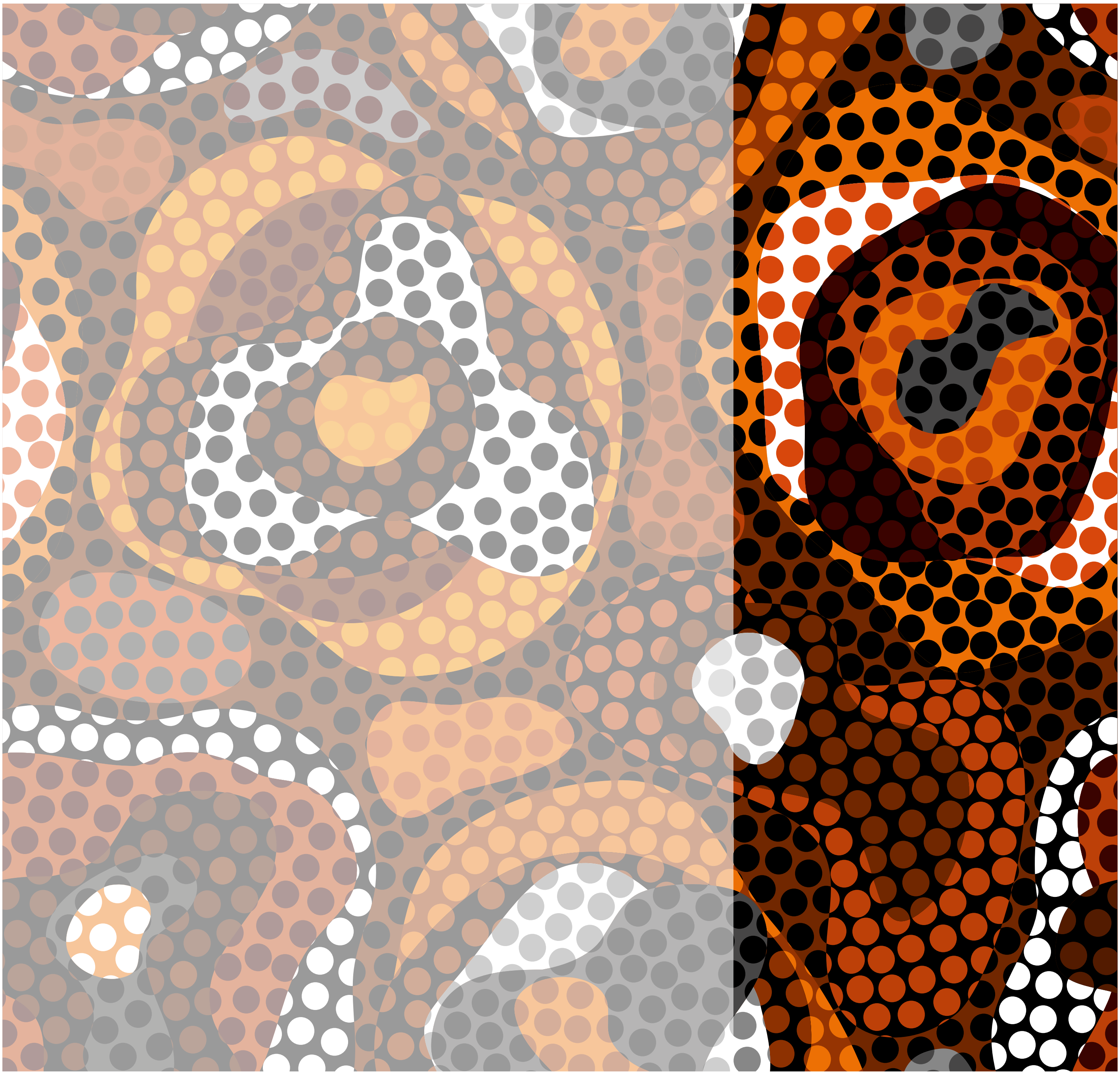
IRENA
International Renewable Energy Agency

RENEWABLE ENERGY MARKET ANALYSIS

AFRICA AND ITS REGIONS



IN COLLABORATION WITH AFRICAN DEVELOPMENT BANK GROUP

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ABOUT IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. A global intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security, and low-carbon economic growth and prosperity.

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FOREWORD

Africa is at a crossroads. For many of the people of this vast and diverse continent, access to affordable, clean and sustainable energy remains an aspiration. The need for better and more abundant energy is evident in many walks of life, from households relying on dirty fuels for cooking and farmers lacking energy to harvest their crops, and from health clinics struggling to power operating rooms to businesses contending with power outages. Climate change is fast adding new challenges in the form of extreme weather events, rising temperatures and more variable rainfall.

We know that renewable energy can help to resolve many of these social, economic, health and environmental challenges. Renewables are key to overcoming energy poverty, providing energy services without damaging human health or ecosystems, and enabling sustainable socio-economic development. As this report shows, a transition to a renewables-based energy system in Africa promises substantial gains in GDP, employment, and human welfare in each of the continent's constitutive regions.

Although Africa's share of global renewable energy investments and capacity installations remained relatively small over the past decade, the continent can draw on a vast wind, solar, hydro, and geothermal resource potential. Falling costs are increasingly bringing renewables within reach, whether through grid extension, mini-grids or stand-alone applications.

A profound energy transition centred on renewables and energy efficiency is increasingly understood as not only feasible but essential for a climate-safe future in which sustainable development prerogatives are met. In fact, a sophisticated understanding of the intimate connections between the energy system and the economy at large is essential in designing policies, along with an appreciation of the ways in which both are linked to the world's ecosystems and human wellbeing.

Experience around the world gives us a strong sense of what it takes to succeed. As this report makes clear, African policymakers can draw on a wealth of experience in planning, financing, and deploying renewable energy projects, and integrating them into energy systems. But as is true in other parts of the world, it is critical that each African country play to its own strengths and understand its weaknesses, whether in terms of its industrial capacities, commodity and trade dependencies, or skills base. Countries can and must learn from each other. Intra-regional and broader international cooperation can overcome drawbacks any individual country may face on its own.

A wide-ranging challenge demands a comprehensive policymaking approach. This report illuminates the array of policy areas that may contribute to a successful energy transition. But rather than picking policies selectively, they all need to be part of an overarching, holistic framework that is more than just the sum of its parts.

The growing discourse on a Green Deal in places like Europe and North America has spotlighted the importance of a bold, systemic approach. A Green Deal will of necessity look different in Africa, tailored to its own circumstances. But the key point is its transformative nature: pursuing synergies in resolving pressing social, economic, health, and environmental issues, recognising that because market-driven approaches alone will not suffice strong public interventions are needed, and placing people at the centre of the transition.

The objectives of Africa's energy transition are far-reaching economic diversification; the creation of decent jobs; environmental stewardship and climate resilience; and universal access to affordable, reliable, sustainable and modern energy. A comprehensive policy package, as detailed in this report, must be underpinned by strong institutions and adequate financial resources, assisted by international collaboration, and supported by communities on the ground.

This report offers policymakers and the interested public a wealth of data, insights, and policy recommendations. It is my hope that it will also prove to be an inspiration, helping to spark the energy transition and driving the continent's sustainable development.

Francesco La Camera
Director-General, IRENA

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Individual chapter authors were as follows:

CHAPTER 1: Rabia Ferroukhi, Laura El-Katiri and Amir Lebdioui (IRENA)
With contribution from Michael Renner, Mirjam Reiner and Abdullah Abou Ali (IRENA).

CHAPTER 2: Laura El-Katiri, Imen Gherboudj, Gerardo Escamilla, Nazik Elhassan and Dennis Akande (IRENA)
With contribution from Arvydas Lebedys, Asami Miketa, Abdullah Abou Ali, Daniel Russo and Sebastian Hendrik Sterl (IRENA).

CHAPTER 3: Costanza Strinati, Faran Rana, Diala Hawila, Sandra Lozo (IRENA), Wikus Kruger and Olakunle Alao (Power Futures Lab, CTU)
With contribution from Ute Collier (IRENA) and Antonio Barbalho (IRENA consultant).

CHAPTER 4: Diala Hawila, Carlos Guadarrama, Abdullah Abou Ali (IRENA), Wikus Kruger and Olakunle Alao (Power Future Labs, CTU)
With contribution from Ute Collier, Michael Renner, Ulrike Lehr, Samah Elsayed, Celia García-Baños, Laura El-Katiri, Amara Kate Bain Slaymaker, Emanuele Bianco, Jinlei Feng, Saida Usmonova, Asami Miketa, Francisco Boshell, Sebastian Hendrik Sterl, Arina Anisie, Elena Ocenic and Jennifer Ifeanyi-Okoro (IRENA). Lea Ranalder (REN21) contributed with a sidebar on Renewable Energy in Cities in Africa.

CHAPTER 5: Rabia Ferroukhi, Xavier Casals, Ulrike Lehr, Laura El-Katiri, Álvaro López-Peña (IRENA)
With contribution from Carlos Guadarrama (IRENA) and Ha Bui, Jamie Pirie, Hector Pollitt, Unnada Chewpreecha, An Vu, Zsófi Kőműves, Sophie Heald and Alistair Smith (Cambridge Econometrics) for the modelling exercise.

CHAPTER 6: Ute Collier and Divyam Nagpal (IRENA)

CHAPTER 7: Michael Renner, Rabia Ferroukhi and Amir Lebdioui (IRENA)
With contribution from Mirjam Reiner, Laura El-Katiri, Diala Hawila and Divyam Nagpal (IRENA)

REVIEWERS: This report benefited from valuable feedback and inputs from: Ahmed Badr, Ali Yasir, Ashani Bartley, Bishal Parajuli, Dolf Gielen, Elizabeth Press, Gurbuz Gonul, Hanbit Lee, Kamlesh Dookayka, Nopenyo Dabla, Sebastian Hendrik Sterl, Tarig Ahmed (IRENA), Daniel Schroth, Franklin Koffi Gbedey, Joao Duarte Cunha, Regina Oritshetemeyin Nesiama and Serign Cham (AfDB), The Infrastructure and Energy Department (African Union), Lars Holm (Boston Consulting Group), Christine Eibs Singer (Catalyst Off-Grid Advisors), Jean Marc Sika (Hivos), Adeola Adebiyi and Bah F. M. Saho and (ECREEE), Maged Mahmoud (RECREEE), Laura Williamson, Lea Ranalder and Rana Adib (REN21), Eugenia Masvikeni (SACREEE), Jem Porcaro, Luc Severi, Nishant Narayan, Olivia Coldrey (SEforALL) and Stratos Tavoulareas (IRENA consultant).

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BACKGROUND AND SOCIO-ECONOMIC OVERVIEW

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- **The economic context**
- Trade, commodity dependence and **industrial diversification**
- Differences between **energy importers and exporters**
- **Human development** and the Sustainable Development Goals

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Africa is a continent rich in land, water and energy resources, with a young and fast-growing population. Already the world's youngest continent, it is expected to grow to nearly 2.5 billion people by 2050, 80% of them in Sub-Saharan Africa (UNPD, 2019). Levels of human and economic development differ widely across the continent, but it is clear that the opportunities the continent offers are vast. Energy plays a fundamental role in Africa's development pathway, and improving livelihoods and access to opportunities will depend crucially on the expansion of access to reliable and affordable and sustainable energy. This is also in view of the expectedly vast impact of climate change on the African continent, the effects of which are already beginning to be felt right now, and in view of the enormous potential for industrial development, job creation and environmental management that more widespread access to sustainable energy sources brings.

The African Union's Agenda 2063 clearly establishes the links between energy and industrialisation (African Union, 2021). However, access to reliable electricity and clean, modern cooking in Africa remains far behind most other parts of the world. With an electrification rate of 46%, 570 million people in 2019 were still without access to electricity in Sub-Saharan Africa, while only 16% had access to clean cooking (IEA, IRENA *et al.*, 2021). This situation reinforces socio-economic inequalities and impedes progress in widening access to basic health services, education, and modern machinery and technology – thus, ultimately, to socio-economic opportunities.

Africa holds significant energy resources. Fossil fuels represent around 40% of African exports, with countries such as Algeria, Angola, Chad, Nigeria and the Sudan being highly dependent on them as a source of revenue. Along with other raw materials that continue to constitute a substantial proportion of African countries' exports, fossil fuels provide revenue but also reinforce commodity-dependence. In the context of a low-carbon future, these and other fossil fuel dependent countries will be increasingly vulnerable to the risks of stranded assets, in addition to the already serious effects of price volatility for internationally traded commodities. Renewable energy, by contrast, offers African economies prospects for economic growth, cost-effective technologies to expand energy access and quality of access, and industrial development along new value-chains, with substantial, local job creation potential (see also subsequent chapters, especially Chapter 5).

Energy development will also have a critical influence on Africa's recovery from the COVID-19 crisis. Recovery from the pandemic heightens the importance of placing sustainable energy

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development at the core of broader economic development and industrialisation strategies. This must include increased efforts and investment to broaden access to energy in vital sectors such as health and education, and the use of recovery-related policy measures and investments to hasten the wider structural shift toward sustainable energy as a pillar of resilient economies and societies (IRENA, 2020a).

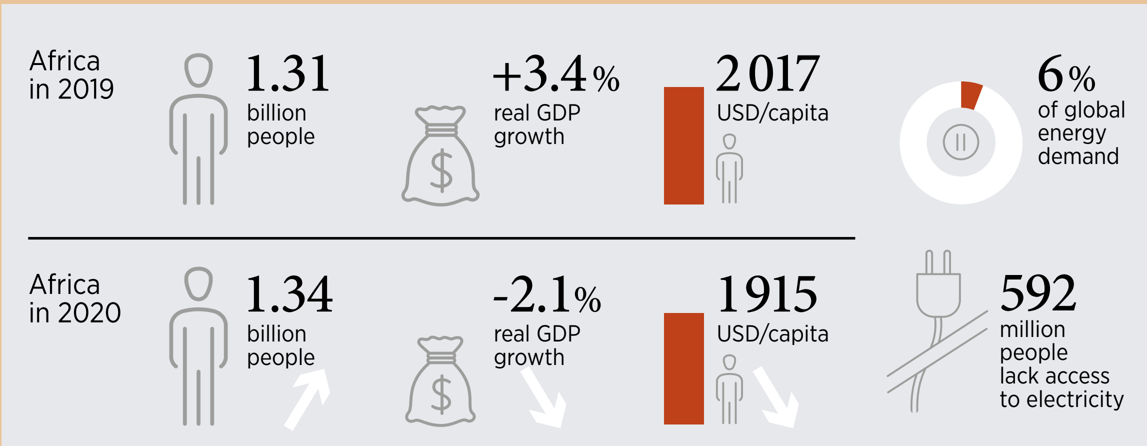
This chapter provides a brief macroeconomic overview of the African continent and its five regions – North, West, East, Central and Southern Africa – focusing on the socio-economic challenges the region faces and the role of energy in meeting those challenges in sustainable ways. Section 1.1 looks at the macroeconomy of the region, focusing on the recent economic and trade trends across the five African regions. Section 1.2 explores the links between trade, commodity dependence and industrial diversification. Section 1.3. takes a closer look at the economic differences between African energy exporters and importers. Section 1.4. looks at human development and the SDGs, and their link to current energy systems in Africa. Section 1.5 provides concluding remarks.

1.1 THE ECONOMIC CONTEXT

KEY MESSAGES AND NUMBERS

- On average, growth in gross domestic product has slowed across African economies in recent years, in part because of lower commodity prices and the effects of the COVID-19 crisis.
- More than 80% of African countries are still commodity dependent.
- Population grew by 26% between 2010 and 2020 and is expected to reach 2.5 billion by 2050.
- The electricity access rate in Sub-Saharan Africa has grown from 33% in 2010 to 46%in 2019, yet 570 million people remain without access.
- Only 16% of the population in Sub-Saharan Africa has access to clean cooking, with the access rate dropping to 4% in rural areas.
- A third of African countries are at risk of a debt crisis.

Source: United Nations, 2021b; UNPD, 2019; IEA, IRENA et al., 2021; AfDB, 2021a; IMF, 2019, 2021.



Africa's economies are widely diverse in their growth trajectories. Many expanded until the mid 2010s on the back of strong international commodity markets, but the pace slowed afterwards, first as a result of falling commodity prices after 2014, and then because of the COVID-19 crisis. Because Africa remains highly dependent on commodity exports, the region's economies rise and fall with international movements in commodity price. Fuelled mostly by the commodity price boom of the 2000s and early 2010s, average gross domestic product (GDP) per capita (in constant 2010 USD) grew at an annual rate of 2.3% between 2000 and 2014 (see Figure 1.1). In some countries the expansion of manufacturing capacity reinforced this growth. One of these was Ethiopia, which has been one of the fastest-growing economies in the world, with a sevenfold increase of GDP per capita between 2000 and 2019. However, persistent commodity dependence and an overall lack of economic diversification has now reversed the earlier trend, as shown in Figure 1.1. Between 2014 and 2019, when commodity prices were low, per capita GDP stagnated (with an average annual rate of -0.01%, and even -0.22% for the 2014 2020 period).

The COVID-19 pandemic has added social, economic and financial stress. Despite weathering the beginning of the pandemic comparably well economically (with almost half of the 24 countries worldwide that experienced any positive GDP growth in 2020 being in Sub-Saharan Africa), economic growth across the region is set to stall in 2021 (IMF, 2021). It is also estimated that over 23 million people will be pushed into poverty in Sub-Saharan Africa (Mahler *et al.*, 2020).

A third of African countries are at risk of a debt crisis.[1] As of December 2020, six were already in debt distress and 14 others were at high risk (AfDB, 2021a).[2] Given weaknesses in the public balance sheets of several countries and reserve buffers below levels typically

considered adequate in more than half of the countries in the region (IMF, 2019), the region is vulnerable to the effects of slower growth, reduced foreign investment and lower remittances as a result of the pandemic – and to the pandemic's effects on commodity export revenues, including those from fossil fuels.

Region-wide economic statistics show important regional economic differences across the African continent. In 2019, East Africa was the continent's fastest-growing region, with average growth estimated at 5.0%. North Africa was the second fastest, at 4.1%, followed by West Africa (3.7%) and Central Africa (3.2%) (AfDB, 2020a). Southern Africa was the only region to see a decline in growth from 2018 to 2019 (1.2% vs. 0.7%), reflecting developments in South Africa and the devastation caused by cyclones Idai and Kenneth in Mozambique. All in all, growth was highly concentrated in a few places. Just five economies – Algeria, Egypt, Morocco, Nigeria and South Africa –accounted for 55% of Africa's growth in 2019 (AfDB, 2020a).

By contrast with this growth record, most African regions experienced a contraction of GDP between 2019 and 2020 in the wake of the COVID-19 crisis. While East Africa continued to grow (by 1.4%), Southern and North Africa experienced the largest GDP decline (-6.4% and -3.9%, respectively). The crisis took less of a toll on GDP in Central and West Africa (-2.3% and -0.9%, respectively).

1 *In 2018, 16 Sub-Saharan African countries were classified as having either a high risk of debt distress (Burundi, Cameroon, Cabo Verde, the Central African Republic, Chad, Ethiopia, Ghana, Sierra Leone, Zambia) or being in debt distress (the Democratic Republic of the Congo, Eritrea, the Gambia, Mozambique, Sao Tomé and Príncipe, South Sudan, Zimbabwe) (IMF, 2019).*

2 *Debt distress is described as an event that occurs when the spreads on sovereign debt in the secondary debt market (where loans are traded as assets by investors) exceed a critical threshold (AfDB, 2021a). Sovereign debt spreads can reflect perceptions of sovereign risk and therefore provide information on the external financing conditions faced by African bond issuers (AfDB, 2021a).*

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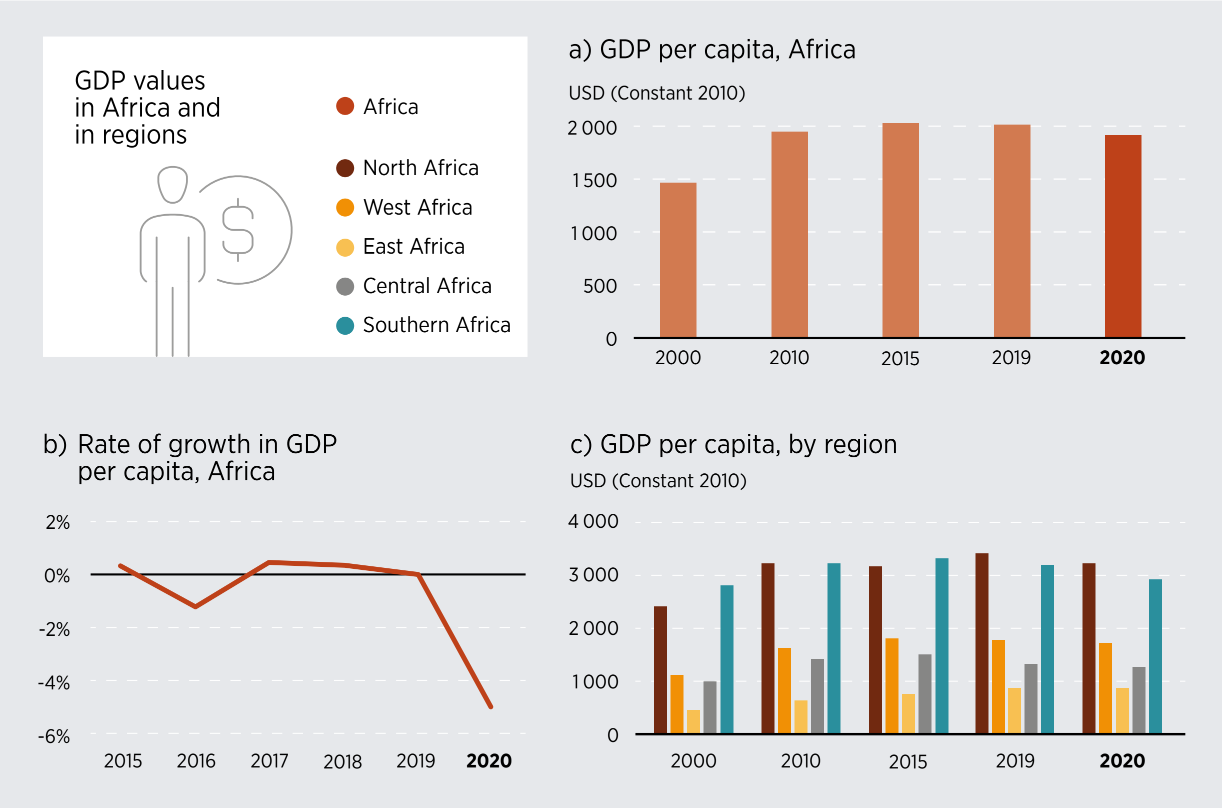
Figure 1.1 Overview of the evolution of key economic indicators in Africa and its regions



Source: World Bank, 2021.
Note: GDP = gross domestic product.

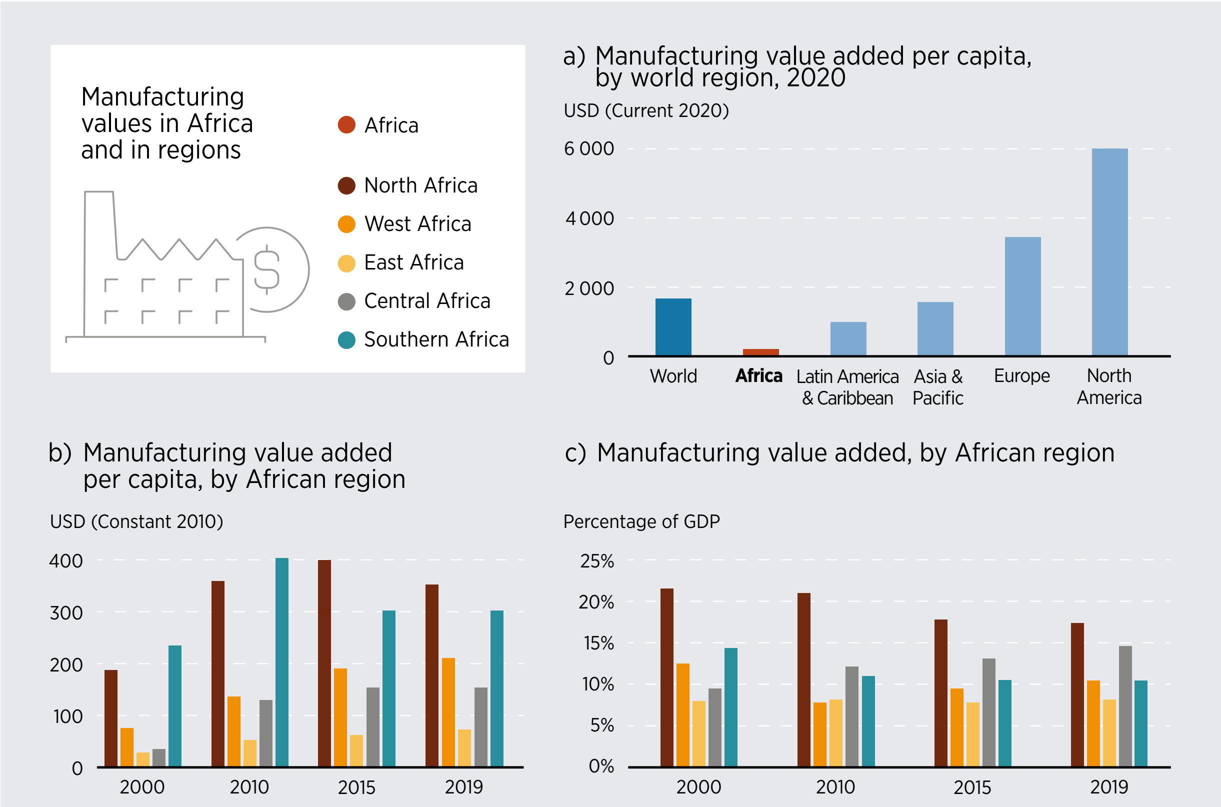
Expanding the **manufacturing** sector is essential for diversifying economies, increasing productivity, promoting innovation and technological advances, and creating jobs (UNIDO, 2020). However, following significant progress in the 2000s, a large majority of African countries saw their per capita manufacturing value added (MVA) rates stagnate in the 2014 2019 period; the rate even decreased in Southern Africa.[3] In 2019, Africa's MVA per capita (of about USD 207) was about eight times lower than the world average (USD 1 683) (see Figure 1.2). Even in the African countries with relatively large manufacturing sectors, such as Ethiopia and the United Republic of Tanzania, value-added and productivity levels remain relatively low (Rodrik, 2021). This is because Africa's economic growth and employment generation have relied heavily on low-value-added sectors, such as raw commodity exports (fossil fuels, mining and agriculture) (ILO, 2019).

Agriculture generates the most jobs in Africa, accounting for nearly half of total **employment**.[4] Although agriculture's share of total employment decreased

3 *The MVA of an economy is the total estimate of residents' net manufacturing output; it is obtained by adding up outputs and subtracting intermediate consumption. The indicator is a useful reflection of the level of industrial activity and value produced in a given region.*

4 *The term "employment" comprises all persons of working age who, during a specified period (such as one week or one day), were in: 1) paid employment (whether at work or with a job but not at work); or 2) self-employment (whether at work or with an enterprise but not at work) (ILO, 2013).*

Figure 1.2 Manufacturing value added (MVA) in Africa and its regions



Source: World Bank, 2021.
Note: GDP = gross domestic product.

from 53.5% in 2011 to 46% in 2019, the sector remains a crucial source of jobs in Africa (Figure 1.3a). The continued employment-related dominance of the sector, where most jobs are informal and incomes and working conditions are worse than in other sectors, coupled with low MVA levels, as outlined above, implies that the structural transformation witnessed in other regions, such as East Asia, has not yet taken place in Africa (ILO, 2020). The agriculture sector is particularly vulnerable to climate shocks, which are increasingly likely to hit harvests, yields and livestock. This vulnerability affects women disproportionately, since the agriculture sector is female-dominated. As a result, women have more difficulty than men in finding decent work because so many of them work in the relatively unproductive and largely informal agricultural sector (ILO, 2020).

