveness of electric cooking options (Couture and Jacobs, 2019). Increasing the efficiency of electric cooking could help merge initiatives on access to electricity and clean cooking by facilitating the integration of very efficient cooking appliances such as pressure- and slow-cookers in decentralised electric systems.

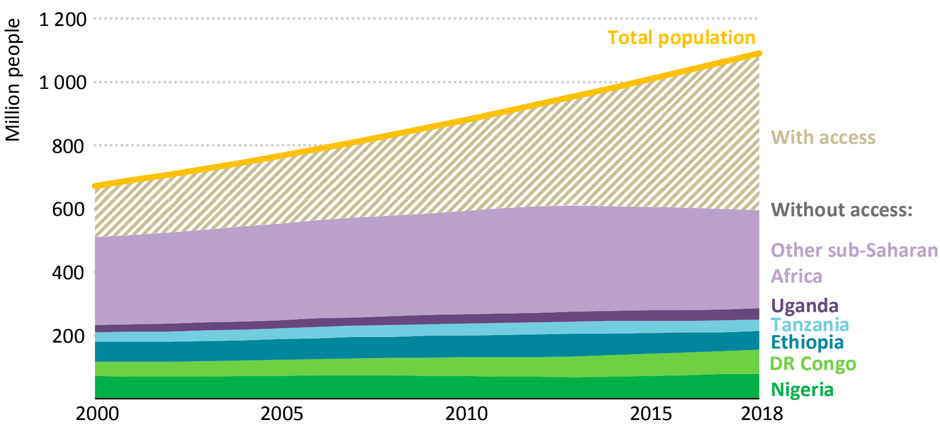
While clean cooking fuels and technologies are now more available, consumer awareness, accessibility and affordability remain significant challenges. The provision of clean cooking solutions does not guarantee that rural and urban communities will stop using traditional cooking methods. In Kenya, while only 26% of households said that charcoal was their primary cooking fuel, almost 70% were using it some of the time (Dalberg, 2018); and in an experiment testing several improved biomass cookstoves solutions some rural Kenyan households said that, although many of the proposed cookstoves allowed faster and more efficient cooking, they were much less flexible and adapted to their needs than traditional three-stone fireplaces (Pilishvili et al., 2016). Many poor and rural recipients of clean cookstove programmes thus continue to use traditional fuels and solutions for socio-cultural, economic and pragmatic reasons. Programmes to replace traditional but unsustainable fuel use are likely to succeed only if they are able to take account of these barriers to adoption in their design.

8.2.2 Electricity

More than two-thirds of people without access to electricity in the world today live in sub-Saharan Africa. North Africa reached almost universal access to electricity by 2018, but the electrification rate in sub-Saharan Africa was 45% in that year. Electrification levels in sub-Saharan Africa remain very low compared to the levels in other developing parts of the world, most notably the 94% rate reached on average across developing countries in Asia. Lack of electricity often obliges households, small businesses and community services that can afford it to use inefficient, polluting and expensive alternative solutions for essential services.

Despite the comparatively low access rate, sub-Saharan Africa has made progress with the pace of electrification accelerating over the past five years. The number of people gaining access to electricity for the first time more than doubled from 9 million a year between 2000 and 2013 to more than 20 million a year between 2014 and 2018, outpacing population growth for the first time. As a result, the number of people without access to electricity in sub-Saharan Africa peaked at 610 million in 2013, before slowly declining to around 595 million in 2018 (Figure 8.9). The region now faces a dual challenge: how to provide access to the 600 million currently deprived while at the same time reaching the millions born every year in areas without access to electricity.

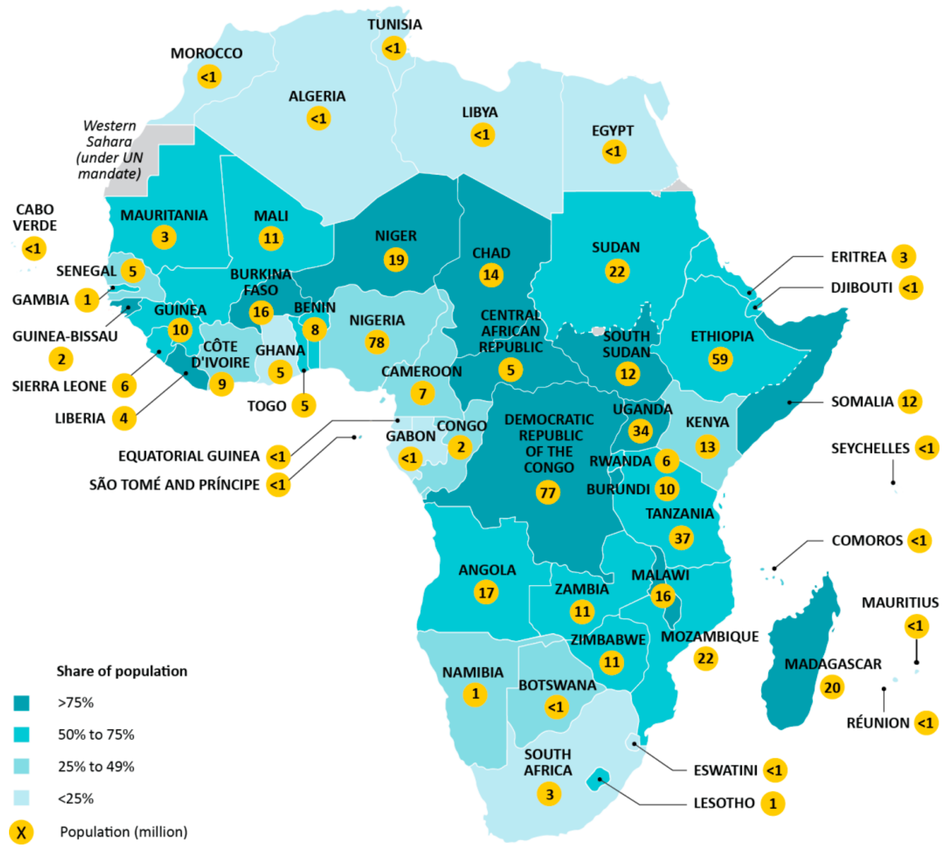
Figure 8.9 ▹ Electricity access by country in sub-Saharan Africa, 2000-2018



Population without electricity access has plateaued since 2013 thanks to the acceleration of connections; almost 50% of those without access live in five countries

About half of the sub-Saharan African population without access to electricity live in five countries: Nigeria, DR Congo, Ethiopia, Tanzania and Uganda (Figure 8.10). Conversely, Ethiopia, Tanzania and Kenya connected the highest number of people between 2014 and 2018, with these three countries accounting for more than 50% of those gaining access.

Figure 8.10 ▷ Population without access to electricity by country in Africa, 2018



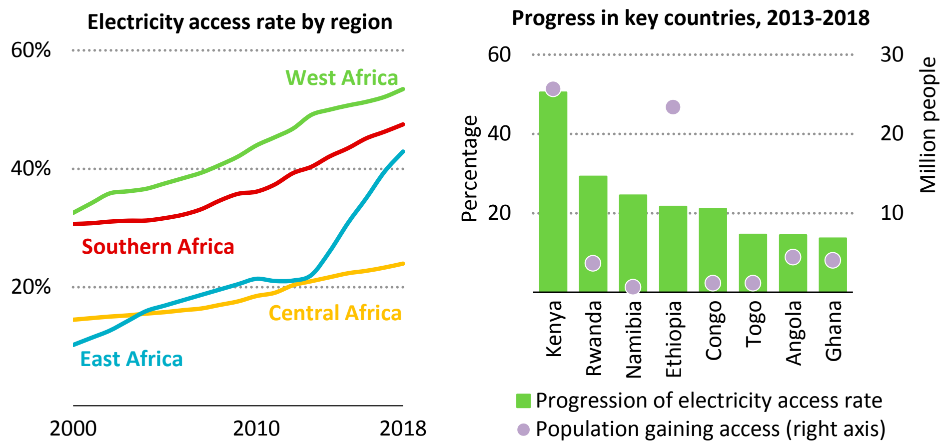
In sub-Saharan Africa 55% of people lack access to electricity; in thirteen countries, more than three-quarters of the population do not have access to electricity

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The energy challenges facing households vary significantly across Africa. In urban areas, on average, almost three-quarters of households have access to electricity, whereas in rural areas this figure falls to one-quarter. In remote rural areas and small cities not connected to a grid, finding affordable off-grid solutions and business models is key. But there are also many people living in informal settlements, with grid infrastructure nearby, that are not connected at all, or are connected illegally to the distribution grid, resulting in a revenue loss for utilities as well as exposure to hazards such as fires and risk of electrocution for those with illegal connections (see Spotlight on communities that live "under-the-grid" but without electricity). Getting or formalising grid access is often complicated not only by the high upfront connection costs for poor households, but also by the quality or absence of local distribution infrastructure. For households already connected, located mainly in urban areas, strengthening the reliability of supply from the grid and the affordability of electricity remains the priority (see section 8.3.3).

East Africa stands out as a beacon of progress. It has more than quadrupled the increase in its electrification rate, going from an increase of around one percentage point per year between 2000 and 2013 to more than four percentage points per year from 2014 to 2018. It contains three strong performing countries in terms of electricity access rate progression: Kenya, Rwanda and Ethiopia (Figure 8.11). Kenya has performed best in recent years, with its access rate going from 25% in 2013 to 75% in 2018. Progress in Kenya is attributable to a combination of factors: a strong grid connection push through the Last Mile Connectivity Project; continuous support by government for decentralised systems expressed through exemption from import and value-added taxes for solar products and the adoption of international standards; and the development of a mature mobile payment infrastructure that enabled innovative business models and payment mechanisms to emerge. These factors allowed the country to increase grid connections by almost one million households per year (or more than five million people), and to provide more than 700 000 households with access to electricity through decentralised systems by 2018.

Figure 8.11 ▷ Electricity access progress in sub-Saharan Africa



Progress on electricity access has accelerated dramatically in East Africa since 2013

Progress has been much slower in Central Africa, but there are brighter signs in both West and Southern Africa, which achieved 53% and 48% access rates respectively in 2018. Early progress in Ghana demonstrated the need for an integrated approach that takes into account all possible solutions to achieve universal access. In 1991, the Ghanaian government developed the National Electrification Scheme, a master plan containing six five-year implementation phases to reach universal access to electricity by 2030 which was drawn up after a two-year National Electrification Planning Study. This scheme supported the use of main grid, mini-grid and renewables stand-alone systems according to which was most appropriate for a given area. Under its Self-Help Electrification Scheme, clearly stated contributions or commitments were expected from both the government and communities seeking to get connected to grid electricity. By 2018, 84% of the population had access to electricity, up from 45% in 2000.

Lessons from other countries confirm the need for strong government leadership; for adequate planning based on precise analyses of the situation; and for clear allocation of responsibilities at the national and local levels in order to be able to achieve steady and effective progress. In Morocco, for example, the national utility (ONEE) increased the rural electrification rate from 18% in 1995 to 97% in 2009. It implemented a utility-led model that focused on grid extension for 95% of households and that used solar home systems to provide access to electricity for those in isolated or dispersed areas on the basis of a fee-for-service model. In India, a strong push from the government resulted in almost 100 million persons gaining access to electricity in 2018. The Saubhagya Scheme, which ran from October 2017 to March 2019, connected 26 million households to electricity for free; almost 99% of these connections were realised through the main grid, while mini-grids and solar home systems helped reach the remaining 1%, usually in remote areas.

While Morocco and India have provided access to electricity primarily through grid connections, the geography, demography and level of infrastructure provision in sub-Saharan Africa points towards the need for strategies specific to each country that integrate centralised and decentralised solutions to reach universal access. As such, governments in sub-Saharan Africa are increasingly allowing for flexibility in their policy design. In Nigeria, the energy ministry has developed a set of policies that cover a wide range of renewable systems as part of their efforts to reach remote populations across the country. The Rural Electrification Agency is currently implementing a large-scale strategy including energy service company-led and utility-led models to accelerate the rate of electrification through grid extension and green mini-grids, and is targeting market clusters, manufacturing centres, schools, universities and hospitals, for electrification using solar PV and hybrid solar PV-diesel systems.

The majority of progress over the past decade has been made as a result of grid connections[7], but the balance has been shifting. Provision of access by means of decentralised solutions has increased considerably since the IEA's *Energy Access Outlook* was published in 2017 (IEA, 2017a). Around 15 million people are now connected to mini-grids in Africa (ESMAP, 2019), while the number of people gaining access through solar

[7] Connections to the grid have been both formal and informal: in Côte d'Ivoire and Ghana, for example, one single formal metered connection can legally serve more than one household.

home systems in sub-Saharan Africa increased from two million in 2016 (IEA, 2017a) to almost five million in 2018 (IEA analysis based on sales data provided by the Global Off-grid Lighting Association). This route to energy access has been concentrated in a few countries: Kenya, Tanzania and Ethiopia accounted for almost 50% of new connections in 2018. In Ethiopia, 32% of rural households are connected through solar home systems (Padam et al., 2018) and in Rwanda around 15%. The market for solar home systems is largely made up of systems below 50 watts which provide access to energy services such as energy-efficient televisions and cooling fans.

The digitalisation of communication and financial services has been critical to the development of mini-grids and solar home systems markets. In some countries in sub-Saharan Africa, the widespread availability of mobile phones, mobile money accounts, and associated telecommunication and payment infrastructures have helped the development of a wide array of energy services (IEA, 2017b). Solar home system providers are offering customers affordable payment plans over several months or years, often with an initial deposit followed by daily payments that cost less than customers currently spend on kerosene (see Chapter 10). Mobile networks enable direct communication with customers and remote control of devices, enabling solar home systems to be disabled when the customer fails to pay. By means of such a scheme, the company Fenix International Inc. has brought affordable solar power to over 500 000 homes in several regions of sub-Saharan Africa with its ReadyPaySolar Systems (Fenix, 2019).

