Africa Energy Outlook 2022

International Energy Agency

World Energy Outlook Special Report

INTERNATIONAL ENERGY AGENCY

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The International Energy Agency (IEA) has been working on African energy issues for more than two decades. We began in 1999 with pioneering work on energy access data, but our efforts have expanded significantly since then in both breadth and depth. In 2015, we began opening the doors of the IEA to major emerging economies and have welcomed South Africa, Morocco and Egypt as Association countries.

The *Africa Energy Outlook*, under the banner of our flagship *World Energy Outlook* series, has become a key contribution to developing a better understanding of the trends and dynamics at work in African energy systems and how they could evolve in the coming decades. This latest edition was produced in co-operation with the African Union Commission, the United Nations Economic Commission for Africa, and more than 20 African experts from 15 different countries.

Today, it is more important than ever to gain a clearer picture of the rapid and varied energy sector developments taking place across a continent where vast gaps remain in terms of reliable data and statistics – and where many millions of people are suffering as a result of energy poverty and the damaging effects of climate change. I find it profoundly unjust that Africa, the continent that has contributed the least to global warming, is the one bearing the brunt of the most severe climate impacts.

It has been just three years since our last *Africa Energy Outlook*, but we find ourselves in a drastically different global context. The Covid-19 pandemic has pushed more than 20 African countries into debt distress and reversed progress on expanding access to electricity. These difficulties are being compounded by the violent increases in energy and food prices triggered by Russia's invasion of Ukraine, which are hurting many consumers and businesses around the world – most severely in the developing world where people can least afford it.

In these challenging circumstances for policy makers, especially those in Africa, we are determined to provide the world with as much rigorous data and analysis as possible to help inform decisions in this crucial time. This *Outlook* offers many powerful insights about Africa's current energy context and its prospects for building a more modern, clean and affordable energy future for all of its people. Its analysis can help African policy makers take informed long-term decisions amid the tumult of today's energy crisis while highlighting how global support can play a greater role.

I would like to highlight here just one of the starkest examples: bringing access to modern energy for all Africans calls for investment of USD 25 billion per year – a sum equivalent to the cost of building just one liquefied natural gas terminal. This underscores the indisputable case for greater efforts to achieve universal energy access and that reaching this goal is well within our means as a global community.

Stimulating the necessary investment requires international support aided by stronger national institutions on the ground laying out clear strategies. This should be the immediate and absolute priority, including in the discussions at the COP27 Climate Change Conference in Egypt in November 2022. This report is designed to aid governments as they prepare for those negotiations, providing them with an authoritative source that places Africa's energy progress at the centre of this year's international energy and climate conversation.

In the Sustainable Africa Scenario developed for this report, all of Africa's energy-related development goals are achieved, including universal access to modern energy services by 2030 and the full implementation of all African climate pledges. In this pathway, energy efficiency and renewables – especially solar – are key pillars for building Africa's new energy economy.

This Outlook examines the shifting tides of the global energy landscape, as more countries commit to rapidly cutting their greenhouse gas emissions, and the implications for Africa's energy sector. Our Sustainable Africa Scenario also sees a role for natural gas and oil this decade to help fuel the continent's economic growth and industrialisation. But the report notes that despite today's extremely high gas and oil prices, decision makers should bear in mind longer term trends of declining demand for fossil fuels as the transition to clean energy advances. The analysis pinpoints how African countries can position themselves today to hedge against new risks and to seize emerging opportunities in areas such as critical minerals and green hydrogen.

I very much hope this report will help African governments, with the support of the international community, build a better energy future for their people. And I would like to thank all the colleagues, both within the IEA and from around the world, who contributed to this important and timely report under the outstanding leadership of Laura Cozzi.

Dr Fatih Birol
Executive Director
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Africa in an evolving global context

Today's global energy crisis has underscored the urgency, as well as the benefits, of an accelerated scale-up of cheaper and cleaner sources of energy. Russia's invasion of Ukraine has sent food, energy and other commodity prices soaring, increasing the strains on African economies already hard hit by the Covid-19 pandemic. The overlapping crises are affecting many parts of Africa's energy systems, including reversing positive trends in improving access to modern energy, with 4% more people living without electricity in 2021 than in 2019. They are also deepening financial difficulties of utilities, increasing risks of blackouts and rationing. These problems are contributing to a sharp increase in extreme poverty in sub-Saharan Africa, with the number of people affected by food crises quadrupling in some areas.

Africa is already facing more severe climate change than most other parts of the world, despite bearing the least responsibility for the problem. With nearly one-fifth of the world's population today, Africa accounts for less than 3% of the world's energy-related carbon dioxide (CO_2) emissions to date and has the lowest emissions per capita of any region. Africans are already disproportionately experiencing the negative effects of climate change, including water stress, reduced food production, increased frequency of extreme weather events and lower economic growth – all of which are fuelling mass migration and regional instability.

For all of these difficulties, the global clean energy transition holds new promise for Africa's economic and social development. As of May 2022, countries representing more than 70% of global CO_2 emissions have committed to reach net zero emissions by around mid-century. This includes 12 African countries that represent over 40% of the continent's total CO_2 emissions. These ambitions are helping set a new course for the global energy sector amid declining clean technology costs and shifting global investment. African countries – nearly all of which are party to the Paris Agreement on Climate Change – are poised to capture the technology spillovers of these changes and attract increasing flows of climate finance.

This *Outlook* explores a Sustainable Africa Scenario (SAS) in which Africa rides these shifting tides to achieve all African energy-related development goals on time and in full. This includes universal access to modern energy services by 2030 and the full implementation of all African climate pledges. Realising all of these goals is a formidable undertaking. African countries need to take the lead with clear strategies and policies, while international institutions must reinforce their commitment to significantly increase their levels of support.

Affordable energy for all Africans is the immediate and absolute priority

Universal access to affordable electricity, achieved by 2030 in the SAS, requires bringing connections to 90 million people a year, triple the rate of recent years. At present, 600 million people, or 43% of the total population, lack access to electricity, most of them in sub-Saharan Africa. Countries such as Ghana, Kenya and Rwanda are on track for full access by 2030, offering success stories other countries can follow. Our detailed analysis shows that extending national grids is the least costly and most prudent option for almost 45% of those gaining access to 2030. In rural areas, where over 80% of the electricity-deprived live, mini-grids and stand-alone systems, mostly solar based, are the most viable solutions.

Achieving universal access to clean cooking fuels and technologies by 2030 requires shifting 130 million people away from dirty cooking fuels each year. Today, 970 million Africans lack access to clean cooking. Liquefied petroleum gas (LPG) is the leading solution in urban areas, but recent price spikes are making it unaffordable for 30 million people across Africa, pushing many to revert to traditional use of biomass. Countries are re-evaluating clean fuel subsidy schemes and exploring alternatives such as improved biomass cook stoves, electric cooking and biodigesters. The improvement rates needed for universal clean cooking access by 2030 are unprecedented, but the benefits are huge: reducing premature deaths by about 500 000 a year by 2030, drastically cutting time spent gathering fuel and cooking, and allowing millions of women to pursue education, employment and civic involvement.

The goal of universal access to modern energy calls for investment of USD 25 billion per year. This is around 1% of global energy investment today, and similar to the cost of building just one large liquefied natural gas (LNG) terminal. Stimulating more investment requires international support aided by stronger national institutions on the ground laying out clear access strategies – only around 25 African countries have them today.

As Africa's demand for modern energy grows, efficiency keeps it affordable

Demand for energy services in Africa is set to grow rapidly; maintaining affordability remains an urgent priority. Africa has the world's lowest levels of per capita use of modern energy. As its population and incomes grow, demand for modern energy expands by a third between 2020 and 2030 in the SAS. However, under existing subsidy schemes, current price spikes risk doubling energy subsidy burdens in African countries in 2022 – an untenable outcome for many facing debt distress. Some countries, including Egypt, Ethiopia and Uganda, are being driven to halt or reduce subsidies, or to reinstate fuel taxes due to growing financial burdens. International support must play a role in the near term to manage prices, but better targeting of subsidies to the households most in need is essential.

Efficiency helps temper demand growth, reduces fuel imports, strain on existing infrastructure and keeps consumer bills affordable. Energy and material efficiency reduces electricity demand by 230 terawatt-hours in 2030 – 30% of electricity demand today. Building codes and energy performance standards, which restrict the sale of the least efficient appliances and lighting, make up 60% of these savings. Energy demand for fans and air conditioning still quadruples over the decade as urbanisation and climate change rapidly increase the need for cooling in Africa, calling for a strong focus on efficient cooling solutions.

As Africa's industry, commerce and agriculture expand, so too does the need for productive uses of energy. In the SAS, energy demand in industry, freight and agriculture grows by almost 40% by 2030. Increased production of fertiliser, steel and cement – as well as manufacturing of appliances, vehicles and clean energy technologies – helps to reduce the burden of imports in Africa, which stands at over 20% of GDP today. Some parts of industry expand their use of the latest, most efficient technologies. In agriculture, which represents one-fifth of Africa's GDP, irrigation pumps are electrified, reducing diesel generator use, and cold-chains (temperature-controlled supply chains) are extended, boosting agricultural productivity and the scope for these products to reach urban markets.

Electricity will underpin Africa's economic future, with solar leading the way

Electricity is the backbone of Africa's new energy systems, powered increasingly by renewables. Africa is home to 60% of the best solar resources globally, yet only 1% of installed solar PV capacity. Solar PV – already the cheapest source of power in many parts of Africa – outcompetes all sources continent-wide by 2030. Renewables, including solar, wind, hydropower and geothermal account for over 80% of new power generation capacity to 2030 in the SAS. Once coal-fired power plants currently under construction are completed, Africa builds no new ones, underpinned mainly by China's announcement to end support for coal plants abroad. If the investment initially intended for these discontinued coal plants were redirected to solar PV, it could cover half of the cost of all Africa's solar PV capacity additions to 2025 in the SAS.

Flexibility is key to integrating more variable renewables, with grid interconnections, hydropower and natural gas plants playing notable roles. Regional power pools contribute to improving reliability of supply – a major problem in Africa. Expanding and modernising Africa's electricity infrastructure requires a radical improvement in the financial health of public utilities, which have been battered by recent economic crises and longstanding under-pricing of electricity. Regulatory reforms are a priority, particularly cost-of-service electricity pricing reforms, which are in place or under discussion in 24 African countries to date.

Gas and oil production focuses on meeting Africa's own demand this decade

Africa's industrialisation relies in part on expanding natural gas use. Natural gas demand in Africa increases in the SAS, but it maintains the same share of modern energy use as today, with electricity generation from renewables outcompeting it in most cases. More than 5 000 billion cubic metres (bcm) of natural gas resources have been discovered to date in Africa, which have not yet been approved for development. These resources could provide an additional 90 bcm of gas a year by 2030, which may well be vital for the fertiliser, steel and cement industries and water desalination. Cumulative CO_2 emissions from the use of these gas resources over the next 30 years would be around 10 gigatonnes. If these emissions were added to Africa's cumulative total today, they would bring its share of global emissions to a mere 3.5%.

Production of oil and gas remains important to African economic and social development, but the focus shifts to meeting domestic demand. Global efforts to accelerate the clean energy transition in the SAS risks dwindling export revenues for Africa's oil and gas. Between now and 2030, Africa's domestic demand for both oil and gas accounts for around two-thirds of the continent's production. This puts greater emphasis on developing well-functioning infrastructure within Africa, such as storage and distribution infrastructure, to meet domestic demand for transport fuels and LPG. In parallel, African countries focus on strengthening energy efficiency policies, and expanding renewables and other clean energy technologies.

Near-term market opportunities must not distract from declining oil and gas export revenues in the future. New projects benefit from speed to market, minimising project costs and delays, and reducing methane emissions. Current price surges are providing a short-term boon to African producers, with new deals signed to deliver Algerian gas to Europe, along with renewed momentum to develop and expand LNG terminals in Congo, Mauritania and Senegal. With the European Union aiming to halt Russian gas imports towards 2030, Africa in principle could supply an extra 30 bcm in 2030. Reducing flaring and venting could quickly make at least 10 bcm of African gas available for export without the development of new supply and transport infrastructure. New long lead time gas projects risk failing to recover their upfront costs if the world is successful in bringing down gas demand in line with reaching net zero emissions by mid-century.

Critical minerals present a major economic opportunity

Africa's vast resources of minerals that are critical for multiple clean energy technologies are set to create new export markets, but need to be managed well. Africa accounts for over 40% of global reserves of cobalt, manganese and platinum – key minerals for batteries and hydrogen technologies. South Africa, Democratic Republic of the Congo and Mozambique have a significant share of global production today, but many other countries may hold undiscovered deposits. In the SAS, Africa's revenues from critical mineral production more than double by 2030. However, investment in mineral exploration in Africa has been declining in recent years. Reversing this trend hinges on improved geological surveys, robust governance, improved transport infrastructure and a particularly strong focus on minimising the environmental and social impacts of mining operations.

Africa can become a leading player in hydrogen made from renewables

Africa has huge potential to produce hydrogen using its rich renewable resources. A number of low-carbon hydrogen projects are underway or under discussion in Egypt, Mauritania, Morocco, Namibia and South Africa. These are focused primarily on using renewables-based power to produce ammonia for fertiliser, which would strengthen Africa's food security. Global declines in the cost of hydrogen production could allow Africa to deliver renewables-produced hydrogen to Northern Europe at internationally competitive price points by 2030. With further cost declines, Africa has the potential to produce 5 000 megatonnes of hydrogen per year at less than USD 2 per kilogramme—equivalent to global energy supply today.

People must be at the centre of Africa's new energy economy

Home-grown energy industries can reduce imports, create jobs and build the local capital base. In the SAS, around 4 million additional energy-related jobs are needed across the continent by 2030, largely to reach universal energy access in sub-Saharan Africa. Many of the jobs offer entry into the formal economy and increase entrepreneurial opportunities for women. African energy companies play an increasing part, with joint ventures and technology transfer helping develop local know-how. Implementing an African Continental Free Trade Area also helps broaden domestic markets for African energy firms.

Climate change calls for investment in adaptation

Africa will remain a minor contributor to global emissions, yet it needs to do far more to adapt to climate risks than the rest of the world. By 2050, Africa accounts for no more than 4% of cumulative global energy-related CO_2 emissions, regardless of the scenario. With today's policies, the global average temperature rise is likely to hit 2 °C around 2050, but this would probably result in a median temperature rise of 2.7 °C in North Africa. That would reduce African GDP by around 8% in 2050 relative to a baseline without any climate impacts. Losses in some regions such as East Africa would reach around 15%.

Urgent action to adapt to climate change would reduce the severity of these economic effects but require much more investment. Funding for climate adaptation could reach USD 30-50 billion per year by 2030 – a huge increase on the USD 7.8 billion that was provided by advanced economies for adaptation projects in 2019. Some of this will be needed to make Africa's energy systems more resilient against climate risks: three-fifths of Africa's thermal power plants are at high or very high risk of being disrupted by water stress and one-sixth of Africa's LNG capacity is vulnerable to coastal flooding.

Unlocking more finance remains key to Africa's energy future

Achieving Africa's energy and climate goals means more than doubling energy investment this decade. This would take it over USD 190 billion each year from 2026 to 2030, with two-thirds going to clean energy. The share of energy investment in Africa's GDP rises to 6.1% in the 2026-30 period, slightly above the average for emerging market and developing economies. But Africa's energy investment in that period is still only around 5% of the global total in the IEA's Net Zero Emissions by 2050 Scenario.

Multilateral development banks must make increasing financial flows to Africa an absolute priority. To mobilise the amount of investment envisioned in the SAS, they will need to increase concessional finance to Africa and use it more strategically to better leverage private capital. This includes domestic financial markets, which need to more than double in size by the second-half of this decade. New capital sources, such as climate finance and carbon credits, can bring more international financial flows to bear. However, cross-cutting investment risks such as high debt burdens remain a challenge.

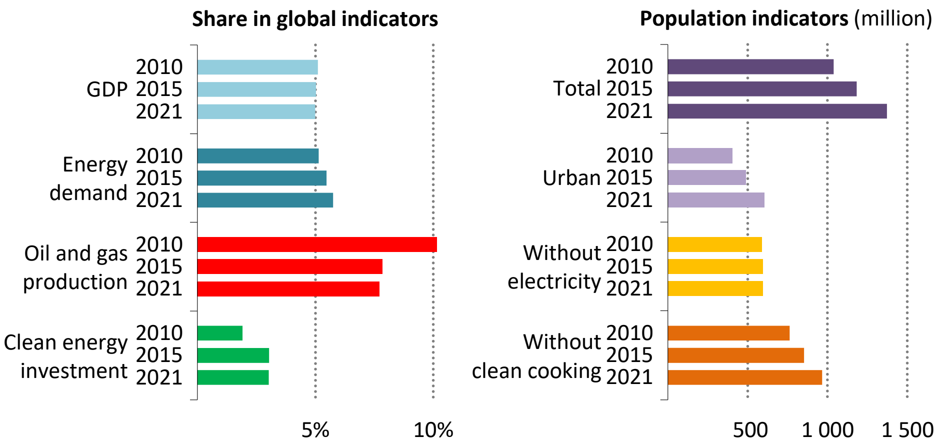
Africa's energy future requires stronger efforts on the ground that are backed by global support. The COP27 Climate Change Conference in Egypt in late 2022 provides a crucial platform for African leaders to work globally to identify ways to drive these changes. This decade is critical, not only for global climate action, but also for the foundational investments that will allow Africa – home to the world's youngest population – to flourish in the decades to come.

In the last two years, the global economic landscape has drastically changed. The Covid-19 pandemic destabilised the global economy and continues to cause supply chain disruptions that have lasting effects on project timelines and prices. Notably, the Russian Federation's (hereafter Russia) invasion of Ukraine in February 2022 has sent global food and fuel prices soaring, hurting households, industries and entire economies – most severely in the developing world where people can least afford it. Energy has been at the centre of many of the unfolding crises, with global demand for oil and gas falling during the onset of the Covid-19 pandemic, only to whipsaw with the restart of major economies and now is being thrown into increased uncertainty caused by Russia's invasion of Ukraine. This was on top of a growing global consensus that global energy systems needed to reach net zero emissions by the middle of this century to limit the severity of rising global temperatures and climate change.

Africa is substantially impacted by these crises. How Africa responds has huge implications for the world. Africa is home to one of the world's fastest growing and youngest populations: one-in-three people born today is an African. Three of the top-ten economies with the fastest rates of economic growth are in Africa, with the continent's overall economy growing on average by 3% between 2010 and 2019, until the Covid-19 pandemic plunged it into its first recession since the global financial crisis in 2009. Growth, however, has not always delivered higher standards of living for most Africans. Nearly 40% of the population in sub-Saharan Africa still live in extreme poverty. While this share has decreased since 2010, there are now 67 million additional people in extreme poverty. Inequality has also increased. In 2019, the wealthiest 10% of Africans owned 70% of the continent's wealth. Both within-country and between-country inequality across Africa has increased since then, rebounding to levels from the early 2010s (World Bank, 2022; WID, 2022). With current price spikes, these inequities are likely to be exacerbated, and coupled with a series of climate-related droughts and extreme weather events that are leading to rising levels of migration both on the continent and to the rest of the world.

Development of Africa's energy system is a similar story. Access to clean, secure and affordable modern energy services has not kept pace with the continent's expanding needs. Africa is home to nearly 18% of the world population, yet accounts for less than 6% of global energy use (Figure I.1). South Africa, one of the continent's most industrialised economies, accounts for around 16% of Africa's energy consumption. Although Africa's total energy demand has been growing quickly, at 2.4% per year over 2010-19, the use of electricity is lagging, rising by just 2.3% over the same period – far below the average for other developing regions. Today, a shocking 64% of Africans rely predominately on gathered wood, and agricultural and animal wastes as fuel for cooking. The traditional use of such fuels accounts for more than 40% of the total increase in final energy use between 2010 and 2019. Depending on how these fuels are gathered, it can also contribute to deforestation, which in some African countries matches levels seen in the Amazon. And while 160 million Africans gained access to electricity over 2010-19, more than 40% of Africans are still deprived of service.

Figure I.1 ▷ Africa's share in selected global energy and economic indicators and key population indicators, 2010-2021



Africa's contribution to global economic activity remains low and the number of people without access to clean cooking has been increasing

How Africa meets increasing demand for modern energy has implications for global trade. Africa made up 10% of global energy demand growth from 2010-19, and 8% of oil demand growth. Africa relies heavily on imports of inefficient, second-hand vehicles and appliances, which consume far more energy for the same service. Electricity supply remains very unreliable in many parts of the continent, impeding economic and social development, and driving businesses and households to rely on costly diesel generators. People that do have access to modern energy often pay more than in richer countries due to inefficient supply systems and heavy reliance on expensive imported fuels, which increases instability in the region.

This instability has implications for Africa's outsized role in global energy supply. From 2010-19, Africa accounted for 8% of global oil and gas production, while only representing 4% of global demand for the same fuels. Africa is fortunate to hold large natural resources, but has struggled to develop them. It is home to 13% of the world's natural gas and 7% of the oil resources. Even as oil and gas prices surge with Russia's invasion of Ukraine, chronic underinvestment in infrastructure is preventing African producers from ramping up production to meet global demand. Africa is also home to some of the best renewable energy resources on the planet and abundant mineral resources, many of which are critical to numerous clean energy technologies. However, poor road and other vital infrastructure mean that these resources remain largely unexploited.

Africa faces enormous challenges to build the infrastructure required to meet those energy needs, while also transforming the energy system to address climate and other environmental goals. Energy investment has fallen far short of what is required to put Africa on the path to universal access to secure and affordable energy. Over 2015-19, energy investment in Africa declined by more than a fifth, due mainly to less spending on export-driven oil and gas projects. These problems are further exacerbated by the omnipresent risk of climate change. Despite contributing less than 3% of the energy-related carbon dioxide (CO_2) ever emitted worldwide, the continent is already disproportionately affected by the changing climate, with worsening drought, famine, flooding and heatwaves, adding to the perennial problems of insecurity and civil strife, and accelerating migration to flee these threats.

IEA's *Africa Energy Outlook 2019* mapped a pathway to develop the energy infrastructure commensurate with its economic and social development goals. It provided details on Africa's energy sector and described the preconditions for achieving universal access to electricity in a cost-effective and increasingly sustainable manner. Since that report, the energy landscape in Africa has undergone major changes.

In the wake of the Covid-19 pandemic, many countries and companies have come under severe financial duress. Progress to improve energy access has been reversed in several countries. Russia's invasion of Ukraine is adding to the upward pressure on international energy prices, leading to higher fuel and food prices for most Africans. While oil and gas producers are seeing their economic outlook brighten with rising prices, the rest of the continent faces grave economic consequences, including worsening debt and soaring prices of basic goods, especially in Africa's least developed economies.

Developments in climate policy are also affecting the long-term development of Africa's energy system. The Glasgow Climate Pact, was agreed upon at the 26th Conference of the Parties (COP26) in November 2021 among an unprecedented number of countries – including twelve in Africa – that committed to reduce their greenhouse gas emissions to net zero. These commitments are set to make clean energy technologies both more widely available and affordable. They have also changed the outlook for fossil fuel producers everywhere, raising uncertainty about the long-term prospects for oil and gas revenues while boosting prospects for critical minerals and hydrogen. In addition, the global financial commitments under the Pact are paving the way for increased climate-related financial flows and discouraging investment in highly carbon-intensive energy assets.

Growing energy security concerns in the wake of Russia's invasion of Ukraine are also driving other regions to seek alternative ways to meet their energy needs, including by accelerating clean energy transitions to reduce dependence on imported fuels. This is starting to impact near-term investment choices in energy supply, which could herald a faster transition in the current decade. This may increase demand for clean alternatives and accelerate spillover effects, especially in places like Africa that import most of their energy-using technologies, vehicles, equipment and appliances.

Africa Energy Outlook 2022 takes account of these recent developments. It maps a new pathway to show how Africa's collective economic, developmental and environmental goals can best be achieved in the current global context. It aims to serve as a guidebook for energy decision makers in the lead up to COP27, which is to be held in Egypt in November 2022. It was prepared in collaboration with the African Union Commission and the United Nations Economic Commission for Africa and involved the participation of more than 20 independent African energy experts and officials.

This *Outlook* sets out a continent-wide energy strategy, taking into account the unique characteristics of each country and region, which necessitates various pathways. The scenario projections are to 2050, but there is a strong focus on the period to 2030 as decisions taken over the current decade are crucial to the path the African energy sector follows in the longer term. We also present specific case studies of successful policy interventions, financial tools and business models. The aim is that this *Outlook* will galvanise all actors in Africa's energy sector and the international community to address the key challenges facing the sector over the coming decade.

This *Outlook* does not endeavour for the comprehensiveness of the 2019 edition, rather it focuses on what has changed since then and the most pressing questions that energy industry leaders, global financiers, climate change negotiators and government officials must address in order to deliver meaningful outcomes at COP27. Chief among these is unlocking higher levels of energy investment across the continent, which is essential to meet the United Nations Sustainable Development Goal 7 (SDG 7) to provide universal access to clean, modern, and affordable energy. This task is central to all aspects of Africa's energy development and is a connecting thread for the discussions in this report.

The report structure is:

- **Chapter 1:** Discusses the central challenges facing Africa's energy sector today, focussing on the impacts of the Covid-19 pandemic and the new global net zero emissions commitments that emerged from the COP26 negotiations.
- **Chapter 2:** Describes in detail a clean energy pathway for Africa and highlights critical milestones.
- **Chapter 3:** Analyses in-depth the most complex questions concerning Africa's clean energy transition and the policy responses needed to appropriately respond.
- **Chapter 4:** Explores the implications of the continent's clean energy pathway for climate change and international trade, economic development, employment and the affordability of energy for households across Africa.

State of play

A new point of departure

SUMMARY

- The global Covid-19 pandemic pushed sub-Saharan Africa into its first recession in 25 years, severely affecting income from fossil fuel production, supply chains and foreign direct investment patterns. Higher energy and commodity prices in the wake of Russia's invasion of Ukraine have added to the problems in import-dependent countries. However, new climate commitments from COP26 and efforts to reduce exposure to energy security risks present new financing opportunities for Africa that could help the transition to a lower carbon development pathway.
- African countries entered the pandemic with high public debt burdens and quickly used up what limited fiscal leeway they had to cushion the economic shock. Together with long-standing governance issues, those burdens are keeping the economy-wide cost of capital high. The new price shock is forcing many governments to choose between measures to keep fuel, food and fertiliser affordable or to repay debt. This is set to dampen the investment outlook for energy, which has been on a steady decline since a peak in 2014.
- Access to modern energy services has deteriorated since the start of the pandemic. Since 2014, the number of Africans without electricity had been declining, but the trend has since reversed as new connections have slowed and the population continues to increase, with 4% more lacking electricity in 2021 than in 2019. The number of people without access to clean cooking fuels continues to rise, reaching 970 million in 2021, with many unable to afford them due to constrained finances and higher LPG prices.
- The sharp fall in oil demand and prices at the start of the pandemic led to a near 20% drop in oil production in Africa. Spending levels have been falling since 2014, which meant producers struggled to ramp up production as a result of years of underinvestment. Natural gas production in Africa held up better, but limited LNG and pipeline infrastructure is hindering efforts to exploit higher global demand for non-Russian gas.
- Some 53 African countries have submitted a Nationally Determined Contribution (NDC) on climate change, which together aim to mitigate 550 Mt CO_2 by 2030 – equal to 40% of Africa's emissions today. Twelve African countries, which together represent over 40% of those emissions, have also announced net zero emissions goals. Many African NDCs include targets that are conditional on financial support from developed countries, amounting to USD 1 200 billion in the period to 2030. This exceeds pledges from developed countries to provide USD 100 billion annually to all developing economies from 2023.

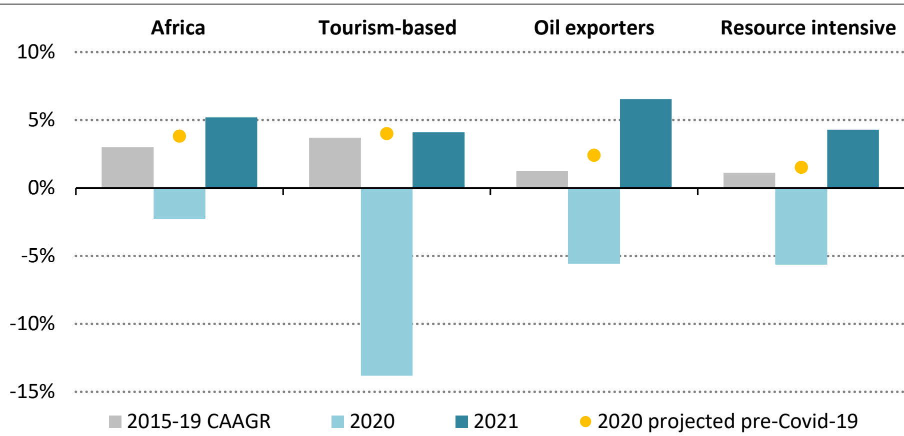
1.1 New economic challenges facing Africa

Since the IEA's *Africa Energy Outlook 2019*, the global Covid-19 pandemic and the ensuing economic crisis have set back progress on economic and social development across the continent with far-reaching consequences for the energy sector. The crisis has exacerbated many of the existing energy challenges facing African countries; economic growth has faltered and rebounded unevenly, wealth inequality has widened, the building of much-needed infrastructure has been delayed and political instability has worsened. The economic fallout from Russia's invasion of Ukraine – notably soaring commodity prices – is making matters worse for resource-poor African countries. This section assesses how the economic situation has deteriorated over the last three years and explores new impending risks.

1.1.1 Impacts of the Covid-19 pandemic and Russia's invasion of Ukraine

The Covid-19 pandemic led to a reversal of many positive development trends in Africa. Africa's gross domestic product (GDP) contracted by 2.3% in 2020, plunging it into its first economic recession in 25 years. However, its recovery has been stronger than expected. The International Monetary Fund (IMF) revised its 2021 sub-Saharan GDP growth estimates to 4.5%, up from the previous estimate of 4% (IMF, 2022a). The impact of the pandemic on growth has varied substantially across the continent, mainly reflecting the structure of individual economies and the health measures taken (Figure 1.1).

Figure 1.1 ▷ GDP rate of change by type of economy in African countries



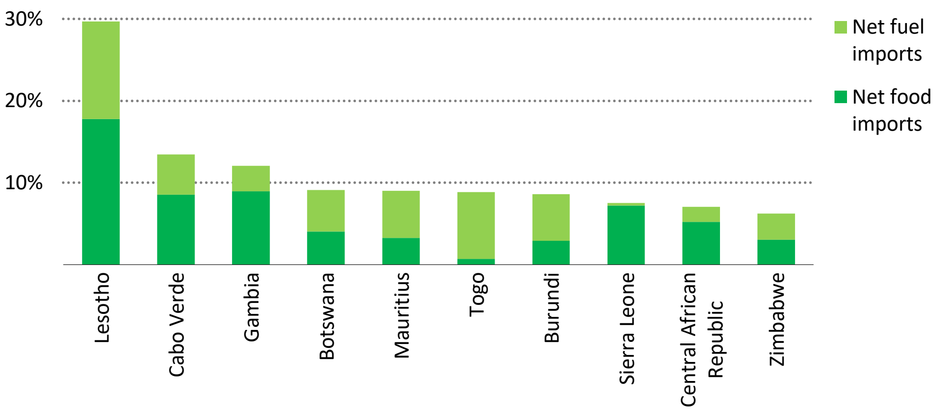
Sub-Saharan Africa plunged into its first recession in 25 years due to the Covid-19 pandemic, hitting hardest on economies based on commodity exports and tourism

Notes: CAAGR = compounded average annual growth rate. GDP expressed in year-2019 USD billion in purchasing power parity terms. Tourism-based countries include Cabo Verde, Comoros, Mauritius and Seychelles. Oil and gas exporters include Algeria, Angola, Cameroon, Chad, Equatorial Guinea, Gabon, Libya, Nigeria, Republic of the Congo and South Sudan. Resource-intensive countries include Botswana, Liberia, Mali, Namibia, Sierra Leone, South Africa, Sudan, Zambia and Zimbabwe. Africa category includes the entire continent. Source: International Monetary Fund (2022b).

Countries dependent on tourism and commodity exports were hit hardest by the crisis initially. As global oil prices fell, the top-ten fossil fuel exporters, which account for around half of Africa's GDP, saw their contribution to Africa's GDP shrink by 2% in 2020 (Table 1.1). Higher prices overall pushed growth rates up again in these countries in 2021. Oil price surges in the first-half of 2022 are boosting the prospects for better returns than previous projections. In spite of the pandemic, Egypt and Nigeria, which represent a third of the continent's GDP, registered little or no impact in 2020 and their GDP rose by over 30% in 2021.

The economic shock of the pandemic hit the poorest people hardest. In 2021, more than 40% of sub-Saharan Africans were living in extreme poverty. The pandemic impacts, worsened by the Russia's invasion of Ukraine and related inflation, may push more than 25 million additional sub-Saharan Africans to extreme poverty by end 2022 (World Bank, 2022b). Mounting inequalities are adding to existing civil conflict, social unrest and political instability in several countries, with protests over prices already unfolding in Morocco, Egypt, Kenya, Tunisia and Sudan.

Figure 1.2 ▷ Net imports of food and fuel as a share of GDP in selected African countries, 2020



Soaring international food and fuel prices are causing severe economic hardship in the African countries most heavily dependent on imports

Surging global prices for fuel and food due to Russia's invasion of Ukraine are adding to the economic duress across Africa. The prices of liquefied petroleum gas (LPG) increased by more than 60% and diesel doubled in some countries, such as Nigeria, over the year to April 2022. Retail price controls have prevented higher wholesale prices of natural gas and electricity from being passed on to consumers, but have added to the financial difficulties of utilities and governments. Disruptions to supplies of wheat and other food from Ukraine and Russia have caused international prices to soar. The consequences of Russia's invasion of Ukraine are also felt on natural gas-based fertiliser markets, further threatening food security in import-dependent countries (Box 1.1). Many African countries are heavily reliant on fuel and food imports, with net imports reaching over 5% of GDP in several countries in 2020 (Figure 1.2).

Many of these countries have depleted their fiscal reserves – drained by Covid-19-related emergency support, measures to make fuel and food more affordable, and an increase in the cost of servicing debt. Seven countries in Africa are now considered to be in debt distress by the IMF, raising the risk of defaulting on public debt in the coming year (IMF, 2022a; IMF, 2022c).

As a result of these problems, the post-pandemic economic recovery in Africa is projected to be slow (see Chapter 2). The IMF projects sub-Saharan Africa's economy to expand by 3.8% in 2022 (following estimated growth of 4.5% in 2021) (IMF, 2022b). GDP per capita across the continent is not expected to recover to pre-crisis levels until 2024.

Box 1.1 ▷ Russia's invasion of Ukraine disrupted the global fertiliser market and threatens food security in many African countries

Africa has significant exposure to variations in global prices of food commodities, as it is highly dependent on imports. According to the United Nations Food and Agriculture Organization (FAO), in recent years the continent has imported more than 30% of its demand for cereals, while in North Africa the share is more than 50%.

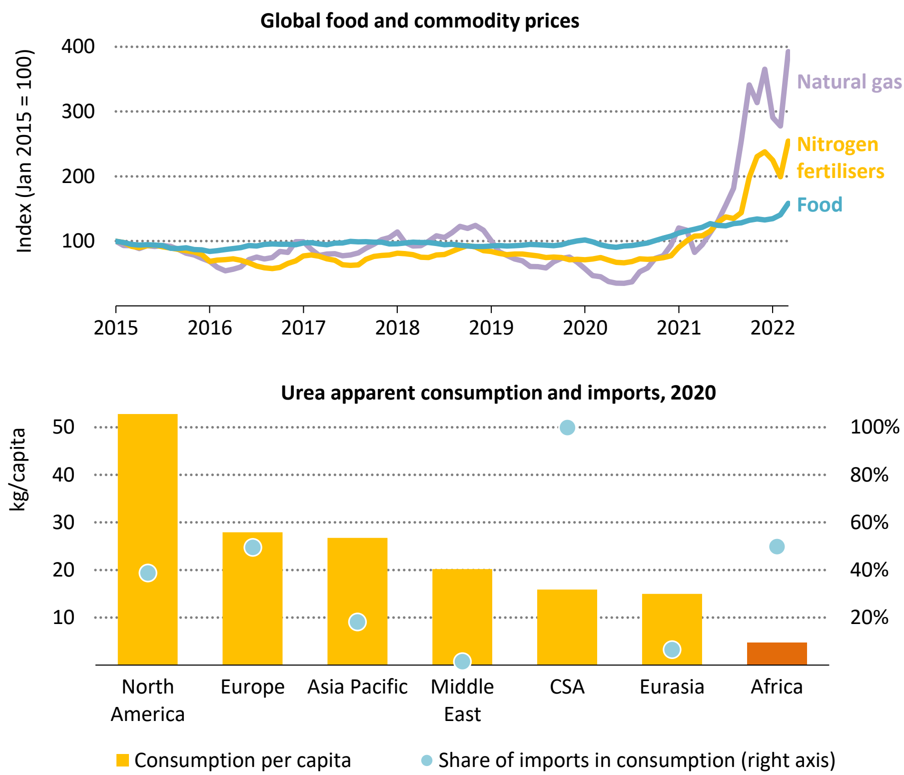
This exposure brutally revealed itself in the first-quarter 2022, as the global food price index rose to the highest levels ever recorded, owing to supply chain disruptions and other market turmoil caused by Russia's invasion of Ukraine.

Another driver of the price spikes is the rising prices of mineral nitrogen-based fertilisers, of which the key is natural gas used to produce ammonia and urea. International urea market tensions started to materialise in 2021 due to high natural gas prices and temporary export restrictions in People's Republic of China (hereafter China) and Russia. These tensions are being felt acutely in Africa, where urea accounts for around 60% of mineral nitrogen-based fertiliser consumption and about half of the apparent consumption is imported.

The balance of trade varies significantly between African countries. Large natural gas producing countries are largely self-sufficient in ammonia production – the pre-cursor to urea – whereas only Egypt, Algeria and Nigeria are self-sufficient in urea production. Some producer countries have domestic carve-outs for their natural gas production at pre-agreed prices, which shields fertiliser consumers from world natural gas market price spikes.

African countries more reliant on imported fertiliser remain highly exposed to price volatility; the burden of higher subsidy costs can strain fragile government balance sheets, while the ability to pass on costs in the form of higher food prices may be limited by a lack of purchasing power. If prices remain elevated, underlying issues of instability, affordability and hunger may come to a head, demanding international support to alleviate the concerns.

Figure 1.3 ▷ Global food, fertiliser and natural gas prices, and apparent consumption and imports of urea by region, 2015-2022



Spikes in natural gas prices cascade to fertiliser and then food prices. Importers of fertiliser in Africa are highly exposed to prices, threatening affordability of basic goods

Notes: Apparent consumption is defined by the FAO as the gross consumption of products per inhabitant of each country. CSA = Central and South America

Table 1.1 ▷ Key economic indicators in selected African countries

	Income classification	2020 GDP growth	2021 GDP/capita (USD)	Population with less than USD 1.90/day	Income held by top 10%	Fragile / conflict-affected state
Tourism-based economies						
Seychelles	High	-13%	26 776	1%	24%	
Cabo Verde	Lower middle	-15%	6 560	3%	32%	
Mauritius	Upper middle	-15%	21 486	0%	30%	
Oil exporters						
Cameroon	Lower middle	-2%	3 726	26%	35%	●
Nigeria	Lower middle	-2%	5 190	39%	27%	●
Algeria	Lower middle	-5%	11 521	0%	n.a.	
Angola	Lower middle	-5%	6 200	50%	40%	
Resource intensive						
Mali	Low	-2%	2 363	n.a.	0%	●
Zambia	Lower middle	-3%	3 385	59%	44%	
Sudan	Low	-4%	4 081	12%	28%	●
South Africa	Upper middle	-6%	13 856	19%	51%	
Namibia	Upper middle	-8%	9 333	14%	47%	
Botswana	Upper middle	-8%	16 550	15%	42%	
Selected other						
Ethiopia	Low	6%	2 445	31%	29%	●
Tanzania	Lower middle	5%	2 870	49%	33%	
Benin	Lower middle	4%	3 601	50%	38%	
Egypt	Lower middle	2%	12 786	30%	32%	
Côte d'Ivoire	Lower middle	2%	5 648	30%	32%	
DRC	Low	0%	1 161	30%	32%	●
Ghana	Lower middle	0%	5 890	13%	32%	
Kenya	Lower middle	-1%	4 727	37%	32%	
Uganda	Low	-1%	2 374	41%	34%	
Mozambique	Low	-1%	1 292	64%	46%	●
Rwanda	Low	-3%	2 270	57%	36%	
Morocco	Lower middle	-6%	7 825	0%	30%	
Tunisia	Lower middle	-9%	10 419	51%	32%	

Notes: DRC = Democratic Republic of the Congo. USD 1.90/day refers to income (at 2011 prices) and corresponds to the World Bank definition of extreme poverty. Income classifications are from the OECD.

Sources: IMF (2022c); World Bank (2022c); World Bank (2022d).

1.1.2 Policy responses to the pandemic and inflationary pressures

Most countries in the region, notably in sub-Saharan Africa, have had very little fiscal room to cushion the economic shock caused by the Covid-19 pandemic and inflationary pressures caused by Russia's invasion of Ukraine.[1] Total government spending on Covid-19-related economic recovery programmes in Africa amounted to only USD 90 billion, or 2.8% of GDP, in 2021 far less than in most other regions (IMF, 2021a). Spending was highest in South Africa (Table 1.2). However, this support has largely been withdrawn in the face of mounting public debt. Overall in Africa, public spending was directed at pandemic-related emergency health support and vulnerable economic actor relief measures at the expense of other areas, including development programmes.

Development banks and other international financial institutions provided some short-term relief to African countries through extended lending facilities, debt relief or reimbursement alleviation instruments. Examples include the G20 Debt Service Suspension Initiative and the IMF Catastrophe Containment and Relief Trust. Official development assistance to African countries increased to a record USD 35 billion in 2021 (OECD, 2021a). The IMF Board of Governors earmarked USD 33 billion for Africa in their Special Drawing Rights allocation in August 2021. However, this aid has not been sufficient to offset the full impact of the dual economic crisis in Africa.

As in other parts of the world, many African countries introduced energy sector measures to protect vulnerable consumers and domestic businesses from the economic crisis related to the pandemic. The most commonly used instrument was cancelling or deferring bill payments to utilities or subsidising electricity costs, along with the widespread practice of having regulators to set tariffs below the full cost of supply. Over 20 African countries adopted such measures, putting strain on utilities that were already in poor financial health. A few have introduced subsidies or tax exemptions for other energy suppliers, covering both renewables and fossil fuels. Five countries – Egypt, Ethiopia, Morocco, Nigeria and South Africa – directed recovery spending to energy infrastructure projects, mainly related to natural gas or improving energy access, with aims to stimulate economic growth in the long term.

Many of these measures were rolled back by 2021, but the jump in fossil fuel prices in the wake of Russia's invasion of Ukraine is putting renewed pressure on many cash-strapped African governments to reinstate affordability measures. For example, in March 2022, the South African government froze petrol and diesel prices, and proposed a two-month reduction in fuel taxes, financed by selling crude oil reserves held in its Strategic Fuel Fund. Other countries introduced similar price and tax cuts or are planning to do so, Nigeria raised consumer fuel subsidies and Morocco is subsidising taxi owners.

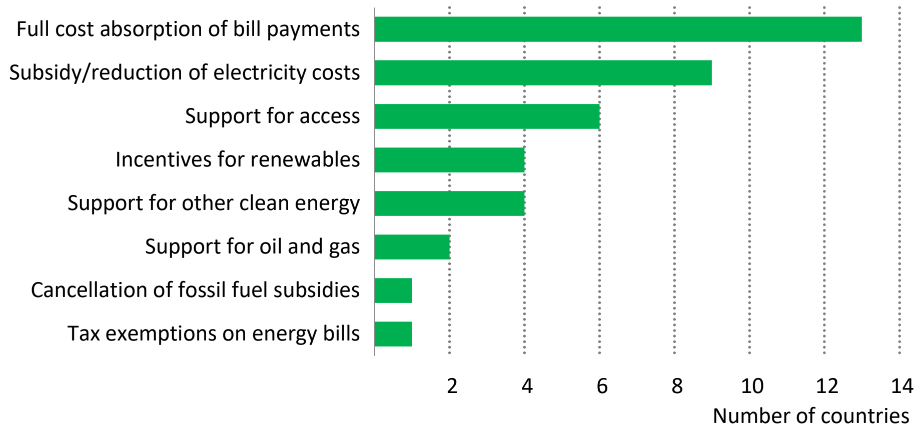
[1] The analysis in this section benefited from inputs provided by the United Nations Economic Commission for Africa and the Mo Ibrahim Foundation.

Table 1.2 ▷ Fiscal measures related to Covid-19 in selected African countries

	Egypt	Kenya	Nigeria	South Africa
Short-term support				
Healthcare system reinforcement (containment, staff, equipment, facilities)	●	●	●	●
Emergency safety net for vulnerable households (food assistance, tax relief, direct payments)	●	●	●	●
Emergency safety net for vulnerable businesses (liquidity provisions/credit guarantees, tax relief, subsidies)	●	●	●	●
Emergency safety net for workers (unemployment schemes, wage subsidies)	●	●	●	●
Long-term economic recovery support				
Housing programme			●	
Support to strategic sectors (agriculture, aviation, forestry, tourism)	●	●	●	●
Small and medium enterprise targeted support	●		●	●
Youth employment programme		●		
Healthcare access measures		●		
Energy sector support				
Short-term energy tax and price relief for consumers	●	●	●	●
Infrastructure investment (transport, energy)		●	●	●
Long-term clean energy access support			●	
Fuel subsidy phase out acceleration			●	
Total fiscal effort (2021)				
USD billion	6.2	2.5	10.4	30
Share of GDP	1.7%	2.5%	2.4%	9.4%

Sources: IEA analysis based on official communications; UNECA (2021); IMF (2021a).

Figure 1.4 ▷ Energy sector measures implemented as part of Covid-19 economic recovery packages in African countries, 2020-2021



African countries that sought to make energy more affordable in response to the pandemic notably cancelled or deferred electricity bill payments or subsidised consumers

Sources: IEA analysis and Akrofi and Antwi (2020).

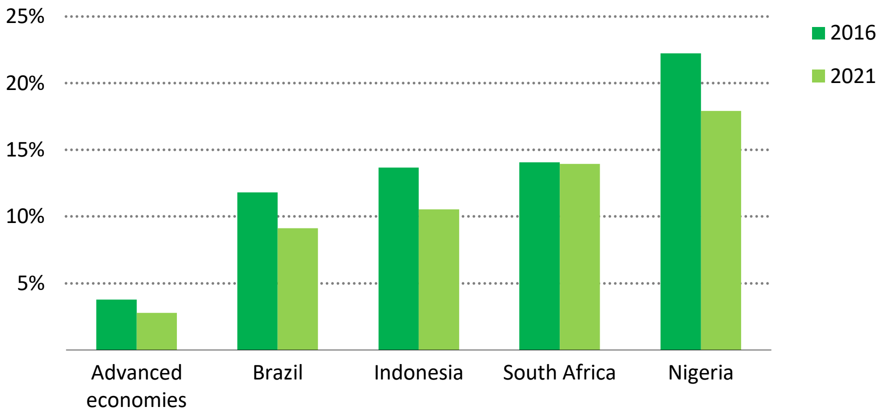
1.1.3 Growing debt burdens

Government debt was climbing in Africa before the pandemic, but many countries are now facing the risk of default due to the dual economic crisis. In sub-Saharan Africa, debt rose from around 30% of GDP in 2014 to 50% in 2019 and more than 57% in 2020 – the highest level in almost two decades. In North Africa, debt rose by 12 percentage points over the same period to 88% of GDP. The structure of this debt has changed substantially in recent years, with countries taking on a broader range of creditors, including private commercial banks or foreign currency denominated bonds on private credit markets. In 2000, 78% of sub-Saharan Africa's debt was concessional, i.e. below market rates, from bilateral (47%) or multilateral (31%) sources; in 2020, only 25% is multilateral concessional and 20% bilateral, with private creditors accounting for 56% of the total. This marks positive progress toward bringing more private capital into African markets, but can be accompanied by less flexible and more onerous repayment terms.

The overall increase in debt in recent years and increased reliance on non-concessional sources has driven up the burden of debt service as a share of GDP. During the pandemic, countries were forced to borrow even more to respond to the health and economic crises, with already highly indebted countries finding themselves increasingly denied of private credit market access (Heitzig, Ordu and Senbet, 2021). This has pushed more countries towards debt distress, whereby a country is unable to fulfil its financial obligations and debt restructuring is required: the IMF listed 25 African countries as being either in, or at high risk of, debt distress in April 2022 (IMF, 2022c). Debt relief and restructuring programmes, such as the G20 Debt Service Suspension Initiative, have provided some assistance, but further support will undoubtedly be needed in many cases if high commodity prices persist.

Concerns over debt sustainability will further limit African countries access to capital markets as investors will likely consider their governments to present a higher risk of default. This will keep the cost of capital higher than other economies. African countries already face economy-wide capital costs that are up to seven-times higher than in Europe or North America due to higher perceived and actual risks (Figure 1.5).

Figure 1.5 ⊳ Nominal economy-wide cost of capital in selected countries



Economy-wide nominal financing costs can be up to seven-times higher in Africa than in advanced economies, making it harder for projects to access debt finance

Source: IEA (2021).

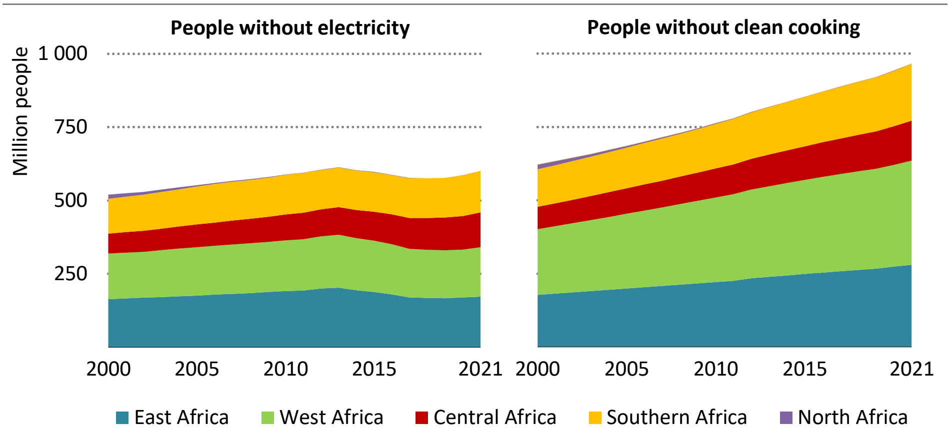
1.2 Impacts of the economic crisis on the energy sector

The lockdowns and associated economic crisis related to the Covid-19 pandemic have led to enormous difficulties in the energy sector across Africa, especially in relation to efforts to improve access to modern energy services, a deterioration in the affordability of energy for the most vulnerable households and businesses, and delays in completing and launching critical infrastructure projects. The subsequent surge in commodity prices has made matters even worse for importing countries. By contrast, oil and gas exporting countries are benefitting financially, especially if they are able to overcome barriers to ramp up production and increase supplies to international markets.

1.2.1 Setback in access to modern energy services

The United Nations Sustainable Development Goal 7 (SDG7) aims to "ensure access to affordable, reliable, sustainable and modern energy for all".[2] By 2019, Africa was already off track to reach the SDG7 for access to electricity and clean cooking, while the expected outcome has deteriorated markedly as a result of the pandemic due to project delays and lower household incomes. In 2021, 43% of the population of Africa, around 600 million people, still lacked access to electricity, 590 million of them were in sub-Saharan Africa (Figure 1.6). The pandemic has slowed the rate of both new grid and off-grid connections. This reflects a combination of logistical and financial hurdles related to the disruption in supply chains caused by lockdowns and other social restrictions, as well as the financial difficulties of households, utilities and equipment suppliers caused by the pandemic-related slump in economic activity. The number of people without access in sub-Saharan Africa is estimated to have increased by 4% in 2021 relative to 2019, effectively reversing all the gains made over the previous five years.

Figure 1.6 ▷ Population without access to modern energy services in Africa



Access to modern energy has deteriorated since the outset of the pandemic; today 600 million Africans lack access to electricity and more than 970 million to clean cooking

Sources: Electricity access: IEA (2022a); clean cooking: WHO (2021) and IEA estimates for 2020-2021.

The number of Africans lacking access to clean cooking fuels and technologies has also increased through the pandemic. More than 970 million people – almost three-quarters of the entire population – lacked access to clean cooking facilities in 2021. The number increased by an average of 17 million, 2% per year between 2010 and 2019, notably as rapid population growth outpaced efforts to increase access. The pandemic has accelerated this

[2] For details, see https://trackingsdg7.esmap.org

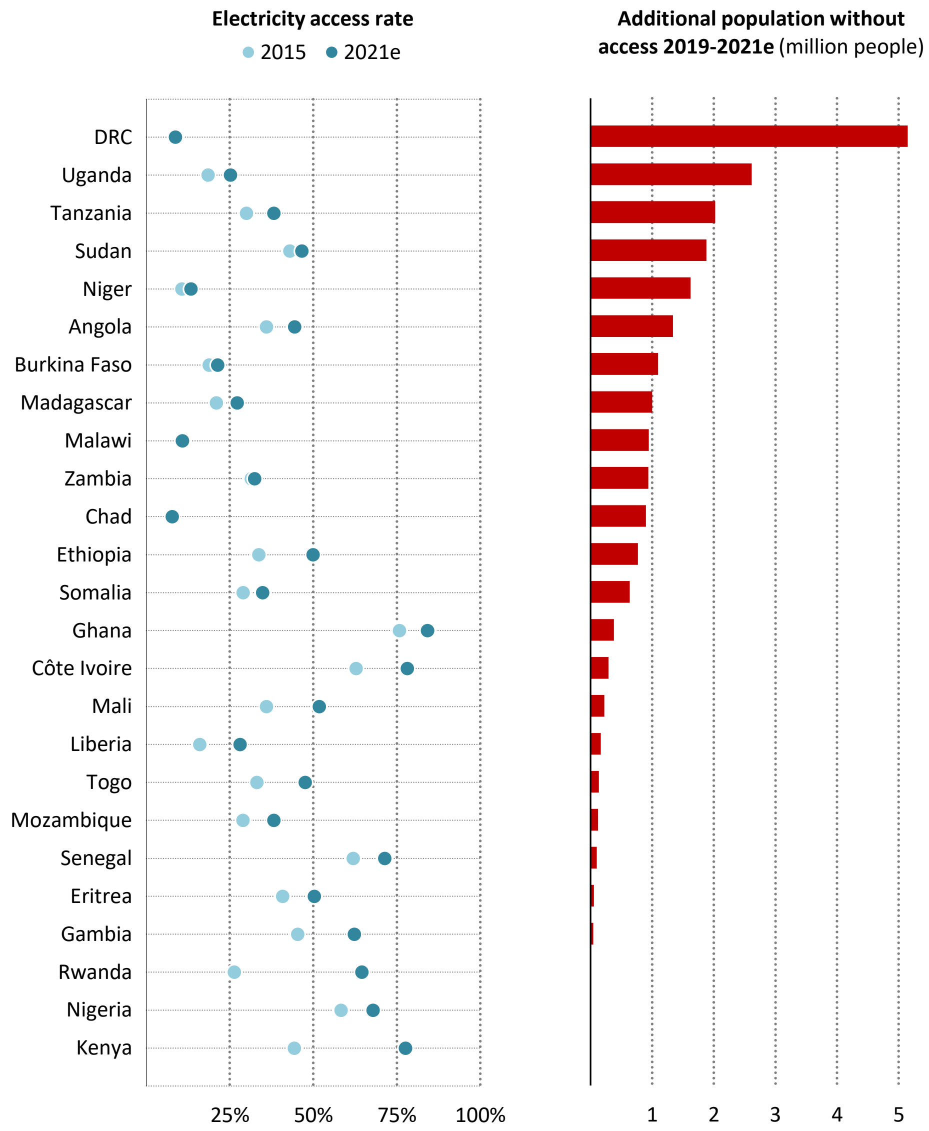
trend. We estimate that on average the number of people without access to clean cooking fuels and technologies increased by around 20 million, 2.5% annually in 2020 and 2021.

While the main reason for the recent deterioration in access to modern energy in Africa is due to new access failing to keep pace with the expanding population, it has also declined as a result of the pandemic-related slump in household incomes and their ability to afford a first-time access or maintain a recently gained one. According to the World Bank, the pandemic impacts, worsened by Russia's invasion of Ukraine and related inflation, may push more than 25 million additional sub-Saharan Africans to extreme poverty by end 2022, taking their total number to around 465 million (World Bank, 2022b). We estimate that at the beginning of 2022, 10 million sub-Saharan Africans that had recently gained access to basic electricity service were no longer able to pay for the service, while around 5 million were no longer able to afford modern cooking fuels such as LPG. With the current spike in LPG prices this number could reach up to 30 million by the end of 2022. Some countries with clean cooking access targets have supported the use of LPG with free or subsidised gas refilling initiatives and programmes that enabled LPG distributors to operate even during lockdowns. However, many countries do not have such programmes nor the financial wherewithal to administer them.

These overall trends mask some marked differences across countries. Some have seen continued progress in improving access to both electricity and clean cooking fuels, albeit slowed by the pandemic, while others have seen an acceleration in the numbers and share of the population lacking access. Almost half of Africans without access to electricity today live in the Democratic Republic of the Congo (DRC), Ethiopia, Nigeria, Tanzania and Uganda. Of these, only Ethiopia and Nigeria made progress in reducing the number of people without access between 2015 and 2019 (they both saw a small rebound, but proved to have more resilient electrification plans through the pandemic in 2020 and 2021). In the other three countries, the number of people without access increased persistently over the 2015 to 2021 period (Figure 1.7). Elsewhere, according to preliminary data, several countries, including Côte d'Ivoire, Ghana, Kenya, Rwanda and Senegal, have continued to reduce or stabilise the number of people without access, even if new connections were slowed by the pandemic. On the other hand, the number of people without electricity access strongly accelerated in 2020 and 2021 in countries such as Chad, DRC, Mali and Uganda.

The pandemic-induced economic slowdowns mostly affected the installation of new stand-alone off-grid systems, while the majority of new connections since the pandemic began have been grid connections. Sales of stand-alone solar home systems, including photovoltaic (PV) panels and a battery, with a capacity of at least 20 Watts fell by about one-fifth in sub-Saharan Africa between the first-half of 2019 and the first-half of 2021 (GOGLA, 2021a).

Figure 1.7 ▷ Access to electricity and Covid-19-related impacts in selected African countries



Electricity access and related progress vary significantly across African countries, with the pandemic increasing the number of people without access in most countries

Notes: 2021e = 2021 estimate. Access rate = people with access as a share of total population.

The decline in off-grid installations reflects the difficulties of reaching customers when social contact restrictions were in place. Together with subsequent increases in costs due to supply chain disruptions and lower household incomes, there were fewer purchases of new systems. Often, government initiatives to make energy more affordable for households are not extended to off-grid customers, even though two-thirds of sub-Saharan African countries include off-grid systems in their framework plans to improve energy access. Yet, there are some important exceptions. For example, Nigeria's Economic Sustainability Plan 2020 set aside around USD 620 million for solar home installations in about 5 million households. In October 2020, the Rwandan government allocated USD 30 million in subsidies to electrify remote and poor areas with solar home systems.

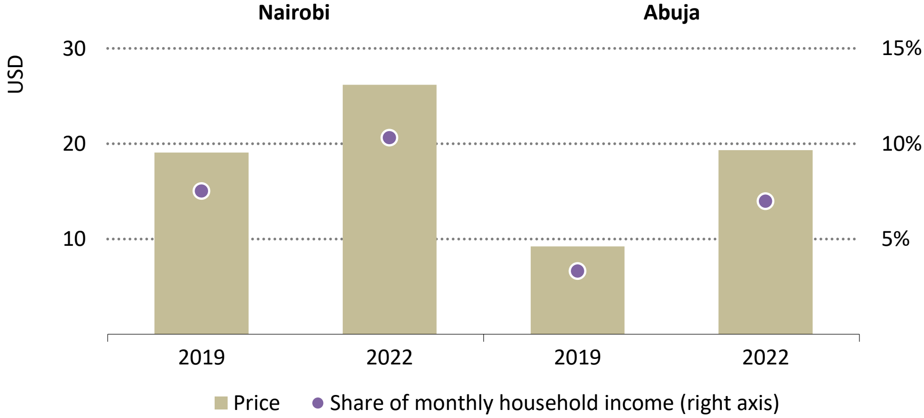
Off-grid private companies have generally been successful in maintaining service to their customers, who usually acquire solar power-based appliances under pay-as-you-go schemes. Some of these companies have offered deferred or reduced payments to the poorest household since the pandemic began (Zaman, van Vliet and Posch, 2021) while most wealthier households have been able to continue making regular payments for solar home systems. Where off-grid private companies have faced financial distress, most have sought financial support from international donors, in contrast to utilities, which have looked to national governments or debt markets.

Long-standing concerns about the affordability of energy in African countries have intensified over the last couple of years. The uneven recovery of the global economy and disruptions to supply chains and investment cycles have caused the prices of all types of energy to rise, as have prices of energy-related equipment such as solar home systems. Although Africa's exposure to international commodity markets is less pronounced than for many other regions, higher energy costs are having a disproportionately severe impact on household living standards, which on average are lower than in any other major world region, and undermine efforts to achieve energy access goals.

Higher LPG prices, in particular, are restraining efforts to expand the use of clean cooking fuels. International LPG prices have jumped by more than 60% since December 2019, pushing up LPG prices by 40-60%. In Kenya, higher LPG prices have driven the upfront cost of a standard 13 kilogramme (kg) LPG cylinder from the equivalent of 7.5% of the poorest household's monthly income to more than 10%, while in Nigeria it has doubled from 3.3% to 7% over the same period (Figure 1.8). This has caused many families to revert to polluting cooking fuels such as charcoal with serious consequences for human health and deforestation.

The jump in LPG prices coincided with moves to remove subsidies in some countries in the face of pressure from multilateral lenders. For example, a 16% value-added tax on LPG was reintroduced in Kenya in July 2021, while fuel subsidies in Sudan terminated in June 2021. Nigeria announced a plan to remove oil subsidies and replace them with direct monthly payments to poor families by mid-2022, but its implementation has been delayed due to rising prices. Many other countries that had planned pricing reforms have delayed them as a result of the pandemic. In all countries, laudable efforts to rationalise prices and eliminate fossil fuel subsidies need to include schemes to protect the welfare of the poorest households through income support.

Figure 1.8 ▷ LPG cylinder retail price in Nairobi and Abuja



International energy prices have climbed steeply since late 2020, driving up the cost of clean cooking fuels and undermining access to clean energy across Africa

Notes: Price shown is for an average 13 kg LPG cylinder. Share of monthly household income is for people in extreme poverty in Nairobi, Kenya and Abuja, Nigeria. Local market prices in January 2022 represent estimated prices for 2022.

Source: IEA data and analysis.

The price of solar home systems has risen steeply since 2020 due to higher raw material prices and supply chain disruptions. In June 2021, the off-grid solar energy industry expected that these factors would increase the price of the systems on average by 14% (GOGLA, 2021b). Since then, the price of polysilicon, a basic material for manufacturing PV wafers, has continued to increase. In May 2022 it reached a level three-and-a-half-times higher than in 2019. Over the same period, prices of other electronic equipment also jumped, making solar PV panels and associated equipment less affordable.

1.2.2 Slowdown in the development of energy infrastructure

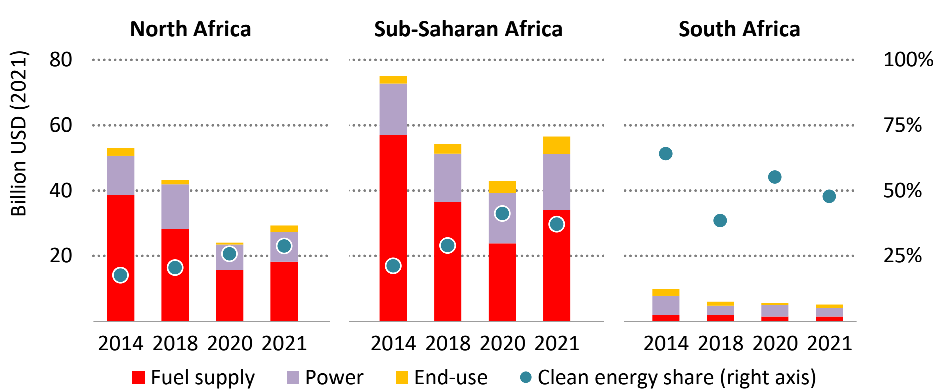
Uncertainties about economic prospects and energy prices are clouding prospects for investment in large-scale energy infrastructure projects in Africa.[3] Rising debt levels among African countries are likely to simultaneously constrain domestic public spending on energy and reduce the ability to attract foreign private capital in the near term. Public utilities play a key role in financing the power sector, particularly networks, but many are facing severe

[3] The analysis in this section benefited from input from Ms Towela Nyirenda-Jere of African Union Development Agency (AUDA-NEPAD) and Mr Fabrice Lusinde of DRC Societe Nationale d'Electricite (SNEL) .

liquidity crunches that risk evolving into longer term indebtedness (Balabanyan et al., 2021). While lockdowns reduced revenues from commercial and industrial users, fixed payment costs to generators and debt servicing obligations did not fall, increasing financial pressures on utilities (see Chapter 3).

Energy investment in Africa has rebounded from the pandemic-induced fall in 2020, but remains well below its 2014 peak, mainly due to lower spending on oil and gas projects. Many African countries were already struggling to attract capital in the energy sector before the pandemic – the region received less than 3% of global clean energy investment over the decade to 2020. Investment in fuel supply halved over that period following the oil price crash in the mid-2010s and new constraints on fossil fuel financing in response to growing action to address climate change, before recovering in 2021 (Figure 1.9). Oil and gas projects account for most of this decline. Combined investment in the power sector and in end-use applications, such as energy efficiency, have been largely flat since 2014 due to financing difficulties.[4]

Figure 1.9 ▻ Energy investment in Africa, 2014-2021



Energy investment in Africa rebounded from the pandemic-induced slump in 2020, but remains well below its 2014 peak, mainly reflecting less oil and gas project investment

Note: Sub-Saharan Africa excludes South Africa.