There are considerable regional differences in the composition of employment (Figure 1.3b). In Central and East Africa, employment is predominantly agricultural (58.2% and 64.9%, respectively), whereas North, Southern and West Africa depend to a larger extent on the services sector for jobs. The share of industry in total employment is highest in North Africa (25.6%), followed by Southern Africa (14.1%) and West Africa (13.9%). Figure 1.3b contrasts the levels of structural transformation and industrialisation in the regions.

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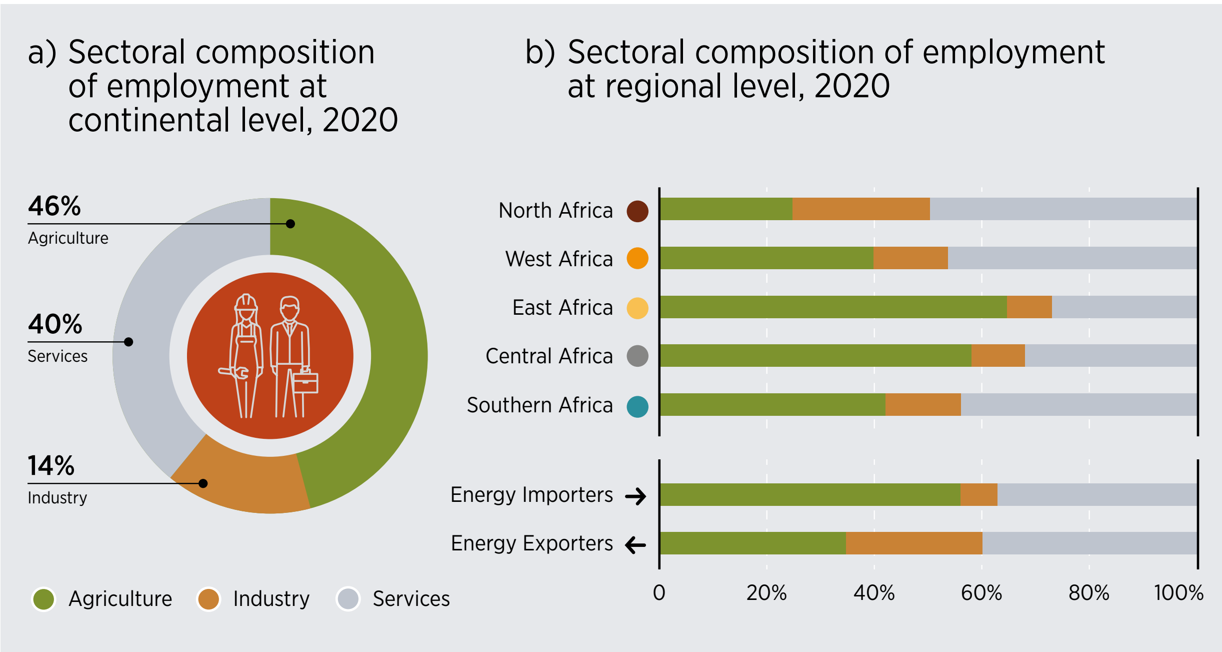
In 2019, Africa's total labour force participation (63.1%) was higher than the global average (60.7%), signalling a large working-age population seeking employment and needing to survive economically – and thus finding themselves accepting informal employment (ILO, 2018, 2020). Since 2000, total employment in Africa has grown by between 2.5% and 3% annually, particularly in East and Central Africa, while Southern Africa has experienced volatility in employment (ILO, 2020). At the regional level, there is also a considerable variation in labour productivity. In 2019, the increase in productivity per worker in East and North Africa (2.4% and 2.3%, respectively) was more than twice that in Southern and West Africa, while Central Africa registered negative growth (ILO, 2020). It should be noted, however, that labour productivity in Africa is difficult to measure, owing to the large proportion workers engaged in subsistence activities (ILO, 2019).

Figure 1.3 Overview of employment indicators in Africa and its regions



Source: ILO, 2020.

1.2 TRADE, COMMODITY DEPENDENCE AND INDUSTRIAL DIVERSIFICATION

Africa is the most commodity-dependent region in the world, with most countries highly dependent on the export of commodities (UNCTAD, 2019).[5] Primary goods – agricultural products, minerals and metals, and fossil fuels – constitute the bulk of Africa's exports (Figure 1.4a), while manufactured goods make up the bulk of its imports. More than half of Africa's imports in 2021 were manufactured goods, while fossil fuels represented about 16.4% of imports (Figure 1.4b). Central, West and North Africa are particularly dependent on fossil fuel exports, while many East and Southern African economies depend to a large degree on agricultural and mineral exports. Some East and Southern African countries (such as Mozambique and Uganda) have just recently joined the ranks of fossil fuel exporters; the share of those exports in their economies is expected to increase over the coming decade.

China is the region's largest trading partner, accounting for about 20% of total trade, followed by the European Union, India and the United States. Africa's imports from China are dominated by consumer goods (45%) and, to a lesser extent, physical capital goods and intermediates (IMF, 2019). Meanwhile, about 70% of the region's exports to China are commodities, particularly oil, minerals and metals, making many African economies highly vulnerable to economic slowdowns in China (IMF, 2019). Intra-regional trade, by contrast, accounts for only 16% of Africa's total trade. The African Continental Free Trade Area, launched in 2018, is designed to change this by promoting trade integration within Africa.

There are important differences in the type of commodities that each of the five regions export (see Figure 1.5). While Central, North and West Africa depend most heavily on fossil fuel exports, Southern Africa concentrates on mining exports. Around half of East Africa's exports are agricultural goods.

The high degree of commodity dependence in Africa is a source of great socio-economic vulnerability. Export levels, government revenues and public spending are exceptionally exposed to exogeneous shocks, including commodity price volatility (Figure 1.3a). By 2019, continental revenues from fossil fuel exports had fallen to less than a third of their 2012 value, in large part due to the drop in fossil fuel prices and higher extraction costs than in other regions. During the same period, agriculture and mining exports remained comparatively stable. Fossil fuels accounted for nearly half of Africa's export revenues through 2018, when, for the first time in 20 years, they dropped below those from mining and manufacturing exports (Figure 1.4a).

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5 The United Nations Conference on Trade and Development (UNCTAD 2019) considers a country to be commodity dependent when commodities represent more than 60% of its total merchandise exports in value terms.

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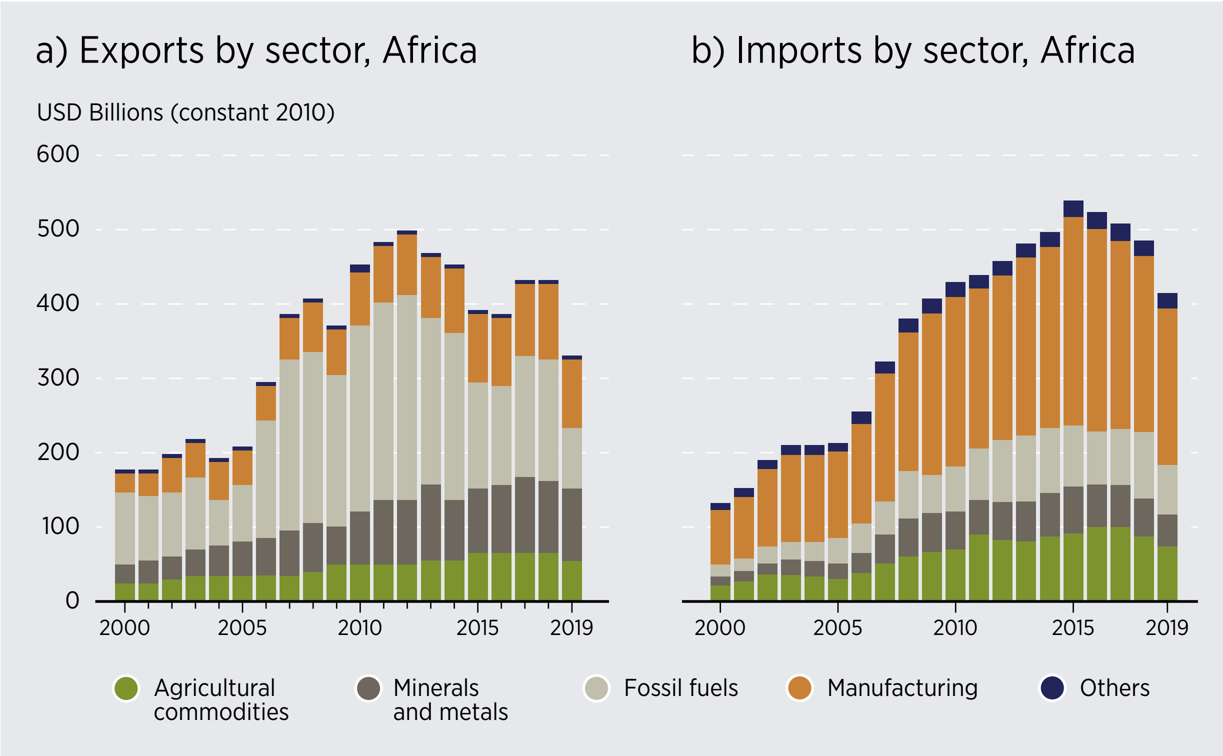
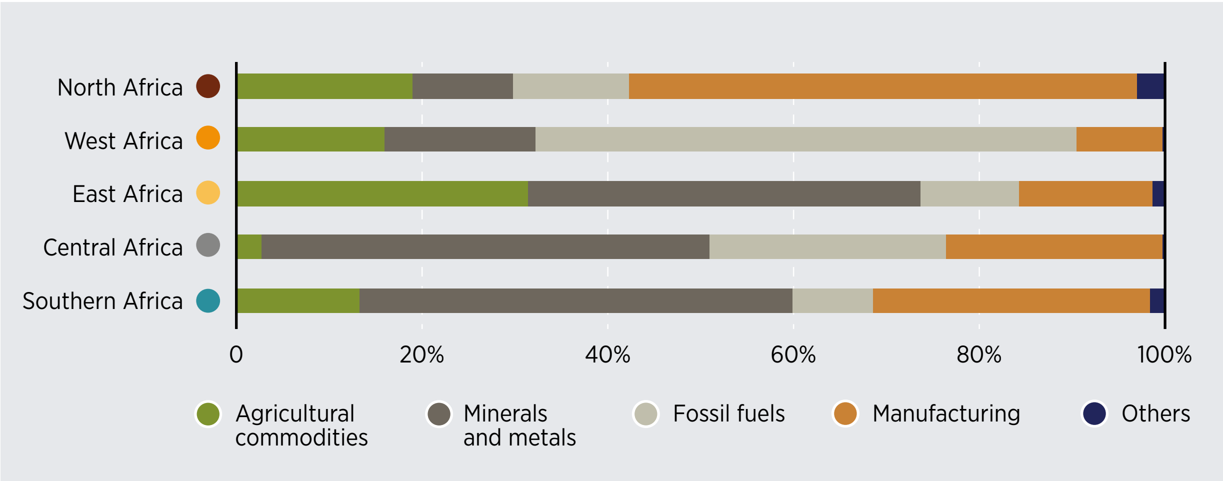
Figure 1.4 Evolution of imports and exports across Africa, by sector, 2000–2019



Source: United Nations (2021b) and authors' calculations.

Figure 1.5 Composition of exports, by region, 2019



Source: United Nations (2021b) and authors' calculations.

1.2.1 Commodity dependence, climate change and the energy transition

Africa's high commodity-dependence also makes the continent exceptionally vulnerable to adverse effects of climate stress, including climate variability and extremes (ACPC, 2013; Anzolin and Lebdioui, 2021; UNECA, 2017). Agriculture-dependent economies are expected to be especially vulnerable to climate change, given the impact of temperature fluctuations and extreme weather conditions on agricultural productivity (ACPC, 2013; Lebdioui, 2020; UNECA, 2017).

Climate shocks have already caused major economic disruptions across Africa in recent years, and are likely to become a significant threat to Africa's socio-political stability. In 2019, Cyclone Idai affected over 3 million people, causing over USD 1.4 billion of damage to physical and productive infrastructure and USD 1.39 billion in losses in Southern and East Africa (Government of Mozambique, 2019). Intense and frequent droughts, floods and storms have affected the livelihoods of 70% of the population in Mozambique (World Food Programme, 2021). There are further risks of drought in North Africa and Southern Africa, as well as above-average rainfall in East Africa. The International Committee of the Red Cross highlights the disastrous potential effects of unmitigated climate change on the social fabric, peace and conflict in vulnerable parts of the world, including Africa (ICRC, 2020). The tourism industry, which has become vital to African economies over the past 20 years, is also likely to be considerably affected by climate change. In 2019, the industry accounted for about 7% of Africa's GDP and contributed USD 169 billion to its economy – roughly the combined GDP of Côte d'Ivoire and Kenya (WTTC, 2020; Monnier, 2021).

The energy transition holds both challenges and opportunities for Africa's commodity exporters. The continent is endowed with many of the minerals that are essential inputs for renewable energy and low-carbon technologies like electric batteries and wind turbines, including manganese, copper, lithium, cobalt, chromium and platinum. The Democratic Republic of the Congo, to take one example, is one of the world's largest cobalt producers, while South Africa is the world's largest producer of platinum and manganese. Rwanda has become the world's largest exporter of tantalum.

Growth in the market for these essential components of renewable energy technologies holds great potential to benefit African producers. On the other hand, the benefit Africa derives from the energy transition will also depend on the extent to which raw material producers invest in and develop processing capacity further up the value chain. Only when economic activity moves from the mere export of raw materials to higher-value products can countries maximise the potential for local job creation and improved livelihoods, topics dealt with in Chapters 5 and 6 of this report.

Effectively managing this transition will be a central challenge for many African economies in the coming decades. Fossil-fuel exporters, by contrast, face longer-term vulnerability, in the form of declining demand for their products. Because fossil fuels remain among Africa's largest exports, many hydrocarbon-exporting African economies face significant socio-economic challenges if they miss the opportunity to diversify their economies today.

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1.2.2 Renewables, industrial diversification and employment generation

Although the development of renewable energy has been incorporated into more and more national and regional structural transformation programmes, more attention must be paid to the feedback loops and synergies between energy, industrialisation and development. Decarbonised energy solutions can create jobs, make developing economies more competitive and steer them towards a more resilient and sustainable future (United Nations, 2019, 2020, 2021a). For many African energy importers, renewable energy also holds vast potential to reduce vulnerability to the external shocks caused by movements in the price of fossil fuels. As such, the development of renewable energy has been incorporated into several regional and regional development strategies and programmes. For instance, the African Union's Agenda 2063 clearly establishes the links between energy and industrialisation.[6] Several regional programmes and initiatives (such as the Africa Renewable Energy Initiative, the Africa Power Vision and the African Clean Energy Corridor) are devoted specifically to the development of renewables and have been championed by various actors, as detailed in Chapter 4.

The fact is, however, that the design and manufacture of most renewable energy equipment, along with high-value service inputs, reside in a handful of non-African countries. During 2018, three quarters of patents related to the renewable energy sector were filed in just four countries (China, the United States, Japan and Germany). To date, few African countries have managed to successfully integrate the high-value-added segments of renewable energy value chains and generate associated employment. As a result, many African countries remain consumers rather than producers of low-carbon technologies, limiting the creation of jobs and other socio-economic benefits relating to construction, operations and maintenance.

The importance of diversifying and regionalising renewable energy supply chains was further highlighted by the COVID-19 crisis, which severely disrupted cross-border supply chains. To improve the long-term resilience of renewable energy deployment against exogeneous shocks, a further diversification of supply chains may be needed. In Africa, the creation of regional supply chains in the renewable energy sector would help support the energy transition while achieving net job gains. The sector today employs more than 12 million people worldwide, but only around 323 000 in Africa (less than 3% of renewables employment worldwide) (IRENA and ILO, 2021[7]). Investments in renewable energy and energy efficiency could generate net gains in employment

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6 Other key regional industrialisation programmes include the East African Community Industrialisation Policy 2012 2032; the COMESA (Common Market for Eastern and Southern Africa) Industrialisation Strategy; the West African Common Industrial Policy, which is championed by the Economic Community of West African States; and the Regional Industrialisation Action Plan and the SADC Industrialisation Strategy and Roadmap 2015 2063, which have been developed by the Southern African Development Community.

7 Data limitations across Africa's employment sector, including in energy, means employment figures for Africa are very likely underestimated. Significant additional employment is also found in the access sector, but these jobs are not accounted for in the cited references.

across the continent, helping to bring down rates of unemployment that remain among the highest in the world (especially in North Africa and Southern Africa).

Renewables can play a central role in further promoting job creation in Africa because investing in energy transition technologies creates close to three times more jobs than fossil fuels do, for each million dollars of spending (Garrett-Peltier, 2017). With the added investment stimulus under IRENA's Transforming Energy Scenario each million of U.S. dollars invested in renewables or energy flexibility would create at least 25 jobs, while each million invested in efficiency would create about 10 jobs. These gains far outweigh the loss of 1.07 million jobs in the fossil fuel and nuclear sectors.

Such jobs gains are particularly important in Algeria, Angola, Nigeria and other countries where large numbers are employed directly or indirectly in the fossil fuel sector, where jobs are at risk because of the global energy transition.

Renewable energy could also help boost intra-African trade in renewable energy technologies, services and electricity. Africa holds significant potential for growth in intra-regional trade. Securing such benefits hinges on leveraging and enhancing local industrial capacities, putting in place adequate education and training programmes, and adopting far-sighted industrial and labour market policies, as further discussed in Chapter 6.

1.3 DIFFERENCES BETWEEN ENERGY IMPORTERS AND EXPORTERS

There are considerable differences in the economic structure, income and socio-economic development levels of energy importers and energy exporters across Africa. Most of the latter have higher GDP per capita than their energy-importing neighbours, although higher GDP per capita is also associated with higher income inequalities. In other words, greater wealth does not by itself imply better living standards for all.

For 10 of Africa's 54 countries, fossil fuels represent more than 60% of total merchandise exports in value terms. These countries are deemed "fossil fuel dependent". Similar to other commodity exporting countries in Africa, energy exporters are highly vulnerable to market cycles in international energy prices. When international prices for oil and gas are high, fossil fuel exporters fare better than importing countries; by the same token, they also tend to be hit hard by global collapses in commodity prices, as in 2014 and 2020. The resulting fluctuations in government revenues are one of the most fundamental threats to the long-term socio-economic stability of these countries. Even more serious is the question of what will underpin their economies as worldwide demand for fossil fuels declines over the coming decades.

The COVID-19 crisis that began in 2020 has also had an uneven economic impact across Africa. Fossil fuel exporting economies, along with other resource intensive economies and tourism-dependent economies, were hit the hardest by the pandemic. As global trade declined in 2020 and governments across the world imposed lockdowns and travel restrictions, commodity prices sank further, causing fossil fuel exporting economies in Africa to contract by 1.5%, while non resource intensive economies shrank by 0.9% (AfDB, 2020a).[8]

8 *The HDI is a summary measure of average achievement in three key dimensions of human development: health, gauged by life expectancy at birth; education, measured in mean of years of schooling for adults aged 25 years or more and expected years of schooling for children of just entering school age; and standard of living, measured by gross national income per capita.*

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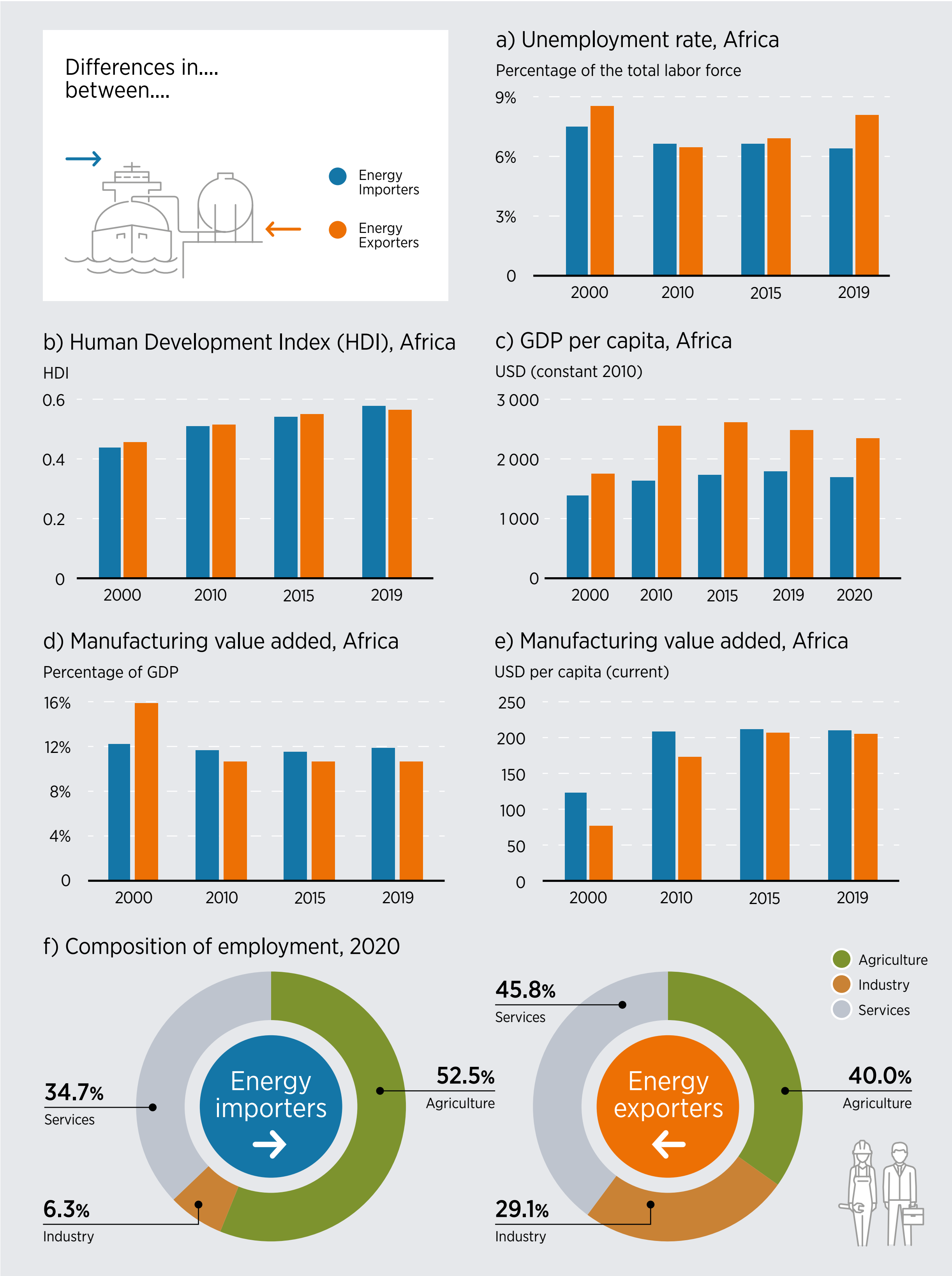
Although energy exporters tend to have much higher rates of GDP per capita than energy importers, the latter perform marginally better on the Human Development Index (HDI), which reflects outcomes in health and education, as well as wealth (see Figure 1.6).

Energy exports have in many cases failed to promote viable and value-added manufacturing activities on a large scale. In energy-exporting economies, the share of MVA in GDP dropped from 15.8% in 2000 to 10.6% in 2019, while stagnating in most energy-importing economies (at around 12%). This suggests that most of Africa's fossil fuel exporters largely failed to leverage commodity booms for industrial development.

There are also differences in terms of employment between energy exporters and importers in Africa. The average unemployment rate in energy-exporting African countries rose from 6.9% in 2015 to 8.0% in 2020 (Figure 1.6a), reflecting the negative impact of commodity price cycles on public spending and employment generation in these countries. Meanwhile, in energy-importing countries, the average unemployment rate dipped from 6.6% to 6.3%.

The composition of employment differs substantially between energy importers and exporters, owing to the large role played by industries associated with fossil fuels in energy-exporting countries. In 2020, while both importers and exporters showed similar shares of employment in the service sector, industry represented just 6.3% of employment in energy-importing countries, compared with 29.1% in energy-exporting countries, thanks to fossil-fuel-related activities (Figure 1.6f). While agriculture remains overwhelmingly important for employment creation in all African countries, energy exporters display a clear shift of employment generation from agriculture towards industry. Agriculture represents 52.5% of employment in energy-importing countries, compared with 40.3% in energy-exporting countries.

Figure 1.6 Socio-economic indicators based on energy exports/imports



Sources: ILO, 2020; UNDP, n.d.; World Bank, 2021.

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1.4 HUMAN DEVELOPMENT AND THE SUSTAINABLE DEVELOPMENT GOALS

As noted, Africa has made uneven progress in socio-economic development over the past decade. The continent's score on the HDI rose from 0.45 in 2000 to 0.57 in 2019, implying overall positive progress (see Figure 1.7e), including on SDGs such as education and poverty alleviation (IEA, IRENA *et al.*, 2021). When adjusted for its environmental footprint, Africa's HDI does not fall as dramatically as in other world regions (due to the continent's low carbon footprint overall) but remains below the planetary pressure–adjusted HDI of other regions (see Figure 1.7g).[9] Still, the fight against poverty and hunger and for access to education, health care and economic opportunity remains one a fundamental challenge in many parts of Africa. With Africa containing 33 of the world's 47 least-developed countries (in the UN classification) and more than half of those earning less than USD 1.90 (purchasing power parity) per day, the scope of the challenge is clear. (Purchasing power parity figures are presented in the annex to this chapter.)

While Africa has made steady improvements over recent decades in terms of health outcomes and towards achieving universal primary education, it remains the global region with the lowest adult literacy rates (Figure 1.7i), lowest average life expectancy and highest mortality ratios (AfDB, 2021a; see also Figure 1.7c). Very high population growth rates, with populations nearly doubling over a period of just twenty years in Africa's most populous regions, in West and East Africa, adds to this challenge (Figure 1.7a and b). Much more needs to be done to improve education completion rates and the quality of primary, secondary and tertiary education. Sub-Saharan Africa also accounts for over 75% of those living without electricity globally and 35% without clean cooking access (IEA, IRENA *et al.*, 2021), with lack of access to modern and sustainable energy severely affecting progress in poverty alleviation, access to quality health services and education, equality (including gender equality), decent work, economic growth, industrialisation, innovation and ultimately sustainable, resilient human settlements. Chapter 2 offers a more detailed discussion of the nexus between energy and achievement of these development goals.

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9 *The planetary pressure-adjusted Human Development Index (PHDI) is an experimental UN index that adjusts the HDI for planetary pressures in the "Anthropocene". It measures the level of human development adjusted by production-based carbon dioxide emissions per person and material footprint per capita to account for the excessive human pressure on the planet. The UNDP writes that: "It should be seen as an incentive for transformation. In an ideal scenario where there are no pressures on the planet, the PHDI equals the HDI. However, as pressures increase, the PHDI falls below the HDI. In this sense, the PHDI measures the level of human development when planetary pressures are considered" (UNDP, n.d.).*

Figure 1.7 Evolution of key socio-economic indicators by African region

Source: UNECA, 2017; UNDP, n.d.

▷ Figure continous next page

Figure 1.7 Evolution of key socio-economic indicators by African region (continued)

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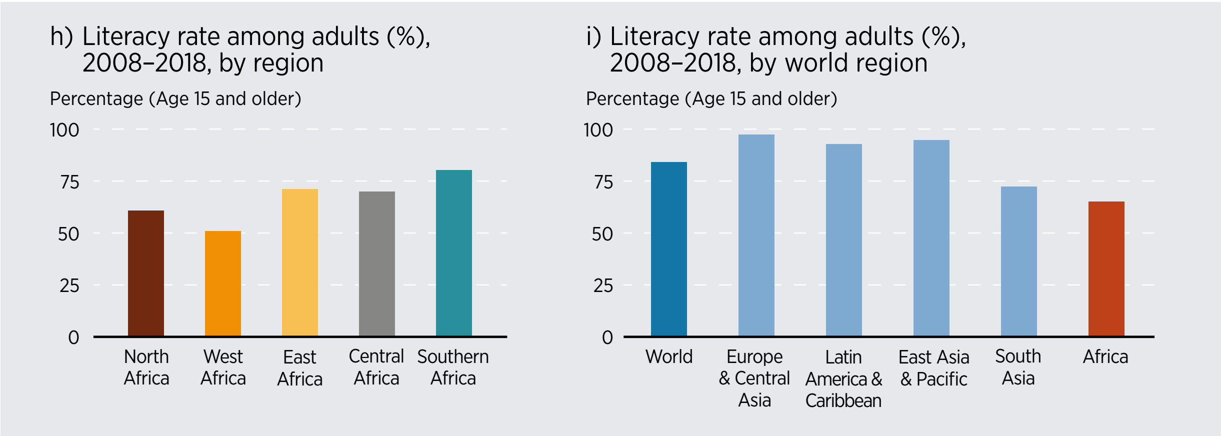


Source: UNECA, 2017; UNDP, n.d.