The relationship between electricity access and priorities such as local development and human capital is an important element of the United Nation's 2030 Agenda for Sustainable Development. The vast majority of rural households in Africa rely on agriculture, and integrating agricultural needs such as irrigation, agro-processing and storage into the design of electricity access business models and technologies can have a very positive impact. Cold storage powered by renewable energy supply, for example, could help reduce post-harvest losses, which are estimated at between 20% and 50% of food produced (depending on the food) in sub-Saharan Africa. Electricity can also play an important role in improving agricultural productivity through irrigation, as several successful examples of stand-alone solar water pumps show, provided that policy makers also tackle wasteful irrigation practices.

The absence of electricity access, or access only to intermittent supply, also deeply impacts the quality of services available to the population. In 2016 in sub-Saharan Africa, around half of lower secondary schools and 57% of upper secondary schools had no access to electricity (UNICEF Institute for Statistics, 2019). Moreover, in 27 sub-Saharan African countries, close to 60% of health centre facilities have no access to reliable electricity (Cronk and Bartram, 2018). Access to electricity is essential to a proper provision of essential services: in health centres, for instance, it supports the use of efficient modern equipment, the preservation of vaccines and medicines, and the ability conduct emergency medical procedures, for instance during childbirth.

S P O T L I G H T

What approaches can help communities that live "under-the-grid" but without electricity?

More than half of the urban population in African countries lives in informal settlements often lacking access to formal electrification services (Tusting et al., 2019). Furthermore, at least 110 million of Africa's 600 million people without electricity access live in informal urban settlements close to or directly under a grid (GTM Research, 2017). A 2017 World Bank study on infrastructure in Africa discovered that connection rates for populations living under-the-grid is lower than 50% in most countries in sub-Saharan Africa, with a few exceptions such as South Africa, Nigeria, Gabon and Cameroon. Depending on the data source, estimates for under-the-grid populations without access to legal electricity in other African countries range from 61% to 78% (World Bank, 2017a).

A few studies provide insights into the consumption of poor urban customers and the reasons why utilities are unwilling or unable to serve them despite the immense commercial opportunity they represent (Baruah B. , Energy Services for the Urban Poor: NGO Participation in Slum Electrification in India, 2010). The price of grid connection is one of the major barriers to connection. Typically, people who live in urban informal settlements are poor, with low incomes and low power demands, and connection prices are frequently unaffordable. Before the Last Mile Connectivity Project, the price of a connection in Kenya was around $400 per household (Lee, Miguel and Wolfram, 2016), nearly one-third the annual average per capita income and over three-times the mean of the willingness to pay of surveyed Kenyans. In Nigeria, 62% of under-the-grid households cite high connection costs as the major reason for not being connected to the grid (GTM, 2017). The Centre for Global Development estimates that there may be up to 95 million people living in under-the-grid areas in Nigeria, Kenya, Tanzania, Ghana and Liberia.

There is an urgent need for innovative approaches to provide affordable legal electricity to those living under-the-grid in African countries. A look at promising practices for providing legal access to electricity to urban poor consumers offers some guidance (Shrivastava, 2017). In 2009, Tata Power Delhi Distribution Limited (TPDDL) in India focused on connecting a particular segment of its customer base living in impoverished neighbourhoods. The most significant interventions introduced by TPDDL included reducing new connection charges to INR 350 (about $7 at the time), offering an affordable 24-month payment plan, waiving outstanding dues, reducing requirements for proof of identification and residency, relaxing commercial formalities on land rights and promoting insurance offerings for those with metered connections. Between 2010 and 2015, TPDDL's unique model connected 175 000 new rate-paying customers in 217 impoverished neighbourhoods near New Delhi. In the process, the utility doubled its customer base and increased its revenues fourfold.

Many of the features TPDDL adopted were replicated in Jamaica, Brazil, South Africa, Philippines and Kenya (in Kenya it was estimated in 2013 that more than three-quarters of off-grid homes are located within 1.2 kilometres of a power line) (Wolfram, 2013). In 2015, Kenya Power & Lighting Co. (KPLC) discovered through a survey that customer willingness to pay for an electricity connection upfront was only 57%. KPLC responded by instituting a subsidised connection fee of around $170 through the Last Mile Connectivity Project and an instalment-based payment plan that led to a thirty-fold increase in legal electricity connections in impoverished neighbourhoods in one year.

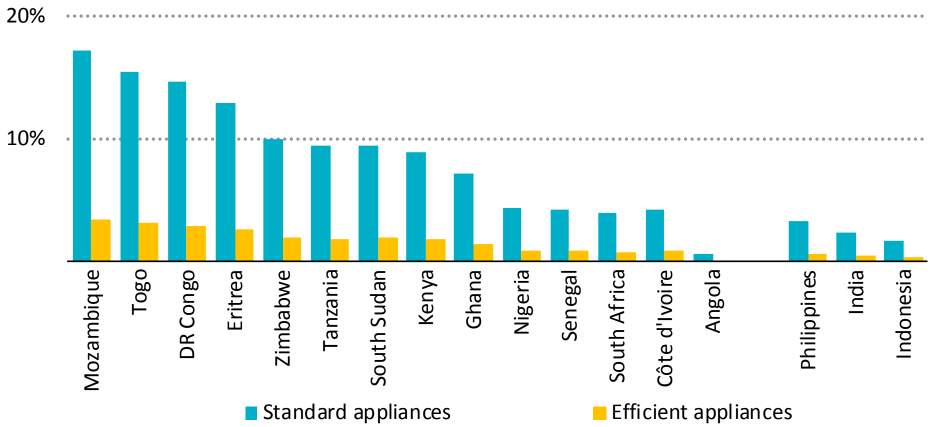
8.2.3 Affordability: energy prices and fossil fuel subsidies

Affordability remains a challenge when it comes to providing households with access and with modern energy services that they can use. The two central elements here are the cost of being connected and equipped (connection to the grid, acquisition of the decentralised system or the stove, appliances); and the cost of the energy used (i.e. electricity supply and cooking fuel refills). Making access to electricity and clean cooking affordable requires an understanding of the current payments made by households for similar services and of the structure of their income. For example, many households in rural areas relying on traditional use of solid biomass use a stove and a fuel which do not require significant capital outlay. As noted above, programmes which have proved to work on a large scale have had to respond to household concerns about capital costs either by subsidising the costs or by spreading payments over time to reduce the required capital outlay.

On the basis of electricity prices in several countries, it appears that paying for electricity to power a few basic appliances (four lightbulbs, a fan, a mobile phone charger and a television) would represent around 10% of the average income of the bottom 40% poorest households (Figure 8.12), while in Mozambique and Togo it would represent more than 15%. As a result of the high cost of power relative to income, electricity consumption rates per household in many sub-Saharan African countries are among the lowest in the world. The average household in most sub-Saharan Africa consumes less than 1 000 kilowatt-hours (kWh) of electricity each year, less than one-seventh of the average consumption of households in advanced economies. Other than South Africa, it is only in Angola that average household consumption exceeds 2 500 kWh, partly because the government subsidises tariffs.

There are actions that governments can take to improve affordability. Cross-subsidy schemes could help lower the costs of electricity for the poorest households. So could the promotion of highly efficient appliances. While such appliances tend to have higher upfront costs, we estimate that they could cut the proportion of income spent on electricity bills. Incentives could be provided to poorer households to encourage the purchase of more efficient appliances instead of or in conjunction with subsidies or cross-subsidies to reduce the price of their electricity. Digital payments could facilitate such schemes: around 90% of the 147 000 televisions sold by in the second-half of 2018 sold by solar home systems companies were through pay-as-you-go mechanisms, with more than 100 000 sold in East Africa (GOGLA, 2019).

Figure 8.12 ▷ Electricity expenses required to power basic appliances as a percentage of household revenues for the poorest 40%



Affordability of electricity remains an issue for many people in African countries. Efficient appliances can help keep costs down

Notes: Electricity consumption is based on a basic bundle of energy services, equating to around 500 kWh per household annually with standard appliances and 100 kWh with highly efficient appliances. This delivers four lightbulbs operating four hours per day, a mobile phone charger, a fan operating three hours per day and a television operating two hours per day. The household revenue is the average gross national income per household for the bottom 40% of households and is computed using the World Development Indicators.

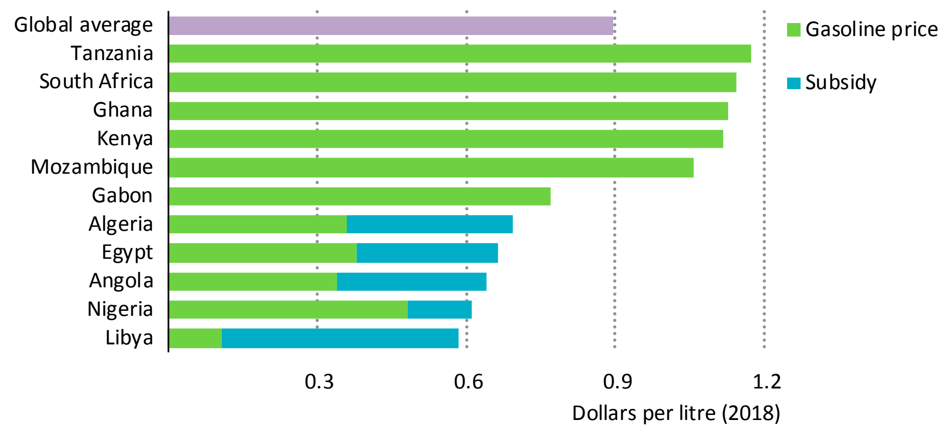
Sources: IEA analysis using World Bank World Development Indicators in some cases.

End-user energy prices vary significantly across countries in Africa, and reflect differences in domestic energy resources, levels of energy access, subsidies and taxes. Retail prices for road transport (gasoline and diesel), for example, are often higher than the world average (Figure 8.13) There are however exceptions: some major hydrocarbon exporting countries supply fuels to their domestic markets at prices lower than those in international markets. Some countries abstain from energy consumption subsidies in order to focus on other policy priorities. Instead of supporting gasoline and diesel prices, for example, Ghana prioritises subsidising kerosene and LPG as part of a strategy to promote switching away from the harmful and unsustainable use of solid biomass.

The interaction of subsidy policies with energy access is a challenge for many sub-Saharan African countries, raising questions about fiscal priorities and about how best to improve access to electricity and achieve sustainable development goals. Consumption subsidies for fossil fuels may once have seemed necessary for development goals, but renewables are increasingly cost competitive with other forms of generation, and many countries are now looking instead at an expansion of low-carbon electricity provision, both via centralised grids and on a decentralised basis (which avoid the costs of transmission and associated losses as well as incurring lower costs for distribution). The situation is different for clean cooking, where some of the viable alternatives to solid biomass are fossil fuels, in particular

LPG, but examples in India and in some African countries show how subsidies can quite effectively be targeted at specific sectors of the population, or limited to a certain number of LPG cylinders per month.

Figure 8.13 ▷ Gasoline end-user prices in selected African countries, 2018



Gasoline end-user prices vary substantially in African countries

For oil-exporting countries in Africa, many of which subsidise fossil fuel consumption, lower prices since 2014 have created strong pressure for pricing reforms to improve fiscal balances and to diversify economies which are highly dependent on hydrocarbons. However, the reform process remains unfinished business in a number of countries. Despite being a net exporter of oil, Nigeria imports most of the oil products consumed in the country (see section 8.3.3) and continues to supply them at subsidised prices; we estimated the value of these subsidies in 2018 at $2.9 billion section. Fossil fuel consumption subsidies are much more prevalent in North Africa, in particular in Egypt (with an estimated consumption subsidy bill of $27 billion in 2018), Algeria ($17 billion) and Libya ($5 billion).