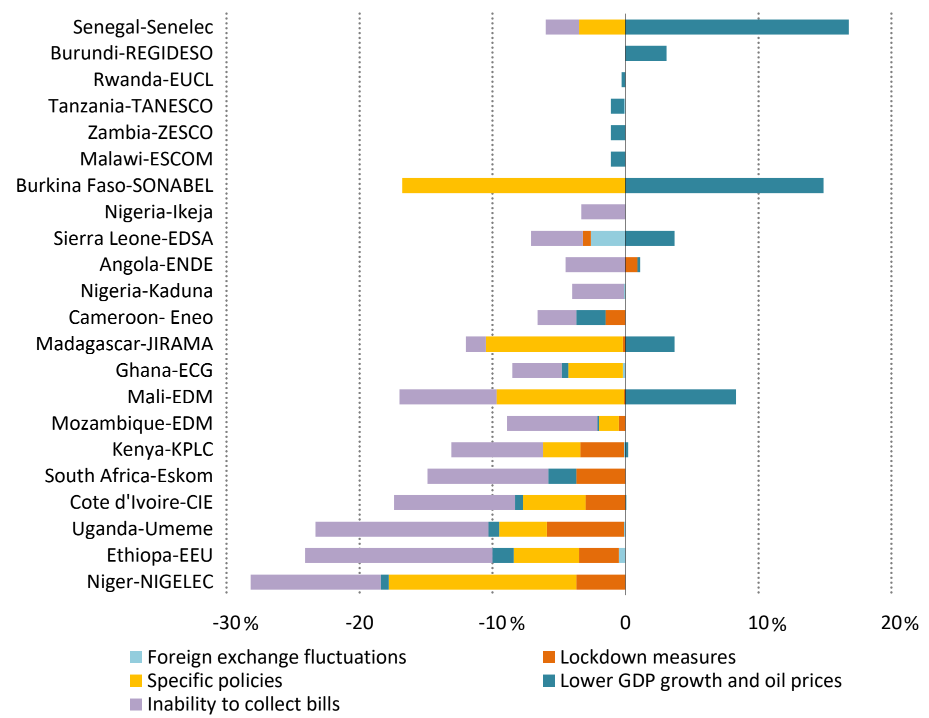
The pandemic has exacerbated the already precarious financial health of many of Africa's energy companies, notably electricity utilities. Much of the region's energy supply infrastructure is in need of expansion and repairs, both of which stalled at the start of the pandemic due to financial and logistical reasons. African utilities face long-standing problems

[4] The methodology for our energy investment analysis can be found at: https://iea.blob.core.windows.net/assets/ce2406cb-adab-4fa2-b172-6f58335dd18c/WorldEnergyInvestment2021_MethodologyAnnex.pdf.

related to poor governance, underinvestment and low cost recovery. The resulting lack of liquidity has severely limited their ability to maintain assets and invest in new ones, leading to poor operational performance, higher costs and lower profitability.

The pandemic has added to these problems, mainly by reducing revenue to varying degrees across the continent. For example, utilities reported a drop in revenues of 8% in Sierra Leone and 25% in Uganda, with most of the losses coming from industrial and commercial consumers (Balabanyan et al., 2021). The finances of most African utilities have also been hit by emergency relief programmes involving cancelling, reducing or deferring the payment of electricity bills by end-users impoverished by the pandemic. This has had a severe impact on their ability to recover operating costs and service debt for three-quarters of African utilities, notably in West Africa, East Africa and Southern Africa (Figure 1.10).

Figure 1.10 ▷ Impact of Covid-related economic events on cost recovery for selected electric utilities in Africa



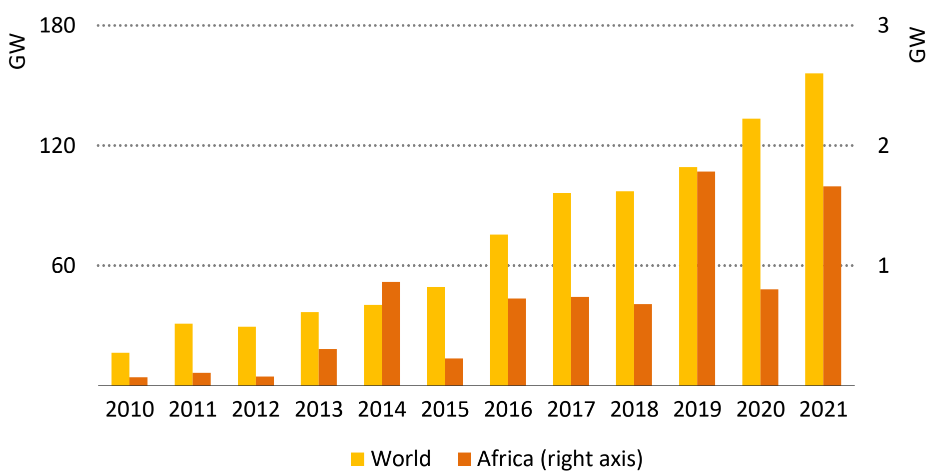
Cost recovery has deteriorated for most African utilities as a result of the pandemic, mainly due to the inability to collect bills and emergency measures to reduce prices to end-users

Note: Results shown are for the 18 months from the outset of the pandemic in March 2020.

Source: Balabanyan et al. (2021).

Although electricity demand has now rebounded, the consequences of the crisis will linger, in the form of mounting debt levels. Operating cost recovery was not expected to return to pre-pandemic levels within 18 months of the initial lockdowns in early 2020 for almost 60% of African utilities (Balabanyan et al., 2021). Utilities in countries that import fuel for power generation have been hit hardest. Now, in light of Russia's invasion of Ukraine, African utilities will be under pressure to extend lifeline tariffs and forgive non-payments, prolonging this period of even higher operating losses. Lower oil and gas prices at the start of the pandemic were partly offset by currency depreciation, but the rally in fuel prices since late 2020 has more than outweighed the financial benefits of the early price declines. It remains to be seen whether regulatory reforms aimed at improving the finances of public utilities, which had registered some progress until 2020, notably in Nigeria and Cameroon, will be slowed by the crisis.

Figure 1.11 ▻ Solar PV capacity additions in Africa and the world, 2010-2021



Solar PV capacity additions in Africa declined sharply in 2020, but rebounded to near pre-pandemic levels in 2021, driven mainly by small- and medium-size projects

Source: IEA (2022b).

The worsening financial health of most electric utilities in Africa is leading to a slowdown in additions of new power generation capacity across the continent. Solar PV installations continued to rise globally in 2020 and 2021, but they fell sharply in Africa in 2020 (Figure 1.11). PV capacity in Africa reached a record high in 2019, mostly due to the completion of the Egyptian Benban mega PV plant, which has a capacity of 1.65 gigawatts (GW). Total installations in 2020 were well below pre-pandemic expectations. Some large-scale projects that were under discussion before the pandemic have been affected due to heightened financial risks. Additions of small-to-medium-size plants held up better in 2021, recovering to just under 2019 levels. Solar installations are gaining momentum. In sub-Saharan Africa (excluding South Africa), 13 countries now have more than 50 megawatts of installed capacity, a level reached five years ago by only Namibia and Senegal.

The extension of electricity transmission and distribution networks, which had slowed since mid-decade to 2019, have received little investment since the start of the pandemic. A large increase in network investment is needed to reduce technical as well as non-technical electricity losses caused notably by cable and energy theft, vandalism and, in some cases, destruction brought about by armed conflict. African grids are prone to frequent, planned and unplanned power outages. This has encouraged end-users, especially large commercial and industrial businesses, to generate their own power. It has also led to a vicious circle of high costs, lower revenues, low cost recovery, underinvestment, worsening reliability and higher losses. A lack of grid capacity prevents the few countries with oversupply, such as Ghana and Kenya, to export or supply domestic centres of demand. In general, Africa lacks regional interconnections, despite efforts to reinforce the five existing African power pools and the vision of a single African electricity market.

Many African companies currently rely on backup diesel generators, which greatly increase operating costs and undermine energy efficiency. In sub-Saharan Africa alone, such capacity amounted to 45 GW in 2021, more than all the renewables-based generating capacity in the region. Of this, 13 GW is in Nigeria, where 25 terawatt-hours (TWh) or 40% of the total electricity is auto-generated by industrial and commercial firms and households using oil products (ECOWAS, 2021). Improvements in grid reliability would enable utilities to earn more from sales to industrial and commercial clients, which are crucial to their revenue basis, by discouraging auto-generation and reducing the need for backup generation during blackouts (UNEP, 2020).

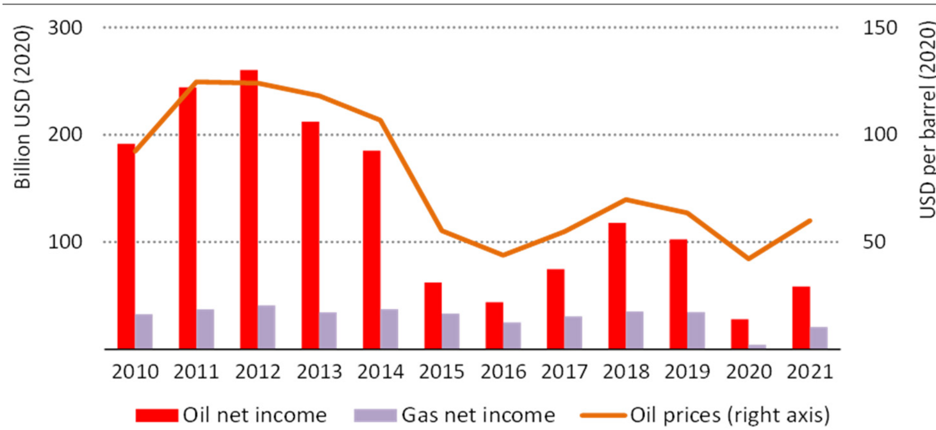
Substantial upgrades are also needed in the fuel delivery infrastructure. Most of it is located in coastal areas, with only minimal facilities to serve inland demand. A few cross-country pipelines are in operation, such as the West African Gas Pipeline from Nigeria to Niger, Togo, Benin and Ghana, and the Mozambique Pipeline Company, which connects the country's onshore gas fields to Sasol's operations in South Africa. While several national or cross-border pipeline projects are planned, notably the Tanzania-Uganda Natural Gas Pipeline, the Trans-Nigeria Gas Pipeline and the Trans-Sahara Gas Pipeline, linking Nigeria and Algeria, financing remains uncertain. In light of Russia's invasion of Ukraine, there is renewed interest in advancing some of these projects, as well as liquefied natural gas (LNG) terminals, to allow African gas to reach international markets, though completing them will take several years.

The operating performance of refineries in Africa is generally very poor due to their age – most were built in the 1970s or 1980s – and inadequate maintenance. They are also hampered by small capacity and simple configurations, limiting their ability to meet fuel quality requirements which have become progressively stringent worldwide. In total, refining capacity across the continent amounts to 3.5 million barrels per day (mb/d), 60% of which is in North Africa. The average utilisation rate in 2020 was below 60% across the continent and under 40% in sub-Saharan Africa (and lower still in some countries such as Nigeria). As a result, many countries rely on imports of refined products, despite the continent being a net exporter of crude oil. The rise in fuel prices on international markets is impeding the capacity of importers to invest in storage and pipeline infrastructure, limiting supply to domestic markets and rising unit costs.

1.2.3 Weak rebound in energy production

The sharp drop in demand for and prices of fossil fuels at the start of the pandemic caused financial difficulties for many oil-producing countries across the globe, but the impacts were particularly acute for African producers. Oil production in Africa declined by almost 20% in 2020, though natural gas production remained relatively resilient, dropping by 2%. Coal production, of which South Africa contributes 95%, fell by around 5%. Oil production in African countries barely increased in 2021, with the exception of Libya, despite the recovery in oil prices. Persistent underinvestment and maintenance have left many African facilities struggling to restart and ramp up production. Nigeria, the region's largest producer, and Angola, the third-largest producer, are not expected to be able to meet their current Organization of the Petroleum Exporting Countries (OPEC) quotas for at least another year, having produced almost 300 000 barrels per day (b/d) less than their combined quotas throughout 2021. Net income from oil and gas production combined doubled in 2021, but remained well below pre-pandemic levels and its historic peak in 2012 (Figure 1.12).

Figure 1.12 ▷ Oil and gas net income in Africa, 2010-2021

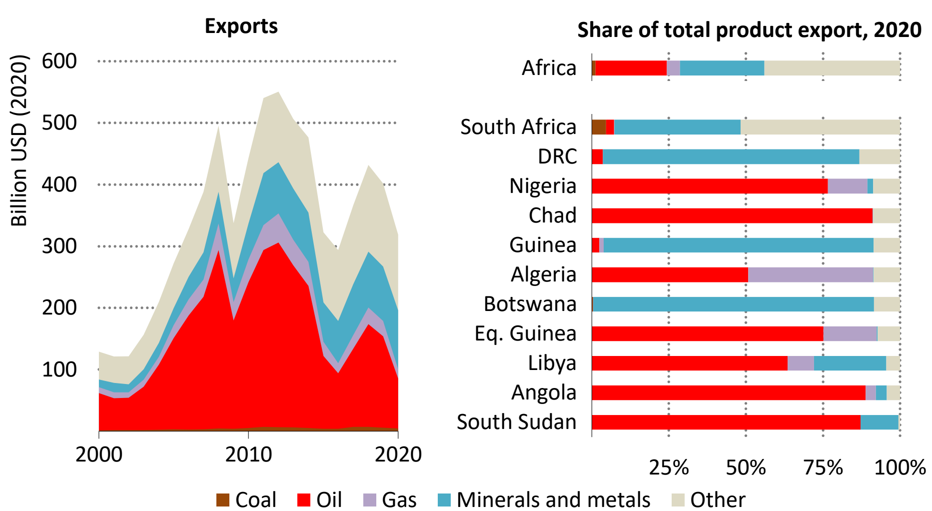


Net income from oil and natural gas production in Africa rebounded strongly in 2021 thanks to higher production and prices, but remained far below pre-pandemic levels

Note: Net income is defined as the difference between the cost of production and revenue from sales on domestic and international markets.

Investment in African oil and natural gas production has been flagging since the price downturn in 2014. The 2020 price shock left producers struggling even more to pay for much-needed maintenance and repairs, as well as to finance the development of new fields. It is a similar story for the region's pipeline and storage infrastructure, which is crucial to serve domestic markets. Many international oil companies, which make up a large part of African oil and gas production, have become increasingly reticent to make large-scale investments due to the lack of regulatory clarity and uncertainty over future global demand. Many of them have refocused their portfolios, prioritising production from fields with higher financial returns. The Russia-Ukraine conflict, however, has encouraged a recent uptick in African natural gas supply to support European countries looking to wean themselves off of fossil fuels from Russia. Eni, for example, has signed deals in Algeria, Egypt and the Republic of Congo all geared towards increasing imports. Looking to the future, TotalEnergies decision to progress Uganda's Lake Albert investment by integrating several renewable energy projects may provide a blueprint for developing both fossil and renewable resources in Africa.

Figure 1.13 ▷ Export value of fossil fuels, minerals and metals from Africa and share in total exports in selected African countries



Many African countries rely heavily on exports of fossil fuels, minerals and metals

Notes: DRC = Democratic Republic of the Congo; Eq. Guinea = Equatorial Guinea. Standard international trade classification (SITC) codes 27, 28, 68, 667 and 971 were included in the minerals and metals category; SITC code 3 categories were used for fossil fuels.

Sources: IEA analysis based on United Nations Conference on Trade and Development (UNCTAD) data (2022).

Sub-Saharan Africa, where half of total export value is derived from fossil fuels, was particularly vulnerable to the global market downturn at the start of the pandemic. This was especially true for the biggest producers, where government revenues from oil and gas production account for a large share of their economy and government budget. For example, in Nigeria, where oil and gas revenues contributed 65% of government revenues in 2019, the 2020 oil price collapse drove Nigeria into a sharp recession, with GDP contracting 1.8%. Mounting debt is debilitating the ability of governments in oil-producing countries to finance the investments needed to compensate for the declines in output from existing fields. Global supply chain challenges for products and labour hinder maintenance and progression of sanctioned projects.

Income from fossil fuel exports, as well as minerals and metals, has been highly volatile over recent decades. In 2020, they accounted for 55% of Africa's of export revenue (Figure 1.13). Oil revenue in sub-Saharan Africa has experienced the most drastic shifts over the past ten years. This makes it all the more important for governments in those countries to optimise the use of tax revenues from resource exports to support the broader long-term development of their economies. While there is greater uncertainty over long-term demand for fossil fuels, demand for critical minerals such as cobalt, copper and manganese is set to rise as more clean energy technologies are deployed. Africa is a leading producer of many of these minerals today, notably cobalt in the DRC, platinum, chromium and manganese in South Africa and graphite in Mozambique. While growing global demand for critical minerals will open new revenue streams, those industries are not immune from the same investment risks related to price volatility that plague the oil and gas industry. This reinforces the need for transparent revenue management and prudent investment in infrastructure to increase and diversify economic growth.

1.3 Implications of COP26 for Africa

The commitments on climate change, including pledges to reach net zero emissions, made by governments around the world at the 26th Conference of the Parties (COP) to the UN Framework Convention on Climate Change (UNFCCC) in Glasgow in November 2021 are sufficient, for the first time ever, to keep global warming to under 2°C – on condition they are met on time and in full.[5] That would have a profound impact on Africa's pathway for energy development. In some respects, the impact would be positive, by improving the affordability and availability of clean energy technologies, increasing demand for the region's critical mineral resources and increasing the levels of climate financing through international commitments, in addition to averting the worst effects of climate change. But in other respects, the impact on Africa would notably increase uncertainty about prospects for fossil fuel production. And climate impacts would still be significant, increasing the risk of drought, food and water scarcity, human migration and political instability in some regions. These factors will increasingly influence energy investment decisions over the next decade as new opportunities arise and the global energy context continues to shift.

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[5] Some of the analysis in this section benefited from inputs provided by Mr Ousmane Fall Sarr (Senegalese rural electrification agency).

1.3.1 Global climate pledges

It was a pivotal year in 2021 for global commitments to address climate change. As of March 2022, more than 80 countries and the European Union had committed to reach net zero emissions by around mid-century, although scope of emissions vary. We estimate that these commitments, if met in full and on time, would allow the world to limit warming by 2100 to around 1.8 °C. In reality, meeting these targets is very uncertain. It is even less certain that the more ambitious goal of limiting the global temperature increase to 1.5 °C can be met, as this would require stronger national targets and measures to be adopted and implemented. Different trajectories for emissions and global temperature imply different outcomes for Africa with regard to warming and the specific climate impacts across the continent, global demand for and prices of the region's fossil fuel resources, and the availability and price of clean energy technologies.

Box 1.2 ▹ Africa's international engagement on climate change

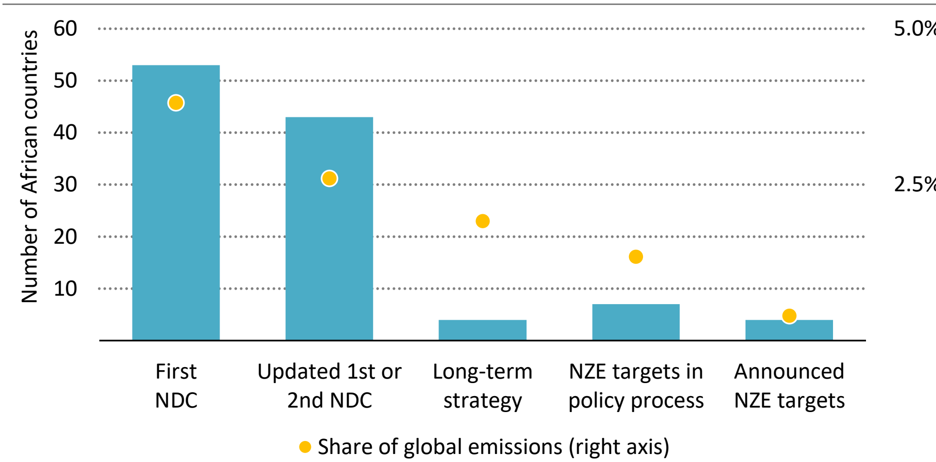
African countries are active participants in international negotiations on climate change. With the next COP due to take place in Egypt in November 2022, the continent will have hosted five of the 27 COPs (the others were in Morocco in 2001 and 2016, Kenya in 2006 and South Africa in 2011). African countries co-ordinate their involvement through the African Group of Negotiators on Climate Change (AGN), which was created in 1995. It has championed several initiatives focused on agriculture, deforestation, climate finance and adaptation. AGN has led key multilateral initiatives, such as the Nairobi Work Programme for Adaptation, and supported the landmark COP17 in Durban, where the Durban Platform for Enhanced Action began negotiations for the Paris Agreement adopted at COP21. The AGN also played an important role in reaching final agreement on the Kigali Amendment to the Montreal Protocol in 2016 to phase out the production of hydrofluorocarbons, which contribute to global warming, according to differentiated schedules for developed and developing countries. AGN also helped to shape the rules for the implementation of Article 6 of the Paris Agreement.

The AGN also works at the ministerial level across the continent. It has contributed to building global momentum for developing the African Risk Capacity Group, under the African Union, which supports the capacity of governments to face extreme weather events and natural disasters through collaborative financing and insurance mechanisms. Other programmes aimed at facilitating concrete actions include the African Renewable Energy Initiative, which fosters the deployment of renewable electricity, and the Africa Adaptation Acceleration Programme developed by the African Development Bank and the Global Centre on Adaptation. At other multi-stakeholder international summits, Africa has raised the profile of forestry, which is crucial for all developing countries. Afforestation and reforestation initiatives gained momentum at the Nairobi One Planet Summit in 2019, while multi-country initiatives such as the Great Green Wall in Sahel and the Congo Basin initiatives were prominent at COP26. The latter attracted USD 1.5 billion in financing as part of a global commitment to halt forest loss and land degradation.

1.3.2 Africa's climate pledges and NDCs

As of May 2022, 53 African countries had submitted a Nationally Determined Contribution (NDC) – a climate action plan to mitigate greenhouse gas emissions and adapt to climate change – to the UNFCCC. Mitigation includes both making future growth less emissions intensive and reducing emissions in absolute terms. Of these NDCs, 80% are updated first or second submissions, with some, although not all, calling for enhanced ambitions. Most contain both unconditional and conditional mitigation and adaptation targets, with conditional targets often involving requests for economic, financial and technical capacity building support from advanced economies. African NDCs – if fully implemented – would collectively mitigate around 550 million tonnes of carbon dioxide (Mt CO_2) in 2030 compared with their own business-as-usual baseline scenarios, equivalent to roughly 40% of the continent's emissions today.

Figure 1.14 ▷ Climate change commitments by type and coverage as share of energy-related CO_2 emissions in African countries, 2020



As of May 2022, 53 African countries had submitted a NDC. Twelve African countries have reached or have pledged to reach net zero emissions

Notes: NDC = Nationally Determined Contribution. NZE = net zero emissions covering either total greenhouse gases or carbon dioxide.

The NDCs submitted by African countries vary in their specificity and coverage. Many are aspirational and do not yet include targets for emissions reductions, while most that do are conditional, notably contingent on obtaining finance (Table 1.3). In addition, many do not define the baselines on which their NDCs are based or specify the origin of emissions reductions. Few countries are yet on track to meet their commitments under current policies.

Table 1.3 ⊳ NDCs in African countries

	Conditional or unconditional	First, updated or second NDC	Sectors covered			
			Energy	Waste	AFOLU	IPPU
Algeria	Both	First	Full	Full	Full	Full
Angola	Both	Updated	Full	Full	Full	Full
Benin	Both	Updated	Full	Full	Full	Full
Botswana	Unconditional	First	Full	Full	Partial	
Burkina Faso	Both	Updated	Full	Full	Full	Full
Burundi	Both	Updated	Full	Full	Full	Full
Cameroon	Both	Updated	Full	Full	Full	Full
Cape Verde	Both	Updated	Full	Full	Full	Full
CAR	Both	Updated	Full	Full	Full	Full
Chad	Both	Updated	Full	Full	Full	
Comoros	Conditional	Updated	Full	Full	Full	Full
Congo	Both	Updated	Full	Full	Full	Full
Côte d'Ivoire	Unconditional	First	Full	Full	Full	
DRC	Both	Updated	Partial	Partial	Partial	
Djibouti	Both	First	Full	Full	Partial	Full
Egypt	Conditional	First	Full	Full	Partial	Full
Equatorial Guinea	Unconditional	First	Full	Full	Full	Partial
Eritrea	Both	First	Full	Full	Partial	Full
Eswatini	Both	Updated	Full	Full	Full	Full
Ethiopia	Both	Updated	Full	Full	Partial	Full
Gabon	Both	First	Full	Full	Full	Partial
Gambia	Both	Second	Full	Full	Full	Full
Ghana	Both	Updated	Partial	Full	Partial	Partial
Guinea	Both	Updated	Full	Full	Full	Full
Guinea-Bissau	Both	Updated	Full	Full	Full	
Kenya	Both	Updated	Full	Full	Full	Full
Lesotho	Both	First	Full	Full	Full	Full
Liberia	Both	Updated	Full	Full	Full	Full
Madagascar	Unconditional	First	Full	Full	Full	

● Full ● Partial

Table 1.3 ▷ NDCs in African countries (continued)

	Conditional or unconditional	First, updated or second NDC	Sectors covered			
			Energy	Waste	AFOLU	IPPU
Malawi	Both	Updated	● Full	● Full	● Partial	● Full
Mali	Unconditional	Updated	● Full	● Full	● Full	
Mauritania	Both	Updated	● Full	● Full	● Full	● Full
Mauritius	Both	First	● Full	● Full	● Full	● Full
Morocco	Both	Updated	● Full	● Full	● Full	● Full
Mozambique	Conditional	Updated	● Full	● Full	● Partial	● Partial
Namibia	Both	Updated	● Full	● Full	● Full	● Full
Niger	Both	Updated	● Full		● Full	
Nigeria	Both	Updated	● Full	● Full	● Full	● Full
Rwanda	Both	Updated	● Full	● Full	● Partial	● Full
São Tomé and Príncipe	Conditional	Updated	● Full	● Full	● Partial	● Full
Senegal	Both	First	● Full	● Full	● Full	● Full
Seychelles	Conditional	Updated	● Partial	● Partial		● Partial
Sierra Leone	Both	Updated	● Full	● Full	● Full	● Full
Somalia	Conditional	Updated	● Full	● Full	● Partial	
South Africa	Conditional	Updated	● Full	● Full	● Full	● Full
South Sudan	Conditional	Second	● Full	● Full	● Full	● Full
Sudan	Conditional	Updated	● Full	● Full	● Partial	
Tanzania	Conditional	Updated	● Full	● Full	● Full	● Full
Togo	Both	Updated	● Full	● Full	● Full	● Full
Tunisia	Both	Updated	● Full	● Full	● Full	● Full
Uganda	Both	Updated	● Full	● Full	● Full	● Full
Zambia	Conditional	Updated	● Full	● Full	● Full	
Zimbabwe	Conditional	Updated	● Full	● Full	● Full	● Full

● Full ● Partial

Notes: NDC = Nationally Determined Contribution; CAR = Central African Republic; AFOLU = agriculture, forestry and land use; IPPU = industrial processes and product use. Libya is not listed as no document was submitted to UNFCCC. Blank cells mean that the sector is not covered, or that it is unspecified. The terminology "first NDC" refers to the first version of a NDC submitted to the UNFCCC. The term "updated NDC" refers to the situation where a country has updated its first NDC with the intention to make commitments more ambitious. A "second NDC" is when the country has submitted a new NDC after its first (or updated first) NDC, which can include new dates, targets or sectoral or GHG emissions scope not included in its first or updated first NDC.

A number of African governments have made commitments related to other important climate and environmental goals. The African Union Agenda 2063 specifies that renewable and clean energy sources should provide the basis for expansion of Africa's energy systems to ensure energy security and decarbonisation. At COP26, seven African countries and the East African Development Bank signed the Statement on International Public Support for the Clean Energy Transition, which stipulates the end of finance for unabated fossil fuel-based power generation by end of 2022. Morocco has pledged not to build any new coal-fired power plants, while Egypt has committed to phase out coal-fired power stations. South Africa has also committed to decarbonise its economy and phase down coal use. Twelve African countries have announced long-term net zero emissions pledges, aiming to reach carbon neutrality by between 2050 and 2070 (Table 1.4). These include several major economies, notably Nigeria and South Africa, as well as several small island developing states and least developed countries. One African country, São Tomé and Príncipe, achieved climate neutrality in 1998 using carbon sinks.

The role of carbon sinks is of particular significance in Africa. NDCs of 48 African countries include land use, land-use change and forestry (LULUCF). Today, one-sixth of the world's forests by area are located in Africa, many of which have been subject to rapid deforestation in recent years. The countries that include LULUCF in their NDCs contain more than 99% of Africa's current forests. In regions such as the Sahel, where risks of desertification threaten food and water security, international initiatives to halt forest loss and land degradation have been launched.

Table 1.4 ▷ Announced net zero emissions pledges in African countries

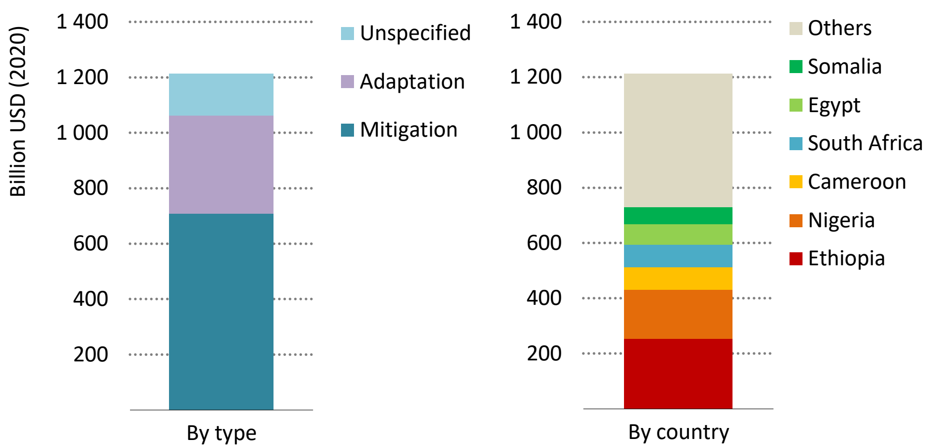
	Share of Africa			Announced pledge
	Population	GDP	CO_2 emissions	
Cabo Verde	0.0%	0.1%	0.0%	Climate neutral by 2050
Côte d'Ivoire	2.1%	2.2%	0.8%	Carbon neutral by 2030
Liberia	0.4%	0.1%	0.1%	Climate neutral by 2050
Malawi	1.6%	0.3%	0.1%	Carbon neutral by 2050
Mauritania	0.4%	0.4%	0.3%	Carbon neutral by 2050
Mauritius	0.1%	0.4%	0.3%	Carbon neutral by 2070
Namibia	0.2%	0.4%	0.3%	Climate neutral by 2050
Nigeria	16.7%	16.3%	8.4%	Climate neutral by 2060
Rwanda	1.1%	0.5%	n.a.	Carbon neutral by 2050
São Tomé and Príncipe	0.0%	0.0%	0.0%	Climate neutral achieved in 1998
Seychelles	0.0%	0.0%	0.0%	Climate neutral by 2050
South Africa	4.8%	11.0%	32.7%	Climate neutral by 2050
Total	**27.4%**	**31.7%**	**43.0%**	

Notes: Population, GDP and CO_2 emissions shares are for 2020. Announced pledges include verbal pledges made by heads of state at COP26 as well as formal submissions and announcements. São Tomé and Príncipe reached climate neutrality in 1998, and now deems itself "carbon negative", which refers to the situation where the net effect between the emissions and sinks of a country is negative.

1.3.3 Climate finance commitments

Financial support from the advanced economies will be vital to efforts to decarbonise Africa's energy systems and implement the NDCs. The vast majority of African NDCs contain mitigation and adaptation targets that are conditional on receiving international financial, technical and capacity building support. In aggregate to date, 48 African countries have requested over USD 1 200 billion of international financial support by 2030 to implement their NDCs. Almost 60% is for climate mitigation actions, around 30% for adaptation and the remaining 10% unspecified or for both mitigation and adaptation. Six countries – Cameroon, Egypt, Ethiopia, Nigeria, Somalia and South Africa – account for about 60% of the finance requested to implement NDCs.

Figure 1.15 ▷ Finance requested for implementation of NDCs to 2030 by type of action and country



African countries have requested over USD 1 200 billion of international financial support to implement their NDCs, around 60% of which is for mitigation actions

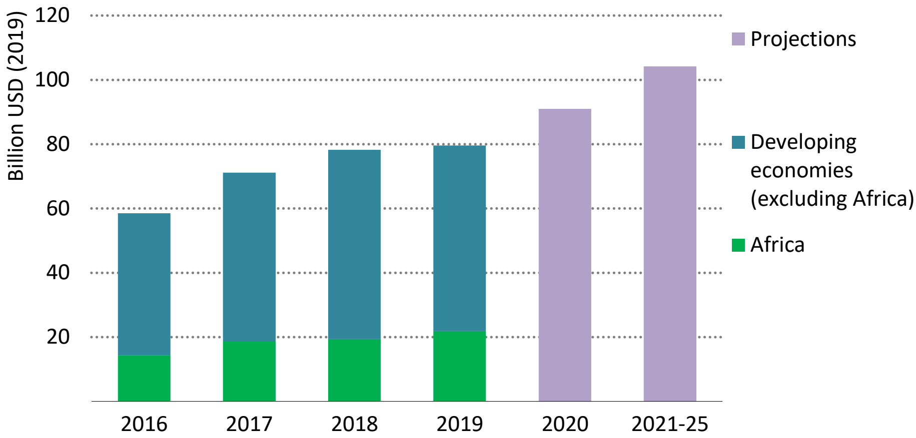
Note: Requests announced as of February 2022.

Specificities of the conditions put forward vary across countries. Only 14 countries specify a precise emissions outcome associated with the request for finance. NDCs rarely specify which sectors would receive the funds, with only around 20% of requested financing designated for energy-related investment. While there is a clear need for clarification of these aspects, the climate finance requests made so far give an indication of the climate action intended as well as of the scale of financing that will be requested in the future.

Financing of climate actions in the developing economies by the advanced economies so far has fallen short of amounts pledged. In 2009, developed countries pledged to jointly provide and mobilise USD 100 billion annually to developing economies by 2020 via bilateral public finance, public financial institutions and private finance.[6] At COP26, developed countries acknowledged they had missed this target. Climate finance provided and mobilised in total reached just USD 79.6 billion in 2019, the most recent year for which data are available (Figure 1.16). The countries re-committed to meeting the earlier pledge by 2022 (OECD, 2021b).

1

Figure 1.16 ▷ Climate finance flows to developing economies



Only a marginal increase in climate finance from developed countries to Africa is seen in recent years, which is failing to meet targets set by both donor and recipient governments

Note: Data for 2016-19 are from the OECD based on tracking the USD 100 billion goal. Projections are based on OECD which assumes that commitments already made for this period will be met fully.

Sources: OECD (2021b and 2021c).

Roughly a quarter of the climate-related financial flows from the developed countries over the 2016-19 period were destined for African countries (OECD, 2021b). Over half of those flows were in the form of debt instruments and roughly 30% were grants. Recent high profile pledges include the 2021 South Africa "Just Energy Transition Partnership", in which France, Germany, European Union, United Kingdom and United States will work with the South African government to raise up to USD 8.5 billion over the next three to five years to fund the transition away from coal (see Chapter 3).[7] Future pledges must be designed in a way that does not add further burden to the increasingly unsustainable debt levels on the continent.

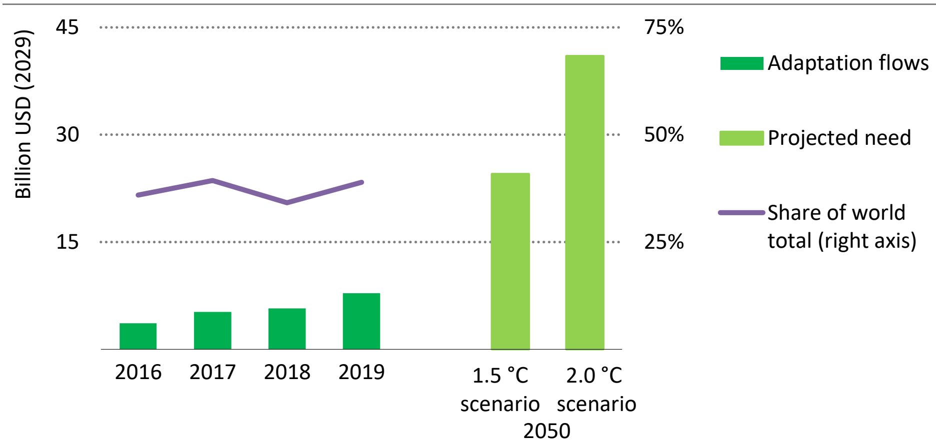
[6] Those involved in this pledge include: Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, European Union, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom and United States.

[7] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_5768

Climate finance from developed countries is only one source of capital to fund Africa's mitigation and energy transition needs. Public and private flows from China, domestic capital and commercial private capital also play important roles (see Chapter 3). For adaptation, concessional funding from developed countries is particularly vital. Climate equity principles imply that governments of developing countries should not have to fully shoulder adaptation costs given their minimal contribution to cumulative global emissions to date. Developed countries have acknowledged the importance of finding a balance between mitigation and adaptation financing; in 2019, only 25% of the USD 79.6 billion of climate finance provided and mobilised by developed countries was for adaptation (OECD, 2021b). It is estimated that adaptation finance in developing nations needs to reach at least USD 70 billion per year between 2020 and 2030 (United Nations Environment Programme, 2021). Recognition of the shortfall in adaptation finance led to a renewed emphasis on this topic at the COP26 negotiations, resulting in the inclusion of a new goal for developed countries to double the funding for adaptation to USD 40 billion per year by 2025 in the Glasgow Climate Pact. In addition, new pledges were made to the Adaptation Fund and the Least Developed Countries Fund, which focus on resilience.

Ensuring an appropriate balance of adaptation and mitigation finance is vital to ensure that NDC targets are met. The continued preference for funding mitigation projects is resulting in an increasing shortfall in funding for adaptation, which will push up the cost of interventions needed later on. Adaptation costs for Africa are estimated at USD 12-36 billion in 2050 under a 1.5 °C scenario and USD 18-59 billion under a 2 °C scenario (Chapagain et al., 2020); (Savvidou et al., 2021) (Figure 1.17).

Figure 1.17 ▷ Climate adaptation finance flows to Africa from OECD countries



Financing from developed countries to Africa for adaptation falls short of pledged contributions which will push up the cost of later interventions

Note: Data for 2016-19 are from the OECD based on tracking the USD 100 billion goal.

Sources: OECD (2021b); Chapagain et al. (2020).

There has been growing pressure on governments and lenders to discontinue funding to certain fossil fuel projects, notably coal-fired power plants. In September 2021, China announced that it would stop building new coal plants overseas, effectively eliminating the last major source of public funding for new coal plants in Africa and other emerging economies. In addition, some major banks, sovereign wealth funds and multilateral financing institutions in developed countries have committed to stop funding new fossil fuel developments. However, certain regulations or commitments include exceptions for natural gas for transition purposes, such as the European Union's Green Taxonomy, a classification system establishing a list of environmentally sustainable economic activities. These regulations are evolving constantly, complicating strategic energy decisions in Africa. Yet the trend is clear: a gradual tightening of the availability of finance for fossil fuel projects, including natural gas, in all parts of the world.

Sustainable Africa Scenario

Shifting gear: A decade of transformation

SUMMARY

- Africa has the world's fastest growing population: almost one-in-two people added to the global population over the next decade will be African. Combined with increasing economic activity and household incomes, this will drive up demand for energy services. Yet many Africans will remain energy poor, despite the region's vast energy resources, unless policy action to stimulate investment and make modern energy affordable is taken urgently.
- In the Sustainable Africa Scenario (SAS), in which all of Africa's energy-related development goals are achieved, modern primary energy supply rises by a third over the 2020-30 decade, while traditional use of bioenergy for cooking is eradicated thanks to universal access to modern fuels and technologies. However, energy use per capita is still less than one-third the world average.
- Households remain the largest final energy consumers in Africa in 2030. The number of air conditioners, fans and refrigerators more than doubles, but minimum energy performance standards restricting the sale of the least efficient appliances and new building codes mitigate impacts on energy demand. Restrictions on the import of inefficient used cars, which make up over 50% of new registrations, boost average fuel economy by 25% over the decade. Africa develops its industry, including low-carbon industrial technologies, such as in EAF steelmaking, which accounts for over 70% of steel output in 2030.
- Africa's electricity demand increases by 75% to 2030. Renewables, mainly solar PV, account for the majority of new capacity additions due to ever-declining costs driven by rapid global uptake. By 2030, solar and wind together provide 27% of power generation, eight-times more than today. Once plants currently under construction are completed, Africa builds no other coal-fired power station with China's announcement in 2021 to end support for coal projects abroad, cutting 15 GW of previously planned capacity. If the investment initially intended for these plants were redirected to renewables, it would cover over half of the cost of solar PV additions to 2025 in the SAS.
- The prospects for oil and gas production hinge primarily on exports, which means that future oil revenues will remain more sensitive to the pace of the global energy transition than to domestic demand trends. Oil output declines substantially with falling export demand to 2030 in the SAS. Natural gas production continues to increase in the near term, reflecting a series of major discoveries in the 2010s. Monetising these resources will require careful balancing of domestic and export needs and tailored infrastructure expansion plans, alongside major efforts to keep project costs and delays down. Africa has the potential to become a major exporter of low-carbon hydrogen by exploiting its enormous low cost renewable resources if it can mobilise the requisite capital.

2.1 Introduction

This chapter describes how Africa's energy sector could be transformed in the years to come to put it on a sustainable path that is compatible with both the continent's own development goals and the climate objectives of the world as whole. This is done by setting out the results of a scenario or pathway – the *Sustainable Africa Scenario* (SAS) – to provide a framework for understanding the key drivers of the energy sector and how they could change, focussing on the period to 2030. The first section describes how the SAS is designed and the key macroeconomic and demographic assumptions underpinning it. The following sections present the results, with trends in total primary energy supply and total final consumption, highlighting the potential for energy efficiency within the buildings and transport sectors, and in productive uses to temper the growth in energy use with rising underlying demand for energy services. It also looks at how the power sector could be transformed while meeting rapidly rising electricity needs. In addition, it includes an assessment of Africa's prospects as a producer and exporter of fossil fuels and emerging clean fuels.

2.1.1 Scenario design

This *Outlook* explores the implications of the Sustainable Africa Scenario, which sets out a pathway that achieves all of Africa's energy-related development goals, including universal access to modern energy services by 2030 and all of the Nationally Determined Contributions (NDCs) and announced net zero emissions pledges on time and in full. It takes into consideration international financial flows consistent with African nations' conditional NDCs, as well as national and corporate commitments to increase climate finance flows and to cease financing certain fossil fuel projects. In the rest of the world, it is assumed that all announced global commitments to reach net zero emissions are fully implemented.[1]

The SAS gives centre stage to economic and social development. Achieving universal access to modern, reliable and affordable energy remains the first priority, as it is vital to help Africa's citizens attain higher standards of living and security. The SAS also takes into account the rising energy services demand from industries and business, which stimulate economic development. The scenario prioritises the most cost-effective solutions that are able to attract the requisite finance and that are readily available and applicable in the African context. The SAS achieves energy services demand growth and universal access across the continent in a manner which does not exclude the world reaching net zero emissions by 2050. Africa's total emissions in 2050 are very small and would not prevent the world as a whole from achieving net zero emissions by then.

Making this scenario a reality is a formidable task. It calls for all African countries to continue to set bold goals for sustainable development and to implement policies to support the foundations for developing a thriving energy economy. It also requires international partners to boost efforts to catalyse a substantial increase in clean energy investment in Africa as a

[1] This is the underlying assumption of the IEA's Announced Policies Scenario.

part of their overall commitments to reach – and subsequently increase – committed levels of climate finance for developing economies.

Any energy pathway that Africa pursues will be deeply intertwined with those of the rest of the world, which will affect the availability, cost and financial viability of the range of technological solutions, as well as global demand for fuels and raw materials and the opportunities for African countries to meet that demand. Where relevant, we have included in this and subsequent chapters sensitivity analyses based on the SAS to explore the implications for African energy production and the deployment of key technologies of various trends in energy prices and global trajectories for the achievement of net zero emissions, including the Net Zero Emissions by 2050 Scenario (NZE) outlined in the *World Energy Outlook-2021* (IEA, 2021a). The aim is to provide insights for African decision makers on how they should prepare for these uncertainties, associated risks and opportunities. The primary counterpoint to the SAS is whether Africa could play a role in exporting more natural gas to the European Union as it reduces its reliance on Russian imports (see Chapter 3). The second counterpoint is how current energy prices influence competitiveness of some technologies to achieve universal access, notably the use of diesel generators for electricity and the use of liquefied petroleum gas (LPG) for clean cooking.

2.1.2 Population and economic growth

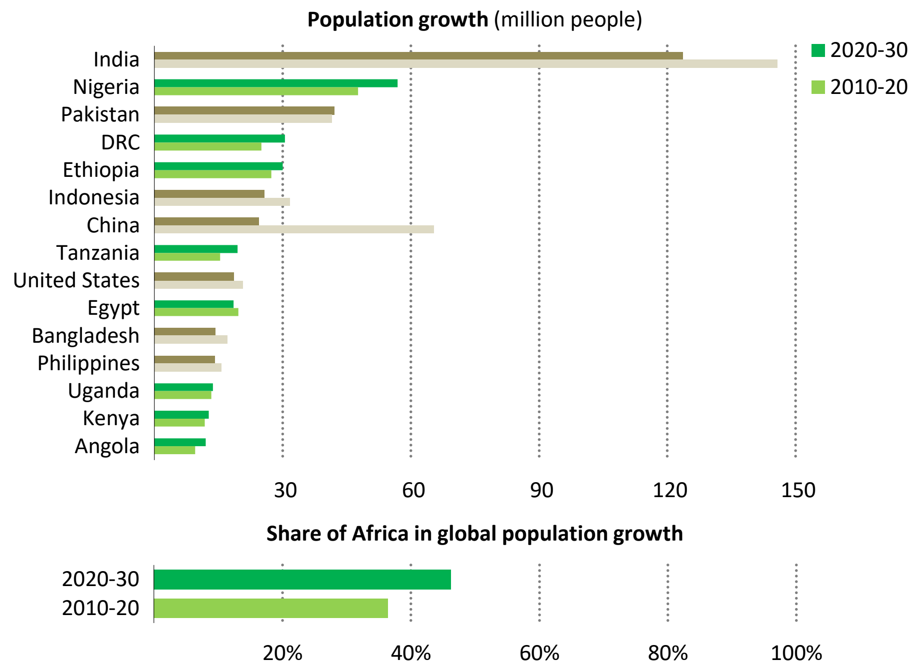
Population growth and economic activity are major drivers of energy demand. Rapid demographic change will undoubtedly continue to drive up demand for energy services across Africa in the coming decades. With more than 1.3 billion inhabitants in 2020, Africa accounts for close to a fifth of the world population. In 2000, this share was only 13%, reflecting the much faster rate of population growth in Africa than in the rest of the world. In the last three years alone, Africa’s population grew by 2.5% each year on average, faster than any other region and more than twice the global rate. Just four countries – the Democratic Republic of the Congo (DRC), Egypt, Ethiopia and Nigeria – account for almost 40% of Africa’s population. Nigeria is the most populated with around 210 million inhabitants. Africa’s population is the youngest in the world: the median age in 2020 was around 20 years and over 40% of the population is under the age of 15, compared with a global average of 30%.

Africa’s population is projected to increase by 350 million, more than the current population of the United States, to 1.7 billion by 2030. Almost one-in-two people added to the global population between 2020 and 2030 will be an African. Of the 15 countries that will see the biggest population growth over that period, eight are in Africa (Figure 2.1). Within the next few years, Africa’s population will exceed that of both India and China. The continent’s population is projected to continue to grow through to the end of the century.

With 750 million people living in rural areas in 2020, more than 55% of Africa’s total population, it is one of the least urbanised parts of the world. Rural populations generally have less access to basic services, including energy, and fewer economic opportunities.

Transport connections between rural areas and the rest of the country vary across the continent. Geospatial analyses show that more than a quarter of the rural population in sub-Saharan Africa lives more than 5 kilometres (km) from the closest road.[2]

Figure 2.1 ⊳ Population growth in top-15 countries and Africa's share of global population growth, 2010 – 2030



Of the world's 15 countries with the biggest population increase to 2030, eight are in Africa, and by that year almost one-in-two people added to the global population are in Africa

Note: Top-15 countries are for the 2020-2030 period.

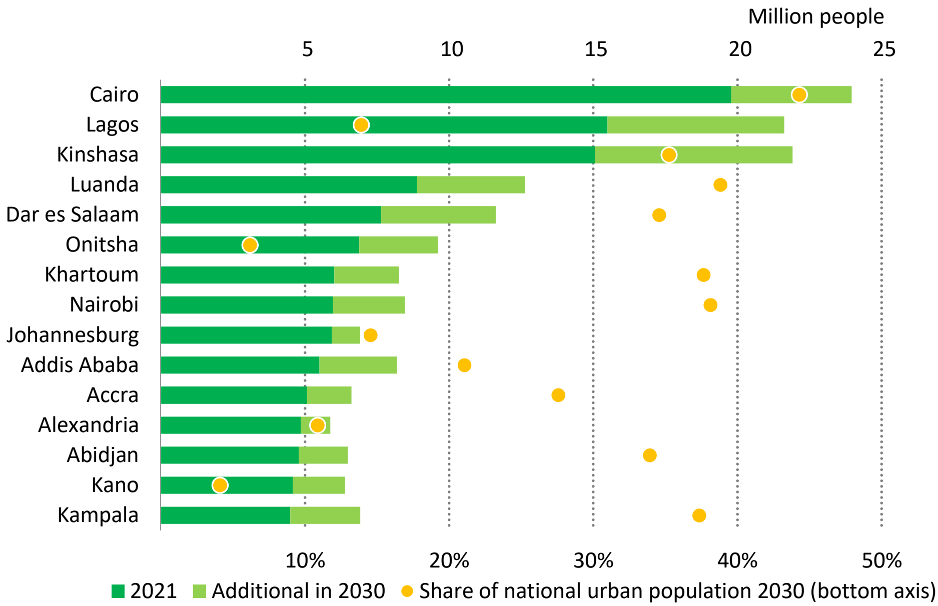
Source: UN DESA (2019).

Today the population is still largely rural, but Africa's urban population has been increasing at an unprecedented rate, twice as rapidly as in the rest of the world. Its urban population is set to expand by 235 million people by 2030, reflecting burgeoning population growth and urban migration. By then, African cities will host around 40% more people than today. There are 67 African cities with more than one million inhabitants and three megacities with more than 10 million: Cairo, Lagos and Kinshasa. Cairo is expected to remain the largest city, followed by Kinshasa and Lagos, with Luanda and Dar es Salam becoming megacities by 2030

[2] The road analysis includes highways, and primary and secondary roads based on the Open Traffic platform provided by Mapzen (Mapzen, 2017).

(Figure 2.2). How the energy needs of a young, fast growing and rapidly urbanising African population are met will be increasingly important in shaping overall energy trends on the continent and the world as a whole (Box 2.1).

Figure 2.2 ▷ Population in the 15 largest cities in Africa, 2021-2030



Africa will be home to five megacities in 2030 – two more than today – collectively accounting for 11% of Africa's urban population

Source: Demographia (2021).

The near-term economic prospects for Africa are highly uncertain. Having endured a recession brought on by the global Covid-19 pandemic, Africa's economy is now being rattled by the global effects of Russia's invasion of Ukraine (see Chapter 1). The economic recovery from the pandemic has been stronger than previously expected in some of its regions, notably in Southern Africa. Higher prices of fuel, food and fertiliser, which are boosting the export revenues of the major energy producing countries, are souring the outlook for the net-importing countries. The financial health of governments and households in those countries, and in some producing countries too, deteriorated badly at the onset of the pandemic as fiscal revenues declined and debt burdens rose. The financial sector health is suffering further from rising inflation. Rising unemployment in Africa, which hit a ten-year high in 2020, compounded by rising prices for basic needs, is fuelling increased political instability and social unrest in some regions. Multilateral banks and international development organisations are stepping in with debt relief and support for fuel and food purchases, which should help counter some of the immediate impacts of the latest economic shocks.

Box 2.1 ▷ Smart cities: Improving urban planning through digitalisation

The rapid expansion of Africa's towns and cities will continue to call for massive investment in basic infrastructure. To accommodate new urban residents, around 70 million new homes will need to be built in the years to 2030, broadly equivalent to a quarter of residential building stock of all countries in Africa today. A huge expansion of transport infrastructure including mass transit systems will also be needed. Amplified by the growing number of middle-income households, the demand for road mobility alone in Africa is expected to increase by two thirds by the end of this decade. Sustainable management of urban growth, including making cities more resilient to climate shocks and improving access to basic health and public services, is a huge task, made all the more difficult by the current poor state of urban infrastructure, including energy, water and waste management systems (IRP, 2018).

Careful urban planning with clear objectives, strategies and decision making informed by accurate data will be vital. "Smart Cities" is one approach to sustainable urban planning, including energy transitions. In smart cities, leaders and citizens are empowered to improve the efficiency, liveability, sustainability and resilience of urban environments by leveraging the power of digitalisation to improve access to data and facilitate data-based decision making (IEA, 2021b). Digital technology can offer detailed real-time access to information about urban services or conditions such as mobility bottlenecks, electricity system performance, water levels and availability and temperature, helping to manage services more efficiently, as well as to more efficiently identify citizens' needs and how to allocate budgets most efficiently.

Some African cities have started to implement projects in line with this approach. For example, as part of the Kigali Smart Bus Project in Rwanda's capital, public buses are being fitted with free Wi-Fi and contactless payment terminals, expanding public access to digital services while at the same time encouraging people to switch to public transportation. In Durban, South Africa, home to more than 4 million people, eThekwini Municipality has launched an electricity distribution automation project, improving the reliability of the distribution network by installing a supervisory control and data acquisition (SCADA) system involving computers, networked data communications and graphical user interfaces.

Investment in high speed connectivity and reliable telecommunications networks is an essential step to develop smart cities. A variety of financing models and innovative financing instruments, such as public-private partnerships, are available to help African municipalities overcome financing barriers. Governments can incentivise the private sector to fund smart city projects through green stimulus packages and by reducing financial risks. They also need to stimulate investment in modern energy systems: inadequate and unreliable energy supplies can hamstring the development of smart cities, with power outages disrupting information and communication systems, commercial activity such as online banking and phone use if access to charging is unavailable or too expensive. Governments also have a role to play in facilitating digital literacy among the population, especially poorer households, and putting in place legislation to ensure data privacy, security and access.

Note: This box was prepared in collaboration with Mr Vincent Kitio of UN-Habitat.

Despite these heightened short-term uncertainties, the longer term prospects for Africa's economy remain consistent with previous projections: GDP in 2030 is projected to be almost 50% larger than in 2020, reaching close to USD 10 trillion (IEA, 2021a). GDP growth averages 4.2% over 2020-30, a level comparable with the average for emerging market and developing economies and 0.6% above the global average. Projected growth rates vary considerably across the continent: sub-Saharan Africa (excluding South Africa)[3] is the fastest with its share of total GDP in Africa rising from 55% in 2020 to 58% in 2030; South Africa's share continues to fall, from 11% in 2020 to 9% in 2030, North Africa's share remains at about one-third. The sectoral contributions to GDP vary among regions, but the overall structure of the continent's economy is set to remain broadly stable over the coming decade. The duration of Russia's invasion of Ukraine remains the major source of uncertainty for Africa's economic outlook to 2030, though the impacts are likely to be more significant for individual countries than for the continent as a whole.

2.1.3 Underlying demand for energy services

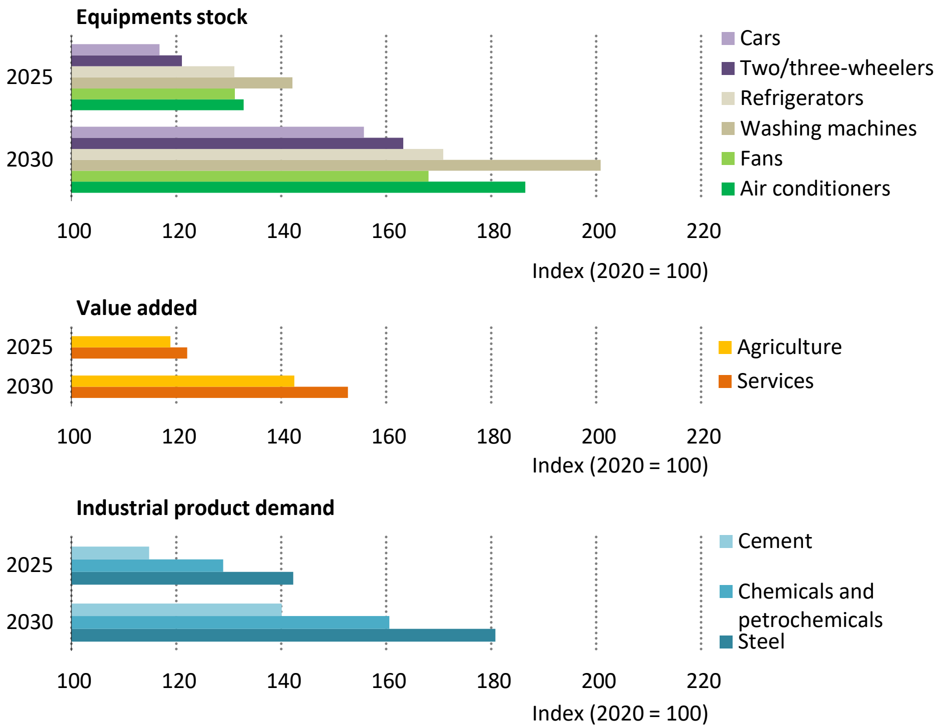
There is considerable scope for growth in demand for energy services in Africa. This holds especially for transport, industry and cooling in houses and commercial premises given the current very low levels of per capita demand compared with the rest of the world, and prospects for rapid growth in both population and incomes. As cities generally provide better opportunities for jobs and income, continued rapid urbanisation and industrialisation will push up demand for energy services. Africa's demand for industrial products is projected to rise by at least a third between 2020 and 2030 on the back of rising construction and increased industrial production (Figure 2.3). A burgeoning middle class with increased spending power, as well as the universal provision of modern energy services to all Africans, contributes to higher demand.

Increased provision of energy services in the household sector forms an integral part of Africa's economic and social development. The United Nations Sustainable Development Goals recognise that access to affordable, reliable, sustainable and modern energy is fundamental to achieving many of the continent's development goals. However, affordability of basic services is an important concern in many African countries, where many households still lack access to basic comforts such as cooled space, mobility or conservation of food and medicines. Ownership levels of appliances such as fans, air conditioners and refrigerators are far below the average of other emerging market and developing economies. For transportation, the picture is similar: in many parts of Africa, ownership of a car remains a

[3] For modelling purposes, Africa is divided into three main regions: North Africa, sub-Saharan Africa (excluding South Africa) and South Africa. All subsequent mentions of sub-Saharan Africa exclude South Africa.

luxury, while ownership of two/three-wheelers, which are used to carry both people and goods, is comparatively more common.

Figure 2.3 ▷ Growth in selected energy-related economic activities in Africa in the SAS, 2020-2030



Demand for energy services in Africa is set to expand rapidly over this decade, with stock of air conditioners and washing machines doubling

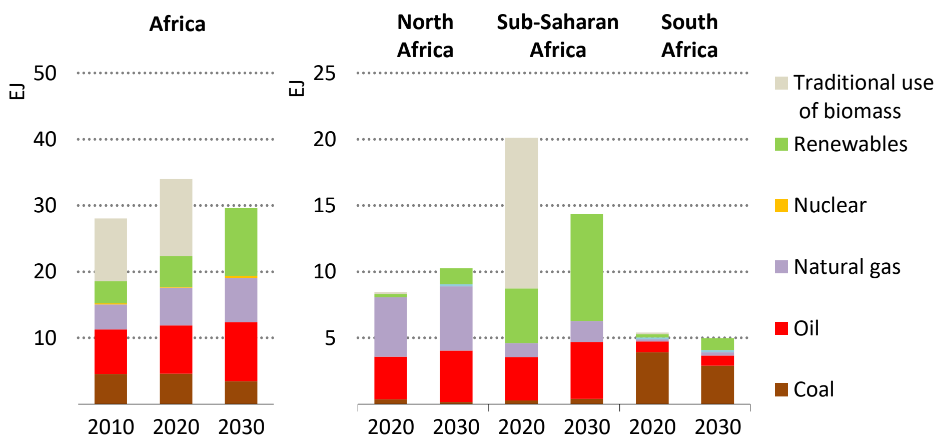
Note: SAS = Sustainable Africa Scenario.

Although energy poverty is both a rural and urban phenomenon, there are important disparities. These reflect differences in income, livelihoods and access to energy infrastructure. The average household in a city consumes more than three-times more oil and electricity than the average rural household in Africa (IEA, 2019). These inequalities within countries are often much more pronounced than inequalities between countries. Within cities, there are also major inequalities between urban and peri-urban areas, where many people live in informal settlements in poor conditions, with limited access to energy, sanitation and water services. In Uganda, for example, incomes of citizens living in primary city districts are on average three-times higher than those of citizens living in secondary districts (International Growth Centre, 2021).

2.2 Total primary energy supply

Economic and population growth in Africa drive an increase in the consumption of all primary fuels, with the exception of traditional use of solid biomass and coal, in the SAS. Modern primary energy supply increases at an average annual rate of 3% between 2020 and 2030, while total primary energy supply (including the traditional use of solid biomass) falls by 13% by 2030. Renewables meet more than three-quarters of the increase in modern energy supply and become the leading fuel category by 2030 (Figure 2.4).[4] The traditional use of solid biomass – fuelwood, waste and charcoal burned in three-stone fires and basic inefficient stoves – is eradicated completely by 2030 with the achievement of full access by households to clean cooking (see Chapter 3).

Figure 2.4 ▷ Total primary energy supply by fuel and region in the SAS



Renewables grow rapidly in all regions to 2030, though oil and gas continue to dominate the fuel mix in North Africa and coal in South Africa

Note: SAS = Sustainable Africa Scenario; EJ = exajoules.

Trends to 2030 are very different across the three main African regions in the SAS. Although modern renewables grow fastest everywhere, oil and gas continue to dominate energy use in North Africa and coal dominates in South Africa, due to the local availability of low cost resources, while renewables become the dominant fuel category in sub-Saharan Africa. In North Africa, the share of oil and gas in primary energy supply drops from 91% in 2020 to 85% in 2030 as the use of wind and solar photovoltaics (PV) in power generation rises from less than 1% to 4%. Egypt becomes a nuclear power producer by 2030. In South Africa, modern renewables replace the majority of the coal supply phased out by 2030, mostly in the power sector (Spotlight). By contrast, the share of fossil fuels rises sharply in sub-Saharan

[4] Renewables refer only to modern renewables and exclude the traditional use of solid biomass.

Africa as the use of LPG for household cooking expands and growing economic activity boosts demand for natural gas and oil products for transport and industry. The share of modern renewables in sub-Saharan Africa also rises, from a fifth today to well over half by 2030.

Primary energy intensity – the amount of energy used per unit of GDP – in Africa declines by 5% per year on average over 2020-30 in the SAS, compared with 1% over the previous decade. This is due to much faster policy driven improvements in energy efficiency, mainly in sub-Saharan Africa, primarily due to the phase-out of the highly inefficient traditional use of solid biomass for cooking. Switching to a modern fuel or stove can be two- to ten-times more efficient than relying on three-stone fires using fuelwood (Box 2.2). Efficiency improvements also come from more reliance on renewables in power generation and the introduction of more stringent minimum energy performance standards (MEPS) and mandatory comparative labels (MCL)[5] in end-use sectors. Excluding traditional use of biomass, energy intensity falls by only 1% per year, with declines in North Africa and South Africa outweighing an increase in sub-Saharan Africa.

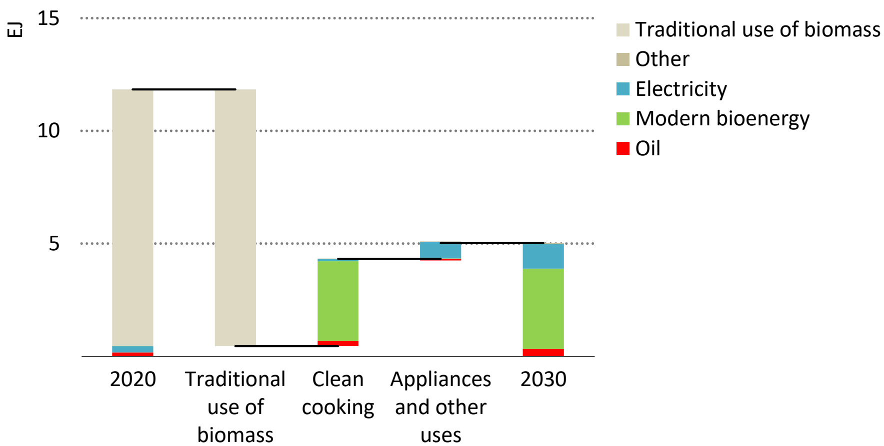
Box 2.2 ▷ Full access to clean cooking boosts household energy efficiency

The traditional use of biomass dominates residential energy demand in sub-Saharan Africa today, with more than 80% of the population relying on it. Three-stone fires and other traditional stoves that burn wood, charcoal and other forms of biomass typically have very low efficiencies, ranging from 10% to 25%. The large amounts of these fuels needed to meet basic cooking needs with such stoves means that they account for more than 95% of total residential energy use in sub-Saharan Africa, resulting in average per capita consumption 16% higher than the average for emerging economies worldwide, even though average residential electricity use is eight-times lower than the average in the emerging market and developing economies.

Universal access to more efficient and clean energy – modern uses of bioenergy and other renewables, electricity, natural gas and oil products – for cooking by 2030 in the SAS reduces total residential energy demand in sub-Saharan Africa, as efficiency gains more than offset the overall increase in the underlying demand for cooking (Figure 2.5). Energy demand for cooking drops by 66%, 7.5 exajoules (EJ), more than offsetting the 180%, 0.7 EJ, increase for other residential uses (appliances, cooling and lighting). Switching to improved biomass cookstoves reduces cooking energy needs by a factor of two, while switching to the most efficient modern solid biomass stoves, biogas, bioliquids and LPG reduces them by half to over 90% depending on the initial stove used and the modern solution adopted. Electric cooking stoves, which are gradually increasing in importance in the cooking energy mix, are the most efficient.

[5] MCL allow consumers to compare the energy consumption of similar products to facilitate comparisons of lifetime running costs into their purchase decisions for appliances and other energy-consuming equipment.

Figure 2.5 ▷ Change in residential energy demand by fuel in sub-Saharan Africa in the SAS, 2020-2030



Replacing traditional use of biomass with more efficient and clean cooking solutions more than offsets rising energy services demand

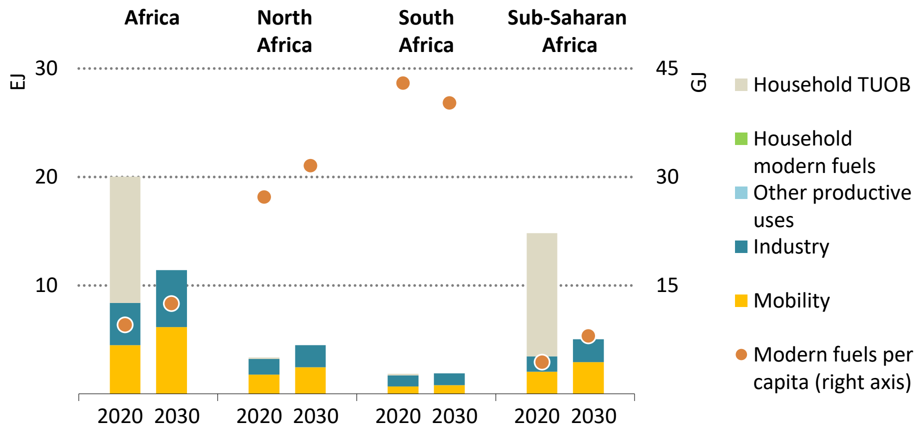
Note: SAS = Sustainable Africa Scenario.

Per capita energy demand also diverges across regions in the SAS. Overall primary energy use per capita declines in sub-Saharan Africa, but modern energy use per capita increases, on average by 2.5% per year to around 10 gigajoules (GJ) in 2030. In North Africa, per capita use of modern fuels increases by 0.7% per year to 44 GJ, but as in sub-Saharan Africa, remains well below the current global average of 70 GJ, 100 GJ in China and 120 GJ in the European Union.

2.3 Total final consumption

Final consumption (i.e. in end-uses) of modern fuels in Africa increases on average by 5% per year between 2020 and 2030 in the SAS, compared with 2% over the previous decade. Households remain the largest consumers, mainly for cooking, appliances and cooling, but their share in total final consumption declines sharply from more than 55% to a third. The replacement of inefficient cookstoves and solid biomass fuels with modern energy in sub-Saharan Africa more than triples the residential consumption of modern fuels, but leads to a reduction of the overall final consumption. Energy use for mobility and productive uses (industry, services and agriculture sectors) increases significantly, on average by 3% per year in both cases (Figure 2.6). Personal mobility and freight expand with rising population, economic activity and incomes.