Important regional differences in human development exist across the African continent. North Africa and Southern Africa are the regions with the highest average HDI rates (0.69 and 0.59, respectively). On average, North Africa is also the best-performing region in achievement of the SDGs, while Central Africa lags behind other regions (Sustainable Development Goals Center for Africa, 2019). In contrast, West Africa featured the lowest HDI value (0.51) in 2019, as well as the lowest life expectancy (58.2 years) and literacy rate (51%) (Figure 1.7). Outside North Africa, average life expectancy did not exceed 66 years in any other African region in 2019 (Figure 1.7d).

The COVID-19 pandemic has had a considerable impact on human development since 2020. The pandemic may have pushed some 100 million people into extreme poverty, the worst setback in a generation (World Bank, 2020a). In addition to its effects on health and mortality rates across Africa, the pandemic struck education systems, cutting back schooling and training opportunities for millions of children and adults (Moyer *et al.*, 2021). The incomes of informal workers in Africa were also reduced (IRENA, 2020a). Long-term effects on human development may emerge, as pandemic-induced reductions in government revenues, remittances and (possibly) international aid could push up government debt and require cuts in government spending for cash transfers, education and health. One devastating result is that indirect mortality in Africa, particularly among children younger than five, could be twice as great as direct mortality from COVID-19 by 2030, given expected cutbacks to basic medical care and related interventions (Cilliers and Kwasi, 2021) and reductions in primary education (Moyer *et al.*, 2021).

1.5 CONCLUSION

With its diverse geography, and its young population, Africa could well turn this coming century into its own. Endowed with significant energy resources – many of them renewable – African countries could push ahead with sustainable energy deployment, ahead of many other parts of the world (for resource endowments, see also Chapter 2). Energy development is intrinsically related to socio-economic issues in Africa, for it is the current energy resource mix, based heavily on non-renewable fossil fuels that has failed to provide populations throughout Africa with complete, reliable and ultimately sustainable energy. In parts of Africa, reliance on fossil fuels, both as a domestic fuel and an export commodity, has had devastating effects on local environments.

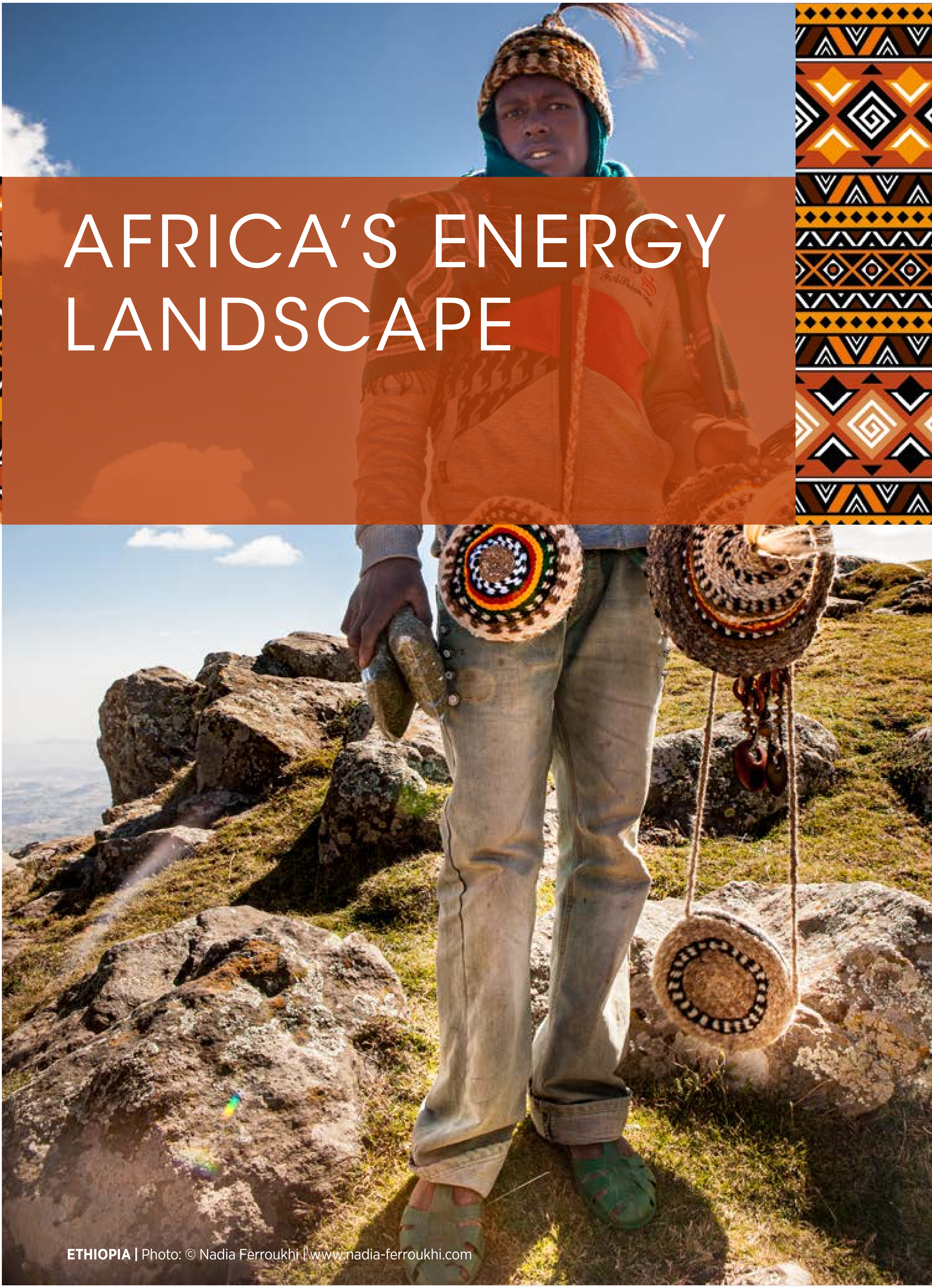
Obstacles to energy access and low electrification rates have exacerbated socio-economic inequalities (including gender and rural–urban divide), contributed to a lack of energy security and hindered industrial development. Population growth, persistent commodity dependence, exposure to price volatility, limited productive capabilities and heightened vulnerability to climate change further increase the importance of determining how renewable energy can promote sustainable development and contribute to prosperity in Africa.

One key area in which it can do so is by promoting greater energy sector and economic diversification. Renewable energy can be a core part of structural economic transformation on the African continent, with the development of green industries holding large potential to reduce various forms of dependencies, including structural, technological and single commodity trade-related. Chapter 7 of this report provides further detail of how such a transformation could be supported by an African New Green Deal. Global policy responses to the ongoing COVID-19 pandemic illustrate a necessary shift in policy toward greater focus on sustainable economic recovery and development initiatives that try and avoid past mistakes. Similarly, future development initiatives in Africa could focus on sustainable energy, including priority given to renewable energy deployment, but also value-chain and human resource development, over conventional technologies.

Modern renewable energy can also play a central role in managing the environmental impacts of growing populations and economies, notably through reduced reliance on fossil-fuel-based power generation and on traditional biomass (wood fuel and charcoal) for heating and cooking. Because some renewable energy projects, in particular large-scale hydropower dams, can impact local biospheres and communities' traditional forms of managing their land, increased deployments of these technologies will require a careful mix of policies to maximise benefits and minimise harm to the environment and local communities (see also Chapter 4).

Unlocking the potential of renewable energy as a lever of socio-economic development will require a structural shift in national energy policies, well-honed policy tools and international co-operation – as explained in the remainder of this report. Chapter 2 surveys Africa's energy landscape. Chapter 3 traces financing options for renewable energy in Africa. Chapter 4 outlines policy options for renewables. Chapter 5 examines the socio-economic impacts of the energy transition on African countries. Chapter 6 analyses the role of renewables in expanding modern energy access on the continent. Finally, Chapter 7 proposes forward-looking steps and policy considerations for the deployment of renewables in Africa.

AFRICA'S ENERGY LANDSCAPE



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As mentioned in the previous chapter, Africa's energy landscape is characterised by a rich, highly diverse range of energy resources, from hydrocarbons to renewable energy. Home to a fifth of the world's population (around 1.3 billion people), Africa accounts for just 6% of global energy demand and 3% of electricity demand (IEA, IRENA *et al.*, 2021). Significant gaps remain in access to modern energy, and, except for the export of raw materials, industrialisation and agricultural productivity lag. These factors that have shaped Africa's energy landscape. This picture will undoubtedly change over the coming decades as the continent grows and develops, increasing energy needs. This chapter provides a panoramic view of the status of the energy sector on the African continent. It covers primary energy supply, final energy consumption, the electricity sector, the status of renewable energy and access to energy across the region.

2.1 ENERGY IN AFRICA – A CROSS-REGIONAL OVERVIEW

Primary energy supply in Africa has grown at a CAGR of around 2% per year over the past decade (2008-2018) on the back of increased oil and natural gas production as well as bioenergy (UNSD, 2018; Figure 2.1). Nigeria, Algeria, Angola and Libya are among the world's 20 largest producers of oil, while Algeria, Egypt and Nigeria are among the world's 20 largest producers of natural gas (IEA, 2021a). Major new natural gas developments in Egypt, Mozambique, Senegal, South Africa and the United Republic of Tanzania, among others, accounted for over 40% of global gas discoveries between 2011 and 2018 (EIA, 2019). Natural gas is also the fastest-growing source of energy in Africa's power sector, increasing at a CAGR of 4.2% per year from 2011 to 2019 (Figure 2.3). Several African countries are also producers of coal, including Botswana, Mozambique, South Africa and Zimbabwe, with South Africa the largest (EIA, 2019).

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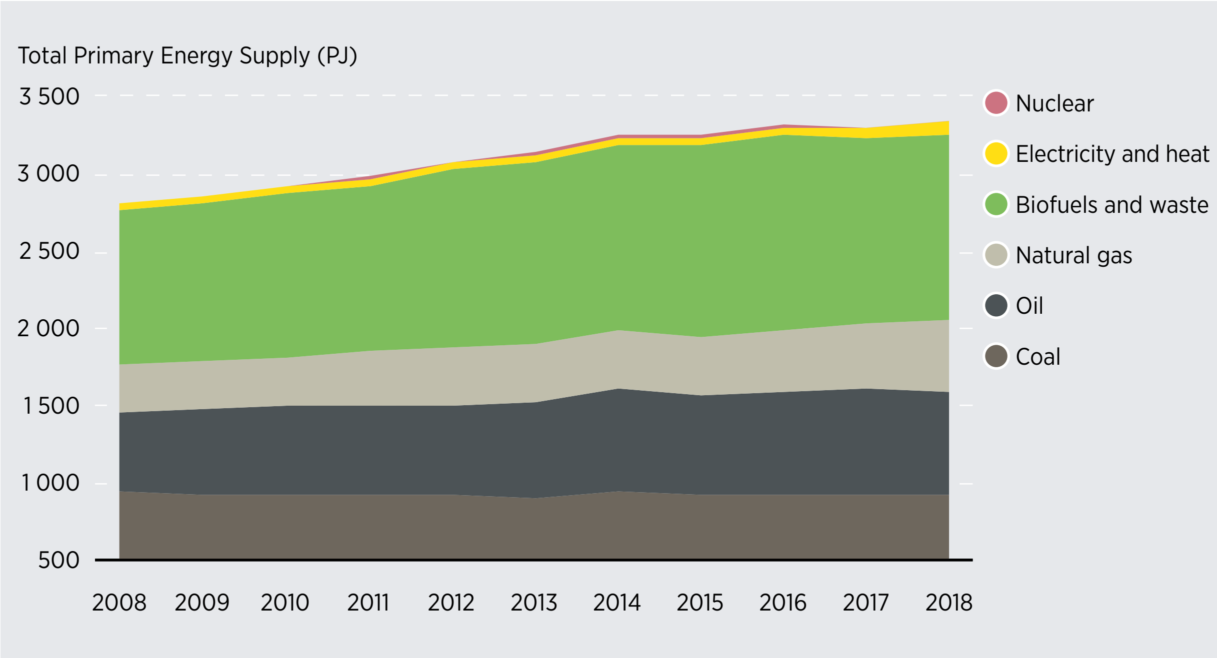
Figure 2.1 Total primary energy supply in Africa, by source, 2008-2018



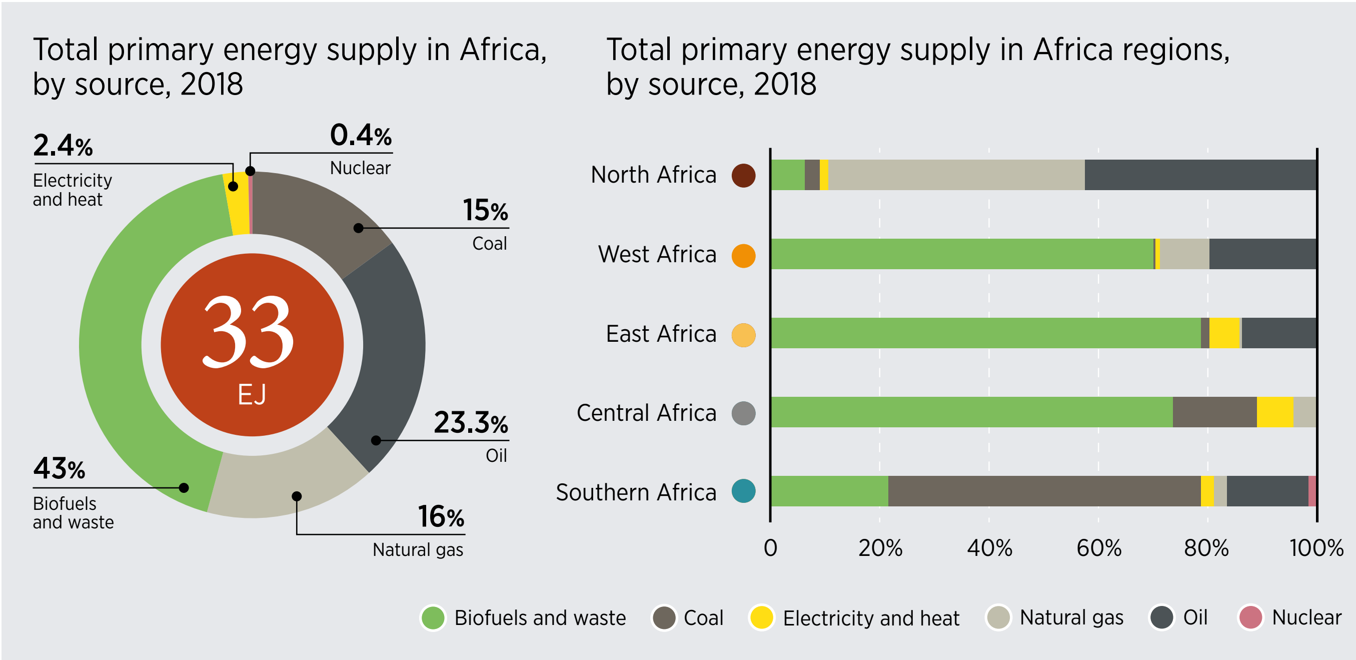
Source: UNSD, 2018.
Note: PJ = petajoule.

Bioenergy and waste remains the most widely used source of energy on the African continent, accounting for over 40% of the continent's energy supply (Figure 2.2). Ranging from traditional biomass to improved traditional biomass technologies[1] and modern bioenergy,[2] bioenergy is a critical source of energy, particularly for household cooking. Some 906 million people in Sub-Saharan Africa lacked access to clean cooking fuels and technologies in 2019 (IEA, IRENA *et al.*, 2021). Traditional biomass is very widely used, involving highly inefficient technologies and a variety of fuel sources, including fuelwood, charcoal, crop residue, animal dung and household waste.

1 *Improved traditional biomass technologies employ direct combustion of biomass; examples are improved kilns and cookstoves.*

2 *Modern bioenergy technologies include liquid biofuels produced from bagasse and other plants, biorefineries, biogas produced through anaerobic digestion of residues, wood pellet heating systems, and other technologies (IRENA, 2020b).*

Figure 2.2 Total primary energy supply in Africa and its regions, by source, 2018



Source: UNSD, 2018.
Note: EJ = Exajoule

Table 2.1 shows fuelwood use and charcoal production in the five African countries with the largest deficits in access to clean cooking fuels and technologies, highlighting the scale of the environmental and developmental problems associated with the lack of access to modern energy. Wood is a main source of energy in most of Sub Saharan Africa; its use for household energy accounts for over 90% of Africa's wood consumption. In addition to health problems caused by incomplete combustion in traditional stoves (problems that particularly affect women and children), Sub-Saharan Africa's large reliance on wood is also a major environmental problem, contributing significantly to deforestation and forest degradation in Africa (IRENA, 2018a; FAO, 2021a).

Oil is the second-most widely used source of primary energy, particularly in the transport sector, in industry and in the power sector (in the form of crude oil and oil products). Natural gas, too, has long been used for power generation in gas-producing countries, such as Algeria, Libya and Nigeria, along with several North, West and Central African countries possessing domestic gas resources sufficient to feed their own power sector. Southern Africa, by contrast, which lacks its own gas reserves, has historically relied on coal for power generation, having its own substantial coal-mining industries; the region accounts for a large share of the continent's coal consumption. Mauritius and Morocco also make substantial use of coal to generate power.

2.1.1 Electricity and renewable energy

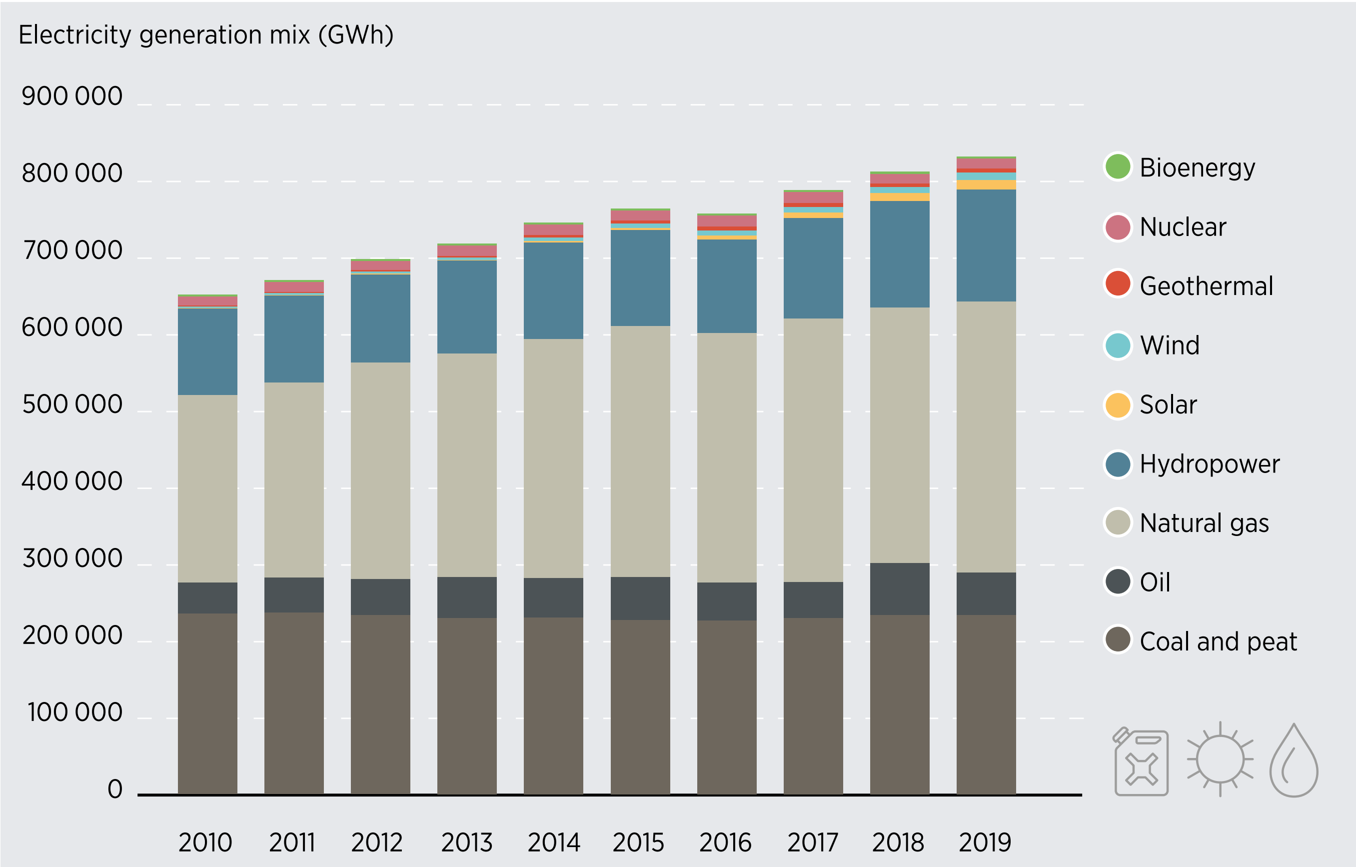
Coal, natural gas and oil together account for about 77% of Africa's total electricity generation during 2019 (Figures 2.3 and 2.4; Annex). Africa's largest electricity-consuming economies – South Africa, Egypt, Algeria and Nigeria – drive these trends, with most of the continent's coal supply going to South Africa. Only one African country, South Africa, currently produces nuclear power. Electricity generation on the continent increased by around a quarter over the past decade, an increase largely driven by new power generation based on natural gas, but with significant growth in renewable energy as well, albeit from a much lower level (in the case of solar and wind technologies).

Table 2.1 Five countries in Africa with the largest deficits in access to clean cooking solutions, and biomass use, 2019

	Firewood (kt)	Wood charcoal production (kt)	Population without clean cooking (mn)
Nigeria	66 541	4 672	175
Ethiopia	113 147	2 092	104
Democratic Republic of the Congo (the)	86 702	2 713	83
United Republic of Tanzania (the)	25 072	4 622	56
Sudan (the)	15 583	588	20

Source: FAO, 2021; IEA, IRENA et al., 2021.
Note: Wood fuel estimates by FAOSTAT are estimates. For an explanation of the data, see Whiteman, Broadhead and Bahdon (2002).
kt = kilotonne.

Figure 2.3 Electricity generation mix in Africa, by source, 2010-2019



Source: IRENA, 2021a.
Note: GWh = gigawatt hour.

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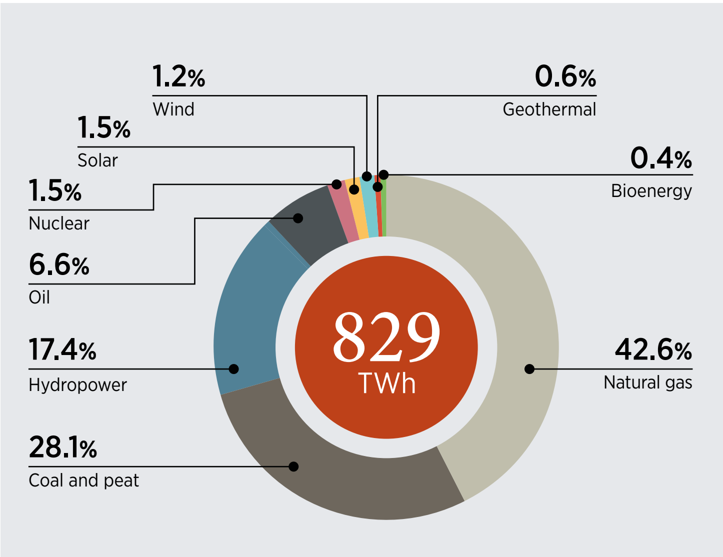
With the exception of hydropower, modern renewable energy – solar, wind, geothermal and modern bioenergy – contribute only marginally to Africa's energy mix. Africa accounts for less than 3% of the world's installed renewables-based electricity generation capacity (IRENA, 2021a). This low rate of use comes despite Africa's vast renewable energy resource potential, as discussed below.

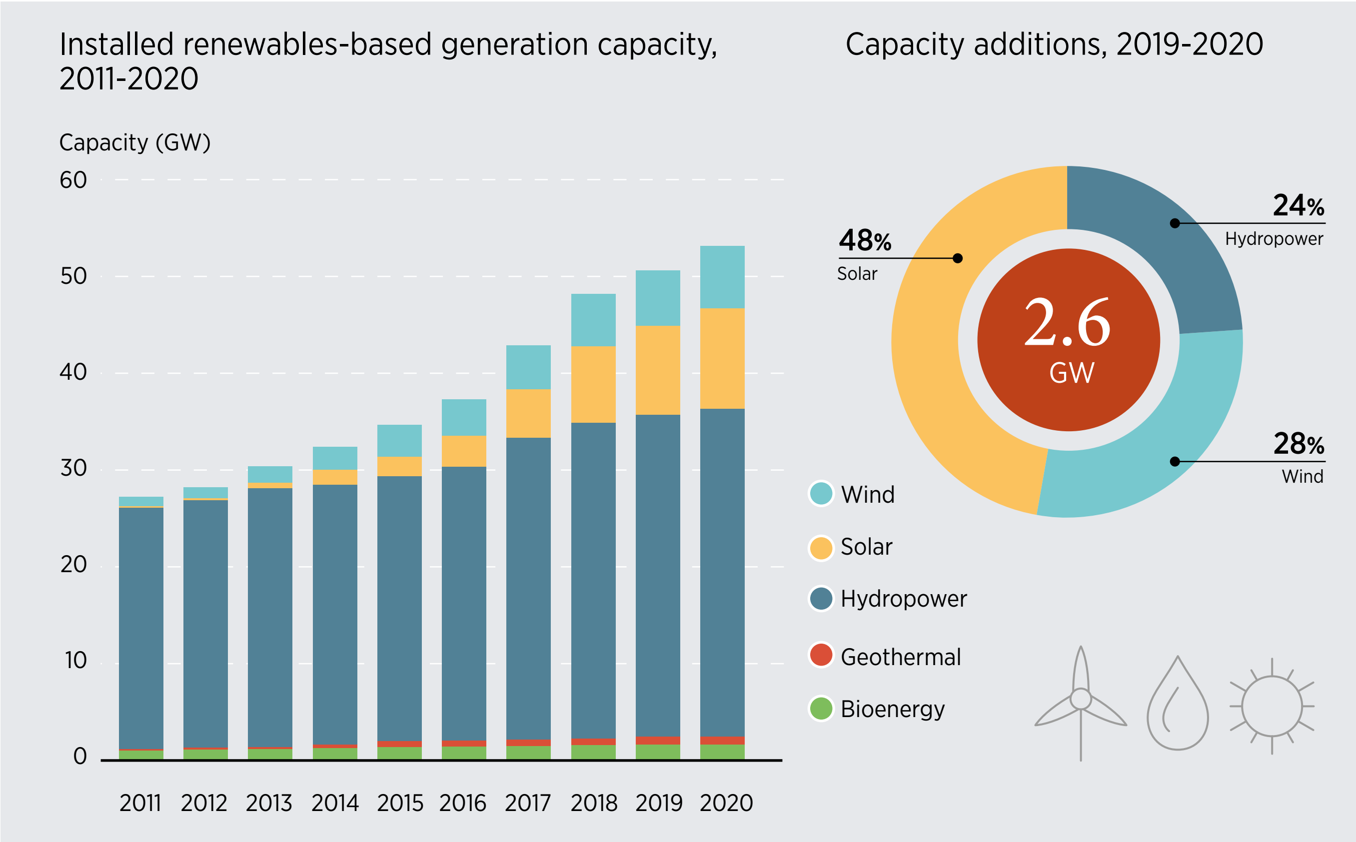
Nevertheless, in more recent years, renewable energy deployment has grown, with renewables-based generation capacity on the continent rising 7% in the last decade (2010-2020). The largest additions were in solar energy (Figure 2.5). Much of the growth has been driven by individual countries' large-scale projects, particularly new utility-scale hydropower and solar PV projects. Regionally, Southern Africa led total renewable generation capacity in 2020 with 17 gigawatts (GW), or around a third of Africa's total, followed by North Africa with 12.6 GW, or a fourth of Africa's total (IRENA, 2021a).