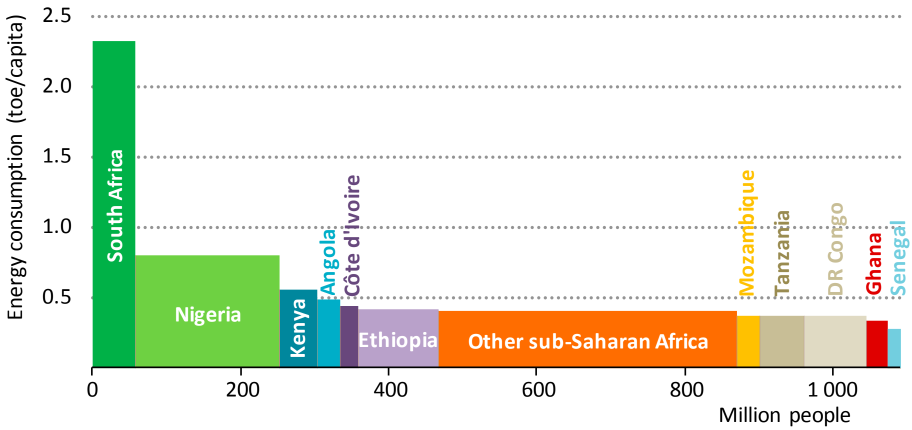
8.3 Energy trends in Africa today

8.3.1 Energy demand

Primary energy demand

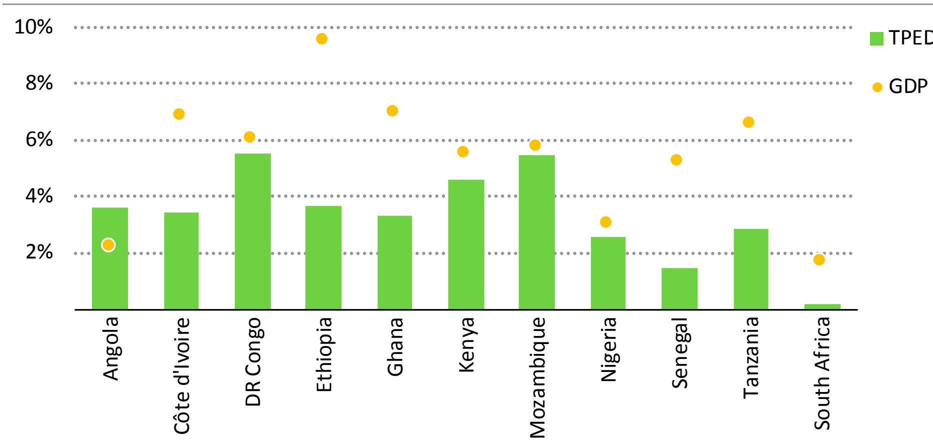
In recent decades, African energy demand has been driven by the growing needs of North Africa, Nigeria and South Africa. In 2018, primary energy demand in Africa was more than 830 million tonnes of oil equivalent (Mtoe): North Africa (24%), Nigeria (19%), and South Africa (16%) together accounted for almost 60% of this despite making up only 35% of the population. Average energy consumption per person in most African countries is well below the world average of around 2 tonnes of oil equivalent (toe) per capita and is broadly comparable to India's average of 0.7 toe/capita. In 2018, per capita consumption in sub-Saharan Africa was highest in South Africa at 2.3 toe/capita and in Nigeria at 0.8 toe/capita (Figure 8.14). Most other sub-Saharan African countries have per capita consumption of around 0.4 toe/capita and in most a large part of it consists of the relatively inefficient use of solid biomass.

Figure 8.14 ⊳ Energy consumption per capita and population in selected sub-Saharan African countries, 2018



Excluding South Africa, per capita consumption in sub-Saharan Africa is 65% below the average for developing economies

Figure 8.15 ⊳ Primary energy demand and GDP annual growth in selected sub-Saharan African countries, 2010-2018



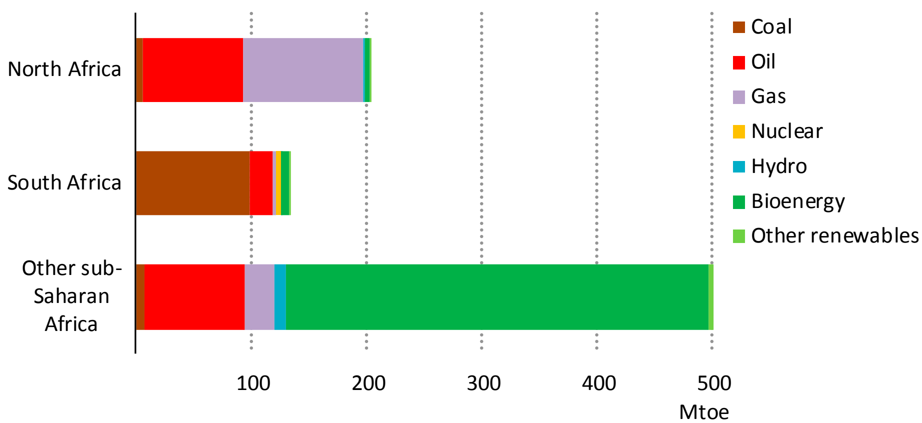
There is wide disparity between annual GDP growth and primary energy demand in many sub-Saharan African countries

Note: TPED = total primary energy demand.

The rate of growth in energy demand in sub-Saharan Africa has slightly slowed in recent years and remains lower compared to GDP growth (Figure 8.15). Between 2000 and 2010, energy demand increased at an annual average rate of 3%, but this slowed to 2.5% from 2010 to 2018, with very marked variations. Countries such as the DR Congo (Africa's fourth most populous country) saw their primary energy demand more than double between 2000 and 2018, whereas others such as Côte d'Ivoire, Ghana and Mozambique have witnessed an increase in demand of around half. The smaller increase in demand does not mean energy services didn't grow at the same rate: in the case of Côte d'Ivoire, the push towards LPG for cooking has resulted in a decline in solid biomass use, and this has produced large efficiency gains.

Traditional biomass is used mostly for cooking in Africa, but is also used in industry. It is by far the most widely used energy source across Africa, with the exception of North Africa, where oil and gas dominate, and South Africa, where the energy mix is coal-heavy (Figure 8.16). In sub-Saharan Africa, bioenergy's share in the overall energy mix has barely changed over the last 25 years, and it continues to dominate the primary energy mix, accounting for 60% of total energy use in the region (if South Africa is excluded, this share increases to almost three-quarters). There is no other region in the world that relies so heavily on bioenergy.

Figure 8.16 ▷ Total primary energy demand by fuel for selected African regions, 2018



With the exception of South Africa, the sub-Saharan Africa energy mix is dominated by solid biomass and oil

Fossil fuels represent almost 40% of the overall energy mix in sub-Saharan Africa and more than half of the African energy mix. Oil demand stands at almost four million barrels per day (mb/d). The transport sector accounts for most oil use (60%), but diesel is also consumed for back-up generators, kerosene or LPG within households for lighting and cooking, and a variety of oil products are used by industry (Table 8.1). Natural gas overtook coal as the third fuel in the African energy mix in 2015. Today, natural gas accounts for 16% of that mix, with nearly 160 billion cubic metres (bcm) consumed each year: almost 80% of this is consumed in North Africa and over 10% in Nigeria. Coal now accounts for 13% of the primary energy mix (compared with around a quarter globally), with consumption of almost 160 Mtce. South Africa accounts for the overwhelming majority of the continent's coal consumption, where it is used for power generation, industrial processes, transport (after coal-to-liquid conversion), and household heating.

Table 8.1 ▷ Total final consumption by fuel and sector in sub-Saharan Africa, 2018 (Mtoe)

	Industry	Transport	Residential	Other
Coal	12	0	5	5
Oil	9	69	5	13
Gas	9	0	0	0
Electricity	17	0	10	7
Bioenergy	18	0	281	13
Other renewables	-	-	0	0
Total	**65**	**69**	**301**	**38**
Share of total final consumption	*14%*	*15%*	*64%*	*8%*

Households

The affordability of basic services is an important concern in many African countries, where there are very low levels of appliance and vehicle ownership (Table 8.2). There are important disparities between urban and rural areas, reflecting their different levels of income (see section 8.2.3). There are also major inequalities within urban and peri-urban areas, where many people live in informal settlements under poor conditions as measured in terms of access to energy, sanitation and water services. While the situation has improved slowly over the last ten years, many households still lack appliances that could improve their quality of life, such as a fan (or even air conditioning) and a refrigerator: ownership levels of these appliances are far below the average of developing countries.

In many parts of Africa, ownership of a car remains a luxury, while ownership of two/three-wheelers is comparatively more common. The number of passenger light-duty vehicles is increasing in many countries as incomes rise, but the efficiency of the fleet is low as many are older vehicles imported second-hand from Europe and Asia (although some countries, for example Angola and Mozambique, restrict the importation of older vehicles). Public transport is also less developed in many places though it could play a pivotal role in boosting economic and social welfare in one of the world's most rapidly urbanising region. Rail networks are scarce, and many were originally built to meet the needs of extractive industries rather than to provide passenger services. In many parts of the continent, households rely on buses and minibuses to travel within or between cities. Providing safer and faster alternatives for transporting large numbers of people would be the first among the many benefits of investing in mass transport. There are a number of success stories in the region to inspire the further development of public transport (Box 8.4).

Table 8.2 ▷ Household size and average household ownership of key items in rural and urban areas in Africa

	Household occupancy (number of people)		Air conditioner (ownership per 1 000 households)		Car (ownership per 1 000 households)		Two/three-wheeler (ownership per 1 000 households)	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Sub-Saharan Africa	**3.8**	**5.5**	**68**	**11**	**125**	**21**	**129**	**96**
Angola	3.7	5.0	164	22	171	12	162	202
Côte d'Ivoire	4.0	5.6	25	10	64	8	161	220
DR Congo	4.3	5.9	9	8	43	1	79	38
Ethiopia	3.2	4.8	13	9	33	2	25	8
Ghana	3.1	4.1	119	33	126	44	91	132
Kenya	3.4	4.4	20	3	109	29	78	107
Mozambique	3.6	4.9	9	8	108	12	111	74
Nigeria	3.9	5.9	92	14	205	64	304	356
Senegal	6.4	11.3	19	9	25	14	112	104
Tanzania	3.8	5.5	16	9	59	14	115	111
South Africa	3.1	3.9	107	34	343	168	31	9
Other	4.1	6.0	62	8	42	1	77	37
North Africa	**3.7**	**5.5**	**235**	**58**	**147**	**57**	**60**	**106**

8

Box 8.4 ▷ A transport success story: Bus Rapid Transit in Dar es Salaam

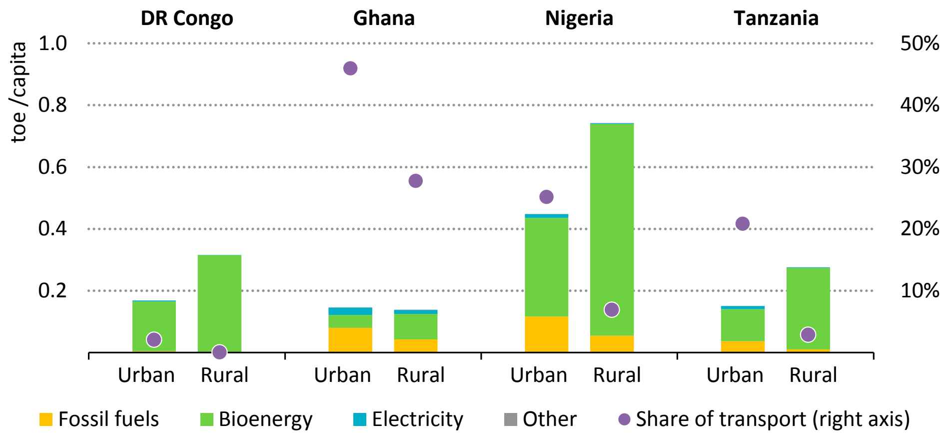
Dar es Salaam, Tanzania is growing at an unprecedented rate and is projected to become a megacity by 2035.[8] Most of the expansion has emerged on the edges of the city, compelling many commuters to travel very long distances to work. After years of struggling with an outdated and overcrowded transportation system that was extremely time-consuming to use, the city has introduced a new bus rapid transit (BRT) system which carries 200 000 passengers a day and has cut average travel times from the city centre to the terminus from two hours to 45 minutes each way. Recognised by the Institute for Transportation and Development (ITDP) as Africa's only "gold standard" BRT rating, this high-quality transit system of dedicated bus lanes offering fast, comfortable and cost-effective services at metro-level capacities is a potential model for other cities.

A similar initiative in Johannesburg in South Africa is called the Rea Vaya or "We are going" bus system. It runs on low-sulfur diesel and operates on predetermined routes in dedicated bus lanes, significantly cutting the time spent travelling through the congested streets. The system is reported by the World Resources Institute to have saved the country around $900 million so far by reducing travel time, improving road safety and reducing carbon emissions.

[8] A megacity is defined by the United Nations as a metropolitan area with a total population of more than 10 million people.

Households in Africa generally have a low level of energy consumption (Figure 8.17). Nonetheless, their overall energy use (including passenger transport needs) accounts for around two-thirds of final energy consumption. The share of households in final consumption is even higher in sub-Saharan Africa, where it reaches more than 70%, largely because of the extent of their reliance on inefficient solid biomass for cooking and poor quality cookstoves.

Figure 8.17 ▷ Urban and rural household energy consumption per capita and by fuel for selected African countries, 2018



Average household energy consumption varies between urban and rural and across countries, as does the fuel mix, though generally with a high share of bioenergy

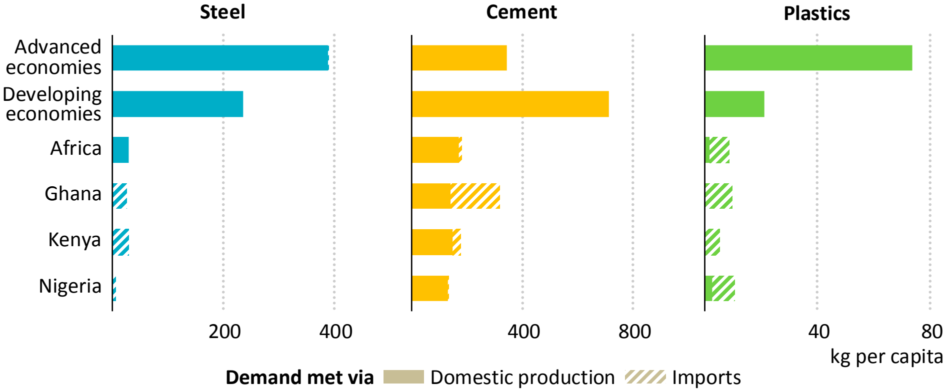
Productive uses

Productive uses, including industry, agriculture and services, account for around a quarter of total final consumption of energy in Africa. Industry employs only 13% of the workforce and generates only a third of GDP but it uses almost 70% of the energy that goes into productive uses. The services sector uses only limited amounts of energy even though it generates half of GDP. Agriculture employs half of the African workforce, but accounts for only 16% of GDP and less than 10% of energy for productive uses.