Figure 2.6 ▷ Total final energy consumption by sector and modern fuel use per capita by region in the SAS



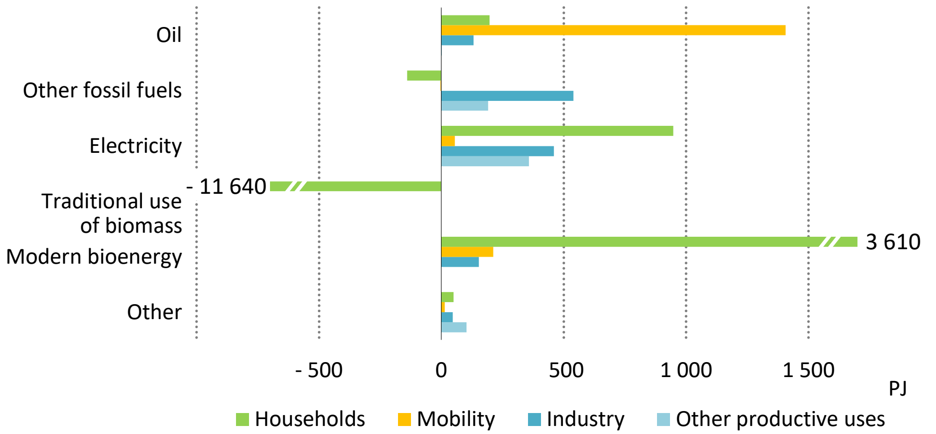
Eradicating inefficient biomass for cooking in sub-Saharan Africa halves total household energy use in Africa by 2030, while use in other sectors increases in most regions

Notes: SAS = Sustainable Africa Scenario; TUOB = traditional use of biomass. Other productive uses include services and agriculture. Household modern fuels include fossil fuels, electricity and renewables, such as the use of biomass in modern stoves.

The sectoral breakdown of final energy use and its evolution to 2030 vary enormously among the three African regions. In North Africa, where car ownership rates are almost ten-times higher than in sub-Saharan Africa, total final consumption continues to be led by transport. In South Africa, industry remains the leading end-use sector and continues to account for around 40% of total final consumption, though transport demand grows twice as much as industry over the same time period. In sub-Saharan Africa, households remain the biggest sector, despite a fall in consumption. Energy consumption in the transport and industry sectors combined rises by almost 50%, the two sectors accounting for 45% of total energy consumption in 2030 compared with 21% today.

Fuel shares in Africa's final energy consumption change substantially over 2020-30, with all modern fuels except for coal increasing. Modern bioenergy, electricity and oil products see the biggest increases, which are more than offset by the large reduction in traditional use of biomass (Figure 2.7). Around 80% of the growth in oil demand comes from mobility (mainly cars and trucks). Electricity use rises in all end-use sectors, with households contributing more than half of the growth due to the achievement of universal access to electricity by 2030 and increased ownership of appliances and cooling systems. As a result, total electricity use per capita jumps by 40%, though it is still just one-quarter that of emerging market and developing economies. Traditional use of bioenergy sees the most significant decline in use in Africa, as almost one billion people switch from traditional use of biomass to more efficient cooking fuels by 2030. Demand for coal in end-use sectors in South Africa declines, as its use as a household cooking fuel is phased out and the use of natural gas in industry rises.

Figure 2.7 ▹ Change in total final energy consumption by fuel and sector in the SAS, 2020-2030



Modern bioenergy, oil products and electricity see the biggest increases in demand to 2030, but are more than offset by a reduction in traditional use of solid biomass

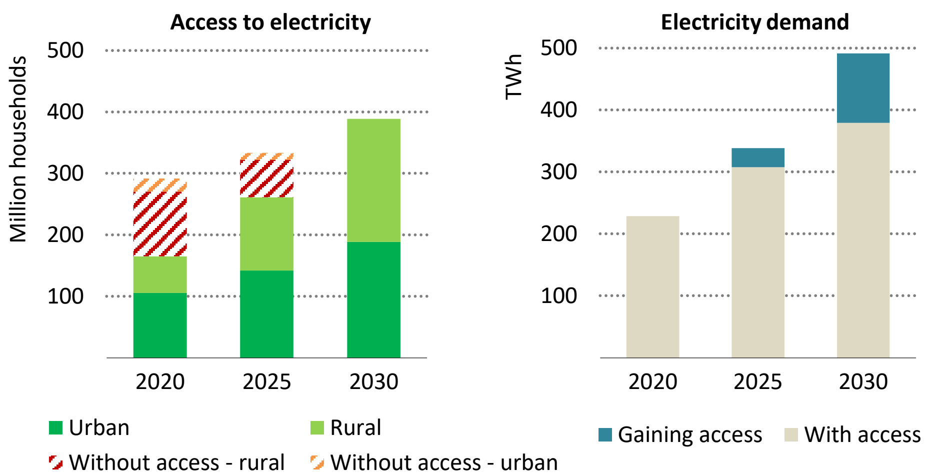
Note: SAS = Sustainable Africa Scenario; PJ = petajoule.

2.3.1 Households

Africa's 300 million households accounted for 56% of the continent's total final energy demand in 2020, despite 120 million of them lacking access to electricity and 200 million being deprived of modern, clean cooking solutions (see Chapter 3, section 3.2). Over the decade to 2030, the growth in household demand for energy services is set to outpace population growth, as rising levels of access to electricity and rising incomes drive up ownership and use of appliances and equipment. In the SAS, most of the growth in demand is met by electricity, its share of total household energy use rising from 6% in 2020 to 26% by 2030. Policy actions to improve energy efficiency coupled with universal electricity access by 2030 temper the growth of electricity demand in the SAS. Reduced imports of inefficient second-hand appliances and the introduction of more stringent MEPS and energy labels contribute to these electricity savings. Refrigerators and air conditioners see the biggest improvements, with the average stock efficiency increasing by around 50% to 2030 for both end-uses.

Universal access to clean energy in 2030 means an additional 900 million Africans have access to electricity relative to 2020. This boosts electricity consumption by 110 terawatt-hours (TWh), equivalent to 50% of total African household use in 2020 and almost half of the total increase to 2030, pushing total household electricity demand to around 500 TWh (Figure 2.8). Switching to modern cooking techniques and fuels reduces the total amount of energy needed for cooking by more than 60% between 2020 and 2030, its share of total household energy demand dropping from 90% to 70%. Traditional use of biomass, practised today by almost two-thirds of African households, is replaced by improved biomass cookstoves, LPG stoves, electricity and other clean cooking technologies such as biogas. LPG use grows rapidly to 2030, before declining as households switch to electricity (urban households initially).

Figure 2.8 ▻ Electricity access and electricity demand for households in the SAS



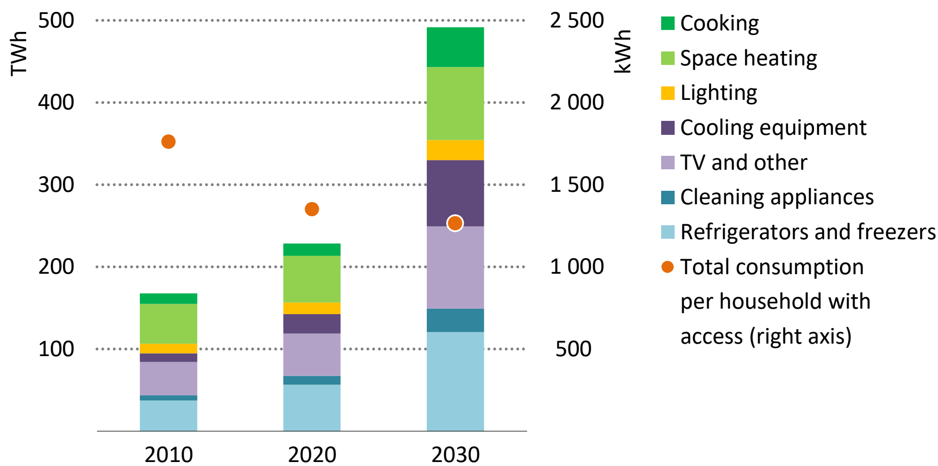
Meeting the goal of universal access to electricity and rising ownership of appliances including air conditioners more than doubles household electricity demand by 2030

Note: SAS = Sustainable Africa Scenario.

Increasing use of appliances, lighting and air conditioning

Rising incomes and expanded access to electricity will result in more Africans buying and using more electrical appliances and equipment, which will push up electricity use. Ownership of air conditioners jumps by around 17 million to 40 million and electric fans by 110 million to around 340 million over 2020-30 in the SAS. The stock of refrigerators increases by over 80 million to nearly 200 million and washing machines by 20 million to around 40 million. As a result, electricity demand for these and other household appliances and equipment more than doubles from around 160 TWh to 350 TWh (Figure 2.9). Among household uses, electricity demand for lighting grows the least in absolute terms due to the rapid shift to light-emitting diode (LED) light bulbs, while demand for cooling and refrigeration increases the most. Growth is fastest in sub-Saharan Africa (excluding South Africa), with electricity use for appliances and other electrical equipment quadrupling by 2030.

Figure 2.9 ▷ Household electricity consumption by type of demand in the SAS

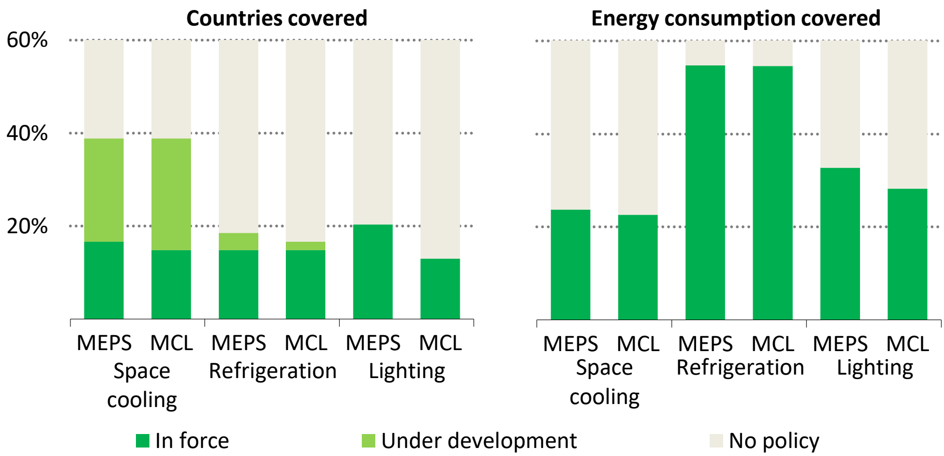


Cooling and refrigeration appliances drive most of the increase in household electricity demand, as all households gain access to electricity and incomes rise

Note: SAS = Sustainable Africa Scenario.

In contrast to total electricity use, average consumption per household that has access to electricity actually falls slightly between 2020 and 2030 in the SAS. This is due to the rapid implementation of mandatory MEPS and MCL across all appliance types and almost all countries on the continent. In particular, the stringency of MEPS increases, pushing sales towards the most efficient models available on the market. Many African countries have already made significant progress in implementing mandatory MEPS that cover at least one major residential end-use, notably in Benin, Ghana, Nigeria and Senegal (all members of the Economic Community of West African States [ECOWAS]), as well as Algeria, Egypt, Kenya, Rwanda, South Africa and Uganda. Today, around 40% of African countries have adopted mandatory MEPS for cooling equipment or are planning to do so, and around 20% for refrigeration (Figure 2.10). Switching to more efficient appliances also requires efforts to halt the dumping of inefficient second-hand appliances on African markets (Box 2.3). Measures to ban all appliances with the lowest efficiency rating saves over 40 TWh of electricity demand in 2030 in the SAS, equivalent to one-third of total appliance-related demand today. Nonetheless, governments would need to take into account the impact of potentially more expensive efficient appliances on their affordability for households, even though they cost less to operate.

Figure 2.10 ▷ Share of African countries and demand covered by mandatory MEPS and MCL in the household sector, 2021



Around 40% of African countries have adopted efficiency standards and labelling for cooling equipment or are planning to do so, and around a fifth for refrigeration and lighting

Notes: MEPS = minimum energy performance standards; MCL = mandatory comparative labels. Energy consumption coverage is for countries with mandatory MEPS and MCL in force.

Box 2.3 ▷ Economy-wide benefits of acting on appliance efficiency

The detrimental effects of weak or non-existent MEPS or MCL in many Africa countries are compounded by a lack of policies to prevent the dumping of inefficient second-hand appliances, especially cooling and refrigeration products. With over 270 million major appliances, including air conditioners, set to be purchased across Africa in the current decade, governments need to act to ensure that those appliances are as efficient as possible. MEPS and restrictions on imported second-hand appliances are key levers available to African policy makers. Such measures can lower energy consumption, cut energy bills, reduce government spending on subsidies and avoid greenhouse gas emissions. They can stimulate investment in local manufacturing of more efficient equipment and reduce dependence on obsolete refrigerants that have very high global warming potentials.

Appliance efficiency measures need to be implemented across the continent as one country that does not implement them risks becoming the dumping ground for the least efficient equipment. Moving together to introduce and harmonise efficiency standards can bring considerable economic gain, by sending strong market signals and reducing the political and institutional cost of designing and implementing policies.

The ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE) is leading efforts in West Africa to develop and harmonise standards. Similar efforts are being made by the East African Centre of Excellence for Renewable Energy and Energy Efficiency and the Regional Centre for Renewable Energy and Energy Efficiency in North Africa, and the Southern African Development Community (SADC) Centre for Renewable Energy and Energy Efficiency and SADC Co-operation in Standardisation in Southern Africa. For example, a 90 lumens per Watt lighting standard – on par with standards in the European Union – was recently adopted in SADC member countries, which should yield major savings. In West Africa, a 2020 West African Economic and Monetary Union directive requires energy labelling of lamps and some appliances. The recently launched African School of Regulation will assist governments with energy efficiency policy design and alignment.

Ghana and Nigeria endorsed the COP26 Product Efficiency Call to Action in November 2021. The initiative, launched by the IEA and the COP26 presidency, aims to set countries on a trajectory to double the efficiency of key products sold globally by 2030, including residential air conditioners and refrigerators/freezers, lamps and industrial motors systems. Ghana and South Africa are also members of the Super-Efficient Equipment and Appliance Deployment Initiative, a collaboration of more than 20 governments, the IEA and other partners to accelerate and strengthen the design and implementation of energy efficiency policies for appliances and equipment.

There is evidence that MEPS and import bans can deliver big savings. In Ghana such policies avoided a cumulative 8.3 TWh of electricity use – broadly equivalent to its current annual electricity demand – and 4.6 million tonnes (Mt) CO_2-equivalent emissions between 2013 and 2020 (Tamakloe, 2022). These savings motivated the government in Ghana to expand its Appliance Standards and Labelling Regime from 3 to 20 appliances. Other African countries are following Ghana's lead, with MEPS in force or under development in most ECOWAS countries as well as several others across the continent.

Note: This box was prepared in collaboration with Mr Kofi Agyarko of the Ghana Energy Commission; Mr Romaric Segla, a consultant to the Organisation International de la Francophone and Union Economique et Monétaire Ouest Africaine; and Mr Charles Diarra of ECREEE.

Energy-efficient air conditioning and building envelopes

Population growth, urbanisation and climate change are driving up the need for cooling in Africa, where ambient temperatures are already among the highest in the world. Many locations across Africa experience 4 000-5 000 cooling degree days (CDDs)[6] annually, roughly an order of magnitude higher than in countries with a temperate climate such as France (250)

[6] CDD is a universally recognised metric that allows comparison of cooling needs between different locations. It measures how warm a given location is by comparing actual temperatures with a standard base temperature (usually 18 °C).

and Italy (630), and significantly higher than in the United States (950) and China (1 100). An estimated 700 million people in Africa live in hot climates.[7] The number increases to around 1.5 billion people in 2050 in the SAS.

The costs associated with purchasing and operating an air conditioner limit its application even in households that have access to electricity. Across Africa, air conditioner ownership currently averages only 0.08 units per household, though fans are somewhat more common, averaging 0.8 units per household. As incomes increase, air conditioner ownership is set to rise rapidly, reaching an average of 0.10 units by 2030 and 0.25 units by 2050 in the SAS. This contrasts with average ownership today of 0.7 units globally and 2.2 units in the United States.

The implications of increased use of cooling equipment for electricity demand, as well as the capacity of households to afford to operate it, will depend on the efficiency of air conditioners sold in the coming decades, the thermal performance of building envelopes, and how people use the cooling equipment (Box 2.4). Today, the average air conditioner sold in Africa is typically less than half as efficient as the best available units on the market, reflecting the fact that many countries lack mandatory MEPS for air conditioners. However, Algeria, Benin, Egypt, Ghana, Kenya, Nigeria, Rwanda, South Africa and Tunisia have mandatory MEPS for air conditioners in place today, while MEPS have been recently proposed by ECOWAS member states and the Seychelles. More stringent policies to improve the energy efficiency of cooling equipment and building envelopes, and to promote passive cooling through better design of buildings and use of vegetation, are adopted in the SAS. This avoids almost 20 TWh of demand by 2030, equivalent to the average generation from around 4 400 MW of gas-fired power plant capacity, the construction of which would cost USD 2.7 billion.

Box 2.4 ⊳ Accelerating efficiency improvements with building energy codes adapted to African contexts

The energy performance and climate resilience of new buildings is central to Africa's future energy needs. The continent is set to embark on one of the biggest expansions of building floor area in the world in the period to 2050. The residential building stock is projected to reach almost 50 billion square metres – more than double its current size. Most new construction will be in urban areas that already suffer from urban heat island effects as well as the effects of climate change. African countries have the opportunity to leapfrog other regions and build energy- and resource-efficient buildings adapted to local climatic conditions with very low operating costs to ensure cooling comfort and to draw on locally available sustainable materials.

[7] An average daily temperature exceeding 25 °C.

Building energy codes are the primary regulation to underpin energy-efficient new buildings across Africa. Expanding on existing efforts across the continent, codes should consider:

- Requirements for bioclimatic design, including orientation, shading, ventilation, reflection, green spaces, reduced glazing, natural lighting and rain water harvesting, adapted to local contexts, thereby reducing mechanical cooling and lighting needs. Inspiration can be taken from locally adapted traditional architecture, such as the Nubian Vault in the Sahel region – an ancient method of timberless vault construction using earth bricks and mortar.
- Appropriate insulation materials, including high performance glazing to reduce cooled air leakage.
- Installation of rooftop solar PV and/or solar thermal water heaters where appropriate.
- Promotion of locally available sustainable and low cost materials, bringing local economic benefits and reducing the need for imported emissions-intensive materials such as steel and cement. Local materials can play a particularly important role in providing climate-adapted and resilient housing for those living in informal settlements. Often built in vulnerable areas and using materials such as corrugated iron which compound heat stress for occupants, those settlements will need to be rebuilt and, in some cases, relocated to improve comfort and reduce exposure to climate-related and other disasters.

The success of building energy codes depends on a number of factors, including local pilot projects that demonstrate how they can be met, effective implementation and enforcement of regulations, and transparent building assessment and certification processes, including ratings based on energy and emissions performance. Training and other capacity building initiatives, targeted at both formal and informal sectors, are needed to underpin all these actions (GlobalABC, IEA and UNEP, 2020).

Note: This box was prepared in collaboration with Mr Kofi Agyarko of the Ghana Energy Commission and Mr Romaric Segla, consultant to the West African Economic and Monetary Union.

2.3.2 Mobility

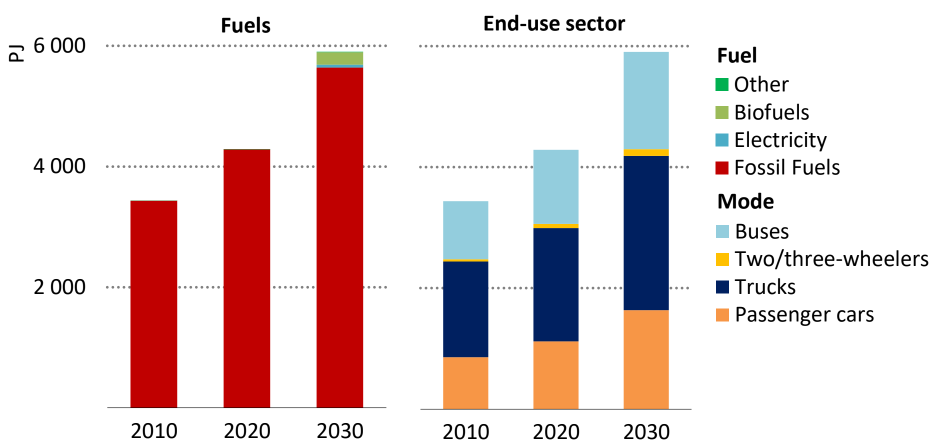
Road transport

Energy use for road transport in Africa rises by almost 40% over the 2020-30 period in the SAS.[8] This is in spite of rigorous policy action to provide sustainable and clean transport, including shared mobility, public transport, improvements in vehicle efficiency and lower emissions (Figure 2.11). Today, oil accounts for over 99% of road fuel consumption in Africa.

[8] The analysis in this section benefited from inputs provided by Ms Jacqueline Senyagwa of the Stockholm Environment Institute - Africa Centre and Mr Kofi Agyarko of Ghana's Energy Commission.

This share drops by four percentage points by 2030 mainly as a result of policies to increase the uptake of biofuels. Biofuels account for around 0.1% of road energy use today. There is enormous potential to increase production of biofuels in many African countries thanks to the size of its agricultural sector. Nevertheless, concerns over food security hamper government abilities to invest and incentivise both production and consumption of biofuels. The availability of non-food crops offers an opportunity for the development of advanced biofuels that rely on industrial waste and do not compete with food production. For instance, sisal produced in Tanzania for the textile industry results in large amounts of waste that could be repurposed to produce biofuels (see section 2.5.2). Other fuels such as autogas – LPG used for road transport – are used only in a very few African countries, notably Algeria, Egypt, Nigeria and Tunisia (World LPG Association, 2018). Autogas does not take off in other countries as it competes with LPG for cooking.

Figure 2.11 ▷ Road transport energy demand by fuel and mode in the SAS



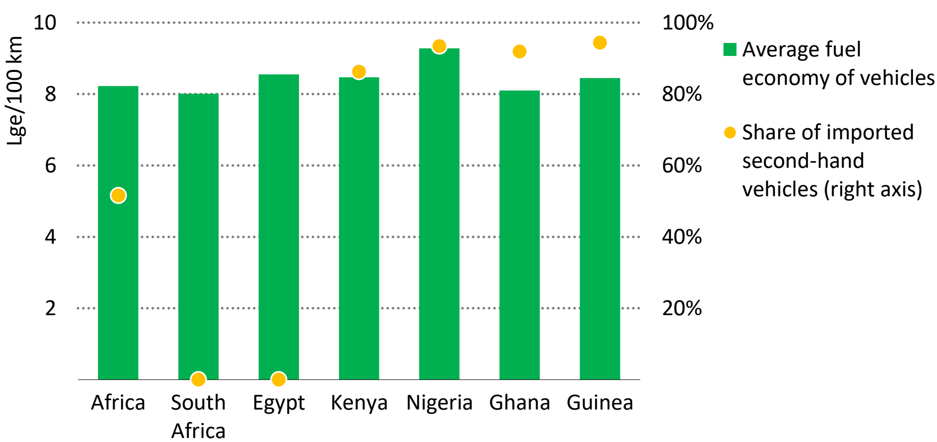
Rapid expansion of the fleet – especially cars and trucks – drives up transport energy demand, with oil remaining the dominant fuel in 2030

Notes: SAS = Sustainable Africa Scenario. Other category includes hydrogen-based fuels and biomethane.

The electrification of road vehicles over the coming decade is limited mainly to two/three-wheelers and some buses in the SAS, primarily as there is insufficient generation and network capacity to meet large-scale penetration of electric cars. Sales of electric two/three-wheelers reach 1.2 million in 2030, accounting for around 35% of all such vehicles sales. Most are in urban areas, where electricity is more widely available and recharging is easier. Electric two-wheelers are generally around USD 1 000-2 000 more expensive than conventional ones, but the total cost of ownership over a ten-year period is lower for some models today and becomes lower by 2025 for most models, even without government incentives, since their operating costs are cheaper (ICCT, 2021). Two/three-wheelers are also easy to charge using solar PV and battery swapping stations. On the other hand, the much higher price of electric cars and trucks means that sales of these vehicles remain very low compared with other parts of the world, reaching little more than 10% in 2030 (current sales are minimal). In preparation for the growing penetration of electric vehicles, the DRC-Zambia Battery Council was recently established with the goal of manufacturing batteries using local raw materials (ZNBC, 2022).

There is considerable potential for the expansion of the road vehicle fleet in Africa over the coming decades as the population and incomes rise. Today, Africa has the lowest per capita private car ownership rate in the world, with only 2.5% of the population owning a car (around 1% in sub-Saharan Africa). Projected ownership rates in 2030 remain well below the global average. Yet, vehicle sales are projected to triple by 2030, including private cars, trucks and buses, the latter driven by policies to encourage public transport in cities and increased investment in transport infrastructure.

Figure 2.12 ▹ Fuel economy of passenger car registrations and share of imported second-hand vehicles in annual sales in selected African countries, 2020



High shares of imported second-hand cars with limited standards result in poor fuel economy and limit the scope for reducing emissions in the medium term

Note: Lge = litres of gasoline equivalent.

Sources: IEA analysis and UNEP (2020).

Africa relies heavily on imports of second-hand vehicles. They account for over 50% of all new registrations across the continent today, despite an import ban in some countries, including Egypt and South Africa – two of Africa's biggest vehicle markets. The share of second-hand imported vehicles is over 85% in Kenya and close to 95% in Guinea (Figure 2.12). This will limit the pace of the transition to cleaner and more efficient vehicles in the medium term, especially as the shift to electric vehicles in key exporters like the European Union will lead auto part companies based in exporting regions to seek new markets for conventional vehicle parts, which could extend the lifespan of used vehicles in Africa. This makes it all the more important for African countries to tighten fuel economy standards for imported cars (new and used) and support biofuels to slow the increase in CO_2 emissions from the road transport sector.

Africa is the biggest importer of used light-duty vehicles (LDVs) in the world. From 2015 to 2020, it accounted for a quarter of total global trade in LDVs, with imports averaging around one million cars per year. Used vehicles in Africa are imported mainly from the European Union and Japan, though the shares of those imported from the United States and Korea have grown considerably in recent years. Libya and Nigeria are the biggest importers. Together with Benin, Ghana and Kenya, they accounted for over half of all used car imports in 2020 (UNEP, 2021).

Table 2.1 ▷ Used vehicle standards for imports in selected African countries

	Vehicle type	Diesel sulphur levels (ppm)	Age limit restrictions (years)	Emissions standards
ECOWAS	All vehicles	50 ppm by 2025	10 (5 recommended for LDVs)	Euro 4
Algeria	LDVs	500-2 000	3	
Chad	LDVs	50-500	3	
Gabon	LDVs	500-2 000	3	
Mauritius	LDVs	15-50	3	
Morocco	LDVs	< 15	5	Euro 4
Libya	LDVs	500-2 000	5	
Tunisia	LDVs	500-2 000	5	
Angola	LDVs	500-2 000	6	
Kenya	LDVs	15-50	8	
Uganda	LDVs	15-50	15	
Rwanda	LDVs	15-50		Euro 4
Botswana	LDVs	50-500		Euro 3
Ethiopia	LDVs	50-500		Euro 2
Egypt, Seychelles, South Africa, Sudan	All vehicles	n.a.	Ban on used vehicle imports	n.a.

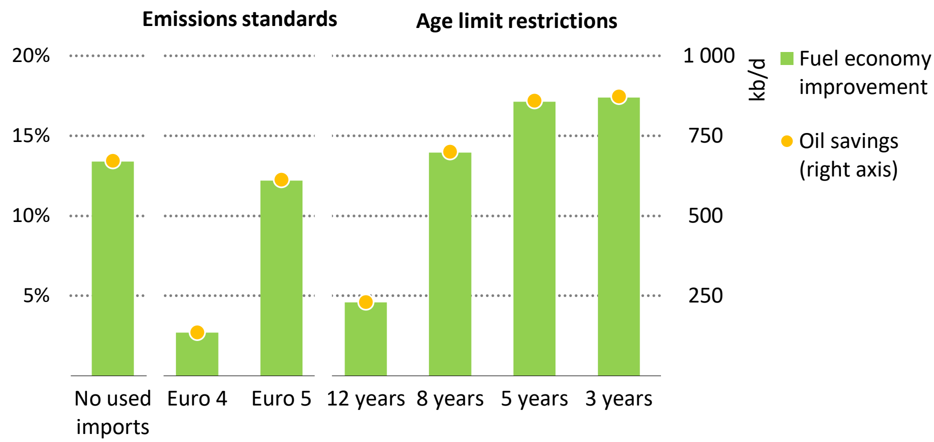
Notes: LDVs = light-duty vehicles; ppm = parts per million. ECOWAS member states include 15 West African countries: Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. Countries with a ban on used vehicle imports may also have emissions standards, e.g. South Africa (Euro 2).

Source: UNEP (2020).

To date, 32 out of 54 African countries have implemented standards for imported second-hand vehicles to date, including four that have banned the import of used vehicles (Table 2.1). The standards vary by country: 25 countries have implemented regulations to limit the age of imported vehicles (ranging from 3 to 15 years) and 19 countries have established emissions standards. The most stringent standard, Euro 4, which is applied in Morocco, Rwanda and the 15 ECOWAS member countries, was superseded in Europe around a decade ago. The number of countries that regulate used vehicles imports doubled at the start of 2021 with the adoption of the ECOWAS fuel economy roadmap. It sets out clear measures including fuel economy standards, labelling and fiscal incentives to improve the efficiency of vehicles and support the transition towards electric mobility. As well as establishing the Euro 4 standard, ECOWAS countries aim to reach an average fuel economy of 4.2 litres of gasoline equivalent per 100 km travelled (Lge/100 km) by 2030 for all newly imported LDVs, which is equivalent to a 40% improvement in fuel economy compared with 2015. To reach this target, an intermediate target of 5 Lge/100 km by 2025 was set (GFEI, 2020). The East Africa Community is also planning to set harmonised vehicle standards equivalent to Euro 4.

Setting an age limit for second-hand vehicle imports is a particularly effective policy instrument for African countries because exporting countries are increasing the stringency of their fuel economy and emissions standards, notably in the European Union. We estimate that a total ban on imported used cars, would lead to an improvement in the average fuel economy of car registrations in sub-Saharan Africa by nearly 15% compared to the current average, while applying Euro 4 standards would cut average fuel consumption by less than 5% (Figure 2.13).

Figure 2.13 ▷ Potential fuel economy improvement of imported used cars and related oil savings by type of measure in sub-Saharan Africa by 2030



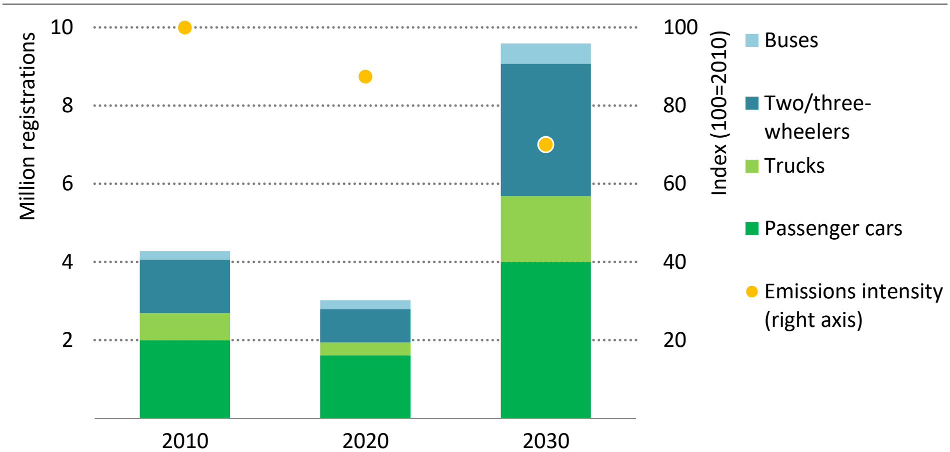
Setting a limit on the age of imported second-hand vehicles could bring more benefits than a complete ban on imported used cars or applying Euro 5 emissions standards

Note: kb/d = thousand barrels per day.

ECOWAS member countries have agreed to ban imported cars older than ten years, which will improve the average fuel economy of imported used car registrations by over 11%, reducing overall fuel demand and pollutant emissions. However, the age restriction of vehicle imports would mean cars, on average, would have an additional USD 1 000-2 000 of value at point of origin, meaning higher prices to customers in Africa. Increased upfront cost would be offset by fuel savings over time, with a payback period of around a decade to recoup the estimated incremental cost. "Cash-for-clunker" programmes, which give incentives to scrap the most inefficient and polluting vehicles, is another approach; it has been used in Morocco and Egypt to remove old taxis.

Applying fuel economy standards on all new car registrations and vehicle imports in all African countries leads to a 25% improvement in the average fuel economy of new car registrations in 2030 relative to 2020 levels in the SAS. The average CO_2 emissions intensity – measured by emissions per distance travelled – of new road vehicles registrations falls by 20% over the same period, thanks mainly to fuel economy improvements and to a smaller extent to the increasing penetration of electric vehicles and use of biofuels (Figure 2.14).

Figure 2.14 ▷ New road vehicle registrations and CO_2 emissions intensity by type in the SAS



Sales more than triple between 2020 and 2030, with vehicle emissions intensity improving by one-fifth thanks to fuel economy gains across all vehicle types

Notes: SAS = Sustainable Africa Scenario. Emissions intensity = CO_2 emissions per distance travelled. Trucks include light commercial vehicles, and medium- and heavy-freight trucks. Registrations include imported used and new vehicles. Registrations in 2020 were exceptionally low due to the effects of the pandemic.

Maritime shipping and rail

Shipping accounts for around 5% of total transport energy demand in Africa today, compared with over 10% globally. Demand for shipping fuel – entirely in the form of oil products –

increases by 7% over 2020-30 in the SAS. Energy efficiency gains temper the increase in energy demand related to growth in trade associated with rising economic activity and the implementation of the African Continental Free Trade Area. The share of oil in total shipping consumption falls to 90% by 2030 as alternative fuels, mostly biofuels and natural gas, start to penetrate the shipping sector driven by innovation and policy measures to make alternative fuels cost competitive and to develop infrastructure.

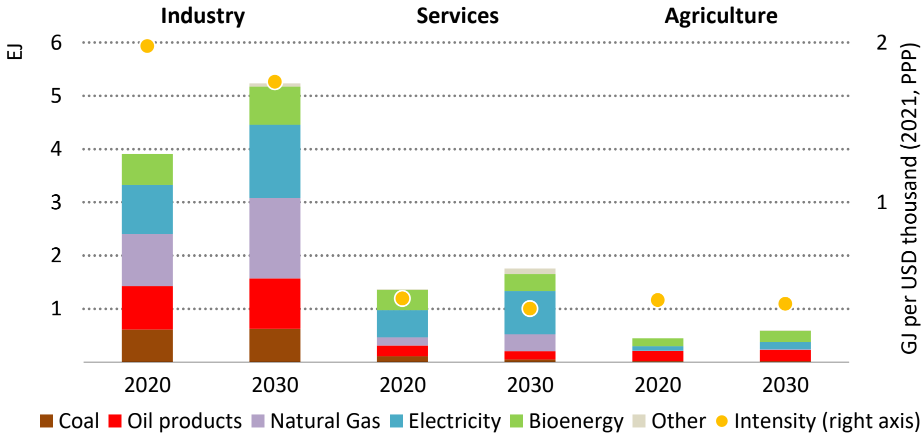
Africa accounted for close to 7% of world maritime export trade and 4.6% of import trade in 2019. Both shares are lower than those of developing Asia and Latin America. Trade remains poorly diversified, with around half of the exports by sea made by tankers (mostly crude oil) and over two-thirds of imports consisting of dry goods (UNCTAD, 2020). Expanding ports could stimulate economic growth and employment. Projects related to port development and their upgrades have received over USD 12 billion in investment since 2010 across the continent (World Bank, n.d.).

There are few railways in Africa. Rail transport accounts for a mere 1% of total transport energy use in Africa. This is explained by the low level of industrialisation in most parts of the continent and limited intra-African trade, reducing the need to transport large amounts of goods over land. Poor access to certain territories due to a lack of roads and difficult terrain also discourage the construction of railways. An increase in energy use by railways of more than 10% between 2020 and 2030 is projected in the SAS, with fuel economy improvements and increased electrification offsetting a projected increase in passenger and freight rail activity of at least 80%. Today, oil products account for around 60% of energy use by railways and electricity for 40%. The share of electricity rises to almost 50% by 2030 in the SAS, causing oil consumption to drop by over 6% compared to 2020 levels.

2.3.3 Productive uses

Industry accounted for two-thirds of energy demand for productive uses in 2020, with services (commercial and public buildings, and desalination) contributing a quarter and agriculture less than one-tenth. Total energy consumption for productive uses across Africa rises by 33% over 2020-30 in the SAS, with the use of almost all major fuels increasing in all three productive sectors (Figure 2.15). Electricity and natural gas grow the most in absolute terms, driven mainly by industry. Electricity consumption increases significantly in both industry and services, where electricity meets almost half of total energy needs by 2030 and more than three-quarters of the rise in energy use driven by increasing use of electricity for space cooling, lighting and appliances. A gradual shift from natural gas to electricity in desalination in North Africa contributes to the growth in electricity use in the services sector. The increase in energy use in the SAS is tempered by the adoption of strong measures to enhance energy efficiency.

Figure 2.15 ▷ Energy consumption in productive uses by sector and fuel in the SAS

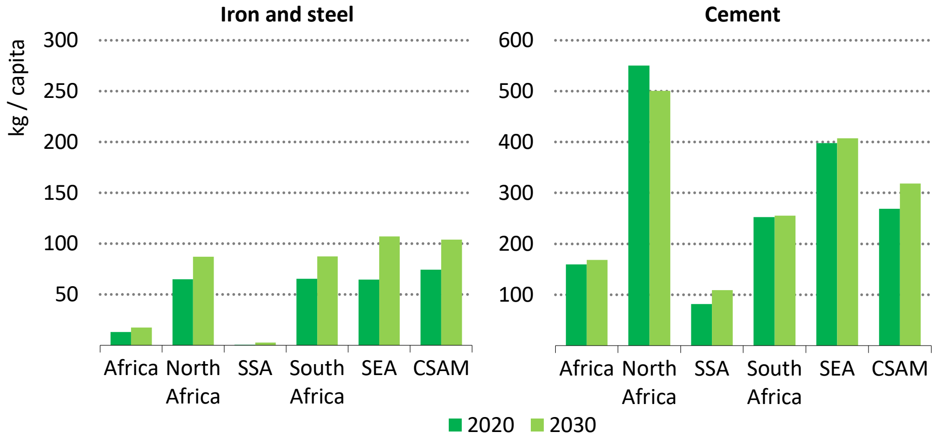


Energy needs in industry and commercial buildings rise substantially to 2030, with most of the increase being met by fossil fuels and electricity

Note: SAS = Sustainable Africa Scenario; EJ = exajoule; GJ = gigajoule; PPP = purchasing power parity.

In **industry,** production of basic materials, including iron, steel and cement, in Africa is projected to expand by 50% between 2020 and 2030 in the SAS driven by economic development, which pushes up domestic demand for goods, buildings and infrastructure. Several new steelmaking projects in Africa have been announced, which aim to reduce its heavy reliance on imports, especially in sub-Saharan Africa where iron and steel production increases eightfold between 2020 and 2030. Nonetheless, materials output remains well below that of other developing regions mainly due to Africa's lower income per capita (Figure 2.16). There are major disparities across the three main African regions. Four- out-of-five Africans live in sub-Saharan Africa, yet the region contributes only half of Africa's industrial value added, reflecting its relative poverty. North Africa contributes 40% of industrial value added and South Africa 10% with only 15% and 5% of the total African population respectively. Due to strong growth in North Africa, these shares do not change fundamentally up to 2030 in the SAS, with the share of sub-Saharan Africa reaching 65% only in 2050. Chemicals production in Africa grows strongly, by 50% in the 2020-30 period, driven mainly by fertiliser demand in North Africa. Growth in output of steel, cement and chemicals in North Africa and South Africa slows after 2030 due to saturation effects.

Figure 2.16 ▷ Per capita iron and steel and cement production in Africa and other developing regions in the SAS



Per capita production of materials increases significantly across Africa, especially in sub-Saharan Africa, but remains below other developing economies

Note: SAS = Sustainable Africa Scenario; SSA = sub-Saharan Africa; SEA = Southeast Asia; CSAM = Central and South America.

There is only a small change in the fuel mix in the industry sector to 2030 in the SAS. Coal continues to be used mainly in the cement and iron and steel industries; natural gas in iron and steel, cement and ammonia and methanol production; and oil (fuel oil and diesel) for chemical feedstock and in light industries in the SAS. Light industries and electric arc furnaces (EAFs) in steelmaking account for most of the use of electricity in industry, while renewables are mostly in the form of bioenergy in light industries and cement, ceramics and glass production. The share of electricity in industrial demand rises from 24% in 2020 to 26% in 2030, driven by increased use in the iron and steel and non-specified industry sectors. Most of the growth in bioenergy demand is in cement and light industries. The use of low-carbon hydrogen reaches 1% of industrial energy demand by 2030 with several announced projects in the pipeline (Table 2.2).

Wide disparities in industrial production across the continent persist in the SAS. Per capita production remains highest in North Africa, which has a major chemical and petrochemicals industry, especially fertiliser. In South Africa, coal continues to play an important role due to its domestic availability, with some coal transformed into oil and gas. In sub-Saharan Africa, light industries, especially mining and food production, continue to dominate, though iron and steel and cement production grow faster than in North Africa and South Africa.

Rapid industrial development over the next decade and the emergence of alternative low-carbon industrial processes provide the opportunity for Africa to leapfrog other regions in adopting low-carbon technologies. For example, new EAF steel plants are currently planned in several countries, with low-carbon EAF steelmaking processes making up 71% of steel output in Africa in 2030 compared with almost 50% in Europe and 30% in China in the SAS. Similarly, in the cement sector, the use of calcined clay in cement production, such as in Ghana, as a substitute for cement clinker helps to lower emissions substantially (Box 2.5). The substitution of coal and heavy fuel oil by bioenergy and waste in cement production, which involves relatively low upfront investment using technologies that are readily available, also contributes. For these technologies to be deployed, support would be needed from financing institutions, while local authorities can assist in ensuring a continuous supply of biomass and waste to cement plants. Ethiopia, Morocco and Rwanda have implemented policies that support industrial growth using more sustainable technologies (Table 2.2).

Table 2.2 ▷ Low-carbon options in industry, selected policies and projects in Africa

Project	Sector	Country	Description
Fundi Cement	Cement	Uganda	Development of a cement type for the domestic market with 54% less CO_2 emissions compared with ordinary Portland cement (Lafarge, 2021).
Groot Steel Plant	Iron and steel	Namibia	Construction of a new EAF steel plant with 3 Mt/year capacity (Global Energy Monitor, 2020).
Industrial Recovery Plan 2021-2023	All sectors	Morocco	Aims to boost industrial competitiveness to reduce import dependency and become a decarbonised industrial centre by exploiting domestic renewable resources (Kingdom of Morocco, 2020).
National Environment and Climate Change Policy	All sectors	Rwanda	Aims to promote sustainable economic development through foreign and domestic direct investment in clean technologies (Rwanda, Ministry of Environment, 2019).
Ethiopia 2030: The Pathway to Prosperity (2021 – 2030)	All sectors	Ethiopia	General plan to develop a climate-resilient environmentally sustainable economy focussing on energy efficiency, clusters across sectors and private sector participation in industry (PHE Ethiopia Consortium, 2021).
Nigerian Energy Support Programme	All sectors	Nigeria	Funded by the European Union and the German government to support renewables and energy efficiency with capacity building, development of directives and simplifying access to financing for Nigerian companies (GIZ, 2019).
Memorandum of Understanding: Eni and Government of Rwanda	Cross-sector	Rwanda	Identifies collaborative opportunities in the areas of the circular economy, agriculture, forestry, innovation and digital technology (Eni, 2022).

Note: EAF = electric arc furnace.

Box 2.5 ▻ Calcined clay project in Ghana: example of leapfrogging in cement production

Clinker-based cement production is highly carbon intensive, with the production of clinker accounting for a large share of the total CO_2 emissions in cement production. Emissions totalled 130 Mt CO_2 in Africa in 2020, accounting for more than half of all industrial emissions. Calcined clay, which is widely available in Africa, notably in Angola, Côte d'Ivoire, DRC, Ghana, Mozambique and Tanzania, can be used to replace up to 40% of the clinker in cement making using new technologies. It is much less carbon intensive, cheaper than clinker and can bring economic benefits by creating local value chains in clay processing.

CBI Ghana, which has a 550 000 tonne/year cement factory outside of Accra in southern Ghana, has recently announced a planned demonstration project using calcined clay to triple the plant capacity by 2024 (FLSmidth, 2022). The expansion will almost double employment at the plant. The project is expected to cut CO_2 intensity by up to 20% compared with current output and up to 47% compared with ordinary Portland cement. As one of the first project of this type on the African continent, obtaining financing hinges on compliance with the new European Union Taxonomy, which is expected by financial institutions and which requires significant preparations during the project planning phase.

Leapfrogging in industry includes energy efficiency.[9] For example, companies in many ECOWAS member countries have launched energy efficiency demonstration projects following International Standards Organisation certifications: nine in Burkina Faso; three in Togo; and eight in Nigeria, according to ECREEE. Measures to promote energy efficiency include sharing information on efficiency levers, their technical implementation and international best practices, supporting government initiatives to promote energy efficiency and simplifying access to financial support for investment in existing and new energy-efficient facilities. The SADC Industrial Energy Efficiency Programme aims to establish supportive policy, regulatory and financial frameworks and promote demonstration projects in member countries. Investing in such projects would boost economic development and job creation, as well as reduce energy costs and emissions (SADC Centre for Renewable Energy and Energy Efficiency, 2018).

Improving material efficiency – using less materials to make a product and increasing material recycling – is another important lever for policy makers to reduce energy use through more efficient waste management and recycling. For example, policies are needed to improve recycling rates for plastics, which averages just 2% across Africa today. Many other developing regions do much better: India, for example, recycles 11% of its plastic. Yet there are examples of successful recycling projects in Africa, including plastic waste in Kenya,

[9] The analysis in this section benefited from inputs provided by Mr Charles Diarra (ECREEE).

aluminium in Côte d'Ivoire, polyethylene terephthalate (PET) in South Africa (UNEP, 2018). In April 2022, the Rwanda government and Eni, an Italian energy company, signed a memorandum of understanding to investigate the feasibility of circular economy projects that focus on collecting used cooking oil and waste oils, waste management valorisation and recycling (Eni, 2022).

Data centres are an important emerging source of electricity demand in the **services** sector in Africa, propelled by an expanding base of internet users and surging demand for digital services from consumers and businesses. Their electricity needs increase from 1 TWh in 2020 to around 5 TWh in 2030 in the SAS, contributing almost 5% of electricity demand growth in the sector. Africa's internet economy has the potential to reach USD 180 billion by 2025 and USD 712 billion by 2050 (Songwe, 2022). The number of internet users in Africa has doubled in just the past six years, but two-thirds of Africans still do not use the internet today, so the potential for growth in traffic is enormous (International Telecommunications Union, 2021). Today, there are around 150 data centres (cloud and co-location services) in Africa, excluding those that are exclusive to their owners. More than two-thirds of data centre capacity is based in South Africa (Africa Data Centres Association, 2021). Yet today most of Africa's data are processed outside the continent due to better climatic conditions, lower costs and more reliable electricity grids (The Economist, 2021). Total capacity in Africa is projected to increase fivefold by 2030, with the biggest increases coming from Ghana, Kenya and Nigeria. The need for more data centres in Africa is driven both by soaring demand, as well as legal and technical requirements for data sovereignty and lower latency.

Most of the projected increase in energy demand in the **agriculture** sector is in sub-Saharan Africa in the SAS, driven by increasing access to electricity for mechanisation of agricultural processing equipment and irrigation pumps (less than 10% of the total cultivated area is currently irrigated) (AU, 2020). However, irrigation is also jeopardised by increasing water stress from drought periods and inconstant rainfall patterns. In the SAS, establishing water management systems to mitigate the risk and improve the efficiency of water usage hinges on technological and financial support to farmers, especially for smaller projects (IEA, 2017; AU, 2020). An example is the Nexus Regional Dialogue in Southern Africa, focused on SADC member countries, which provides screening tools and capacity building and identifies project investments (Nexus, 2020). A governance framework to improve co-ordination across sectors and regions was agreed in October 2020. Examples of other projects supporting irrigation include the Food Security through Small-scale Irrigation project run by Deutsche Gesellschaft für Internationale Zusammenarbeit, (the German international development agency), which provides training and financial support to farmers in Mali (GIZ, 2021), and the Transforming Irrigation Systems in Southern Africa project funded by the Australian government focussing on Mozambique, Tanzania and Zimbabwe (Agribusiness, 2021).

2.4 Electricity sector

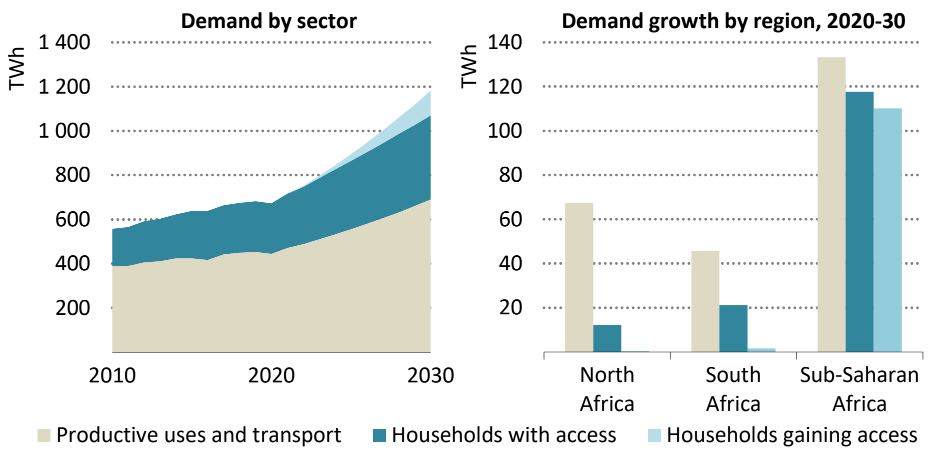
This section provides an overview of the electricity demand and supply outlook in the SAS over the period to 2030. Ensuring universal access to reliable electricity to all households, schools, hospitals, companies and entrepreneurs means electricity becomes the fastest growing component of final demand, putting the expansion and transformation of the electricity sector at the heart of the transition.

Some critical aspects related to challenges and opportunities along the way are explored in more detail in Chapter 3: notably in section 3.1 which focusses on key areas for policy action to achieve universal access; section 3.2 on the enabling factors to improve the reliability of a more renewable-based power system; and section 3.4 where investment needs and financing sources are analysed in detail.

2.4.1 Electricity demand

African electricity demand surges by around 75% from 680 TWh to 1 180 TWh over the decade to 2030 in the SAS (Figure 2.17). In total, households account for over half of the increase, driven by increased ownership of appliances and other electrical equipment for those that already have access as well as new household connections. Industry contributes most of the rest. Total per capita electricity demand climbs from 500 kilowatt-hours (kWh) in 2020 to 700 kWh in 2030, but remains far below that of other developing regions. It is even lower in sub-Saharan Africa, despite growing faster than in any other region, where it rises from 170 kWh to 390 kWh.

Figure 2.17 ▷ Electricity demand by sector and region in the SAS



Electricity demand almost doubles by 2030, with households making up over half of the increase and industry most of the balance

Note: SAS = Sustainable Africa Scenario.

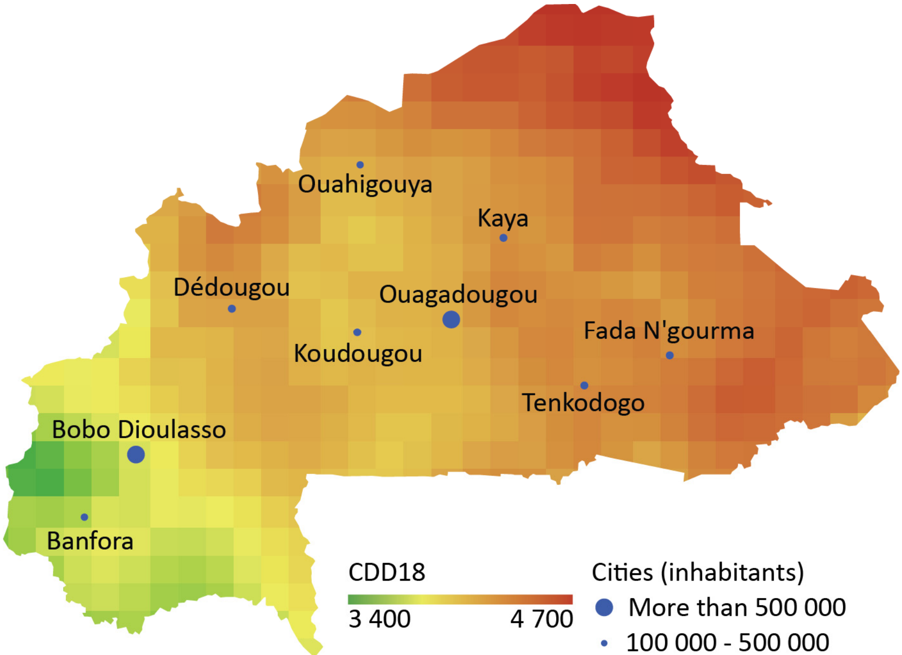
Energy efficiency and conservation policies are critical to clean energy transitions and play a significant role in slowing the increase in electricity use in Africa in the SAS. They avoid around 230 TWh in 2030, mainly in buildings, reducing the need for additional power generation capacity and infrastructure to meet peak demand, stress on the network and electricity bills for end-users. Incentives to support energy efficiency already exist across the continent and they tend to be a particularly important policy consideration in countries that rely on imports to produce electricity or face electricity supply shortages. For example, Botswana, Lesotho, Mozambique, Namibia, South Africa and Zimbabwe recently introduced programmes for solar water heating systems to reduce electricity demand. Egypt has introduced tax exemptions for materials needed to manufacture energy-efficient products. Morocco has strengthened thermal efficiency regulations and standards for buildings. Burkina Faso, and some other countries, have introduced soft measures to temper the electricity growth from increased cooling needs (Box 2.6). All these measures are adopted more widely and strengthened in the SAS.

Box 2.6 ▷ Building public awareness and engagement for more efficient cooling in Burkina Faso

Burkina Faso is one of the hottest countries in the world and has enormous needs for cooling. It is among the top-five countries in terms of annual cooling degree days (CDDs) – over 4 100 in 2021 (Figure 2.18), relative to just over 600 CDDs in South Africa, 1 400 in Kenya and 950 in the United States. By 2030, this level of CDDs could increase further as the planet warms. Average air conditioner ownership in Burkina Faso is rising rapidly, albeit from a very low base: expanding access to electricity and rising incomes increase air conditioner ownership rates to around 0.04 units per household in 2030 and approaching 0.1 units per household by 2050 in the SAS.

To temper the rise in cooling needs, Burkina Faso is implementing minimum energy performance standards and building energy codes, which are expected to achieve electricity savings of 20% or more. It is also looking at innovative approaches. The National Agency for Renewable Energy and Energy Efficiency (ANEREE) supports physical and social media-based campaigns to spread energy-saving tips among the population, through a programme called " 10 Actions Canicule", which reached around half a million social media users in 2021. It aims to reduce wasteful energy consumption, particularly during the hottest months when load shedding – a last resort measure to bring electricity demand into balance with supply during peak periods – is common. For example, it encourages citizens to set air conditioner temperatures to between 24 °C and 28 °C and to turn them off 30 minutes before leaving the room to reduce consumption without compromising comfort.

Figure 2.18 ▷ Cooling degree days in Burkina Faso



Urban migration along with higher temperatures due to climate change will drive up electricity demand for cooling

Notes: 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. CDD18 = cooling degree days, population-weighted over the cell area of 0.25 x 0.25 degrees using a daily average base temperature of 18 °C. The full data set can be found at https://www.iea.org/commentaries/is-cooling-the-future-of-heating. CDD is a universally recognised metric that allows comparison of cooling needs between different locations. It measures how warm a given location is by comparing actual temperatures with a standard base temperature (usually 18 °C).

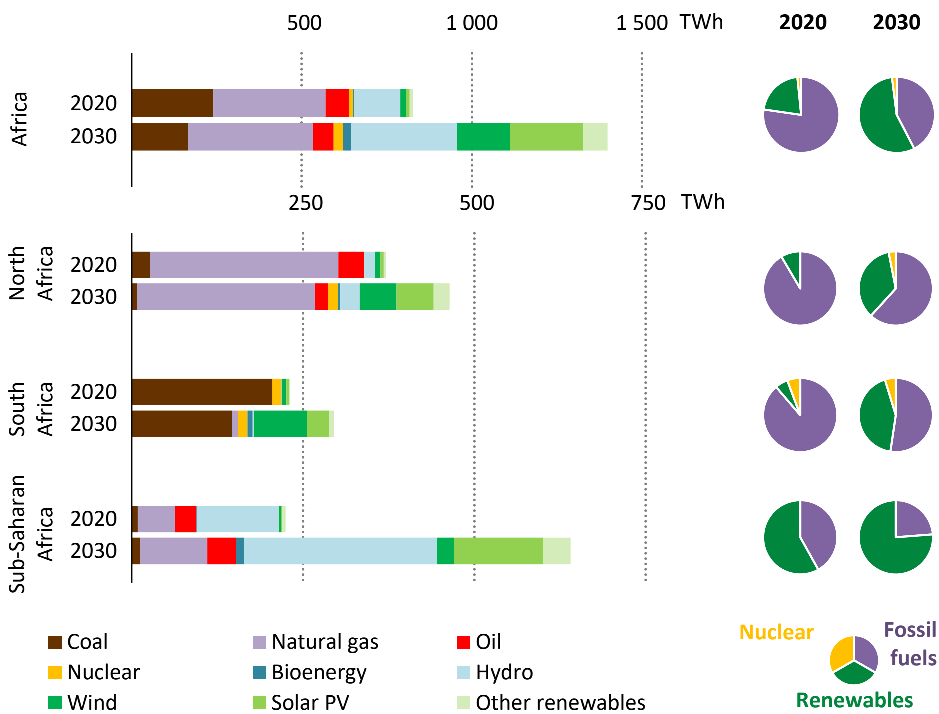
This box was prepared in collaboration with Ms Aida Siko of ANEREE in Burkina Faso.

2.4.2 Electricity supply

Electricity generation

While many African countries rely on domestic oil, gas or coal resources to generate electricity, others depend on imported fuels, leaving them vulnerable to volatile international markets. Reducing reliance on fossil fuels, which currently provide over three-quarters of all the electricity generated in Africa, will be central to cutting CO_2 emissions and improving energy security. Natural gas was the largest source in 2020, contributing 40% of total power generation, followed by coal (30%). Gas use is concentrated in North Africa and coal use in South Africa. The shares of natural gas and coal, neither of which are abated at present, fall over the 2020-30 period in the SAS, offset by rising shares of hydropower, wind and solar PV. The shift to renewables is driven by a continuing fall in relative costs and policies to promote low-carbon energy, which increase opportunities to exploit Africa's huge domestic potential for renewables. For example, it is home to the most abundant solar resources in the world. By 2030, solar PV and wind combined contribute to 27% of power generation – eight-times more than in 2020 – with major implications for the operation of power systems to ensure the balance of supply and demand at all times (see Chapter 3, section 3.3.1).

Figure 2.19 ▷ Electricity generation by source and region in the SAS, 2020 and 2030



Pace of growth in electricity supply and evolution of the generation mix to 2030 vary markedly across regions, reflecting differences in resources, costs and policy priorities

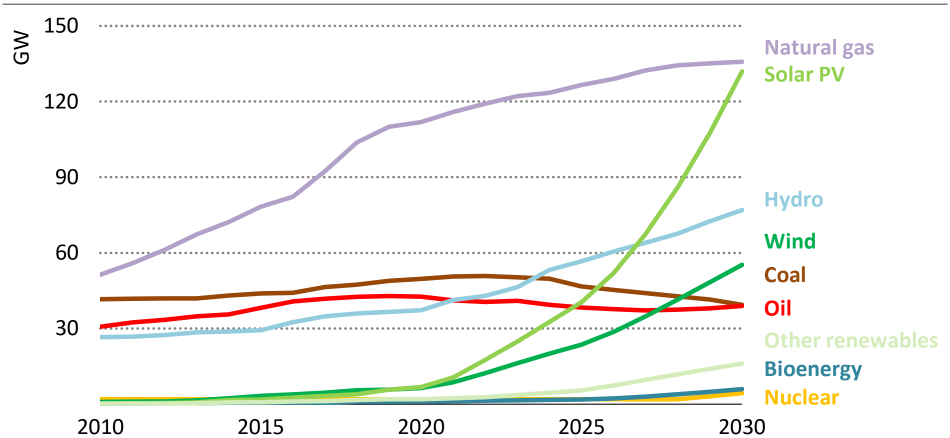
Notes: SAS = Sustainable Africa Scenario. Includes on-grid, mini-grid, stand-alone systems and backup generation.

In the SAS, the pace of growth in electricity supply and the evolution of the generation mix over the decade to 2030 vary considerably across the continent, reflecting differences in resources, costs and policy priorities (Figure 2.19). Sub-Saharan Africa sees the fastest growth in output and highest share of renewables, notably hydropower and solar PV. Hydropower output more than doubles, accounting for almost half of total generation by 2030, while the share of solar PV jumps from almost nothing in 2020 to 20%. Output from coal plants rises slightly due to the ongoing expansion of capacity at the Hwange power station in Zimbabwe. Gas-fired generation continues to increase in the near term driven by countries with large domestic resources such as Mozambique and Nigeria. The increase in oil-fired generation remains limited mostly to private diesel generators used for backup electricity in businesses and for stable electricity flows in mini-grids. There is increasing scope in many cases for cheaper alternatives, especially with current oil prices (see Chapter 3, section 3.2.1). In North Africa, fossil fuel plants remain the main sources of generation through to 2030, though output from each source falls; this is more than offset by much higher output from renewables and the start of nuclear power production. In South Africa, a fall in coal output is more than compensated by a big increase in renewables, their share in total generation jumping from 5% in 2020 to nearly 45% by 2030.

Installed capacity

Installed capacity in Africa doubles in the SAS, from 260 gigawatts (GW) in 2020 to 510 GW in 2030, with a profound shift in the type of power plants built across the continent. Once the projects currently under construction are completed, coal loses ground, while among renewables, solar PV overtakes hydropower before 2030 and challenges natural gas as the largest source of power generation capacity (Figure 2.20). The relative stability of the oil-fired plant fleet hides different regional dynamics, with an increase in capacity related to expanded access in sub-Saharan Africa offset by a decline in North Africa, where about 5 GW of oil plants over 30-years old are retired in the period to 2030.

Figure 2.20 ▷ Installed power generation capacity by source in the SAS



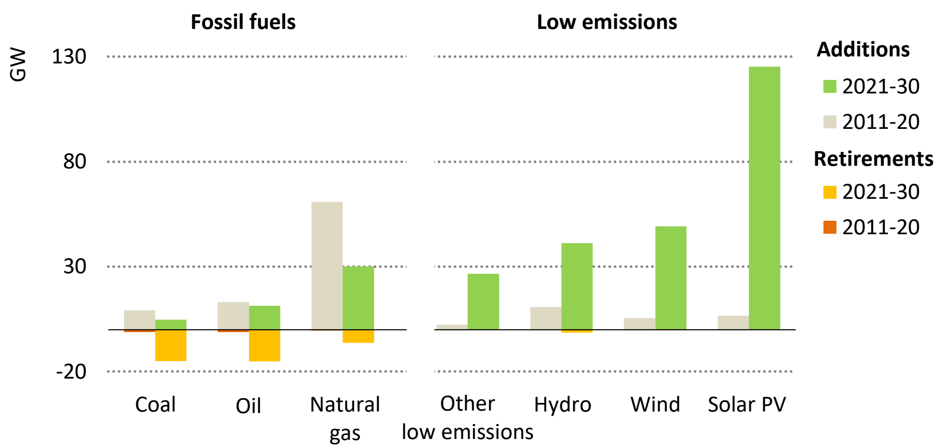
Solar PV, hydropower and wind capacity surpass that of coal and oil this decade, while the dominant position of natural gas is overturned in the 2030s

Note: SAS = Sustainable Africa Scenario.

Renewables account for most of the generating capacity additions to 2030 in the SAS (Figure 2.21). Solar PV leads the way, with 125 GW of capacity added between 2021 and 2030, over 40% of total capacity additions. Of the top 20% of solar sites globally, Africa is home to around 60% of them by land area. However, today, Africa holds only 1% of the world's installed solar PV capacity. The projected average rate of solar PV capacity additions is roughly equal to that of India in recent years. Wind power capacity also expands rapidly, especially in North and East Africa where resources are located close to demand centres. The land needed for this expansion would represent less than 1% of total land excluding areas potentially suitable for uses such as agriculture or forests. Integrating these variable renewables into power systems, which give rise to larger swings in the supply-demand balance, is crucial to their deployment. Hydropower also remains a cornerstone, with several large-scale projects currently under development to provide affordable and dispatchable electricity.

In line with global commitments to halt new coal plant construction, no new coal plants beyond those now under construction are brought on line in the SAS and a large amount of capacity, mostly in South Africa, is retired before 2030 in line with its pledge to reach net zero emissions by 2050 (Spotlight). Around 30 GW of natural gas-fired capacity is brought on line by 2030, half the pace of the previous decade, to help meet rapidly rising demand and to meet increased needs for system flexibility as the share of variable renewables rises and as a backup for hydropower in the event of drought.

Figure 2.21 ▷ Power generation capacity additions and retirements by source in the SAS



Renewables account for 80% of the 290 GW of capacity additions to 2030, while the commissioning of new fossil fuel plants is halved relative to the previous decade

Note: SAS = Sustainable Africa Scenario.

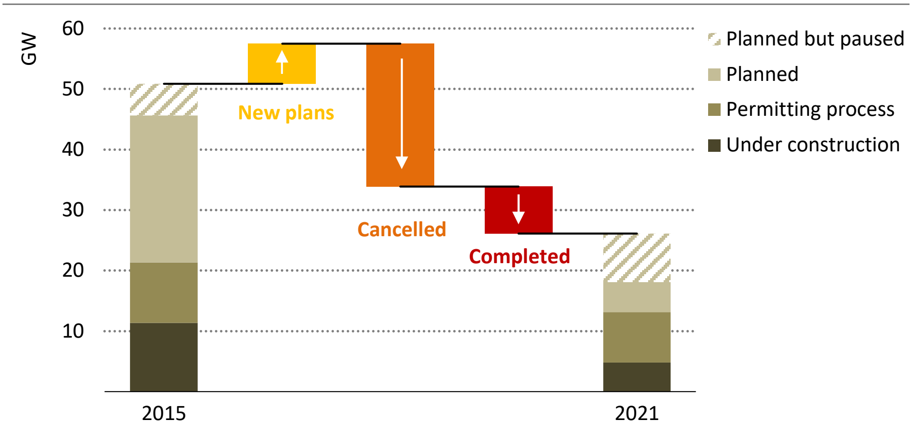
SPOTLIGHT

Changing landscape for coal-fired electricity generation

Cheaper and less polluting sources of electricity are increasingly undermining the prospects for coal-fired power in Africa, as are national policies and international pressure that make new coal projects difficult to finance. South Africa's NDC and net zero pledge are accelerating its transition away from coal, while new projects elsewhere on the continent have been called into doubt by China's decision, previously the largest source of financing for coal plants globally, to end support abroad.