Figure 2.4 Electricity generation in Africa, by energy source, 2019



Source: IRENA, 2021a.
Note: TWh = terawatt hour.

Figure 2.5 Installed renewables-based generation capacity, 2011 2020, and capacity additions, 2019-2020



Source: IRENA, 2021a.
Note: GW = gigawatt.

Hydropower

Hydropower has been used in Africa for many decades owing to the presence of the continent's large rivers, which have an average annual discharge of 17.7 cubic metres per second (Hoes, 2014). At almost 34 GW capacity by the end of 2020, hydropower is also the renewable energy source used most extensively for power generation.

As of 2020, Ethiopia, Angola and South Africa hold Africa's largest hydropower capacity (Figure 2.6). Ethiopia is building yet another mega-dam, the 6 GW Grand Ethiopian Renaissance Dam, which will be the largest in Africa in terms of capacity when it enters into operation in 2022. In several African countries with large rivers crossing through their territory, hydropower accounts for half or more of electricity generation capacity. Chief among these countries are Angola, the Democratic Republic of the Congo, Ethiopia, Gabon, Guinea and Uganda (IRENA, 2021a).

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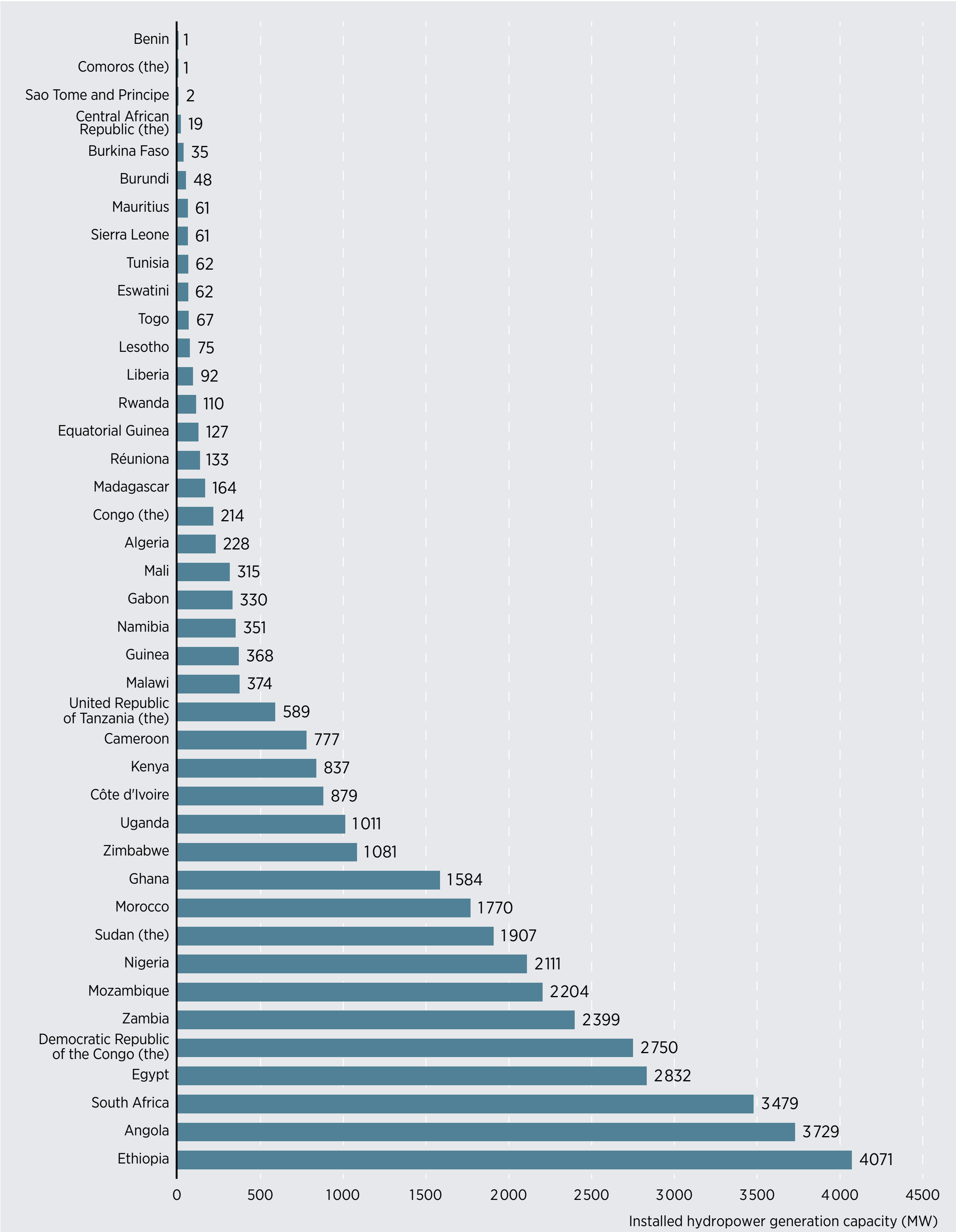
Figure 2.6 Installed hydropower generation capacity, Africa, 2020

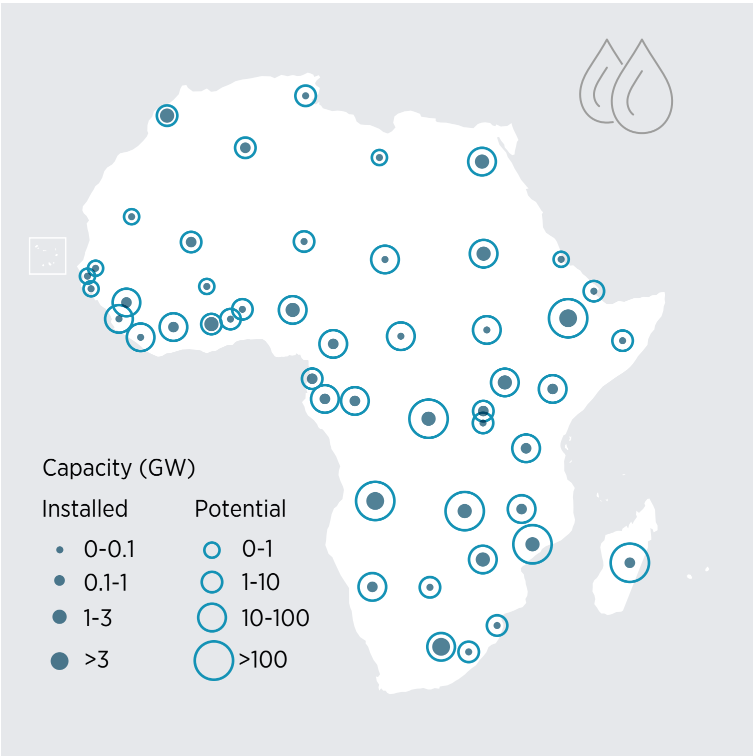


Source: IRENA (2021a)
Note: Hydropower (including pumped storage)

At present, large-scale hydropower is the largest source of renewable electricity in Africa, with sizeable unexploited potential (Figure 2.7). Africa's largest hydropower producers are Ethiopia, Angola, South Africa, Egypt, the Democratic Republic of the Congo, Zambia, Mozambique, Nigeria, the Sudan, Morocco and Ghana. The Delft University of Technology estimates the continent's unexploited hydropower potential to be 1753 GW (Hoes, 2014), with Angola, the Democratic Republic of the Congo, Ethiopia, Madagascar, Mozambique and Zambia leading.

IRENA collects data on hydropower projects around the world, including existing, committed, planned and candidate hydropower plants. The sum of these plants in Africa currently is close to 131 gigawatts. The largest committed projects in the region include Ethiopia's Renaissance hydropower project (at around 6 GW the largest hydropower project in Africa at the time of writing), the 3 050 MW Mambilla project in Nigeria, the 2 160 MW Cacula Cabasa and the 2 071 MW Lauca projects in Angola, and the 1500 MW Mphanda Nkuwa hydropower plant in Mozambique. Candidates for the largest capacity additions are the Democratic Republic of the Congo, Ethiopia, Cameroon, Nigeria, Angola and Mozambique (Figure 2.8).

Figure 2.7 Hydropower potential and installed capacity, Africa



Source: Hydropower potential, Africa: Hoes, 2014 (Delft University of Technology); Installed hydropower capacity, Africa: IRENA, 2021a; Base map: UN boundaries.

Note: Includes pumped storage. GW = gigawatt; km = kilometre.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

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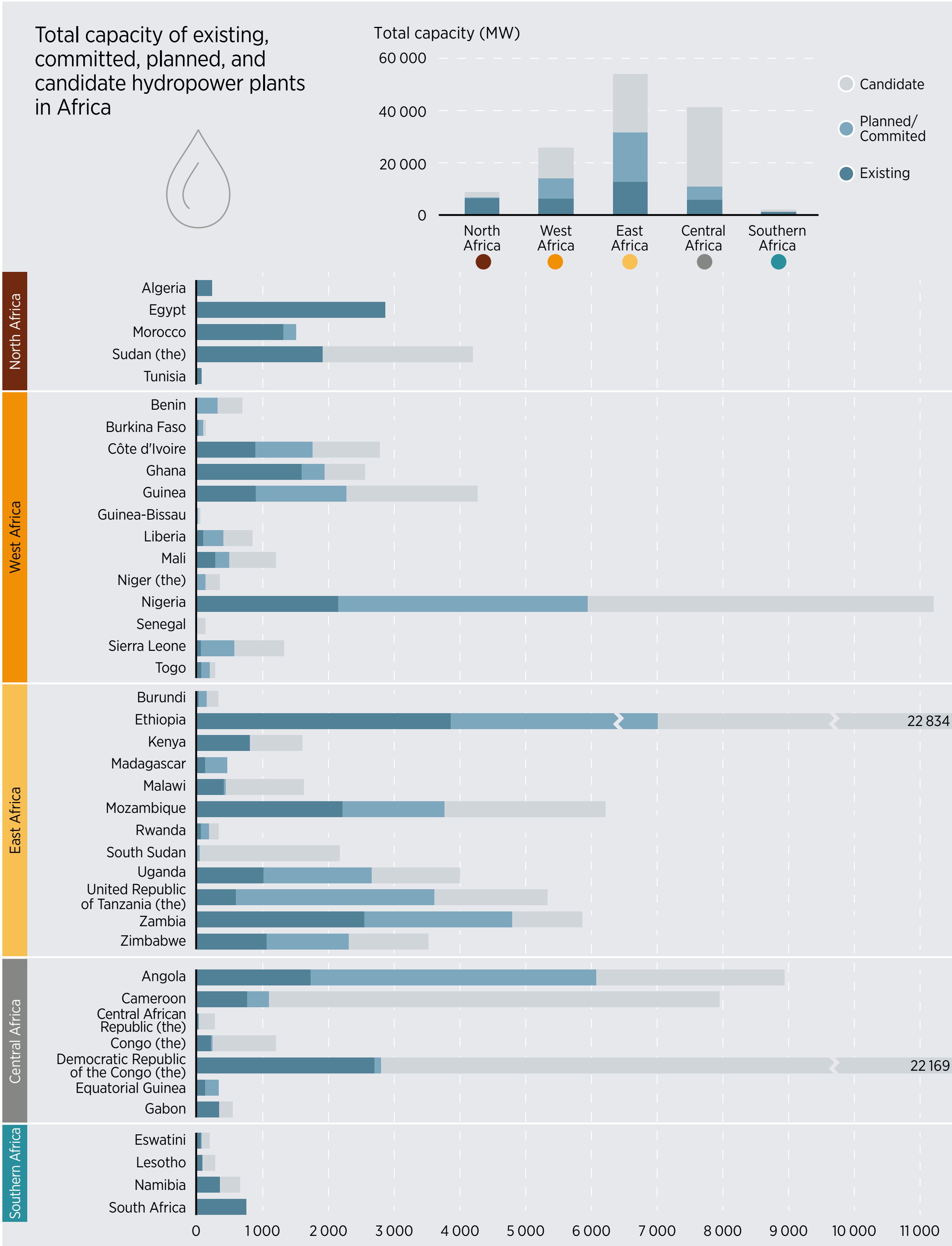
Figure 2.8 Total capacity of existing, committed, planned and candidate hydropower plants in Africa



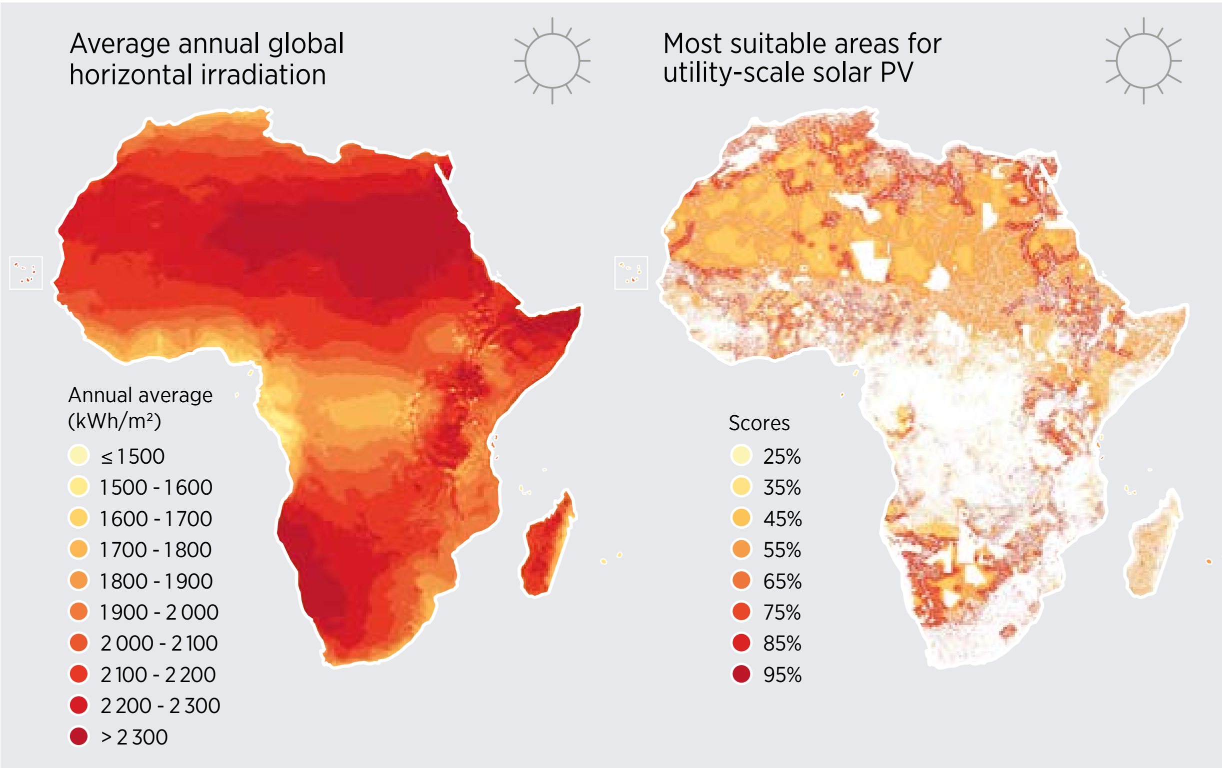
Source: IRENA forthcoming; Sterl et al., 2021.

Solar

Africa possesses some of the globe's greatest potential for solar power generation. As displayed in Figure 2.9a, the continent receives annual average solar irradiation of 2 119 kilowatt hours per square metre (kWh/m²) with most countries across North, West and Southern Africa receiving an average in excess of 2 100 kWh/m² annually (Figure 2.9). IRENA estimates the continent's solar technical potential at 7 900 GW (assuming a 1% land-utilisation factor), indicating vast potential for the generation of solar power (Figure 2.9). But despite that potential, utility-scale solar power has been systematically deployed in just a few countries. South Africa and Egypt are Africa's two largest solar producers, accounting for over three-quarters of installed solar capacity in 2020 (Figure 2.10 and 2.11).

Solar energy is now the fastest-growing renewable energy source in Africa. Between 2011 and 2020, solar capacity in Africa grew at an average compound annual growth rate (CAGR) of 54%, two and a half times that of wind (22.5%), almost four times that of geothermal (14.7%) and almost 17 times that of hydropower (3.2%). Total solar additions over the past decade amounted to 10.4 GW (9.4 GW solar photovoltaic [PV]; 1 GW concentrated solar power) with the most additions made in 2018 (2.9 GW).

Figure 2.9 Africa: (a) average annual global horizontal irradiation; (b) most suitable areas for utility-scale solar PV



Source: (a) Global Solar Atlas (ESMAP, 2019b); (b) IRENA Global Atlas for Renewable Energy (IRENA, 2021d).

Note: kWh/m² = kilowatt hours per square metre; PV = photovoltaic.

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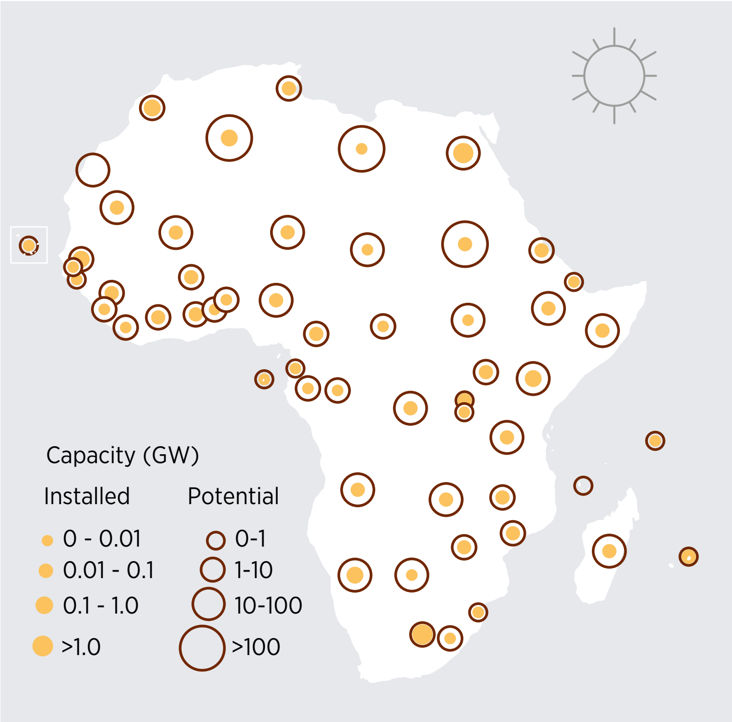
Figure 2.10 Solar PV potential and installed capacity, Africa

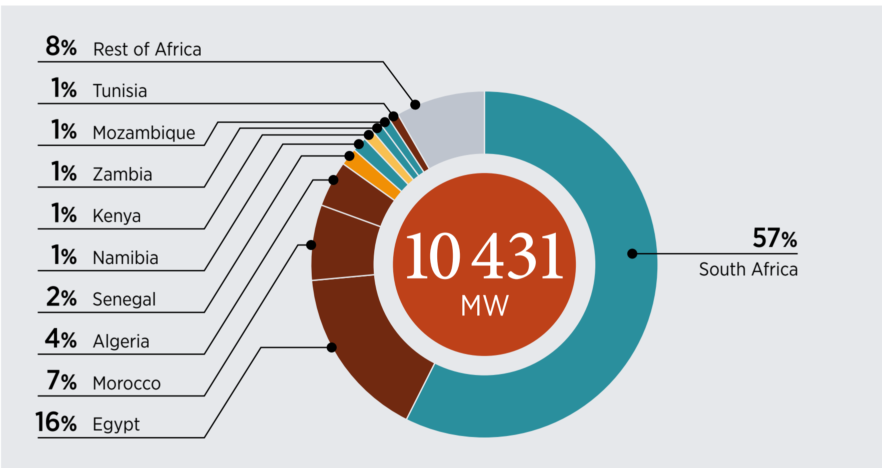


Source: Solar potential, Africa: IRENA; Installed solar capacity, Africa: IRENA, 2021a; Base map: UN boundaries

Note: GW = gigawatt; km = kilometre.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

Figure 2.11 Africa's installed solar generation capacity, 2020



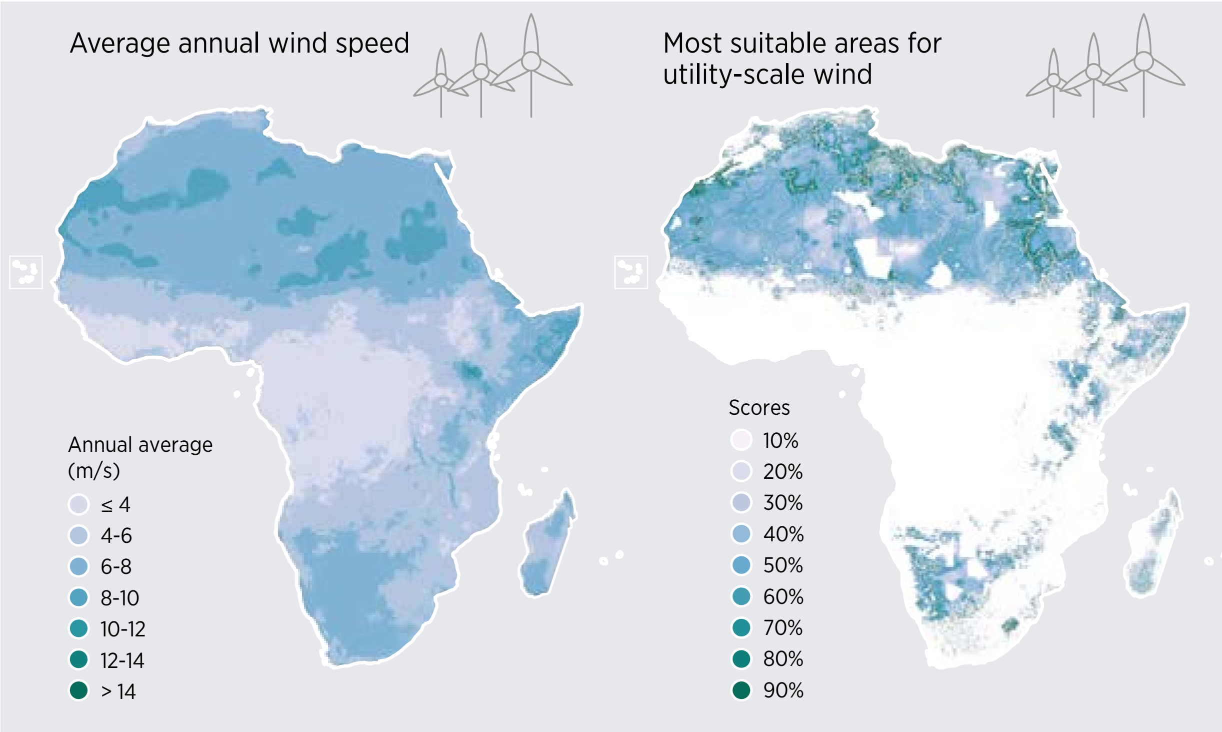
Source: IRENA, 2021a.
Note: MW = megawatt.

Wind

IRENA estimates the technical potential of wind power generation at an immense 461 GW (assuming a 1% land-utilisation factor), with Algeria, Ethiopia, Namibia and Mauritania possessing the greatest potential. Wind power facilities are unequally distributed across the continent, being tied to the geography of wind resources and policy interest in developing them. Wind power contributes substantially to some countries' electricity mix. Annual average wind speeds in North Africa and Southern Africa are high, reaching 7 metres per second (m/s) (Figure 2.12a). Figure 2.12b shows the areas suitable for utility-scale project development. Yet wind resources remain highly underexploited in Africa, in particular in parts of North Africa and the Sahel area (Figure 2.13).

At the end of 2020, wind generation capacity in Africa amounted to 6.5 GW, of which some 0.7 GW was added in 2020. Countries with significant generation capacity are South Africa, Morocco and Egypt, as well as Kenya, Ethiopia and Tunisia, which together account for over 95% of Africa's total wind generation capacity (Figure 2.14).

Figure 2.12 Africa: (a) average annual wind speed; (b) most suitable areas for utility-scale wind



Source: (a) Global Wind Atlas (DTU, 2015); (b) IRENA Global Atlas for Renewable Energy (IRENA, 2021d); Base map: UN boundaries.

Note: m/s = metre per second; m = metre; s: second.

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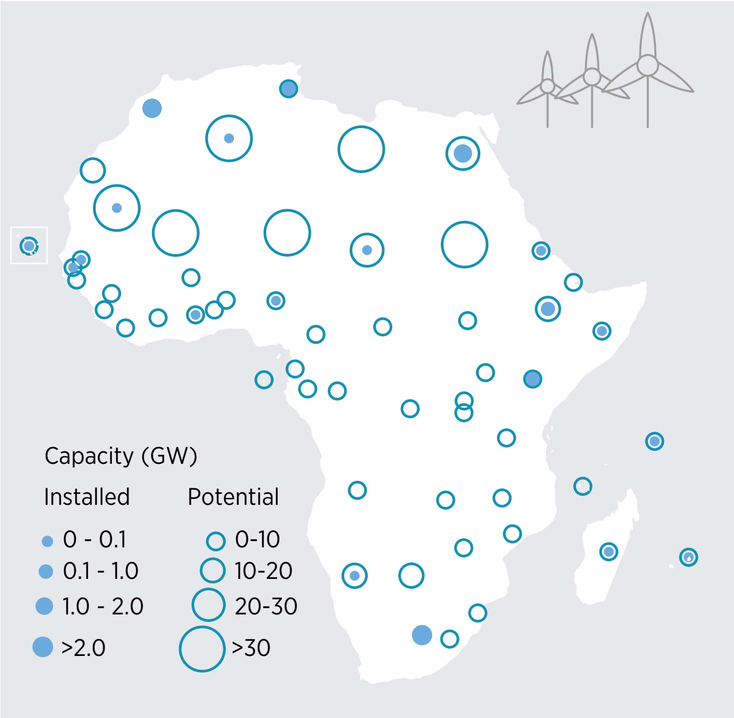
Figure 2.13 Wind potential and installed capacity, Africa

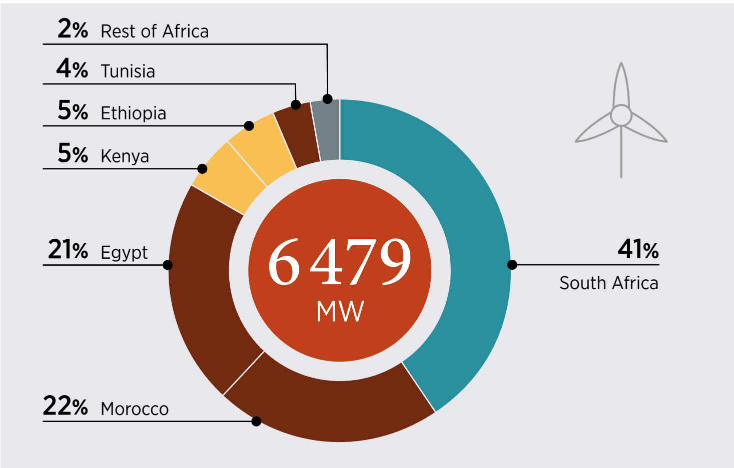


Source: Wind potential, Africa: IRENA; Installed solar capacity, Africa: IRENA, 2021a; Base map: UN boundaries.