Agricultural productivity per hectare in sub-Saharan Africa is well below that of other regions in the world: this reflects low energy inputs, but also a lack of modernisation, limited use of irrigation to raise crops yields and unpredictable weather (IEA, 2017a). As a result, food production per capita has not changed significantly since 2000.

The lack of transport infrastructure acts as a brake on the development of the African economy. It hinders the development of trade within the continent as well as export (and import) of finished goods. Tackling this would help Africa to take advantage of opportunities arising from the new African Continental Free Trade Agreement (AfCFTA), which entered into force in May 2019. With the right enabling conditions, the AfCFTA has the potential to have a significant impact on the continent's development. The United Nations Economic Commission for Africa UNECA has predicted that by 2040 it will raise intra-African trade by 15-25%, or from $50 billion to $70 billion, compared to an Africa without the AfCFTA (UNECA, 2018a).

Figure 8.18 ▷ Per capita consumption of key materials, 2017



Per capita consumption of key materials such as cement, plastics and steel in Africa is low compared to developing economies elsewhere

Notes: Plastics consumption is based on 2015 data and includes key thermoplastic resins; developing economies elsewhere refers to Developing Economies less African economies in the group.

As things stand, sub-Saharan African countries represent a very small share of global industrial production: they are responsible for around 2% of global cement and aluminium production and less than 1% of steel production. As a result, Africa continues to rely on imports of many energy-intensive materials and manufactured goods (Figure 8.18).

8.3.2 Power sector

Electricity demand

Despite being home to almost a fifth of the world's population, Africa accounts for little more than 3% of global electricity demand and North African countries (42%) and South Africa (30%) represent nearly three-quarters of this. Africa's electricity demand is growing, but only at half the rate of developing Asian countries: it rose to 3% a year on average between 2010 and 2018, increasing from 560 terawatt-hours (TWh) in 2010 to around 705 TWh. The latter figure is equivalent to a fifth of electricity demand in Europe in 2018.

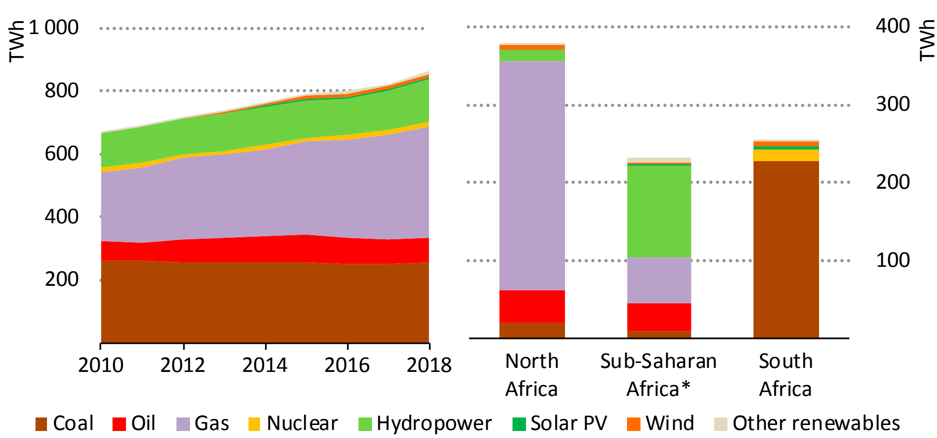
Electricity accounts for around 10% of Africa's total final energy consumption, but per capita electricity demand in Africa remains very low at around 550 kWh (370 kWh in sub-Saharan Africa) compared with 920 kWh in India and 2 300 kWh in Developing Asia.

Higher demand from the buildings sector accounted for almost 70% of the increase since 2010, largely, as a result of increased demand (more than 60 TWh) in residential buildings from appliances, water heating and cooling. Demand in heavy industry was largely stagnant over 2010-18 with lighter industries making up 90% of the almost 40 TWh demand increase across industry. South Africa alone accounted for more than 40% of African electricity demand from industry in 2018 although demand in the sector has been largely flat since 2010. Electricity use in transport remains very low across Africa, but is highest in South Africa, where parts of the rail network are electrified.

Electricity supply from centralised grids

Electricity generation in Africa increased to 870 TWh in 2018 from 670 TWh in 2010. Natural gas and coal (the latter largely in South Africa) accounted for 40% and 30% of generation output in 2018 respectively. Hydropower accounted for a further 16% and oil for 9%. However, there are large regional differences. In North Africa, for example, natural gas contributed more than three-quarters to power generation in 2018. South Africa in contrast is hugely reliant on coal and to a modest extent on nuclear power while in the remainder of sub-Saharan Africa, hydropower provides over half of generation output with oil and gas accounting for most of the balance. Although non-hydro renewables in sub-Saharan Africa (excluding South Africa) increased by 250% over the 2010-18 period, accounting for slightly more than 7% of all renewables and 4% of total generation output (Figure 8.19) in 2018.

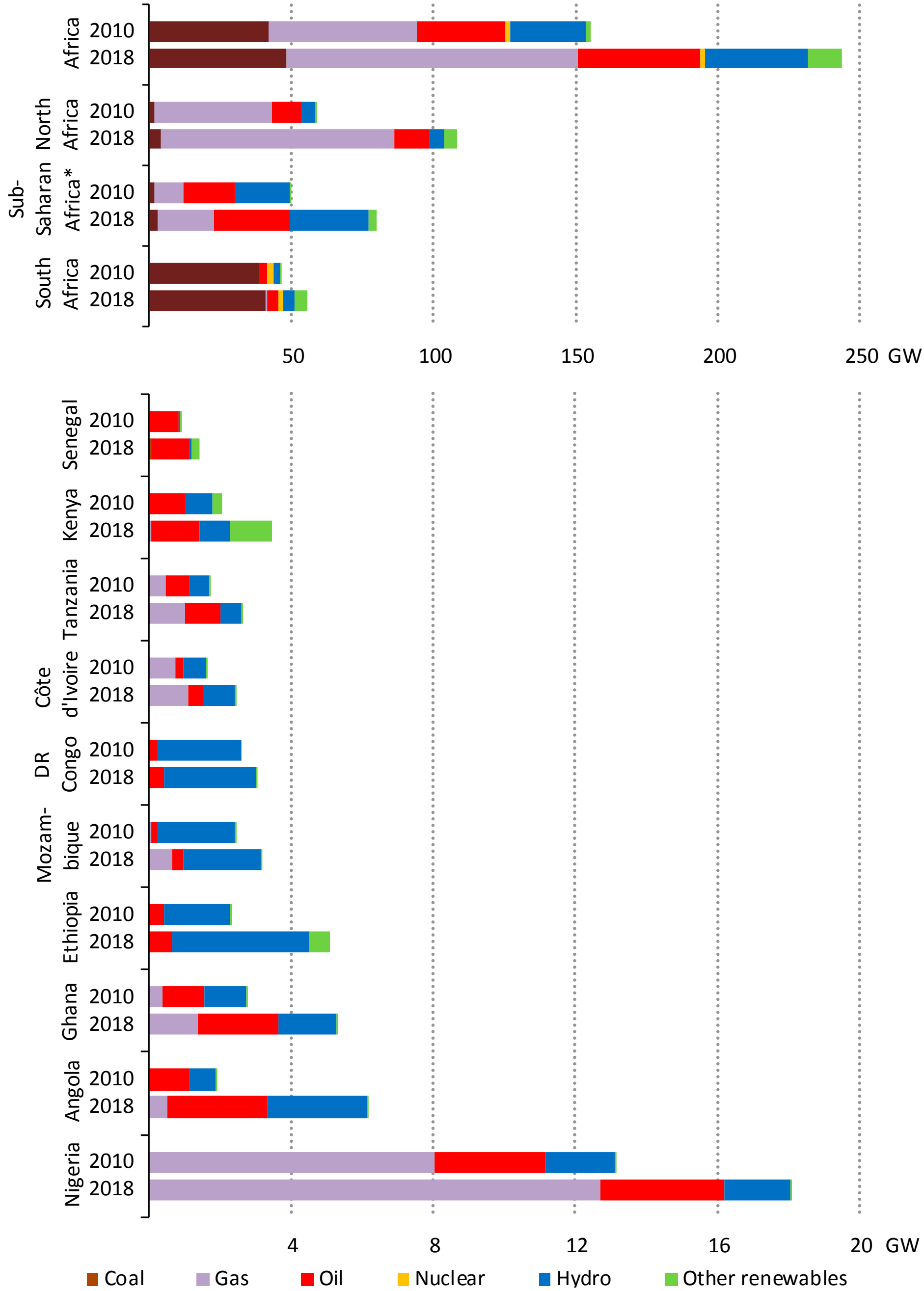
Figure 8.19 ▷ Electricity generation by fuel in Africa, 2010-2018 (left) **and in key regions in 2018** (right)



Natural gas fuelled most of the increase in electricity supply for the continent on the whole, but fuel shares varied by region and coal dominated in South Africa

* Excluding South Africa.

Figure 8.20 ⊳ Installed power capacity by fuel in selected regions/countries



Fossil fuels dominate the power mix but the role of non-hydro renewables is increasing

* Excluding South Africa.

Between 2010 and 2018, total installed generation capacity in Africa increased from around 155 gigawatts (GW) to almost 245 GW, or about a quarter of the capacity in European Union countries. South Africa and North African countries account for around 165 GW of this installed capacity. The capacity mix by fuel varies across the continent by country and region. North Africa accounts for almost 85 GW of Africa's 100 GW of gas-fired power plants, while the remainder is concentrated in Nigeria, Ghana, Côte d'Ivoire, Tanzania and Mozambique. South Africa accounts for 85% of the almost 50 GW of coal-fired capacity on the continent. Oil-fired capacity totals just over 40 GW; its relative importance varies greatly by country.

Renewable power capacity increased from 28 GW in 2010 to almost 50 GW in 2018. Hydropower is the largest source of renewable power by far and its capacity increased from 26 GW in 2010 to 35 GW in 2018, although its share in the overall generation mix has remained relatively constant at around 15%. Other renewable sources have started to develop but, for the moment, their share in generation and capacity is low. Although it has expanded in recent years, wind power development in Africa has been limited in scale compared to hydro with close to 5.5 GW of installed capacity in 2018, up from almost 1 GW in 2010. North Africa accounts for around 2.6 GW of this capacity and South Africa for around 2 GW. The growth of wind power in South Africa is in part a result of its Renewable Energy Independent Power Producer Procurement Programme that was launched in 2011 and has delivered close to 3 GW of new capacity over the past five years: notable projects include the Loeiresfotein and Khobab Wind Farms (140 megawatts each) which were commissioned in 2017. Countries such as Ethiopia, Ghana, Tunisia, Kenya and Morocco are making efforts to increase their wind deployment by adopting the independent power producers (IPPs) model (Greentech Media, 2019).

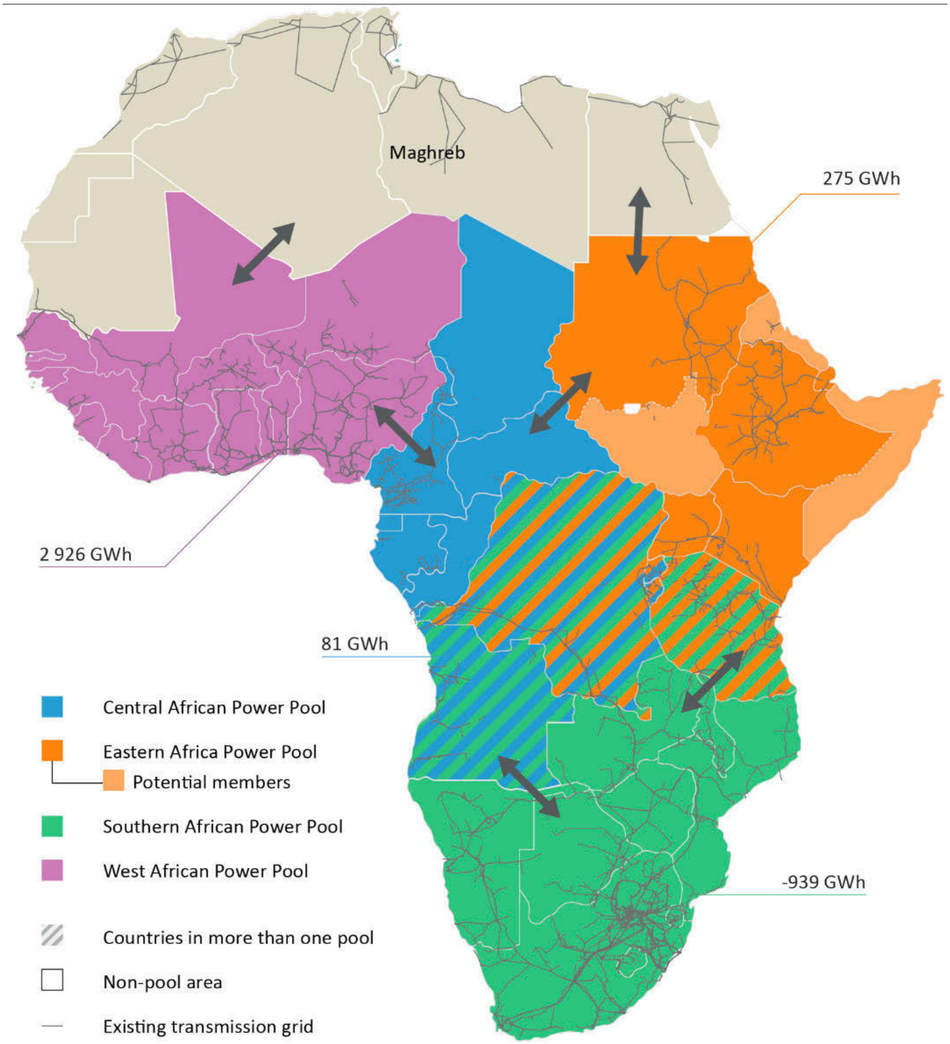
Solar PV installed capacity is around 4.5 GW. Capacity increased in 2019 when the 1.6 GW Benban Solar project, the largest utility-scale solar PV project on the continent to date, recently started service in Egypt. South Africa currently has close to 2 GW of installed solar PV capacity and a number of concentrating solar power (CSP) projects including the 100 megawatt (MW) Xina Solar One project and the 100 MW Ilanga-1 plant, which were commissioned in 2017 and 2018 respectively (IEA, 2018b). These projects brought the country's total installed CSP capacity to 0.4 GW, close to 40% of Africa's installed capacity of CSP.