South Africa's "Just Energy Transition Partnership" announced at COP26 in late 2021 will provide USD 8.5 billion in grants and affordable loans over the next five years to support its move away from coal. The partnership programme aims to retire coal plants early, build new cleaner energy sources and provide financial support to coal-dependent regions. It is funded by European Union, France, Germany, United Kingdom and United States. Eskom, the state-owned power company in South Africa, estimates that it needs around USD 30-35 billion in total to accelerate the transition. In 2020, South Africa had 42 GW of unabated coal-fired capacity in operation, 85% of all the coal capacity in Africa. These plants emitted 215 Mt CO_2 in 2020. In the SAS, the rapid decline in unabated coal capacity is offset by deployment of more wind and solar PV, which jump from 5 GW in 2020 to 40 GW in 2030 and 130 GW in 2050.

Figure 2.22 ▷ Pipeline of coal-fired power projects in Africa



Half of planned coal capacity was cancelled between 2015 and 2021, most of the remaining plans are either on hold or tied to Chinese stakeholders

Sources: IEA analysis based on S&P Global (2022).

The pipeline of coal power projects has dwindled markedly in the last few years (Figure 2.22). By the end of 2015, over 50 GW of coal plants were planned or under construction in Africa, half of it in sub-Saharan Africa. By 2021, this dropped to 26 GW due mainly to cancellations of planned projects. Nine African countries — Angola, Egypt, Ethiopia, Mauritania, Mauritius, Morocco, Senegal, Somalia and Zambia — committed to end new unabated coal-fired power generation projects either by joining the Powering Past Coal Alliance launched in 2017 during COP23 or by signing the Global Coal to Clean Power Transition Statement at COP26. Only South Africa and Zimbabwe are still building new coal plants today.

China's announcement in 2021 to end support for coal-fired power projects abroad has already had a big impact. Chinese developers or financial institutions were involved in 25 coal power projects in 14 African countries, totalling 15 GW of capacity (70% of the total coal-fired power project pipeline in sub-Saharan Africa) prior to the announcement. In many cases, Chinese participants have already withdrawn. At the same time, China announced its intention to step up investment in renewables-based electricity in Africa. We estimate that if the investment initially intended to develop the planned coal plants was redirected to utility-scale solar PV, it would cover more than half of the total solar PV additions needed by 2025 in the SAS.

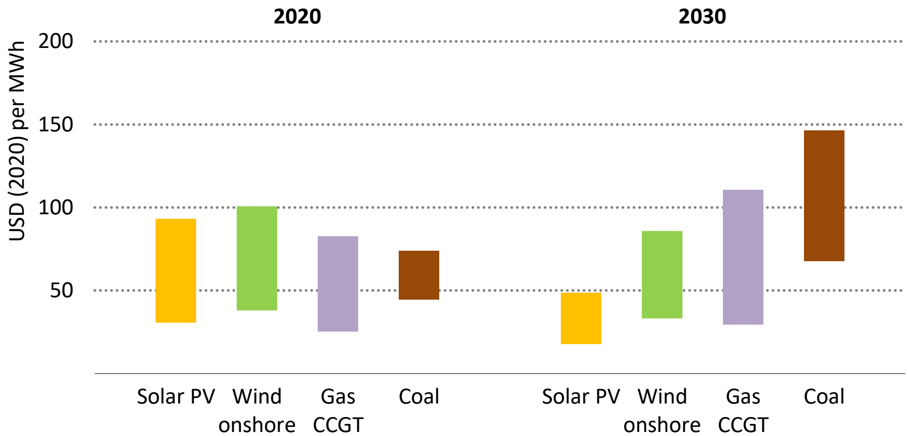
Generating technology costs

The evolution of Africa's electricity system will be shaped by expected ongoing reductions in the relative cost of renewables, which are already the cheapest generating option in many locations across the continent (Figure 2.23). We project further significant declines in the levelised cost of electricity – the average net present value of the cost of generation for a plant over its operating lifetime – for renewables-based technologies, particularly solar PV. By contrast, the cost for gas- and coal-fired plants is projected to rise substantially, in part due to higher carbon penalties, which reach USD 40 per tonne of CO_2 in South Africa by 2030 (no explicit pricing is assumed in other parts of Africa).

Although the levelised cost metric captures direct technology and financing costs, it does not take into account costs related to the overall functioning of power systems, which vary across sources. As energy transitions progress across the continent, rising shares of variable renewables mean that the overall competitiveness of different technologies will be more and more affected by their operational attributes as well as their pure cost of generation. These attributes include dispatchability (the ability of a plant to generate when required and when it is most valuable) and the overall contribution to the adequacy and flexibility of the system.

The projected expansion of generating capacity across Africa in the SAS also hinges on the ability to raise finance. The SAS projections require annual power sector investment to ramp up to around USD 80 billion per year on average over the period 2021-30, compared with USD 30 billion over the previous decade. The Covid-19 pandemic has tested the resilience of utilities that were already struggling with poor financial performance and underinvestment (see Chapter 1). Declining revenues, expected cost increases, higher costs of capital, the risk of payment default, staff health problems, operational complaints and supply chain constraints are undermining the cash flow and credit worthiness of African utilities. Improving the financial health of state-owned utilities and mobilising private capital will be crucial to putting Africa's electricity sector on the sustainable path depicted in the SAS.

Figure 2.23 ▷ Levelised cost of electricity for selected sources in the SAS



Best-in-class solar PV and wind projects are already cheaper than new gas and coal plants in most parts of Africa, and become even more competitive by 2030

Notes: SAS = Sustainable Africa Scenario; CCGT = combined-cycle gas turbine. Levelised cost of electricity is the average net present cost of electricity generation for a generating plant over its lifetime, including the cost of capital, decommissioning, fuel and CO_2 costs, fixed and variable operations and maintenance costs, and financing costs. Historical costs and performance for solar PV and wind are from IRENA (2021).

2.5 Energy production

Africa needs to deal with a dual challenge of meeting rising demand for fossil fuels while preparing for a potential decline in hydrocarbon income. The continent also needs to mobilise large-scale investment to unlock the potential for clean fuels such as low-carbon hydrogen and ammonia. This section provides an outlook for fossil fuels and low-carbon fuels in the SAS over the coming decade.

Chapter 3 explores how global energy transitions reshape the role of African resources, including fossil fuels, critical minerals and emerging clean fuels. Chapter 3, section 3.4 highlights Africa's potential contribution to reduce reliance on Russian resources and section 3.5 discusses implications for investment and financing.

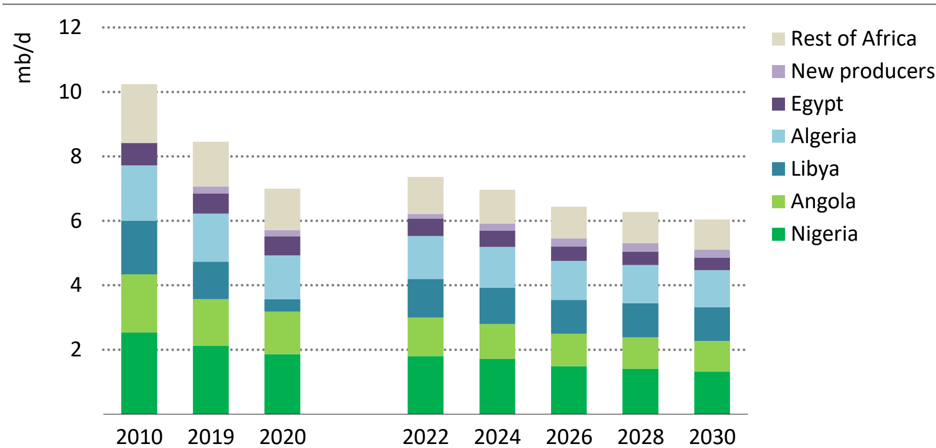
2.5.1 Fossil fuels

Oil

Africa's oil production is mainly exported, so its outlook is greatly influenced by global demand trajectories, competitive dynamics in export markets and prices. As a result, future oil revenues will probably remain more sensitive to the pace of the global energy transition than to domestic demand trends. While recent commodity price increases provide higher income to African producers, accelerating global efforts to reduce emissions as envisaged in the SAS highlights the longer term risks. This gives renewed urgency to the need for economic reforms and diversification, as well as strategic thinking on future infrastructure investment.

Africa's oil and gas production has been hit hard by the Covid-19 pandemic. The fall in output in 2020 was abrupt and the pace of recovery in 2021 was slower than in most other parts of the world. Libya is a notable exception. Libya's oil production collapsed in 2020 due to political turmoil, but rebounded strongly to 1.2 million barrels per day (mb/d) in 2021 as the situation eased. In the SAS, oil production in Africa falls steadily over the period to 2030 due to a combination of slower growth in global oil demand, worsening financing conditions and project delays (Figure 2.24). Lower world oil demand and lower prices push down total African oil production from over 8 mb/d in 2019 to around 6 mb/d in 2030. This has major implications for government revenues and fiscal balances in producing countries.

Figure 2.24 ▷ Oil production by country in the SAS



Africa's oil production does not return to pre-pandemic levels, falling steadily over the period to 2030 as new projects fail to stem declines in output at mature fields

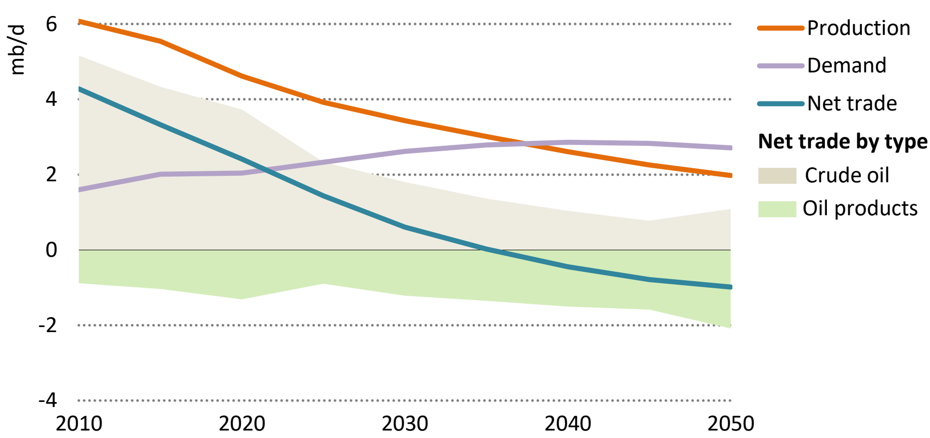
Notes: New producers include Ghana, Kenya, Senegal and Uganda.

Output is projected to decline in all the major African oil producers in the SAS. Libya's production declines slowly through to 2030 even on the assumption that political instability does not worsen. Angola's oil production continues to trend downwards as new projects are insufficient to stem declines in maturing fields. Nigeria, the largest oil producer in Africa, also struggles to stem the slump in output as uncertainties surrounding fiscal terms and high operational risks hamper investment in large projects needed to offset output declines at existing fields.

The pandemic has dealt a blow to African countries looking to join the oil producers club, including Ghana, Kenya, Senegal and Uganda. While Uganda recently reached a final investment decision on the USD 10 billion Lake Albert development project, the timeline for other new projects in these countries remains uncertain due to persistent delays, technical problems and weak regulation. As a result, oil production in sub-Saharan Africa is projected to contract by one-quarter between 2021 and 2030 as shrinking global oil demand weakens the investment climate for new field developments.

In sub-Saharan Africa (including South Africa), the projected decline in oil production contrasts starkly with growing demand for oil products (Figure 2.25). The region's net oil exports fell by 40% in the 2010s to 2.4 mb/d in 2020 on the back of dwindling production and surging demand. This trend is projected to continue, with the region becoming a net importer of oil in the mid-2030s.

Figure 2.25 ▷ Oil production, demand and net trade in sub-Saharan Africa (including South Africa) in the SAS



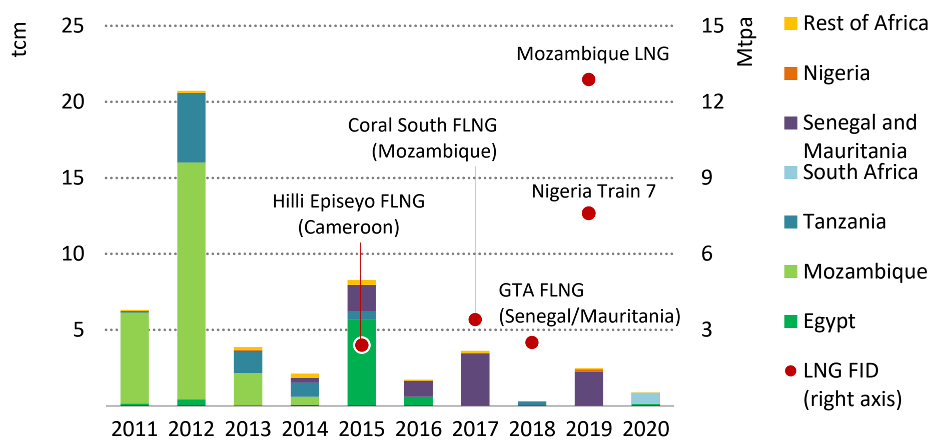
Sub-Saharan Africa becomes a net importer of oil in the 2030s as demand outstrips domestic production, but continues to export crude oil due to inadequate refining capacity

The evolution of trade in sub-Saharan Africa in the SAS differs between crude oil and oil products. Due to its weak refining system, sub-Saharan Africa (including South Africa) currently imports the bulk of its oil product needs while exporting crude oil. Refining capacity in the region stands at 1.3 mb/d today, but utilisation rates are lower than those of other regions – around 40% in 2020 compared with the global average of over 70% – because many of the region's refineries are old, inefficient and unable to supply in-demand premium, low-sulphur transport fuels. Several refineries are being closed or are at risk of closure as they are unable to meet fuel quality standards and cannot secure financing for much-needed investment in upgrades or maintenance. This has made the region one of the world's largest importers of transport fuels (gasoline, diesel and kerosene). The 650 kb/d Dangote refinery being built in Nigeria, which is due to come into operation in the early-2020s, will improve the trade balance for oil products for a while, but product import requirements are projected to increase again in the mid-2020s as few other projects are planned and fuel quality regulations become increasingly stringent.

Natural gas

The prospects for Africa's natural gas sector are somewhat better than for oil due to a series of major discoveries in the 2010s (Figure 2.26).

Figure 2.26 ▻ Natural gas discoveries and final investment decisions for LNG projects in Africa, 2011-2020



Major gas discoveries in the 2010s triggered a series of investment decisions for export-driven LNG projects

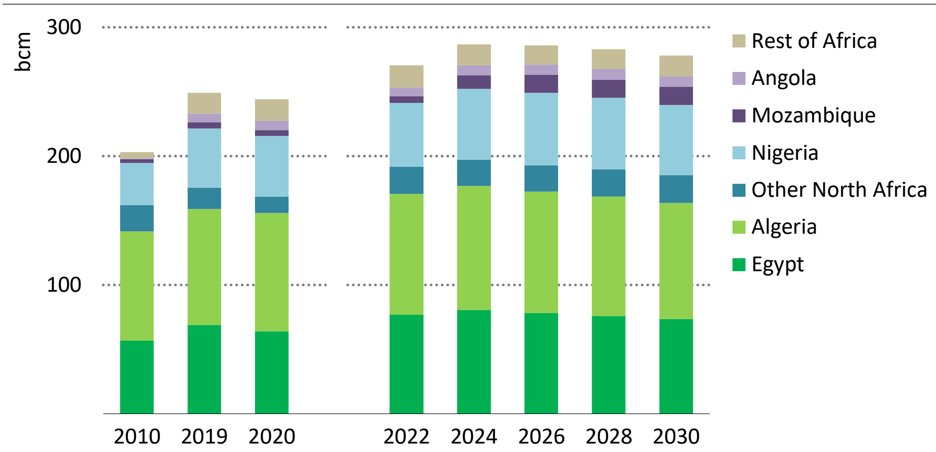
Note: tcm = trillion cubic metres; Mtpa = million tonnes per annum; GTA = Greater Tortue Ahmeyim; FLNG = floating liquefied natural gas; FID = final investment decision.

Source: Rystad Energy (2021) for resource discovery.

Between 2010 and 2020, 40% of all the gas discovered worldwide was in Africa. Discoveries in Mozambique and Tanzania in the early- 2010s were followed by a series of discoveries in Egypt in 2015, and Senegal and Mauritania in the late-2010s. Recently, large gas condensate resources have also been discovered off the southern coast of South Africa in the Luiperd and Brulpadda fields. This contributed to the 20% growth in natural gas production in the 2010s, the bulk of it in sub-Saharan Africa. It also triggered a number of large-scale, export-driven liquefied natural gas (LNG) projects. Final investment decisions for Coral South LNG in Mozambique and Greater Tortue Ahmeyim (GTA) LNG in Senegal and Mauritania were made in the late-2010s, followed by larger projects such as Mozambique LNG and Nigeria Train 7. Additional projects have been proposed, including GTA Phase 2, Rovuma LNG in Mozambique, Cameroon Phase 2, Nigeria Floating LNG (FLNG) and Congo-Brazzaville FLNG. The construction of the Trans-Saharan Gas Pipeline, which connects Nigeria to Niger and Algeria, recently resumed, which will add to a few existing cross-border pipelines such as the West African Gas Pipeline.

The long-term outlook for African natural gas production hinges on export demand, which will determine the extent to which the huge resources that have been discovered can be exploited. Gas production increases by around 15% over 2020-30 in the SAS, driven mainly by new projects in Egypt and Nigeria, as well as Mozambique (although security and financing challenges remain for the LNG projects there). In North Africa, production continues to grow in Egypt, but remains stagnant in Algeria due to declines at the Hassi R'Mel complex, which has been producing for many years. Higher domestic demand in North Africa means that its production is less sensitive to global market developments compared with sub-Saharan Africa. From the mid-2020s, output across the continent starts to decline as global demand weakens with stronger policies to accelerate the transition away from fossil fuels (Figure 2.27).

Figure 2.27 ▷ Natural gas production by country in the SAS



Natural gas production in Africa grows by 15% between 2020 and 2030, driven mainly by new projects in Egypt, Nigeria and Mozambique

Note: bcm = billion cubic metres.

Boosting the contribution of natural gas to meet Africa's energy needs and reaping the economic benefits from developing its vast resources depend on finding new ways to attract investment (see Chapter 3). Recent geopolitical upheavals, including Europe's efforts to reduce its dependency on Russian gas, might increase the call on Africa's gas. But in the absence of strong domestic markets and given uncertainty over the long-term outlook for global gas demand, obtaining the finance to develop Africa's large gas resources is likely to remain challenging. Investors are increasing their scrutiny of the commercial viability of export-driven projects and the speed of execution of new projects is emerging as a crucial factor in investment decisions. Africa's track record for gas projects in this regard is not encouraging. Total's Mozambique LNG project has been halted since 2021 following the declaration of force majeure due to security risks. The GTA LNG project is also encountering problems with cost overruns, environmental concerns and the impact of the pandemic. These problems are weighing on the prospects for investment decisions for other African LNG projects in the pipeline.

Coal

The prospects for coal production in Africa are weak, due largely to declining export demand and the increased competitiveness of alternative low-carbon domestic energy sources. Output is projected to decline gradually by around 3% per year through to 2030 in the SAS. Production continues to be dominated by South Africa. While Botswana, Mozambique and Zimbabwe aim to boost output, mobilising investment and building infrastructure to connect production sites to demand and export centres will remain difficult.

2.5.2 Emerging clean fuel production

Low-carbon hydrogen and hydrogen-based fuels

The use of low-carbon hydrogen in Africa today is minimal, but, as in other parts of the world, that energy carrier is expected to play a major role in the continent's clean energy transition, including by displacing fossil fuel use in several industries such as fertiliser production. Today, the hydrogen produced and used at industrial scale in Africa, mostly to make ammonia-based fertiliser and to refine oil in North Africa and Nigeria, is not low-carbon. The bulk of Africa's hydrogen production for ammonia is based on natural gas feedstock, while South Africa produces ammonia from coal on a slightly smaller scale. The largest share of hydrogen production today is met by fossil fuels without carbon capture.

Strong policy support and timely investment in infrastructure triggers rapid growth in the production and domestic uptake of low-carbon hydrogen in the SAS, and Africa develops significant potential to export to demand centres in Europe (see Chapter 3, section 3.4.3). Total hydrogen production increases from nearly 3 Mt (360 petajoules [PJ]) today (all of it based on unabated fossil fuels) to more than 5 Mt (600 PJ) by 2030 (15% of which is low-carbon from electrolysers or fossil fuel plants fitted with carbon capture) and to 20 Mt (2 400 PJ) by 2050 (80% low-carbon).

Table 2.3 ▷ Low-carbon hydrogen production projects in Africa

Project	Lead developer	Year	Capacity	Use	Status
Egypt					
EBIC Ammonia	Fertiglobe	2024	100 MW electrolysis	Ammonia production	Feasibility studies
EEHC – Siemens MoU	EEHC Siemens	n.a.	100-200 MW electrolysis	Unspecified	Announced
Mauritania					
Aman Green Hydrogen	CWP Global	2030	1.8 Mt H_2/year	Ammonia fuel, fertiliser, exports	Announced
Project Nour	Chariot	n.a.	10 GW electrolysis	Exports	Announced
Morocco					
OCP Group demonstration	OCP Group	2022	260 t H_2/year	Fertiliser	Under construction
Masen green hydrogen	Masen	2025	100 MW electrolysis	Exports	Feasibility studies
HEVO-Morocco	Fusion Fuel	2026	31 kt H_2/year	Ammonia fuel, exports	Feasibility studies
Namibia					
O&L Group - CMB.TECH hydrogen hub	O&L group CMB.TECH	2023	4 MW electrolysis	Transport	Under construction
Renewstable Swakopmund	HDF Energy Namibia	2025	24 MW electrolysis	Electricity generation	Feasibility studies
Hyphen Hydrogen Energy - Phase I	Hyphen Hydrogen Energy	2026	120 kt H_2/year	Exports	Feasibility studies
Hyphen Hydrogen Energy - Phase II	Hyphen Hydrogen Energy	n.a.	3 GW electrolysis	Exports	Announced
South Africa					
Anglo-American Mogalakwena mine	Anglo-American	2022	3.5 MW electrolysis	Mining trucks	Under construction
Sasolburg green hydrogen	Sasol	2023	2 kt H_2/year	Chemicals, steel, transport, power	Feasibility studies
Nelson Mandela Bay green ammonia	Hive Hydrogen	2026	140 kt H_2/year	Ammonia fuel, fertilisers, exports	Feasibility studies
Secunda SAF – Phase I	Sasol	n.a.	8 kt H_2/year	Synfuels	Feasibility studies
Secunda SAF – Phase II	Sasol	2040	1.3 Mt H_2/year	Synfuels	Announced
Boegoebaai green hydrogen	Sasol	n.a.	400 kt H_2/year	Chemicals, synfuels, exports	Feasibility studies

Note: H_2 = hydrogen; MW = megawatt; GW = gigawatt; Mt = million tonnes; t = tonnes; kt = thousand tonnes; n.a. = not available; MoU = memorandum of understanding.

Sources: IEA analysis based on Anglo-American (2021); Fraunhofer Energie (2020); IEA (2021c); Plug Power (2021); Masen (2021); Fusion Fuel (2021); Hyphen Hydrogen Energy (2021); Siemens Energy (2021); Collins (2021); Atchison (2021).

Of this production, nearly 10% is exported in 2030 and almost one-third in 2050, as pure hydrogen or hydrogen-derived fuels such as ammonia and synthetic fuels, drawing on its ample low cost renewable energy resources, especially solar PV.

The growth in Africa's domestic demand for low-carbon hydrogen in the SAS comes from the production of hydrogen-based fuels (ammonia and synfuels) to replace current unabated fossil-based hydrogen and ammonia production, and to increase the use of hydrogen in remote power generation and heavy-duty vehicle transport. A number of export projects have already been announced, targeted mainly at Europe (Table 2.3). While Egypt, Morocco and South Africa are taking the lead, recent significant announcements have been made in Mauritania and Namibia. In a show of their steadfast intentions to commit to low-carbon hydrogen production, six countries, Kenya, South Africa, Namibia, Egypt, Morocco and Mauritania, formally launched the African Green Hydrogen Alliance on 18 May 2022.

Only a couple of small projects which focus on meeting domestic demands are currently under construction. In South Africa, Anglo-American is installing a 3.5 MW electrolyser to produce hydrogen for use in a demonstration project for mining trucks. In Morocco, OCP Group is building a 260 tonne/per year demonstration plant for the production of renewables-based ammonia with the long-term objective of avoiding the need for its fertiliser industry to import ammonia.

Other projects under consideration are still at early stages of development, such as the Fertiglobe renewables-based ammonia plant in Egypt and the Sasolburg project in South Africa, which look to replace unabated fossil fuel-based hydrogen in industrial applications. A series of ambitious projects to deploy very large electrolysers with capacities up to 10 GW using renewables-based electricity have been announced recently, but they face significant financial barriers due to the high upfront capital requirements, often comparable to the size of the host country's economy. For example, the Hyphen Hydrogen Energy project in Namibia is estimated to cost USD 9.4 billion, compared with national GDP of around USD 11 billion. These projects clearly will not proceed without massive international financial support.

Modern bioenergy

Modern bioenergy include biofuels used predominantly in transport, biogas used as a clean cooking fuel, biomethane used for power generation and solid biomass in the form of wooden pellets for household heating. Biogas is a mixture of methane, CO_2 and small quantities of other gases produced by anaerobic digestion of organic matter. The precise composition of biogas depends on the type of feedstock and the production pathway. Today, production is minimal, but there is enough sustainable feedstock to satisfy the entire energy demand for clean cooking in Africa. Based on a bottom-up assessment, we estimate that the continent holds the potential to provide nearly 2 EJ of locally produced low-carbon biogas, which could potentially double to 4 EJ by 2040 (IEA, 2020).

2

Today, the use of biogas in Africa is concentrated in countries with specific support programmes. Some governments, such as in Benin, Burkina Faso and Ethiopia, provide subsidies that can cover up to half of the investment, while numerous projects promoted by non-governmental organisations provide practical know-how and subsidies to lower the net investment cost (SNV, 2019). In addition, credit facilities have been set up in a few countries, such as a lease-to-own arrangement in Kenya that financed almost half of the anaerobic digesters installed in 2018.

The use of biogas for cooking in Africa grows to 66 PJ by 2030 in the SAS, playing a significant role in providing access to clean cooking. This is driven by large subsidies to lower the relatively high upfront cost of a digester. In Africa, the costs for an average size household unit with a technical lifetime of over 20 years can range from USD 500 to USD 800. Installation costs for other clean cooking technologies are much lower. However, on a total cost of ownership basis, digesters can be cheaper after two years of continuous use since fuel costs are low or non-existent. They can also produce bio-fertilisers as a by-product. Senegal put in place a strategy to lower the cost of biodigesters through developing a market for bio-fertiliser under its National Domestic Biogas Programme.

Biofuels for transport account for a small share of total final consumption in Africa today, but there is a huge potential for growth. Increasing biofuel production from the transformation of agricultural waste can be sustainable if based on the intensification of crop production and livestock grazing on existing agricultural lands, rather than the extension of crop and grazing lands. One area that is gathering interest is the use of the waste from the sisal crop to produce fuel in Kenya and Tanzania (Box 2.8). The production of biofuels is projected to rise from less than 1 000 barrels of oil equivalent per day (boe/d) in 2020 to almost 110 000 boe/d in 2030 in the SAS.

Box 2.7 ▷ Potential of sisal as a crop for waste to fuel

Sisal (agave sisalana) is a tropical plant cultivated worldwide for its stiff fibre leaves. Kenya and Tanzania are among the largest growers of sisal in the world. Extraction of the fibre produces significant amounts of bio-waste and residue rich in sugars, which can be used to produce ethanol and other high value products such as butanol. Sisal production does not compete with food crops for land use and it can be grown in marginal areas where other crops do not grow as well. The plant makes efficient use of water, rendering it a suitable crop in regions vulnerable to climate change.

Currently, around 2% of the sisal plant is utilised for fibre and the residue, known as bole, is treated as waste. Only a fraction of the pulp and fibre waste is utilised in sisal digesters to generate electricity for industrial purposes, while most of the sisal bole is burned on farms directly. It is estimated that this waste has the potential to annually produce 1.6 Mt of sugar and 60 kt of alcohol from the inulin (dietary fibres) it contains (Elisante and Msemwa, 2010).

Note: This box was prepared in collaboration with Ms Jacqueline Senyagwa of the Stockholm Environment Institute Africa.

Key areas for policy action

Connecting the dots

S U M M A R Y

- Among Africa's energy challenges, today a few rank among the most pressing for African leaders. First and foremost is achieving universal access. In the power sector, it is improving reliability, truing up power company balance sheets and integrating fourteen-times more solar PV and wind capacity by 2030. For oil and gas producers, it is balancing near-term signals to increase production with flagging export revenue to 2030, and allocating sufficient capital to capture new markets for low-carbon hydrogen and critical minerals. Notably, it is increasing energy investment and pivoting financial flows to clean energy to meet domestic demand.
- Reaching universal access to electricity by 2030 requires a tripling of the current rate of progress – a pace that has been reached in some African countries – and relies on mini-grids and stand-alone systems for more than half of the connections from now to 2030 in the Sustainable Africa Scenario (SAS). Achieving universal access to clean cooking requires unprecedented action, which recent spikes in LPG prices make even more difficult. The switch to clean cooking also reduces GHG emissions and frees up time for women to participate more in society and economic activities.
- Renewables meet more than 80% of electricity capacity additions this decade in the SAS, stressing the need for increased flexibility and network capacity. Additional flexible capacity needs are largely met by hydropower and natural gas to 2030, but expanding power pools, along with batteries and clean fuel switching, play a role too. Upgrading networks, which are in a parlous state today, requires a tripling of annual investment in the SAS over 2016-20 levels to USD 40 billion per year on average between 2026-30 – 40% of total electricity sector investment over that period.
- Current price rallies and efforts to phase down Russian oil and gas have resulted in renewed interest in African production. New projects benefit from speed to market, minimising project costs and delays, and reducing methane emissions, which help guard against an outlook to 2030 that finds oil and gas income falling by more than 40% in the region and up to a half for some key producers in Africa. Conversely, in the SAS critical minerals export revenues double by 2030, and cost declines globally put delivered costs for low-carbon hydrogen from Africa on par with that produced in Northern Europe, hinting at the emerging role for these commodities.
- Achieving the SAS requires doubling energy investment in Africa by 2030. This would require increasing the role of private capital to 60% of cumulative energy investment between now and 2030, as well as tapping into newly available capital streams, such as climate finance, carbon credits and growing domestic financial markets. Public concessional finance can play a catalytic role in bringing down capital costs, especially as debt burdens increase and inflation drives up servicing cost.

3.1 Introduction

Africa is a diverse continent and each country faces different challenges and opportunities in the development of its energy sector. Yet there are some energy concerns that are relevant to many if not all African countries and that are critical to the energy future of Africa, as well as prospects for socioeconomic development. This chapter delves into the following cross-cutting matters:

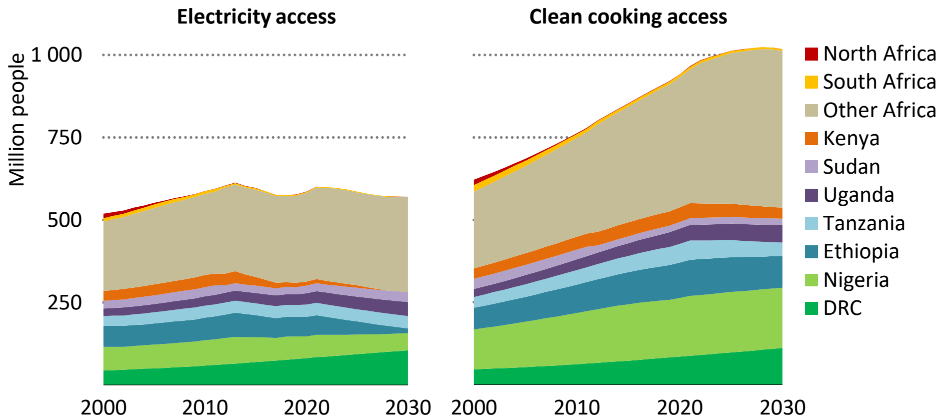
- **Achieving universal access to electricity and clean cooking**: How to bring policy measures, planning, new business models and finance together to accelerate action?
- **Building a reliable, renewables-based power system**: How can Africa's electric power companies and utilities rapidly expand renewables, develop flexible capacity, and develop transmission and distribution needed to meet rising demand in a sustainable, reliable manner?
- **Role of fuels and resources**: How to balance short-term demand for increased fossil fuel production with declining demand in the long term caused by clean energy transitions? How can Africa capitalise on the rise in demand for new energy-related commodities such as critical minerals and low-carbon hydrogen?
- **Investment and financing**: How to reduce investment risks and harness new sources of finance to mobilise the finance needed to double capital spending in the energy sector over the current decade?

3.2 Achieving universal energy access

Today, more than three-quarters of all the people in the world that lack access to electricity and more than a third that lack access to clean cooking fuels and/or technologies are in Africa. These shares have been increasing in recent years. Most of the 600 million without electricity and the 970 million that relied on harmful fuels for cooking in 2021 were sub-Saharan Africans. Almost half of them are concentrated in five countries: Democratic Republic of the Congo (DRC), Ethiopia, Nigeria, Tanzania and Uganda. Africa was already off track to reach the United Nations Sustainable Development Goal (SDG) of universal access to modern energy by 2030 (SDG7) at the beginning of 2020 and the Covid-19 pandemic has set back progress even more (see Chapter 1).

Current government policies fall far short of what is required to meet the goal: without additional measures, 565 million people will still be without access to electricity and around one billion to clean cooking in 2030 (Figure 3.1). Among the five countries with the highest number of people without access to electricity, Ethiopia is the only one that would see significant improvement without additional measures, reaching a 90% access rate, thanks to its sustainable and comprehensive national electrification plan. In no country does the number of people without access to clean cooking decline significantly. However, recent policy actions to introduce clean cooking programmes and tariffs, notably in Ethiopia, Kenya and Nigeria, are for the first time "bending the curve" and slowing the growth in the number of people without access to clean cooking. These trends are subject to a high degree of uncertainty related to Russia's invasion of Ukraine, which could have lasting effects on the affordability of access solutions.

Figure 3.1 ▷ Population without access to modern energy services by region/country absent new access measures in Africa



Absent additional efforts, 565 million Africans will still have no access to electricity and around 1 billion will still rely on traditional fuels for cooking in 2030

Notes: DRC = Democratic Republic of the Congo. Other Africa = rest of sub-Saharan African countries.

Getting Africa on track to achieve universal access to modern energy services by 2030 – a central pillar of the Sustainable Africa Scenario (SAS) – requires policy action to be stepped up to unprecedented levels across the continent. Some countries in Africa are already making good progress in expanding access to electricity, which others could emulate, but no country is currently doing enough to reach universal access to clean cooking by 2030. Africa may also look to countries in South Asia for models to accomplish the rates needed to meet these targets. Stimulating more investment requires international support aided by stronger national institutions on the ground laying out clear access strategies – around 25 African countries have them today for electricity and 20 for clean cooking. This has been made all the more difficult by the current fossil fuel and food price surges, which accentuate the economic difficulties brought on by the Covid-19 pandemic and made it even more challenging to keep energy affordable for the more than 40% of sub-Saharan Africans living in extreme poverty.[1] International support will be vital to improve the affordability of energy in the near term and to advance the cause of universal energy access.

[1] Extreme poverty is defined as income below the poverty line of USD 1.90 per day, based on 2011 prices and at purchasing power parity (equivalent to USD 2.19 in 2020 prices).

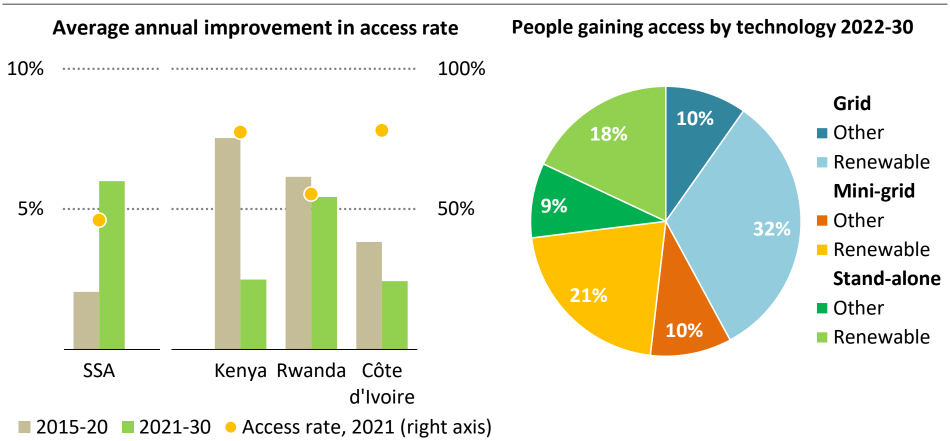
3.2.1 Electricity access

Gaining access to electricity

For every African to have access to electricity by 2030 – SDG 7.1 – as assumed in the SAS, 90 million people, or 6% of the current total population, including 70 million from rural areas, would need to gain access each year on average from 2022. More than 99% of this population are in sub-Saharan Africa, where the effort needed equates to increasing the average rate of access by six percentage points each year – almost three-times faster than just prior to the pandemic (Figure 3.2). In rural areas, where more than 80% of Africans without electricity access live today, progress needs to be even faster. Access rates in rural areas would need to improve by more than eight percentage points each year in the SAS, a fourfold increase from pre-pandemic levels. Rural customers predominately gain access through stand-alone and mini-grid systems, which can provide first access quickly and represent roughly two-thirds of new connections by 2030.

This is achievable in principle: between 2015 and 2019, prior to the pandemic, seven countries came close to achieving the rates of progress needed to achieve full access by 2030, including Côte d'Ivoire, Gambia, Kenya and Rwanda. But most countries fell far short. In 22 other countries, including Chad, DRC, Madagascar, Malawi, Mozambique and Niger, which make up more than half of sub-Saharan Africans without access today, population growth exceeded the number of people gaining access over the same period.

Figure 3.2 ▷ Improvement in access to electricity and number of people gaining access by technology in sub-Saharan Africa in the SAS



Rates of new access to electricity in sub-Saharan Africa need to improve threefold to 2030, emulating those achieved in some countries prior to the Covid-19 pandemic

Notes: SAS = Sustainable Africa Scenario; SSA = sub-Saharan Africa. Access rate is defined as the share of the population with access to electricity. Improvement is shown as the annual increase in percentage points.

The way in which sub-Saharan Africans gain access to electricity varies across countries in the SAS. The projections start from geospatial least cost analysis, which takes into account distance to the grid, expected demand and the size of each community to model the least cost solutions for each settlement. It then considers other factors such as the potential speed at which grid and off-grid systems can provide access, the potential for simultaneously electrifying other sectors such as industry, agriculture or transport, the optimal solution for maximising reliability, resilience and quality of supply, and the attractiveness of investment to different investors and vendors.

Based on historical evidence, new grid connections in Africa, even where concerted policy support is in place, have not seen strong accelerations from year to year, and drastically slow progress as they reach deeper into rural areas (Power for All and GTM, 2018). For example, in Nigeria, grids would be the least cost solution for over 80% the population that have yet to gain first access, around 10 million people each year on average over 2022-30. However, at most, Nigeria has connected 4.3 million people to the grid in a single year and, in 2021, 95% of Nigerians without access lived in rural areas, where distribution companies struggle to see a return on investment to connect these poor and remote communities. If annual grid connections were conservatively capped at 4.5 million, then 60% of the population would be left to gain access via mini-grids and stand-alone systems.

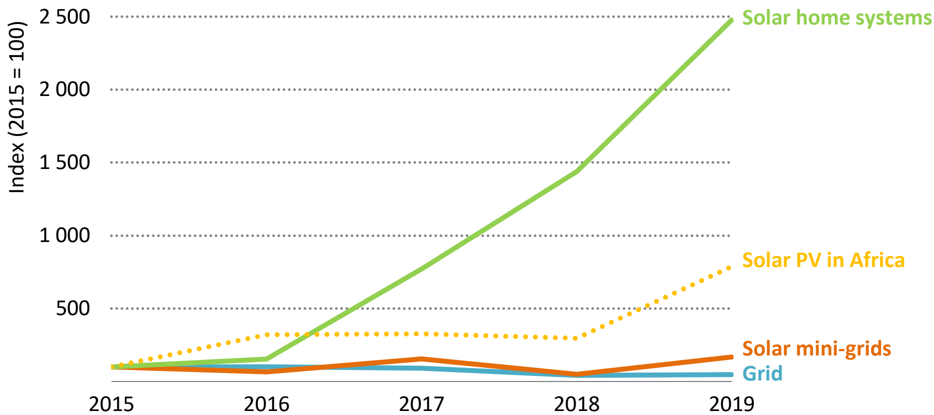
Conversely, decentralised, modular systems, particularly solar home systems (SHS) [2], have accelerated since 2015, facilitated by innovations in phone-enabled pay-as-you-go business models (PayGo). Annual sales of SHS large enough to power an essential bundle of appliances[3] reached around 1.3 million units between July 2020 and June 2021 in Africa (GOGLA, 2021). In the SAS, annual sales of SHS, are four-times higher on average over 2022-30, providing first-time electricity services to 18% of all the people gaining access. In Ghana, Kenya and Nigeria, installed SHS growth far exceed the flat trend in new grid connections and are showing a stronger acceleration trajectory than that of solar photovoltaics (PV) capacity additions in Africa over the same period (Figure 3.3).

The co-existence of different electrification options with a high share of mini-grids and stand-alone systems – primarily SHS – helps to boost competition and accelerate electrification, while enhancing reliability and resilience to climate and security risks in the SAS. Many of the households that gain first-time access through mini-grids and stand-alone systems are eventually connected to a grid, with off-grid systems, especially mini-grids, becoming integrated into it so as to improve the overall reliability of the electricity network. Only the most remote settlements still lack a grid connection in 2050.

[2] Solar home systems are typically used as a first means of providing electricity access and are often sold together with appliances. Solar lighting systems based on small PV modules of up to 10 Watts, which power mainly lighting devices, do not count as electricity access in IEA statistics, but are an important first step in replacing flammable lighting devices and are often replaced with larger solar home systems at a later date.

[3] An essential bundle includes four lightbulbs operating for four hours per day, a television for two hours and a fan for three hours. SHS able to power an equivalent energy service to the essential bundle have capacities ≥ 25 Watts.

Figure 3.3 ⊳ Increase in new connections in Ghana, Kenya and Nigeria by type versus solar PV overall in Africa



The rate of growth of solar home systems in Ghana, Kenya and Nigeria over the five years to 2020 accelerated at a pace that exceeded that of solar PV overall in Africa

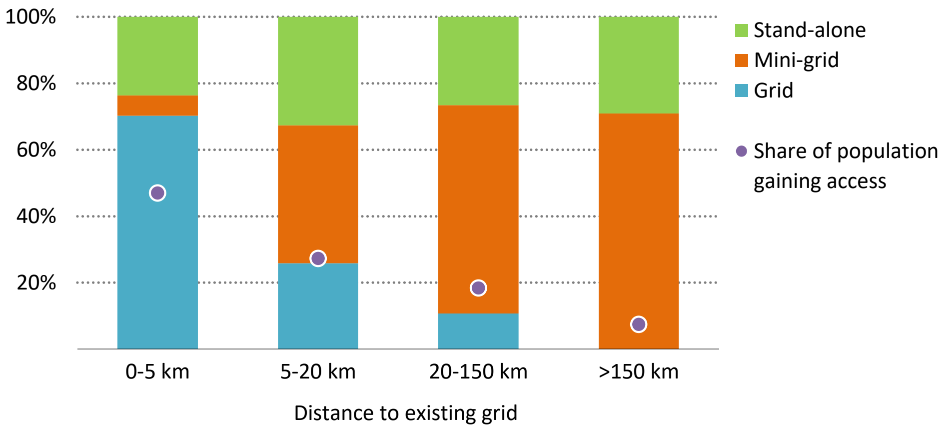
Notes: Grid, solar mini-grids and solar home systems growth is based on the annual number of new connections in Ghana, Kenya and Nigeria. Overall solar PV in Africa growth is based on added capacity of solar PV on the continent.

Sources: IEA data and analysis complemented with data from GOGLA (2021); IRENA (2021); Mini-grids Partnership (2020).

Almost 45% of the population that gain access for the first time in sub-Saharan Africa in the SAS do so via a grid connection, mainly urban dwellers and rural communities living within reach of existing or planned grids. However, some small communities located close to a grid are served at first by stand-alone systems and so-called "under-grid mini-grids" (isolated, small off-grid networks in broad areas covered by national or regional grids) as it is often not profitable for grid operators to connect them initially, but still represents interesting profits for mini-grid and stand-alone system providers. This includes people living in urban slums and other informal settlements, where mobile and lightweight SHS can provide essential energy services until they move to more secure and permanent housing.

Where rural communities of more than 200 inhabitants are near a road, but more than 10 kilometres (km) from a main grid, mini-grids prevail in most situations. Mini-grids represent around 30% of new household connections in the SAS. Incremental installed capacity averages around 300 megawatts (MW) per year over 2021-30, of which 225 MW is based on solar PV, slightly less than the 280 MW of solar mini-grids already operating throughout the region. Mini-grids meet 65% of new connections in communities more than 20 km from grid infrastructure in the SAS (Figure 3.4).

Figure 3.4 ▷ Share of new electricity connections by technology and distance from a grid in sub-Saharan Africa in the SAS, 2022-2030



Mini-grids meet 65% of new connections in sub-Saharan African communities located more than 20 km from a grid and stand-alone systems for most of the rest

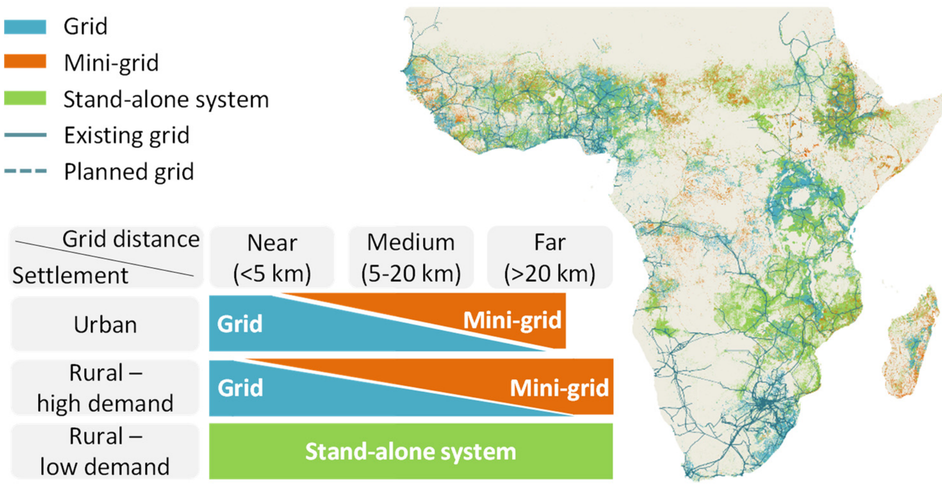
Note: SAS = Sustainable Africa Scenario.

For the remaining quarter of the population gaining access, mainly low demand and remote settlements, stand-alone systems are the preferred solution. Around 70% of stand-alone systems are renewables-based (mainly SHS) and the rest are diesel or gasoline generators. While diesel prices are surging, the availability of cheap diesel generators are unlikely to deter those gaining access from buying them, however, under high prices, users typically elect not to use them. If prices remain high in the longer term, more users may look to add new SHS to make up the energy use gap.

How new connections are made varies considerably by country and region (Figure 3.5). In Senegal, a country with relatively high projected demand and an already stable and well developed grid, the bulk of new connections over 2022-2030 are provided by the main grid. By contrast, in Somalia, everyone is gaining first access via off-grid solutions by 2030, reflecting the lack of a developed national grid and active markets for off-grid solutions.

Connections for non-household uses, including public services such as schools or health facilities and commercial businesses, also increase substantially in the SAS. Businesses, notably in agriculture, mining and telecommunications, often serve as important anchor customers for grid extensions and mini-grid projects, so integrating energy and rural business development planning is crucial to accelerate connections. An anchor customer can lower costs and tariffs, boost household incomes and, in turn, improve repayment rates to facilitate the financing of electricity access projects. This calls for better access to credit and the simultaneous development of infrastructure, notably roads (Morrissey, 2018).

Figure 3.5 ▷ People gaining access to electricity by technology by 2030 in Africa in the SAS



Settlements along existing main grids are most often connected to them, while stand-alone systems provide the bulk of access in low demand rural areas

Notes: 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. SAS = Sustainable Africa Scenario. High demand = settlements with more than 115 inhabitants; low demand = settlements with less than 115 inhabitants. Average urban settlement = 18 000 inhabitants; average rural settlement = 70 inhabitants. For visualization purposes, only transmission lines are shown, but distribution lines are also considered.

Larger SHS can be an effective solution for farmers. For example, electric irrigation pumps can improve yields or reduce costs if they replace diesel-powered pumps. Making use of agricultural waste to produce biogas and electricity (possibly in combination with PV plants) can bring important broad benefits to rural economic and social development by powering tools, heating greenhouses, producing sustainable fertiliser, connecting households and improving public services (IEA, 2020).

Climbing the electricity ladder

Consumption by individual households tends to rise once the initial connection has been made. This has implications for access planning to meet increasing demand efficiently and cost effectively in the years to come. In the SAS, rural households that gain access initially consume around 250 kilowatt-hours (kWh) per year and urban households around 500 kWh per year. This can be provided either by grid and mini-grid connections or bigger SHS with a capacity of at least 25 Watts (W) in rural areas and 50 W in urban areas.

Larger SHS of more than 100 W can power more than an essential bundle of appliances but would struggle to produce enough power for additional services such as refrigeration, electric cooking or air conditioning. In the SAS, investments are made in upgrading electricity connections to ensure Africans can power these additional services by 2040. Appliance efficiency plays a key role to achieve this in the SAS. SHS access providers are integrating high efficiency appliances in their bundled offerings, which enables smaller systems to handle more and larger appliances. For example, high efficiency DC refrigerators consume around 80% less energy than standard AC ones.

Demand stimulation measures such as those that provide incentives for the uptake of the most efficient appliances help households to benefit from gaining access to electricity and to improve affordability of its use.

As demand increases there is the inevitable need to upgrade connections. Some households are already "stacking" stand-alone systems, by buying additional systems to power more appliances. In the SAS, rural communities of a certain size gradually shift to mini-grids or grid connections after gaining initial access via stand-alone systems. Mini-grids built to provide first access are also gradually upgraded in the SAS, integrating more generation capacity and storage as demand rises. However at a certain point, substantial redesigns may be required, as oversizing mini-grids in anticipation of demand growth negatively impacts project economics and generally makes financing more difficult.

Accordingly, in the SAS, some mini-grids are interconnected to a broader grid, especially if built near planned grid expansions. For that to occur, interoperability standards for mini-grid systems and specific regulations to guarantee future integration must be developed today. Some countries such as Kenya, Nigeria, Tanzania and Rwanda have developed technical codes and standards that permit mini-grid connections to the grid, but few have put in place a legal framework to clarify mini-grid buy-outs or guarantee revenues once they are interconnected.

Managing affordability

Making electricity affordable is essential to reap the full social, economic and health benefits of extending electricity services to all Africans while enabling households that already gained access to climb the electricity ladder. In sub-Saharan Africa, the number of people in extreme poverty has been increasing in recent years, a trend accelerated by the Covid-19 pandemic, Russia's invasion of Ukraine and the resulting surge in global inflation, which drastically reduce their ability to pay for basic electricity services. In 2021, almost 390 million people, or more than three-quarters, of the population in sub-Saharan Africa that already have an electricity connection are unable to pay for an extended bundle of electricity services. And more than 150 million, or 30%, cannot afford even an essential bundle at national household grid tariffs. The numbers and shares vary by country and how prices are structured.

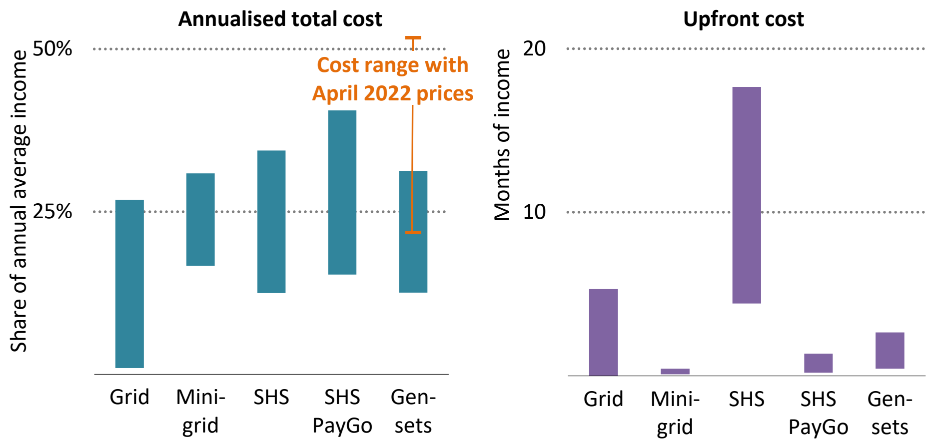
Targeted affordability support for both upfront and energy costs are crucial to expand access to electricity, though the eventual goal is to ensure that most people are able to afford to pay the full cost of supply by boosting incomes. Grid tariffs in some countries, such as Angola, Ethiopia, Ghana, Nigeria and Sudan, are low enough that most people in extreme poverty can afford to pay for enough electricity for an essential bundle of goods. In others, such as Benin, Madagascar, Mali, Rwanda and Somalia, electricity for an essential bundle would cost poor households close to or more than 10% of their income if not subsidised. Tiered rates, whereby those who use the least energy pay the lowest price, are a commonly used and administratively clear way to make electricity more affordable to newly connected households in the short term. Balancing the burden of subsidies with affordability is explored further in Chapter 4.

Another important consideration for customers is the upfront cost of connection. For grid electricity, many customers face both connection charges from the service provider and the cost of buying appliances, which together represent on average around three months of income and can reach up to six months for those living in extreme poverty (around 40% of the population of sub-Saharan Africa). Some African utilities and regulators in countries such as Côte d'Ivoire, Ghana, Kenya, Mozambique and Rwanda, subsidise the cost of connecting households to the main grid with government support and/or regulatory means to recover the cost over a longer period in their rates. Extending this type of financial support to mini-grids and SHS, which is not yet common in Africa, would allow off-grid electricity providers to offer more affordable services to poor households.

To help overcome upfront cost hurdles, most mini-grid and SHS providers offer alternatives. For example, SHS providers often offer a PayGo model, based on rent-to-own or leasing arrangements. For SHS between 20 and 80 Watts, typically customers pay a small upfront deposit of USD 20-70 for the system and appliances, and then pay back the cost of the system through monthly fees of USD 20-30 for the next three years. PayGo models also include access to finance and to digital payment methods to customers without access to traditional banking services, which enables them to build a credit history. SHS packages are often bundled with appliances while mini-grid providers are starting to propose financing options for appliance purchases to their customers. Some utilities are offering incentives to buy appliances in order to boost electricity demand. For instance, the Kenya Power and Lighting Company is heavily involved in developing an electric cooking campaign (Box 3.2).

For people in extreme poverty, using an essential bundle of appliances via off-grid solutions, costs between 15% and 35% of their annual household income, considering both annualised upfront and operational costs (Figure 3.6). Grid-based electricity service is the cheapest way of providing access in most cases, thanks to low social tariffs applied in many countries. But for many customers, the upfront connection cost, if borne by the customer in full, still represents an important barrier to gain access to electricity.

Figure 3.6 ▷ Annualised cost of gaining access to electricity as a share of the annual income of extremely poor people in sub-Saharan Africa, 2020



Powering an essential bundle in most cases represents more than 10% of the average annual income of the poorest households in sub-Saharan Africa

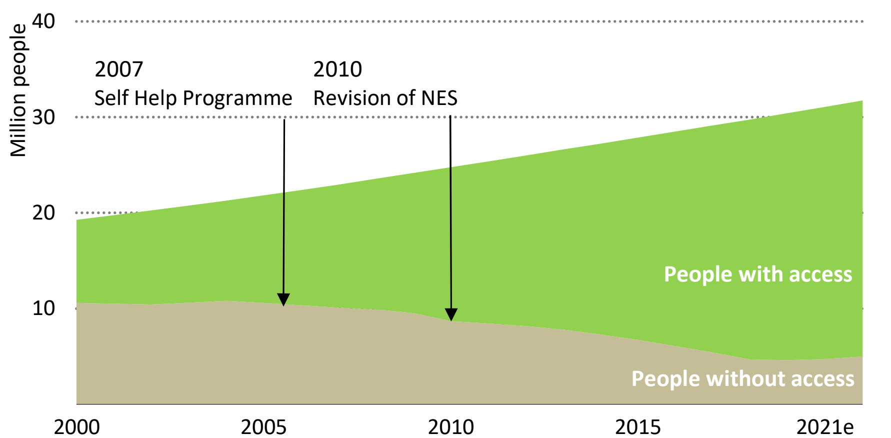
Notes: SHS = solar home systems; gensets = gasoline and diesel generators; PayGo = pay-as-you-go model. Costs are annualised upfront and ongoing costs for a connection to supply enough power for an essential bundle of appliances spread over ten years. The current spike in PV module and electronic component prices for SHS and mini-grids is not taken into account. Upfront costs and payments cover connection fees, wiring and appliances. PayGo cost represents just the cost of the deposit. Genset cost includes the purchase of a new system. Ongoing costs include per kWh electricity charges and other fees, such as monthly rent for PayGo. Solar home system costs are based on systems with a capacity between 20 and 80 W and an assumed lifetime of five years for the analysis.

Gasoline or diesel generators are common stand-alone solutions in some African countries due to their low upfront cost, especially for second-hand generators. However, they have higher operating costs than renewables-based alternatives, especially when oil prices soar as they have since 2021, and so can be more expensive over their operating life. When oil prices are high, most users forgo electricity and do not run their diesel generators. If high prices persist, more households may turn to SHS to offset the gap in electricity service. High energy and other commodity prices are also pushing up the cost of PV modules and electronic components used in SHS and mini-grids, by up to 20% since early 2021. However, the overall impact of these increases on annualised upfront and operating costs of a SHS would be more than 70% lower than the impact of the 2019-22 spike in diesel prices on the use of generators.

Box 3.1 ▷ Ghana's successful programme to expand electricity access

The share of the sub-Saharan African population with access to electricity would need to improve by six percentage points a year on average over the next eight years to achieve the goal of universal access in sub-Saharan Africa. Faster deployment of decentralised connections is required to meet this goal but a constant delivery of new grid connections is key. Some countries have demonstrated that it is possible, e.g. Ghana and Kenya. Ghana's success story dates back to the late 1980s, when only 15% of the population were connected to the grid. At that time, grid extensions were the most common option for providing access to electricity. The National Electrification Scheme (NES) was introduced in 1989 with an aim to provide access to all communities with a population of more than 500 people by 2020. By 2005, more than half the population had electricity access and today around 85% are connected – the highest rate in sub-Saharan Africa (excluding small states) (Figure 3.7).

Figure 3.7 ▷ Population with and without access to electricity in Ghana, 2000-2021



Ghana has made consistent progress to provide access to electricity to its growing population, thanks to sound access programmes

Note: 2021e = 2021 estimate.

The NES started by electrifying the most urbanised areas and later moved to grid extensions to more remote areas. Under the NES, the government also launched the Self Help Electrification Programme in 1993; it offered financing of cables and transformers to communities within 20 km of a high voltage transmission line provided that the community bore some of the upfront installation costs and that at least 30% of households in each village would be connected to the grid and that the villages would be responsible to install wooden poles for the low voltage lines. This proved successful and today the only communities still lacking electricity access are in remote rural, island or lakeside areas where the cost of grid extensions is prohibitive. To serve such areas, the government strategy now is to develop mini-grids and to promote stand-alone systems in order to achieve universal access by 2025.

Ghana's success can be attributed to a number of factors, notably the continuity of efforts spread over more than 30 years involving periodic strategy reviews and updates. Close attention has been paid to tracking access and determining the most cost-effective strategies for on- and off-grid connections, involving the use of analytical methods, such as geographic information systems that use software tools for managing, analysing and visualising geographic data. In addition, the expansion of generation and demand was carefully co-ordinated. The government also provided targeted affordability supports to poor households, with the help of development aid and private capital.

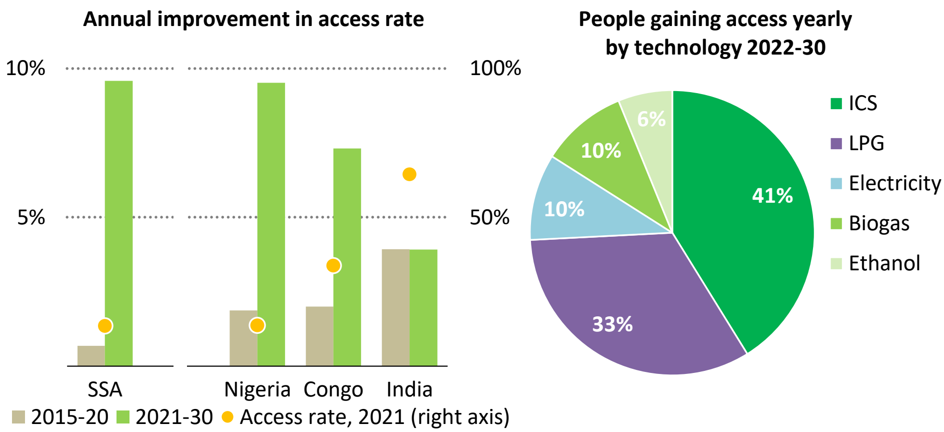
Note: This box was prepared in collaboration with Mr Salifu Addo of the Ghana Energy Commission.

3.2.2 Clean cooking

Achieving universal access to clean cooking fuels and technologies by 2030 in Africa requires an unprecedented reversal of current trends where the population without access has continuously climbed from 2010 to 2019. In the SAS, 130 million Africans (including 80 million from rural areas) gain access to clean cooking each year between 2022 and 2030, roughly 10% of the current Africa's population each year. The few sub-Saharan African countries that improved clean cooking access between 2015 and 2019 are home to less than 3% of the population without access in the region. The fastest rate of improvement in these countries, if maintained, would be far too low to close their access gap by 2030 (Figure 3.8). For comparison, India and Indonesia, where clean cooking access has progressed fastest in recent years, managed to increase their access rate by almost 4% every year between 2015 and 2019. Yet even if sub-Saharan Africa were able to match this pace, it would still leave 535 million people to rely on traditional uses of biomass fuels in 2030.

Around 40% of the people gaining first-time access to clean cooking over 2022-30 in the SAS do so with the use of solid biomass in improved biomass cook stoves. This is generally the cheapest and most practical means of providing clean cooking as it avoids the need to switch fuels and build new supply infrastructure. One-third of the people gain access via liquefied petroleum gas (LPG), 10% via electricity, 10% via biogas from biodigesters and 6% via ethanol. In urban areas, LPG represents the easiest and quickest clean cooking solution, accounting for half of the people gaining access in urban areas by 2030, followed by electricity (20%). In rural areas, improved biomass cook stoves represent around 60% of the people gaining access, LPG around 20% and biogas from biodigesters around 10%. Electric cooking remains a niche solution as a primary cooking source, especially in rural areas, but plays an increasingly important role in backing up or complementing other options due to the increasing penetration of kettles, microwaves, rice cookers and electric pressure cookers. More African households adopt electric cooking after 2030 as electricity becomes more reliable and incomes rise.

Figure 3.8 ▷ Improvement in access to clean cooking and number of people gaining access by technology in sub-Saharan Africa and selected countries in the SAS



Clean cooking access in sub-Saharan Africa needs to improve around 15-times faster over 2022-2030 than historic levels – an improvement rate unprecedented anywhere in the world

Notes: SAS = Sustainable Africa Scenario; SSA = sub-Saharan Africa; ICS = the use of solid biomass in intermediate and advanced improved biomass cook stoves (ISO tier ≥ 1); LPG = liquefied petroleum gas. Access rate is defined as the share of the population with access to clean cooking. The figure on the right shows the primary cooking fuel of people gaining access to clean cooking (some fuels/technologies such as electric stoves might also be used).

The increase in LPG demand for clean cooking projected in the SAS requires rapid development of infrastructure, including primary and secondary storage, refilling stations and cylinders. Fossil fuel LPG can gradually be blended with renewable LPG or bioLPG, produced from municipal and agricultural waste, although major advances are required to bring this market to scale. A major advantage of bioLPG is that it is chemically identical to conventional LPG, making it a genuine "drop-in" fuel that can be used in its pure form or blended with conventional LPG, without any need to modify existing supply infrastructure or end-use equipment (WLPGA, 2022).

The current spike in international energy prices has driven up the price of LPG cylinders in most African countries, with some cities facing prices that are twofold the 2019 price. Meanwhile, some African governments are in the process of removing LPG subsidies to reduce ballooning subsidy burdens. Subsidy removal in parallel with shifting market prices are making it unaffordable for many that had gained access to LPG and driving them to revert to traditional biomass fuels. This trend has been observed at least since September 2021 in African countries such as Kenya and Nigeria as well as in India, and in the first-half of 2022 prices continue to increase. If high prices persist, households gaining access would be increasingly likely to shift to alternative solutions such as biogas, ethanol or improved biomass cook stoves. Electric cooking could also play a more important role, especially in urban households.

Box 3.2 ▹ Electricity access and electric cooking in Kenya

Households newly connected to a grid tend to consume only small amounts of electricity and be on the lowest tariff band, making it difficult for utilities to recover the cost of investing in the connection. The adoption of efficient electric cooking appliances is a way to stimulate demand, and thereby revenue, to accelerate cost recovery for the energy distributor. The additional cost of cooking with electricity, which is generally regarded as a premium cooking option, would be limited by the savings on other fuels.

Increased electricity access, reliability and generation capacity in Kenya make electric cooking an attractive proposition for both consumers and utilities. Kenya Power and Lighting Company (KPLC) is keen to increase domestic demand to exploit excess renewable power production capacity. Around 80% of households use polluting fuels, even though more than three-quarters have increasingly reliable access to electricity at relatively low rates. To encourage switching to electric cooking, KPLC is exploring on-bill repayment for electric cooking appliances.

This dovetails with Kenya's recent announcement to develop a National eCooking Strategy – the first of its kind in Africa. This will support Kenya's target to reach universal clean cooking by 2028. The strategy plans to boost the adoption of electric cooking in urban and rural areas by overcoming cultural barriers, through cooking classes, recipes for how to cook local cuisine in electric cookware, demonstrations on time-saving techniques and contests to compare dishes. The KPLC campaign "Pika na Power" uses television advertisements, social media campaigns and live cooking classes to demonstrate the ease and affordability of using electricity for cooking. Uganda is following Kenya's lead and introduced a cooking tariff in January 2022.

Note: This box was prepared in collaboration with Dr Faith Wandera-Odongo of the Kenyan Ministry of Energy and experts from the Modern Energy Cooking Services programme.