Note: GW = gigawatt; km = kilometre.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

Figure 2.14 Installed wind generation capacity, Africa, 2020



Source: IRENA, 2021a.

Geothermal energy

The continent's geothermal resources are found in the East Africa Rift System, where an estimated 15 GW of potential remains untapped (BGR, 2016). At the end of 2020, Kenya was the continent's only substantial producer of electricity from geothermal power, with a generation capacity of 823.8 MW. Ethiopia, the only other African country currently producing geothermal energy, operates a 7.3 MW pilot plant. At the end of 2019, 1 GW of new geothermal capacity was being planned in Djibouti, Uganda and the United Republic of Tanzania (IEA, 2019a).

Bioenergy

Although biomass is the most widely used energy source on the continent, most of it is consumed for cooking, using inefficient traditional practices. Modern uses for electricity generation represented only 1% of all renewable electricity generation in 2019, although it is not clear how much of the fuel was sustainably sourced. In East Africa, most new co-generation plants (bagasse fired) are located close to sugarcane plantations to decrease the cost of transportation from farms to the plant site, and to reduce the chances of spoilage. There are also prospects for using advanced biofuels in the transport sector in several African countries. The U.S. Energy Information Administration estimates that West Africa alone might possess the potential to produce over 100 megatonnes per year of agriculture residues that could be converted into biofuels like ethanol and biobutanol, or into electricity (UNSD, 2018; EIA, 2019).

2.1.2 Final energy consumption

Widespread household use of biomass (coupled with limited industrialisation) makes households the largest final energy consumer in Africa, particularly in Sub-Saharan Africa (Figures 2.15 and 2.16). The energy mix in manufacturing, commerce and most other sectors is more varied, except for the transport sector, which is entirely dominated by oil, as in other parts of the world (Figure 2.15).

In the industrial sector (manufacturing, construction and mining), energy is put to various uses, chiefly co-generation, process heating and cooling, air conditioning, lighting, heating, and steam generation. Energy-intensive industries such as chemical and petrochemical, iron and steel, and non-metallic minerals are unevenly distributed in Africa. Industrial and municipal waste, bagasse, rice husk and wood are examples of modern biomass energy used in industry. According to an IRENA report on the circular carbon economy, biomass could play a major role in the decarbonisation of the industry sector, providing a sustainable alternative to fossil fuels (IRENA, 2020c).

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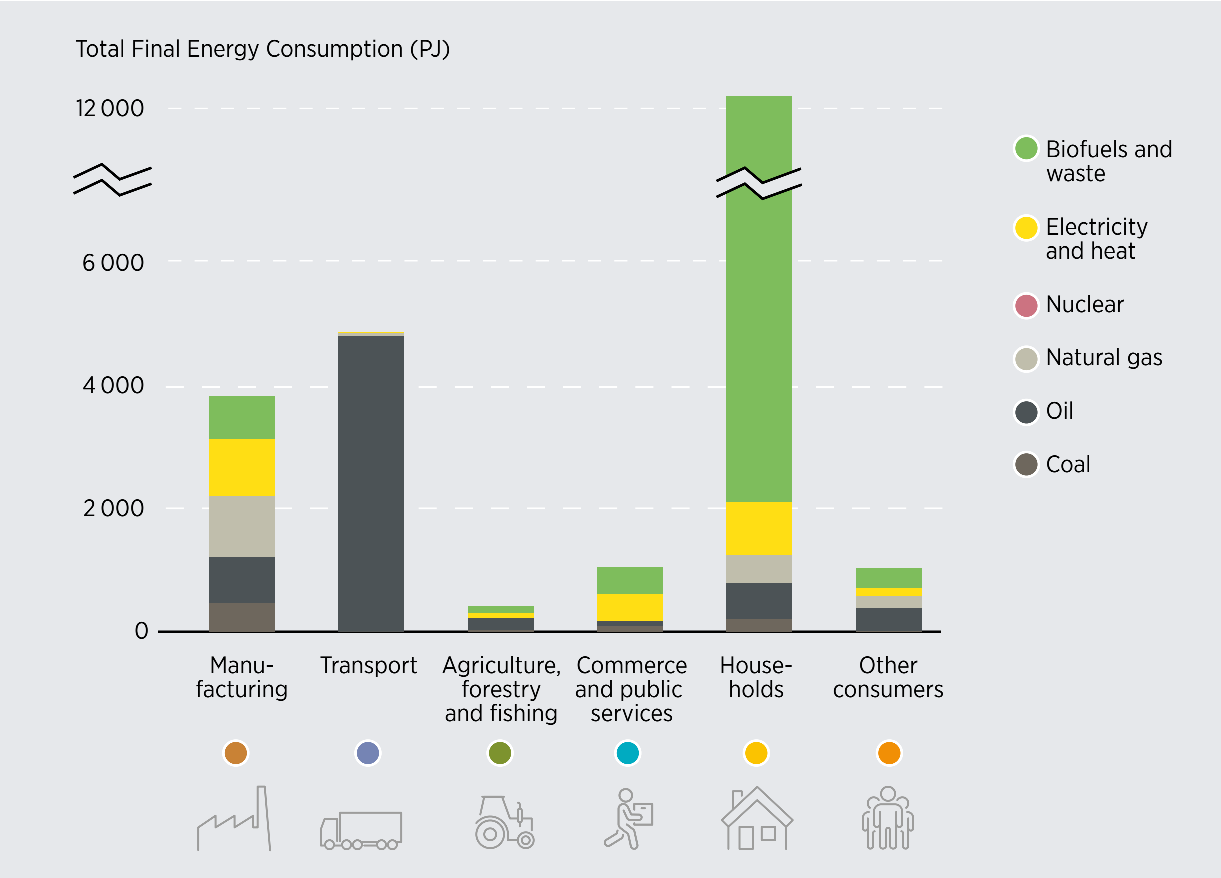
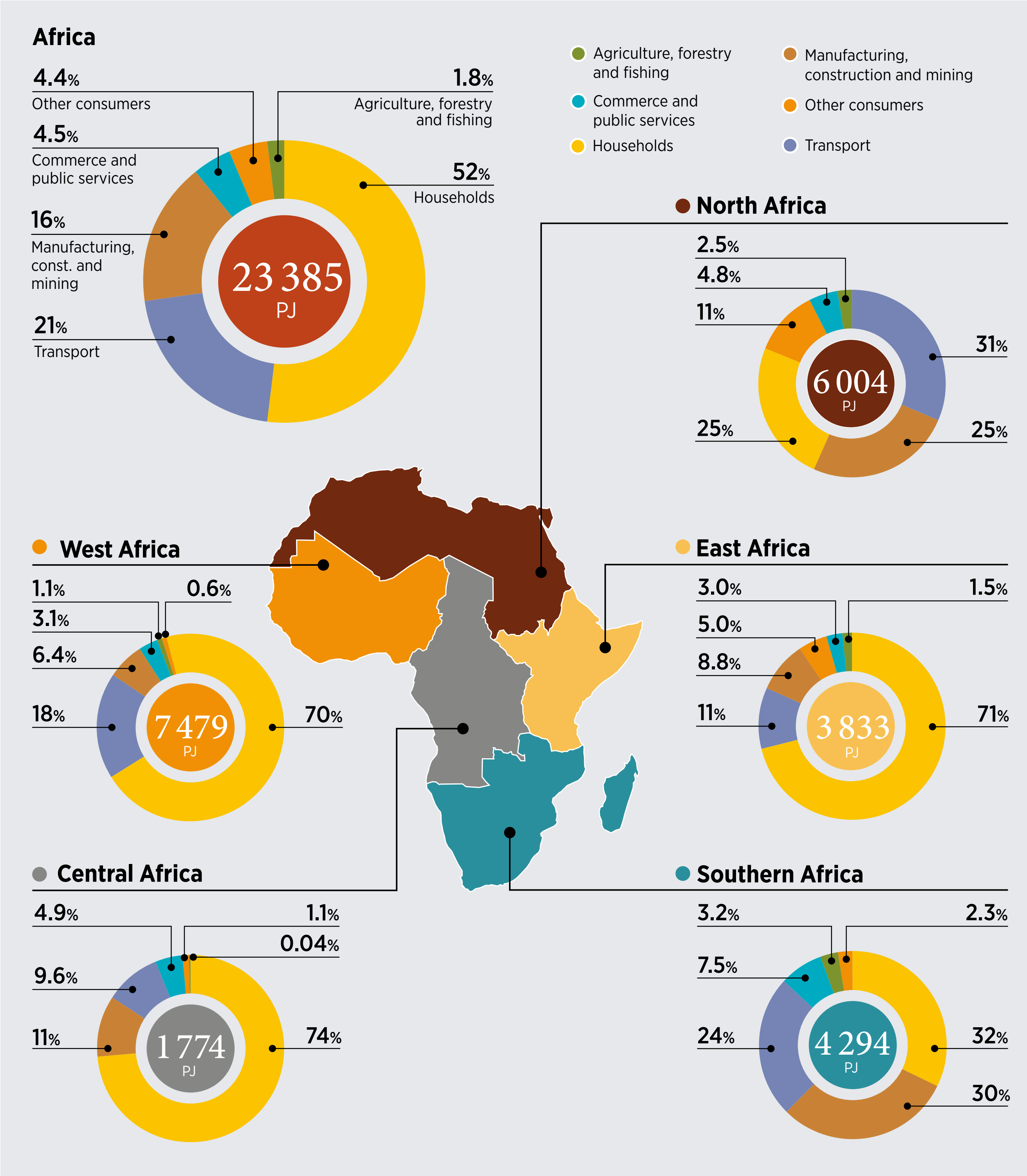
Figure 2.15 Total final energy consumption in Africa by sector and source, 2018



Source: UNSD, 2018.
Note: PJ = petajoule.

Regional energy resources, mining histories, the dynamics of socio-economic development, and the degree of access to modern fuels and electricity all shape the patterns and levels of energy consumption in Africa's regions. Southern Africa and North Africa are relatively industrialised; together they account for more than a third of final energy consumption on the continent. South Africa alone accounted for over 40% of industrial electricity consumption in 2018, despite flat demand since 2010 (IEA, 2019a; IRENA, 2021a; EIA, 2019). The nature of the economies in these two regions is also reflected in the relatively larger share of the manufacturing and transport sectors in their final energy mix (Figure 2.16).

Figure 2.16 Final energy consumption in Africa and its regions by sector, 2018



Source: UNSD, 2018.

Note: PJ = petajoule.

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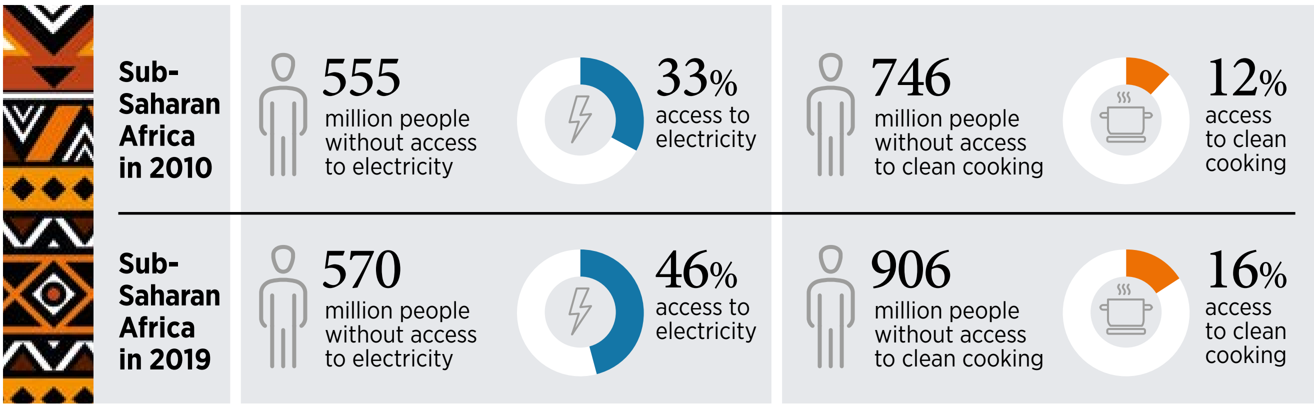
2.1.3 Energy access

Africa has made great progress over the past decade in expanding access to energy, but because population growth has outpaced the rate of expansion in many parts of Sub-Saharan Africa the goal of universal access to modern energy remains elusive. While the rate of access to electricity in Sub-Saharan Africa as a whole rose from 33% in 2010 to 46% by 2019, 570 million people still lacked access to electricity in 2019, an increase of about 20 million people over 2010, many of them in rural areas (World Bank, 2021). As of 2020, the access rate in 24 African countries was below 50%. Electricity access is often higher in urban centres, where great progress has been made in recent decades all across Africa, though the quality of service often remains low (IEA, IRENA *et al.*, 2021). Of the Africans who lack access to electricity 37% live in just three countries: the Democratic Republic of the Congo, Ethiopia and Nigeria.

Rural electrification, by contrast, has not increased in many parts of Sub-Saharan Africa, reinforcing a persistent urban-rural divide characterised by an 78% electrification rate in urban areas compared with 25% in rural areas. Much rural access is Tier 1, implying only basic electricity for lighting and mobile charging, with insufficient power for the income-generating activities needed to drive wider economic development in rural areas.

According to a regional study by the World Bank, more than 30% of households in Sierra Leone, Liberia and Uganda report never having electricity despite being connected to the grid (Blimpo and Cosgrove-Davies, 2019). About 60% of healthcare facilities in 27 Sub-Saharan African countries are unable to access reliable electricity (Cronk and Bartram, 2018). Because of reliability issues, many businesses in Sub-Saharan Africa use diesel generators to supplement their power needs; Nigeria is the largest user of oil-fired back-up generators on the African continent (IEA, 2019b).

Access to clean cooking fuels and technologies is even more precarious. Although access on the African continent grew by 13% between 2010 and 2019, population growth outpaced increases in access, with the result that 196 million more people relied on inefficient stoves and traditional biomass for cooking in 2019 than ten years earlier.[3] Only 16% of Sub-Saharan Africa's population had access to clean cooking in 2019, most of them in urban areas, leaving over 900 million people behind (WHO, 2021).



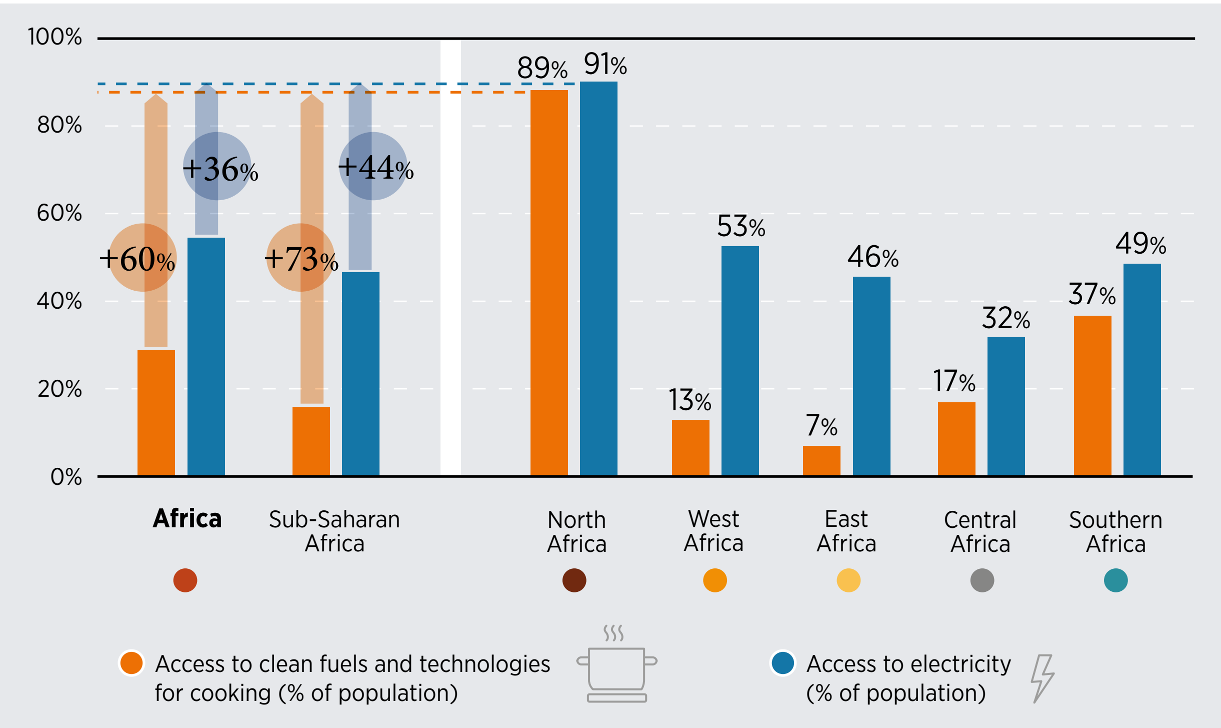
3 Simple growth calculated based on IEA, IRENA et al. (2021).

The major factors limiting the use of clean fuels in rural and remote areas in many parts of Sub Saharan Africa are (i) reluctance to adopt new technologies, (ii) information gaps, (iii) the real or perceived higher price of cleaner fuels as opposed to low-quality liquid fuels such as paraffin or "free" traditional biomass, (iv) the cost of the initial investment in improved stoves and lighting systems, and (v) underdeveloped roads and rail lines (IRENA, 2021c; Schlag and Zuzarte 2008; Tait, Merven and Senatla, 2013). The COVID-19 pandemic led to a further deterioration in access to modern energy in Africa, implying stagnation and, in many cases, reversals of the progress made in previous years (IEA, 2021b; IEA, IRENA *et al.*, 2021; see also Box 2.1).

Intra-regional differences

Within Africa, progress in access to modern energy differs greatly by region. While most North African countries have achieved near universal access to electricity and clean cooking, a significant deficit remains in Sub-Saharan Africa (IEA, IRENA *et al.*, 2021). Factors driving near-universal electricity access in North Africa include the geographic clustering and urbanisation of a larger percentage of the population than in most Sub-Saharan African countries. In addition, significant efforts have been made across North Africa to electrify both urban and rural areas (IEA, IRENA *et al.*, 2021). Progress has been much slower in Central Africa than in West and Southern Africa, which by 2019 had achieved 53% and 49% access rates, respectively (Figure 2.17), with the exception of South Africa itself, which, at 85%, has Sub-Saharan Africa's highest electrification rate.

Figure 2.17 Access to electricity and clean cooking fuels in Africa, 2019



Source: World Bank, 2021; WHO, 2021.

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Traditional biomass, the most widely used energy source across the continent, also differs substantially in its geographical use. In 2019, access to clean fuels and technologies for cooking in North Africa was 89% compared with 16% in Sub-Saharan Africa and 29% on the continent as a whole.

Decentralised energy systems

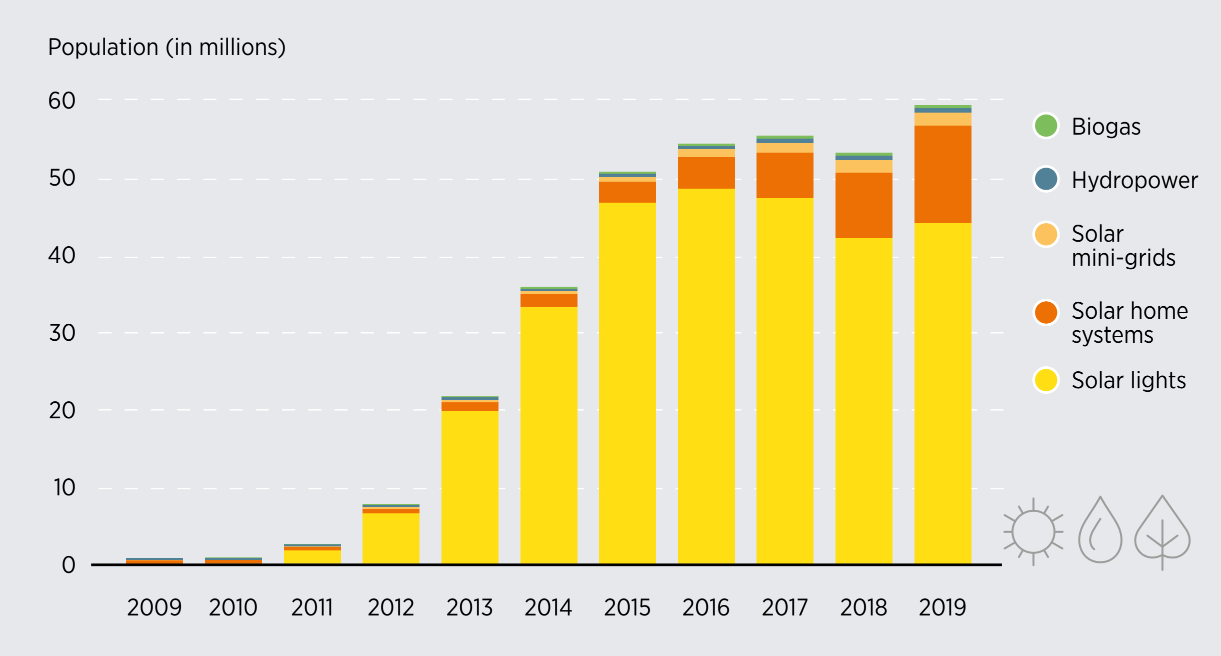
Access in Sub-Saharan Africa continued to rise over the past decade thanks to the deployment of stand-alone systems. Figure 2.18 shows that the population served by off-grid renewable power took off after 2011 with the decreasing cost of solar PV and innovations in financing models, as discussed in greater depth in Chapter 3. As a result, the use of solar-based solutions – solar lights, solar home systems, and mini-grids – grew at a CAGR of 62% over the last decade. About 8.5 million people in Sub-Saharan Africa gained access to electricity through solar home systems between 2016 to 2019, the majority in East Africa (IRENA, 2021b).

Some 1500 mini-grids are in use across Africa today, with plans to install 4 000 more (ESMAP, 2019a). IRENA reported that nearly 700 000 people in Sub-Saharan Africa were connected to mini-grids between 2016 and 2019 (IRENA, 2021b). Kenya has made particularly good progress in electrification since 2010; after India, Kenya has the most people (17 million) connected to some form of off-grid energy solution (IEA, IRENA *et al.*, 2021).

At the end of 2019, 410 000 Africans were using biogas for residential cooking, consuming the lion's share of 47 million cubic metres of biogas. The average annual growth rate of biogas production for cooking was 50.6% over the past decade; however, year-on-year growth declined continuously in that same period, eventually producing a decrease in production in 2019 (Figure 2.19). The decline in growth could be attributed to a lack of maintenance, a shortage of feedstock or the upfront initial cost of installing a biodigester (IEA, 2019a).

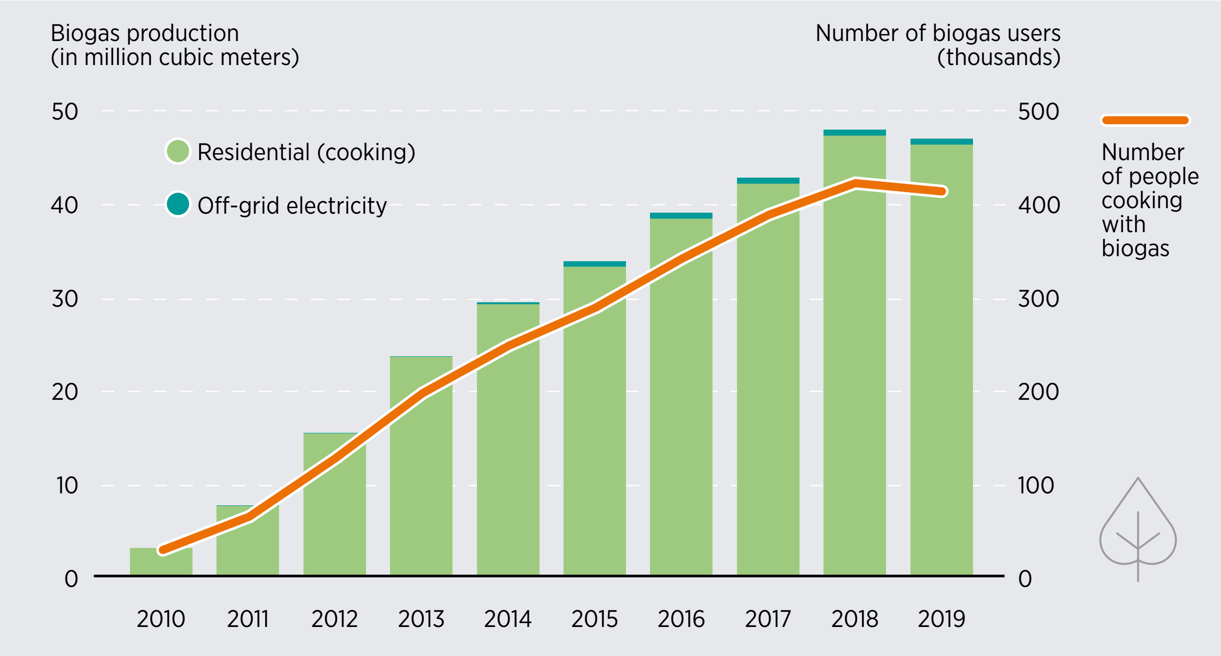
Chapter 6 delves deeper into the energy access challenge across Africa to analyse the role of decentralised renewable energy solutions in achieving universal access to electricity and clean cooking.

Figure 2.18 African population served by off-grid renewable power, 2009-2019



Source: IRENA, 2021b.

Figure 2.19 Trends in biogas production in Africa, 2009-2019



Source: IRENA, 2021b.

Box 2.1 The impact of the COVID-19 pandemic on the energy landscape in Africa

As elsewhere in the world, the COVID-19 pandemic has had far-reaching effects on energy in Africa. The sharp decline in global oil prices triggered by the pandemic has cut the revenue streams of African oil-producing countries, many of which depend on export revenues for a substantial share of their government budgets. Drastic fiscal pressure has hit countries such as Nigeria, Angola and Algeria. Compounding the problem, funds intended for energy projects have been transferred to tackling the pandemic or easing the burden on revenue-strained government budgets. Cutbacks to energy projects have worsened the pre-existing financial difficulties of utilities (ALB, 2020).

Despite the pandemic, Africa added 2.5 GW of renewable energy capacity in 2020, overcoming the 1 GW of non-renewable additions, which had a steep decline from 7.8 GW additions in 2019. This means that the pandemic also presents an opportunity for Africa to reduce its dependence on fossil fuels and develop a more resilient energy sector.

Energy access, on the other hand, along with progress toward the other Sustainable Development Goals, have been severely affected by the pandemic. Gains in access have been reversed throughout Africa, as basic electricity services become unaffordable for as many as 30 million people who had previously enjoyed access (IEA, IRENA *et al.*, 2021). The International Energy Agency also estimates that the population without access to electricity in Sub-Saharan Africa could have risen in 2020 for the first time since 2013 (IEA, 2021b), reinforcing the vicious circle of poor (or no) access to electric power, few opportunities for income-generating activities, and the resulting persistence of hunger, poverty and other problems.

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2.1.4 Electricity trade

While electricity trading within Africa remains limited, the potential for expansion is great. Africa is home to several regional power pools and cross-border interconnections, as well as interconnection projects that enable neighbouring countries, in theory, to share backup power and to engage in electricity trading. The maturity and effectiveness of these interconnected networks varies widely, however, with the most significant regional trading taking place in the Southern African Power Pool. The West African Power Pool, on the other hand, is not expected to become operational for several years, after the region becomes fully interconnected. A significant portion of existing trade is bilateral, using existing infrastructure rather than a multilateral trading platform. The existence of several large, interconnected cross-border grids nevertheless highlights the potential for future trade (see further discussion in Chapter 4). Existing pools consisting of physical interconnections, either complete or in progress at the time of writing, are as follows:

- **Maghreb Electricity Committee** (COMELEC), which includes Algeria, Libya, Mauritania, Morocco and Tunisia
- **West African Power Pool**, which includes Benin, Burkina Faso, Côte d'Ivoire, the Gambia, Ghana, Guinea Bissau, Liberia, Mali, Mauritania, Morocco, Nigeria, Senegal, Sierra Leone and Togo
- **Eastern Africa Power Pool**, which includes Burundi, Djibouti, the Democratic Republic of the Congo, Egypt, Ethiopia, Kenya, Libya, Rwanda, the Sudan, Uganda and the United Republic of Tanzania
- **Central African Power Pool**, which includes Angola, Burundi, Cameroon, the Central African Republic, Chad, the Congo, the Democratic Republic of the Congo, Equatorial Guinea, Gabon, São Tomé and Príncipe and Chad
- **Southern African Power Pool**, which includes Angola, Botswana, the Democratic Republic of the Congo, Eswatini, Lesotho, Malawi, Mozambique, Namibia, South Africa, the United Republic of Tanzania, Zambia and Zimbabwe.