Geothermal resources are generally concentrated in the eastern part of Africa where tectonic regimes indicate potential equivalent to more than 15 GW (Geothermal Energy Association, 2019). With excellent geothermal resources, Kenya has installed more than 600 MW of capacity: plans are underway to develop an additional 1 000 MW from three geothermal projects (Geothermal Development Company, 2019). Other countries in East Africa, including Ethiopia, Djibouti, Eritrea, Tanzania and Uganda are also looking to tap their geothermal resources.

Electricity trade

Africa is home to five regional power pools: Eastern Africa Power Pool (EAPP); Central African Power Pool (CAPP); Southern African Power Pool (SAPP); West African Power Pool (WAPP); and Maghreb Electricity Committee (COMELEC) (*Comité Maghrébin de l'Electricité*) (Figure 8.21). These pools vary greatly in terms of scale, governance and effectiveness.

Figure 8.21 ▷ Electricity trade between power pools in sub-Saharan Africa, 2018



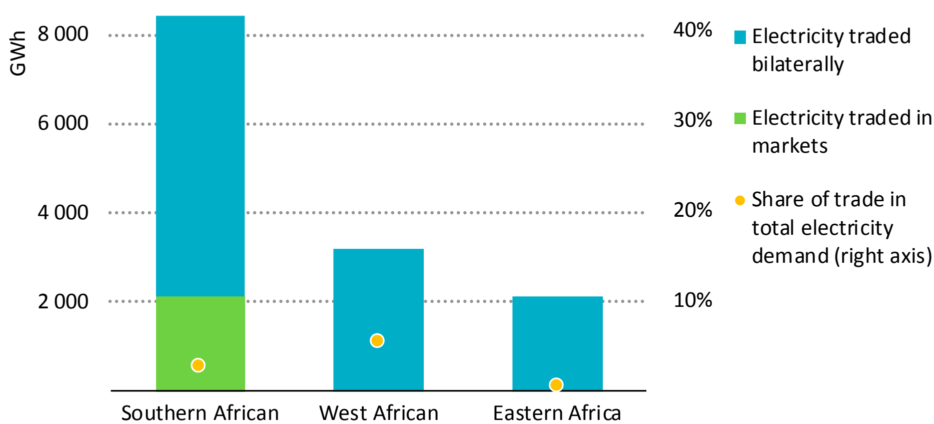
Regional power pools help to connect power generation sources across Africa

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Sources: World Bank (2017b) and AfDB's Africa Energy Portal (AfDB, 2018).

The SAPP has 17 members from 12 countries and operates four competitive electricity markets. Annual power trade amounts to around 3% of the member countries' demand, of which a growing portion is traded in the market. The COMELEC is relatively advanced while the WAPP and EAPP, both comparatively new, are making progress. The WAPP was established in 1999 and currently has 29 members, utilities and IPPs but remains underdeveloped compared with SAPP and COMELEC. The EAPP, established in 2005, comprises 11 state-owned utilities in Eastern Africa. The WAPP and EAPP have been working to harmonise their regulatory systems and develop market rules (e.g. standardised contracts and regional wheeling tariff methodology). Various transmission interconnections are under construction in EAPP, including an interconnection with SAPP (through a 400 kilovolt Tanzania-Zambia line). The CAPP was established in 2003 by utilities of eleven central African countries and is the least advanced.

Figure 8.22 ▷ Power traded bilaterally and through competitive markets in the Southern African, West African and Eastern Africa power pools



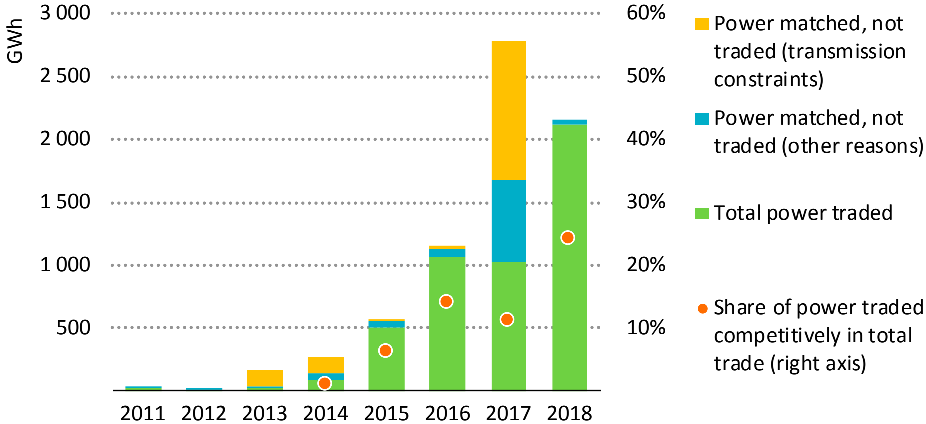
Power trade is low across the power pools and, except for the Southern African Power Pool, only bilateral trade

Note: GWh = gigawatt-hours.

Trade across the region remains low and is mostly realised through bilateral contracts (Figure 8.22). At present, in sub-Saharan Africa only SAPP has a functioning market. Some countries remain isolated from regional grids. Even where transmission interconnections exist, these are sometimes congested and need to be upgraded to facilitate trading. Around 1.8 TWh of electricity were matched in the competitive markets in SAPP in 2016/17, but were not traded because of transmission constraints (Figure 8.23).[9]

[9] Market players submit bids to buy and sell electricity in the wholesale market. When the power offered coincides with that requested, or vice versa, the electricity is said to be 'matched'. Yet, electricity can be matched but not traded, as technical constraints can come into play, like lack of transmission capacity to transport the matched electricity.

Figure 8.23 ▷ Electricity matched and traded in Southern African Power Pool and share of power traded in competitive markets, 2011-2018



Power traded in the competitive market has increased, though transmission constraints risk impeding further exchanges

Note: GWh = gigawatt-hours.

Source: SAPP annual reports (SAPP, 2019).

Most interconnections are state- or utility-owned and publicly funded. Transmission interconnections are capital-intense investments that require strong co-ordination among two or more governments and have high perceived risks, including risks related to transmission pricing. This makes it difficult for them to attract private sector finance, while domestic utilities are loss-making and have a low ability to raise funds themselves to finance these assets. This results in low investment and substantial delays. For example, the Zimbabwe-Zambia-Botswana-Namibia Interconnector (ZiZaBoNa) was initiated with the signing of an inter-utility memorandum in 2007 but has yet to reach financial closure. The situation looks set to improve with foreign donors such as the World Bank, the European Union, the European Investment Bank and US Agency for International Development Power Africa committed to providing financial and technical assistance for transmission interconnection projects, including the Cameroon-Chad Electricity Interconnection Project (PIRECT) and the 225 kilovolt (kV) interconnection of the electricity grids between Guinea and Mali.

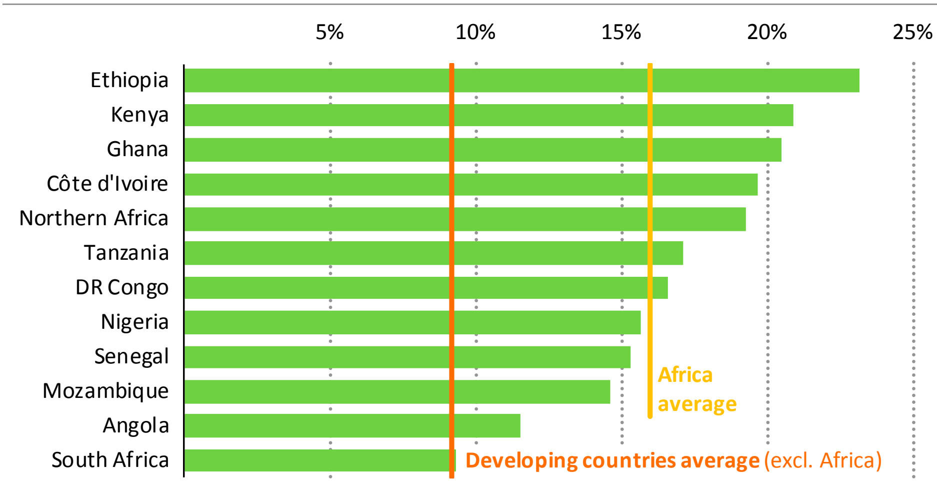
Regional power integration has the potential to reduce the level of infrastructure investment needed to meet demand by opening up a wider range of sources of supply (SAPP estimates savings in generation and transmission infrastructure of $37 billion over the 2017-40 period). It would also help to improve the resilience of countries energy systems by providing access to diverse and complementary markets, and help countries take advantage of economies of scale and realise large, low-cost projects that would not be justified based on domestic electricity demand alone. The potential benefits of the power pools mean that it makes sense to continue efforts to reduce investment risks and increase the bankability of projects, despite the challenges. This means improving transmission infrastructure and finding the right business model to scale up cross-border investments. Setting up a market in the EAPP and WAPP would allow countries to benefit from price differences within power pools, but will need improvements in trading regulations, wheeling methodology and regional grid codes.

Power system performance

According to World Bank Enterprise Surveys, unreliable electricity is perceived as a major constraint by almost 40% of firms in sub-Saharan Africa (World Bank, 2019). The vast majority of firms in sub-Saharan Africa experience electrical outages on a regular basis. In many countries, outages average 200 to 700 hours each year. In some countries they can be much worse than the average: A typical Nigeria firm experienced more than 32 electrical outages in 2018. These outages can vary in duration from less than one hour to more than a day, and in some countries they cost firms as much as a quarter of potential annual turnover and up to 2% of annual GDP.

Technical electricity losses are also high in Africa: in 2018, average losses amounted to 16%, which is almost seven percentage points higher than the average losses observed in other developing countries (Figure 8.24). The scale of these losses also varies significantly by region. In South Africa, average electricity losses were 9%. This is markedly lower than in other sub-Saharan Africa and North Africa countries, where electricity losses hovered between 17% and 19% respectively. Higher losses in these regions are a combination of a number of factors including poor operational performance on the part of utilities and theft of electricity from utilities. Reducing the level of losses would bring large efficiency gains.

Figure 8.24 ▷ Average electricity losses in selected African power systems today



Potential efficiency gains are possible by addressing the high levels of losses

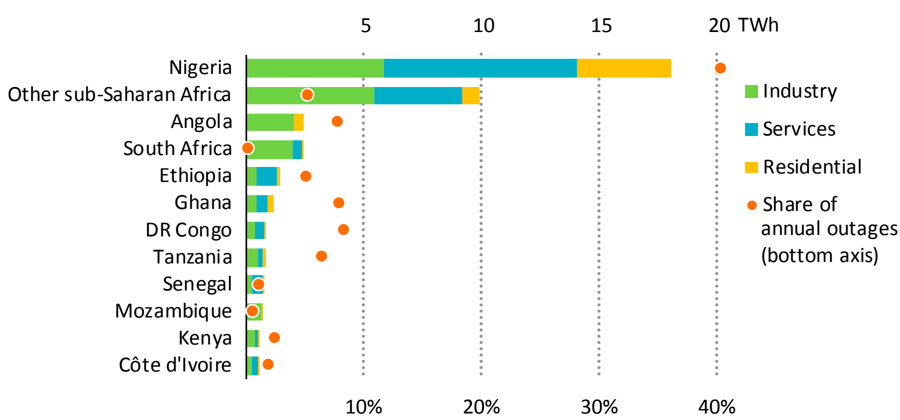
The frequent power outages in sub-Saharan Africa have resulted in a proliferation of stand-alone solar capacity and increased use of back-up generators to supplement the power needs of industry and households (Box 8.5). In Ethiopia, which depends on hydropower for much of its electricity generation, power rationing was in force during part of 2019 as a result of mechanical difficulties at dams and low water levels resulting from diminished rainfall (Africa Report, 2019). Kenya, South Africa, Zambia and Zimbabwe also experienced electricity price hikes or outages during the dry season in 2019 as a result of low water levels in hydropower systems. This may be a recurring problem if climate change results in lower rainfall.

Box 8.5 ⊳ Use of back-up generators in Africa

The poor maintenance regime and ageing infrastructure in certain countries means that electricity outages are an everyday affair for many Africans. On average, many parts of countries such as Ghana and Mozambique experience outages once or twice a week. This has a direct impact on the daily lives of citizens and on the ability of the country to attract business, while the use of diesel fuel in back-up generators contributes significantly to emissions of CO_2 and air pollutant emissions.

IEA analysis estimates that 40 TWh of power was generated from 40 GW of back-up generating capacity in sub-Saharan Africa in 2018, which is equivalent to 8% of electricity generation. Nigeria accounted for almost half, generating 18 TWh of power from about 9 GW of back-up generation (Figure 8.25). Most back-up generation is used by businesses; households are often unable to afford the extra costs.