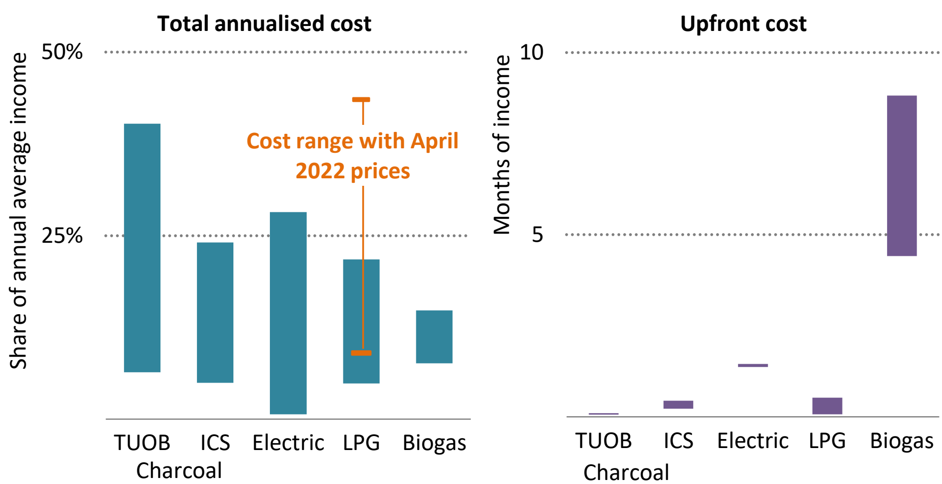
Managing affordability

Policies, measures and programmes to encourage switching to clean cooking fuels are needed to overcome many barriers. Of which, the most important is affordability of the cleaner fuels including the initial upfront costs. The best solutions and business models vary according to local circumstances. Upfront costs, particularly of stoves and related equipment, can represent a large share of monthly income for extremely poor sub-Saharan African households. For example, the price of an improved charcoal cooking stove typically represents on average around one-third of monthly income, half for LPG, about three-quarters for electricity and around six-times for biogas stoves and digesters[4] (Figure 3.9).

[4] Household biodigester systems require access to water and at least two to three head of cattle to be functional.

However, switching to modern cook stoves can pay back up to four-times the upfront investment within a year due to higher efficiency of the stove. For households that collect biomass, switching to an improved biomass cook stoves can save up to 60 hours per month spent on wood collection and cooking, providing women and children more time for working, studying or participating in community activities (Jagoe et al., 2020). But for some households, the initial cost is still a major hurdle, especially where there are few opportunities for women to make use of the freed time to earn money from other activities.

Figure 3.9 ▷ Annualised cost of cooking and average upfront cost as a share of income for extremely poor people in sub-Saharan Africa, 2020



Clean cooking solutions have higher upfront cost than using traditional charcoal, but the differential is paid back within a few months in most cases due to their higher efficiency

Notes: TUOB = Traditional use of biomass; ICS = the use of solid biomass in intermediate and advanced improved biomass cook stoves (ISO tier ≥ 1). Total cost includes upfront and fuel costs annualised over ten years. Electric cooking includes both traditional and induction hot plates. Biogas cost includes a basic stand-alone household digester, but excludes the production of bio-slurry that can boost agricultural production and/or avoid the need to buy commercial fertiliser. Traditional and improved fuelwood stoves are not shown as the fuel is often non-commercial and collected virtually for free, though they carry important hidden costs (IEA, 2017).

Clean cooking companies have adopted solutions to manage and spread upfront costs based on the PayGo business model for solar home systems by recovering their costs through instalment payments. This model has helped Kopagas, an LPG distributor in urban Tanzania, increase its sales rapidly in recent years. PayGo Energy and Envirofit's Smart Gas have enjoyed similar success in Kenya.

The cost of cooking with electricity ranges widely across African countries depending on electricity tariffs. In many cases, it is more expensive than other cooking solutions despite social or lifeline tariffs. However, encouraging the use of electric cooking can boost the sales and profitability of utilities and mini-grids operators, enhancing their ability to invest in expanding access and enabling them to propose lower tariffs. Gaining access with electric cooking, nonetheless, is likely to remain limited in rural households that lack a grid or mini-grid connection. Electric cooking devices require a large amount of instantaneous power supply compared with other appliances, ranging from 600 W for electric pressure cookers to 1.6 kW for induction cooking, requiring solar PV systems of 300-700 W when coupled with batteries suited to this use (Ifri, 2022). These levels of supply are higher than the SHS that are currently marketed in sub-Saharan Africa, which generally have a maximum capacity of around 200 W, and already represent an affordability burden to poor households. New high efficiency clean cooking appliances are being developed for this market, but they still have yet to hit price points that enable widespread adoption, without additional support.

Measures to support the transition to clean cooking solutions should be adapted to local circumstances, including the availability of fuels and requisite infrastructure, income levels and population density. Governments in sub-Saharan Africa have often subsidised clean cooking fuels, particularly LPG. However, in many cases these subsidies were poorly targeted and so benefited mainly wealthier customers in urban areas. They have often brought a huge burden on public finances, pushing some governments to phase them out, often also under pressure from bilateral donors looking to curb fossil fuel use. Many clean cooking programmes focus on providing stoves for free or at reduced prices with support from the government. However, a lack of training on the use and benefits of cooking with clean cooking stoves, higher fuel prices and supply problems have often stymied these programmes, highlighting the need for long-term and holistic strategies.

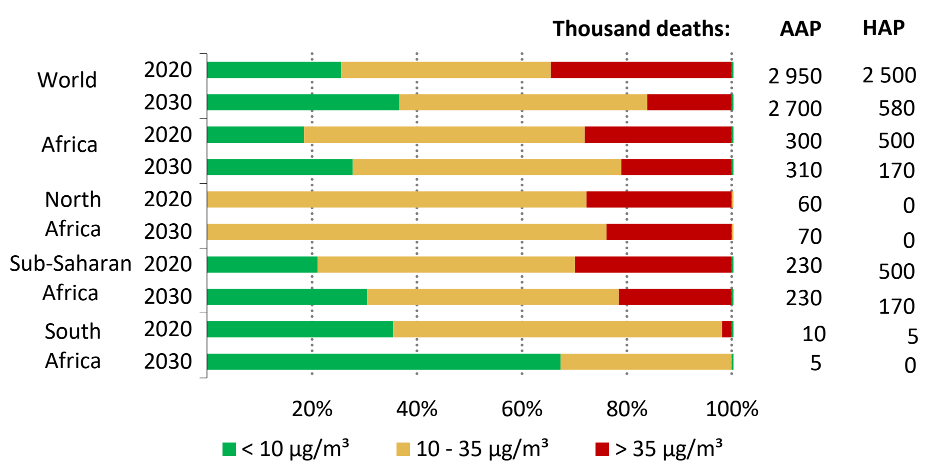
Strong government regulation of energy markets can contribute to boost downstream energy supplies for clean cooking, including the sustainable production of charcoal and other forms of biomass. Those strategies should also consider the risks associated with volatile fuel prices and avoid locking consumers into fuels they cannot afford. Stove and fuel stacking – the practice of households owning and interchangeably using traditional and clean cooking technologies – is very common in Africa, with households switching fuels according to availability and affordability. The extent to which households can do this depends on reliable fuel supply chains and diversity of fuel options. For instance, the price of a 6 kilogramme (kg) LPG cylinder more than doubled in a matter of weeks in Mombasa, Kenya during third-quarter 2021 while prices continued to increase in early 2022, forcing customers to revert to traditional biomass for cooking. Informal charcoal markets in urban areas can also experience radical short-term and seasonal price swings as sellers respond to swings in demand, including those caused by higher LPG prices. Food price inflation in the wake of the Russia's invasion of Ukraine is also exacerbating the situation in terms of affordability in Africa.

Health implications

Achieving universal access to clean cooking would bring major health and development benefits. Around 500 000 people in Africa died prematurely from exposure to household (indoor) air pollution and around 300 000 from ambient (outdoor) air pollution in 2020, making air pollution among the leading causes of premature deaths on the continent (Gouda et al., 2017; Fisher et al., 2021). Cooking with dirty fuels is the leading cause of indoor pollution in all African regions. Exposure to polluted air also has significant economic costs. The cost of premature death from air pollution, measured by loss of productivity, is estimated at almost 9% of Africa's GDP and more than 12% in some North African countries based on 2019 data (AUC and OECD, 2022).

In the SAS, exposure to high concentrations of fine particulate matter of 2.5 microns or less ($PM_{2.5}$) declines in all African regions in the period to 2030. This results in over 300 000 fewer premature deaths, of which over 85% are associated with improved household air quality due to clean cooking (Figure 3.10). Sub-Saharan Africa, where household pollution is most acute today, has the biggest gains. However, premature deaths from poor ambient air quality remain significant in 2030 in North Africa, largely due to pollution from vehicles and industrial processes.

Figure 3.10 ▷ Share of population exposed to $PM_{2.5}$ concentrations and premature deaths from air pollution in the SAS, 2020 and 2030.



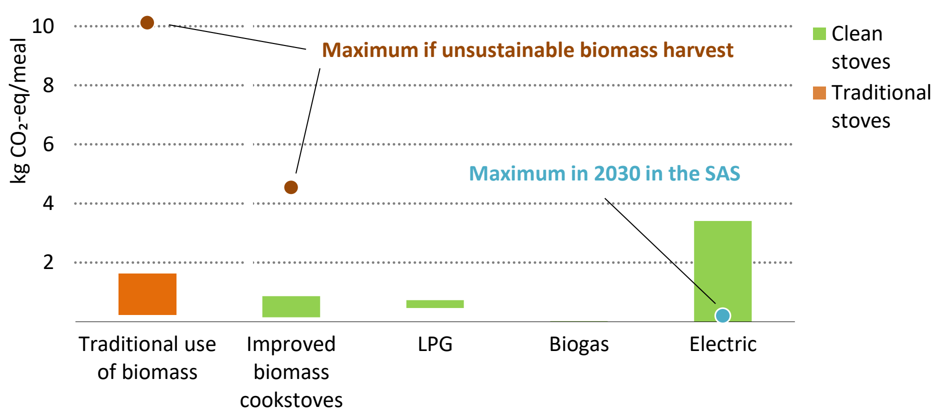
Universal access to clean cooking would sharply reduce exposure to particulate matter in all African regions resulting in over 300 000 fewer premature deaths in 2030

Notes: SAS = Sustainable Africa Scenario; AAP = ambient air pollution; HAP = household air pollution. $PM_{2.5}$ = particulate matter of 2.5 microns or less in width; µg/m^3 = micrograms per cubic metre of air.

Implications for climate change

Providing universal access to clean cooking across Africa would also reduce greenhouse gas (GHG) emissions. Cooking a meal with biomass on a traditional stove emits on average 1 kilogramme of carbon dioxide equivalent (kg CO_2-eq), but if fuelwood is harvested unsustainably emissions can be as high as 10 kg CO_2-eq. This means that, on average, traditional use of sustainably harvested biomass for cooking is around 60% more GHG emissions intensive than cooking the same meal using fossil fuel LPG and around 40-times more than using biogas (Figure 3.11). The emissions associated with electric cooking in Africa depend on the carbon intensity of the electricity supply and the efficiency of the stove used; they range from almost zero to more than two-and-a-half-times the average traditional biomass stove. For example, cooking a meal with an induction stove in Ethiopia, where electricity generation is dominated by hydroelectricity, emits far less than cooking with the same stove in Chad, where electricity generation is mostly based on fossil fuels. In the SAS, the average emissions intensity of electric cooking in sub-Saharan Africa drops to just 0.2 kg CO_2-eq per meal by 2030, around 50% lower than in 2020 and below many other options.

Figure 3.11 ▷ GHG emissions from cooking by fuel in Africa, 2020



Traditional use of biomass is on average more than 1.5-times as emissions intensive as LPG, but can be more than fifteen-times if the biomass is harvested unsustainably

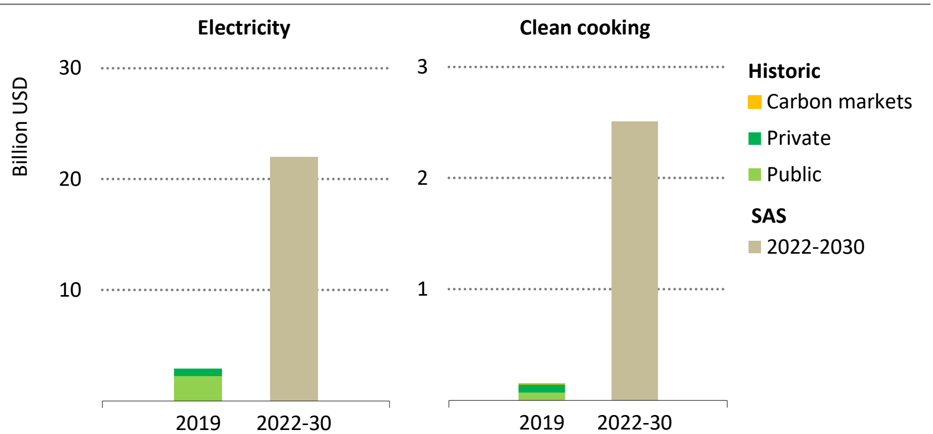
Notes: SAS = Sustainable Africa Scenario. Ranges reflect various stove efficiencies and conditions in each category. In the case of electricity, emissions also vary according to the emissions intensity of power generation and network losses. Traditional use of biomass and improved biomass cookstoves include wood and charcoal. Improved biomass cookstoves refer to ISO Tier 1 and above stoves. The upper range for wood and charcoal cooking includes emissions from charcoal combustion and emissions during its production in traditional earth kilns. Unsustainable biomass harvesting includes the CO_2 emissions from combustion (excluded in the case of sustainable biomass as it is considered renewable). LPG includes downstream emissions from combustion, production, transport and storage.

From a GHG emissions perspective, the relative merit of switching from traditional uses of biomass to clean cooking solutions depends on whether fuelwood is harvested sustainably, and in the case of charcoal also on the efficiency of kilns used for its production. For example, if 30% of fuelwood and charcoal originates from unsustainable sources switching away from a traditional wood fuel stove generates GHG emissions savings regardless of the chosen clean cooking solution, including fossil fuel LPG in basic and inefficient cookstoves.[5] LPG use can be further decarbonised by switching to bioLPG in the longer term. The effect on climate of moving away from the traditional use of biomass may be significantly greater than the estimates might suggest, as they do not include the effects of black carbon.

3.2.3 Investment and financing for modern energy access

Achieving full access to modern energy in Africa by 2030 would require investment of USD 25 billion per year – equal to around a quarter of total energy investment in Africa prior to the pandemic – but just slightly above 1% of total energy investment globally and comparable to the cost of just one large LNG terminal investment. Almost half of this investment would be in just five countries – DRC, Ethiopia, Nigeria, Tanzania and Uganda. Electricity connections alone require USD 22 billion per year in capital spending on grids (mainly distribution networks), generating plants and off-grid solutions. Clean cooking requires around USD 2.5 billion per year of investment in clean cookstoves and other end-use equipment. Current investment falls far short of these levels. In 2019, it amounted to just 13% of the average needs for 2022-30 in the case of electricity and 6% for clean cooking (Figure 3.12).

Figure 3.12 ▷ Average annual investment to extend access to modern energy in Africa in the SAS



An important increase in investment is needed to reach universal access to modern energy by 2030

Note: SAS = Sustainable Africa Scenario.

Sources: IEA analysis and SEforALL and CPI (2021).

[5] It is estimated that on average 27-33% of fuelwood in developing countries is currently harvested unsustainably, though the share is as high as 60% in some parts of East Africa.

Ramping up financial flows to provide modern energy access will require much stronger local government and international development support, including concessional finance. At the United Nations High-level Dialogue on Energy in September 2021, governments, private actors, international organisations, non-governmental organisations and other stakeholders committed a cumulative total of over USD 520 billion toward achieving the SDG7 goals by 2030. This represents a substantial increase on previous commitments, though some had already been announced and many do not directly address first-time access in developing economies. In Africa, only Ethiopia, Kenya, Nigeria and Zambia submitted a commitment to improve access to electricity and only Ethiopia, Kenya, Malawi, Nigeria and Rwanda submitted one for clean cooking.

Even if all these commitments are respected, finding the projects and facilities by which to disburse this finance in the next eight years will be difficult, especially given the limited number of projects that are ready to be financed. The increase in the activities of local green banks and micro-finance institutions across the continent will undoubtedly help support off-grid and clean cooking enterprises, but large government programmes administered by utilities and dedicated government agencies will also need to play an important role to reduce the perceived risks by creating an investment climate that is conducive to attracting private capital. Development aid could focus on reinforcing or creating rural electrification and clean cooking agencies by providing training and funding positions within these agencies, which are often understaffed. Funding the establishment of field offices in rural provinces can improve the standing of programmes among the local population, which may be mistrustful of centralised efforts.

3.3 Transforming the electricity sector

A profound transformation of the electricity system is central to Africa's clean energy transition. Africa needs to generate 575 terawatt-hours (TWh) more in 2030 than in 2020 to meet the increase in electricity demand projected in the SAS, an average rate of growth of 5% per year. Over the past decade, most of the increase in demand was met by natural gas, followed by hydropower. The increase in generation between 2020 and 2030 comes largely from low cost solar PV and other non-hydro renewables (see Chapter 2).

The projected trends in generation hinge on more flexible operation of networks to permit the integration of variable renewables and to improve the quality and reliability of electricity supply to enable customers to commit to grid services for power needs. Dispatch protocols need to be improved to make systems more efficient and better suited to manage high penetration of variable renewables. Distribution networks, which in many regions remain largely underdeveloped, are characterised by old equipment and technologies that need to be updated to improve stubbornly high network losses. As well as modernising domestic transmission and distribution networks, investment is needed to enhance interconnections between national and regional systems. Cross-border transmission interconnection projects are capital-intense investments that require careful collaboration and co-ordination among governments and utilities.

Financing these investments faces headwinds. Over half of sub-Saharan Africa's utilities currently are unable to cover their operating costs due to high network losses, under-pricing and poor revenue collection mechanisms. Many are facing the threat of insolvency. As a consequence, traditional regulatory frameworks are incapable of de-risking projects so as to attract international finance. There are many successful models of regulatory reform and power market restructuring in emerging market and developing economies that could be relevant in Africa. With the support of international financial institutions, African utilities must introduce measures to improve their balance sheets and attract more private sector participation in electricity networks, otherwise the transformation of the electricity system depicted in the SAS and the achievement of SDG7 targets will remain beyond reach.

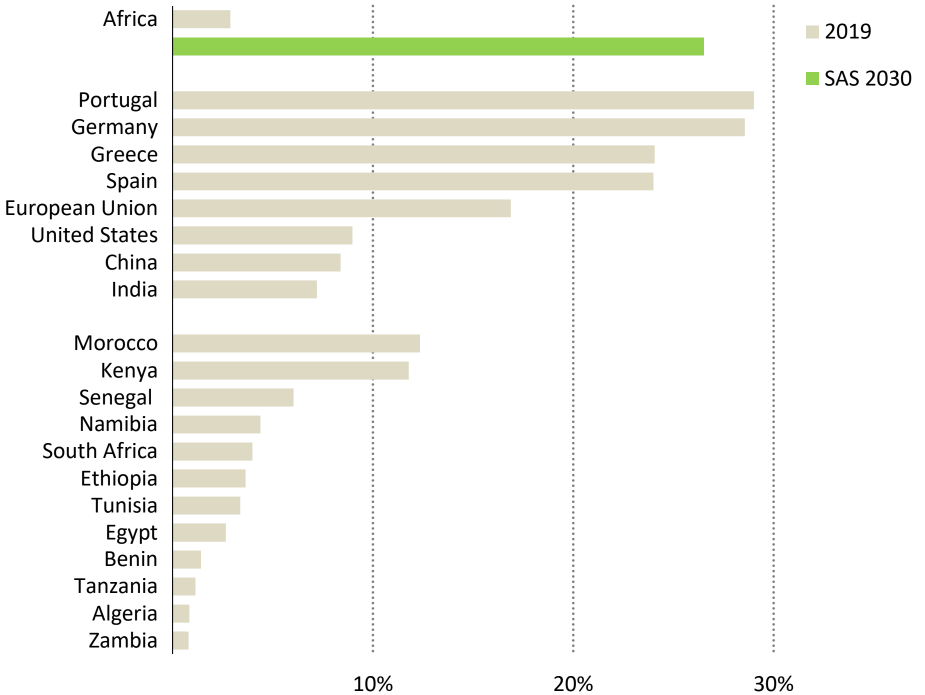
3.3.1 Integration of renewables and need for flexibility

Variable renewables comprise the bulk of the increase in electricity generation in Africa in the SAS, mainly solar PV and wind. Their combined share of total generation is rising from 3% in 2020 to 27% by 2030 (see Chapter 2). However, the deployment of variable renewables varies widely across the continent (Figure 3.13). The share of solar PV and wind is above 10% today in Kenya and Morocco, higher than in China, India and the United States. Integrating large amounts of variable renewables into the power system creates a need to provide more flexibility to accommodate increased variability of generation and ensure that sufficient generating capacity is always available, including when the sun does not shine or the wind does not blow.[6] In the SAS, national power systems are gradually integrated into increasingly interconnected regional power pools, consistent with the objectives of the African Union's Agenda 2063 (see Chapter 1).

A range of assets and measures are developed to support flexibility in the SAS, including energy storage, hydrogen electrolysis, hydropower facilities (including pumped storage), gas-fired power plants, geothermal plants and demand response (whereby consumers adjust their electricity consumption in real time in response to price incentives). Fossil fuel power plants accounted for almost 80% of flexibility sources for power systems in 2020, with hydropower accounting for most of the remainder. In the SAS, natural gas remains the leading source of flexibility in 2030, with an additional 25 gigawatts (GW) added on a net basis, accounting for a quarter of total installed capacity. Hydropower is the second-largest source of flexibility by 2030, overtaking oil. Geothermal and concentrating solar power (CSP) play an increasingly important role in generating baseload electricity, as well as boosting flexibility as a low emissions dispatchable form of generation. Battery storage starts to emerge, but plays only a minor role in 2030 before going on to play a much larger role in 2050. The location of these assets is region specific: hydropower, geothermal and CSP capacity is added where the resources and political will permits, while gas-fired plants are mostly built in gas-producing countries.

[6] Flexibility is broadly defined as the capability of a power system to maintain the required balance of electricity supply and demand in the face of uncertainty and variability in both supply and demand.

Figure 3.13 ▷ **Share of solar PV and wind in electricity generation in selected African and other countries in the SAS**

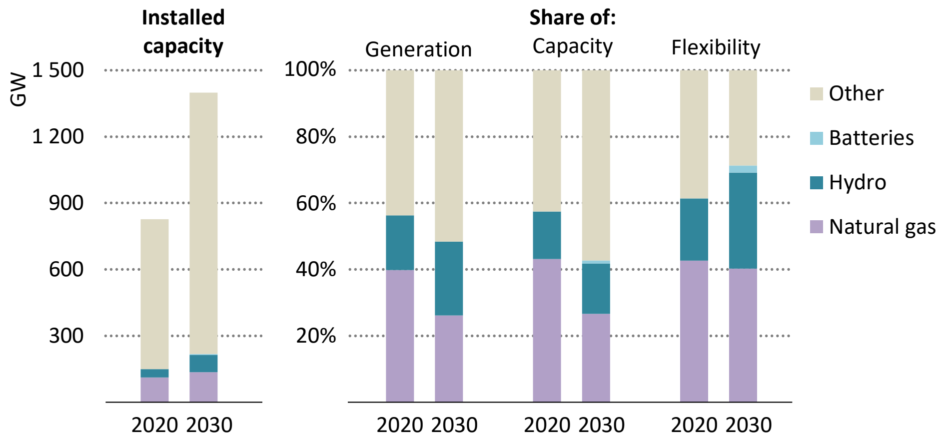


Share of variable solar and wind in total power generation in Africa jumps from 3% in 2020 to 27% in 2030 – close to levels in many parts of Europe today

Note: SAS = Sustainable Africa Scenario. Data shown here are from 2019 as the shares of solar and wind in 2020 were distorted by the effects of the Covid-19 pandemic.

Natural gas plays an important role in providing flexibility as well as producing electricity, with 30 GW of capacity (25 GW net) added through to 2030, 10% of all new capacity added during that period. It provides around 40% of total flexibility needs in 2030 (Figure 3.14). Gas-fired power stations are built near existing pipeline infrastructure to avoid the need to expand pipelines or build new ones that would not be needed later as fossil fuels are phased out. In regions with low levels of access to modern energy and new natural gas discoveries, such as Mozambique, gas developments can support industrialisation while helping to extend access to electricity. In West Africa, natural gas displaces heavy fuel oil to reduce costs and improve local air quality. New natural gas power stations are built to handle high blends of other clean gaseous fuels, such as biomethane or low-carbon hydrogen, aligned with new manufacturer specifications. New gas-fired plants are predominantly highly efficient combined-cycle gas turbines and have the flexibility to operate as baseload or as load-following plants, matching the evolving needs on Africa's electricity networks.

Figure 3.14 ▷ Electricity generation capacity and flexibility in Africa in the SAS



Gas remains the main source of flexibility in 2030, despite a drop in its share of total generation and capacity, and increasing contributions from hydropower and batteries

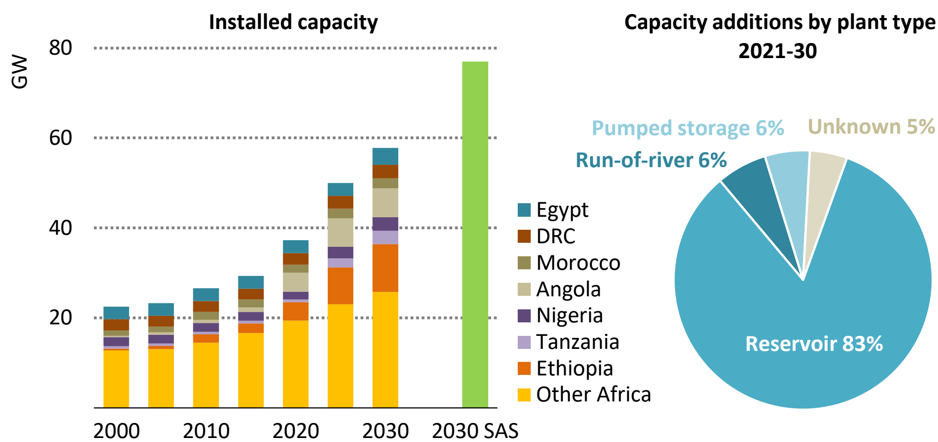
Note: SAS = Sustainable Africa Scenario.

Most natural gas use in Africa is at pre-agreed prices with set volumes from production facilities under long-term contracts designed to support growth in domestic consumption, so soaring international natural gas prices due to Russia's invasion of Ukraine should not cascade through into higher power prices. In the SAS, 80 billion cubic metres (bcm) of gas – equal to 30% of the region's gas production – is needed to operate its fleet of gas-fired power stations, down 5 bcm from 2020 thanks to efficiency improvements. If African gas production increases faster than projected in the SAS as a result of European efforts to reduce reliance on gas imports from Russia, the use of gas for domestic power generation could expand as well. However, expanding domestic use at sub-market pricing needs to balance against forgone market revenues and lending contingencies related to the removal of fossil fuel subsidies.

Hydropower is set to remain a major source of flexibility for Africa's power systems. It provided 16% of Africa's electricity output in 2020 with 90% of hydropower generation located in sub-Saharan Africa, mainly in Angola, DRC, Ethiopia, Mozambique and Zambia. In the SAS, hydropower provides a quarter of total flexible supply capacity in Africa by 2030 and its capacity doubles to nearly 80 GW. Large hydro projects are already in the pipeline in 15 countries, notably Angola, Ethiopia, Nigeria and Tanzania (Figure 3.15). Reservoir plants, which are more flexible in producing power and managing water flow than run-of-river plants, make up well over 80% of this expansion. This necessitates better co-ordination across jurisdictions to avoid geopolitical tensions on the management of watersheds that can slow the development of projects, as was the case with the Grand Ethiopian Renaissance Dam, which started operations in 2022 and could become Africa's largest hydroelectric project once completed in 2024. Where possible, pumped storage capacity is built along with the new dams, with projects planned in Egypt and Morocco. Run-of-river plants make up 6% of the hydro capacity expansion. With the exception of one large project in Uganda, these plants are less than 100 MW and concentrated in central and east Africa (IEA, 2021a).

Hydropower balances the provision of electricity supply and flexibility, along with their important role in managing irrigation, water supply and flood control. These functions become increasingly important as climate change makes drought and flood cycles more severe and persistent in parts of the continent. This, in turn, limits the availability of hydro for flexibility purposes: dams may need to run in by-pass mode during floods, when power production is at its maximum, leaving no flexibility, and may need to conserve water during droughts, limiting throughput. Harmonised flooding and drought management protocols, established in concert with all water users, are crucial to ensure the co-ordinated action of operators located in a shared river basin. Investment is needed to expand storage capacity and for technical improvements to improve resilience and optimise hydropower operations during extreme hydrological events (US DOE, 2021). In addition, operation and maintenance strategies need to be improved to enhance the reliability and operating performance of hydro plants: many plants today underperform or are falling into disrepair.

Figure 3.15 ▹ Hydropower installed capacity and additions by country and plant type in Africa in the SAS



Planned projects would boost Africa's hydro capacity to nearly 60 GW. An additional 20 GW is projected in the SAS, but requires accelerated approvals to come online by 2030.

Notes: SAS = Sustainable Africa Scenario. Capacity additions reflect announced projects to date.

Only small amounts of battery storage capacity are deployed before 2030 in the SAS. Batteries, often coupled with solar PV, support efforts to expand household access to electricity and the reliability of supply to key industries. They are also sited near large utility-scale solar and wind projects and critical transmission and distribution grid infrastructure. While batteries are extremely flexible, they cannot meet all flexibility needs, and at current price points, their use is limited to short-duration flexibility and providing storage in remote applications. However global price declines show promise in making batteries increasingly cost competitive. For example, we project that global average utility-scale stationary battery costs would fall from around USD 310/kWh today to about USD 180/kWh by 2030 assuming stated policies, and even further under more aggressive scenarios (IEA, 2021b).

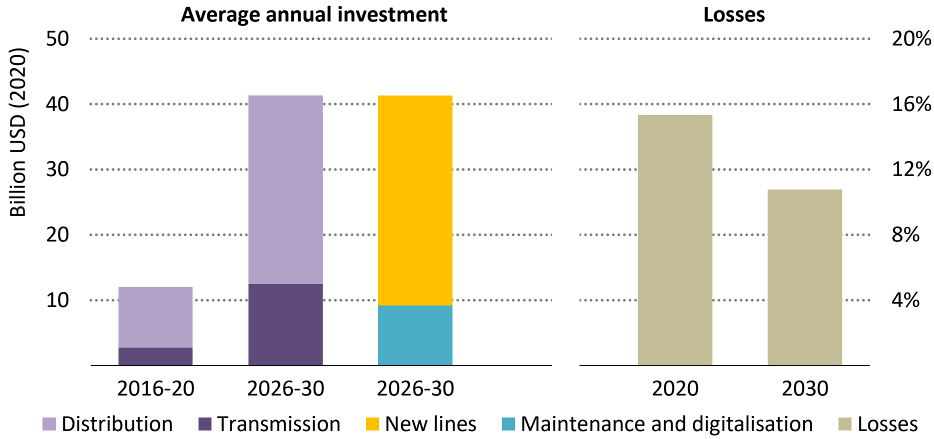
Demand response, a major source of untapped system flexibility in many other parts of the world, makes a very small contribution to flexibility to 2030 in the SAS. The first priority for Africa remains to increase reliability for end-users; today 80% of firms and close to 60% of households in sub-Saharan Africa face regular unplanned and lengthy outages. Load-shedding protocols for crisis management, as well as strong emergency dispatch procedures to minimise the worst adverse effects of blackouts and improve management of short-term supply shortages, need to be put in place urgently. Developing such programmes requires a substantial increase in dispatch centre capability – a current target area for development aid involvement and capacity building.

3.3.2 Grid investment

Massive investment in Africa's grids is critical to improve system reliability, expand access and facilitate the integration of variable renewables. Worsening financial difficulties experienced by many utilities are hampering investment in new transmission and distribution assets, resulting in a progressively obsolescent system. These problems are manifested in extremely high network losses, which averaged 15% across the continent in 2020 – almost twice the global average of 8%. Countries often lack tools to monitor the condition of the grids and to accurately assess the location, duration and cause of blackouts or brownouts (Box 3.3).

Annual investment in electricity grids more than triples in the 2026-30 period in the SAS compared with 2016-20, reaching USD 40 billion per year on average (Figure 3.16). Distribution networks account for over two-thirds of the total. With millions of new customers to be connected and increasing demand, investments are largely focussed on new lines and increasing grid density to support increased generation. Maintenance and modernisation of existing infrastructure represent almost a quarter of the total, helping to reduce losses by 30% in 2030 compared with 2020.

Figure 3.16 ▹ Average annual investment in electricity grids and network losses in Africa in the SAS



Network investment more than triples in the 2026-2030 period relative to 2016-2020 to meet rising demand, integrate distributed renewables, reduce losses and improve reliability

Notes: SAS = Sustainable Africa Scenario. Losses are calculated as the share of electricity injected into the grid lost during transmission and distribution.

Box 3.3 ▹ Using innovative tools to improve grid performance

Africa's power grids suffer from poor reliability and high technical and commercial losses due mainly to underinvestment and ageing infrastructure, though other factors such as overgrown vegetation (especially in remote areas), natural disasters, vandalism and theft contribute. Most utilities and system dispatchers are poorly equipped to deal with these operational problems due to a lack of real-time data, low visibility on grid status, limited automation of generation and grid equipment, and underdeveloped dispatch and operational codes. Digitalisation offers opportunities to address some of these difficulties cost effectively. Prominent measures include geographic information systems, outage management systems and smart metering (Table 3.1).

Digital innovation alone cannot solve all reliability problems: the focus must remain on addressing the root causes whether they are lack of monitoring, lack of resilience or lack of capacity. But some digital technologies are essential to improve reliability and are well suited to address the uniquely acute operational risks in Africa. For example, they can be very effective in monitoring critical infrastructure, which can be subject to cable and transformer theft and targeted attacks in conflict zones. Power companies across the world are increasingly turning to drones for surveillance. Coupled with artificial intelligence, drones are able to identify power line defects, such as rusted bolts and damaged cables, as well as internal faults using thermal imagery. Drones are also being used to undertake light maintenance and repair operations such as burning rubbish off power lines and trimming overgrown vegetation. They can help cut labour and maintenance costs, reduce response times in emergencies and boost revenues by preventing costly and frequent power outages, especially in the case of utilities that cover large service areas with limited means of conducting inspections in person.

Table 3.1 ▷ Selected measures to improve grid reliability in Africa

Target outcome	Measures	African countries implementing measures
Improve grid maintenance	Install monitoring, optimisation and automation tools.	**Ghana**: GIS, outage management system, automation and control on medium voltage lines, resulting in a 15-fold reduction in the number of hours of average outage duration for each customer served in Accra.
	Install computerised maintenance management system.	**Ghana:** Use of management software since 2017 to collect data digitally, with built-in data validation.
Enable real-time and secure data exchange	Install smart sub-stations.	**Senegal**: First fully digital high voltage substation on the continent commissioned in September 2021. **DRC**: Plans to install an automated substation and associated distribution systems, communicating with digital prepaid meters for 1 million clients in Kinshasa.
	Upgrade transmission lines and add fibre optic cable.	**Ethiopia**: 1 600 km of fibre optic cable added to transmission lines for an optical switching network. **Kenya**: Fibre optic cable network deployed along transmission lines, both for communication between generation and control centres, and to provide internet connectivity.
Reduce losses and increase payment collection	Install smart meters to distribution feeders and transformers.	**Benin**: Plans to roll out 40 000 smart meters and an energy prepayment management platform for consumers in Cotonou, aiming to reduce losses by 5-10% and billing errors. **Kenya**: Kenya Power plans to install smart meters at 1 300 distribution feeders, 73 000 distribution transformers and 600 000 large consumers, aiming to bring in additional revenue of USD 627 million over eight years.
Increase quality of supply	Enable mini-grids to operate in grid-connected areas.	**Nigeria**: A hybrid mini-grid is operated by a private developer in agreement with the local utility, providing uninterrupted power supply to 2 100 shops in a market near Abuja that previously relied on backup generators.
	Install digitally managed battery storage on grid.	**South Africa**: Eskom deploys digital storage systems to better dispatch renewables-based generation and reduce fossil fuel generation used at peak load.

Notes: GIS = geographic information systems. A distribution feeder is a conductor connecting a substation or decentralised generating plant to the area where power is to be distributed.

A growing number of African utilities are using drones for grid surveillance and inspection, monitoring and analysis of defects or planning to do so. Côte d'Ivoire is to train 20 pilots to cover the country's 25 000 km of high voltage transmission lines, while its Drone Academy is open to other West African utilities, agriculture and mining companies. Ghana and Kenya plan to use thermal-based tools with drones for routine inspections to locate hotspots on the grid, and other drones to monitor the completion of infrastructure works, manage vegetation and plan the construction of new lines using digital terrain modelling. However, the wider adoption of drones is constrained in several countries by restrictive regulations, with military or civil aviation authorities forbidding or strictly supervising their use.

Increased investment in cross-border electricity transmission infrastructure between African countries could play an important role to ensure reliability. We assume an acceleration of regional integration in the SAS, with national systems gradually integrated into regional power pools and increased cross-border trade. Power pools play a vital role as they aggregate multiple sources of supply, including high levels of variable renewables, and loads over a larger area, pooling supplies and enhancing flexibility. This makes system balancing easier by taking advantage of various supply sources, which can complement each other to the extent they have different production profiles or face varying weather conditions, to meet different demand patterns across the pooled supply area. Today there are five power pools at various stages of development in Africa. Some are encountering problems, but others, including the Western African Power Pool, are proving successful (Box 3.4).

Box 3.4 ▻ Western African Power Pool

The nature of power pools is that they connect a number of areas, which may be at various levels of development, both in grid infrastructure and operational protocols and in their generation mix.

The Western African Power Pool (WAPP), created in 1999 by the Economic Community of West African States (ECOWAS), is bringing together disparate national systems into co-ordinated power trade with the aim to improve reliability and reduce costs.

Technical integration of the fourteen member countries covered by WAPP is almost complete.[7] In 2021, new transmission lines reached Guinea and Sierra Leone, leaving only Gambia, Guinea Bissau and Liberia to be connected, which is due to occur by end-2022. While the interconnection process is underway, there are requirements to train operators and to align operational codes before all areas can be brought together in a single, synchronised grid. WAPP still operates with three different synchronous zones, partly to avoid poor reliability in some areas cascading over into others. Bringing all grids into a synchronous interconnected network offers a substantially better flexibility and cost-efficiency profile than operating them separately.

WAPP's initial focus is to create a regional electricity market, which is progressing in three phases. Launched in 2018, the first phase involves the negotiation of bilateral contracts

[7] Cabo Verde, an island country, is the only ECOWAS member not involved in the WAPP initiative.

for electricity supply. Phase two will involve the introduction of energy trading in a day-ahead market in parallel with bilateral agreements, and phase three the introduction of intra-day trading. WAPP is considering adding ancillary service markets at a later stage. Interconnected WAPP countries exchanged 6 TWh in 2020, or 8% of total power generated. Trade is expected to double by 2025.

WAPP has already led to improvements in reliability thanks to the pooling of available generating resources, especially hydropower plants where output varies markedly by season and country. In each member country, between 20% and 50% of installed capacity is unavailable on average on a given day. In the long-run, enhanced interconnections will reduce the total amount of new capacity needed in the region, especially for flexibility. WAPP plans to build interconnections with the north of Africa through Morocco and with the Central African Power Pool, where a major hydropower project at Inga in DRC is planned.

In June 2021, the African Union launched an initiative to develop what could become the world's largest single electricity market known as the African Single Electricity Market (AfSEM). AfSEM aspires to be operational by 2040 and will be supported by a Continental Power System Masterplan.

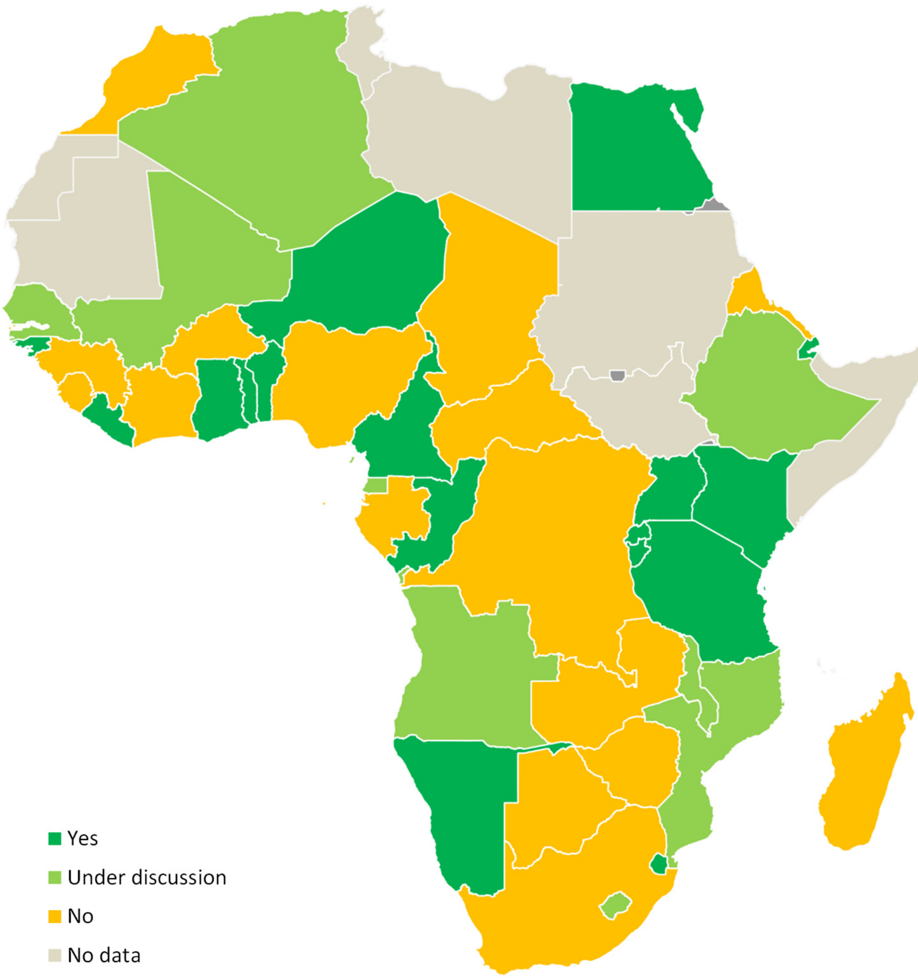
Note: This box was prepared in collaboration with Dr Mawufemo Modjinou and Mr Sié Kam of the WAPP.

3.3.3 Market reforms

Public utilities will need to be responsible for much of the investment in upgrading the electricity systems across the African continent. This is a daunting prospect, given their perilous financial state today: operating losses among all African utilities are thought to have exceeded USD 150 billion in 2020. Poor payment collection rates, theft, cost increases (including the cost of capital), operational problems and supply chain constraints are reducing cash flows and driving up debt. Priority areas for action include tariff structure reform, the use of concession agreements granting rights to private operators, regulatory carve-outs for private sector investment and ownership, and the introduction of auctions and competitive tenders.

Reforms to make electricity tariffs cost reflective has been implemented or is under discussion in 24 African countries, often at the behest of multilateral development banks, which have included such reforms as a contingency for lending. These reforms are intended to reduce operating losses and target subsidised tariffs to customers most in need. However, reforms started prior to the pandemic have been delayed as governments seek to protect households hit by rising poverty. They are becoming even more urgent for utilities to avoid defaulting on their loans in the face of rising costs, but also more precarious politically. International support is likely to be critical to get these reforms back on track. Planned reforms are assumed to be implemented and subsequently extended to all countries in the SAS, with the process being completed in all regions by 2035. This brings the combined operating losses of African utilities down by more than 70%, from just over USD 150 billion in 2020 to less than USD 50 billion (in real terms) by 2030. Around two-thirds of this improvement is related to subsidy removal, while about one-third results from higher electricity sales.

Figure 3.17 ▷ Status of cost-reflective tariff reform in selected African countries, 2021



Cost-reflective tariff reform has been implemented or underway in 24 African countries, with pressure from international lenders to implement fully, as envisioned in the SAS

Notes: 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. Under discussion is defined as having a completed cost of service study within the last five years or having an active design of policy documents underway.

Sources: AfDB Electricity Regulatory Index for Africa (2021).

Introducing more competition in electricity supply and attracting more private investment is being explored in several Africa countries. Today, some utilities are called on to build new generating plants through unsolicited proposals and sole sourcing under power purchase agreements, which in some cases has led to over procurement, over pricing and graft. Governments have been forced to step in to renegotiate these contracts in some instances, which has unnerved private investors. Although private participation in generation in Africa has been increasing gradually, Zambia is the only country where private sector operators are represented in generation, transmission and distribution. Analysis shows that where private sector participation is allowed, private operators outperform their public counterparts across a range of technical and commercial indicators (Grids4Africa, 2021). While the benefits of private participation are clear, public concessional finance, most likely from development finance institutions and multilateral development banks, is likely to be necessary to de-risk projects, particularly in the early stages.

Auctions for new capacity have proven to be effective in bringing down supply costs, notably for utility-scale renewables projects, e.g. Ghana. This approach, combined with improved integrated resource planning, can lead to lower costs. Other models to introduce competition and private sector participation include concessions and regulatory carve-outs that allow other grid or mini-grid operators to build and operate assets within utility territories under certain conditions. This and other models are being explored in Nigeria, which has some of the least reliable electricity services in Africa. Private companies operating networks under a concessional arrangement with the utility have proven successful in Uganda, where Umeme, a private company, has an arrangement with UEDCL, the public utility, to operate almost all of the country's distribution networks.

3.4 Changing role of energy resources

Africa is endowed with abundant natural resources of energy and minerals. They include fossil fuels, exports of which have been an important source of income and a driver of economic growth for decades, and critical minerals, which are vital to many clean energy technologies such as batteries, solar panels and wind turbines. Plus, it is rich in renewable energy resources, e.g. bioenergy, solar and wind. Solar and wind power could be transformed into hydrogen to serve energy demand in Africa as well as to generate income through exports.

The SAS poses some unique challenges and opportunities for Africa with respect to its energy-related resources. As countries look to develop their fossil fuel resources to meet rising domestic demand and generate export revenue, the declines in long-term global demand for fossil fuel imports projected in the scenario mean countries need to carefully plan how to manage the risks of volatility and uncertain income streams. The SAS also projects a huge rise in demand for new energy-related commodities and hydrogen; the key challenge becomes how to mobilise investment into these resources on a large scale. How Africa navigates the challenges and opportunities will have major implications for energy trade and for energy transitions in Africa and the rest of the world.

3.4.1 Prospects for fossil fuels

Balancing recent price surges with long-term uncertainty over demand

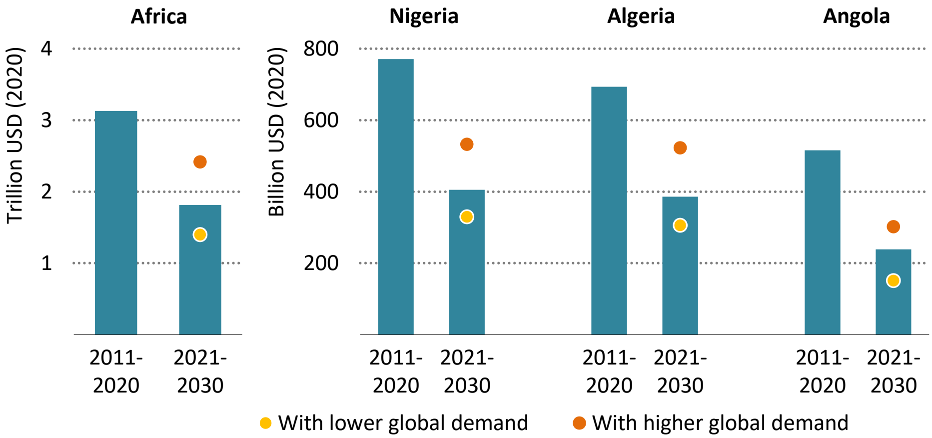
African countries that have ample resources rely heavily on revenues from hydrocarbon exports to fuel their economies. Recent commodity price increases mean that these countries are seeing much higher income from fossil fuels exports. Many of these producers, as well as new and emerging entrants such as Mozambique, Tanzania and Uganda, are looking to develop new resources and to expand export infrastructure. A major additional push comes from efforts by European countries to reduce their reliance on fossil fuel imports from Russia and the potential for shortfalls in global fossil fuel production given sanctions and embargoes on Russia.

A key challenge for producers in Africa is to attract capital for resource developments. While current high prices should help these efforts, institutional investors, banks and development financial institutions are becoming more reluctant to commit large amounts of capital to big and long-lead time projects and an expanding number committing to divest away from fossil fuels. The fact that oil and gas investment in Africa mainly has been driven by large international oil companies (IOCs), rather than national oil companies or local private companies, also weighs on the prospects for attracting capital as IOCs are generally more proactive in recalibrating their portfolios in the face of growing calls for faster energy transitions.

New large projects approved for development will typically take many years to come online. In addition, developers in the region have a mixed record of delivering large and complex projects on time and on budget. This presents a risk for exporters, especially for new and emerging producers. If energy transitions accelerate, newly approved projects may enter the market as demand and prices are falling and they could struggle to recover their upfront development costs.

The SAS highlights the risks for existing and new producers in a world that takes firm action on GHG emissions reductions. In this scenario, cumulative oil and gas revenues in Africa between 2021 and 2030 would be over 40% lower than in the 2010s (Figure 3.18). Revenues could be higher if the world keeps current climate policy settings but would fall even more if energy demand in the rest of the world slackens quicker on the back of accelerated action to reach the goal of net zero emissions by 2050. This would have major knock-on impacts on government expenditure, external debt and macroeconomic and political stability. The impacts could be particularly damaging in countries where governments have taken on more of the upfront risk to attract investment in major projects in contractual arrangements.

Figure 3.18 ▷ Cumulative oil and gas revenues in Africa and selected African countries in the SAS



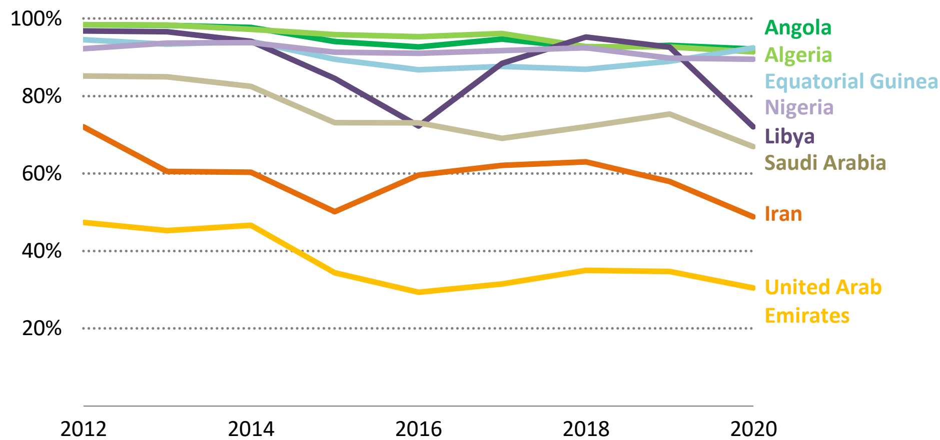
Without rapid economic diversification, global energy transitions could take a heavy toll on the revenue of major oil and gas producers

Notes: Revenues are the total proceeds to oil- and gas-producing companies from domestic sales and exports. Higher global demand corresponds to an energy trajectory that reflects current policy settings based on existing and announced policy measures by governments around the world. Lower global demand corresponds to an energy trajectory consistent with achieving global net zero energy-related CO_2 emissions in 2050 (assuming unchanged demand in Africa).

The risks of loss on new project developments and declining hydrocarbon income for many African producers highlights the importance of diversifying their economies. There are few signs that African producers are moving in this direction. In many cases, the share of hydrocarbons in their total product exports has barely changed over the past decade (Figure 3.19). Even where the share has declined, such as in Libya, this is mainly due to falling production rather than major strides in economic diversification. Periods of high commodity prices that buoyed government spending in the early 2010s had only a limited impact on diversification in most producer countries in Africa, in contrast to the progress made by several producers in other regions.

The current surge in fossil fuels prices has led to a new wave of interest in developing large-scale fossil fuel infrastructure in Africa. But, as illustrated in the SAS, if global energy transitions accelerate, producer economies could be faced with the prospect of a deterioration of the financial health of state-owned companies, harder access to private capital, and flagging export sales and tax revenues. Economic diversification efforts need to go hand-in-hand with mechanisms to guard against the impact of price volatility on future revenue streams. Some countries have set up sovereign wealth funds to smooth out the use of hydrocarbon income. Other countries may choose to use their revenues to reduce debts or invest in social infrastructure. All producers must balance competing spending priorities to meet both short-term fiscal goals and long-term diversification objectives. Fundamental changes to the development model of African producers look increasingly unavoidable, perhaps more so than at any other point in history.

Figure 3.19 ▷ Share of fossil fuels in total product exports in selected producer economies



Progress on economic diversification has been extremely slow in Africa compared with major producer economies in other regions

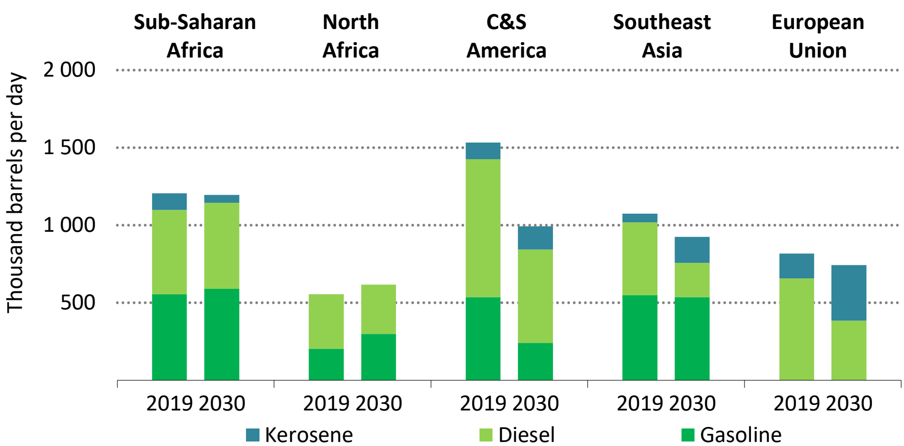
Source: IEA analysis based on UNCTAD (2022).

Strategic imperatives for oil infrastructure

Despite the weak outlook for oil production in Africa in the SAS, projected consumption trends do not follow the same trend, with domestic demand for oil products – mainly gasoline, diesel and LPG – increasing by 30% between 2020 and 2030. Due to its weak refining system, sub-Saharan Africa becomes the world's largest importer of transport fuels (Figure 3.20). This would justify investing in new refineries in the region, but mobilising the huge investment required to build new capacity is a daunting task given the difficult business environment and ample refining capacity elsewhere in the world. Moreover, the Covid-19 pandemic has increased pressure to rationalise refineries, especially those that are less efficient and not able to meet tighter fuel quality requirements. For these reasons, several refineries in Africa, such as in South Africa, Zambia and Nigeria, have closed despite growing domestic demand. Cameroon's only refinery, which shut in 2019 after a fire, remains offline as it has been unable to secure financing for repair work.

A strategic approach is needed to reduce the burden from growing imports of refined products in African countries. In general, there may be a need to tailor investment to the dynamics of the transition, focussing less on large-scale, complex greenfield projects and more on smaller, essential upgrades given refiners' limited cash flow and working capital. A number of small-scale refinery projects have recently been proposed, for example in Nigeria, Congo and Equatorial Guinea. It is estimated that producing cleaner, low sulphur fuels across the continent would require USD 16 billion in investment in refinery upgrades (ARDA, 2021).

Figure 3.20 ▻ Net imports of transport fuels in selected regions in the SAS



Import requirements for transport fuels remain high in sub-Saharan Africa, making the region the world's largest importer

Notes: C&S America = Central and South America. Data shown here are for 2019 as trade in 2020 was distorted by the effects of the Covid-19 pandemic.

Higher imports are not necessarily problematic especially if excess products are available at relatively lower prices on the global market, as is the case in the SAS. However, consumers in Africa do not benefit fully in that scenario due to the lack of distribution pipelines and storage infrastructure, which keep delivered prices high. There is, therefore, a case for strengthening midstream infrastructure such as ports, storage terminals and pipelines (Box 3.5). Midstream infrastructure generally involves less capital and, by serving domestic markets, is less at risk of being stranded by lower global demand as a result of the clean energy transitions.

Box 3.5 ▻ Investing in oil midstream infrastructure in sub-Saharan Africa

Given that sub-Saharan Africa is likely to rely on imports to meet its growing appetite for oil products, attention is increasingly being paid to the storage and distribution infrastructure needed to deliver products to consumers. Existing capacity – ports, onshore depots, tank farms and pipelines – is generally old and must be upgraded and expanded to ensure cost-effective delivery. Major improvements are needed all along the supply chain. For example, it is estimated that increasing the minimum depth of key

African ports to 14 metres (to allow medium range tankers to berth) would save up to USD 15 per tonne of imported products, with additional environmental benefits. For a country like Nigeria, which imported about 21 million tonnes of gasoline, diesel and kerosene in 2021, the benefits would be enormous.

Distribution systems, including pipelines and rail transport, are also needed to replace road trucks, in order to reduce overall transport costs and enhance safety. Several pipeline projects are under review, for example, between Bolgatanga in Ghana and Bingo in Burkina Faso, and the Djarmaya pipelines in Chad. Expansion of inland storage depots is also vital, especially for land-locked countries such as Burkina Faso, where key depots are being expanded and new ones are being built, and pipelines to Côte d'Ivoire and Ghana are planned. West African countries, including Ghana, Nigeria and Senegal, also need to upgrade their coastal LPG terminals, bottling and transport infrastructure to serve their growing domestic markets.

There is also a need for an integrated and coherent regional roadmap for midstream oil product infrastructure. Sharing of storage and distribution infrastructure among coastal and land-locked countries is instrumental in the seamless delivery of products continent wide. However, the lack of harmonisation in product specifications, pricing, tariffs, subsidies, and regulations on smuggling and fuel adulteration are hampering investment and causing higher prices to consumers. For example, Africa currently has more than 10 different fuel quality standards for sulphur in diesel ranging from 10 to 10 000 parts per million (ppm) and for gasoline ranging from 10 to 2 500 ppm. Also, infrastructure planning is generally confined to a national boundary, leading to inefficiencies when products pass through multiple countries to end-users and bottlenecks occur due to inadequate investment at certain points along the route.

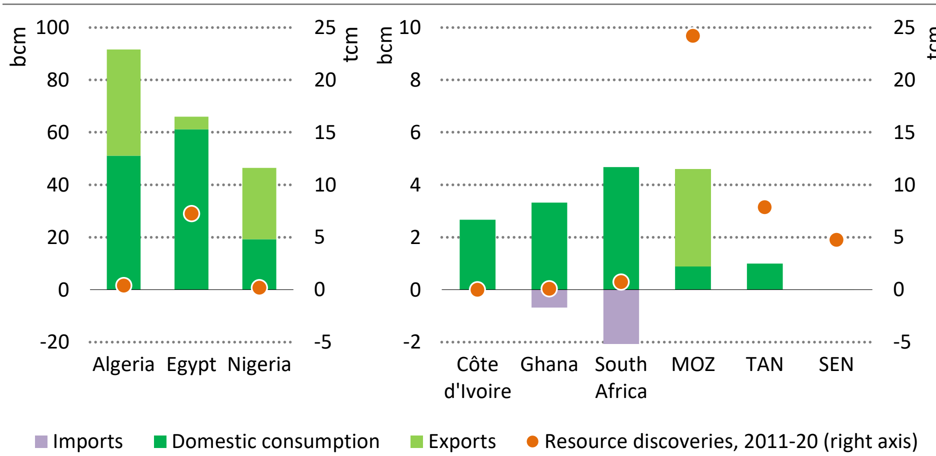
Note: This box was prepared in collaboration with Mr Anibor Kragha of the African Refiners and Distributors Association.

Utilising natural gas resources

The continent's large resource discoveries over the past decade provide an opportunity for natural gas to play an expanded role in Africa's energy system. More than 5 000 bcm of natural gas resources have been discovered to date in Africa that have not yet been approved for development. These resources could provide an additional 90 bcm of gas a year by 2030. Cumulative CO_2 emissions from the use of these gas resources over the next 30 years would be around 10 Gt — around four months of global emissions from the energy sector today. Africa's share of cumulative energy-related CO_2 emissions from 1890 to today is around 3%. If the cumulative emissions from burning this gas over the entire lifetime were added to Africa's current contribution, it would raise Africa's share to just under 3.5%. However, there is a risk that new projects with long lead times could struggle to recover their upfront costs if the world is successful in bringing down gas demand in line with reaching net zero emissions by mid-century.

From now to 2030, domestic demand accounts for two thirds of production. Increased use of natural gas could help displace costly oil products, especially diesel and heavy fuel oil, and meet the needs of industry and the power sector as a flexible and dispatchable source of electricity generation to complement renewables, though the economics of switching to gas vary by their sources and costs of transport. Natural gas demand in Africa rises through to 2030 in the SAS, with industry, including fertiliser, steel, cement and water desalination, contributing increasingly to growth over time, but in sub-Saharan Africa, demand for power generation also grows notably during this time frame. Yet there are major barriers to stimulating demand, including the relatively small size of individual markets, which makes it difficult to achieve economies of scale, and the lack of creditworthy off-takes, which weakens the case for investing in capital-intensive, long-lived infrastructure. There is also increasing competition from renewables in power generation and from electricity in end-use sectors, including industry.

Figure 3.21 ▷ Natural gas demand, supply and resource discoveries in selected African countries, 2020



Prospects for natural gas vary across Africa depending on the existing energy mix, resource endowment and policy ambitions

Note: bcm = billion cubic metres, tcm = trillion cubic metres; MOZ = Mozambique; TAN = Tanzania; SEN = Senegal.

Broadly there are three main groups of countries in Africa with regard to prospects for natural gas (Figure 3.21). The first group includes Algeria, Egypt and Nigeria, where natural gas is a mainstream source of energy. Natural gas consumption has risen in line with production growth in these countries. The main objectives here are to stem the declines from maturing fields and maintain production levels in order to meet domestic demand and generate export revenues. The second group includes countries such as Côte d'Ivoire, Ghana and South Africa that envisage a larger role for gas in their energy mix using either domestically produced gas or imported liquefied natural gas (LNG). However, the creditworthiness of off-takers remains a major barrier in attracting investment in import terminals (primarily floating storage and regasification), pipelines and gas-fired plants, in addition to all the risks associated with complex commercial and contractual structures.

Putting in place a structured process to address the precarious financial state of power generation and natural gas distribution companies will be crucial in these countries as investors are wary of committing capital to projects with poor payment performance and unpredictable tariff schemes. There is also a need to broaden attention from focussing solely on power generation to targeting a wider set of industrial customers as they are set to drive future demand growth and in general are more creditworthy. A more strategic approach to infrastructure investment is also called for, involving clusters – mixed power and industrial zones near resources or import terminals – to lower risks and exploit economies of scale. The relative economics of gas pipelines and electricity grids also need to be assessed carefully on a case-by-case basis as they vary depending on local circumstances. Gas-to-power projects have also been gaining traction in recent years, appealing to buyers that lack the financial resources to build large-scale regasification infrastructure. Regional co-operation is key to overcoming the small scale of individual national markets.

The third group is made up of countries such as Mozambique, Senegal and Tanzania that aim to develop their massive resources with large, export-driven LNG projects. The recent surge in fossil fuel prices has intensified interest in delivering approved projects as quickly as possible and developing a new wave of projects in these countries. Financing for new projects is still a challenge, since most are either debt-financed by banks or export credit agencies domiciled in countries with net zero emissions targets or equity-financed by IOCs with similar climate goals. Optimising costs, avoiding schedule delays, expediting time-to-market and reducing supply chain emissions are prerequisites for new African LNG projects to secure financing.

There is an opportunity to channel finance into developing a local gas market through domestic market obligations on LNG export projects, which could help make revenues less vulnerable to volatile global market conditions. This approach has been used in a few established exporters, such as Angola or Nigeria, with mixed success. A careful balance needs to be struck between the risk perceptions of international investors and the interests of host governments in providing affordable gas to nurture domestic industries. Mozambique LNG, which involves the largest project financing in African history so far, has an obligation to supply 0.7 million tonnes per annum (Mtpa) to the domestic market once the terminal is operational. Despite this guaranteed supply, initially proposed gas-to-liquids, fertiliser and power projects have all been shelved due to difficulties in reconciling various stakeholder interests. Given the intense competition in global markets, monetising gas resources may require multiple routes, balancing domestic outlets and export volumes, and tailored infrastructure expansion plans.

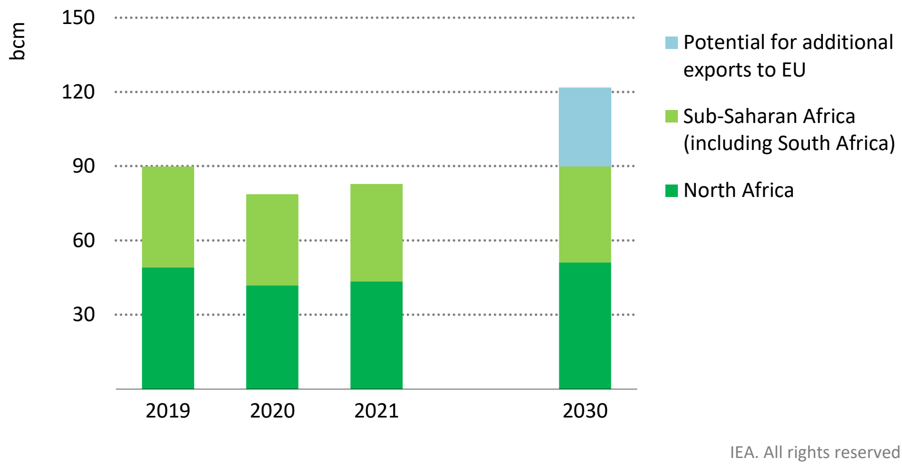
Box 3.6 ▹ Can Africa fill a potential supply gap stemming from Russia's invasion of Ukraine?

Russia's invasion of Ukraine has prompted many countries to seek to reduce their reliance on Russian resources, including energy. The European Union announced a plan to reduce Russian natural gas imports by two-thirds by end-2022 and halt deliveries well before 2030. This may present an opportunity for African producers to fill the gap and help diversify sources of gas supply to Europe, though the call on African gas will be affected by other measures, including energy efficiency, renewables, behavioural change and LNG volumes from other regions (IEA, 2022a). Countries in North Africa are well placed to benefit in the near term given their existing export infrastructure. Eni recently signed a deal with Algeria to gradually increase exports by an additional 9 bcm in 2023-24 via the TransMed pipeline and another with Egypt to provide LNG volumes of up to 3 bcm in 2022. If fully implemented these deals will increase gas flows from Africa to Europe in the short term, but there are question marks on the ability of these countries to sustain higher exports in the longer term given the lack of new supplies from mature fields and the priority given to domestic demand. LNG projects that are slated to start in the coming years, such as Greater Tortue Ahmeyim LNG in Mauritania and Senegal, could also provide additional volumes to the European Union. Increasing exports further would require investments in new projects given the limited spare capacity of existing exporters.

If the European Union is successful in halting all Russian natural gas imports by 2030 and Africa fills 20% of the shortfall this creates, it would increase the call on African gas by 30 bcm, or one-third, in 2030 in the SAS (Figure 3.22). The potential for additional exports to Europe could give renewed momentum to numerous LNG projects that have been delayed or stalled for many years. Eni is trying to fast-track the development of its long stalled Congo-Brazzaville floating LNG project, while other IOCs, which recently decided to exit from Russia, are also reviewing a number of LNG projects in Africa.