Based on available data on intra-regional electricity trade,[4] South Africa, Nigeria, Ghana and Mozambique were the largest electricity exporters in Africa in 2019, while Namibia, Togo, Zimbabwe and Angola were the largest importers (IRENA, 2021a).

For the longer term, proposals have been advanced to connect all African power pools to form a single African electricity market facilitated through the development of a Continental Systems Master Plan (AfDB, 2020b). IRENA and the International Atomic Energy Agency, with financial support from the European Union, are partners for the development of this master plan, which would provide, among other things, modelling tools to help establish a long-term continent-wide planning process (IRENA, 2021c).

Morocco's two undersea interconnections with Spain link Africa's power market to Europe. Although electricity trade is limited at present (Tsagas, 2019), this link could be used in the future to trade renewables-based electricity from North Africa to Europe.


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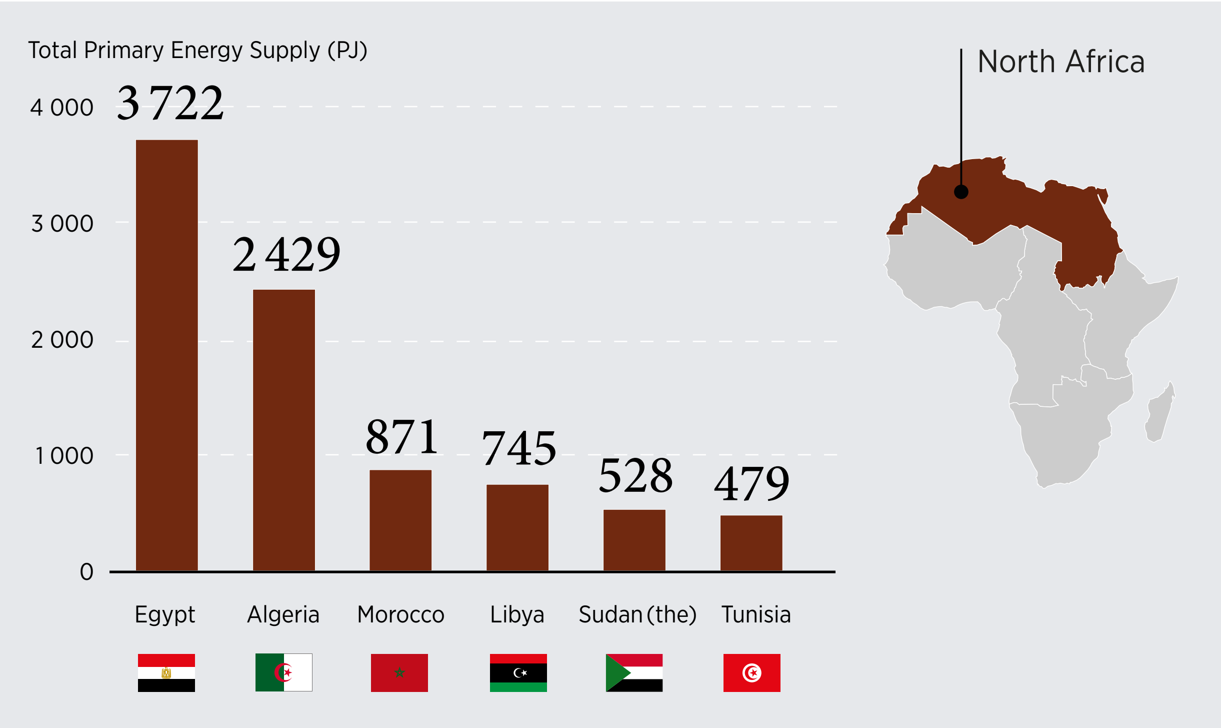
4 IRENA collects international electricity trading statistics on a regular basis; however, available data for several African countries contain gaps.

2.2 NORTH AFRICA

North Africa is the African continent's largest energy market. The region has a distinct energy landscape that, like its socio-economic development status, sets it apart from Sub-Saharan Africa. With the exception of the Sudan, North Africa is made up of middle-income countries. Algeria, Libya, Egypt and the Sudan are endowed with significant hydrocarbon resources and have been long-standing exporters of oil and natural gas (Figure 2.20).

The countries of North Africa have achieved some of Africa's highest rates of access to modern energy, with access to electricity and clean cooking being almost universal in all but the Sudan and, to a lesser degree, in conflict-torn Libya (Figure 2.21). Egypt and Algeria are by far the largest energy markets in Africa, reflecting their large populations and historically high rates of access to modern forms of energy.

Figure 2.20 North African countries in total primary energy supply, 2018



Source: UNSD, 2018.

Note: PJ = petajoule.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

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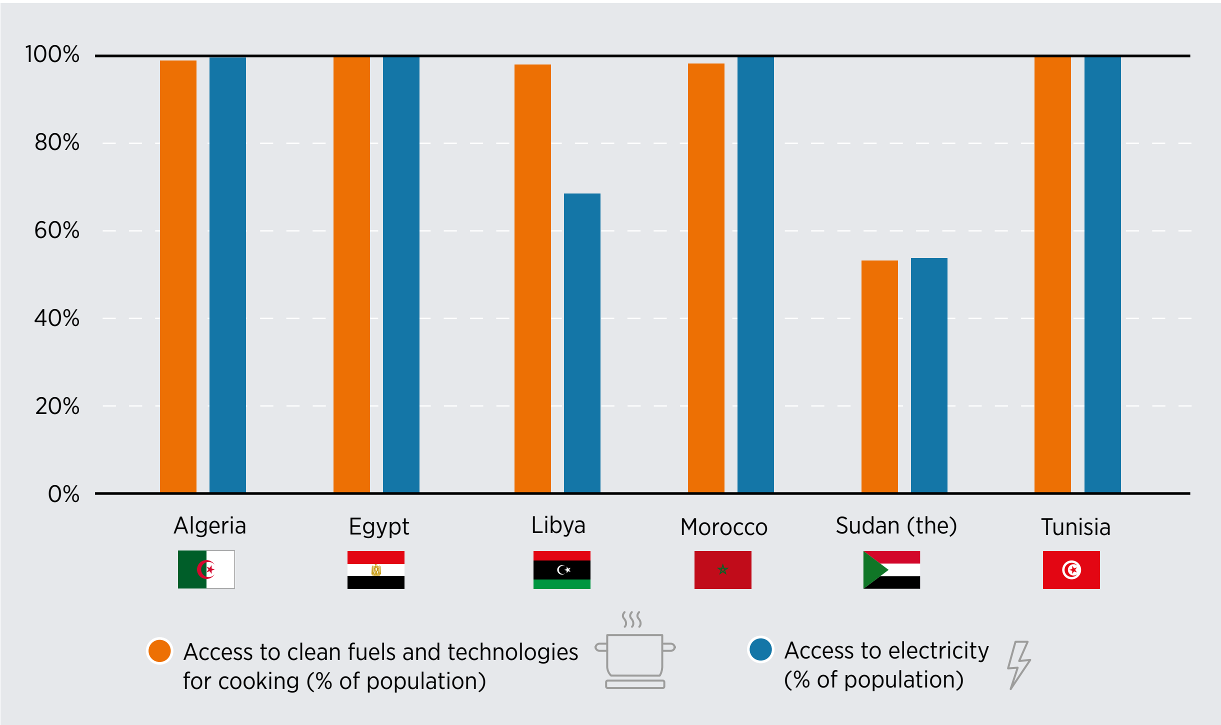
While biomass plays a predominant role in much of Sub-Saharan Africa's primary energy supply, its role in North Africa is more limited. Oil and natural gas, historically available at comparatively low cost in many North African countries, supply more than 80% of the region's primary energy needs (Figure 2.22). Only Morocco and Tunisia (the latter being the only North African country without substantial fossil fuel resources) use coal – in small volumes.

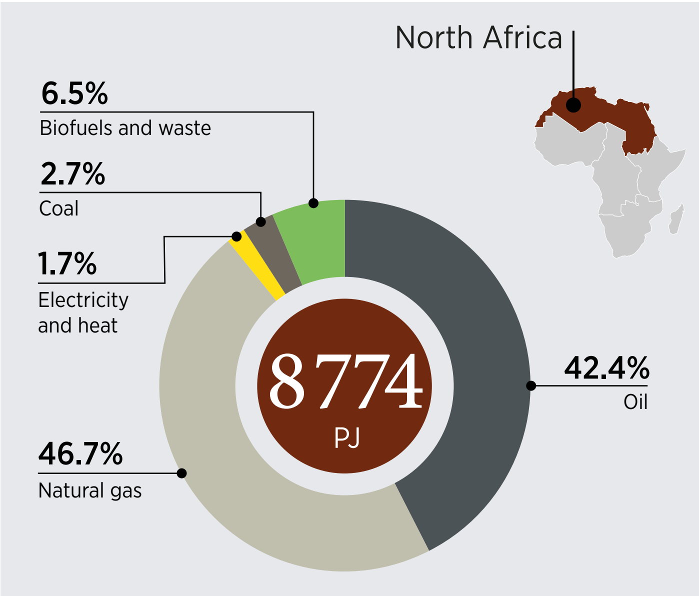
Natural gas supplies almost two-thirds of North Africa's electricity, and the region accounts for 93 GW of Africa's total 113 GW of gas-fired power plants and gas/oil hybrids. Hydropower (including pumped storage) is a significant additional contributor to the electricity mix in several North African countries, with Egypt, the Sudan and Morocco having Africa's fourth-, ninth- and tenth-largest hydropower production capacity, respectively. Egypt is the largest electricity market in North Africa, with capacity in excess of 64 GW capacity serving a population of more than 100 million. Egypt is followed by Algeria (50 GW) and Libya (14 GW) (IRENA 2021a).

Figure 2.21 Access to electricity and clean cooking fuels in North Africa, 2019



Source: World Bank, 2021; WHO, 2021.

Figure 2.22 Total primary energy supply in North Africa, by source, 2018



Source: UNSD, 2018.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

2.2.1 Electricity and renewable energy

The share of renewable energy in the electricity mix remains much smaller in North Africa (9.5% of electricity generation) than in other parts of Africa. This is due to several factors – chief among them the region's far higher rates of historical energy access, urbanisation and income, all entwined with the availability of relatively cheap electricity and liquid fuels supplied from the region's own substantial hydrocarbon resources.

Natural gas is the primary fuel used for power generation in Algeria, Egypt, Libya and Tunisia, with bottles of liquefied petroleum gas widely available for household use (Figures 2.23–25). At the same time, the Sudan, Morocco and Egypt have relied on hydropower for many decades. Egypt, Morocco and Algeria, with 1680 MW, 734 MW and 448 MW, respectively, have Africa's second-, third- and fourth-largest solar power generation capacity after South Africa; and Morocco and Egypt are Africa's second- and third-largest wind power producers after South Africa, with 1.4 GW and 1.38 GW capacity, respectively (IRENA, 2021a).

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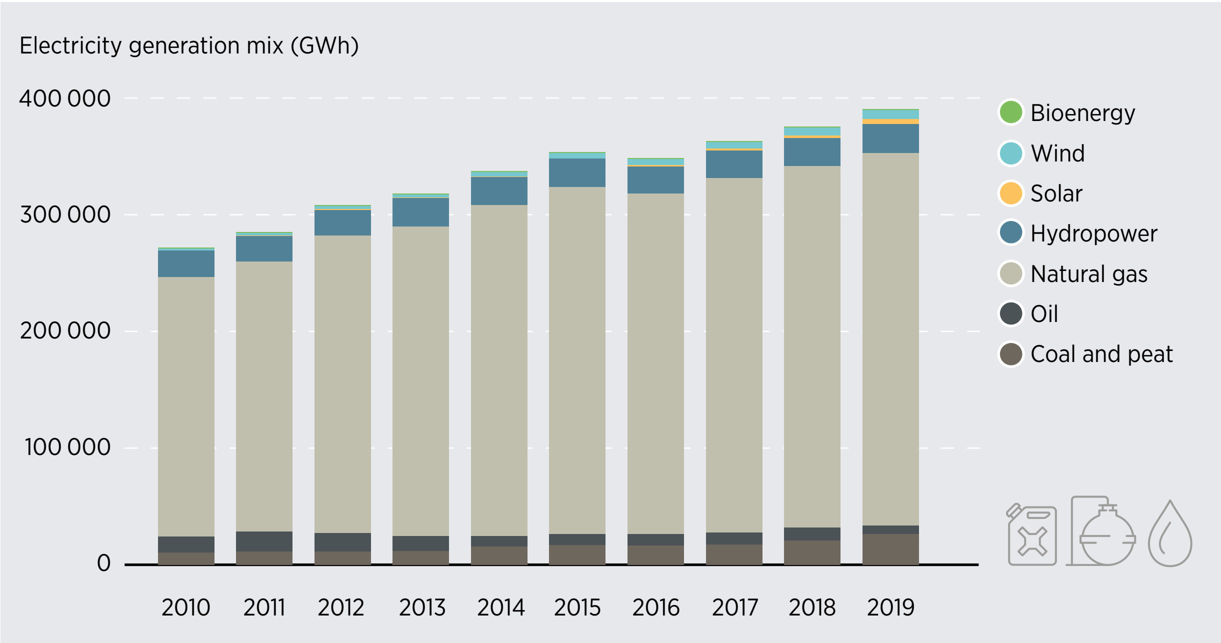
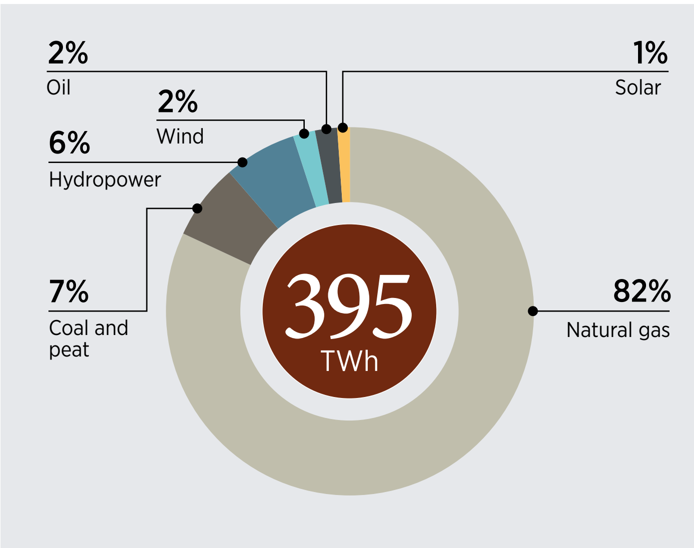
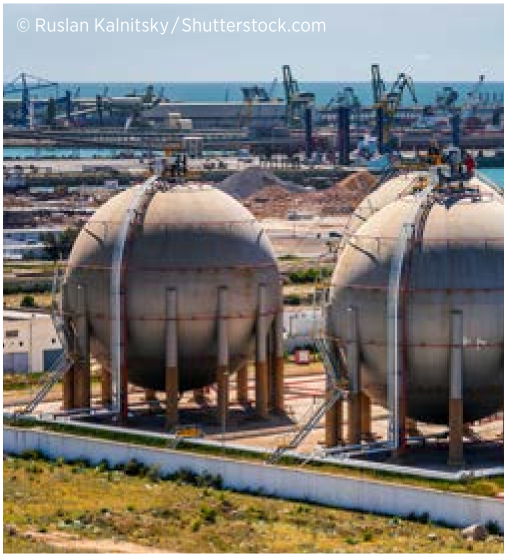
Figure 2.23 North Africa's electricity generation mix, by source, 2010-2019



Source: IRENA, 2021a.
Note: GWh = gigawatt hour.

Figure 2.24 Electricity generation in North Africa, by source, 2019



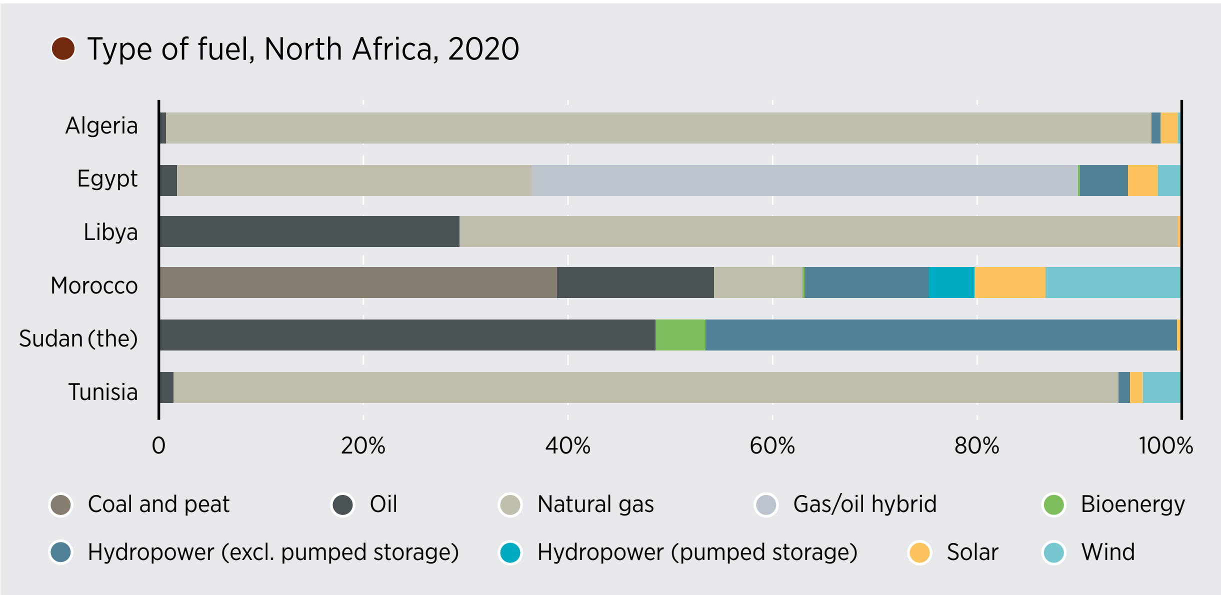


Source: IRENA, 2021a
Note: TWh = terawatt hour.

At the same time, renewable generation capacity has been growing at an encouraging compound rate of 6% annually since 2011. As Africa's leader in new utility-scale wind and solar projects, North Africa is now home to almost half of Africa's total installed wind-power-generating capacity in addition to a fifth of the continent's grid-based solar power generation capacity.

Notable renewable energy projects in recent years include the 1.5 GW Benban solar PV park and the 262.5 MW Ras Ghareb wind farm, both in Egypt; the 1.3 GW Merowe hydropower dam (2009) and the 320 MW Upper Atbara and Setit dam complex (2017) in the Sudan; the 510 MW Ouarzazate solar power station (2016-2018) in Morocco and the 301 MW Tarfaya wind farm (2014) in Morocco (IRENA 2021a).

Figure 2.25 North Africa's electricity generation capacity by country and source, 2020



Source: IRENA, 2021a.

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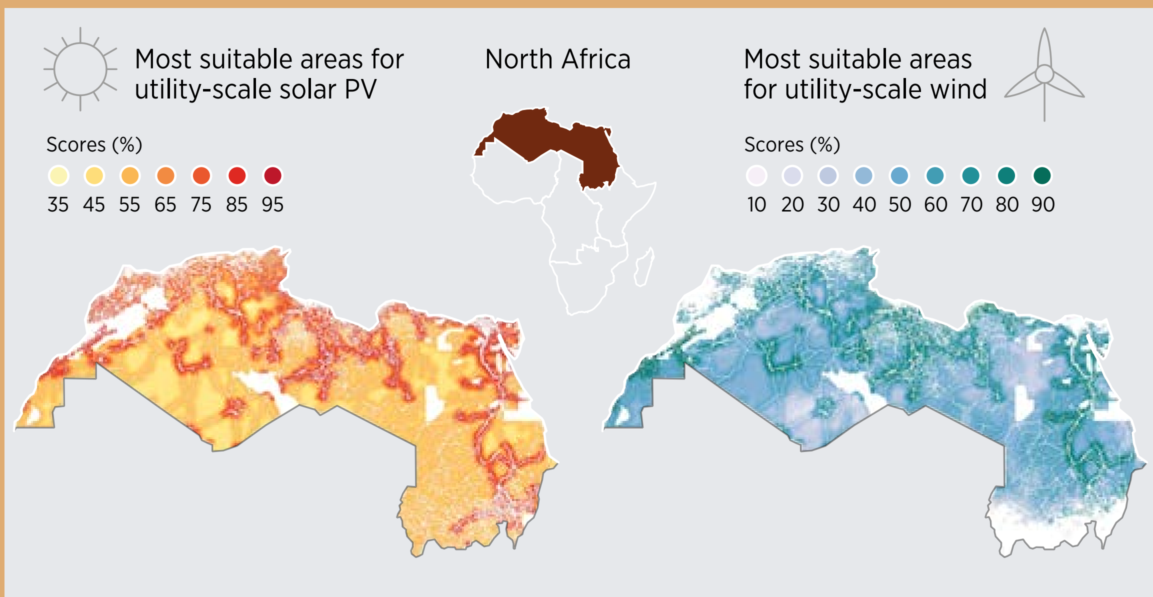
Box 2.2 Renewable energy potential in North Africa

North Africa possesses the continent's greatest potential for the development of solar and wind power. The region's annual average solar irradiation is high, at around 2 200 kilowatt hours per square metre; wind speeds average a high 7 metres per second, reaching 9.5 metres per second in Algeria and Libya (Figure 2.26). Assuming a land-utilisation factor of 1% for solar and wind, IRENA estimates the technical installable capacities at 2 792 gigawatts for solar and 223 for wind. The Delft University of Technology estimates hydropower potential at 112 gigawatts (Hoes, 2014).

Figure 2.26 Most suitable areas in North Africa for utility-scale solar PV and wind



Source: Suitability scoring and areas: IRENA; Base map: UN boundaries.

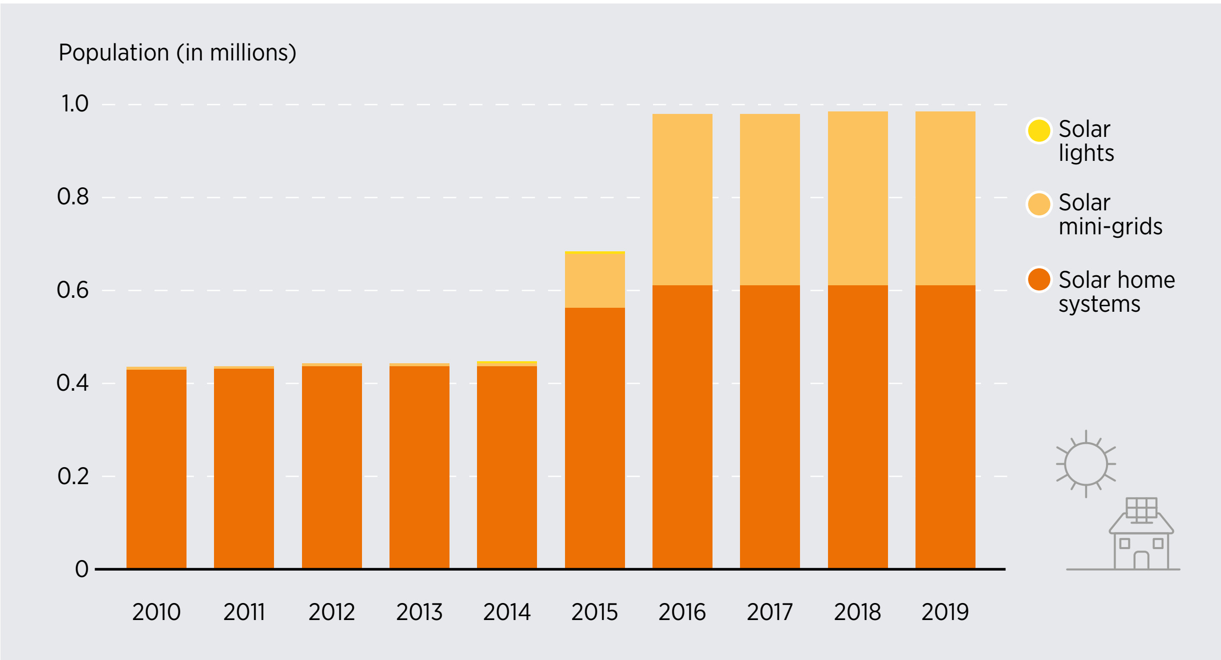
Note: PV = photovoltaic.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

2.4.2. Decentralised electricity access

Because access to grid-based electricity is close to universal in North Africa (except in the Sudan), decentralised solar systems and mini-grids are less common than in other parts of Africa. Around 611 000 people had access to solar home systems and 374 100 people via solar mini grids in 2019 (Figure 2.27). Decentralised systems still have a role to play in rural electrification. Morocco's national utility (ONEE), for example, increased the country's rural electrification rate from 18% in 1995 to 97% in 2009 by expanding the grid in areas where it was technically and economically feasible to do so, while introducing solar home systems and hybrid systems were in isolated areas where grid expansion was not possible (IEA, 2019a).

Figure 2.27 North African population served by off-grid renewable power, 2009-2019



Source: IRENA, 2021b.

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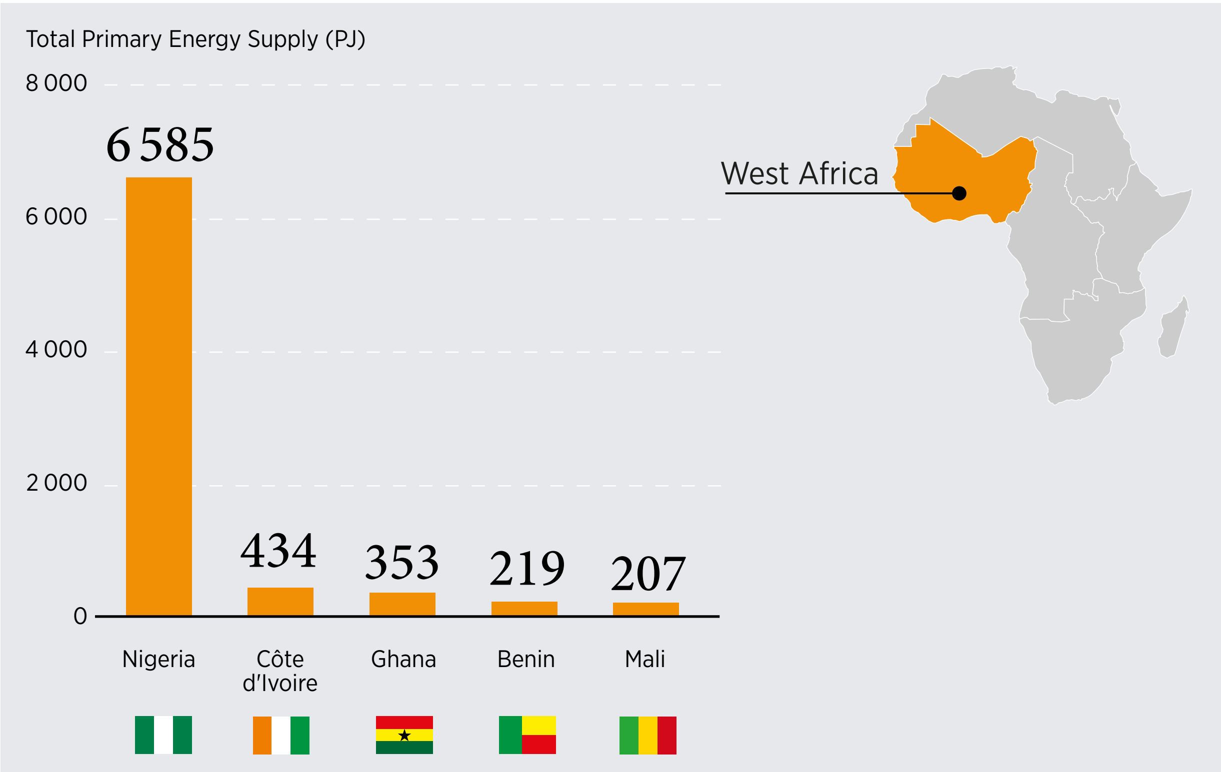
2.3 WEST AFRICA

West Africa is the continent's second-largest energy market, close in size to North Africa's. Nigeria, with its population of almost 200 million people, is the largest economy in Africa, and accounts for almost three-quarters of West Africa's total primary energy supply (Figure 2.28). Several West African countries are oil and gas producers, including Nigeria, Côte d'Ivoire and Ghana.