Figure 8.25 ⊳ Electricity demand served by back-up generators and share of hours of electricity supply lost to outages in 2018



Unreliable power supply means that businesses and households turn to back-up generators in many sub-Saharan countries

8

Mini-grid and stand-alone systems

Grid extension is generally most cost effective when built to serve an area with a high density of demand. In more isolated (and often rural) areas, decentralised systems may be more cost effective. There are two main kinds of decentralised system: mini-grids and stand-alone systems.

Mini-grids are localised power networks, with infrastructure to transmit electricity within a defined service area. Generally, mini-grids provide electricity at a higher levelised cost than the main grid. Like any grid, mini-grids need a stable flow of power to function properly and often use either a small diesel generator or (increasingly) renewable-based power and battery systems for back-up. Mini-grids also require a certain demand threshold to justify the initial investment in the network, and therefore benefit from sizeable anchor loads provided by industrial and commercial customers or public buildings such as hospitals and schools. Mini-grids can be scaled up in line with rising demand, and eventually be connected to the main grid.

Electricity access can also be provided through stand-alone systems. These are systems not connected to a grid and typically power single households. Today, this market is dominated by diesel generators and solar PV systems (solar home systems). Stand-alone systems may be the most cost-effective option (from a system cost perspective) in sparsely populated and remote areas. Both solar PV systems and batteries can be built at different scales to match a need, which has led to innovative products coupling stand-alone generation with appliances. These products can be scaled up as power demand grows, and can supply a range of needs, from lighting and mobile phone charging to fans, televisions and sometimes refrigerators. Table 8.3 describes the main features of the mini-grids and solar home system markets and business models in sub-Saharan Africa.

The least-cost option to provide electricity access for a given area depends on its distance from the main grid, current and expected demand, and the lifetime of the assets needed for service delivery.[10] Least-cost options are generally identified in National Electrification Plans. Countries that have been successful in rolling these out tend to have plans that specify the technical, institutional and financial aspects of implementation.

There are around 1 500 mini-grids installed across Africa today and 4 000 more are planned; over half of them in Senegal and Nigeria, according to a 2019 World Bank market report (ESMAP, 2019). Demand has increased reflecting reductions in the capital costs of renewable-based generation. Policies and regulations have helped to promote investment and increase private sector participation.

Access through stand-alone systems has also been on the rise in sub-Saharan Africa, where East African countries are taking the lead. Almost five million people gained access to electricity through solar home systems in sub-Saharan Africa in 2018.[11] Many of these

[10] The IEA and the KTH Royal Institute of Technology Stockholm have developed a detailed geospatial model determining least-cost technologies to achieve universal access to electricity in sub-Saharan Africa, which is presented in detail in Chapter 10.

[11] This figure is based on solar home systems of at least 8 W and does not include multi-lighting systems.

bought through the pay-as-you-go (PAYG) method, where private companies lease the solar products to customers who pay periodic instalment costs and can become owners once the loan is repaid. A market report prepared by a global association for the off-grid solar energy industry (GOGLA) and others shows that PAYG accounted for more than 80% of the value of sales (mostly solar home systems) made by the main private companies in the second-half of 2018.

Table 8.3 ▷ Features of mini-grids and solar home systems in sub-Saharan Africa

		Mini-grids	Solar home systems
Systems installed		1 500*	n.a.**
Capacity of systems		Installed capacity varies substantially by system and can range from a few kW to above a MW, depending on number of people supplied, demand and uses.	• Entry level: 11.0-20.9 watts (W) • Basic capacity: 21.0 - 49.9 W • Medium capacity: 50.0 - 99.9 W • Higher capacity: > 100 W***
Business models applied		• Private models, led mainly by private developers but also demand-driven (e.g. small industries). • Public models, led by utilities. • Co-operative models.	• Private models, led by private developers. • Some public programmes, led generally by rural electrification agencies.
Private business models	Description	• Mainly pay-as-you-go (PAYG). Private companies finance upfront investment costs and customers prepay for electricity. • Revenues depend on customer demand and tariffs levels.	• Mainly PAYG (e.g. lease-to-own: customer makes small deposit upfront and pays periodic instalments). • Revenues depend mainly on loan repayment rates.
	Tariff setting	Depends on regulatory framework and/or system capacity, including: • Set as per national uniform tariff. • Set according to system cost-recovery level and return on investment, often with approval from regulator.	n.a.**
	Ownership of assets	Mini-grids owned by developers or community.	Customer acquires solar home system by the end of lease period (lease-to-own model). Can also own it from the beginning (in cash-based models), though this is less common.
	Main risks	Regulatory risk (mainly around tariff setting and what happens when main grid arrives) and revenue risk.	Revenue risk (given customers have low and unpredictable income).

* ESMAP (2019). ** Data on number or cumulative capacity of solar home systems in the region is not available (n.a.). *** Categories as defined by GOGLA (2019).

Countries with clear targets, well-designed electrification strategies, and predictable policy and regulatory frameworks show a consistent growth in sales and uptake of stand-alone systems. Kenya and Ethiopia are cases in point. Tanzania was one of the first countries to promote stand-alone systems, but recent policy uncertainty has led to stagnation in sales. The commercialisation of these products has also been linked to business models that promote local job creation and training. "Solar Sisters" is an initiative that trains local women entrepreneurs to supply clean energy products to rural households and it is impacting the lives of women and local communities (Box 8.6).

Box 8.6 ⊳ Impacts of clean energy entrepreneurship by women

Much of the existing research on access by women to renewable and clean energy technologies has focused on decentralised solar and bioenergy projects that disseminate technologies such as solar lanterns, improved cook stoves and solar home systems. Initiatives such as Solar Sisters, Envirofit, Barefoot College, Kopernik and Grameen Shakti have reached millions of low-income people in African and Asian countries using similar strategies.

In 2015, the International Center for Research on Women conducted a qualitative assessment in Tanzania to better understand whether and how being a Solar Sister clean energy entrepreneur impacts women's and men's lives at the individual, family and community levels. A secondary focus of the study was to reveal initial insights about the benefits experienced by customers as a result of using Solar Sister's clean energy products. Solar Sister's unique model of recruiting, training and supporting female clean energy entrepreneurs was found to create benefits for individual women and their households and communities by enhancing income and autonomy; business skills and leadership; equality and communication; household health and stability; child education; mobility and status; and community safety (Solar Sisters, 2019).

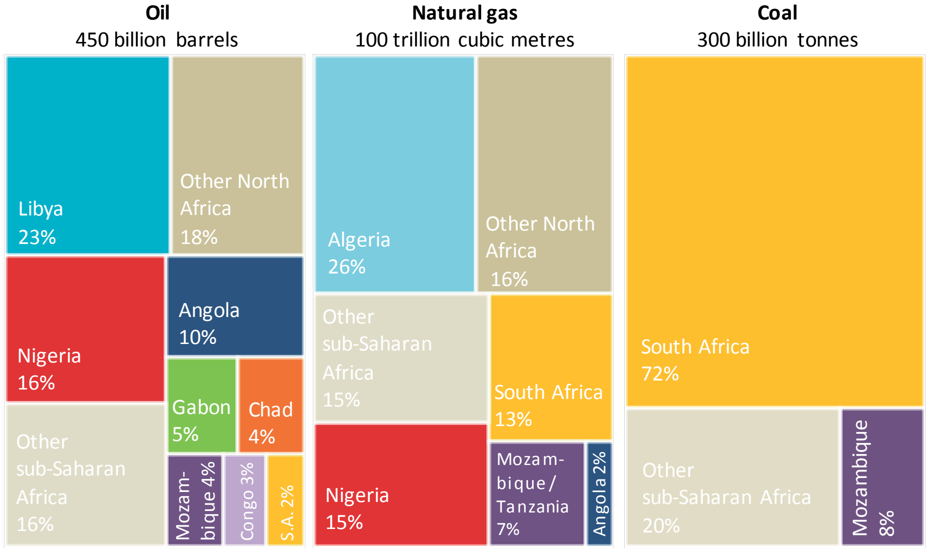
8.3.3 Fossil fuel resources and supply

Africa has large fossil fuel resources, with sub-Saharan Africa holding around half of the continent's oil and gas resources and nearly all of the coal resources. Remaining technically recoverable oil resources in Africa amount to some 450 billion barrels or around 7% of the world's oil resources. The 100 trillion cubic metres of remaining recoverable gas resources in Africa represent 13% of the world's gas resources. Coal resources are relatively small and concentrated in South Africa and, to a lesser extent, Mozambique (Figure 8.26).

Africa is also home to many of the minerals essential to the energy industry. It has around 20% of the world's uranium resources and 40% of the manganese reserves. It also produces a large share of key precious and base metals – for example, two-thirds of global cobalt production comes from DR Congo.

The continent's resource wealth has attracted interest from international companies. Between 2011 and 2014, Africa accounted for around 20% of global oil discoveries with six countries – Angola, Nigeria, Republic of the Congo (Congo), Ghana, Mozambique and Senegal – adding around 5 billion barrels of offshore resources. With major discoveries in Mozambique and Tanzania, Africa also accounted for around 45% of global gas discoveries during this period.

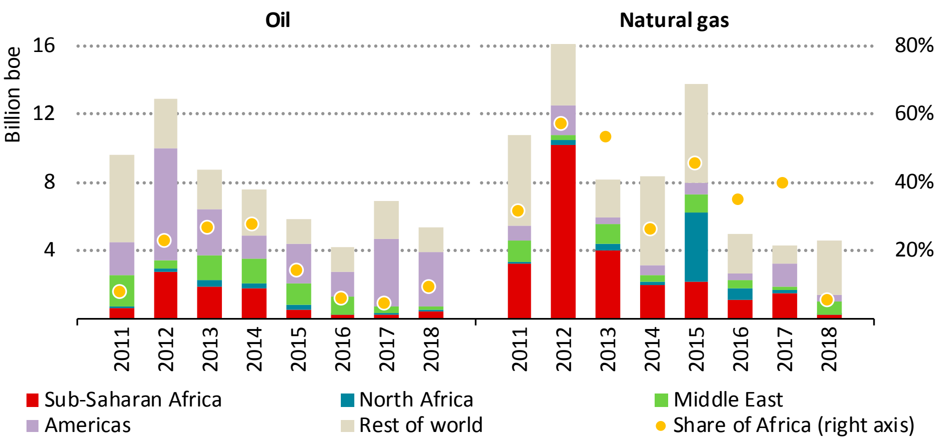
Figure 8.26 ⊳ Remaining recoverable fossil fuel resources in Africa, 2018



Africa has abundant fossil fuel resources; sub-Saharan Africa accounts for around half of the continent's oil and gas resources

Since the fall in oil prices in 2014, oil exploration has fallen sharply, and Africa accounted for less than 10% of global oil discoveries between 2015 and 2018. There has however been a series of major offshore gas discoveries in Egypt (2015), Mauritania and Senegal (2015-17) and South Africa (2019) (Figure 8.27).

Figure 8.27 ⊳ Global discoveries of oil and natural gas by region



Africa's share in global oil discoveries has fallen markedly since the oil price fall, but the region has seen significant gas discoveries

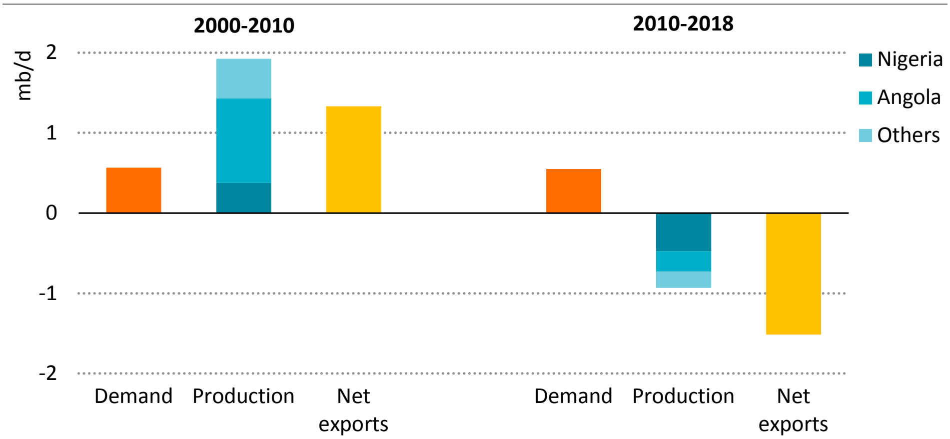
Note: boe = barrels of oil equivalent.

Oil

Oil production in Africa has seen major swings since 2000. In the early years after 2000, sub-Saharan Africa showed strong production growth as the expansion in Nigeria and Angola was joined by new producers such as Chad and Equatorial Guinea. The pace of production growth in sub-Saharan Africa was four-times faster than the global average and the region accounted for almost a quarter of global production growth between 2000 and 2010. This resulted in a 50% increase in net export volumes and, thanks to rising oil prices, a threefold increase in oil revenue.

However, sub-Saharan Africa faced a sharp reversal of fortune after 2010. Nigerian oil production started to decline from 2010 as regulatory uncertainties, militant attacks and the theft of oil took their toll, and Nigerian sweet crude oil also faced fierce competition from surging US tight oil output in export markets. Angola too struggled to keep up production levels as new investments failed to compensate for the rapid decline in maturing fields. Other producers such as Equatorial Guinea and Gabon also registered a gradual output decline. As a result, oil production in sub-Saharan Africa decreased by 15% from its peak in 2010 to 5 mb/d in 2018. Coupled with a 35% increase in domestic demand, this led to a 35% decline in net exports and associated revenue (Figure 8.28).