The longer term potential for Africa to meet additional natural gas needs from Europe would be smaller with the decline in gas use implied with achievement of its ambitious decarbonisation targets. The European Union's need for additional African gas would gradually decline after 2030. This prospect complicates investment decisions as it would oblige new projects to find non-European export markets that are set to continue to grow in the longer term in parallel with European buyers in order to secure project financing. Expediting project development schedules and avoiding delays would, in any case, be essential for new African projects to get the go-ahead, as there are competing projects in other regions. And any near-term windfall from additional export volumes and higher prices does not reduce the need for transparent and effective revenue management to support long-term economic diversification.

Figure 3.22 ▷ Natural gas exports from Africa and potential for additional export to the European Union in the SAS



Europe's efforts to reduce imports from Russia could increase the call for African gas by 30 bcm in 2030, but the potential diminishes in the longer term

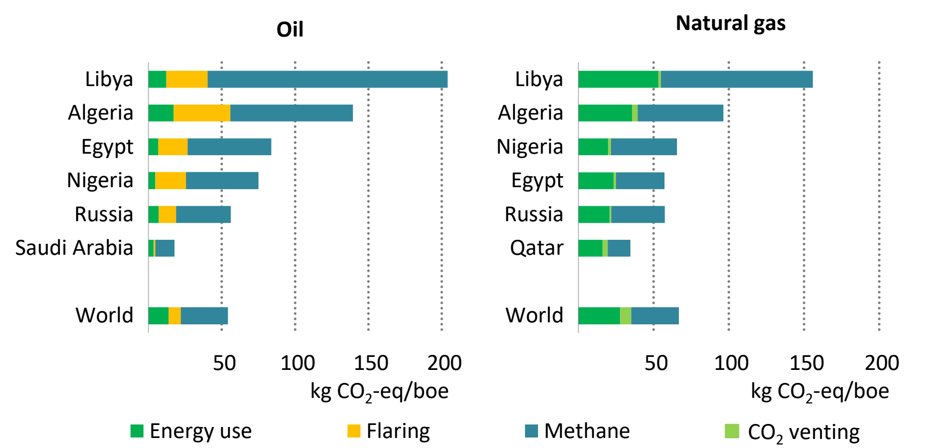
Notes: EU = European Union. Additional export potential is based on the assumption that Africa fills 20% of EU import needs as a results of halting Russian gas imports by 2030.

Cutting the emissions intensity of oil and gas operations

Reducing the GHG emissions footprint of oil and gas operations is becoming an important factor in attracting investment given increasing scrutiny of the environmental impact of imported commodities and goods in major markets. African producers' reliance on exports, particularly to Europe, means that it is affected by the tightening regulatory environment the energy transition brings. This poses a threat to them, as the GHG emissions intensities of oil and gas production in Africa are among the highest in the world, especially in North Africa (Figure 3.23). Above-ground operational practices – methane leakage and flaring – are responsible for the majority of these emissions. Reducing methane emissions is particularly important, as methane is a much more potent GHG than CO_2. According to the latest IEA estimates, the combined methane emissions of African oil and gas producers amounted to around 10 million tonnes in 2020, approximately 12% of global emissions (IEA, 2022b). Besides the environmental damage caused, these emissions represent an enormous wasted economic opportunity. We estimate that the current abatement potential amounts to around 10 bcm, around 14% of today's natural gas output in sub-Saharan Africa.

The good news is that there are ample, cost-effective opportunities to reduce these emissions. We estimate that almost 45% of global methane emissions could be avoided with current technologies at no net cost (IEA, 2021c). More than half of upstream methane emissions can be eliminated by robust leak detection and repair operations, updated technology standards and halting non-emergency flaring. Tackling flaring emissions requires stricter enforcement of regulations to reduce routine flaring across assets. For example, Nigeria successfully reduced the volume of gas flared by 70% between 2000 and 2019 through the introduction of penalties and incentives for investment in equipment (IEA, 2021d). Increasing focus on energy efficiency and electrification of operations, notably in LNG plants, can also help to reduce emissions.

Figure 3.23 ▷ Oil and natural gas upstream GHG emissions intensity for selected producers, 2020



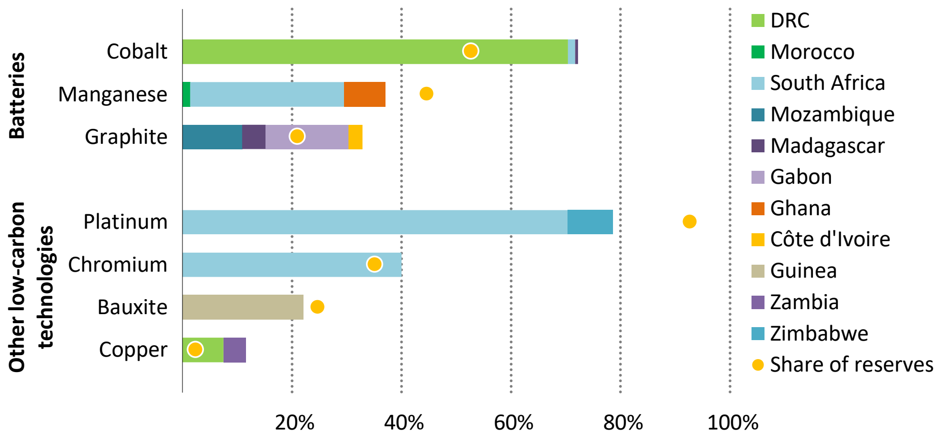
Emissions intensity of major African oil and natural gas producers is significantly higher than in most other regions

Note: CO_2-eq/boe = carbon dioxide equivalent per barrel of oil equivalent.

3.4.2 Critical minerals

Africa holds huge amounts of mineral resources, many of which are critical to various clean energy technologies. For some mineral resources such as cobalt, platinum-group metals (PGMs) and manganese, the region is already a major supplier to the global market. South Africa dominates global supplies of PGMs and is also a leading producer of chromium and manganese. DRC accounts for about 70% of global cobalt production. The continent also holds a sizeable share in the production of other mineral resources such as bauxite, graphite and copper (Figure 3.24). There are also substantial untapped resources of other minerals such as lithium and nickel. A number of lithium mining projects are currently under development in Ghana, DRC, Mali, Namibia and Zimbabwe, though their scale is small compared with other regions.

Figure 3.24 ▷ Share of Africa in global production of selected minerals, 2020



Sub-Saharan Africa holds a significant share of the world's mineral resources that are critical to clean energy technologies

Note: Graphite refers to natural graphite.

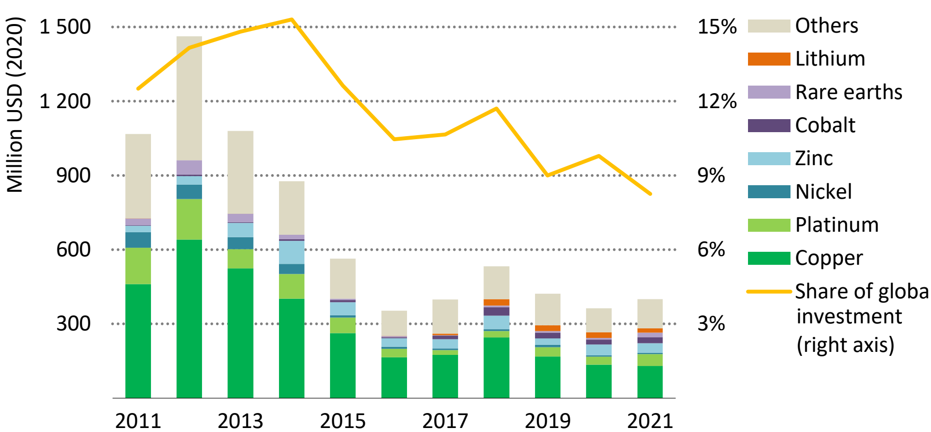
Sources: USGS (2021) and S&P Global (2022).

Production of mineral resources is already a vital source of income for Africa, representing around 8% of government revenues in resource-rich African countries (IMF, 2021). In 23 African countries, minerals represent over 30% of total product exports (IEA, 2021e). The mining sector has also been one of the main recipients of foreign direct investment in the region. The potential economic contribution of mineral production is much greater as demand for many critical minerals is set to grow quickly as a result of global energy transitions.

Exploiting those minerals can bring multiple benefits to African countries such as job creation, local economic and social development, and improved infrastructure. As mining operations require a range of supporting infrastructure such as roads, railways and power supply, they can act as an anchor investor to develop infrastructure that can be used by other sectors and local communities. Shared infrastructure can reduce the investment burden by spreading the cost over multiple users. So far, sharing of mining-related infrastructure has not been common in Africa as companies prefer to mitigate political risks by keeping control over the facilities and find it difficult to co-ordinate varying interests among multiple potential users (CCSI, 2015). Changing this calls for better co-operation between host governments and mining firms. Mineral development in Africa can also bring global benefits, by enhancing the security of mineral supplies in the face of a looming mismatch between projected demand and supply, and high levels of geographical concentration of production.

Several hurdles need to be overcome for Africa to capitalise on its mineral resources. The first step is to improve the quality of geological surveys to gain a better understanding of the resource potential. A large part of Africa's mineral resources remain under-explored due to the lack of adequate geological mapping. For example, despite limited official reporting on nickel reserves, BHP struck a deal to invest USD 100 million in the Kabanga Nickel project in Tanzania, reporting it as one of the world's largest nickel sulphide deposits. Adjacent areas, often called the East African Nickel Belt, are also reported to have huge potential. Many of the least explored countries are in West Africa, where the resource potential is believed to be significant. Yet exploration spending in Africa fell sharply between 2012 and 2016, and has remained stagnant since then, in contrast with growing exploration activities in other regions (Figure 3.25).

Figure 3.25 ▷ Investment in exploration for selected mineral resources in Africa, 2011-2021



Africa's resources remain under-explored. Its share of global exploration spending has been declining since the early 2010s

Note: Excludes gold and diamonds.

The Africa Mining Vision, a policy framework created by the African Union in 2009, highlights the need to improve resource development and governance capacity to incentivise investment in new mines and facilities further down the value chain.[8] Attracting investment requires a combination of robust governance, transparent regulatory frameworks, adequate incentives and infrastructure support, all of which necessitate strengthening the capacity of local authorities to design, monitor and regulate resource development regimes. A number of international initiatives, such as the Extractive Industries Transparency Initiative, and

[8] An update of the Vision has recently been proposed to take account of the changing global context, notably increased attention to climate change and tightening environmental and social standards (CCSI, 2021).

institutions are assisting capacity building and promoting sound mining sector governance. Some countries are eyeing opportunities beyond mining such as the value added transformation of minerals (e.g. refining and active material production), though strong policy support would be needed to provide incentives for investment, nurture the development of local workforces and ensure reliable electricity supplies. For example, in 2022, DRC and Zambia set up a common governance structure – the DRC-Zambia Battery Council – to create a business environment conducive to the development of a battery value chain.

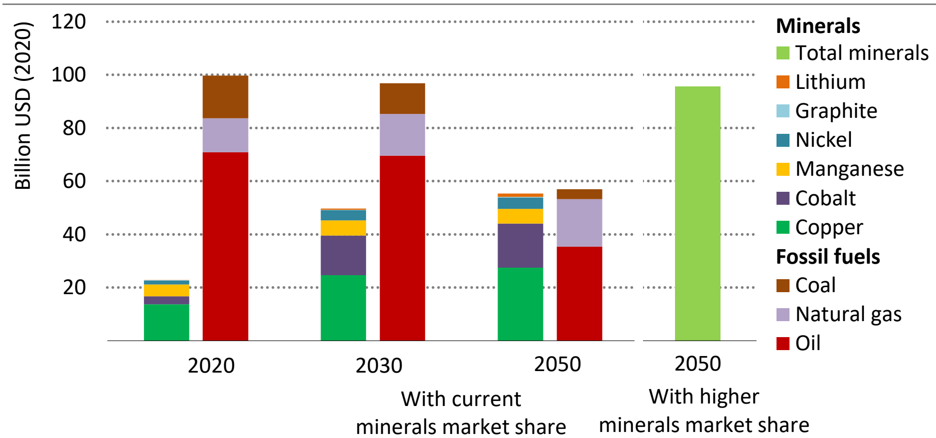
As with fossil fuels, there is a strong need for transparent mineral wealth management to translate mining revenues into widespread economic prosperity and use them to support diversification of the economy. Countries with sizeable mineral resources often rely heavily on mining revenues to fuel their economies. While future demand prospects for minerals are more favourable than for fossil fuels, they do not eliminate the risks of over dependence on narrow and volatile sources of revenue. Volatile commodity prices often result in wasteful spending during boom times followed by fiscal strain during downturns. Heavy reliance on mineral income can also lead to underinvestment in other sectors, making the economy more vulnerable to changes in global commodity prices. Corruption, which is prevalent in the region, makes matters worse. Investment in conflict-affected areas can also be diverted to finance armed conflict.

The environmental and social effects of exploiting mineral resources also need to be managed carefully, both to protect local communities and to gain public acceptance for future projects. As consumers and investors are increasingly demanding sustainably and responsibly produced volumes, favourable environmental and social performance emerged as a crucial determinant to raise capital for new projects. Some forms of harm are more attention grabbing than others, particularly child labour concerns. However, African governments need to cast their net more widely to encompass other concerns such as emissions, local air pollution, poor waste and water management, inadequate worker safety and corruption. Supply chain due diligence, with effective regulatory enforcement, can be a critical tool to identify, assess and mitigate risk, and increase traceability and transparency. The OECD's due diligence guidance for responsible mineral supply chains provides a good example (OECD, 2016). Efforts to formalise artisanal small-scale mining activities can also help improve both health and safety conditions, as well as reduce the use of child labour. Besides being a major source of employment in many countries, these activities can contribute to enhancing the security of mineral supplies as it can quickly switch production on and off in response to market conditions, complementing industrial mining projects.

As global demand for critical minerals soars, so will their potential to contribute to the economic growth of African resource holders. Getting these new value chains up and running would offer a major opportunity for Africa to benefit from the global energy transition. For example, revenues from copper and key battery metals production in Africa are estimated to have totalled just over USD 20 billion in 2020 – 13% of the global market. With rising demand for these minerals, African revenues from their sale would more than double by

2030 in the SAS assuming no increase in its market share. By 2050, it reaches the level of the combined revenue from fossil fuel production. If the region were able to raise its market share to 20%, revenue could more than quadruple through to 2050 (Figure 3.26).

Figure 3.26 ▷ Revenues from production of copper, battery metals and fossil fuels in sub-Saharan Africa in the SAS



Revenue from copper and battery metals production in Africa is set to more than double by 2030 based on its current global market share

Notes: Revenues are the total proceeds from domestic sales and exports. Assumes average 2021 prices for minerals in 2030 and 2050. Higher market share assumes that Africa's share reaches 20% for copper and battery metals, up from 13% in 2020.

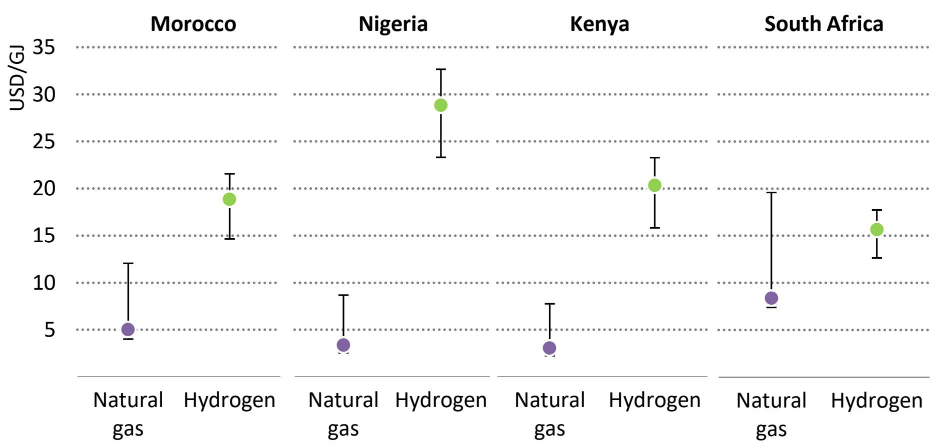
3.4.3 Low-carbon hydrogen

The production of low-carbon hydrogen and hydrogen-based fuels such as ammonia using Africa's ample low cost renewable resources offers another major economic opportunity. When used in end-use sectors, these fuels can help reduce emissions by displacing unabated fossil fuel-based hydrogen in existing applications, such as fertiliser production and oil refining, and directly replacing fossil fuels in end-use sectors, such as heavy industry, shipping, aviation and electricity generation. Switching from fossil fuels to hydrogen could also enhance energy security in importing African countries in the face of volatile international fuel prices and geopolitical tensions. Beyond domestic demand, hydrogen exports could also help to compensate for potential declines in hydrocarbon income in producing countries over the coming decades. This would require massive investment in production and export facilities, as well as in renewables-based electricity production, power grids, seawater desalination and CO_2 transport and storage.

Local demand for low-carbon hydrogen will be harder to stimulate in Africa than in other parts of the world due to the significant capital requirements to build production capacities.

Low-carbon hydrogen would not be cost competitive against fossil fuels in the near term for most end-uses in Africa without targeted policies to stimulate domestic demand and innovation, despite the potential to produce relatively low-cost hydrogen using solar PV and wind power (Box 3.7). Even in natural gas importing countries such as South Africa, there is still a significant cost gap between natural gas and low-carbon hydrogen for industrial use in 2030 (Figure 3.27). Tilting the balance in favour of hydrogen would require increased excise duties on fossil fuels or carbon pricing, which would affect industrial competitiveness, alongside strong demand-side policies and large-scale international financing.

Figure 3.27 ▷ Industry natural gas prices and renewables-based hydrogen production costs in selected African countries, 2030



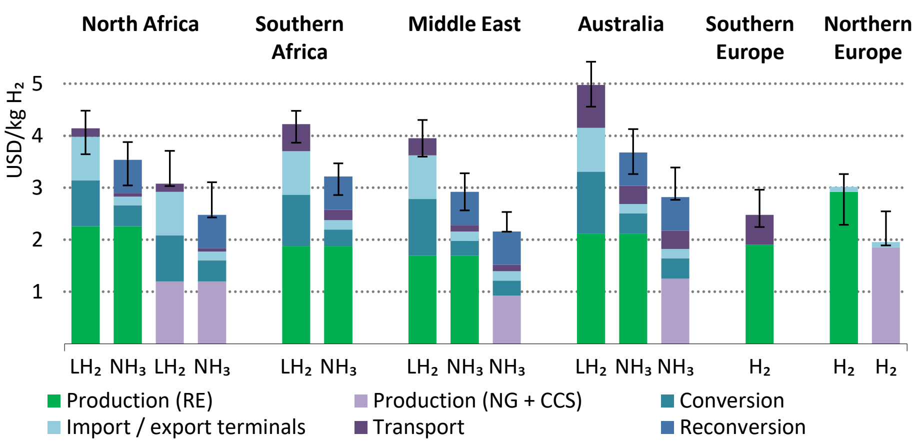
Without demand-side policies, domestic low-carbon hydrogen production would struggle to compete with natural gas for industrial uses

Notes: SAS = Sustainable Africa Scenario; GJ = gigajoule. Natural gas in Morocco, Kenya and South Africa is imported. Natural gas baseline shows the price in the SAS. Range bars reflect possible ranges including price volatility due to geopolitical instability. The dots show the price in the SAS. The price ranges reflect uncertainties across different global scenarios. Hydrogen production costs are based on dedicated hybrid solar PV and wind plants. Price ranges reflect the range of module cost assumptions across the scenarios explored in the *World Energy Outlook-2021* (IEA, 2021b).

Developing markets for low-carbon hydrogen in industry, shipping, aviation and power generation in Africa would require careful planning and support by governments and international finance. There is scope to improve the economics of projects by focussing on domestic industries located close to export facilities, transmission lines, solar resources, and available land and seawater for use after desalination. The pace of development of the hydrogen industry would depend critically on that of the power sector. There are question marks on whether sufficient electricity could be available for electrolysers given the need to increase electricity supply to other sectors, including households that currently lack access.

Beyond domestic demand, the rising global momentum for energy transitions and geopolitical tensions present an opportunity for Africa to export low-carbon hydrogen, especially to Europe. But African producers would need to compete on delivered costs with countries in the Middle East, where there is strong potential to produce low-carbon hydrogen from renewables and fossil fuels with carbon capture cheaply, and in southern Europe, where renewable resources are abundant. Low-carbon hydrogen production costs in the Middle East are among the lowest in the world, with transport distances similar to or shorter than from many African regions. Costs in southern Europe are in the same range as in best locations for African countries, but conversion and transport costs to high demand centres in northern Europe would be lower since distances are shorter and can be covered by transmission pipelines.

Figure 3.28 ▷ Delivered costs of low-carbon hydrogen from selected producer regions delivered to Northern Europe, 2030



Africa has potential to export low-carbon hydrogen, especially as ammonia, produced from renewable electricity to demand centres in Europe at competitive prices

Notes: H_2 = gaseous hydrogen; LH_2 = liquid hydrogen; NH_3 = ammonia; RE = renewables-based electricity; CCS = carbon capture and storage. NG + CCS = natural gas based electricity production with carbon capture and storage. Southern Africa includes South Africa and Namibia. Northern Europe is chosen as reference destination for exports. Transport from southern Europe is by pipeline and not shipping. Pipeline capacity is assumed to be 1 000 tonnes of H_2 per day. Cost assumptions in 2030: utility-scale solar PV - USD 480-1 130/kW; offshore wind - USD 2 320-2 650/kW; electrolyser - USD 318-600/kW; NG (steam methane reforming) + CCS - USD 1 459/kW H_2; natural gas prices - USD 1-9/million British thermal units (MBtu). Range bars reflect possible ranges including price volatility due to geopolitical instability. Price ranges reflect the range of module cost assumptions across the scenarios explored in the *World Energy Outlook-2021* (IEA, 2021b). Further assumptions concerning techno-economic parameters can be found in *Global Hydrogen Review 2021* (IEA, 2021f)).

Intra-Europe hydrogen transmission infrastructure is not ready yet, but planning is advancing. The European Hydrogen Backbone (European Union, 2021), a multi-stakeholder initiative for a dedicated hydrogen transport system, could be completed ahead of most large-scale projects for the production of low-carbon hydrogen in Africa. Nevertheless, with a strong policy push and international support, IEA analysis suggests that the landed costs of African low-carbon hydrogen supplied to northern Europe could be comparable to those of other regions such as the Middle East or Australia, especially if delivered in the form of ammonia (Figure 3.28). Moreover, observing the current situation of energy price shocks, the production of hydrogen with renewable energy in Africa would be more competitive if natural gas prices remain high. Hydrogen produced in Africa from renewables-based electricity could compete on costs with regions producing low-carbon hydrogen predominantly using fossil fuels with carbon capture. Beyond cost-competitiveness, the possibility of diversifying suppliers and strengthening energy security can also attract the interest of European investors and stakeholders.

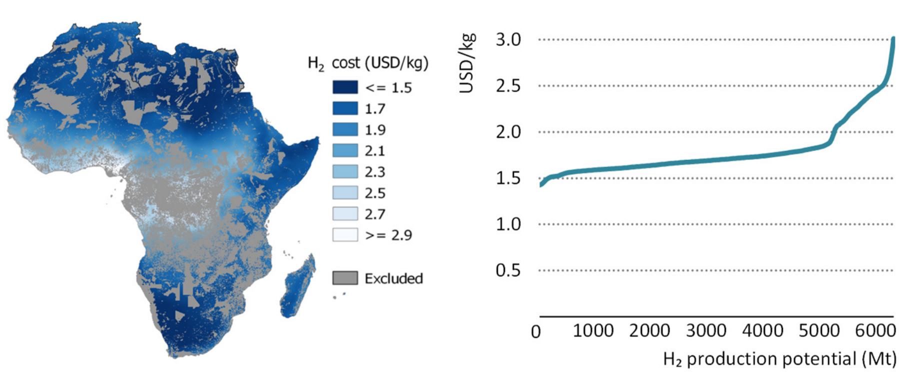
Low-carbon hydrogen projects in Africa are currently in the planning stage. Numerous large-scale export projects with capacity of more than 1 GW with the support of European companies are being considered, though most are at early stages of development (see Table 2.3). The most advanced hydrogen projects are small-scale demonstration plants to serve domestic markets, particularly transport uses and ammonia production. Fertiliser production represents a reasonable entry point for low-carbon hydrogen in primary industrial applications. This would help reduce ammonia and natural gas import dependence, shielding importing countries from international price volatility. In 2020, countries on the African continent import around half of the urea and a fifth of the ammonia they consume in aggregate, although the balance of trade varies significantly between countries.

Realising the ambitions to export low-carbon hydrogen and hydrogen-derived fuels would require substantial investment and strong international support from project developers, commercial banks and development finance institutions. Given the financial constraints faced by African governments, the availability of international finance and the establishment of long-term contracts with off-takers would play a major role in reducing risks for investors. For example, the H2Global programme recently launched by the German government is a prominent effort undertaken with this purpose. Project lead times will also need to be reduced to seize opportunities in overseas markets. In any case, the viability of all export projects depends on the development of an international hydrogen market. Discussions to establish the principles for such a market are underway in international fora. Regional co-operation on this matter could help ensure that Africa’s voice is reflected in these dialogues.

Box 3.7 ▹ Potential for low cost production of hydrogen from solar PV and onshore wind in Africa

Spanning 30 million km^2, Africa has one of the largest potentials in the world for producing hydrogen from low cost renewable electricity, largely from solar power, but also wind power, in arid and semi-arid areas, especially in North Africa, the Horn of Africa and Southern Africa. Should solar module and electrolyser costs decline consistent with the IEA's Net Zero Emissions by 2050 Scenario (IEA, 2021g), it could result in hydrogen production costs falling to around USD 1.4-2.0/kg in 2030 in Africa compared with USD 1.3-4.0/kg in the rest of the world (and USD 2.2-3.2/kg from offshore wind in northern Europe). This is equivalent to a natural gas cost of USD 12.3-17.6/MBtu. Just from areas within 200 km from its coastline, Africa has the renewable energy potential to produce up to 5 000 Mt per year at a cost below USD 2/kg—ten-times the volume of low-carbon hydrogen needed globally for the Net Zero Emissions by 2050 Scenario (IEA, 2021g). Wind power, alone or in conjunction with solar PV configurations, allows for higher full load hours for hydrogen production, and can thus be favourable in several regions such as Mauritania, Namibia or the Horn of Africa.

Figure 3.29 ▹ Hydrogen production costs and potential supply from dedicated hybrid solar PV and onshore wind in Africa, 2030



Due to its expansive land and abundant natural resources, Africa has vast potential to produce low-carbon hydrogen from renewables at relatively low cost

Notes: 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. Grey colour represents areas that are excluded due to other land uses and protected areas, though hydrogen projects may not be precluded in practice. For each location, lowest production costs were obtained by optimising the mix of solar PV, onshore wind and electrolyser capacities. The supply curve considers only locations less than 200 km from the coast.

Sources: Based on hourly wind data from (Copernicus Climate Change Service, 2018) and hourly solar data from (Renewables.ninja, n.d.). Land-use data from (UNEP-WCMC, 2017); (USGS, 1996); (ESA, 2011).

In the most favourable regions, round 150 million tonnes (Mt) (18 exajoules [EJ]) could be produced at less than USD 1.5/kg less than 200 km from the coast, a volume significantly above the current total domestic hydrogen demand in Africa of just under 3 Mt (Figure 3.29). All these regions have existing export terminals or industries that could make use of the low-carbon hydrogen. For example, for fertiliser production in Egypt and Morocco, renewables-based ammonia could replace fossil fuel-based ammonia (currently imported in many cases), and in North Africa and South Africa, steel making could experiment with the reduction of iron ore using hydrogen. Intracontinental demand for hydrogen could also include fuel for mining trucks, an option being explored in South Africa, and ammonia for maritime shipping for short distances. Off-grid power systems, using hydrogen to store electricity from variable renewables, could replace expensive and carbon-intensive diesel generator systems currently in use.

3.5 Investment and financing

For Africa to pursue the energy pathway set out in the SAS, there needs to be a sea change in the way energy projects are financed. Over 2015-19, 70% of energy investment on the continent went to oil and gas projects, primarily predicated on foreign off-take. By contrast, two thirds of investment over 2021-30 in the SAS is in clean energy, mainly to meet growing domestic demand. Total energy investment doubles by 2030 in the SAS, driven largely by the power sector.[9] These changes underscore the need to fundamentally change the way energy infrastructure is financed. Mobilising the requisite finance hinges on reducing risks and harnessing new sources of finance. Priority needs to be given to making more effective use of public capital, from international and domestic sources, in order to better leverage private capital.

3.5.1 Investment needs

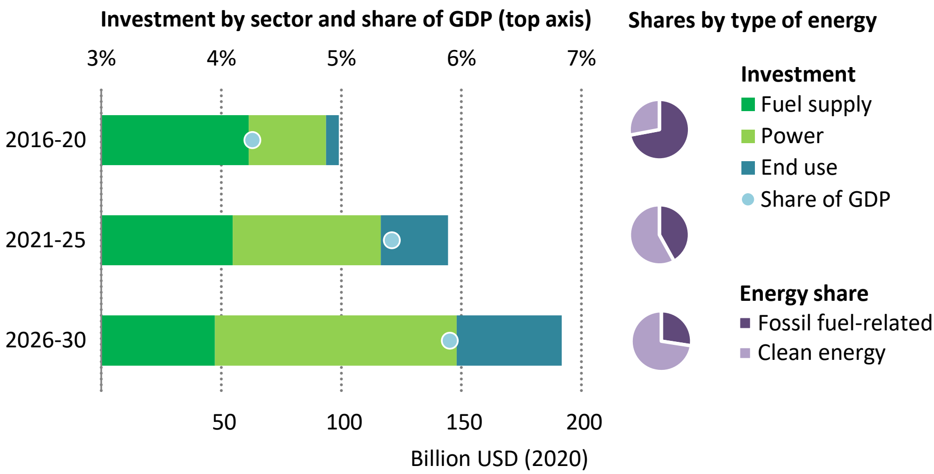
While Africa accounts for almost one-fifth of the world's population, it attracts less than 5% of global energy investment. This is spread unevenly across the continent. Ten countries accounted for 90% of private investment in energy and electricity infrastructure on the continent over the last ten years, South Africa alone accounting for nearly 40% (World Bank, 2021). Total energy investment in Africa was already declining prior to the pandemic and fell even more quickly in 2020, by over 20%. The USD 73 billion invested in 2020 was equal to just 3% of Africa's GDP. In 2021, spending is thought to have recovered to just below its 2019 level. Historically, fossil fuel supply has accounted for the majority of energy investment in Africa, driven by oil production. However, since 2016, capital spending on fuel supply has fallen by more than a fifth with a shift to less risky projects elsewhere. Clean energy

[9] The methodology for our energy investment analysis can be found at: https://iea.blob.core.windows.net/assets/ce2406cb-adab-4fa2-b172-6f58335dd18c/WorldEnergyInvestment2021_MethodologyAnnex.pdf

investment has failed to make up the difference, with around 60% of total spending still going to fossil fuel supply over the past five years.

The clean energy transition in Africa depicted in the SAS requires not just a shift in investment flows away from fossil fuels, but also a near doubling of total capital over 2026-30 compared with 2016-20. This pushes up energy investment's share of GDP to 6%, slightly above the average for emerging economies as a whole. Investment averages about USD 190 billion per year across all segments of the energy sector, including access, over 2026-30. Clean energy investment, mainly in the power sector, increases sixfold, taking its share of total investment to 70% (Figure 3.30). The heightened call on capital in the SAS comes at a time when African governments are confronted by financial pressures, made worse by Covid-19-related debt, meaning private markets will have to play a key role.

Figure 3.30 ▷ Annual average investment by sector in Africa in the SAS

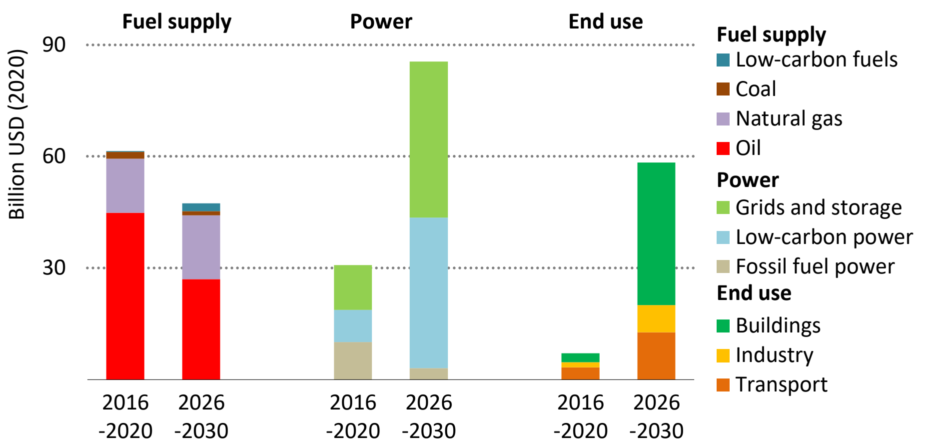


Energy investment almost doubles over the 2026-2030 period relative to 2016-2020, reaching the equivalent of 6% of GDP, with spending on clean energy increasing sixfold

There is a major reallocation of capital to the power sector in the SAS (Figure 3.31). The achievement of universal energy access and rapid growth in electricity use drives a near tripling of investment in the power sector over 2026-30 compared with 2016-20. The power sector's share of total energy investment jumps from around one-third to over half. Investments in fossil fuel supply continue to decline, though they remain significant in the producer economies of North Africa, accounting for 40% of energy investment over the current decade. Natural gas investments ramp up to account for nearly half of fuel supply investment, as new gas discoveries move ahead in Senegal and Mauritania and existing fields are developed further. LNG terminals and supporting infrastructure also come online to support exports in Mozambique. The shift in spending to power is most pronounced in sub-

Saharan Africa, where roughly a third of investment in that sector over 2021-30 is needed to expand electricity access. End-use investment jumps nearly sevenfold driven by a surge in purchases of more efficient appliances, cooling systems and vehicles.[10] New financing structures that prevent customers taking on unsustainable costs will need to accompany this rise in spending.

Figure 3.31 ▹ Average annual energy investment by fuel and sector in Africa in the SAS



Investments in power and end-use efficiency surge to 2030, driven mainly by low-carbon power plants and grid expansion, as well as appliances and cooling equipment

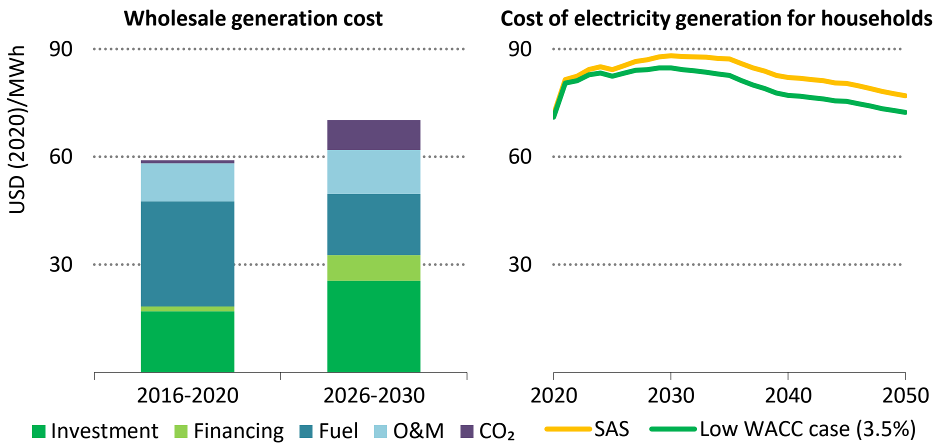
Notes: SAS = Sustainable Africa Scenario. Low-carbon power refers to renewables and fossil fuel power with carbon capture, utilisation and storage.

Financing costs – capitalised interest on debt and equity returns – also increase due to the shift in investment from fossil fuels to power, which is more capital intensive, though the additional costs are largely offset by savings on operating costs, notably fuel in power generation and energy savings in end-uses. With the shift to more capital-intensive projects, the cost of capital becomes an important determinant of total investment costs. In the SAS, financing costs for power generation capacity rise from 2% of electricity generation costs in 2016-20 to 10% in 2026-30. The weighted average cost of capital (WACC) for energy projects in varies, with actual and perceived risks resulting in an average cost of up to seven-times higher in Africa than in Europe and North America. The equity risk premium and country

[10] End-use investment includes spending only on energy-efficient appliances, equipment and vehicles. Much of that spending is by consumers for which purchases of more efficient goods are not investments per se. Investment in energy efficiency includes incremental spending by companies, governments and individuals to acquire equipment that consumes less energy than what they would otherwise have bought. Fossil fuel and power sector investments are those that raise or replace energy supply, while energy efficiency investments are counted as those that reduce energy demand.

default risk in some leading African economies were declining before the onset of the Covid-19 pandemic, but have rebounded due to growing public debt and increased investment risks. Were the WACC for solar and wind projects in Africa to fall to the average level in the advanced economies, financing costs would be reduced by USD 3.8 billion in 2030, lowering the levelised cost of generation of electricity supplied to households by USD 3.4 per megawatt-hour (MWh), or 4% (Figure 3.32).

Figure 3.32 ▷ Total generation cost under different weighted average cost of capital assumptions for solar PV and wind in Africa in the SAS



Costs of generating electricity for households would drop by 4% if the cost of capital for solar PV and wind generation projects in Africa was equivalent to advanced economies

Notes: SAS = Sustainable Africa Scenario; O&M = operations and maintenance. WACC = Weighted average cost of capital. The low WACC case only applies to solar PV and wind. Costs do not include taxes. The same WACC is assumed in each year, rather than a gradual decline. The average WACC in the Sustainable Africa Scenario is 7%.

Policy action targeted at energy projects could help reduce their WACC. Measures include competitive tendering, contract enforcement and revenue support mechanisms, such as guarantees, together with measures to improve the credit worthiness of off-takers. But they would not be sufficient to bring down the WACC to levels prevailing in the advanced economies due to underlying, economy-wide factors related to macroeconomic stability, private ownership rights and underdeveloped financial systems. Macroeconomic conditions and the general investment climate have worsened across the continent since the start of the pandemic resulting in the downgrading of 18 sovereign credit ratings covering African countries since the pandemic began (see Chapter 1). Morocco has been downgraded from investment to junk grade, leaving only Botswana and Mauritius in the former category. All countries in Africa rank below the average for the advanced economies in the World Bank's Doing Business (World Bank, 2020). International investors are often deterred by the prospect of long project lead times due to inefficient bureaucracies, the lack of energy expertise within the workforce and higher corruption and contract risks than in their home markets. Cross-cutting risks primarily stem from weak governance, poor policy design and a lack of administrative capacity, as well as market designs that favour state companies and skewed pricing arrangements, including subsidies.

African governments are seeking to lower these risks. For example, the Moroccan Agency for Sustainable Development was created as a tendering agency, an intermediary offer-taker and a hub for most project-related inquiries to improve the tendering and interconnection process for independent power projects. Pricing reforms are also underway, with countries such as Egypt and Tunisia, reforming fossil fuel subsidies, and South Africa, Côte d'Ivoire and Senegal either implementing or reviewing the possibility of carbon pricing. That said, some of the more fundamental risks – such as the lack of available skilled labour – are likely to prove more time consuming and complex to fully resolve.

Creating a pipeline of bankable projects for a range of investors is one of the biggest tasks in scaling up energy investment in Africa. The high level of perceived and actual risks in Africa raises the bar for projects to be considered viable by financiers, particularly for projects with smaller transaction sizes that already struggle to attract finance from major international capital providers. Using concessional finance for technical assistance, project preparation and early stage project development are vital to creating such a pipeline.

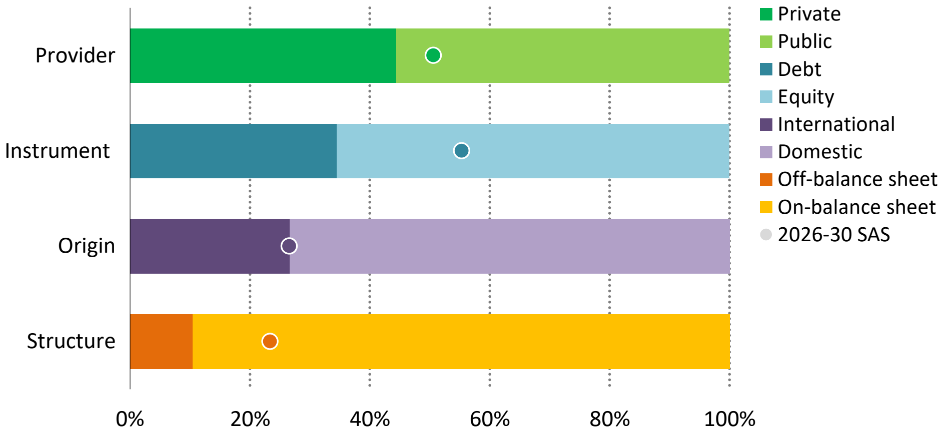
3.5.2 Structure of energy finance

The way energy investment in Africa is financed must evolve to support the more than doubling of energy investment by 2030 and a shift towards low-carbon projects as in the SAS pathway (Figure 3.33). This includes the type of capital provider, instrument, origin of the provider and financing structure.[11]

- **Capital providers** can be private or public sector. The private sector accounted for over 60% of total energy investment in Africa in the 2016-20 period. Public sector entities, such as public utilities and national oil companies, play a larger role in energy sector investment in Africa than in other regions. State-owned enterprises, particularly utilities, often face high debt levels. In recent years this has required repeated capital injections either from the state or from public finance institutions (PFIs), which reduces their ability to finance higher investment. State enterprises need to continue to play an important role as co-investors, but private sector participation will need to grow, particularly in the power sector. Regulatory barriers to private sector participation are assumed be lowered in the SAS, including through a larger role for PFIs to provide blended financing to reduce perceived risks and financing first-of-a-kind projects. PFI financial flows grow to account for 10% of overall investment by 2030, helping to leverage more private finance.

[11] The estimates presented here do not include secondary flows to financial intermediaries, which are particularly important in extending loans to consumers and small businesses. Given the difficulties in synthesising complex financial transaction data, which are not always complete or transparent, modelling results should be seen as providing a broad indication of trends.

Figure 3.33 ⊳ Financing parameters of energy investment in Africa in the SAS, 2016-2020



Expanding investment in the energy sector in Africa calls for increased reliance on private investment and debt instruments

Note: SAS = Sustainable Africa Scenario.

- **Instrument:** Debt financing makes up less than 40% of energy investment in Africa today, reflecting the prevalence of equity-based financing from IOCs. The high share of equity compared with the global average persists in the SAS, due to the perceived risks of investing in domestic projects, nonetheless, reliance on debt financing rises. Given concerns about the sustainability of public debt, this will require increasing the availability of privately sourced debt, which is generally constrained in Africa. Commercial banks, which have a preference for short- and medium-terms loans, and institutional investors often lack the institutional expertise to assess infrastructure credit risks.
- **Origin of finance:** International financial flows, which went mainly to oil and gas projects over 2016-20, shift to power and end-use sectors, requiring an unprecedented level of international private capital.[12] This hinges on an increase in international concessional financial flows through new sources of climate-related finance and regulatory reforms that attract more private capital. Domestic capital also expands in absolute terms, almost doubling by 2026-30 compared with 2016-20, but like international private capital, often requires concessional finance to de-risk projects, opening participation by African pension plans and commercial banks. This expansion of domestic financial

[12] The origin of finance remains one of the hardest financing parameters to assess. This report estimates the role of international sources in financing projects directly, but does not account for the full range of financial flows, such as those provided to domestic financial intermediaries for on-lending, which also underpin investment, especially in energy efficiency.

participation also remains key to hedging against currency and inflation risk, which may remain high in the near term, and can help cultivate local capital markets. Direct foreign investment from Chinese firms has played a major role in African infrastructure investment (Box 3.8).

- **Financing structure:** The majority of primary financing for energy investments both globally and in Africa currently comes from capital incorporated into a company's balance sheet or from consumer assets. Oil and gas projects and electricity grid investments are almost exclusively funded through the balance sheets of the developer. In the SAS, improved policy and regulatory frameworks strengthen the reliability of returns on clean power assets, allowing the share of off-balance sheet or project financing to double to over 20% of energy investment by 2026-30. Important measures include introducing auctions and standardised power purchase agreements, such as under the GET FiT scheme in Uganda and Zambia, and allowing private participation in regulated networks in more established markets. Energy service contracts, such as those used in Morocco, or aggregation of small-scale assets, including access solutions based on PayGo models, help to strengthen off-balance sheet structures for end-use sectors, but remain highly dependent on the financial situation of particular countries.

Box 3.8 ▷ Changing role of Chinese financing

China's role in African economies has been increasing since the early 2000s. It became the continent's largest trading partner in 2009. China is now the fourth-largest investor in Africa and accounts for about one-fifth of all lending, much of which goes to energy and infrastructure projects. China committed to USD 148 billion in loans to Africa between 2000 and 2018, roughly a quarter of which were in the energy sector (Brautigam et al., 2020). However, lending to African power projects fell from its peak of almost USD 8 billion in 2016 to USD 1.5 billion in 2019 as China's policy banks focus more on domestic projects (Brautigam et al., 2020).

Financing from China has primarily been in the form of large low cost loans from development banks or energy and construction state-owned enterprises. The level of lending has led to concerns around the sustainability of debt, particularly as Chinese loans are generally exempt from Paris Club debt restructuring arrangements.[13] Several African countries have been forced to renegotiate repayment terms, notably in the case of loans to railways in Kenya and Ethiopia. Default risks on the continent are rising due to the combination of increased debt since the start of the Covid-19 pandemic and rising inflation in the first-half of 2022.

Changing dynamics point to a shift in China's dealings with Africa. At the Forum on China Africa Co-operation in November 2021, China's president announced a one-third reduction in public financing to Africa and emphasised the growing role of Chinese

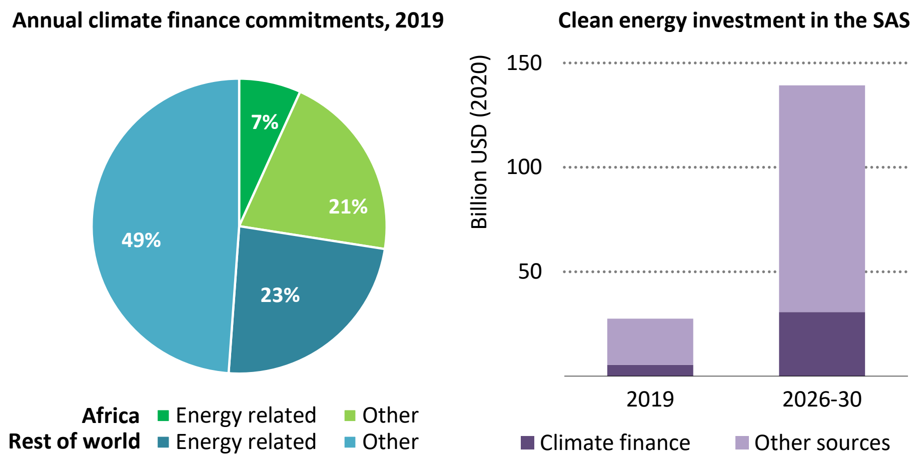
[13] Paris Club is a group of officials from major creditor countries whose role is to develop co-ordinated solutions to address payment difficulties in debtor countries.

private investment, although no specific targets have been announced. Together with China's move away from funding coal plants abroad, this is likely to result in more emphasis on renewable energy projects via Chinese developers.

3.5.3 Tapping into new sources of finance

Mobilising the required level of finance will mean taking advantage of new sources of financing for clean energy. Since the signing of the Paris Agreement in 2015, global climate commitments have resulted in a new avenue for financing energy transitions in Africa. Meanwhile, economic development in Africa is driving up the pool of available domestic capital, though most domestic financial markets remain underdeveloped and ill-equipped to channel this capital into clean energy projects.

Figure 3.34 ▷ Climate finance from developed countries to Africa in the SAS



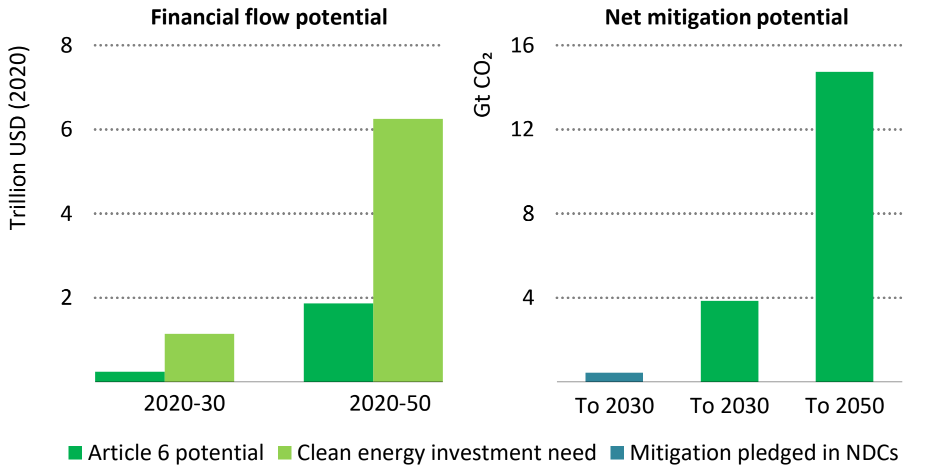
Climate finance flows from developed countries to Africa increase fivefold by 2026-30 compared with 2019 to meet clean energy investment needs

Notes: SAS = Sustainable Africa Scenario. IEA investment projections are based on actual spend in the relevant year, whereas the climate finance data are pledges that will be disbursed over a period of time. As a result, they are not strictly comparable. Projected climate finance is based on the growth rate of spending from public finance institutions over the same period.

Sources: IEA analysis based on OECD (2021).

Climate finance is an increasingly important source of financing in the SAS. Developed countries jointly provided and mobilised USD 79.6 billion in climate finance in 2019, of which roughly US 5 billion, or 7%, went to energy projects in Africa (OECD, 2021). In order to catalyse the increase in clean energy investment projected in the SAS, we estimate that annual climate finance flows from developed countries to Africa would need to increase fivefold in the 2026-30 period compared with 2019 (Figure 3.34).[14] Reaching this target will depend on developed countries continuing to direct concessional financial support to climate mitigation and on balancing this long-term priority with the urgent need for debt relief and emergency support to guard against skyrocketing food and fuel prices.

Figure 3.35 ▷ Article 6 financial flows and CO_2 emissions reduction potential in Africa in the SAS



Article 6 financial flows could reach over 20% of investment in clean energy in Africa in 2020-30 and roughly 30% in 2020-2050

Notes: SAS = Sustainable Africa Scenario; Gt CO_2 = gigatonnes of carbon dioxide. The investment and mitigation potential for Article 6 refers to African countries under a "staggered co-operative net zero scenario" (Yu et al., 2021), where lower income countries set a date later than 2050 for their net zero emissions targets based on relative income differences, with co-operative implementation. Current NDCs only include targets to 2030.

Sources: IEA analysis based on data from Yu et al.(2021).

Carbon markets could help African countries develop mitigation projects and receive further climate-related investment.[15] COP26 agreed the rules for Article 6 of the Paris Agreement, which enables countries to pay for GHG reductions or removals in another country to meet and go beyond their domestic emissions reduction commitments. This can be done bilaterally through Article 6.2 using internationally transferred mitigation outcomes (ITMOs),

[14] A lack of data on disbursements makes comparisons between climate commitments from developed countries and investment projections difficult. Many sources, including multilateral development banks, do not release data on disbursements, but numerous studies and anecdotal evidence indicate the lack of bankable projects and project delays result in lower disbursement ratios for climate finance than other forms of development aid (Savvidou et al., 2021).

[15] Carbon markets can provide financial flows similar to results-based finance for climate. They are not included in climate finance goal of developed countries to mobilise USD 100 billion per year by 2020.

or through a new international carbon market, known as the Article 6.4 mechanism.[16] Twenty-four African countries have signalled their strong interest or intention to take part in carbon markets under Article 6 in their latest NDC submissions (Michaelowa et al., 2021). ITMOs could generate USD 225-245 billion in net financial flows to African countries and prevent the emission of 3 500-3 850 Mt CO_2 over 2020-30 (around 22-24% of Africa's total energy-related CO_2 emissions over the period), and USD 1 130-1 865 billion and 14 750 Mt CO_2 over 2020-50, compared with scenarios without Article 6 co-operation (Yu et al., 2021). This implies the implementation of Article 6 mechanisms could deliver financial flows that exceed 20% of investment in clean energy in Africa by 2030 and reach roughly 30% by 2050 in the SAS (Figure 3.35).

Table 3.2 ▻ Key elements of Article 6 climate finance readiness

Element	Measure	Examples of readiness in sub-Saharan countries
Article 6 policy strategy	Establish guiding principles for the eligibility of activities that can generate ITMOs.	-
	Consult with relevant private sector stakeholders about Article 6 opportunities and benefits.	Burkina Faso, Nigeria, Senegal
	Define a national Article 6 strategy.	-
	Develop Article 6 pilot projects.	Gambia, Senegal, Togo
	Establish procedures to comply with the modalities, procedures and guidelines of the Enhanced Transparency Framework.	Liberia, Sierra Leone
Institutional framework / governance structure	Establish a national legal framework for Article 6 participation, including authorisation and approval procedures, and ITMOs accounting rules.	Senegal
	Update UNFCCC GHG Inventory.[17]	Benin, Liberia, Senegal
	Establish the designated national authority for Article 6.	-
Monitoring, reporting and verification	Develop a national ITMO registry.	-
	Technical capacities to develop baselines and methodologies in line with Article 6 requirements.	Ghana, Togo

Notes: ITMO = internationally transferred mitigation outcomes; UNFCCC = United Nations Framework Convention on Climate Change; GHG = greenhouse gases. Examples cover sub-Saharan African countries only. Some North African countries that could be more advanced in certain elements are not shown here, e.g. Morocco and Egypt.

Sources: IEA analysis based on Michaelowa, et al. (2021); West African Alliance on Carbon Markets and Climate Finance (2021); Eastern Africa Alliance on Carbon Markets and Climate Finance (2021).

[16] This market can be considered a successor to the Clean Development Mechanism established under the Kyoto Protocol.

[17] Eligibility precondition for Article 6 participation.

African countries need to develop new systems, institutional frameworks and monitoring procedures in order to exploit Article 6 opportunities (Table 3.2). Article 6.2 bilateral trading of ITMOs can already take place, with Ghana, Morocco and Senegal having signed co-operation agreements with Switzerland (BAFU, 2021). Issuing credits under the Article 6.4 mechanism may take up to two years. Two new coalitions, the West African and Eastern Africa Alliances on Carbon Markets and Climate Finance, aim to foster sub-regional co-operation and enhance readiness for implementing Article 6, with pilot activities in 17 African countries already underway (Climate Finance Innovators, 2020).

African capital markets remain small, despite growth in recent years. Many financial systems in Africa do not have sufficient liquidity to provide long-term financing, which results lending for short time periods (70% of lending is less than five years). However, sovereign wealth funds (SWFs) and pension funds are growing sources of long-term capital, with total assets under management (AuM) for SWFs estimated at USD 80-90 billion, almost 90% of which are in oil-producing countries in North Africa (IFSWF, 2021; Murgatroyd, 2020).[18] The AuM of African pension funds was last estimated at over USD 300 billion in 2019 but are projected to grow significantly (BrightAfrica, 2019).

Unlocking these sources for energy projects requires regulatory changes to increase their allocation towards infrastructure or to bring in concessional finance, such as grants, first-loss loans or guarantees, to make energy projects investment grade. For example, in Kenya, the Retirement Benefit Authority increased the threshold for pension fund allocations to infrastructure assets from 5% to 10% in 2021, which resulted in the Kenya Pension Funds Investment Consortium committing to spending over Kenyan shilling 25 billion (USD 229 billion) on infrastructure over 2021-26 (US Embassy Kenya, 2020). But there are still a number of cross-cutting risks that deter domestic capital and few bankable projects, i.e. projects that have a viable financial, economic and technical plan and acceptable credit risk. Green banking institutions, often supported by international grants and concessional capital, can help to lower these risks (Box 3.9).

Box 3.9 ▹ Supporting domestic capital via green banks

Green banks can act as important intermediaries between capital markets and energy projects by hosting expertise on clean energy project risk assessment and experience with tailoring de-risking solutions. Green financing institutions are starting to emerge both at regional and national levels to support local know-how on clean energy financing.

- **Regional organisations:** The African Green Infrastructure Investment Bank, sponsored by the African Union and the African Sovereign Wealth and Pension Fund Leaders Forum, was launched in 2021 with a view to increase African institutional investor involvement in green infrastructure projects. A flagship initiative of the

[18] These estimates include Libya's sovereign wealth fund, LIA, which is the largest on the continent with USD 65 billion of AuM. It is currently subject to international economic sanctions.

bank is a Model Law on Institutional Investor-Public Partnerships, which is intended to support the African Union's 5% Institutional Infrastructure Investment Agenda – an initiative to increase African asset owner allocation for infrastructure to at least 5% of assets under management by providing a standardised legislative framework to increase collaboration between institutional investors and the public sector. The model law also includes a streamlined procurement process and contract management framework, including dispute resolution.

- **Domestic institutions or funds**: The Coalition for Green Capital (CGC) is spearheading an initiative to create more green banks in developing countries. It is partnering with the African Development Bank (AfDB) on a feasibility study to launch green banks in six African countries. This follows CGC's involvement in the creation of the Rwanda Catalytic Green Investment Bank, which will focus on blended finance instruments for commercial, but not yet bankable green projects, and the Southern Africa Climate Facility, a specialised lending facility designed to increase private investment in climate-related infrastructure.

Note: This box was prepared in collaboration with Mr Hubert Danso of the Africa Investor Group.

3.5.4 Using public funds to mobilise private capital

Maximising the catalytic potential of public finance while not crowding out private capital is crucial to financing clean energy projects in Africa. Highly concessional capital, particularly grants, have been used for developing many projects that have struggled to reach bankable status in least developed countries. However, many projects that used to rely exclusively on grant financing, such as electricity access projects in remote villages, have begun to use models that rely on a mix of concessional and commercial financing. These models, which are forms of blended finance mechanisms, use limited concessional public capital to lower financing costs and attract private finance (Table 3.3).[19] This approach gained traction in the 2010s and since 2015, blended finance transactions have averaged approximately USD 9 billion per year worldwide. Africa makes up the largest share of these, accounting for 60% of transactions in 2020 (Convergence, 2021). Several innovative approaches have been developed, including financial institutions using blending to increase their own lending base, as well as the more traditional use at project level (Box 3.10).

Despite clear potential for blended finance, it does not always attract much private capital. Available evidence shows that blended finance is most often used by DFIs and multilateral development banks to de-risk their own capital. The requirements for investment returns at these institutions result in most of their concessional support going to projects where they are the dominant financier, instead of targeting the concessional capital to de-risk projects

[19] Definitions of blended finance vary and data on the level of concessionality and mobilisation ratios are limited due to lack of comprehensive reporting by providers. The most common structuring approaches use junior or first-loss debt or equity, technical assistance grants and guarantees, or risk insurance instruments. They can be structured at project, fund or institutional level.

to a level that would be attractive to a private sector, particularly in the least developed countries (Attridge and Engen, 2019). A lack of data on the amount of private capital mobilised by blended finance transactions also limits the ability to analyse which instruments have proven most effective under different conditions. This contributes to an over reliance on concessional loans, which are the most common instrument used and are therefore often the easiest for providers to analyse and prepare. Understanding where the private sector can take the lead versus where international public capital must continue to play the primary role is important to target limited concessional finance flows more effectively.

Box 3.10 ▻ Case study: Eastern and Southern African Trade and Development Bank Group

Organisations can blend concessional and private capital in multiple ways to maximise the investment potential. Trade and Development Bank (TDB) Group, a development finance institution (DFI) in east and southern Africa, uses blended finance in the traditional capacity – issuing guarantees, providing commercial and concessional funding, and offering capacity building or technical assistance grants – but it also has an innovative hybrid public-private capital structure in its operations. Since 2013, TDB has allowed institutional investors to become shareholders. Institutional investors have historically struggled to increase their involvement in the clean energy sector in Africa due to risk concerns and lack of technical expertise to assess infrastructure assets.

This model has proved mutually beneficial, expanding TDB's own capital base while also allowing institutional investors to participate in the energy sector via an investment grade rated partner. By being a shareholder in TDB as a whole rather than just partnering on specific projects, institutional investors spread their risk across all the activities of the DFI, which includes a variety of trade and project finance, while still receiving competitive returns. The initiative initially targeted African pension funds, insurers and DFIs, but later expanded to include investors from around the world.

Their approach presents a model that could be replicated elsewhere on the continent that can prove particularly beneficial for higher risk countries. For example, 16 of TDB's members are least developed countries, which are difficult for institutional investors due to higher risk levels and limited investment grade rated partners. Ensuring that least developed countries are not left behind despite their more challenging investment environment is vital to achieving the path projected in the SAS.

Note: This box was prepared in collaboration with the TDB Group.

Ways in which blended finance solutions have been applied in Africa include:

- **Enabling environment:** Development aid has provided technical assistance grants, training, fund internships and personnel exchanges, and project preparation grants. Lack of technical expertise in government bodies and domestic financial institutions can delay project development and drive up financing costs.
- **Energy access:** Concessional and blended finance has supported mini-grid development and solar home system connections in several countries, including DRC, Kenya and Nigeria. Connection costs for poorer households can be subsidised via grants and social impact bonds (a form of results-based financing), or with innovative new carbon finance models, such as in Senegal. Grants can also be used to fund pilot projects for productive uses, e.g. irrigation pumps, cement kilns, as in Kenya, or to support bundling of small projects into one investable unit.
- **Electricity networks**: International concessional finance has been used to strengthen the health of utilities, such as in Kenya, or to support governments with reforms that will allow more private participation in grids, for example in Sierra Leone and Uganda. Private participation in transmission and distribution networks currently is not widely authorised in Africa, though new reforms are being tested in Kenya. Concessional capital can be used for demonstration projects of private sector participation in grid operation or development, lowering perceived risks to private investors.
- **Clean power generation:** Where renewables are less well established, concessional public funds have been used as a tool to de-risk projects via blended finance vehicles with varying degrees of concessionality based on market readiness. For example, in established markets, public funds can be used to provide guarantees, including in the local currency, such as in Nigeria, to draw in more domestic investors.
- **End-use and efficiency:** Grants have been used to support initial projects via the creation of super energy service companies (Super ESCOs) or cooling-as-a-service companies, such as in Morocco and South Africa.[20] In the transport sector, donor and impact focussed investor funded pilot projects have been successful in attracting private equity and venture capital in Rwanda and Nigeria, while affordable debt financing has been used for public transportation projects in Uganda.
- **Domestic gas markets and low-carbon fuel supply:** Public bodies can provide guarantees to de-risk investment in domestic infrastructure or fund research and development of low-carbon gases, such as in Namibia. Constraints on finance for natural gas projects risk preventing the development of low-carbon fuels for domestic markets.

Based on the latest inventory of African energy projects, Table 3.4 identifies the degree of concessionality that may be required for each of the key focus areas outlined above that will support energy investment to reach the levels projected in the SAS. Table 3.5 provides case studies.

[20] A Super ESCO is an entity established by a government or via a public-private partnership as an intermediary between the government, facility owners and ESCOs to coordinate large-scale energy efficiency projects.

Table 3.3 ▹ Examples of blended finance in Africa

Type	Example	Approach
Project level	IFC Scaling Solar	Launched in 2015, it is designed as a "one-stop shop" for countries to step up deployment of solar PV. The IFC works with governments to create standardised project documentation, support procurement and provide access to blended finance. This approach creates a pipeline of bankable projects and provides access to competitively priced debt finance.
Fund facility	Climate Investor One	A three-tiered blended finance facility focussed on renewable energy, made up of a development fund, a construction equity fund and a refinancing fund. The first two tiers use higher blends of concessional finance to guide projects through their riskier development and construction phases, but once the project is operational and proven, projects are refinanced with higher levels of commercial debt, freeing up concessional capital for more projects in the development phase.
Institution level	AfDB's Room2Run	A risk transfer agreement signed in 2018 whereby the bank transferred the mezzanine credit risk[21] of a USD 1 billion portfolio of 47 private sector loans to investors for a fee, freeing up an expected USD 650 million in capital for additional lending. The deal is the first ever synthetic portfolio securitisation between a multilateral development bank and private sector investors.
Specialised intermediary	InfraCredit	An AAA-rated entity focussed on infrastructure projects that provides credit guarantees in local currency, specifically to attract local institutional investors. It is backed by the Nigeria Sovereign Investment Authority, GuarantCo, KfW Development Bank, AfDB and InfraCo Africa. It has tapped into Nigerian Naira 54 billion (USD 130 million) of local currency finance (including 15 local pension funds), with all its bond issuances to date being oversubscribed.

Note: IFC = International Finance Corporation; AfDB = African Development Bank.

[21] The credit risk associated with mezzanine debt, i.e. debt that is subordinated to another debt issue but where the lender has the right to convert the debt to equity in the case of default.