West Africa has the second-highest electricity access rate on the continent (53%) after North Africa. Access to modern clean cooking fuels stood at 15% in 2019, having increased by 10% in the past two decades. Cabo Verde and Ghana had the highest electricity access rates in West Africa in 2019, at 96% and 84%, respectively (Figure 2.29).

At the same time, Nigeria, Africa's most populous country, continues to suffer from access rates of 55%. With 90 million of its citizens lacking access to even basic electricity, Nigeria is at the top of the list of access-deficit countries in 2019 (IEA, IRENA *et al.*, 2021). Ghana is among several countries that have developed long-term, comprehensive strategies to achieve universal access. The population of the country with access to electricity rose by 90%, up from 44% in 2000 (World Bank, 2021; IRENA, 2021b). Cabo Verde has the highest rate of access to clean cooking, at 78% (SE4All, 2015; Figure 2.29).

Figure 2.28 Top five West African countries in total primary energy supply, 2018



Source: UNSD, 2018.
Note: PJ = petajoule.
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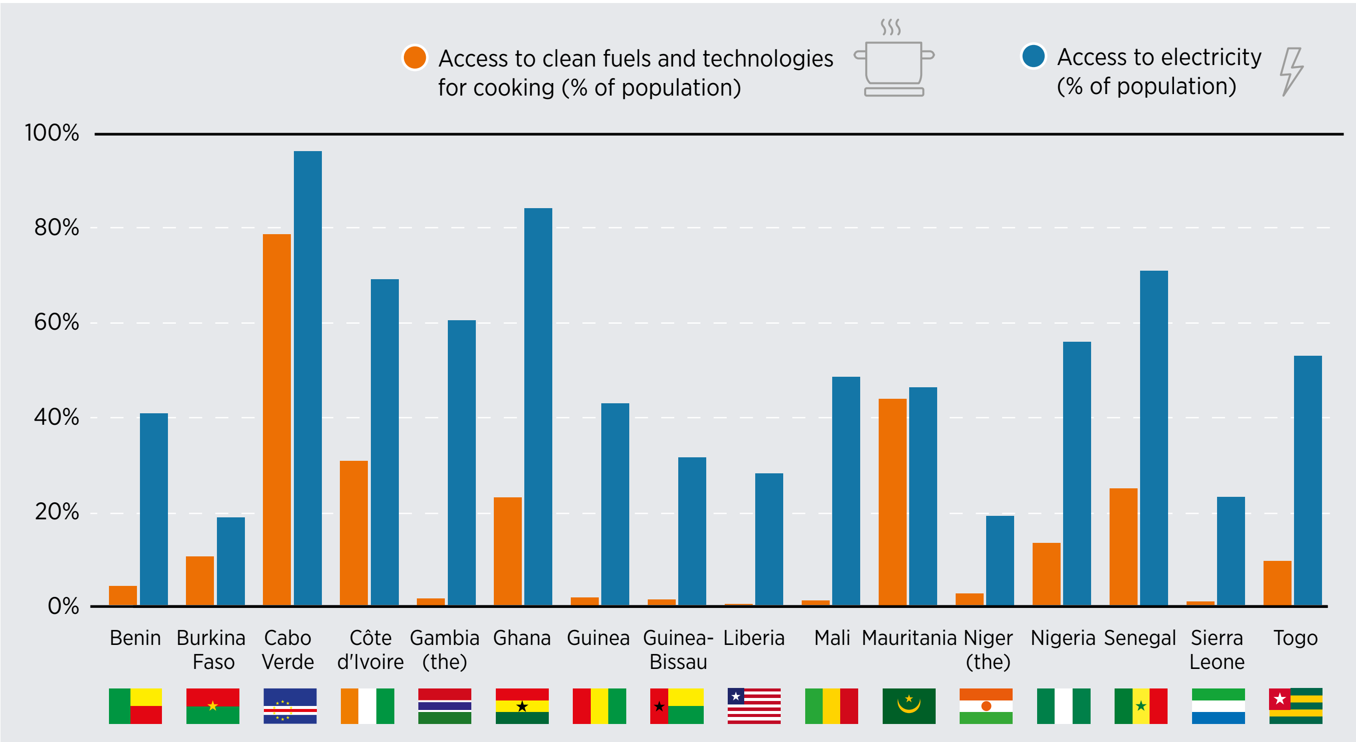
Biofuels and waste (mostly fuel wood and charcoal) make up the largest component of the energy mix, with about 80% of the population of the Economic Community of West African States (ECOWAS) still using traditional biomass for cooking, often on inefficient stoves and in an unsustainable way. Cabo Verde has the highest rate of access to clean cooking, at 78% (SE4All, 2015; Figure 2.29).

The ECOWAS Initiative on Safe, Sustainable and Affordable Cooking aims to ensure that the entire ECOWAS population has access to efficient, sustainable and modern clean cooking by 2030. This is likely to mean that bioenergy will continue to play a major role in the regional energy mix, as traditional biomass energy is replaced with modern biomass energy (ECREEE, 2020).

2.3.1 Electricity and renewable energy

West Africa has a fast-growing electricity sector, with some 11.3 GW of installed capacity added between 2011 to 2020. With a total of 25.9 GW installed electricity generation capacity, West Africa is the continent's third-largest electricity market. Nigeria and Ghana were the biggest contributors to the generation mix, contributing 33.5 terawatt hours (TWh) (44.%) and 18.3 TWh (16.8%), respectively, in 2019. Fossil fuels account for most electricity generation in West Africa (Figures 2.31 and 2.32), with large shares of natural gas in Nigeria, Benin, Côte d'Ivoire, Ghana, Senegal and Guinea (Figure 2.33).

Figure 2.29 Access to electricity and clean cooking fuels in West Africa, 2019



Source: World Bank, 2021; WHO, 2021.

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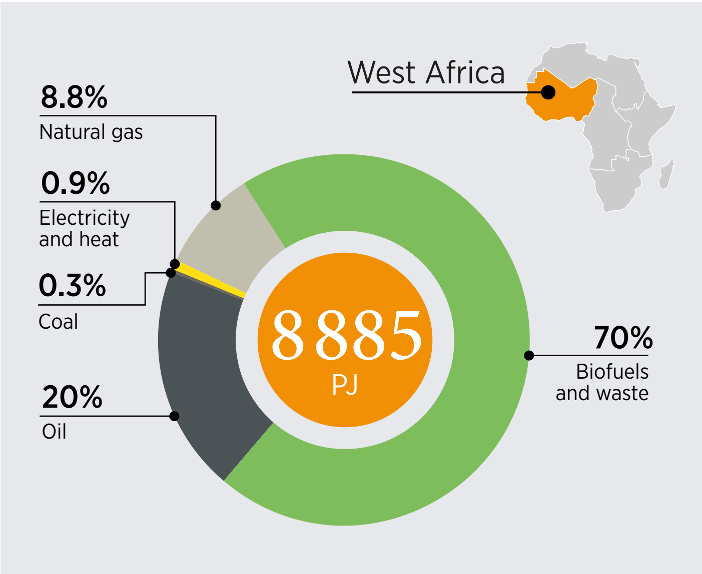
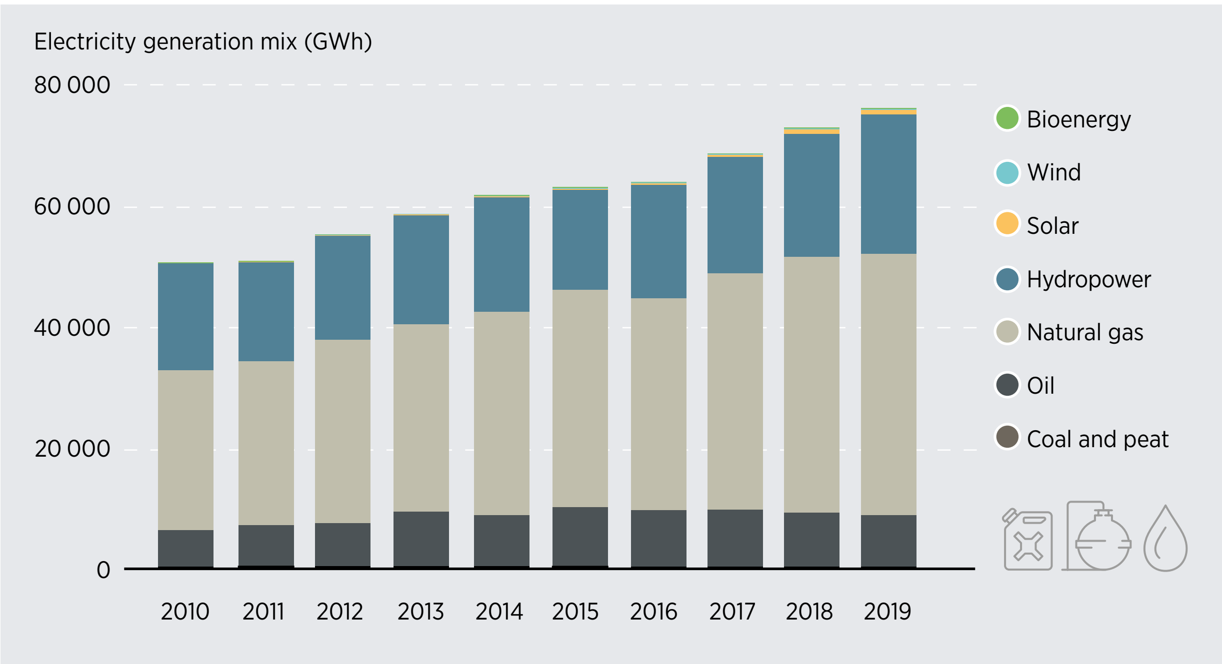
Figure 2.30 Total primary energy supply in West Africa, by source, 2018



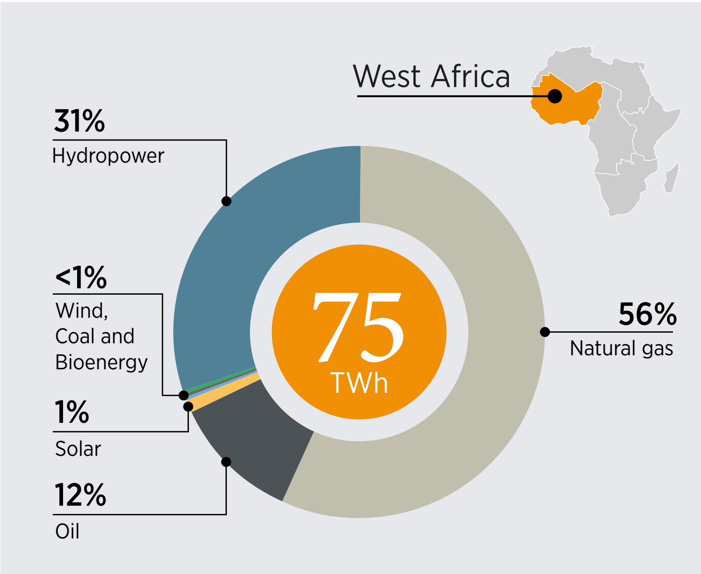
Source: UNSD, 2018.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

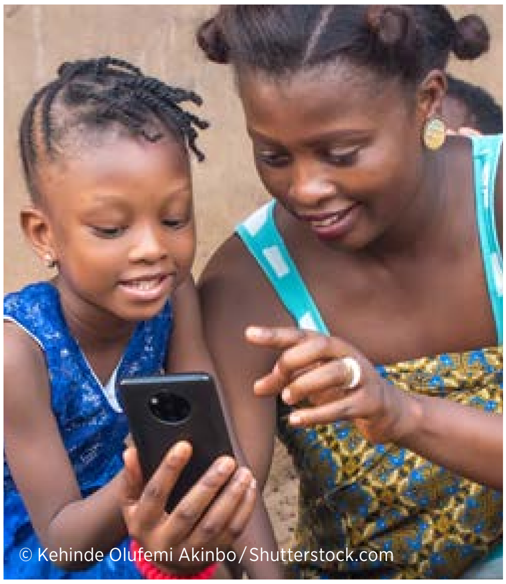
Figure 2.31 West Africa's electricity generation mix, by source, 2010-2019



Source: IRENA, 2021a.
Note: GWh = gigawatt hour.

Figure 2.32 Electricity generation in West Africa, 2019





Source: IRENA, 2021a.
Note: TWh = terawatt hour.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

Many other West African countries continue to rely on oil products for most of their electricity generation. In Burkina Faso, Cabo Verde, the Gambia, Guinea-Bissau, Mauritania and the Niger, the share of oil in power generation exceeds 80% (Figure 2.33). The Niger is one of a handful of African countries outside Southern Africa that also uses coal. Ghana added significant amounts of oil and natural gas thermal generation capacity after water levels at the Akosombo Dam fell below operational levels for several years (IRENA 2021a; Kumi, 2017).

Hydropower plays a role in several West African countries, particularly Guinea, Liberia, Côte d'Ivoire and Mali (Figure 2.33). Nigeria possesses Africa's eighth-largest hydropower generation capacity, with its 2.1 GW being the country's only significant alternative generation source apart from natural gas (Figure 2.33). Some notable renewable energy additions in West Africa in recent years include the 400 MW Bui hydroelectric plant commissioned in 2013 in Ghana; the 240 MW Kaléta hydropower plant commissioned in 2015 in Guinea; the 275 MW Soubré hydropower plant in Côte d'Ivoire (commissioned in 2017) and a 65 MW solar plant installed in Senegal in 2017. Total electricity generation from renewables in the region in 2019 amounted to 23.9 TWh, far below potential levels (Box 2.3).

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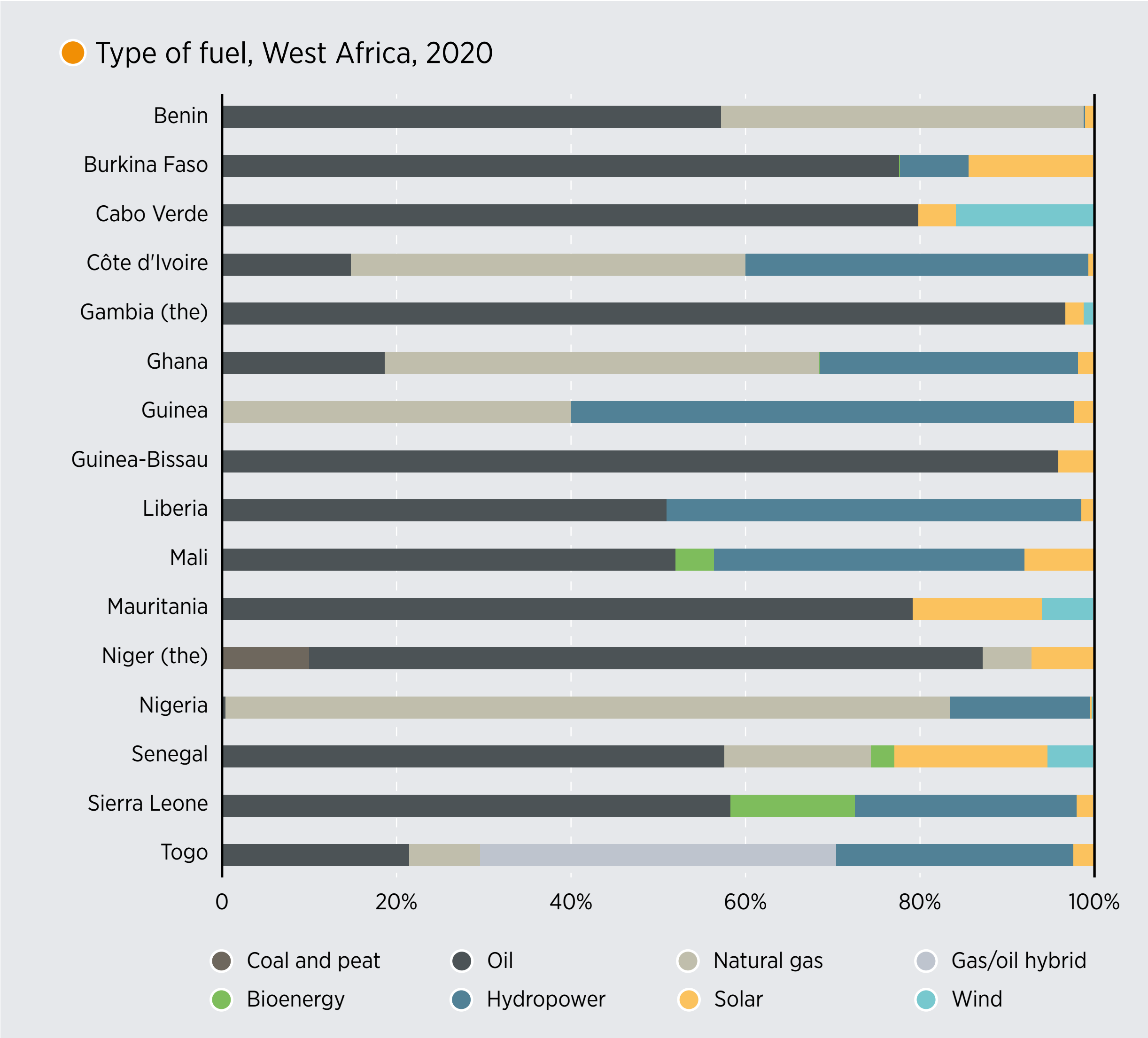
Figure 2.33 Electricity generation capacity in West Africa, by country and source, 2020

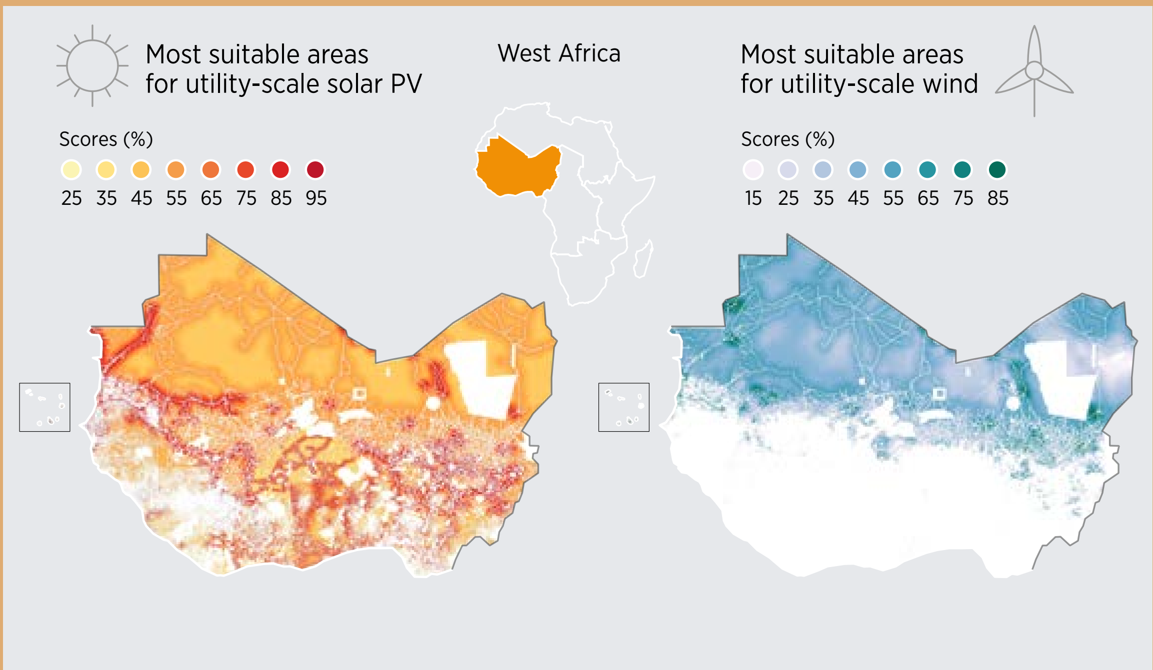


Source: IRENA, 2021a.

Box 2.3 Renewable energy potential in West Africa

West Africa is rich in solar, wind and hydropower resources. It has a high annual average solar irradiation of 2100 kilowatt hours per square metre and wind speeds averaging 6 metres per second. The average reaches 8 metres per second in Mauritania and the Niger. Assuming a land-utilisation factor of 1%, IRENA estimates the technical installable capacities at 1956 gigawatts for solar and 106 for wind. The Delft University of Technology estimates hydropower's technical potential to be 162 gigawatts (Hoes, 2014), with peaks in Mali for solar, Mauritania for wind and Nigeria for hydropower.

Figure 2.34 Most suitable areas in West Africa for utility-scale solar PV and wind



Source: Suitability scoring and areas: IRENA; Base map: UN boundaries.

Note: PV= photovoltaic.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

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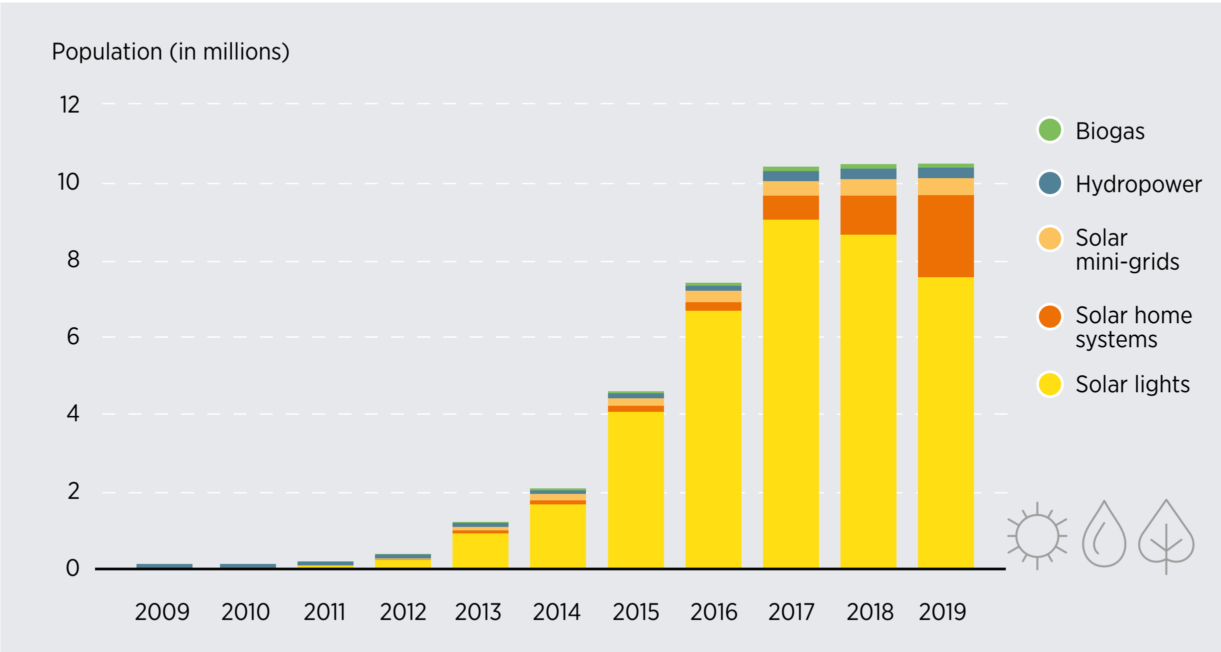
2.3.2. Decentralised electricity access

Some 10 million people in West Africa were served by solar lights, solar home systems or solar-based mini-grids in 2019, an encouraging number that shows progress towards the use of solar home systems over mere lighting services (Figure 2.35).

Figure 2.35 West African population served by off-grid renewable power, 2009-2019



Source: IRENA, 2021b.

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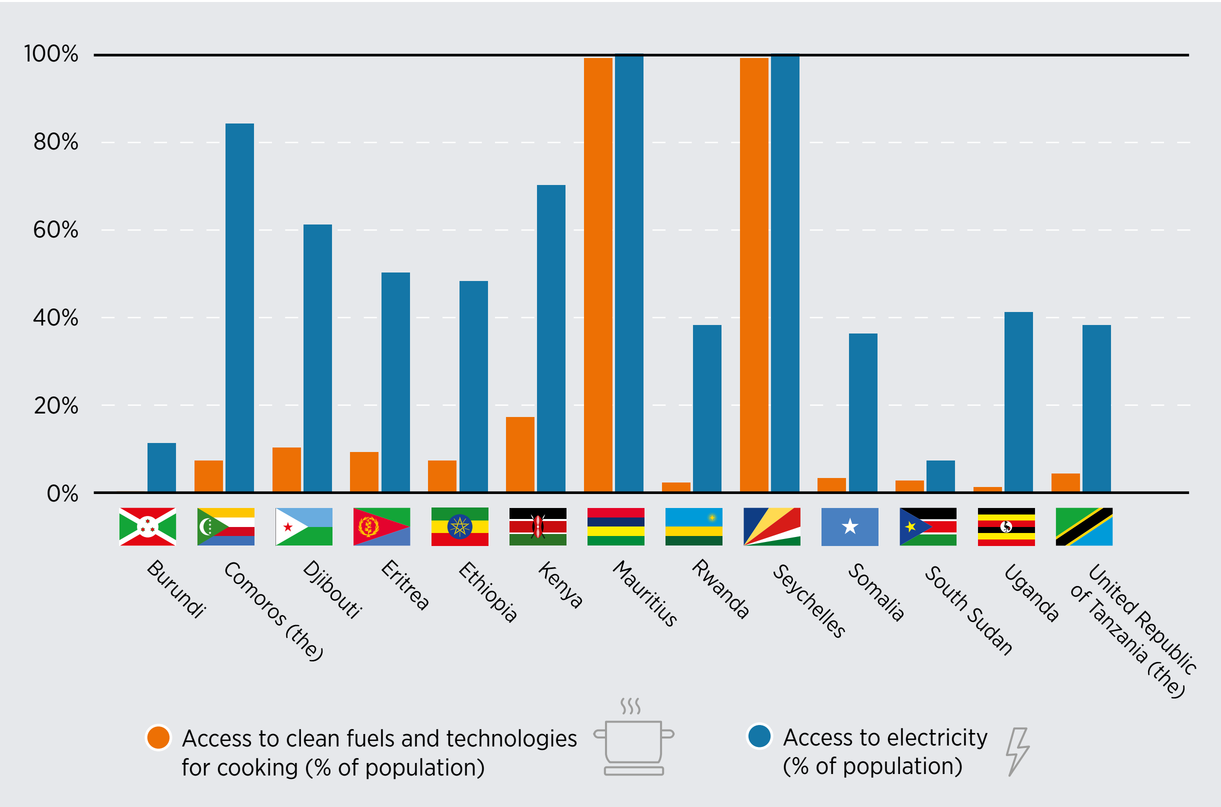
2.4 EAST AFRICA

East Africa is one of the African continent's smaller energy markets. With several medium-sized countries – Ethiopia, Kenya, Uganda and the United Republic of Tanzania – East Africa has a diverse economic and energy landscape. Electricity access in East Africa stands at around 46%, with access to clean cooking at a mere 7% at the end of 2019 (IRENA, 2021a). Kenya has seen some of East Africa's most rapid progress in electricity access, driven by determined policies that include the country's Last Mile Connectivity Project, which drove strong grid connections while also allowing for a reduction in the connection fee, tax exemptions to reduce the cost of solar products and the development of a mature mobile payment infrastructure (IEA, 2019a). As a result, over 5 million people gained access to electricity from 2018 to 2019; approximately 2.8 million of that number were served by decentralised systems (see Figure 2.43) (IRENA, 2021b). East Africa's smaller island states, Mauritius and the Seychelles, have achieved virtually universal access to modern energy, while Burundi, the Comoros and South Sudan have some of Africa's lowest access rates (Figure 2.36).