Figure 8.28 ▷ Changes in oil demand, production and net exports in sub-Saharan Africa

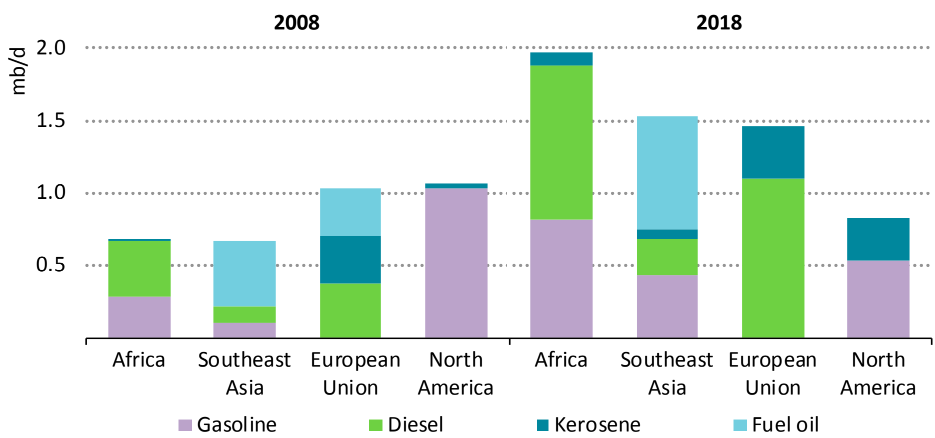


Coupled with the continued increase in demand, falling oil production in sub-Saharan Africa since 2010, led to a major drop in net exports

Major producers have recently managed to halt output declines. Nigeria's production has risen since 2016 as militant attacks in the Niger Delta have eased, but remains below the peak level reached in 2010. Long-standing issues holding back upstream investment, notably the uncertainties around the Petroleum Industry Bill, remain unresolved. In 2019, Angola succeeded in mitigating output declines due in part to the start-up of the Kaombo project, and the new government has initiated an overhaul of its oil and gas sector to stimulate investment, creating a new regulator, reorganising the role of Sonangol and streamlining investment procedures. In North Africa, output in Libya has been highly volatile given the instability and unrest there. Production registered a major drop in 2011 and remains well below 2010 levels. Output in Egypt has been in gradual decline since 2014 as investments have been directed towards natural gas developments.

Although Africa remains a major crude oil exporter, its growing oil demand and under-performing refining sector have combined to make it the world's largest importer of refined products. Africa holds 3.5 mb/d of refining capacity, which could theoretically serve three-quarters of its oil product demand, but it runs at low utilisation rates. On average, the utilisation rate was 58% in 2018; the rate was 25% in West Africa and just 9% in Nigeria.[12] African refineries tend to have fairly simple configurations, with low upgrading capabilities, and often suffer from poor maintenance. They also face growing competition from Asian and Middle Eastern refiners who are keen to export surplus diesel, and from European refiners who want to export excess gasoline. Poor refining performance has led to a growing deficit of refined products (Figure 8.29). Africa has now overtaken North America as the world's largest gasoline importer and is also the second-largest diesel importer after the European Union (IEA, 2019b).

Figure 8.29 ▷ Net imports of key refined products in selected regions



Growing demand for transport fuels and under-performing refineries have made Africa the world's largest importer of refined products

Natural gas

Africa's gas production increased rapidly in the 2000s, led by strong growth in Nigeria where the rise in oil production was accompanied by a large amount of associated gas, and in Egypt where shifting attention to gas use brought about threefold production growth. However Africa's gas production stagnated from about 2010. Egyptian production started to trend downwards until 2016 as unfavourable energy price schemes, mounting arrears to

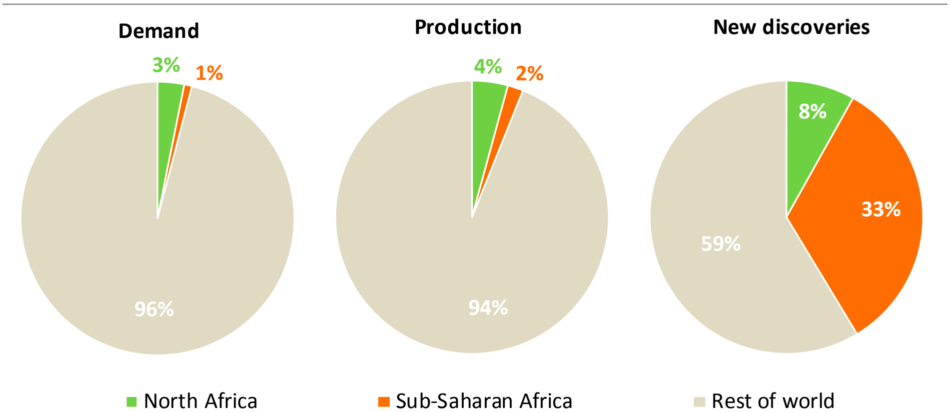
[12] Early data suggest that the utilisation rate dropped further to below 6% in the first-half of 2019.

international companies and social unrest caused a significant reduction in investment. Nigeria's rapid production growth also came to a halt as fiscal and legislative uncertainties weighed on investment. Algeria managed to maintain output levels, although its largest gas field, Hassi R'Mel, is already mature.

A series of major new gas discoveries seem likely to boost future gas production in Africa (Figure 8.30). The start of production at the large Zohr offshore field has already led to a turnaround in Egypt. A gas discovery on the maritime border of Mauritania and Senegal has been followed by a final investment decision (FID) on the Tortue liquefied natural gas (LNG) project. FIDs on new onshore liquefaction plants are coming to fruition in Mozambique to exploit the huge offshore resources in the Rovuma basin.[13] Total has also recently made a significant gas condensate discovery off the southern coast of South Africa, and the estimated volume of resources is over 20% of the world's entire gas discoveries in 2018.

Gas in Africa is at a critical juncture (see Chapter 11). Where resources are plentiful, it could provide the continent with additional electricity for baseload and flexibility needs, energy for industrial growth and a sizeable source of revenue. But whether that happens depends on countries with gas putting in place well-articulated strategies to turn the discoveries into production and to build infrastructure to deliver gas to consumers cost-effectively in a competitive global LNG market.

Figure 8.30 ▹ Share of Africa in global gas demand and production, 2018, and new discoveries, 2011-2018



Recent discoveries offer the potential to fundamentally change the role of gas in Africa

Coal

Coal production in Africa is dominated by South Africa, which accounted for 93% of the continent's output in 2018. Production in the main current producing region in

[13] Coral LNG reached a FID in 2017 and started construction in 2018. Mozambique LNG reached a FID in 2019 and Rovuma LNG by ExxonMobil is approaching a FID at the time of writing.

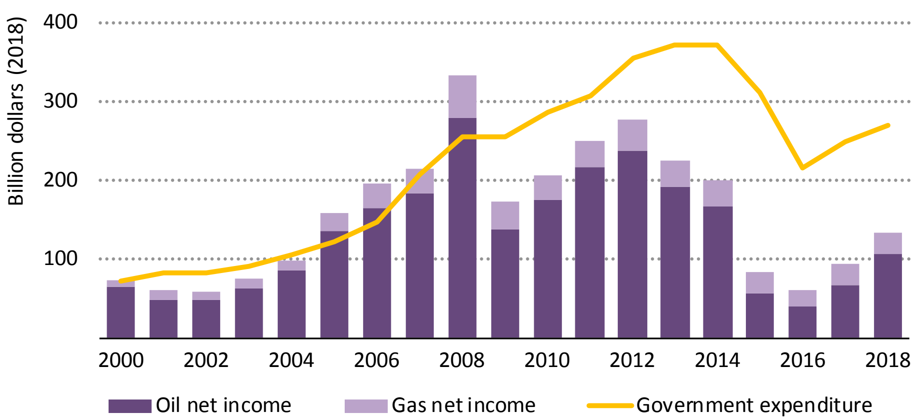
Mpumalanga province is starting to fall, and mining activities are now shifting to the northern Limpopo province on the border with Mozambique (IEA, 2018c). Around two-thirds of the country's output is consumed in domestic markets and most of the rest is exported via the Richards Bay Coal Terminal. Mozambique started coal production in 2010 and is the second-largest coal producer in Africa. Other countries such as Botswana and Zimbabwe are aiming to ramp up coal output, although building infrastructure – rail or roads – to connect production sites to demand or export centres remains a challenge.

Imperatives for resource producers

Energy resources have long been a crucial element in the economic outlook for Africa. There is a chance that recent discoveries will lead more countries to join the ranks of resource exporters. However, translating resource endowments into economic prosperity can be a daunting task. The net income[14] from resource production has been volatile over the past few decades and has tended to lead to high levels of public spending during boom times followed by periods of fiscal strain during downturns (Figure 8.31). This pro-cyclical spending has often undermined the effectiveness of government expenditure in promoting economic growth and structural transformation. Moreover, the rise of shale and the shift to clean energy also pose serious questions for development models that rely heavily on fossil fuels. It therefore is critical for both existing and potential producers to assess the resilience of their resource production and associated revenues and devise productive ways to manage and utilise resource income, a topic explored in more detail in Chapter 11.

8

Figure 8.31 ▹ Net income from oil and gas production and government expenditure in top-ten producers in Africa



Net income from oil and gas production in Africa has been volatile as the impacts of fluctuating commodity prices have been amplified by domestic circumstances

[14] Net income from oil and gas production is defined as the difference between the costs of various types of oil and gas production and the value realised from their sale on either domestic or international markets.

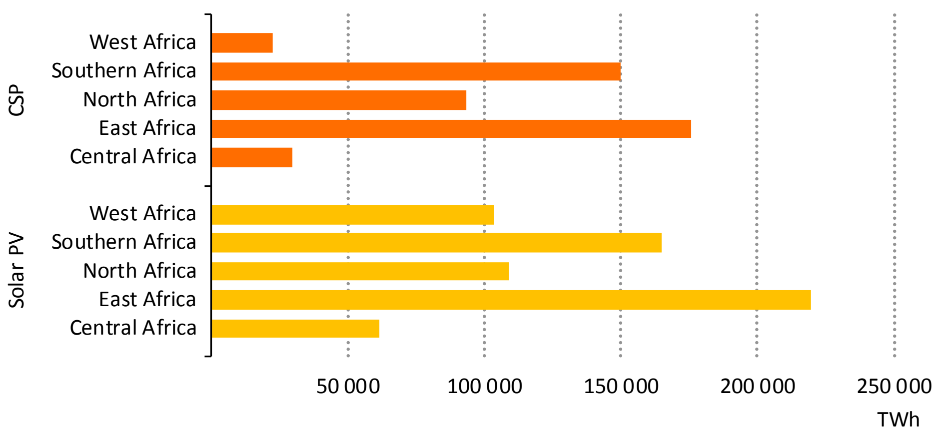
8.3.4 Renewable resources and supply

Africa is home to abundant renewable energy resources and its renewable energy power potential is substantially larger than the current and projected power consumption of the continent. Growth has been constrained, so far, by limited access to financing, underdeveloped grids and infrastructure, unstable off-taker financial arrangements and, in many countries, an uncertain policy environment (IEA, 2018b). Despite this, recent advances in renewable energy technologies and accompanying cost reductions mean that the large-scale deployment of renewable energy now offers Africa a cost-effective path to sustainable and equitable growth. In many parts of Africa, decentralised renewable energy technologies offer an economical solution for electrification in remote areas as well as for grid extension.

Solar

A study undertaken by the International Renewable Energy Agency (IRENA, 2014) assessed the theoretical potential of a range of renewable energy technologies in Africa (Figure 8.32). It estimated that Africa's solar PV theoretical potential could provide the continent with more than 660 000 TWh of electricity a year, far above its projected needs. East Africa was identified as having the highest theoretical potential (more than 200 000 TWh/year), followed by Southern Africa (more than 160 000 TWh/year).[15]

Figure 8.32 ▷ Solar energy resource potential per year in Africa



East Africa and Southern Africa contain the highest solar resource potential

Note: CSP = concentrating solar power.

Source: IRENA (2014).

[15] These potentials are purely theoretical potentials, with no techno-economic evaluation undertaken. These resource potentials, therefore, are subject to a significant reduction when economic parameters are applied.

Development of solar in Africa has been slow, with only around 4 GW of new solar PV capacity added between 2010 and 2018, more than two-thirds of it in sub-Saharan Africa. The main challenges and barriers that countries face include limited institutional capacity within government, lack of scale and competition, high transaction costs and the perceived high risk of such projects (World Bank, 2018). This has prompted the World Bank to start the Scaling Solar initiative to address these challenges by providing a "one-stop shop" to help governments mobilise privately funded grid connected solar projects at competitive costs.

IRENA also assessed the potential of CSP on the continent and estimated the likely potential as being around 470 000 TWh a year. Again, East Africa has the highest potential, followed by Southern Africa. Here too development has been slow with the exception of large solar CSP projects in Morocco and South Africa.

Hydropower

Hydropower has been the main renewable energy resource developed to date with around 35 GW of hydro capacity across Africa, with Angola, Ethiopia, DR Congo, Zambia, South Africa, Sudan, Mozambique and Nigeria each having 2 GW or more. Ethiopia has hydropower capacity of nearly 4 GW and more developments are planned, most notably the 6 GW Grand Ethiopian Renaissance Dam, which will be the largest in Africa when it comes into service in 2022. South Africa has installed hydropower capacity of close to 4 GW including the recent 1.3 GW Ingula plant.