Table 3.4 ▷ Role of concessional capital in energy investment in Africa

<table>
<tr><th rowspan="2">Focus area</th><th colspan="3">Degree of concessionality</th></tr>
<tr><th>Grants</th><th>Concessional loan/equity</th><th>Commercial capital</th></tr>
<tr><td rowspan="3">Enabling environment</td><td>Support energy system planning and market design.</td><td></td><td></td></tr>
<tr><td colspan="2">Strengthen bankability with project support and creation of project hubs.</td><td></td></tr>
<tr><td colspan="2">Support the establishment of green domestic finance institutions.</td><td></td></tr>
<tr><td rowspan="3">Energy access</td><td colspan="2">Provide concessional funding for electrification of rural areas and poor urban households.</td><td></td></tr>
<tr><td></td><td colspan="2">Prioritise growth in demand for modern energy for productive uses and appliances.</td></tr>
<tr><td colspan="2">Roll out clean cooking programmes.</td><td></td></tr>
<tr><td rowspan="2">Electricity networks</td><td></td><td colspan="2">Expand financing for transmission and distribution networks.</td></tr>
<tr><td colspan="2">Improve performance of utilities and develop alternative creditworthy intermediaries.</td><td></td></tr>
<tr><td rowspan="3">Clean power generation</td><td>Run pilot projects and support project preparation in riskiest markets.</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">De-risk investment in renewables in new markets.</td></tr>
<tr><td></td><td></td><td>De-risk investment in renewables in existing markets.</td></tr>
<tr><td rowspan="2">End-use and efficiency</td><td></td><td colspan="2">Fund demonstrations of commercial viability of efficiency investments in buildings and appliances.</td></tr>
<tr><td colspan="3">Fund pilot projects of efficient and electrified mobility solutions.</td></tr>
<tr><td rowspan="2">Domestic gas markets and low-carbon fuel supply</td><td></td><td></td><td>Fund natural gas development and supporting infrastructure for domestic markets.</td></tr>
<tr><td></td><td colspan="2">Finance low-carbon fuel projects.</td></tr>
</table>

Table 3.5 ▷ Examples of concessional-finance supported energy initiatives in Africa

Action area	Key financing mechanism	Example
Enabling environment		
Support energy system planning and market design	Technical assistance and development grants; knowledge sharing and training	Regulatory reform in 17 African countries through RES4Africa and UNECA's Missing Link programme A geospatial integrated energy planning tool in Nigeria, in collaboration with UN Sustainable Energy for All Training and workshops for staff at utilities and energy regulators across the continent Launch of national gender policy in energy sector in Kenya, and adopting regional gender mainstreaming in energy policy making in 15 ECOWAS countries
Strengthen bankability with project support and creation of project hubs	Technical assistance and development grants; knowledge sharing and training Creation of project hubs to support project preparation and investment partnerships	Funding of project preparation and providing access to low-cost finance via initiatives such as AfDB's Sustainable Energy Fund for Africa Facilitating improved access to finance for developers via platforms such as TDB Group's Renewable Energy DealRoom
Support the establishment of green domestic finance institutions	Technical assistance grants; knowledge sharing; on-lending and co-financing	Training for local financial institutions to develop their expertise in assessing clean energy projects in Mozambique and Rwanda Creation of domestic green banks and financing facilities to develop bankable projects in Rwanda and South Africa
Energy access		
Provide concessional funding for electrification of rural areas and poor urban households	Blended finance models for mini-grids; viability gap funding (grants to support projects that are economically justified but not financially viable) for connections to poorest households	Public concessional finance and impact capital for mini-grids in DRC, Kenya and Nigeria Carbon finance to subsidise connection fees for low-income households in Senegal (led by the World Bank) UNECA's SDG7 Initiative issuing local currency green bonds in South Africa Transaction support and access to finance for off-grid companies under Power Africa's Beyond the Grid initiative
Prioritise growth in demand for modern energy for productive uses and appliances	Local currency debt financing; on-bill repayment models; bundling projects	Integration of services and solar products through pay-as-you-go programmes in West Africa Support for solar-powered irrigation and other productive uses of electricity in East Africa Aggregation of demand for solar to reduce purchasing costs and improve access to low-cost finance in Nigeria
Roll out clean cooking programmes	Grants; results-based finance; equity investments	Creation of dedicated clean cooking funds to facilitate knowledge transfer and co-financing, such as ESMAP's Clean Cooking Fund Launch of microfinance programmes for LPG in Cameroon and Kenya

Electricity networks		
Expand financing for transmission and distribution networks	Technical assistance grants; subordinated debt for demonstration projects; public-private partnerships	Promotion of public-private partnerships for electrification in Sierra Leone Funding of interconnectors between Mali and Guinea to increase the reach of the West African Power Pool
Improve performance of utilities and develop alternative creditworthy intermediaries	Liquidity support; partial risk guarantees; debt restructuring	Restructuring of debt to fund access investments in Kenya Reduction of revenue-related risks with creditworthy intermediaries such as Africa GreenCo in southern Africa
De-risk renewables investments in existing markets	Guarantees; subordinated debt; convertible loans; equity; political risk insurance	Local currency guarantees for institutional investor involvement in infrastructure in Nigeria Blended finance as part of schemes, such as the Renewable Independent Power Producer Programme in South Africa
End use and efficiency		
Fund demonstrations of commercial viability of efficiency investments in buildings and appliances	Grants and subordinate debt to develop energy-as-a-service models	Transformation of a state entity into a 'super energy services company' in Morocco to drive efficiency projects in the public sector Development of cooling-as-a-service business models in South Africa
Fund pilot projects of efficient and electrified mobility solutions	Grant, donor and impact investor funded pilots; blended instruments to mobilise venture capital and private equity interest; local currency debt financing; green loan facility for electric vehicles and recharging infrastructure	Development of a local electric bus business in Uganda Energy efficient cold-chain logistics pilot projects in Nigeria Support for innovative models for affordable green moto-taxis in Rwanda
Domestic gas markets and low-carbon fuel supply		
Fund natural gas development and supporting infrastructure for domestic markets	Subordinated debt and guarantees for domestic gas infrastructure	Private international investment in liquefied natural gas infrastructure in Mozambique
Finance low-carbon fuel projects	Knowledge sharing and training; equity; political risk insurance	Funding of research and development and feasibility studies for hydrogen development in Namibia

Implications of a sustainable African energy system

Seizing the moment

SUMMARY

- Africa is facing a greater threat from the impact of climate change than most other regions, despite contributing less than 3% to energy-related global GHG emissions and having the lowest emissions per capita in the world. The emissions trajectory for Africa in the Sustainable Africa Scenario (SAS), combined with that of the Stated Policies Scenario in the rest of the world, would lead to a substantial rise in the average global surface temperature, reaching 2.6 °C in 2100. But if emissions in the rest of the world were to follow the trajectory described in the **Net Zero Emissions by 2050 Scenario**, with Africa following the SAS pathway, the temperature rise would be limited to just over 1.5 °C in 2050, falling to around 1.4 °C by 2100. In both cases, far more would need to be done to adapt to climate risks.
- The way global energy systems evolve has an outsized impact on Africa: the need for climate adaptation, the global flow of commodities and affordability. Yet, Africa can also shape this future. In the SAS, Africa climate proofs investments, expands energy infrastructure to support its expanding industries, reduces import exposure and makes domestic food systems more robust and productive. Africa expands its production of fertiliser, steel and cement. Plus, local assembly of vehicles, appliances and solar home systems could alleviate import needs, which today represent 20% of GDP in Africa. Road, rail, port, telecommunications and cold chain infrastructure are reinforced with expanding energy infrastructure. In the SAS, energy demand by industry and goods transport increases by a third by 2030.
- The development of Africa's energy system could stimulate the creation of decent jobs with wide-ranging skill needs. In the SAS, 4 million energy-related jobs are created across the continent by 2030, over half coming from the provision of universal access to modern energy to households in sub-Saharan Africa. Many jobs related to access create an entry point into the formal economy, increasing employment and entrepreneurial opportunities for women. Around 450 000 miners are formally employed and many more informally employed to produce minerals relevant for clean energy technologies, for which demand is set to rise strongly.
- Ensuring that energy is affordable, especially for poor households, will remain an important energy and climate policy objective. Energy subsidies in Africa were around USD 40 billion in 2020, of which about 60% were for households. With the current energy price spikes, this subsidy burden could nearly double. A concerted effort to phase them out see subsidies fall to around USD 3 billion in 2030 in the SAS. These savings could be used to provide targeted affordability payments to the poorest households, aid efforts for universal access and help African households climb the energy ladder.

4.1 Overview

Global climate change and actions to address it will have an increasingly important impact on Africa's socioeconomic development and the evolution of its energy system. The continent is facing a greater threat from changing climate systems than most other parts of the world, despite historically being a minor contributor to global greenhouse gas (GHG) emissions that are causing those changes. Climate impacts pose major risks to Africa's economic growth and its hopes of achieving stability and prosperity. But Africa can shape its own future. Efforts to develop its energy system can dovetail with those to jumpstart its industry, reduce its exposure to imports and create local employment footholds.

This chapter explores the broader implications of a sustainable African energy system, for the continent itself and the world. It first assesses the implications of several global trajectories of emissions and temperature for Africa, and the associated adaptation needs. It then assesses the impact of global energy transitions on Africa's energy trade and the potential benefits of structural changes to its economy based on a shift to clean energy, including improved government finances, more and better jobs, broader participation by women in the workforce, and more affordable modern energy services for households.

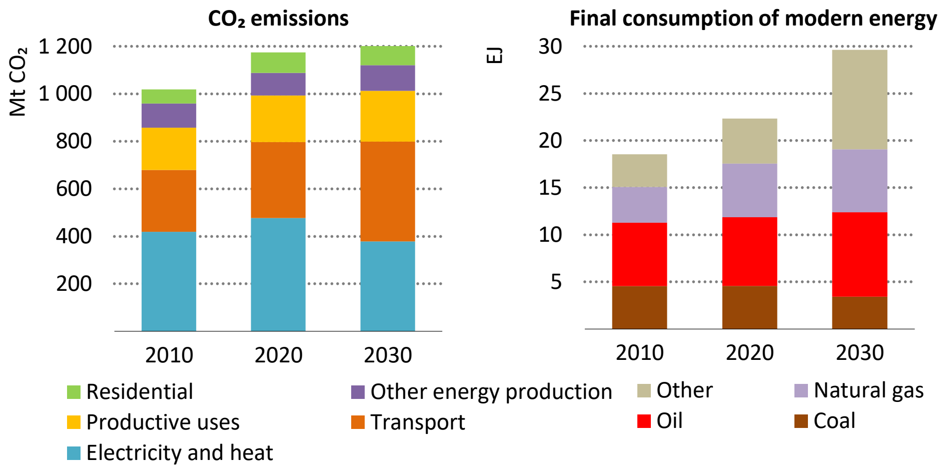
4.2 Climate change

4.2.1 Energy-related CO_2 emission trends in Africa

Africa is a minor contributor to global climate change. It accounts for less than 4% of global energy-related carbon dioxide (CO_2) emissions today and has the lowest emissions per capita in the world. Of the 1.2 gigatonnes (Gt) emitted in 2020, 40% came from electricity and heat generation, a quarter from transport and another 17% from productive uses. In the Sustainable Africa Scenario (SAS), emissions rise marginally to just over 1.2 Gt in 2030, about 3% above the 2020 level (Figure 4.1). Emissions from electricity generation plummet by more than 20% to 2030 as coal-fired generation is phased down and most incremental electricity demand is met by renewables, almost entirely offsetting big increases in emissions from transport, productive uses and energy production. Africa's non-CO_2 GHG emissions also fall rapidly, due to reductions in the traditional use of biomass, alongside concerted efforts to reduce methane emissions, which fall from around 4.2 million tonnes (Mt) in 2020 to 1.4 Mt in 2030.

In the SAS, emissions are driven up by overall industrial growth, infrastructure development and expanding cities, but these are kept in check by a larger share of renewables (replacing coal and heavy fuel oil), process electrification and, more importantly, bigger energy and material efficiency gains, with a particular focus on efficient motors, boilers and heat recovery optimisation. Switching to bioenergy and waste involves relatively low upfront investment and technologies that are available (they are being increasingly used in Southeast Asia and other developing regions). It can also reduce waste pollution. Encouraging fuel switching hinges on support from financing institutions and efforts by local authorities to establish local bioenergy value chains.

Figure 4.1 ▻ Energy-related CO_2 emissions and energy consumption in Africa by sector in the SAS



With a rapid decline in coal use, lower emissions from the electricity and heat sectors almost entirely offset a jump in emissions from transport and productive uses

Note: SAS = Sustainable Africa Scenario.

Box 4.1 ▻ Climate impacts in Africa in alternative global scenarios

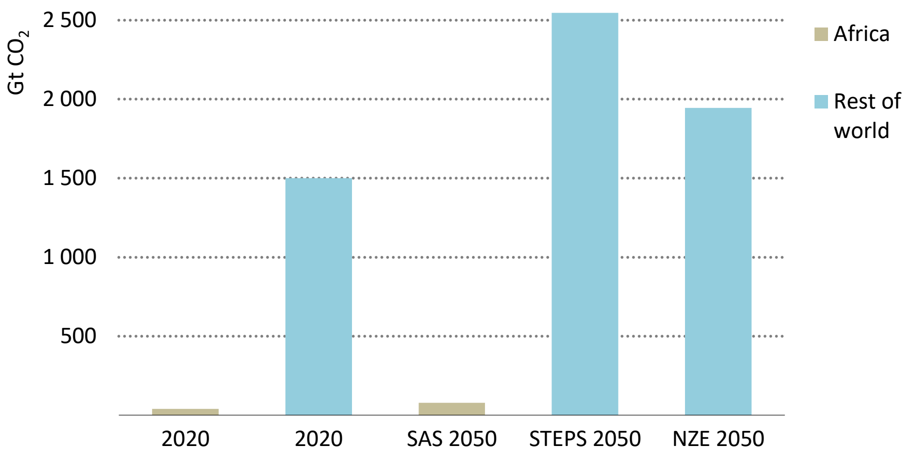
The impact of climate change in Africa will depend to a far greater extent on GHG emissions outside the continent than domestic emissions. To model the range of possible global temperature increases and their implications for Africa, we consider two additional scenarios taken from the *World Energy Outlook-2021* (IEA, 2021a).

- **Stated Policies Scenario** (STEPS): Reflects current policy settings based on a sector-by-sector assessment of the specific energy and climate policies that are in place, as well as those that have been announced by governments around the world.
- **Net Zero Emissions by 2050 Scenario** (NZE): Sets out a narrow but achievable pathway for the global energy sector to achieve net zero CO_2 emissions by 2050.

Emissions trajectories and climate outcomes in these scenarios diverge significantly. Global energy-related and industrial process CO_2 emissions, which totalled 34 Gt in 2020 and rebound quickly in 2021, rise to around 35 Gt in 2030 in the STEPS, leading to a rise in global temperature by the end of the century of around 2.6 degrees Celsius (°C). By contrast, in the NZE, emissions fall to 21 Gt in 2030 and net zero in 2050, limiting the mean temperature rise to just over 1.5 °C.

Africa has contributed less than 3% to global cumulative energy-related emissions since 1890. Its contribution remains very small through to 2050 in all of the scenarios explored in the *World Energy Outlook-2021* (Box 4.1). For example, Africa's cumulative emissions would be less than 4% of cumulative emissions in the NZE from 1890 to 2050 (Figure 4.2).

Figure 4.2 ▷ Global cumulative energy-related CO_2 emissions and African share since 1890 by scenario



Africa has contributed less than 3% of global cumulative emissions since 1890, a share that rises only marginally to 2050 in the SAS regardless of emissions trends in the rest of the world

Notes: SAS = Sustainable Africa Scenario; STEPS = Stated Policies Scenario; NZE = Net Zero Emissions by 2050 Scenario. Rest of world = all countries outside of Africa.

4.2.2 Global temperature rise

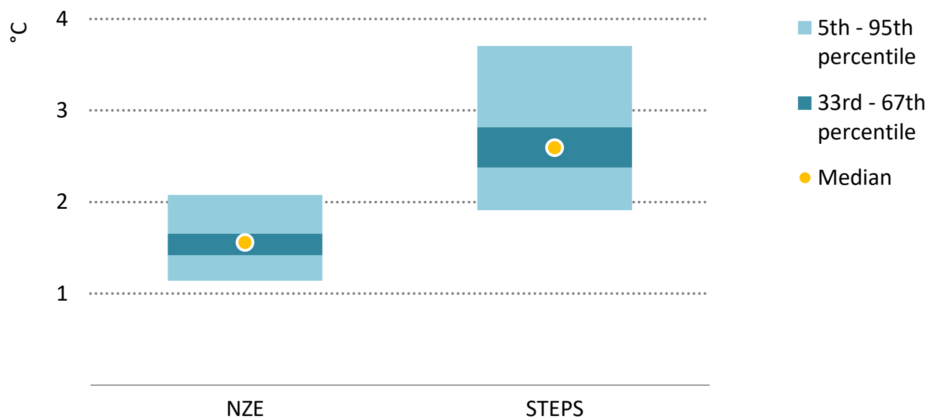
As discussed in the *World Energy Outlook-2021* (IEA, 2021a), the STEPS GHG emissions pathway would lead to a substantial rise in the average global surface temperature. Using the Model for the Assessment of Greenhouse Gas Induced Climate Change[1] (MAGICC), we estimate that the temperature rise in the STEPS would exceed 1.5 °C by around 2030 and 2 °C just after 2050.[2] If emissions were to continue to follow their long-term trend after 2050, and if there were to be similar changes in non-energy-related GHG emissions, such as those from deforestation and other land-use changes, the median temperature rise in 2100 would

[1] MAGICC 7, the version used in this analysis, is one of the models used for scenario classification in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2022). All changes in temperatures are relative to 1850-1900 and match the IPCC Sixth Assessment Report estimation of warming of 0.85 °C between 1995-2014.

[2] Unless otherwise stated, temperature rise estimates quoted in this section refer to the median temperature rise, meaning that there is a 50% probability of remaining below a given temperature rise.

reach 2.6 °C (Figure 4.3). However, if emissions were to follow the trajectory described in the NZE, the temperature rise would be limited to just over 1.5 °C around 2050, falling to about 1.4 °C by 2100.

Figure 4.3 ▷ Global mean average surface peak temperature rise between 2021 and 2100 and associated probability ranges by scenario



NZE pathway gives a 50% chance of limiting the peak temperature rise to below 1.6 °C

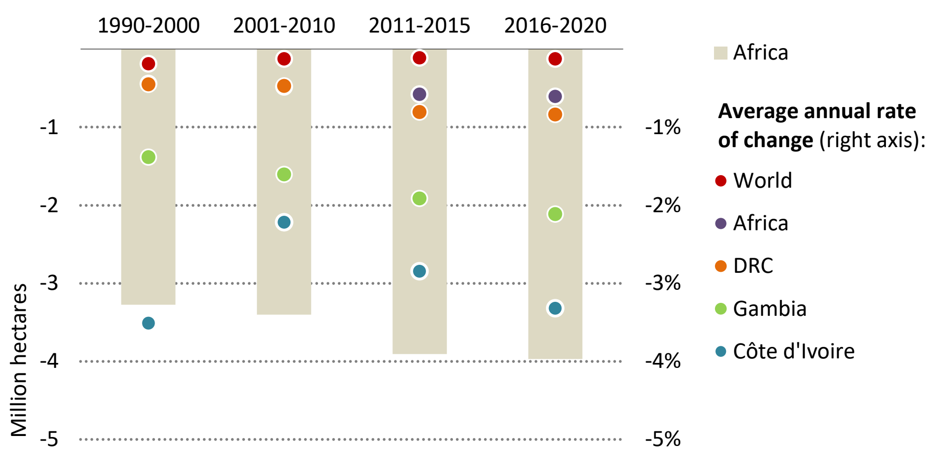
Note: STEPS = Stated Policies Scenario; NZE = Net Zero Emissions by 2050 Scenario.

A sensitivity analysis indicates that Africa's small contribution to cumulative CO_2 emissions in the SAS would have a negligible impact on both the peak temperature rise in the NZE, as well as the median temperature rise in 2100. The climate outcomes in the NZE are contingent not only on rapid reductions in energy-related GHG emissions, but also on co-ordinated global action to reverse deforestation and tackle methane emissions from agriculture and waste management. Notwithstanding the uncertainty surrounding the potential to achieve rapid reductions in all sources of GHG emissions globally, there are inherent uncertainties in the output of climate models, meaning that potentially even more catastrophic rises in temperature than that in the STEPS cannot be ruled out. For example, there is a roughly 5% chance of exceeding a temperature rise of 3.7 °C by around 2100 in the STEPS. The high degree of uncertainty in predicting how the earth system will respond to continuing emissions of GHGs, compounded by the uncertainty in physical risks associated with global warming, makes the need for concerted and co-ordinated efforts on climate mitigation and adaptation all the more urgent, if the most damaging consequences of the climate crisis are to be averted (see Chapter 1).

4.2.3 Deforestation, afforestation and Africa's climate commitments

Africa contains around 16% of the world's forested land area, the maintenance of which is key to achieve biodiversity and climate goals. However, deforestation has accelerated in recent years in Africa, with 4 million hectares – about twice the size of Wales – lost every year between 2016 and 2020 on average (Figure 4.4) (FAO, 2020). During this period, the annual rate of forest loss in Africa (0.6%) far outpaced that globally (0.1%) and in South America (0.3%), with particularly big declines in Côte d'Ivoire (3.3%), Democratic Republic of the Congo (DRC) (0.9%) and Gambia (2.1%). Some of this deforestation is driven by inefficient and unsustainable charcoal production, adding urgency to the need to improve access to clean cooking fuels. Although annual fluctuations can be significant, agriculture, forestry and land use (AFOLU) combined have contributed around 10% of total global anthropogenic CO_2 emissions in recent years.

Figure 4.4 ▷ Average annual change in forested area in Africa and rate of change in selected African countries and the world



Deforestation has accelerated in recent years in Africa, especially in Côte d'Ivoire and Gambia, with 4 million hectares in total lost every year on average between 2016 and 2020

Source: Global Land Analysis and Discovery (2022).

The economic effects of the Covid-19 pandemic are likely to pose additional risks for sustainable forest management and forest protection. For example, an abrupt decline in eco-tourism in 2020 reduced revenues from forestry-related conservation activities, while there have been reports of increased illegal logging in Kenya, Tanzania and Uganda. Financial hardship is pushing farmers to encroach on protected forest lands, while increased poverty has caused many households with access to clean cooking to revert to using traditional biomass, with adverse consequences for sustainable fuelwood production (see Chapter 3)

(Attah, 2021). Satellite monitoring shows that the loss of tree cover in primary forests was around 10% higher in 2020 and 2021 than the average during 2010-19 (Global Forest Watch , 2022).

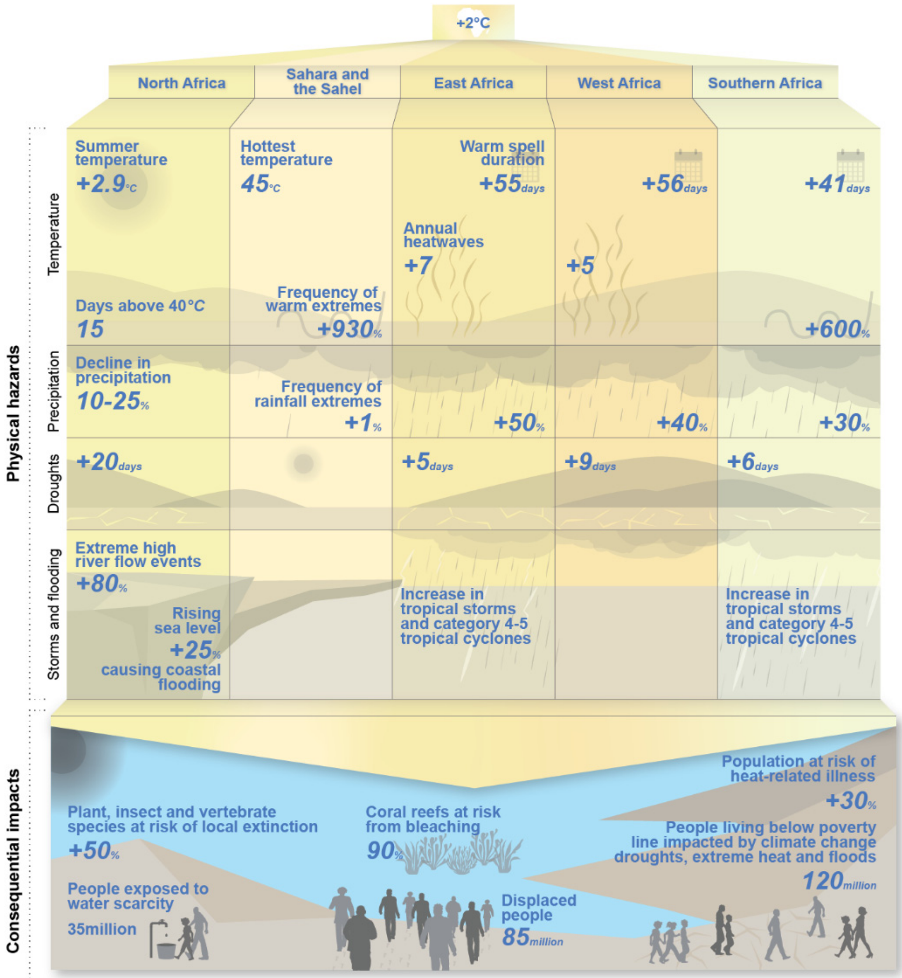
Achieving the climate goals assumed in the SAS can only happen if the clean energy transition is accompanied by commensurate actions to reduce AFOLU emissions. A significant move in this direction was made at COP26, where 141 parties accounting for more than 90% of global forest land pledged to halt and reverse forest loss and land degradation by 2030 (UK Government, 2021). Signatories included 31 African countries that are home to around 12% of the world's forest land and 76% of Africa's forest land. In addition, several African countries have made unilateral commitments to reduce or end deforestation in updates to their Nationally Determined Contributions (NDCs) under the Paris Agreement. For example, Namibia has pledged an 80% reduction in GHG emissions from AFOLU in 2030 compared with a national reference scenario.

4.2.4 Need for climate adaptation

Climate adaptation – the process of adjusting to actual or expected climate change and its effects – is a pressing need in Africa. The second part of the IPCC Sixth Assessment Report, which focusses on climate adaptation, impacts and vulnerability, notes that Africa has already experienced widespread loss and damage attributable to anthropogenic climate change, including biodiversity loss, water shortages, reduced food production, loss of lives and reduced economic growth (IPCC, 2021). Over the last 30 years, sea level rise has been higher in Africa than the rest of the world, causing severe coastal flooding and erosion. Heavy precipitation events and extreme weather events such as cyclones have also been observed. For instance, Mozambique was hit with three cyclones between 2019 and 2021.

The increase in temperature that has already occurred in Africa exceeds the average for the world, a trend that is set to continue. A global average temperature rise of 2 °C, which happens around 2050 in the STEPS, would most likely be accompanied by a median temperature rise of 2.7 °C in North Africa and 2.1 °C in Southern Africa (IPCC, 2021; IPCC, 2022). The risk exposure to physical hazards associated with a 2 °C temperature rise differs between African regions. For example, the expected frequency of warm extremes is expected to increase by over tenfold in the Sahara and the Sahel compared with current levels, and by around 600% in Southern Africa (Figure 4.5). Heavy precipitation events will intensify almost everywhere in Africa and coastal flooding in low-lying areas will become more frequent and severe. But an average 10-25% decline in precipitation is projected in parts of North Africa, whereas East Africa would experience a 50% increase in the frequency of rainfall extremes.

Figure 4.5 ▷ Physical hazards and consequential impacts associated with a global 2 °C temperature rise in African regions around 2050



A 2 °C temperature rise occurs around 2050 in the STEPS, leading to increased risks of physical hazards and consequential impacts

Notes: Warm spell duration = longest consecutive period over 6 days with a maximum temperature exceeding the 90th percentile (baseline = 1996-2015). Warm extremes = annual daily maximum corresponding to a 1-in-20 year event in 2018. Heatwave = more than 2 consecutive days with maximum temperatures above the 95th percentile (baseline = 1971-2005). Rainfall extremes = annual maximum precipitation during 1 day that would have been a 1-in-20 year event in 2018. Drought = standardised precipitation index for 12 months of less than 0.5 (baseline = 1976-2005). Extreme river flow event = 1-in-100 year event (baseline = 2006-2015). Drought and flooding hazards in Sahara and the Sahel are not modelled as they are desert regions. Data are taken from different scenarios but correspond to a medium-term (2041-2060) global temperature rise around 2 °C.

Sources: Aerenson et al. (2018); IPCC (2021); Kharin et al. (2018); McKinsey & Company (2020); Naumann et al. (2018); Weber et al. (2018), (IPCC, 2022).

Consequential impacts on society and ecosystems

Climate change on the scale depicted in the STEPS would have wide-ranging effects, some of which have been the subject of extensive study in Africa. These impacts include:

- **Food insecurity:** Conflicts, climate change, the locust invasion in 2019 and the Covid-19 crisis have led to a deterioration in food security. In 2020 alone, the share of the African population affected by food insecurity increased by 40% compared to 2019 due to a decline in crop yields (WMO, 2020). Climate change has reduced agricultural productivity growth by over one-third since 1961, more than in any other world region (IPCC, 2022). The projected global temperature rise consistent with the STEPS would reduce productive grazing and farm lands even more.
- **Displaced people:** The World Bank estimates that around 85 million people will be displaced in Africa by 2050 due to the effects of climate change on the liveability of current areas of human settlement (World Bank, 2021a). This builds on already high levels of displacement related to climate. In 2020, an estimated 1.2 million people in East Africa were displaced due to natural disasters, representing nearly 10% of global displacements (WMO, 2020).
- **Educational attainment:** Extreme weather events, especially in the growing seasons, can result in children being removed from school to assist in income generating activities. Childhood under nutrition associated with low harvests can hinder cognitive development (IPCC, 2022).
- **Heat exposure:** The number of Africans exposed to dangerous levels of heat and humidity, especially in cities, could rise by 150% between the 2030s and the 2060s in a warming profile consistent with the STEPS. Major cities, such as Dar es Salaam and Kinshasa, could see growth of around 200% in such exposure levels over that period respectively (Flacke et al., 2019). There is evidence linking heat exposure and drought to civil conflicts, particularly among agriculturally dependent and politically excluded groups (IPCC, 2022).
- **Wealth inequality:** The least well-off stand to suffer the most from climate change. The World Meteorological Organization (WMO) estimates that by 2030 around 120 million people living below the poverty line in Africa will be severely affected by climate change, including droughts, extreme heat and floods, if adequate response measures are not put in place (WMO, 2020). Employment in Africa is predominantly in climate-exposed sectors: around half of jobs in sub-Saharan Africa are in agriculture (World Bank, 2021b).
- **Gender inequality:** Women commonly face higher risks and greater burdens from the impacts of climate change in situations of poverty. They are most reliant on natural resources for their livelihoods and/or have the least capacity to respond to natural hazards. Women typically have unequal participation in decision-making processes. Labour markets compound inequalities and often prevent women from fully contributing to climate-related planning, policy making and implementation.
- **Loss of biodiversity and ecosystems:** African plants are expected to suffer significant losses and there is a 50% increase in the number of plant, insect and vertebrate species at risk of becoming extinct locally by 2050 compared to 1971 - 2000 (IPCC, 2022).

A temperature rise above 2 °C would make the risk of sudden and severe biodiversity losses widespread in West, Central and East Africa, with implications for the spread of invasive species. The loss of robust ecosystems and biodiversity would also threaten the effectiveness of many adaptation measures (IPCC, 2022).

The ability to manage these impacts depends on many factors, one of which is energy access, which can reduce reliance on rain-fed irrigation to boost agricultural productivity and mitigate exposure to drought. Increased refrigeration of food can reduce post-harvest losses, estimated to be 30-50% of all the food produced in sub-Saharan Africa (Deloitte, 2015), thereby improving food security and reducing methane emissions associated with bio-waste. Energy systems in turn will be affected by these societal and ecological factors. Africa is home to more than 20% of the global population that need cooling to manage extreme heat, yet ownership of cooling devices is rare (only three in four households own a fan and only around one-in-thirteen owns an air conditioner). Providing access to electricity in order to provide cooling is a health imperative, but one that drives up electricity demand quickly in Africa (see Chapter 2). Passive cooling solutions, such as natural ventilation[3], and the use of white paint on roofs, are fast and effective measures to dampen increasing electricity demand for cooling (Taleb, 2014).

Economic impacts

Climate-induced economic impacts will have a range of knock-on effects including: increasing pressure on budgetary and fiscal balances; increasing financing costs for infrastructure projects (due to higher climate-related risk); and adverse impacts on labour markets.[4] Household incomes could suffer, especially in rural farming communities. Such impacts could generate a vicious circle in which adaptation efforts across all economic strata become more expensive. It has been estimated that a temperature rise commensurate with that in the STEPS would reduce African GDP by around 8% in 2050 compared with a baseline without any climate impacts (UNECA and African Development Bank, 2019), with losses in some regions, such as East Africa, reaching up to 15% (Figure 4.6). There is a high degree of uncertainty associated with these economic impacts; for example there is around a one-in-forty chance than the reduction in GDP in East Africa and West Africa in 2050 would exceed 40%. For comparison, clean energy investment in Africa in the SAS over 2020-30 averages just over 1% of GDP. While the global temperature rise in the NZE also hinders economic growth, regional GDP losses by 2050 would likely be at least 40-70% less severe than those in the STEPS.

Climate adaptation will be costly but worthwhile. The cost of adaptation has been estimated at USD 30-50 billion per year through to 2030 for sub-Saharan Africa alone, representing 2-3% of its GDP (WMO, 2020). But the cost of the damage that would occur in the absence of

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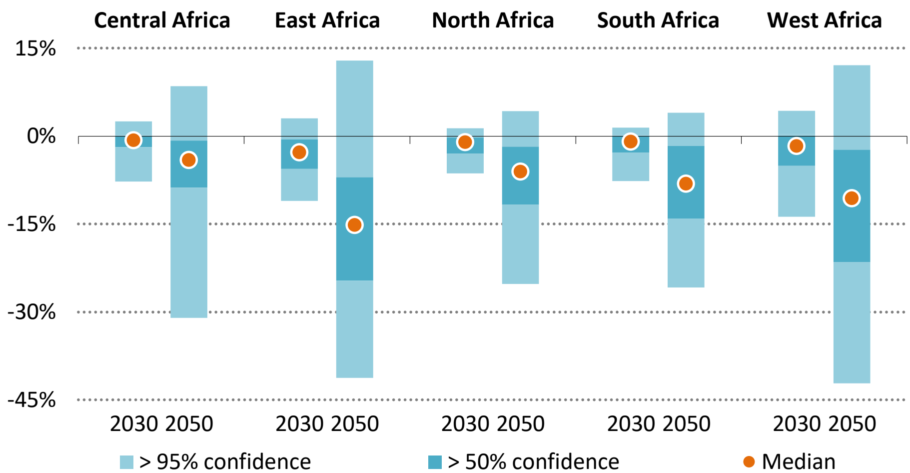
[3] Natural ventilation uses temperature gradients within buildings to sustain a current of air which acts to provide space cooling.

[4] Some of the analysis in this section benefited from inputs provided by the United Nations Economic Commission for Africa (UNECA).

any adaptation would be five-times higher (UNECA, 2017). Estimates of the adaptation costs and the cost of inaction need to be taken with caution, as there is a lot of variability in estimates and methodologies (UNEP, 2021).

Figure 4.6 ⊳ Climate-related impacts on GDP per capita by region in Africa, 2030 and 2050



A temperature rise of 2 °C in 2050 would reduce median GDP per capita by 4-15%, but there is a higher than one-in-four chance of a 20% reduction in East Africa and West Africa

Notes: Impacts based on representative concentration pathway 8.5 which has a median temperature rise of around 2 °C in 2050, in line with that in the STEPS. Impacts are relative to a baseline without climate change.

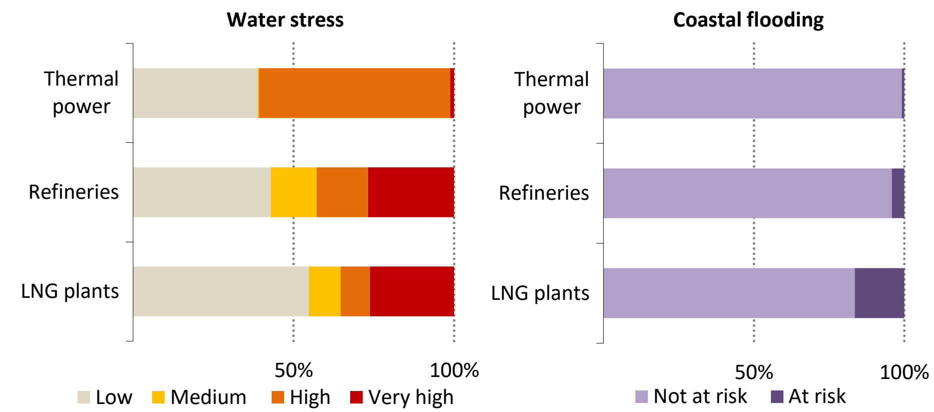
Sources: Baarsch et al.(2020); UNECA and African Development Bank, (2019).

4.2.5 Climate-proofing energy infrastructure

Climate change poses major threats to African transport, telecommunications and water supply infrastructure, as well as energy assets. Infrastructure damage can result from extreme weather events, as well as forced migration, political instability, famine, declining labour productivity, poor sanitation and deterioration in public health. All of these have implications for the ease, cost and viability of clean energy transitions, as well as progress in meeting the United Nations Sustainable Development Goals.

Energy infrastructure is particularly vulnerable to many of the extreme weather events that are set to become more severe and more frequent as result of climate change. For example, droughts limit the water needed to operate hydro and thermal power stations, while heavy flooding can increase sediment and force dams to operate in bypass mode, reducing hydroelectric output. Today, over 60% of thermal power plants in Africa are at high or very high risk of being disrupted by water stress.[5] A significant fraction of refining and liquefied natural gas (LNG) capacity is exposed to medium or high water stress risk (Figure 4.7). In addition, around one-sixth of LNG plant capacity, which is usually located on the coast, is vulnerable to the risk of flooding from rising sea levels caused by climate change; a smaller fraction of refineries and thermal power plants are exposed as they are more often located inland. In addition to water stress and coastal flooding, a variety of other climate-related events such as cyclones and heatwaves have caused disruption to power systems in recent years, notably in 2021 and 2019 in South Africa (Table 4.1).

Figure 4.7 ▷ Share of key energy infrastructure capacity at risk from water stress and coastal flooding in Africa, 2020



The majority of Africa's thermal power plants are at high or very high risk of water stress, while around one-sixth of LNG capacity is at risk of coastal flooding

New energy plants will need to be built and existing ones adapted to be climate resilient, i.e. they need to be able to anticipate, absorb, accommodate and recover from the effects of a potentially hazardous event related to climate change (IEA, 2021a). Some best practices for boosting climate resilience in energy infrastructure include:

- **Conducting an assessment of climate change risks**. Governments can fund studies to assist business decisions and policy making. Commitments to carry out such studies have featured in some African NDCs, e.g. Egypt.
- **Building climate resiliency into policies and regulations.** Best practice can include resiliency standards in construction codes and environmental assessments, requiring regular assessment of climate risks during operation and maintenance, and establishing incentives for reliable energy service during major climate-related events. Governments

[5] Water stress depends on the ratio of water withdrawals to available renewable surface and ground water supplies and so can be triggered by drought or extreme precipitation.

can also develop early warning systems and provide public insurance for climate-related disasters.

- **Upgrading infrastructure, monitoring and operations**. Best practice can include expanding hydro reservoir capacity and building upstream sediment control facilities. In the case of grid infrastructure, it can involve the use of drones for improved infrastructure monitoring and putting particularly vulnerable power lines underground. For power generators, it can include devising hot weather operational protocols.
- **Diversifying energy resources**. This can guard against droughts or heavy rain patterns that can disrupt renewable energy operations and fuel deliveries to power stations. Countries such as Morocco have created diversification plans. Regional interconnections can reduce risks, though they can increase exposure to other weather-related disruptions.

Investing in energy system resiliency can end up costing up to twelve-times less than disaster relief measures (IMF, 2020). Such investments need to be considered in parallel with other measures aimed at addressing security risks such as sabotage, vandalism and theft of components, for instance cables that contain valuable metals such as copper.

Table 4.1 ▷ Selected recent climate-related incidents and their impact on energy facilities in Africa

Date	Location	Type of climate event	Affected segment	Impacts
Apr 2021	Central African Republic	Torrential rains	Electricity towers	Power supply interrupted for weeks, impacting water supply and health facilities.
Jan 2021	Mozambique, South Africa	Tropical cyclone and associated flooding	Electricity grid and coal power plants (wet coal problem)	Falling trees and poles caused power outages in South Africa and Mozambique. Eskom lost 14 GW of generation and had to implement contingency measures.
Apr 2020	Uganda	Flooding	Hydropower plants	20% of grid capacity suddenly went offline causing a blackout because two of Uganda's hydropower plants were blocked by flood debris caught in the turbines.
Dec 2019	Zambia	Drought	Hydropower plants	Affected around 80% of electricity generation. The Kariba dam dropped to 10% of its capacity, leading to load shedding.
Mar 2019	Mozambique, Madagascar, Malawi, Zimbabwe	Cyclone and flooding	Electricity grids and hydropower plants	Two major hydropower plants in Malawi went offline, reducing capacity from 320 MW to 50 MW and causing blackouts and the loss of hydro export revenue. Power was only fully restored six weeks later.
Dec 2017	Malawi	Drought	Hydropower plants	Frequent blackouts lasting up to 25 hours.

Note: GW = gigawatt; MW = megawatt.

Sources: Eskom (2021a), Kings (2020), Mwenda (2019), Mushota (2019), CDP (2019), Club of Mozambique (2019), The Guardian (2017), Hill and Mitimingi (2019)

4.2.6 Financing climate adaptation

Funding to African countries for climate adaptation remains far below what is required. USD 30-50 billion could be needed annually by 2030 – a huge increase on the USD 7.8 billion that was provided by advanced economies for adaptation projects in 2019, (the latest year for which data are available) (OECD, 2021a; IMF, 2020).[6] The actual amount that will be needed will depend on the speed with which adaptation projects are rolled out as well as progress on mitigating climate change. Delays in either of these areas would result in higher adaptation costs and needs in the longer term.

International climate finance from advanced economies is crucial to investment in climate adaptation in African countries due to the sheer scale of the financial needs and their limited capacity to mobilise capital (see Chapter 3). Commercial capital also needs to play an important role, however, most African countries do not yet have the enabling environment to support it. For example, only six countries in Africa have submitted National Adaptation Plans to the UN Framework Convention on Climate Change to date (Global Center on Adaptation, 2021). Few private lenders are prepared to put up capital in the absence of such plans. Adaptation projects in non-market sectors in least developed countries, over 70% of which are in Africa, require highly concessional capital. Technical assistance grants are often required initially to support adaptation planning and strategy, as well as climate data assessment expertise in public bodies. Grants can also be used for pilot projects or to support commercial projects by reducing upfront costs.

For Africa, only 40% of adaptation finance from advanced economies in 2019 was in the form of grants, with the rest being debt (Figure 4.8). Although bilateral and multilateral climate financing includes significant amounts of grants, financing from multilateral development banks, which accounted for over half of total climate finance to all countries from advanced economies in 2019, is primarily debt dominated (OECD, 2021a). This not only increases the fiscal burden for recipient countries, but also directs finance to countries that can most easily absorb debt and create bankable projects rather than to those with the most significant adaptation needs. The reliance on debt instruments combined with difficulties in commercialising adaptation projects also contributes to lower estimated disbursement ratios (the ratio of actual disbursed amounts and the disbursable amount) than other forms of development or climate finance.[7]

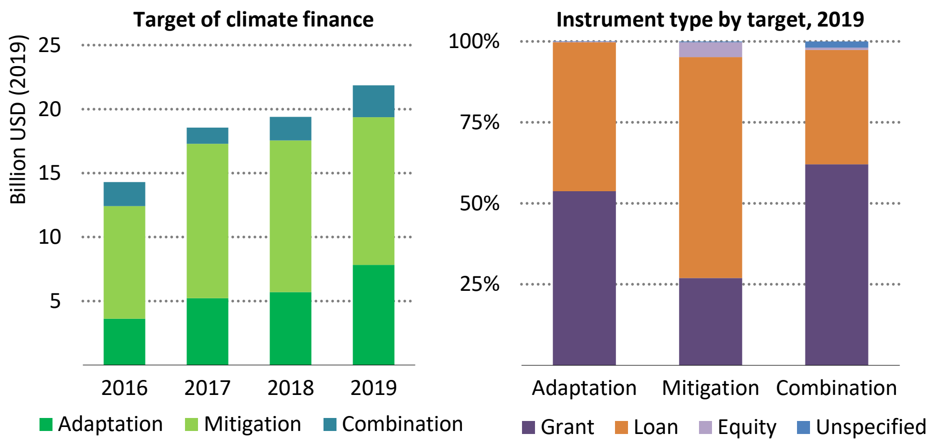
New financing approaches for climate adaptation are starting to emerge to address the shortfall in funding. In 2021, the government in Gabon announced an innovative approach to finance forest protection via green bond issuances and sales of carbon offsets. The African Development Bank (AfDB) is piloting an adaptation benefits programme that could create a

[6] Finance from advanced economies is based on data reported to the Development Assistance Committee (DAC) of the Organisation for Economic Co-operation and Development (OECD).

[7] Multilateral development banks do not report their disbursement ratios. Estimates of other sources show disbursement ratios of development aid often reach over 95%, but in the case of adaptation finance, it has been estimated to be as low as 46% (Savvidou et al., 2021).

pipeline of bankable projects across the continent for public and private capital (Box 4.2). Other established de-risking mechanisms, such as the use of guarantees or blended finance approaches, could help to mobilise more private capital, freeing up public funds to target least developed countries and other high risk, low revenue projects.

Figure 4.8 ▷ Primary climate finance by target and instrument type in Africa



So far, the bulk of climate finance commitments in Africa have targeted mitigation, while funds for adaptation have been mostly in the form of debt

Notes: Other = equity and shares in collective instruments, mezzanine finance instruments and unassigned. Data are based on reporting to the OECD Development Assistance Committee.

Source: OECD (2021a).

Box 4.2 ▷ Adaptation Benefit Mechanism

Today, the African Development Bank (AfDB) is the only multilateral development bank to have reached parity between climate change adaptation and mitigation finance. Adaptation has accounted for over half of its climate finance since 2018 and reached 63% in 2020. One of AfDB's flagship initiatives – the Adaptation Benefit Mechanism (ABM) – is a results-based financing facility in line with Article 6.8 (covering non market-based approaches) of the Paris Agreement.

The ABM allows projects to create certified adaptation benefits (CABs) which are sold to governments or private entities via adaptation benefit purchase agreements and logged in a central registry. The price of CABs varies by project, based on the cost of generation plus a risk premium. They are neither fungible nor transferable. The scheme, developed with the support of the Climate Investment Fund (CIF) – one of the world's largest multilateral climate finance mechanisms for developing countries – is in a pilot phase until 2023, during which it will oversee 10-12 demonstration projects to develop methodologies for calculating and certifying adaptation benefits.

By increasing the commercial aspects of adaptation projects, CABs are designed to incentivise private sector involvement while simultaneously helping governments track progress of their NDC priorities. The success of the ABM will depend on whether it can create a transparent and effective methodology, the ease and affordability of certification for developers, and whether it can generate enough interest from CAB buyers.

Note: This box was prepared in collaboration with the African Development Bank.

4.3 Transforming Africa's economy

Africa's economic development is heavily intertwined with its energy development. Universal access to modern energy service, more reliable electricity and less volatile energy pricing would all contribute to accelerating Africa's economic development, which in turn would drive up demand for energy services. Seizing this opportunity calls for an economic transformation that goes beyond energy supply, including an expansion of key industries, including fertiliser, steel and cement, and the manufacture and assembly of appliances, vehicles and clean energy technologies. That would generate wealth, create jobs and reduce Africa's burden of imports generally, which is becoming an urgent concern in the wake of Russia's invasion of Ukraine.

Such economic diversification is an integral part of the SAS. But attracting investment in those industries implies a need to build more infrastructure to connect African markets, including transport links, telecommunication networks and energy networks. An African free trade area could play an important role to enable this, notably in unifying energy markets, establishing cold chains (low temperature-controlled supply chains) for agriculture and developing industrial zones.

4.3.1 Infrastructure development

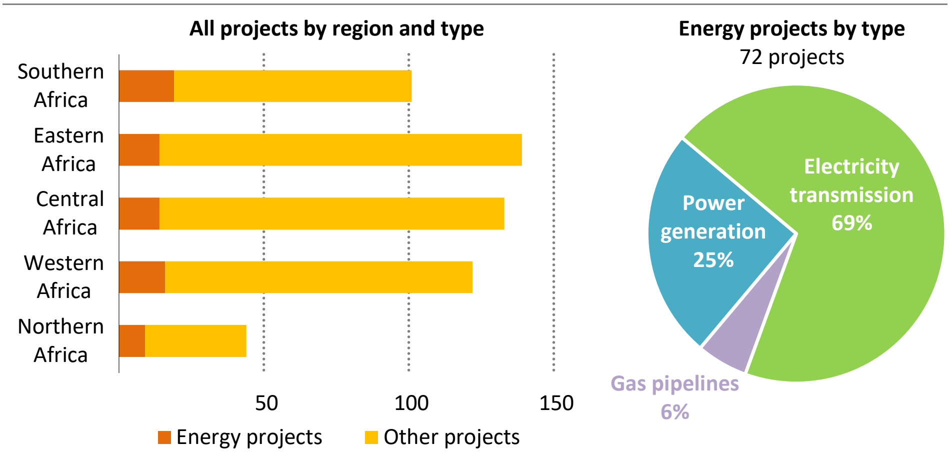
A lack of basic infrastructure remains one of the main barriers to industrial development and increased trade across the continent. Much of the infrastructure needed to support Africa's growing industry, jobs and food security depends on reliable and affordable energy supplies. The Programme for Infrastructure Development in Africa (PIDA) aims to promote the development of needed infrastructure.[8] The construction of roads, railways, ports and telecommunication networks included in the PIDA are taken into account in the SAS. The projected infrastructure development boosts transport of agricultural and industrial products to major cities and markets, delivery of clean cooking fuels, distributed electricity

[8] PIDA is co-led by three executive agencies: African Union Commission, New Partnership for Africa's Development (NEPAD) Secretariat and African Development Bank.

access solutions enabled by phone-based payment systems, and the wider uptake of appliances and vehicles across the continent.

PIDA's two Priority Action Plans include 72 energy infrastructure projects, which make up 15% of all projects (most concern transport and telecommunications). Over 60% of the energy projects are located in sub-Saharan Africa and more than two thirds are to increase electricity transmission capacity, in support of the Africa Single Electricity Market and the Continental Power System Master Plan, which aim to establish long-term planning for regional power pools (Figure 4.9). Power generation projects are the second-largest in number, of which all but one are hydropower plants. There is one pipeline project, the Trans-Sahara Gas Pipeline to link Nigeria and North Africa. The pipeline project has a long history of delays due to security problems and waning public support, but is receiving increased attention in light of Russia's invasion of Ukraine as a means of bringing Nigerian gas to Europe (though its completion would take many years).

Figure 4.9 ▷ PIDA infrastructure projects, 2013-2020



Almost 70% of all PIDA energy projects are to increase electricity transmission capacity, mostly for interconnectors

Note: PIDA = Programme for Infrastructure Development in Africa.

Expanding transport infrastructure requires supporting energy infrastructure to be built in parallel, such as fuelling stations along roads, guidelines for rail, electricity for cell towers (cellular base stations) and data centres, and refrigeration for food and health supply chains. Road and railway infrastructure goals in the PIDA focus on connecting African countries and linking interior regions that produce mineral and agricultural products to coastal ports. These transport corridors could also be used as major corridors for electrical transmission and telecommunications infrastructure to reduce costs.

Telecommunications infrastructure already reaches many parts of Africa and is to be expanded and reinforced through the PIDA and other initiatives. Since 2019, more Africans have been able to access telecommunications networks than electricity. In sub-Saharan Africa (including South Africa), only around 20% of the population do not having access to a mobile phone network compared with 51% without electricity, though 65% of those with access to a mobile phone network do not make use of it (GSMA, 2021). Mobile money services have played a major role in the expansion of Africa's commercial activities, and have been essential to the rapid expansion of mobile pay enabled solar home systems. At the end of 2020, there were 548 million registered mobile pay accounts in sub-Saharan Africa, over 150 million of which were active on a monthly basis (GSMA, 2021).

Many rural telecommunication sites and cell towers are not connected to the grid, relying instead on expensive industrial-grade diesel generators, usually two per site in order to ensure a backup solution. In sub-Saharan Africa, diesel can represent up to 40% of network operating costs (GSMA, 2021). In the SAS, a growing number of these facilities are powered by solar PV mini-grids coupled with batteries (or diesel generators), which today can provide electricity that is 23-60% cheaper than the use of stand-alone diesel generators, depending on the region (MGP, BloombergNEF and SEforAll, 2020). Telecommunication companies represent important anchor clients with reliable records for repayment to help secure investment in mini-grids. However, in some cases, theft can deter companies from adopting such solutions, as PV panels are worth more than diesel generators.

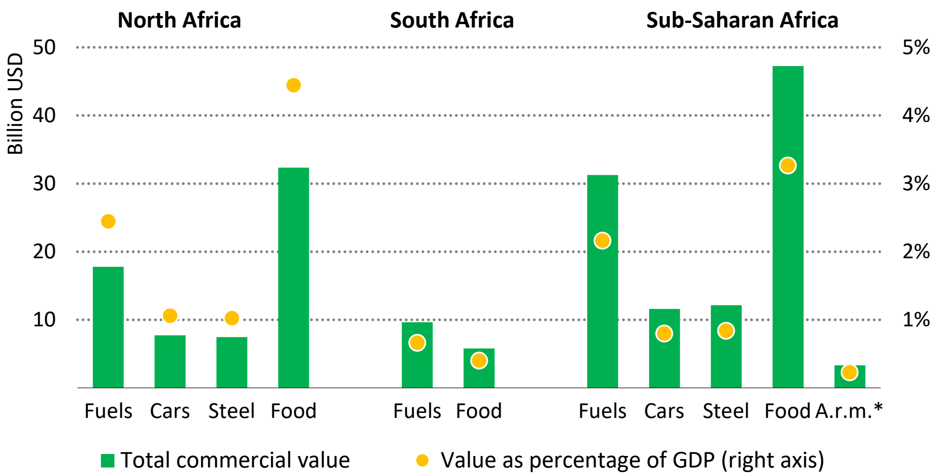
Refrigerated supply chain infrastructure (cold chains) has become an area of increased focus in Africa, especially since 2020 because of the refrigeration needs of Covid-19 vaccine distribution. Better cold chain infrastructure and logistics could facilitate more and better quality food production, extend shelf life of food stuffs and reduce the need for imports. Critical segments for cold chains are the first stage, from harvest to storage, and last-mile delivery (on motorbikes for example). Refrigeration is all but impossible without access to reliable power supplies, especially in rural areas. The cold chain requirements of Covid-19 vaccines have driven the private sector to explore the use of dry ice, liquid nitrogen and ammonia for cooling during transport to remote areas and the installation of ice-cool storage boxes in rural areas. These solutions, while less practical than electrical-based refrigeration, can serve as temporary solutions in anticipation of the arrival of full access to electricity, helping remote farmers deliver their produce to urban centres and fetch higher prices. Better geospatial mapping of cold chain networks would help to optimise the development of electricity networks in parallel with energy access programmes with government and international development aid support.

4.3.2 Reducing import exposure

Several African countries aim to reduce their exposure to imports of various goods by expanding domestic production – an increasingly urgent goal amid soaring global inflation, especially of food and fuel prices. Imports represent nearly 20% of GDP in Africa, with the most acute exposure being in sub-Saharan Africa, where fuel and food imports each represent over 2% and 3% of GDP respectively (**Error! Reference source not found.**).

Priorities for reducing imports include fertiliser, steel, vehicles, appliances and solar products, particularly those needed to accelerate energy access. Further expansion of the African Continental Free Trade Area (see section 4.3.3) could contribute to national efforts to boost domestic output of these goods.

Figure 4.10 ▷ Imports of selected commodities in Africa, 2020



Africa is heavily dependent on imports of fuels, steel, vehicles and food, leading some countries to devise plans to boost domestic production

*A.r.m. = agricultural raw materials.

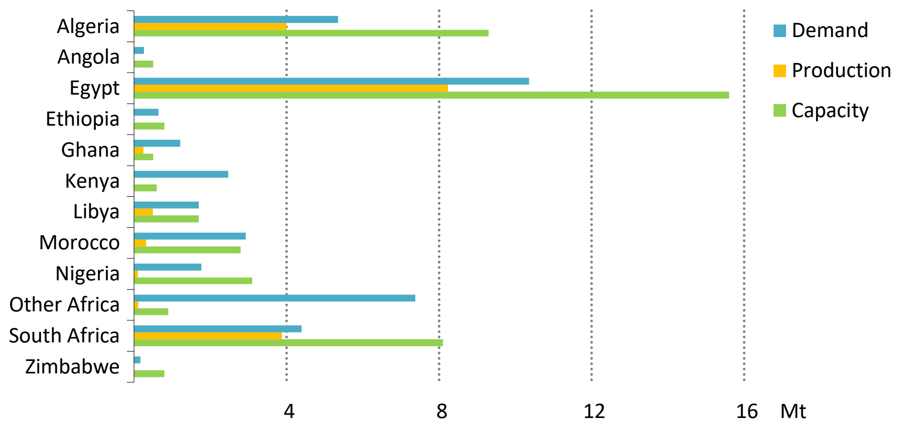
Source: UNCTAD product groupings and composition (Standard International Trade Classification Rev. 3).

Despite producing more oil and gas than it consumes, Africa is a net importer of hydrocarbon fuels today as its refining capacity is not able to produce the needed fuel types (see Chapter 3). When completed, the Dangote Refinery in Nigeria will reduce import exposure. But it will not cover the full fuel import requirements for the continent, especially with rising liquefied petroleum gases (LPG) demand, which grows by 40% between 2021 and 2030 in the SAS. Renewing or upgrading some of the existing refining capacity would help. Africa is also a big net importer of fertiliser, which makes it particularly vulnerable to the recent surge in prices. Nigeria, South Africa and much of North Africa have fertiliser manufacturing, which mitigates the continent's overall exposure, but many countries, notably South Africa and Ethiopia, are very import dependent.

Steel imports are another major economic burden for Africa. Sub-Saharan Africa relies almost completely on imports. North Africa reduced its import dependency from 50% in 2010 to 40% in 2020, with increased production capacity in Algeria, Egypt and Morocco. South Africa is almost self-sufficient (Figure 4.11). In the SAS, African countries reduce their steel import dependency in line with the African Union's 2063 Agenda – a blueprint for transforming

Africa into a global economic powerhouse.[9] Planned projects in Namibia, Mozambique and North Africa, most of which use the low emissions electric arc furnace steelmaking method, would increase steel capacity in the region by 7-9% in 2023 compared with 2020, if completed on time (see Chapter 2). Additional capacity is also planned in three of the four countries with the highest steel demand – Ghana, Kenya and Tanzania. In some countries, available capacities have utilisation rates of less than 50%. These rates increase in the SAS, reducing the need for new capacity.

Figure 4.11 ▹ Iron and steel capacity, production and demand in selected African countries, 2020



The majority of countries in Africa, especially in sub-Saharan Africa, do not utilise much of their available steel production capacity and rely heavily on imports

Sources: IEA analysis based on OECD (2021b) and World Steel Association (2022).

Demand for electrical appliances and vehicles in Africa is set to boom as incomes rise and more people gain access to electricity. In the SAS, appliance stock increases by two-thirds and vehicle sales threefold over 2020-30. The majority of appliances and vehicles sold today are second-hand imports. This has exposed Africans to dumping of broken or highly inefficient appliances and vehicles, with some appliances consuming many times more electricity than best available models. This exacerbates Africa's fuel import needs and puts strain on electricity systems. Some African governments, including Ghana, have begun to strictly enforce bans on imports of the least efficient appliances to help curb the growth in electricity demand and are pushing other members of the Economic Community of West African States (ECOWAS) to follow suit. This opens opportunities for domestic manufacturing of appliances most in demand, in particular solar home systems, which are increasingly being sold in bundles with special appliances that require little power.

[9] https://au.int/agenda2063/overview

African countries rely heavily on imports for solar home systems and, in order to help make them affordable, they are typically exempt from duty and value-added tax (see Chapter 3). While these exemptions remain essential to accelerate universal access to affordable electricity, they undermine efforts to nurture domestic production. Most African companies involved in the value chains for solar home systems focus on the assembly of batteries and PV panels, which are no longer produced on the continent. A few companies pioneered production of solar panels as early as 2011 in Kenya and 2012 in South Africa, but have since turned away from manufacturing to focus on distributing panels in partnership with Southeast Asian manufacturers. However, there are plans to build new production facilities, such as in Burkina Faso. The DRC-Zambia Battery Council aims to lay the groundwork for developing battery supply chains based on their indigenous critical mineral resources.

Expanding manufacturing centres to meet domestic demand requires stronger energy, transport and digital infrastructure. Dedicated industrial parks with reliable and affordable supplies of energy and other services can be a way to attract anchor industries.[10] Reliability is particularly important to attract industry, as African enterprises experienced power interruptions of more than 50 hours a month on average in 2018, a loss of 25 days of economic activity per year (World Bank, 2019). There were an estimated 189 industrial parks in Africa in 47 countries in 2019, mostly in Eastern Africa, Egypt, Morocco, Nigeria and South Africa. Many industrial zones rely on individual diesel or gasoline generators to provide backup power. Improving the reliability of electricity, particularly for industrial customers, is essential to increase productivity, attract more industry and reduce diesel imports.

4.3.3 Building a single African market

The creation of the African Continental Free Trade Area (AfCFTA), which became operational in January 2021, creates a common market with a combined GDP of USD 3.4 trillion (World Bank, 2020).[11] The objective is to encourage the growth in trade within Africa by removing trade barriers. It complements other efforts like the PIDA and those of the African Union Development Agency (AUDA-NEPAD) to improve intra-African infrastructure. Currently, tariffs and physical infrastructure barriers limit intra-African trade, which accounts for only 14% of total African exports (UNCTAD, 2021). Only four African countries – Benin, Kenya, Mozambique and Senegal, all located on the coast and crucial to exchanges with several landlocked countries – have another African country as their primary export destination.

AfCFTA aims to reduce tariffs on 90% of all goods within ten years and facilitate free movement of goods, services, capital and people (Songwe, 2019). The UN Conference on Trade and Development (UNCTAD) estimates this will boost intra-African trade by a third (Grynspan, 2021). However, not all countries are equally well positioned to take advantage of this opportunity. Manufactured goods exported to elsewhere in Africa exceed 10% of total

[10] Industrial parks include any specialised entities designed to support trade, investment and industrial policy, including special economic zones, free zones and export processing zones.

[11] The analysis in this section benefited from inputs from UNECA and the Mo Ibrahim Foundation.

exports only in South Africa and Kenya (UNCTAD, 2021). Although trading has officially started under AfCFTA, major obstacles remain. Rules of origin are yet to be confirmed, not all countries have ratified the agreement and each country needs to reform its regulatory framework to support the agreement. Trade agreements with third parties also need to be harmonised and the role of existing regional trading blocs, which have differing tariffs and standards, clarified and aligned with AfCFTA.

In order to facilitate increased intra-African trade, critical infrastructure needs to be built, including energy, communications, road, rail and port infrastructure. Improving the efficiency and energy intensity of logistics would stimulate more trade. Improved logistics are needed to limit "empty miles" – driving an empty truck after goods have been delivered – in order to minimise costs and reduce strain on infrastructure. More efficient technologies, such as electric trucks, are likely to require financial support, such as grants or concessional finance. More efficient cold chain supply services are needed to support the targeted growth in agricultural trade.

4.4 Energy sector employment

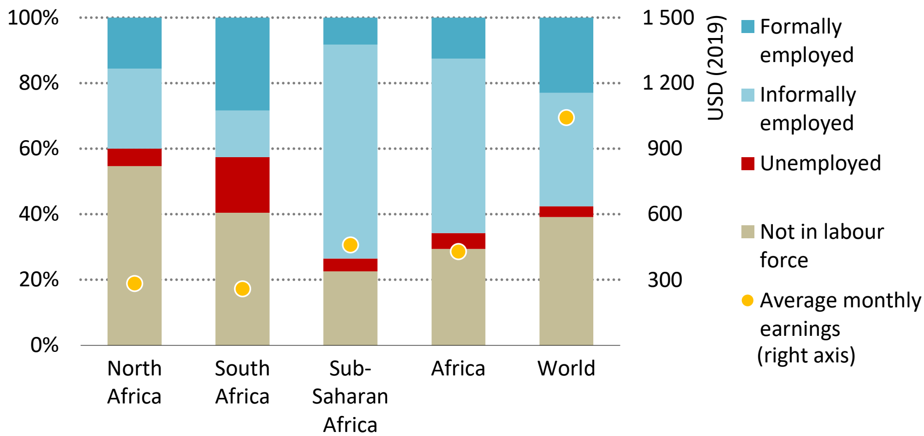
4.4.1 Trends in energy-related jobs

There is enormous pressure to create decent jobs in all African countries in the face of rising population and widespread under employment. The continent has the youngest population of any major region in the world, with around 15 million people joining the labour force each year. The unemployment rate across sub-Saharan Africa was 7% in 2020, slightly above the global average (Figure 4.12), but rates were much higher in certain countries, including South Africa where it was near 30% (ILO, 2022; World Bank, 2021c). The situation has worsened everywhere as a result of the Covid-19 pandemic, with around 7.8% of working hours and 30 million jobs lost in 2020 due to disruptions to economic activities (ILO, 2022; UNECA, 2021).

There is an urgent need in Africa not only to create jobs, but to create jobs that are productive and well paid to underpin that employment can be a strong path out of poverty. Most African countries are characterised by under employment, widespread informal employment and limited social system protection. Over 80% of employed Africans work in the informal sector, where wages are low and jobs less secure. Forty-five percent of the employed work in agriculture, earning on average just one dollar per day, while 13% work in manufacturing and 38% in services.

Development of Africa's energy system offers major opportunities to stimulate the creation of decent jobs that require wide-ranging skills. According to official data, around 2 million Africans were employed in the energy sector in 2019, accounting for about 0.5% of the total labour force (ILO, 2022; UNIDO, 2022; UNCTAD, 2021; IRENA, 2020). There are many more informal energy-related workers, particularly in the sectors requiring low skilled labour such as the commercial collection and sale of biomass. In rural areas, harvesting of firewood and production of charcoal provides an important source of income and employment in many sub-Saharan African countries. Considering economy-wide ratios between formal and informal employment, total energy-related employment may be as high as 11 million.

Figure 4.12 ▷ Employment and earnings by region in Africa, 2019



Official unemployment rates are relatively low in several African countries, but wages are also very low and informal labour commonplace

Note: Based on a working population of 15-years old and above.

Sources: IEA analysis based on ILO (2022).

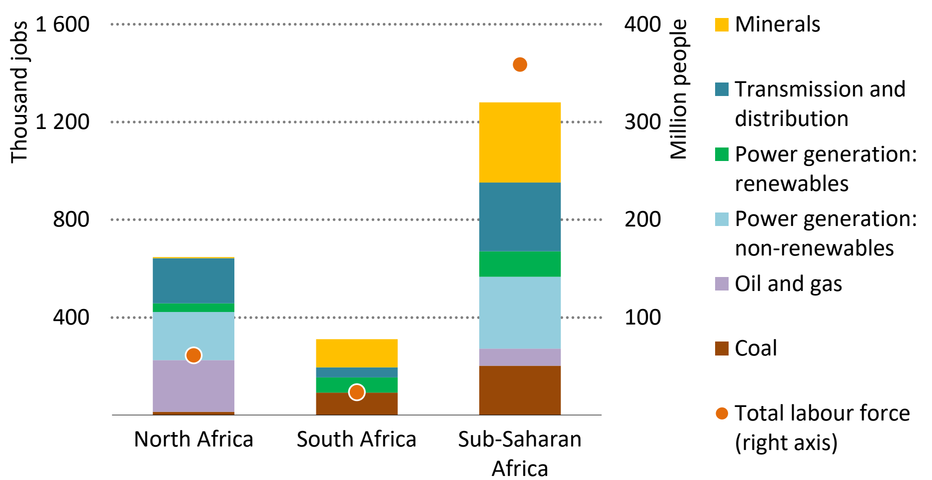
Energy-related employment varies enormously by region.[12] The oil and gas sector and thermal power generation are important employers in North Africa, while coal mining jobs make up a relatively high share in South Africa (Figure 4.13). Hundreds of thousands of workers are formally employed in the mining of critical minerals, especially in central African countries, where the total number working in mining could be four- to eight-times higher when informal workers in artisanal and small-scale mines are included. In DRC, for example, the formal mining sector employs 120 000 people, while estimates of informal employment range from 500 000 to 1 million (BGR, n.d.).

Employment in Africa's energy sector will undoubtedly grow rapidly in the coming years and decades as the demand for energy services rises and power capacity expands. In the SAS, 4 million energy-related jobs in total are created across the continent in the 2021-30 period, largely as a result of providing universal access to modern energy to households in sub-Saharan Africa and the rapid deployment of clean energy technologies. Some of the new

[12] Energy-related employment includes all workers in the commercial production of fossil fuels and bioenergy, in power generation, transmission and distribution, as well as the mining of minerals critical to energy technologies. This refers to direct employees only.

construction or manufacturing jobs disappear as the wave of construction and installation slows with the achievement of universal access. However some of these jobs remain as smaller systems are upgraded and replaced. Other workers move to other permanent jobs, some related to local electricity grids and mini-grids and LPG distribution, others as general electrical repair workers.

Figure 4.13 ▹ Direct formal jobs in the energy sector by region in Africa, average for 2015-2019



Around 2 million Africans are employed formally in the energy sector, accounting for about 0.5% of the labour force, but there are many more informal jobs in energy

Note: Formal employment in commercial production of energy and related minerals only.