8

Central Africa has very rich hydropower resources thanks mostly to the Congo River, the deepest river in the world and the second-longest in Africa after the Nile. There is a large mismatch between the significant hydropower potential in this region and the much more limited local electricity demand. This means that large-scale regional interconnections will be essential to promote its development. The DR Congo in particular has enormous hydropower potential that has been estimated at 100 GW, which could generate about 774 TWh of electricity per year. Plans in DR Congo to develop the Grand Inga Dam further have been beset with difficulties, but projects have been moving forward elsewhere.

While state-owned enterprises remain the largest developers of hydropower projects, many have been built by Chinese developers and backed by concessional financing. Chinese investors accounted for 60% of investment in sub-Saharan hydropower projects between 2010 and 2015.

Small-scale hydropower (1-10 MW) and mini-hydro power (0.1-1 MW) could provide power for rural electrification in some areas of sub-Saharan Africa, and there is particular potential in the central and south-eastern parts of the continent. A recent study estimated around 21 800 MW of small-scale hydropower technical potential (Korkovelos et al., 2018), with the central corridor of the sub-continent and especially South Africa, DR Congo and Sudan having the most potential. The same study also estimated that total mini-hydropower technical potential in sub-Saharan Africa was around 3 400 MW.

Wind

With close to 5.5 GW of installed wind power capacity in 2018, there is plenty of room for expansion given its theoretical potential to produce as much as 460 000 TWh of electricity a year (IRENA, 2014). Most wind resources are found close to coastal locations, mountain ranges and other natural channels in the eastern and northern regions of the continent. Algeria, Egypt, Somalia, South Africa and Sudan are among the countries with the highest wind energy potentials (IRENA, 2014). The best offshore wind energy potential is found off the coasts of Madagascar, Mozambique, Tanzania, Angola and South Africa.

Wind can be cost competitive with other technologies where the resources are good, but other factors could limit its deployment. For example, in East and North Africa, where the best resource potential is estimated, domestic markets are small and power grids are not well developed, meaning that significant variable generation from wind could be challenging to manage without additional grid investment.

Geothermal

Geothermal resources can be found throughout Africa but the bulk of the potential is concentrated in the East Africa Rift System, where total potential could be as much as 15 GW (BGR, 2016). This potential is largely untapped at present. Only Kenya has tapped its geothermal potential and installed capacity of almost 700 MW. Other countries in East Africa are now taking steps to make use of geothermal energy: Ethiopia is operating a 7 MW pilot plant and new developments totalling more than 1 GW are planned in Djibouti, Eritrea, Tanzania and Uganda. The expansion of geothermal power in the East Africa region faces a number of barriers, but technical and financial support is available (notably from Japan) to help countries formulate geothermal master plans and to promote private sector funding and local capabilities.

Bioenergy

Bioenergy continues to dominate the sub-Saharan energy mix and made up almost 60% of primary energy use in 2018. Almost three-quarters of bioenergy demand are accounted for by the traditional use of solid biomass in the residential sector, although there is also some use of solid biomass and biogas for modern power generation and heat.

Bioenergy can generate around 800 MW of electricity from current installed capacity, mainly in East and South Africa. However, large-scale deployment will be challenging, as the levelised costs of power generation from bioenergy are often higher than gas-fired generation and hydropower, due in part to the cost of collecting the biomass. Biogas has emerged as a substitute for firewood for cooking purposes in some areas, primarily in rural East Africa. Recently bio-slurry obtained from biogas production has started to be collected and utilised as fertiliser to increase agricultural production. Although at present there are technical and financial barriers limiting its application, biogas has a potentially important role to play in reducing indoor air pollution and related premature deaths (especially of women and children), limiting deforestation, and improving sanitation and the quality of life (especially for women) in rural and agricultural areas.

Advanced biofuels for transport have significant potential in many African countries. West Africa alone is estimated to have the potential to produce over 100 Mt per year of agriculture residues that could be converted into electricity or advanced biofuels such as ethanol and bio-butanol.

8.3.5 Environment

Water

Africa has less than 9% of the world's renewable freshwater water resources, and more than 50% of it is held in just six countries in Central and West Africa (UNESCO, 2019). The continent is home to roughly 80 transboundary lakes and rivers with most large river basins shared by five or more countries (UNECA, 2018b). Today, sub-Saharan Africa is in the midst of its worst drought in 35 years. In 2018, Cape Town almost ran out of water. In 2019, several cities in Mozambique, Zimbabwe, Ghana and Côte d'Ivoire experienced water shortages. Alongside changing and uncertain precipitation patterns brought on by climate change, Africa's water scarcity is compounded by a lack of water storage, supply and management infrastructure. By 2025, it is estimated that over 450 million people, mostly in West Africa, could be at risk of water stress (UNECA, 2018b).

Agriculture is the largest water user in sub-Saharan Africa today, despite the fact that just 3% of its total cultivated land is irrigated. Groundwater is estimated to be plentiful — the region withdraws less than 5% of its renewable groundwater whereas India, for example, withdraws almost 60% — but there is increasing evidence that some aquifers are being depleted (WWAP, 2019). Water use by the energy sector is low today, with coal and oil accounting for most of it. However, water availability could increasingly become a critical issue for energy sources, in particular for hydropower (see Spotlight in Chapter 10).

Household water use is also low and the World Health Organization (WHO) estimates that on average a person in Africa uses just 20 litres of water per day, well below the recommended minimum of 50 litres. Sub-Saharan Africa is also home to 745 million people that have no access to safely managed drinking water (over 70% of which reside in rural areas) and almost 840 million people that lack access to safely managed sanitation (roughly 60% of which are in rural areas) (UNICEF and WHO, 2019). Low rates of wastewater collection and treatment mean that a significant amount of untreated wastewater is released into the open. Contaminated drinking water has a significant health impact: diarrhoea is a major cause of mortality for children under five in sub-Saharan Africa.

Significant progress will be required to reach the targets set under the Sustainable Development Goal 6 (clean water and sanitation) by 2030 (Box 8.7). Water demand is projected to increase more in Africa than in any other part of the world rising by almost 300% from 2005 to 2030, and a large share of it is projected to occur in municipalities reflecting rapid urbanisation and more people gaining access to clean water (Wijnen et al., 2018). This will also result in larger amounts of wastewater to be collected and treated (which can increase energy demand depending on the level of treatment).

Box 8.7 ▹ How does energy provision look different if viewed alongside water and food?

Millions of people in sub-Saharan Africa do not have adequate access to the basic building blocks of economic and societal development: energy, water and food. While providing electricity access at a household level is critical, it is not enough on its own to ensure economic development. Approaching development from an integrated water-energy-food perspective allows for a broader and more durable view of local economic development, and could also change the scale and type of the energy technologies deployed. The value of this perspective for sub-Saharan Africa is visible at both a household and a broad economic level. At a household level, it is clear that the technologies being deployed to provide access to electricity can also be used to provide access to clean drinking water (IEA, 2019c). At an economic level, viewing energy development though this prism can advance the prospects for sustainable productive uses, such as agriculture. Moreover, such an approach can help address the central role of women in providing these resources.

The potential for such an approach is highlighted by a recent micro and macroeconomic modelling exercise that looked at the Ikondo-Matembwe project in rural Tanzania (RES4Africa Foundation, 2019). This project, which serves eight villages, consists of two community-scale hydro-powered mini-grids that power an anchor client, an agribusiness focused on producing animal feed, hatching poultry, and providing electricity and water to the surrounding households. The preliminary results of this study, which used a cost-benefit analysis based on the project's investment data to assess the benefits of single versus multi-service scenarios, indicate that over its 20-year lifespan a renewable energy-based integrated project has more than twice as much economic impact[16] on a local community as a project geared to the provision of energy alone. Investing in an integrated approach also had a multiplier effect, significantly increasing local purchasing power which translated into improvements in other areas. Some of the biggest benefits came in the form of increased access to better education, improved agricultural productivity and time saved from having water and energy access on site.

More research and examples are needed of these kinds of projects to understand the scope for replicating them at scale, but it is evident that looking at energy, food and water together in an integrated way has clear potential to trigger captive energy demand, increase economic productive capacity, and set African communities and economies on a path that looks beyond the immediate imperatives to meet the 2030 sustainable development goals.

[16] Measured in net-present value.

GHG emissions

In 2018, Africa accounted for around 4% of the world's energy-related carbon dioxide (CO_2) emissions despite being home to around 17% of the population. The power sector was the largest emitting sector (480 Mt CO_2) followed by transport (355 Mt CO_2) and industry (150 Mt CO_2).

Total energy related CO_2 emissions in North African countries in 2018 were around 490 Mt or 40% of Africa's energy-related CO_2 emissions (1 215 Mt CO_2). South Africa's energy sector emitted 420 Mt CO_2 with its coal-fired power fleet responsible for more than half of the country's energy-related CO_2 emissions and more than three-quarters of the sub-Saharan region's power sector emissions.

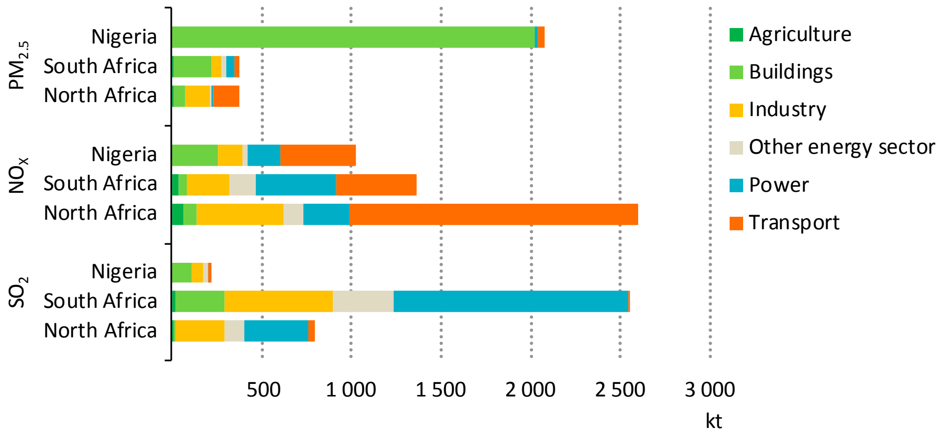
While the sub-Saharan African energy sector makes a very small contribution to global CO_2 emissions, the region is among those most exposed to the effects of climate change. For sub-Saharan Africa, which has experienced more frequent and more intense climate extremes over the past decades, the consequences of the world's warming by more than 1.5 degrees Celsius (°C) would be severe. Temperature increases in the region are projected to be higher than average global temperature increase; regions in Africa within 15 degrees latitude of the equator are projected to experience an increase in warmer nights and longer and more frequent heat waves (UN, 2019b). A recent report published by the Intergovernmental Panel on Climate Change found that the potential impacts of global warming levels on key sectors at local to regional scales, such as agriculture, energy and health, remain uncertain in most regions and countries of Africa (IPCC, 2018).

Local air pollution

Around 6.8 Mt of fine particulate matter ($PM_{2.5}$) were emitted in Africa in 2018, of which almost 85% was from the burning of biomass indoors. Damage to air quality from these sources disproportionately affects the poorest in Africa. Nigeria, with its large population and low levels of access to modern energy services, accounted for around a third of Africa's $PM_{2.5}$ emissions, emitting 2.1 Mt in 2018. This compares to around $PM_{2.5}$ emissions of 0.4 Mt in South Africa, 0.3 Mt in Tanzania and 0.2 Mt in Kenya in 2018. Efforts have been made across the continent to reduce $PM_{2.5}$ emissions mainly through incentivising the use of modern cooking fuels, such as LPG and natural gas. South Africa's National Environmental Management Air Quality Act of 2004 is one example of an African country regulating air quality and setting emissions standards, imposing limits on new and existing power plants and industrial installations.

Nitrogen oxides (NO_X) emissions in Africa were around 7.5 Mt in 2018, of which nearly 50% came from vehicle tailpipe emissions, a further 18% from industry, 16% from the power sector and 11% from buildings. In North Africa, vehicle tailpipe emissions made up almost two-thirds of NO_X emissions, reflecting the relatively high number of cars on the road. In South Africa, which has sub-Saharan Africa's largest car fleet, vehicle tailpipe emissions accounted for about a third of NO_X emissions: a further third came from the power sector (33%), largely as a result of the large share of coal in South Africa's power mix.

Figure 8.33 ⊳ Emissions of $PM_{2.5}$, NO_X and SO_2 by sector in Nigeria, South Africa and North Africa, 2018



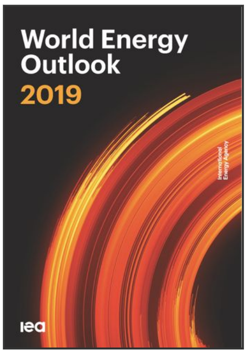
Nigeria accounts for a very large share of Africa's $PM_{2.5}$ emissions, North Africa for a large share of NO_X emissions and South Africa for its SO_2 emissions

Note: kt = kilotonnes.

Source: International Institute for Applied Systems Analysis.

Sulfur dioxide (SO_2) emissions were almost 5 Mt in 2018, almost 40% of which came from power generation, largely as a result of coal combustion in South Africa, and nearly 40% from the industry and transportation sectors (Figure 8.33).

In Africa, almost 500 000 premature deaths each year can be attributed to household air pollution, a health problem which is closely related to the lack of access to modern forms of energy. Fewer deaths in Africa are attributable to outdoor pollution than to household air pollution, but the number still stands at more than 300 000 per year, with most occurring in sub-Saharan Africa (excluding South Africa).



From:

World Energy Outlook 2019

Access the complete publication at:

https://doi.org/10.1787/caf32f3b-en

Please cite this chapter as:

International Energy Agency (2019), "Africa today", in *World Energy Outlook 2019*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/7e97f145-en

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