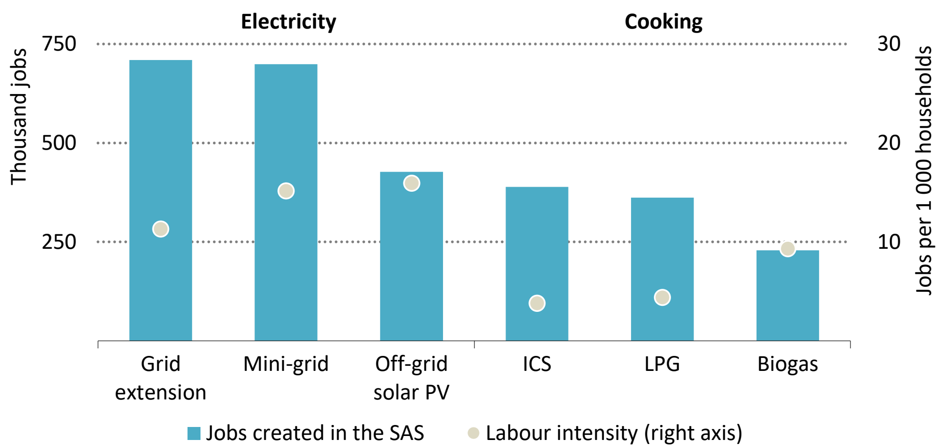
Sources: IEA analysis based on data from ILO (2022); UNIDO (2022); UNCTAD (2021); IRENA (2020).

In order to create more jobs and improve the security of supply chains, governments need to develop the human resources, as well as physical infrastructure, required for the local assembly of clean energy technologies. Shortages of skilled labour for large-scale renewable capacity installations could emerge in the coming years. With increased digitalisation and automation, it is crucial that governments and companies boost education and training to ensure that more workers can participate in the clean energy sector.

4.4.2 Employment to provide energy access

Installing the infrastructure, supply chains and appliances to give households access to modern energy services, particularly in rural areas, requires an extensive local work force, both in building new facilities, as well as operating and maintaining them. In total, 2.8 million jobs are created in Africa over 2021-30 in the SAS to provide universal energy access, of which around 55% are jobs in operations and maintenance. Providing universal access to electricity alone by 2030, as assumed in the SAS, generates around 1.8 million jobs across the continent. Around 700 000 of these jobs are related to grid connections, for the construction of grid infrastructure and the refurbishment or construction of power plants; another 700 000 jobs are created for mini-grid connections and around 400 000 for the manufacturing and installation of solar home systems (Figure 4.14).

Figure 4.14 ▷ Jobs created in providing access to modern energy services in Africa in the SAS, 2021-2030



Providing universal access creates 2.8 million local jobs over 2021-2030, of which 55% are needed for operations and maintenance after universal access is achieved

Note: SAS = Sustainable Africa Scenario; ICS = improved cookstoves; LPG = liquefied petroleum gas.

Sources: IEA analysis based on AMDA and ECA (2020); GOGLA, GIZ and Vivid Economics (2019); IEA (2020; IRENA (2020); Power for All (2019).

Governments are already trying to leverage their household electricity access programmes to support job creation. For example, Nigeria's Economic Sustainability Plan, which provides funding for access to electricity for 5 million households and targets at least 500 000 solar home systems by 2023, aims to create up to 20 000 manufacturing, assembly, installation and retail jobs (Government of Nigeria, 2020).

Achieving universal access to clean cooking facilities and fuels is expected to create fewer jobs than access to electricity, but across a wider range of occupations. In the SAS, 393 million Africans gain access to LPG cookstoves by 2030. This creates an estimated 350 000 jobs, boosting the total workforce in the African LPG sector by about a third. In total, the jobs created along the LPG supply chain are split between terminals and filling plants (approximately 30%), retailing and distribution (60%) and other cross-cutting professional positions in sales, administration and finance (10%). In countries that produce LPG, additional jobs (not included here) are created in refineries and cylinder manufacturing.

Safety is an important concern for LPG workers and companies investing in LPG operations. Operators of terminals, storage, cylinder refilling and delivery networks, including drivers of LPG tank trucks and local installers, must be well trained in following safety procedures to prevent accidents and to handle them efficiently if they do occur (WLPGA, 2018).

Biogas digesters is another important clean cooking solution for households. In the SAS, 117 million Africans gain access to clean cooking this way by 2030. This generates around 230 000 new jobs across the continent, around 50 000 in construction, cement production, manufacturing of electronic machinery and equipment and metal smelting, as well as 180 000 jobs in operating and maintaining digesters.

In the SAS, jobs related to energy access decline after 2030, even though jobs for maintaining, replacing and upgrading access solutions remain important even after universal access is achieved. As millions of households switch to clean cooking fuels, workers are needed to operate the relevant value chains, for example via the distribution of new LPG canisters and in charcoal production and sales. Conversely, the majority of jobs created by deploying electricity access solutions are related to their installation and manufacturing, where less workers are required to maintain and operate these systems, similar to the power sector. Demand for new systems and upgrades keeps many of these workers employed, but many can find new work using basic electrician skills to service appliances, vehicles, and repair and replace wiring. Jobs related to energy access are most attractive as entry-level jobs to policy makers, as a concrete step into the formalised economy. This can help give workers the needed skills and experience to take new jobs in services, manufacturing and construction amid broader shifts in the labour force and urbanisation.

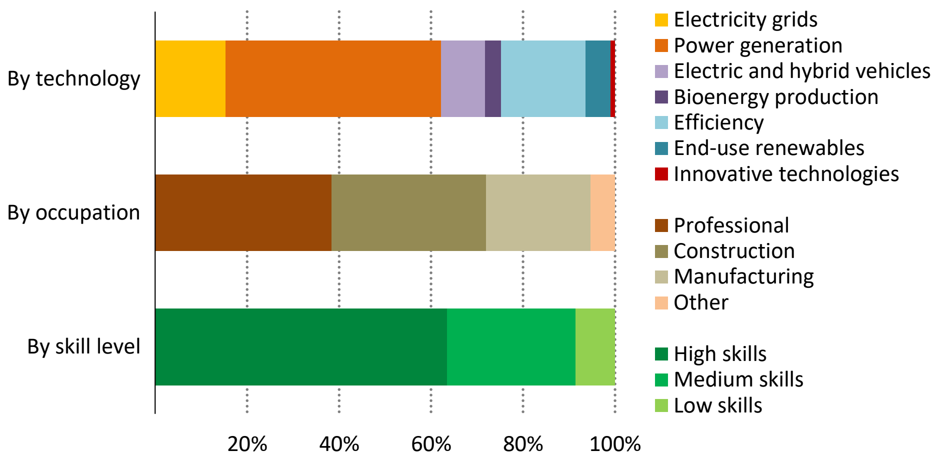
Job creation as a result of extending energy access goes beyond the energy sector itself, as it would stimulate economic activity in the communities gaining access. The number of jobs created this way is potentially far greater than those in the energy sector itself. The expansion of reliable and affordable electricity supplies, in particular, is a key driver of economic activity, higher incomes and employment. For example, access to electricity would allow households to power small appliances such as sewing machines or refrigerators, which can support entrepreneurial opportunities – especially for women (Carlsson-Kanyama and Lindén, 2007; Elnakat and Gomez, 2015).

Expanding electricity supply to non-residential uses such as agriculture would also create jobs. Larger scale infrastructure developments that electrify the entire agricultural value chain can bring additional benefits for agricultural employment and productivity (Omoju et al., 2020). The potential for electricity access to create jobs depends heavily on the reliability of power supply. Power cuts reduce the output and productivity of existing firms, causing them to reduce worker wages (Hardy and McCasland, 2021). Doubts about the reliability of electricity supply also constrain investment, and the creation of new enterprises to the detriment of the competitiveness of African firms in export markets (Mensah, 2018).

4.4.3 Employment for other clean energy

Additional labour will be needed to realise the clean energy transition in Africa. In the SAS, 1.3 million jobs are created by 2030 in addition to those that result from expanded energy access. Over 60% of the new jobs in the SAS are related to power generation and grids and another 20% are related to energy efficiency (Figure 4.15). Unlike jobs related to energy access, those related to the construction and installation of clean energy facilities, equipment and appliances are likely to continue growing beyond 2030 as demand for energy keeps on rising. About one-third each of these jobs are in professional services, construction and manufacturing or other occupations. Most of the jobs require extensive skills, calling for specialised training and education. Around 100 000 are low skilled, offering opportunities for those that lack access to education.

Figure 4.15 ▹ Jobs created in clean energy and related sectors in the SAS, 2021-2030



Of the clean energy jobs created across Africa to 2030, the majority are related to power generation and energy efficiency, spread across occupations

Notes: SAS = Sustainable Africa Scenario. All jobs include those related to the construction of new energy projects, including upstream manufacturing, and the jobs related to the ongoing operation of these assets. In efficiency, this includes jobs in retrofitting buildings, industrial energy efficiency and the manufacture of efficiency appliances. End-use renewables includes biogas digesters, biomass boilers and solar hot water. Innovative technologies include batteries, low-carbon hydrogen production and carbon capture, utilisation and storage.

There is also a need to make sure jobs created in clean energy-related sectors, particularly in minerals production, are decent. The expected growth in demand for critical minerals holds the potential to lift some of Africa's poorest people out of poverty. However, miners face bigger occupational health and safety risks compared with most other professions, especially in small-scale mining operations, where regulatory standards are weak and health care or compensation in the event of an accident are often non-existent. Human rights violations, child labour and poor environmental, social and corporate governance are also rife in this sector. Efforts by policy makers, traders and mining companies to formalise small-scale mining may help to improve health and safety. In the longer term, increased mechanisation and digitalisation of mining including the increased use of sensors and big data means that some low skilled jobs may be replaced by skilled jobs in remote urban offices (IGF and IISD, 2021).

Box 4.3 ▻ A "just transition" for coal workers in South Africa

South Africa's goal to reach net zero emissions by 2050 will require a rapid shift away from coal, which currently accounts for 89% of its electricity generation. Such a transition will inevitably affect employment in coal mining and related industries. Of South Africa's labour force of 23 million, around 92 000 work in coal mining and another 45 000 for Eskom, the national electricity utility that operates coal-fired power plants (Minerals Council South Africa, 2020; Eskom, 2021b).

The impact of a transition away from coal would be felt most in the Mpumalanga region, which accounts for 90% of South Africa's total coal production and 70% of Eskom's coal-fired generating capacity (CSIS, 2021). The unemployment rate in that region is already 34%. Of those employed today, 5% work directly in coal mining, compared with an average of 0.1% in other areas of South Africa (Statistics South Africa, 2021).

In response to the prospect of a radical change in job requirements in the energy sector, the government has established a Presidential Climate Change Co-ordinating Commission (P4C) to develop a transition framework for governance, economic diversification, labour market intervention and social support to be finalised in 2022. It has prepared a "just transition framework" setting out goals for distributive, procedural and restorative justice for all stakeholders. In addition, the "Just Energy Transition Partnership" announced at COP26, whereby European Union, France, Germany, United Kingdom and United States will work with the South African government to raise up to USD 8.5 billion over the next three to five years to fund the transition away from coal (see Chapter 1). It allocates funds for worker transition and community support. This initiative could provide a model for targeting support from the international community to other emerging economies facing major coal phase outs.

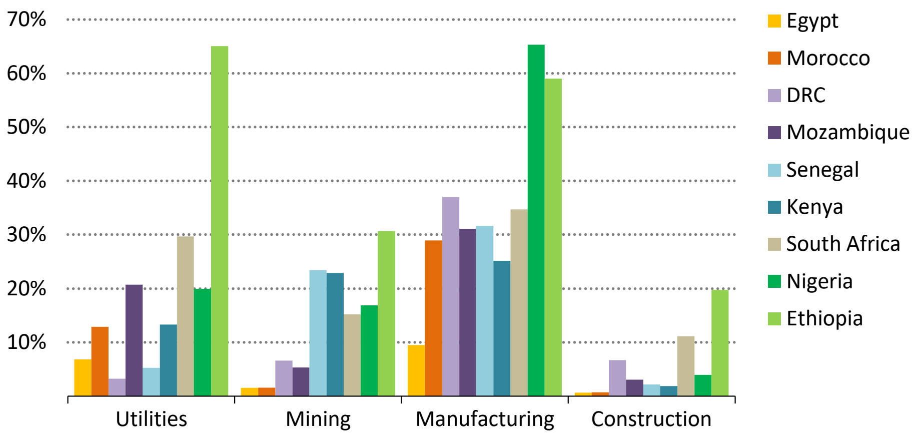
4.4.4 Female employment

Women constitute around 43% of economy-wide employment across Africa today, a rate of participation that is on a par with that in advanced economies.[13] As elsewhere, female

[13] The analysis in this section benefited from inputs from Ms Liliane Munezero Ndabaneze of Women's Initiative for Delivering Clean Energy to Africa (WID Energy) Zambia.

participation in Africa unsurprisingly varies widely across the economic sectors with links to energy, from 44% in manufacturing to only 5% in construction based on 2019 data. Female employment averages only 16% in mining and 22% in utilities. Female participation also varies greatly across African countries according to cultural norms, averaging 21% in North Africa compared with 47% in sub-Saharan Africa and 44% in South Africa (Figure 4.16). In sub-Saharan Africa, the regional share of female participation exceeds the level in the advanced economies as well as the world average in utilities, mining and manufacturing.

Figure 4.16 ▷ Female share of employment by economic activity in selected African countries, 2019



Female participation averages 43% across Africa, similar to that in advanced economies, but varies significantly across countries and tends to be lower in mining and construction

Note: DRC = Democratic Republic of the Congo.

Sources: IEA analysis based on ILO (2022).

Despite high rates of female participation in some sub-Saharan African countries, women are more likely than men to work in the informal sector, where jobs are often less stable and pay lower wages, due to their more limited access to education, household and childcare responsibilities, and worries about safety when commuting to work. Women attempting to enter the workforce, including the energy sector, face numerous barriers such as gender stereotypes and bias, and lack of training, mentorship and networking. In Ghana, for example, the number of women graduating with science, technology, engineering and mathematics (STEM) degrees is increasing, but not female employment in the electricity sector (Dejene, 2020). As a result, women with STEM degrees and technical training certificates often end up working in unrelated fields, underutilising their skills.

Overcoming obstacles to female employment in Africa's energy sector would bring multiple benefits. All countries could raise their GDP considerably by increasing gender equality in employment (IMF, 2018). Studies show that companies with greater gender diversity in senior management positions perform better (IEA, 2021b; McKinsey & Company, 2016). Increasing women's' access to careers through internships and mentoring, as well as human resource policy reform in public utilities and private companies, would increase female economic empowerment, as well as improve energy sector performance.

Several initiatives aim to increase female empowerment through energy access programmes in Africa, including the Clean Energy Ministerial, ENERGIA, ECOWAS Policy for Gender Mainstreaming in Energy, the Global Alliance for Clean Cookstoves, Power Africa's Women in Rwandan Energy, and SEforAll and Enel Foundation's Open Africa Power programme. These initiatives provide networking, training in technical skills and apprenticeship opportunities to encourage women to build careers in the energy sector. In addition, a growing number of companies are recruiting, training and supporting female entrepreneurs and workers in the clean energy sector. Jaza Energy, a Tanzanian company, trains and hires all-female local teams to operate a distributed network of solar powered battery charging stations (Jaza Energy, 2018). Around 40% of the sales agents employed by WID Energy in Zambia, which distributes solar home systems, are women (Ndabaneze, 2021). These companies also achieve a larger reach by having female sales agents and staff, who are often better at convincing households and communities to adopt clean energy solutions and teaching how to operate and maintain solar home systems.

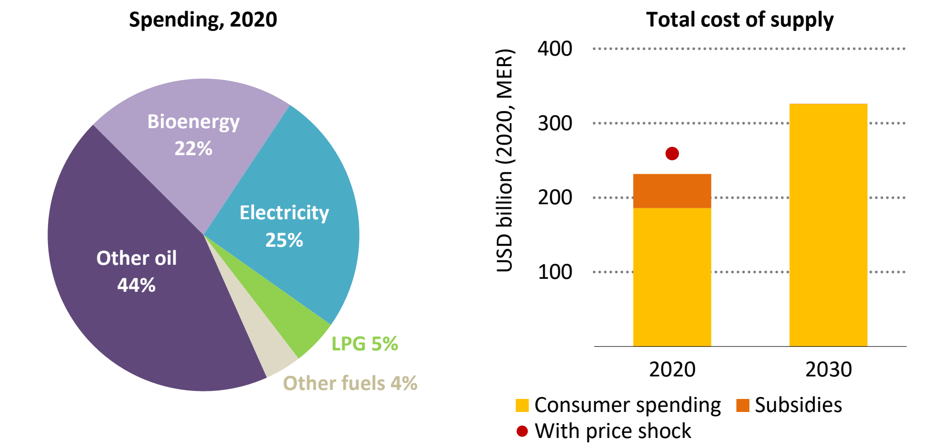
Improved energy access and the use of clean energy also supports gender parity in other ways. At a household level, clean cooking reduces health risks related to indoor air pollution, particularly for women and children (see Chapter 3). Spending less time collecting firewood – a task that mostly falls to women – frees up time for other activities, including employment outside the home (Burney et al., 2017). Household lighting enables chores and homework to be done in the evening. Access to phones and other communication devices help to increase access to information as well as to reduce the acceptability of domestic violence (Jensen and Oster, 2009). Street lighting is also important for making walking or commuting safer for women, who are often less likely than men to have access to a private vehicle. Improved transportation options can help to improve daily commutes and shorten the time it takes to receive emergency health care (IEA, 2019).

4.5 Energy affordability

Ensuring that energy is affordable for end-users in Africa, particularly poor households, is a crucial objective for policy makers. Substantial investment is required to put Africa on the clean energy pathway projected in the SAS. Capital costs would need to be recouped through the prices charged for fuel and electricity to consumers. In the SAS, prices are kept in check by spreading them across a large consumption base, as more customers gain access to modern energy and rising household incomes lead them to consume more. While price shocks, like those induced by Russia's invasion of Ukraine, remain a risk, the increased reliance on renewables and energy efficiency reduce exposure. Governments frequently implement measures to make energy more affordable for households, however, these subsidies can encourage wasteful consumption and are often distributed inequitably. They add further burden to already constrained public budgets.

Energy subsidies are widespread in Africa today. In 2020, African consumers – households, businesses and other end-users – spent USD 190 billion on energy for final use. But they only paid around 80% of the real cost of the energy consumed, which totalled USD 230 billion, with government subsidies filling the gap.[14] Around half of consumer energy spending (net of subsidies) in 2020 was for oil products, mainly transportation fuels (gasoline, diesel and jet kerosene), LPG and kerosene for cooking, and diesel for small generators and industrial use (Figure 4.17).

Figure 4.17 ▷ Consumer spending on energy and subsidies in Africa in the SAS, 2020 and 2030



Energy subsidies fall to around USD 3 billion in 2030, on the assumption they are phased out in line with current climate policy commitments and that international prices decline

Notes: SAS = Sustainable Africa Scenario; MER = market exchange rate. The price shock indicates the total cost of consumption, whether borne by governments or citizens, if prices for transport fuels, diesel and natural gas for electricity generation, and LPG all remain elevated at levels consistent over first-quarter 2022. The price shock is in 2022 current USD billion (MER), not adjusted for inflation.

Electricity accounted for a quarter and bioenergy for the rest. Around 60% of the energy subsidies in Africa in 2020 were for households for electricity, cooking and transport fuel. Eight African countries account for roughly half of the USD 40 billion in subsidies. The bulk are in North Africa, where oil and gas producers subsidise energy the most through

[14] Using the true cost of supply or, in the case of exportable fuels, the value of the energy at international prices net of transport costs.

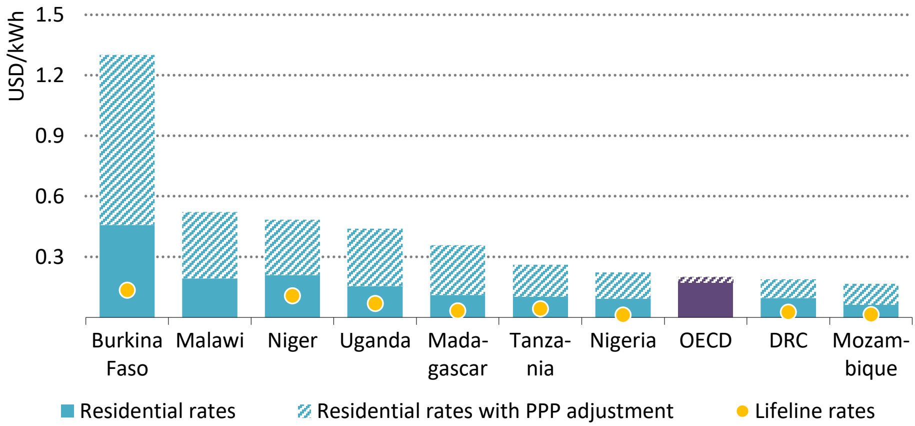
discounted prices for local markets. Many sub-Saharan African governments also heavily subsidise energy, especially for oil, electricity, and gas. Subsidising oil and gas by setting domestic prices below international levels allows the local population to benefit directly from domestic hydrocarbon resources, but deprives the producing companies of sales revenue and national governments of tax revenue, impeding their ability to fund much needed investment and spending on social programmes. Subsidies were low in 2020, due to pandemic-related fuel price declines. Although data are not yet available, they are sure to rise sharply in 2022, probably at least doubling. As a consequence, some countries, including Egypt, Ethiopia and Uganda, are being driven to halt or reduce subsidies, or to reinstate fuel taxes due to growing financial burdens.

Energy subsidies in Africa decline to around USD 3 billion (at 2020 prices) in 2030 in the SAS, on the assumption that they are phased out almost entirely by 2030 in line with current climate policy commitments and international price declines. The Covid-19 pandemic and Russia's invasion of Ukraine have delayed the planned implementation of subsidy reforms in many countries. Additionally, fuel taxes were reduced in countries such as Tanzania, while Nigeria committed to subsidise jet fuel to allow domestic airlines to continue servicing routes to locations that cannot be easily reached on overland roads. However, for fuels like LPG that are directly exposed to global market prices in importing countries, some countries, including Kenya, have or are now accelerating reforms as the burden on public finances mount. In the near term, all countries face the task of balancing the urgency of pricing reforms with a need to maintain economic stability and protect the poorest households in the midst of a shifting price environment.

Poverty is the fundamental reason why so many African households struggle to afford to pay for modern energy services, even when subsidised. Over 40% of sub-Saharan Africans live below the poverty line. But, in some cases, high energy prices also undermine affordability. In the case of electricity, for example, average residential rates in several sub-Saharan African countries were higher than the average of OECD countries in 2020 even before considering differences in purchasing power between the economies (Figure 4.18). Even lifeline tariffs (subsidised tariffs for very low consumption) for the poorest customers, adjusted for purchasing power parity (PPP), exceeded the OECD averages in some African countries. This drives many Africans to forgo essential energy services on a day-to-day basis, even if, in principle, they have access to them.

Affordability support remains essential to help poor Africans gain access to modern energy services and afford to use them in the SAS. Subsidies, in the form of prices set below the true cost of supply, represent a direct, simple means of providing this support, but can be difficult to target, such that they also benefit richer households and businesses that do not need them. In addition, subsidies are usually focused on modern commercial fuels rather than the forms of energy most commonly used by the poor, such as off-grid solutions for cooking. International actors can play a near-term role in helping the poorest African countries financially, including through debt relief, however, longer term subsidy reform remains central to the SAS.

Figure 4.18 ▷ Average residential electricity prices and lifeline tariffs for selected African countries and average of OECD countries, 2020



Many African households, including some which benefit from lifeline tariffs, pay higher rates for electricity than in OECD countries adjusted for purchasing power parity

Notes: PPP = purchasing power parity; DRC = Democratic Republic of the Congo.

Subsidy arrangements in many countries need to be reformed in order to reduce rising budgetary burdens and avoid price signals that encourage wasteful consumption. We have assessed how the financial savings made by removing energy subsidies could be redistributed most effectively to boost affordability of household fuels. Based on data for 2020, it considers two categories of energy use in household.

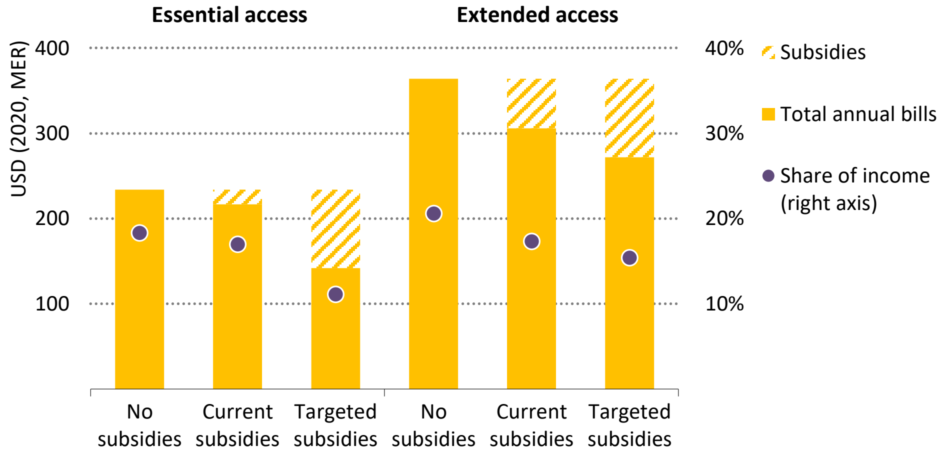
- **Essential household energy use**: Households that have recently gained access and use energy only for the essential bundle of electricity services[15] as well as an improved biomass cook stoves[16] and do not have access to personal transport. These households are assumed to live below the World Bank poverty line, defined as per capita income of less than USD 1.90 per day (at 2011 prices and in PPP terms).
- **Extended household energy use**: Households that use energy for an extended bundle of electrical service,[17] fuel for clean cooking solutions and have access to a motorbike, shared or individual, which is used on average to travel around 1 kilometre per day. These households are assumed to have per capita income of between USD 1.90 and USD 3.20 per day.

[15] An essential bundle includes four lightbulbs operating for four hours per day, charge for a phone, a television for two hours and a fan for three hours.

[16] Cookstoves in the International Organization for Standardization Tier >=1 category.

[17] Four lightbulbs operating for four hours per day, a fan for six hours per day, a radio or television for four hours per day and a refrigerator.

Figure 4.19 ▷ Impact of subsidies on average annual household energy bills by access tier for households in sub-Saharan Africa, 2020



Targeted affordability payments can be made to the poorest households in the SAS to ensure better affordability outcomes

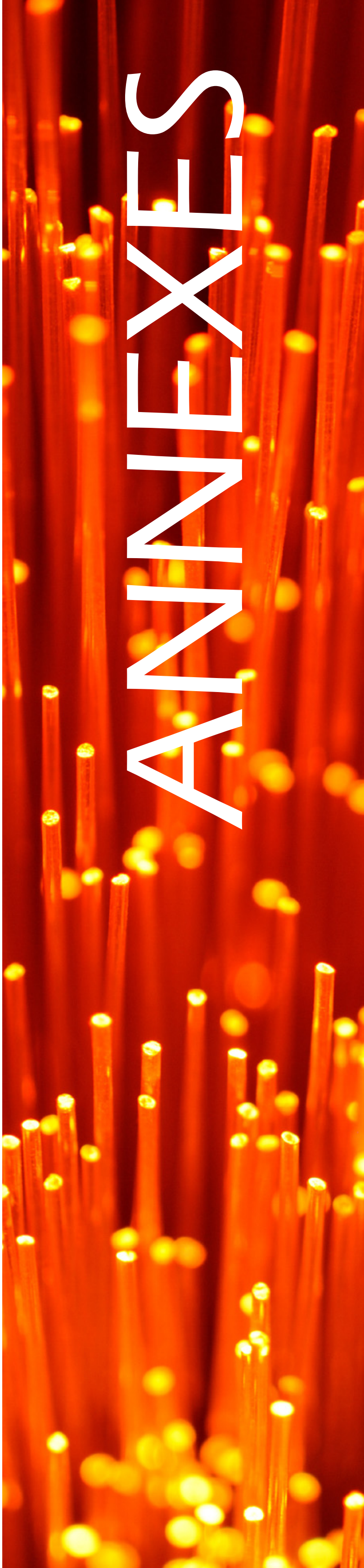
Notes: MER = market exchange rate. Current subsidies are based on 2020 data. Targeted subsidies assume that the total amount of subsidies in place in 2020 are distributed evenly across households through welfare payments.

Our analysis shows that targeting subsidies at poor sub-Saharan African households would significantly improve affordability of the basic energy services without increasing the overall financial burden on public utilities or public budgets. Both essential and extended household energy use results in households spending on average around 15% of their income on energy. If there were no subsidies, both household types would have to spend a little more on energy: about 8% more in the case of essential access households and about 20% more for extended access ones. As of today, electricity to poor households, especially in remote communities, is not heavily subsidised and their consumption of subsidised fuels is relatively low so they benefit less than richer households. But if all the subsidies in sub-Saharan Africa were distributed evenly across all households in absolute terms, for example as social welfare payments, rather than as a lower price per unit of fuel consumed (as is generally the case today), the energy bills of poor households would be reduced substantially: by about one-third compared with today in the case of essential energy use households and almost 10% for extended energy use ones. The former would then spend a little over 10% of their income on energy and the latter 15%, compared with 18% today for both groups.

The even redistribution of subsidies to households, assumed in our analysis, is a less progressive way of providing affordability support than some other methods, such as lifeline tariffs for electricity, progressive block tariffs (whereby a household pays an increasing price for each block of electricity it consumes over the billing period), or vouchers to the poorest households. Using more targeted means can also reduce the total subsidy burden by only providing support to those most in need, but are more difficult to administer since they require robust civil registration and statistical systems. There is an urgent need to demonstrate and scale up approaches to reach poor and vulnerable communities and households (including households headed by females, displaced persons and their host communities). In Kenya, for instance, an electronic voucher system capitalises on the ubiquity of mobile phones to provide farmers financial support directly for seeds, fertiliser and other agricultural inputs. Similar models could be used, especially for mobile pay access solutions.

Subsidy reform is easier said than done. Governments face a number of barriers to implement subsidy reform. Foremost is garnering public support in the face of often fierce opposition from those who stand to lose the subsidy (IEA, 2021c). Some African governments may have limited capacity to administer targeted welfare payments. Expanding household access to modern energy service would help the authorities identify households most in need of support.

ANNEXES



Definitions

This annex provides general information on terminology used throughout this report including: units and general conversion factors; definitions of fuels, processes and sectors; regional and country groupings; and abbreviations and acronyms.

Units

Area	km^2	square kilometre
	Mha	million hectares
Coal	Mtce	million tonnes of coal equivalent (equals 0.7 Mtoe)
Distance	km	kilometre
Emissions	ppm	parts per million (by volume)
	t CO_2	tonnes of carbon dioxide
	Gt CO_2-eq	gigatonnes of carbon-dioxide equivalent (using 100-year global warming potentials for different greenhouse gases)
	kg CO_2-eq	kilogrammes of carbon-dioxide equivalent
	g CO_2/km	grammes of carbon dioxide per kilometre
	kg CO_2/kWh	kilogrammes of carbon dioxide per kilowatt-hour
Energy	EJ	exajoule (1 joule x 10^{18})
	PJ	petajoule (1 joule x 10^{15})
	TJ	terajoule (1 joule x 10^{12})
	GJ	gigajoule (1 joule x 10^{9})
	MJ	megajoule (1 joule x 10^{6})
	boe	barrel of oil equivalent
	toe	tonne of oil equivalent
	ktoe	thousand tonnes of oil equivalent
	Mtoe	million tonnes of oil equivalent
	MBtu	million British thermal units
	kWh	kilowatt-hour
	MWh	megawatt-hour
	GWh	gigawatt-hour
	TWh	terawatt-hour
	Gcal	gigacalorie
Gas	bcm	billion cubic metres
	tcm	trillion cubic metres

Mass	kg	kilogramme (1 000 kg = 1 tonne)
	kt	kilotonnes (1 tonne x 10^3)
	Mt	million tonnes (1 tonne x 10^6)
	Gt	gigatonnes (1 tonne x 10^9)
Monetary	USD million	1 US dollar x 10^6
	USD billion	1 US dollar x 10^9
	USD trillion	1 US dollar x 10^{12}
	USD/t CO_2	US dollars per tonne of carbon dioxide
Oil	kb/d	thousand barrels per day
	mb/d	million barrels per day
	mboe/d	million barrels of oil equivalent per day
Power	W	watt (1 joule per second)
	kW	kilowatt (1 watt x 10^3)
	MW	megawatt (1 watt x 10^6)
	GW	gigawatt (1 watt x 10^9)
	TW	terawatt (1 watt x 10^{12})

General conversion factors for energy

		Multiplier to convert to:				
		PJ	Gcal	Mtoe	MBtu	GWh
Convert from:	PJ	1	2.388 x 10^5	2.388 x 10^{-2}	9.478 x 10^5	277.8
	Gcal	4.1868 x 10^{-6}	1	10^{-7}	3.968	1.163 x 10^{-3}
	Mtoe	41.868	10^7	1	3.968 x 10^7	11 630
	MBtu	1.0551 x 10^{-6}	0.252	2.52 x 10^{-8}	1	2.931 x 10^{-4}
	GWh	3.6 x 10^{-3}	860	8.6 x 10^{-5}	3 412	1

Note: There is no generally accepted definition of boe; typically the conversion factors used vary from 7.15 to 7.40 boe per toe.

Definitions

Advanced bioenergy: Sustainable fuels produced from non-food crop feedstocks, which are capable of delivering significant lifecycle greenhouse gas emissions savings compared with fossil fuel alternatives, and which do not directly compete with food and feed crops for agricultural land or cause adverse sustainability impacts. This definition differs from the one used for "advanced biofuels" in US legislation, which is based on a minimum 50% lifecycle greenhouse gas reduction and which, therefore, includes sugar cane ethanol.

Agriculture: Includes all energy used on farms, in forestry and for fishing.

Agriculture, forestry and other land use (AFOLU) **emissions:** Includes greenhouse gas emissions from agriculture, forestry and other land use.

Ammonia (NH_3)**:** Is a compound of nitrogen and hydrogen. It can be used directly as a fuel in direct combustion processes, as well as in fuel cells or as a hydrogen carrier. To be a low emissions fuel, ammonia must be produced from low-carbon hydrogen, the nitrogen separated via the Haber process with electricity generated from low-carbon sources.

Aviation: This transport mode includes both domestic and international flights and their use of aviation fuels. Domestic aviation covers flights that depart and land in the same country; flights for military purposes are included. International aviation includes flights that land in a country other than the departure location.

Back-up generation capacity: Households and businesses connected to a main power grid may also have some form of back-up power generation capacity that, in the event of disruption, can provide electricity. Back-up generators are typically fuelled with diesel or gasoline. Capacity can be as little as a few kilowatts. Such capacity is distinct from mini-grid and off-grid systems that are not connected to a main power grid.

Balance sheet finance: Involves the explicit financing of assets on a company's balance sheet using retained earnings from business activities, including those with regulated revenues, as well as corporate debt and equity issuance in capital markets. To some extent, it measures the degree to which a company self-finances its assets, though balance sheets also serve as intermediaries for raising capital from external sources. This report also refers to "corporate finance" when describing balance sheet financing.

Battery storage: Energy storage technology that uses reversible chemical reactions to absorb and release electricity on demand.

Biodiesel: Diesel-equivalent, processed fuel made from the transesterification (a chemical process that converts triglycerides in oils) of vegetable oils and animal fats.

Bioenergy: Energy content in solid, liquid and gaseous products derived from biomass feedstocks and biogas. It includes solid bioenergy, liquid biofuels and biogases.

Biogas: A mixture of methane, carbon dioxide and small quantities of other gases produced by anaerobic digestion of organic matter in an oxygen-free environment.

Biogases: Include both biogas and biomethane.

Biomethane: Biomethane is a near-pure source of methane produced either by "upgrading" biogas (a process that removes any carbon dioxide and other contaminants present in the biogas) or through the gasification of solid biomass followed by methanation. It is also known as renewable natural gas.

Blended finance: A broad category of development finance arrangements that blend relatively small amounts of concessional donor funds into investments in order to mitigate specific investment risks. This can catalyse important investments that would otherwise be unable to proceed under conventional commercial terms. These arrangements can be structured as debt, equity, risk-sharing or guarantee products. Specific terms of the arrangements, such as interest rates, tenor, security or rank, can vary across scenarios.

Buildings: The buildings sector includes energy used in residential, commercial and institutional buildings and non-specified other. Building energy use includes space heating and cooling, water heating, lighting, appliances and cooking equipment.

Bunkers: Includes both international marine bunker fuels and international aviation bunker fuels.

Carbon capture and storage (CCS): Carbon capture and storage without utilisation of captured carbon for any other applications

Carbon capture, utilisation and storage (CCUS): The process of capturing carbon dioxide (CO_2) emissions from fuel combustion, industrial processes or directly from the atmosphere. Captured CO_2 emissions can be stored in underground geological formations, onshore or offshore or used as an input or feedstock in manufacturing.

Carbon dioxide (CO_2): Is a gas consisting of one part carbon and two parts oxygen. It is an important greenhouse (heat-tapping) gas.

Clean energy: In *power*, clean energy includes: generation from renewable sources, nuclear and fossil fuels fitted with CCUS; battery storage; and electricity grids. In *efficiency*, clean energy includes energy efficiency in buildings, industry and transport, excluding aviation bunkers and domestic navigation. In *end-use* applications, clean energy includes: direct use of renewables; electric vehicles; electrification in buildings, industry and international marine transport; use of hydrogen and hydrogen-based fuels; CCUS in industry and direct air capture. In *fuel supply*, clean energy includes low emission fuels, liquid biofuels and biogases, low-carbon hydrogen and hydrogen-based fuels.

Clean cooking systems: Cooking solutions that release less harmful pollutants, are more efficient and environmentally sustainable than traditional cooking options that make use of solid biomass (such as a three-stone fire), coal or kerosene. This refers primarily to improved solid biomass cookstoves, biogas/biodigester systems, electric stoves, liquefied petroleum gas, natural gas or ethanol stoves.

Coal: Includes both primary coal (i.e. lignite, coking and steam coal) and derived fuels (e.g. patent fuel, brown-coal briquettes, coke-oven coke, gas coke, gas works gas, coke-oven gas, blast furnace gas and oxygen steel furnace gas). Peat is also included.

Coalbed methane (CBM)**:** Category of unconventional natural gas, which refers to methane found in coal seams.

Coal-to-liquids (CTL)**:** Transformation of coal into liquid hydrocarbons. It can be achieved through either coal gasification into syngas (a mixture of hydrogen and carbon monoxide), combined using the Fischer-Tropsch or methanol-to-gasoline synthesis process to produce liquid fuels, or through the less developed direct-coal liquefaction technologies in which coal is directly reacted with hydrogen.

Coking coal: Type of coal that can be used for steel making (as a chemical reductant and a source of heat), where it produces coke capable of supporting a blast furnace charge. Coal of this quality is also commonly known as metallurgical coal.

Concentrating solar power (CSP)**:** Solar thermal power generation technology that collects and concentrates sunlight to produce high temperature heat to generate electricity.

Concessional financing: Resources extended at terms more favourable than those available in the market. This can be achieved through one or a combination of factors: interest rates below those available on the market; maturity, grace period, security, rank or back-weighted repayment profile that would not be accepted/extended by a commercial financial institution; and/or by providing financing to the recipient otherwise not served by commercial financing.

Conventional liquid biofuels: Fuels produced from food crop feedstocks. Commonly referred to as first generation biofuels and include sugar cane ethanol, starch-based ethanol, fatty acid methyl ester (FAME), straight vegetable oil (SVO) and hydrotreated vegetable oil (HVO) produced from palm, rapeseed or soybean oil.

Critical minerals: A wide range of minerals and metals used in clean energy technologies. They include chromium, copper, battery metals (lithium, nickel, cobalt, manganese and graphite), molybdenum, platinum group metals, zinc, rare earth elements and other commodities, as listed in the Annex of the IEA special report on the *Role of Critical Minerals in Clean Energy Transitions* available at: https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

Demand-side integration (DSI)**:** Consists of two types of measures: actions that influence load shape such as energy efficiency and electrification; and actions that manage load such as demand-side response.

Demand-side response (DSR)**:** Describes actions which can influence the load profile such as shifting the load curve in time without affecting total electricity demand, or load shedding such as interrupting demand for a short duration or adjusting the intensity of demand for a certain amount of time.

Dispatchable generation: Refers to technologies for which power output can be readily controlled, i.e. increased to maximum rated capacity or decreased to zero, in order to match supply with demand.

Economic activities: Refers to industry groupings such as mining and quarrying, manufacturing and construction, which are categorised in accordance with revision 4 of the International Standard Industrial Classification of All Economic Activities (ISIC) – the international reference classification of productive activities.

Electricity demand: Defined as total gross electricity generation less own use generation, plus net trade (imports less exports), less transmission and distribution losses.

Electricity generation: Defined as the total amount of electricity generated by power only or combined heat and power plants including generation required for own use. This is also referred to as gross generation.

End-use sectors: Include industry (i.e. manufacturing, mining, chemical production, blast furnaces and coke ovens), transport, buildings (i.e. residential and services) and other (i.e. agriculture and other non-energy use).

Energy-related and industrial process CO_2 emissions: Carbon dioxide emissions from fuel combustion and from industrial processes. Note that this does not include fugitive emissions from fuels, flaring or CO_2 from transport and storage. Unless otherwise stated, CO_2 emissions in *Africa Energy Outlook 2022* refer to energy-related and industrial process CO_2 emissions.

Energy sector greenhouse gas (GHG) emissions: Energy-related and industrial process CO_2 emissions plus fugitive and vented methane (CH_4) and nitrous oxide (N_2O) emissions from the energy and industry sectors.

Energy services: See useful energy.

Ethanol: Refers to bio-ethanol only. Ethanol is produced from fermenting any biomass high in carbohydrates. Currently, ethanol is made from starches and sugars, but second generation technologies will allow it to be made from cellulose and hemicellulose, the fibrous material that makes up the bulk of most plant matter.

Fischer-Tropsch synthesis: Catalytic production process for the production of synthetic fuels. Natural gas, coal and biomass feedstocks can be used.

Fossil fuels: Include coal, natural gas, oil and peat.

Gases: Include natural gas, biogases, synthetic methane and hydrogen.

Gaseous fuels: Include natural gas, biogas, biomethane, hydrogen and synthetic methane.

Gas-to-liquids (GTL): Process featuring reaction of methane with oxygen or steam to produce syngas (a mixture of hydrogen and carbon monoxide) followed by synthesis of liquid products (such as diesel and naphtha) from the syngas using Fischer-Tropsch catalytic synthesis. The process is similar to that used in coal-to-liquids.

Geospatial analysis (GIS)**:** The IEA GIS modelling approach combines the most recent available country-level data with high resolution spatial data to determine least-cost electrification options. It uses the OnSSET modelling framework[1], in particular the most up-to-date version under the Global Electrification Platform (GEP)[2] initiative (GEP-OnSSET). Major updates include methodological adaptions and alignment of key modelling parameters to IEA's scenarios such as population growth, urbanisation rates, household size and demand levels, technology costs and expected access rates per country. Geospatial data complement the analysis using energy resource potential, access to functional infrastructure, socio-economic characteristics as well as estimating the current status of access at a settlement level using a combination of the above. Based on the available data, the model provides least-cost electrification solution for over 8.5 million settlements in 44 countries in sub-Saharan Africa. These results are one input to the IEA World Energy Model along with the availability of infrastructure, funding and national policies.

Geothermal: Geothermal energy is heat derived from the sub-surface of the earth. Water and/or steam carry the geothermal energy to the surface. Depending on its characteristics, geothermal energy can be used for heating and cooling purposes or be harnessed to generate clean electricity if the temperature is adequate.

Green bank: Refers to a public, quasi-public or non-profit entity established specifically to facilitate private investment for low-carbon, climate-resilient infrastructure.

Green bond: Refers to a bond that is a type of fixed-income instrument created to fund projects that have positive environmental and/or climate benefits.

Heat (end-use)**:** Can be obtained from the combustion of fossil or renewable fuels, direct geothermal or solar heat systems, exothermic chemical processes and electricity (through resistance heating or heat pumps which can extract it from ambient air and liquids). This category refers to the wide range of end-uses, including space and water heating and cooking in buildings, desalination and process applications in industry. It does not include cooling applications.

Heat (supply)**:** Obtained from the combustion of fuels, nuclear reactors, geothermal resources and the capture of sunlight. It may be used for heating or cooling, or converted into mechanical energy for transport or electricity generation. Commercial heat sold is reported under total final consumption with the fuel inputs allocated under power generation.

Low-carbon hydrogen: To be low-carbon hydrogen, either the emissions associated with fossil fuel-based hydrogen production must be prevented (e.g. by carbon capture, utilisation and storage) or the electricity for hydrogen production from water must be low-carbon

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[1] Mentis et al. (2017), Lighting the World, The first global application of an open source, spatial electrification tool (OnSSET), with a focus on sub-Saharan Africa, Environmental Research Letters Vol. 12, no 8, https://doi.org/10.1088/1748-9326/aa7b29

[2] World Bank et al.(2021), Global Electrification Platform (GEP), https://electrifynow.energydata.info/about.

electricity. In this report, hydrogen refers to total hydrogen produced by all processes whereas low-carbon hydrogen specifically refers to hydrogen produced from renewables or fossil fuels with CCS. Hydrogen is used in the energy system to refine hydrocarbon fuels and as an energy carrier in its own right. It is also produced from other energy products for use in chemicals production. In this report, total hydrogen demand includes gaseous hydrogen for all uses, including transformation into hydrogen-based fuels and biofuels, power generation, oil refining, and on-site production and consumption. Final consumption of hydrogen includes gaseous hydrogen in end-use sectors, excluding transformation into hydrogen-based fuels and biofuels, power generation, oil refining and on-site production and consumption.

Hydrogen-based fuels: Include ammonia and synthetic hydrocarbons (gases and liquids). Hydrogen-based is used in the figures in this report to refer to hydrogen and hydrogen-based fuels.

Hydropower: The energy content of the electricity produced in hydropower plants, assuming 100% efficiency. It excludes output from pumped storage and marine (tide and wave) plants.

Improved cook stoves (ICS): Intermediate and advanced improved biomass cook stoves (ISO tier ≥ 1). It excludes basic improved stoves (ISO tier 0-1).

Industry: The sector includes fuel used within the manufacturing and construction industries. Key industry branches include iron and steel, chemical and petrochemical, cement, aluminium, and pulp and paper. Use by industries for the transformation of energy into another form or for the production of fuels is excluded and reported separately under other energy sector. There is an exception for fuel transformation in blast furnaces and coke ovens, which are reported within iron and steel. Consumption of fuels for the transport of goods is reported as part of the transport sector, while consumption by off-road vehicles is reported under industry.

Informal employment: Comprises workers whose main or secondary jobs are associated with informal sector enterprises, workers whose production is exclusively for final use by their own household, and workers whose employment relationship is not subject to national labour legislation, social protection, income taxation and/or employment benefits.

International aviation bunkers: Includes the deliveries of aviation fuels to aircraft for international aviation. Fuels used by airlines for their road vehicles are excluded. The domestic/international split is determined on the basis of departure and landing locations and not by the nationality of the airline. For many countries this incorrectly excludes fuels used by domestically owned carriers for their international departures.

International marine bunkers: Covers those quantities delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, in coastal waters and on inland lakes and waterways. Consumption by ships engaged in domestic navigation is excluded. The domestic/international split is determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship.

Consumption by fishing vessels and by military forces is excluded and instead is included in the residential, services and agriculture category.

Investment: Investment is measured as the ongoing capital spending in energy supply capacity, energy infrastructure and energy end-use and efficiency. All investment data and projections reflect spending across the lifecycle of a project, i.e. the capital spent is assigned to the year when it is incurred. Fuel supply investments include production, transformation and transportation for oil, gas, coal and low emissions fuels. Power sector investments include new builds and refurbishments of generation, electricity grids (transmission, distribution and public electric vehicle chargers) and battery storage. Energy efficiency investments include those made in buildings, industry and transport. Other end-use investments include direct use of renewables; electric vehicles; electrification in buildings, industry and international marine transport; use of hydrogen and hydrogen-based fuels; fossil fuel-based industrial facilities; CCUS in industry and direct air capture. Investment data are presented in real terms in year-2020 US dollars unless otherwise stated.

Light-duty vehicles (LDVs)**:** Includes passenger cars and light commercial vehicles (gross vehicle weight <3.5 tonnes).

Light industry: Includes less energy-intensive industries such as food processing, machinery, mining or construction.

Liquid biofuels: Liquid fuels derived from biomass or waste feedstock and include ethanol, biodiesel and biojet fuels. They can be classified as conventional and advanced biofuels according to the combination of feedstock and technologies used to produce them and their respective maturity. Unless otherwise stated, biofuels are expressed in energy-equivalent volumes of gasoline, diesel and kerosene.

Liquid fuels: Includes oil, liquid biofuels (expressed in energy-equivalent volumes of gasoline and diesel), synthetic oil and ammonia.

Low-carbon electricity: Includes renewable energy technologies, hydrogen-based generation, nuclear power and fossil fuel power plants equipped with carbon capture, utilisation and storage.

Lower heating value: Heat liberated by the complete combustion of a unit of fuel when the water produced is assumed to remain as a vapour and the heat is not recovered.

Low emissions fuels: Include liquid biofuels, biogas and biomethane, hydrogen and hydrogen-based fuels that do not emit any CO_2 from fossil fuels directly when used and also emit very little when being produced.

Mini-grids: Small electric grid systems comprised of generation unit(s) and distribution lines, not connected to main electricity networks that link a number of households and/or other consumers. Mini-grids can be eventually connected to a main grid.

Modern energy access: Includes household access to a minimum level of electricity (initially equivalent to 250 kWh annual demand for a rural household and 500 kWh for an urban household); household access to less harmful and more sustainable cooking and heating fuels, and improved/advanced stoves; access that enables productive economic activity; and access for public services.

Modern fuels: include fossil fuels, electricity and renewables and exclude traditional use of biomass.

Modern liquid bioenergy: Includes bio-gasoline, biodiesel, biojet kerosene and other liquid biofuels.

Modern renewables: Include all uses of renewable energy with the exception of traditional use of solid biomass.

Modern solid bioenergy: Refers to the use of solid bioenergy in intermediate and advanced improved biomass cook stoves (ISO tier ≥ 1), requiring fuel to be cut in small pieces or often using processed biomass such as pellets.

Natural gas: Comprises gases occurring in deposits, whether liquefied or gaseous, consisting mainly of methane. It includes both non-associated gas originating from fields producing hydrocarbons only in gaseous form, and associated gas produced in association with crude oil as well as methane recovered from coal mines (colliery gas). Natural gas liquids, manufactured gas (produced from municipal or industrial waste, or sewage) and quantities vented or flared are not included. Gas data in cubic metres are expressed on a gross calorific value basis and are measured at 15 °C and at 760 mm Hg (Standard Conditions). Gas data expressed in tonnes of oil equivalent, mainly for comparison reasons with other fuels, are on a net calorific basis. The difference between the net and the gross calorific value is the latent heat of vaporisation of the water vapour produced during combustion of the fuel (for gas the net calorific value is 10% lower than the gross calorific value).

Natural gas liquids (NGLs)**:** Liquid or liquefied hydrocarbons produced in the manufacture, purification and stabilisation of natural gas. NGLs are portions of natural gas recovered as liquids in separators, field facilities or gas processing plants. NGLs include, but are not limited to, ethane (when it is removed from the natural gas stream), propane, butane, pentane, natural gasoline and condensates.

Nominal (terms): Nominal (value or terms) is a financial and economic term that indicates the statistic in question is measured in actual prices that exist at the time. Nominal value of any economic statistic means the statistic is measured in terms of actual prices that exist at the time.

Non-energy use: Fuels used for chemical feedstocks and non-energy products. Examples of non-energy products include lubricants, paraffin waxes, asphalt, bitumen, coal tars and oils as timber preservatives.

Nuclear: Refers to the primary energy equivalent of the electricity produced by a nuclear power plant, assuming an average conversion efficiency of 33%.

Off-grid systems: Mini-grids and stand-alone systems for individual households or groups of consumers not connected to a main grid.

Offshore wind: Refers to electricity produced by wind turbines that are installed in open water, usually in the ocean.

Oil: Includes both conventional and unconventional oil production. Petroleum products include refinery gas, ethane, liquid petroleum gas, aviation gasoline, motor gasoline, jet fuels, kerosene, gas/diesel oil, heavy fuel oil, naphtha, white spirits, lubricants, bitumen, paraffin, waxes and petroleum coke.

Other energy sector: Covers the use of energy by transformation industries and the energy losses in converting primary energy into a form that can be used in the final consuming sectors. It includes losses by gas works, petroleum refineries, coal and gas transformation and liquefaction. It also includes energy own use in coal mines, in oil and gas extraction and in electricity and heat production. Transfers and statistical differences are also included in this category. Fuel transformation in blast furnaces and coke ovens are not accounted in other energy sector.

Passenger cars: A road motor vehicle, other than a moped or a motorcycle, intended to transport passengers. It includes vans designed and used primarily to transport passengers. Excluded are light commercial vehicles, motor coaches, urban buses, and mini-buses/mini-coaches.

Payback period: Refers to the period of time required to recover the amount invested in a project from its benefits (cash inflow).

Power generation: Refers to fuel use in electricity plants, heat plants and combined heat and power plants. Both main activity producer plants and small plants that produce fuel for their own use (auto-producers) are included.

Project finance: Involves external lenders, such as commercial banks, development banks and infrastructure funds, sharing risks with the sponsor of the project. It can also involve fundraising from debt capital markets with asset-backed project bonds. They often involve non-recourse or limited recourse loans where lenders provide funding on a project's future cash flow and have no or limited recourse to liability of the project parent companies.

Process emissions: CO_2 emissions produced from industrial processes which chemically or physically transform materials. A notable example is cement production, in which CO_2 is emitted when calcium carbonate is transformed into lime, which in turn is used to produce clinker.

Productive uses: Energy used towards an economic purpose: agriculture, industry, services and non-energy use. Some energy demand from the transport sector (e.g. freight) could be considered as productive, but is treated separately.

Renewables: Includes bioenergy, geothermal, hydropower, solar photovoltaics (PV), concentrating solar power (CSP), wind and marine (tide and wave) energy for electricity and heat generation.

Residential: Energy used by households including space heating and cooling, water heating, lighting, appliances, electronic devices and cooking.

Road transport: Includes all road vehicle types (passenger cars, two/three-wheelers, light commercial vehicles, buses and medium and heavy freight trucks).

Self-sufficiency: Corresponds to indigenous production divided by total primary energy demand.

Services: Energy used in commercial facilities, e.g. offices, shops, hotels, restaurants and in institutional buildings, e.g. schools, hospitals, public offices. Energy use in services includes space heating and cooling, water heating, lighting, appliances, cooking and desalination.

Shipping/navigation: This transport sub-sector includes both domestic and international navigation and their use of marine fuels. Domestic navigation covers the transport of goods or people on inland waterways and for national sea voyages (starts and ends in the same country without any intermediate foreign port). International navigation includes quantities of fuels delivered to merchant ships (including passenger ships) of any nationality for consumption during international voyages transporting goods or passengers.

Skill level: Indicates whether a high, medium or low level of education and/or training is required for carrying out a job, as classified by the International Standard Classification of Occupations 08 (ISCO-08).

Solar: Includes solar photovoltaics and concentrating solar power.

Solar home systems (SHS)**:** Small-scale photovoltaic and battery stand-alone systems (with capacity higher than 10 watt peak [Wp]) supplying electricity for single households or small business. They are most often used off-grid but also where grid supply is not reliable. Access to electricity in the IEA's definition considers solar home systems from 25 Wp in rural areas and 50 Wp in urban areas. It excludes smaller solar lighting systems, for example solar lanterns) of less than 11 Wp.

Solar photovoltaics (PV)**:** Electricity produced from solar photovoltaic cells.

Solid bioenergy: Includes charcoal, fuelwood, dung, agricultural residues, wood waste and other solid wastes.

Solid fuels: Include coal, modern solid bioenergy, traditional use of biomass and industrial and municipal wastes.

Stand-alone systems: Small-scale autonomous electricity supply for households or small businesses. They are generally used off-grid but also where grid supply is not reliable. Stand-alone systems include solar home systems, small wind or hydro generators, diesel or gasoline generators, etc. The difference compared with mini-grids is in scale and that stand-alone systems do not have a distribution network serving multiple costumers.

Synthetic methane: Low-carbon synthetic methane is produced through the methanation of low-carbon hydrogen and carbon dioxide from a biogenic or atmospheric source.

Synthetic oil: Low-carbon synthetic oil produced through Fischer-Tropsch conversion or methanol synthesis from syngas, a mixture of hydrogen (H_2) and carbon monoxide (CO).

Total energy supply (TES)**:** Represents domestic demand only and is broken down into electricity and heat generation, other energy sector and total final consumption.

Total final consumption (TFC)**:** Is the sum of consumption by the various end-use sectors. TFC is broken down into energy demand in the following sectors: industry (including manufacturing, mining, chemicals production, blast furnaces and coke ovens), transport, buildings (including residential and services) and other (including agriculture and other non-energy use). It excludes international marine and aviation bunkers, except at world level where it is included in the transport sector.

Total final energy consumption (TFEC)**:** Is a variable defined primarily for tracking progress towards target 7.2 of the United Nations Sustainable Development Goals. It incorporates total final consumption by end-use sectors but excludes non-energy use. It excludes international marine and aviation bunkers, except at world level. Typically this is used in the context of calculating the renewable energy share in total final energy consumption (indicator 7.2.1 of the Sustainable Development Goals), where TFEC is the denominator.

Total primary energy demand (TPED)**:** See total energy supply.

Traditional use of biomass: Refers to the use of solid biomass with basic technologies, such as a three-stone fire or basic improved cook stoves (ISO tier 0-1), often with no or poorly operating chimneys.

Transport: Fuels and electricity used in the transport of goods or people within the national territory irrespective of the economic sector within which the activity occurs. This includes fuel and electricity delivered to vehicles using public roads or for use in rail vehicles; fuel delivered to vessels for domestic navigation; fuel delivered to aircraft for domestic aviation; and energy consumed in the delivery of fuels through pipelines. Fuel delivered to international marine and aviation bunkers is presented only at the world level and is excluded from the transport sector at a domestic level.

Trucks: Includes all size categories of commercial vehicles: light trucks (gross vehicle weight less than 3.5 tonnes); medium freight trucks (gross vehicle weight 3.5-15 tonnes); and heavy freight trucks (>15 tonnes).

Unabated coal: Consumption of coal in facilities without CCUS.

Unabated fossil fuels: Consumption of fossil fuels in facilities without CCUS.

Unabated gas: Consumption of natural gas in facilities without CCUS.

Useful energy: Refers to the energy that is available to end-users to satisfy their needs. This is also referred to as energy services demand. As result of transformation losses at the point of use, the amount of useful energy is lower than the corresponding final energy demand for most technologies. Equipment using electricity often has higher conversion efficiency than equipment using other fuels, meaning that for a unit of energy consumed, electricity can provide more energy services.

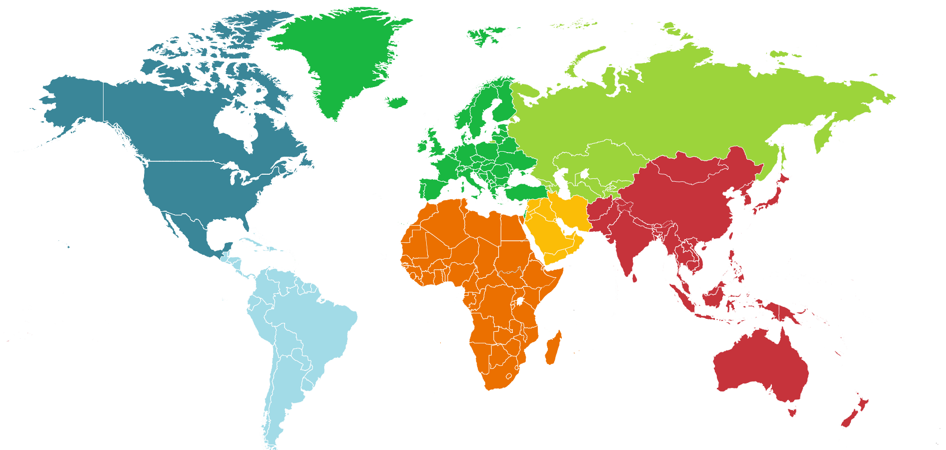
Variable renewable energy (VRE)**:** Refers to technologies whose maximum output at any time depends on the availability of fluctuating renewable energy resources. VRE includes a broad array of technologies such as wind power, solar PV, run-of-river hydro, concentrating solar power (where no thermal storage is included) and marine (tidal and wave).

Weighted average cost of capital (WACC)**:** The weighted average cost of capital is expressed in nominal terms and measures a company's required return on equity and the after-tax cost of debt issuance, weighted according to its capital structure.

Zero emissions vehicles (ZEVs)**:** Vehicles that are capable of operating without tailpipe CO_2 emissions (battery electric and fuel cell vehicles).

Regional and country groupings

Figure C.1 ▷ Main country groupings



Note: 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.

Advanced economies: OECD regional grouping and Bulgaria, Croatia, Cyprus[1,2], Malta and Romania.

Africa: North Africa and sub-Saharan Africa regional groupings.

Asia Pacific: Southeast Asia regional grouping and Australia, Bangladesh, Democratic People's Republic of Korea (North Korea), India, Japan, Korea, Mongolia, Nepal, New Zealand, Pakistan, People's Republic of China (China), Sri Lanka, Chinese Taipei, and other Asia Pacific countries and territories.[3]

Caspian: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

Central Africa: Cameroon, Central African Republic, Chad, Congo, Democratic Republic of the Congo (DRC), Equatorial Guinea and Gabon.

Central and South America: Argentina, Plurinational State of Bolivia (Bolivia), Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, Bolivarian Republic of Venezuela (Venezuela), and other Central and South American countries and territories.[4]

China: Includes the (People's Republic of) China and Hong Kong, China.

Developing Asia: Asia Pacific regional grouping excluding Australia, Japan, Korea and New Zealand.

Eastern Africa: Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Somalia, South Sudan, Uganda, United Republic of Tanzania, Zambia and Zimbabwe.

East Africa Community: Burundi, Kenya, Rwanda, South Sudan, Tanzania and Uganda.

Economic Community of West African States (ECOWAS)**:** Member states include Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo.

Emerging market and developing economies: All other countries not included in the advanced economies regional grouping.

Eurasia: Caspian regional grouping and the Russian Federation (Russia).

Europe: European Union regional grouping and Albania, Belarus, Bosnia and Herzegovina, North Macedonia, Gibraltar, Iceland, Israel[5], Kosovo, Montenegro, Norway, Serbia, Switzerland, Republic of Moldova, Turkey, Ukraine and United Kingdom.

European Union: Member states include Austria, Belgium, Bulgaria, Croatia, Cyprus[1,2], Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain and Sweden.

IEA (International Energy Agency)**:** OECD regional grouping excluding Chile, Iceland, Israel, Latvia, Lithuania and Slovenia.

Latin America: Central and South America regional grouping and Mexico.

Middle East: Bahrain, Islamic Republic of Iran (Iran), Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic (Syria), United Arab Emirates and Yemen.

Non-OECD: All other countries not included in the OECD regional grouping.

North Africa: Algeria, Egypt, Libya, Morocco and Tunisia.

North America: Canada, Mexico and United States.

OECD (Organisation for Economic Co-operation and Development)**:** Member states include Australia, Austria, Belgium, Canada, Chile, Czech Republic, Colombia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. Costa Rica became a member of the OECD in May 2021; its membership is not yet reflected in the *Africa Energy Outlook* projections for the OECD grouping.

OPEC (Organisation of the Petroleum Exporting Countries)**:** Algeria, Angola, Republic of the Congo (Congo), Equatorial Guinea, Gabon, the Islamic Republic of Iran (Iran), Iraq, Kuwait, Libya, Nigeria, Saudi Arabia, United Arab Emirates and Bolivarian Republic of Venezuela (Venezuela).

Sahel: Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal.

Southern Africa: Botswana, Eswatini, Lesotho, Namibia and South Africa.

Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam. These countries are all members of the Association of Southeast Asian Nations (ASEAN).

Southern African Development Community: Angola, Botswana, Comoros, Democratic Republic of the Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, United Republic of Tanzania, Zambia and Zimbabwe.

Sub-Saharan Africa: Angola, Benin, Botswana, Cameroon, Republic of the Congo (Congo), Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Mauritius, Mozambique, Namibia, Niger, Nigeria, Senegal, South Sudan, Sudan, United Republic of Tanzania (Tanzania), Togo, Zambia, Zimbabwe and other African countries and territories.[6] For the purposes of this report, South Africa is presented separately from sub-Saharan Africa as its energy demand trends and energy composition differs substantially from the rest of sub-Saharan Africa, and can mask trends in the region

Western Africa: Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo.

Country notes

[1] Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the island. There is no single authority representing both Turkish and Greek Cypriot people on the island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

[2] Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

[3] Individual data are not available and are estimated in aggregate for: Afghanistan, Bhutan, Cook Islands, Fiji, French Polynesia, Kiribati, Macau (China), Maldives, New Caledonia, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste and Tonga and Vanuatu.

[4] Individual data are not available and are estimated in aggregate for: Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, Bonaire, British Virgin Islands, Cayman Islands, Dominica, Falkland Islands (Malvinas), French Guiana, Grenada, Guadeloupe, Guyana, Martinique, Montserrat, Saba, Saint Eustatius, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and Grenadines, Saint Maarten, Turks and Caicos Islands.

[5] The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD and/or the IEA is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

[6] Individual data are not available and are estimated in aggregate for: Burkina Faso, Burundi, Cabo Verde, Central African Republic, Chad, Comoros, Djibouti, Kingdom of Eswatini, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Réunion, Rwanda, São Tomé and Príncipe, Seychelles, Sierra Leone, Somalia and Uganda.

Abbreviations and acronyms

AEO	Africa Energy Outlook
AfDB	African Development Bank
AFOLU	Agriculture, forestry and other land use
APS	Announced Pledges Scenario
CAAGR	compound average annual growth rate
CCGT	combined-cycle gas turbine
CCUS	carbon capture, utilisation and storage
CO_2	carbon dioxide
CO_2-eq	carbon-dioxide equivalent
COP	Conference of Parties (UNFCCC)
DER	distributed energy resources
DSR	demand-side response
EHOB	extra-heavy oil and bitumen
EOR	enhanced oil recovery
EPA	Environmental Protection Agency (United States)
EU	European Union
EU ETS	European Union Emissions Trading System
FAO	Food and Agriculture Organization of the United Nations
FiT	feed-in tariff
GHG	greenhouse gases
GIZ	Gesellschaft für Internationale Zusammenarbeit [German Corporation for International Cooperation]
GTL	gas-to-liquids
IGCC	integrated gasification combined-cycle
IMO	International Maritime Organization
ITMO	Internationally transferred mitigation outcomes
LCOE	levelised cost of electricity
LCV	light commercial vehicle
LED	light-emitting diode
LPG	liquefied petroleum gas
LULUCF	land use, land-use change and forestry
MEPS	minimum energy performance standards
MER	market exchange rate
MCL	mandatory comparative label
NEA	Nuclear Energy Agency (an agency within the OECD)
NOC	national oil company
NZE	Net Zero Emissions by 2050 Scenario
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PHEV	plug-in hybrid electric vehicles
PM	particulate matter
$PM_{2.5}$	fine particulate matter

PPA	power purchase agreement
PPP	purchasing power parity
PV	photovoltaics
SAS	Sustainable Africa Scenario
SADC	Southern African Development Community
STEPS	Stated Policies Scenario
R&D	research and development
SDS	Sustainable Development Scenario
SMR	steam methane reformation
T&D	transmission and distribution
TFEC	total final energy consumption
TPED	total primary energy demand
TSO	transmission system operator
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USGS	United States Geological Survey
VALCOE	value-adjusted levelised cost of electricity
WACC	weighted average cost of capital
WEM	World Energy Model
ZEV	zero emissions vehicle

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Chapter 1: State of play

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Africa Energy Outlook 2022

World Energy Outlook Special Report

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