Figure 2.36 Access to electricity and clean cooking fuels in East Africa, 2019



Source: World Bank, 2021; WHO, 2021.

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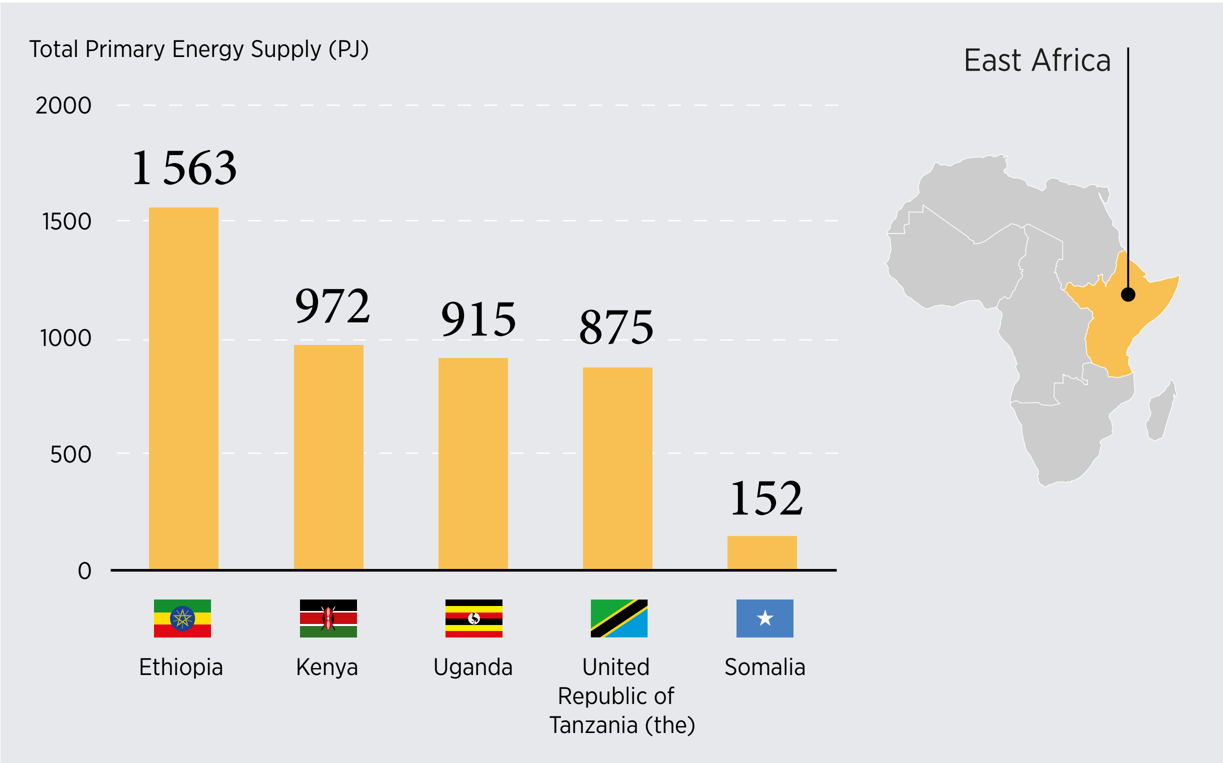
The presence of the Great Lakes, the Great Rift Valley and the Nile Basin have contributed to the major role played by hydropower (represented as electricity and heat in Figure 2.38) in the region's total primary energy supply regional mix. Ethiopia, Uganda and Kenya ranked 1st, 13th and 15th, respectively, in total installed hydropower capacity on the continent in 2020 (IHA, 2020). Besides hydropower, Kenya also uses geothermal energy (IRENA, 2021a). Natural gas plays a marginal role in East Africa's current energy supply (Figure 2.38), but this may change in the coming years as major new gas developments along the coasts of Mozambique and the United Republic of Tanzania are expected to start supplying domestic markets. Ethiopia alone accounts for around a third of East Africa's total primary energy supply (Figure 2.37).

As in other parts of Sub-Saharan Africa, incomplete electricity access and low access rates to clean cooking mean biofuels and waste (mostly fuel wood and charcoal for cooking) remain the most important source of primary energy in East Africa (Figure 2.38). Biogas has emerged as a substitute for cooking fuel wood principally in rural East Africa, while bio-slurry from biogas production is being utilised as fertiliser to increase agricultural production and biomass briquettes are increasingly being promoted as a cleaner and more efficient alternative to traditional biomass (IEA, 2019a; UNSD, 2018). In Kenya, 26% of households reported charcoal as their primary cooking fuel, but almost 70% still used it occasionally (Dalberg, 2018).

Figure 2.37 Top five East African countries in total primary energy supply, 2018



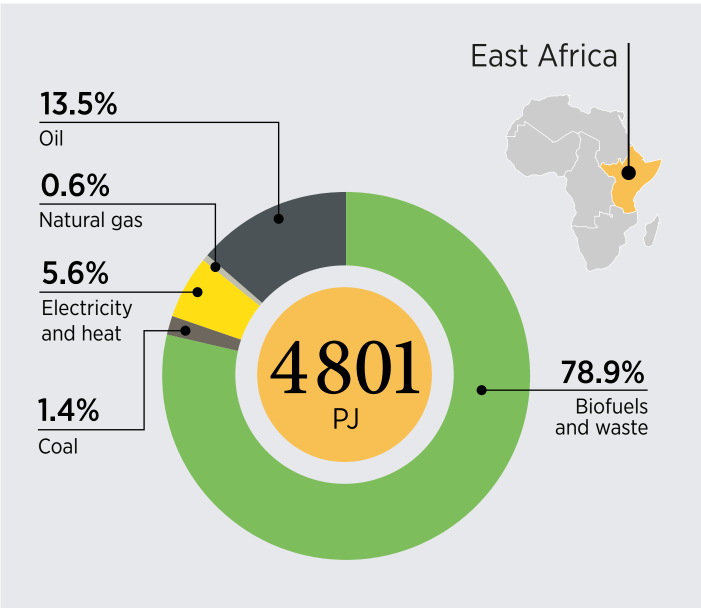
Source: UNSD, 2018.
Note: PJ = petajoule.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

2.4.1 Electricity and renewable energy

Electricity generation has grown steadily in East Africa on the back of population growth and rising living standards. In total, East Africa added some 6 GW of new electricity generation capacity between 2011 to 2020, almost doubling the region's total electricity generation capacity to 14 GW by 2020. Renewable energy contributed around 80% of this capacity increase, primarily through hydropower, but also through geothermal (all in Kenya), wind and solar power (Figure 2.39 and Figure 2.41).

The largest capacity additions in 2018 came from the 310 MW Lake Turkana onshore wind plant in Kenya and the 240 MW Kinyerezi II natural gas plant in the United Republic of Tanzania. Both Ethiopia and Uganda rely on hydropower for around 80% of their electricity generation capacity. Other East African countries remain heavily reliant on fossil fuels, particularly oil and oil products; the Comoros, Djibouti, Eritrea, the Seychelles, Somalia and South Sudan generate more than 80% of their electricity from oil (Figure 2.41). Ethiopia has with over 4 GW Africa's second largest hydropower generation capacity and is, along with Kenya, East Africa's largest wind power producer (both with around 330 MW capacity each) (IRENA, 2021a; see also Figure 2.6 above).

Figure 2.38 Total primary energy supply in East Africa, by source, 2018



Source: UNSD, 2018.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

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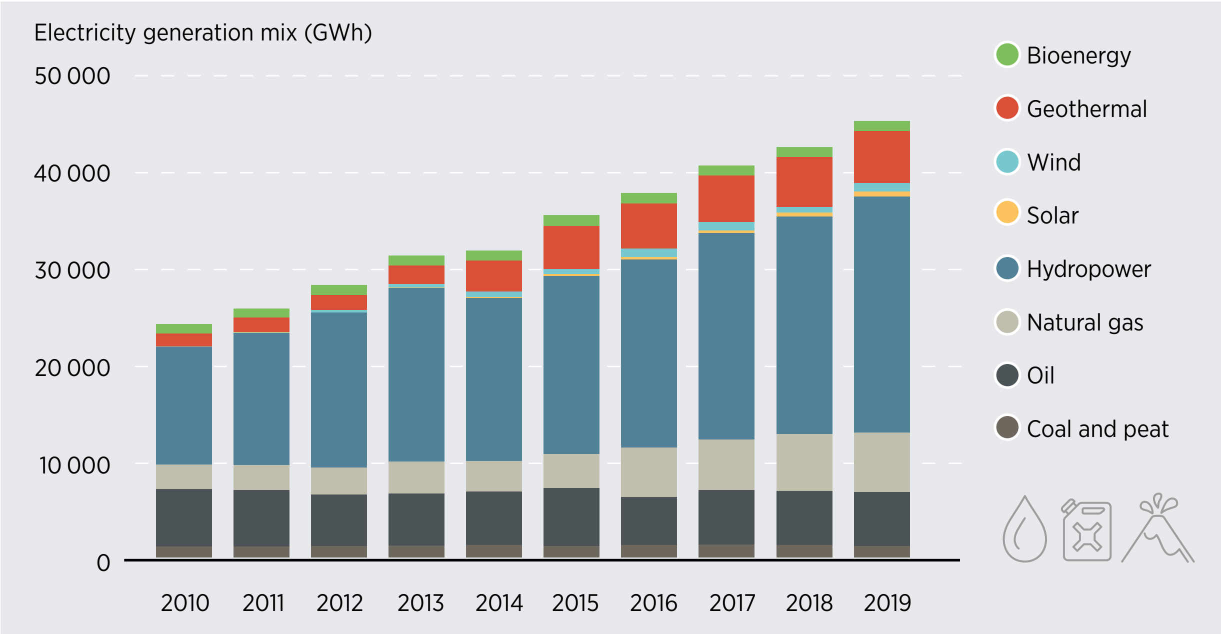
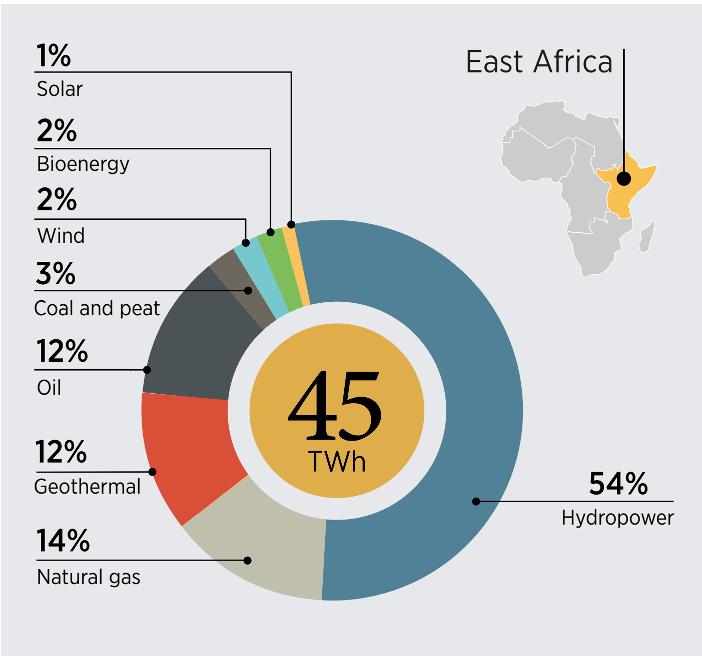
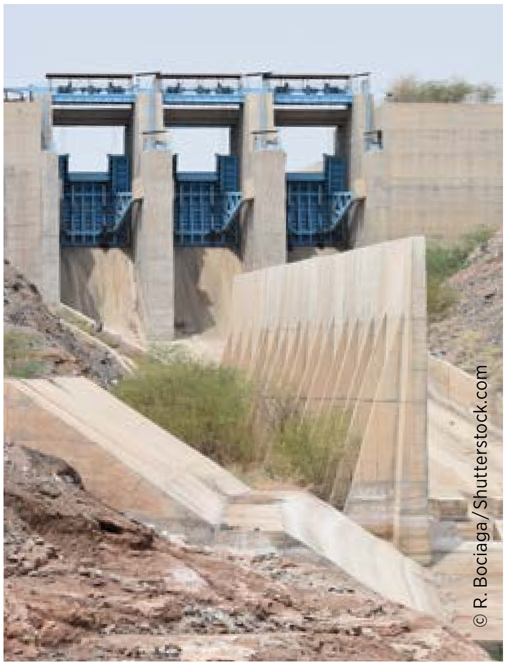
Figure 2.39 East Africa's electricity generation mix, by source, 2010-2019



Source: IRENA, 2021a.
Note: GWh = gigawatt hour.

Figure 2.40 Electricity generation in East Africa, by source, 2019

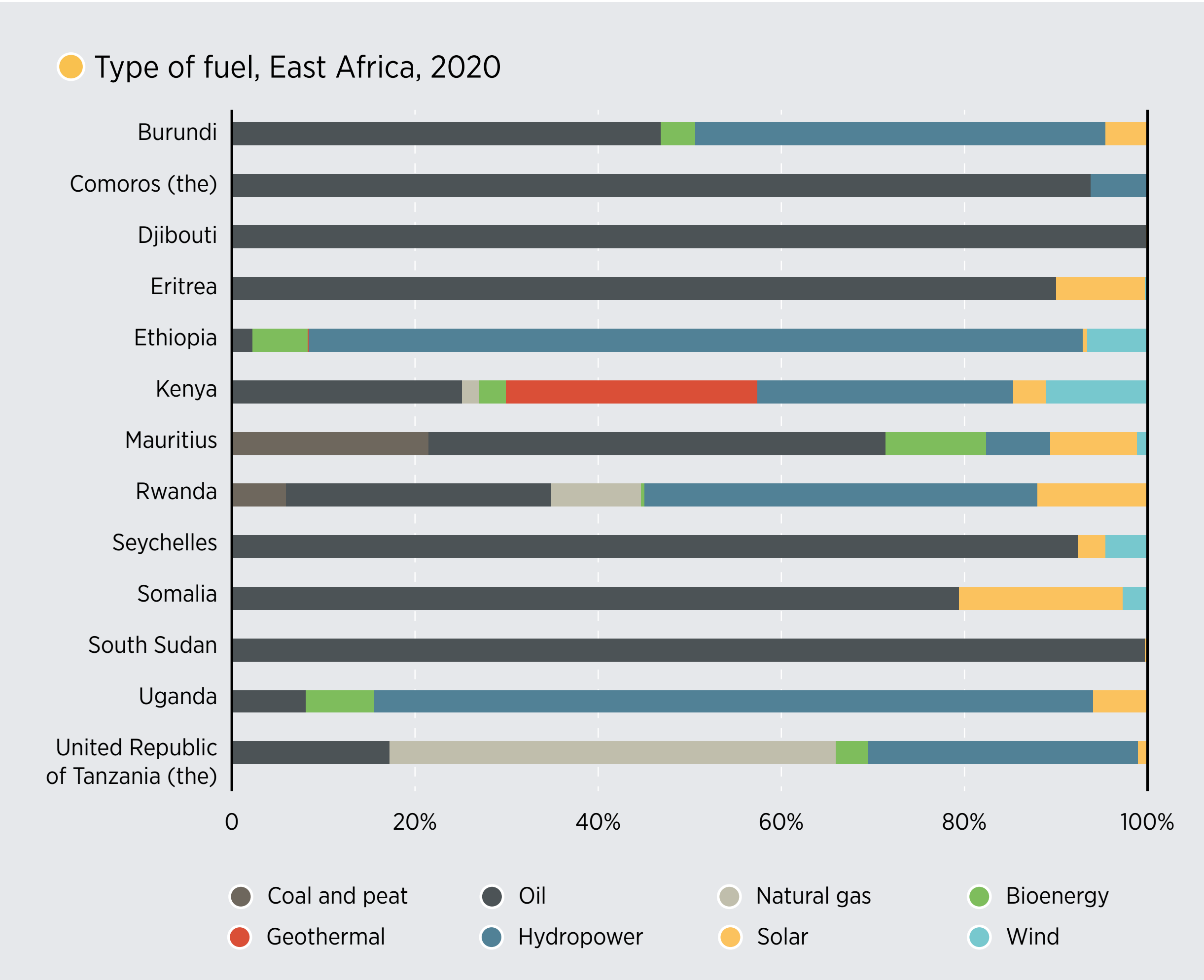




Source: IRENA, 2021a.
Note: TWh = terawatt hour.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

Some of the largest renewable energy projects commissioned in the region are the aforementioned 310 MW Lake Turkana wind plant (2018), the 160 MW Olkaria V geothermal plant (2019), 160.6 MW geothermal plants (combined Olkaria and wellheads in 2014) and 237.8 MW geothermal plants (combined Olkaria and wellheads in 2015), all found in Kenya, as well as the 658.6 MW Gilgel Gibe III hydroelectric plant (2017) in Ethiopia; and the 183.2 MW Isimba hydropower plant in Uganda (2019).

Figure 2.41 Electricity generation capacity in East Africa, by country and source, East Africa, 2020



Source: IRENA, 2021a.

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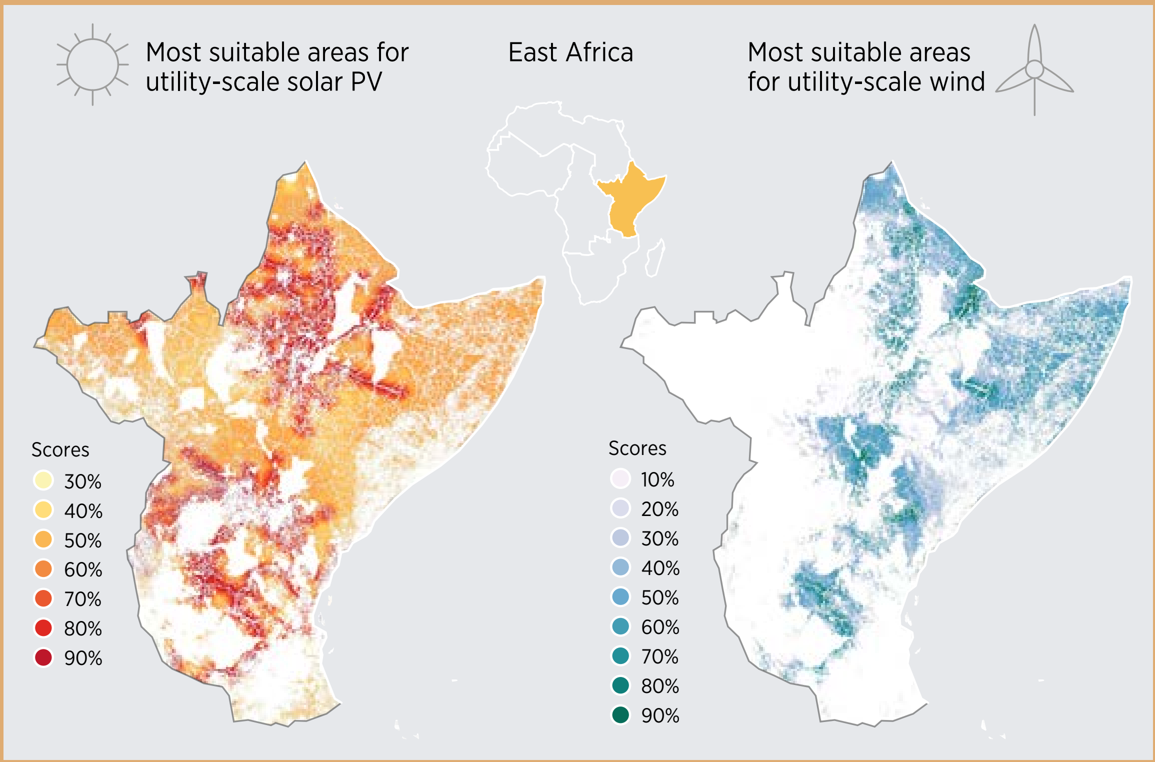
Box 2.4 Renewable energy potential in East Africa

East Africa is also rich in renewable resources. The region has a high annual average solar irradiation of 2100 kilowatt hours per square metre and modest wind speeds averaging at 5.5 metres per second, which can reach up to 8 metres per second in countries such as Ethiopia, Kenya and Somalia. Assuming a land-utilisation factor of 1% for solar and wind, IRENA estimates the technical installable capacities at 1067 gigawatts for solar and 47.2 for wind; the Delft University of Technology estimates the hydropower potential to be 263 gigawatts (Hoes, 2014) with peaks in Ethiopia for solar, wind and hydropower.

Figure 2.42 Most suitable areas in East Africa for utility-scale solar PV and wind



Source: Suitability scoring and areas: IRENA; Base map: UN boundaries.

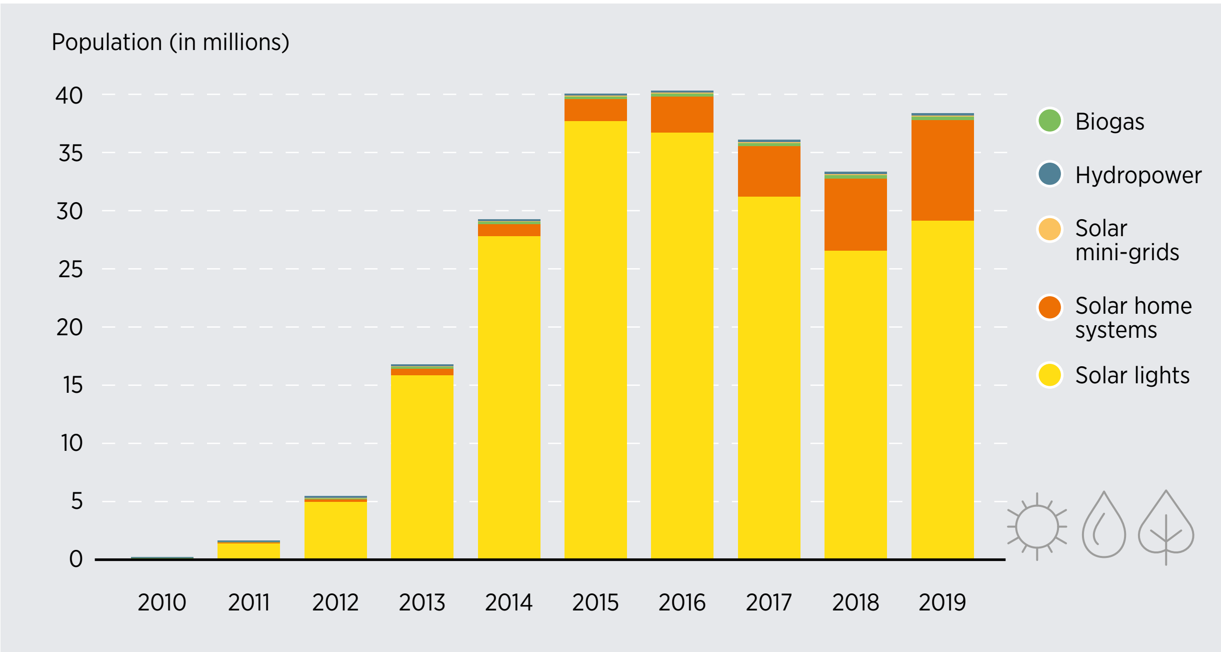
Note: PV= photovoltaic.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

2.4.2. Decentralised electricity access

At the end of 2019, 38.5 million people in East Africa were using decentralised systems (Figure 2.43), four times more than in West Africa and almost eight times more than in Southern Africa. Kenya accounted for 42.4% of the total, followed by Ethiopia (20.5%), Uganda (16%) and the United Republic of Tanzania (9.5%). Solar lights accounted for 75.6% of the decentralised systems, followed by solar home systems (22.5%) (IRENA, 2021b).

Figure 2.43 East African population served by off-grid renewable power, 2009-2019



Source: IRENA, 2021b.

02

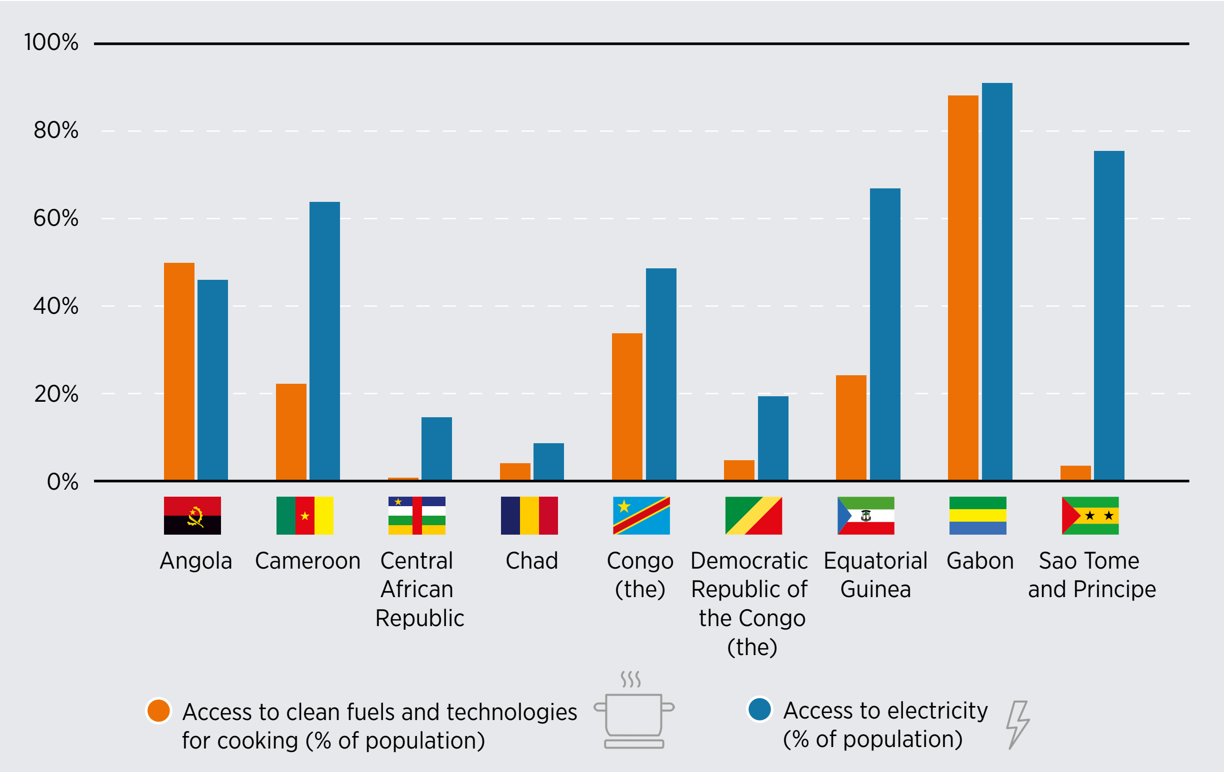
2.5 CENTRAL AFRICA

Central Africa is Africa's smallest energy market. Access to electricity has expanded much more slowly here than in other parts of Africa, with 2019 access to electricity at a low 32%, and clean cooking at 17%. The Central African Republic and Chad have some of Africa's lowest rates of access. Owing to its large population, the Democratic Republic of the Congo has Africa's second-largest population without access to electricity, behind Nigeria.

Angola is Africa's second-largest producer of crude oil and has Africa's third-largest hydropower generation capacity. Even so, as of 2019, Angola had no national electricity grid owing to damage to transmission and distribution networks during the 27-year civil war from 1975 to 2002 (EIA, 2019). By contrast, Gabon boasts one of Sub-Saharan Africa's highest rates of access to modern energy; São Tomé and Príncipe has a high rate of access to electricity (Figure 2.44).

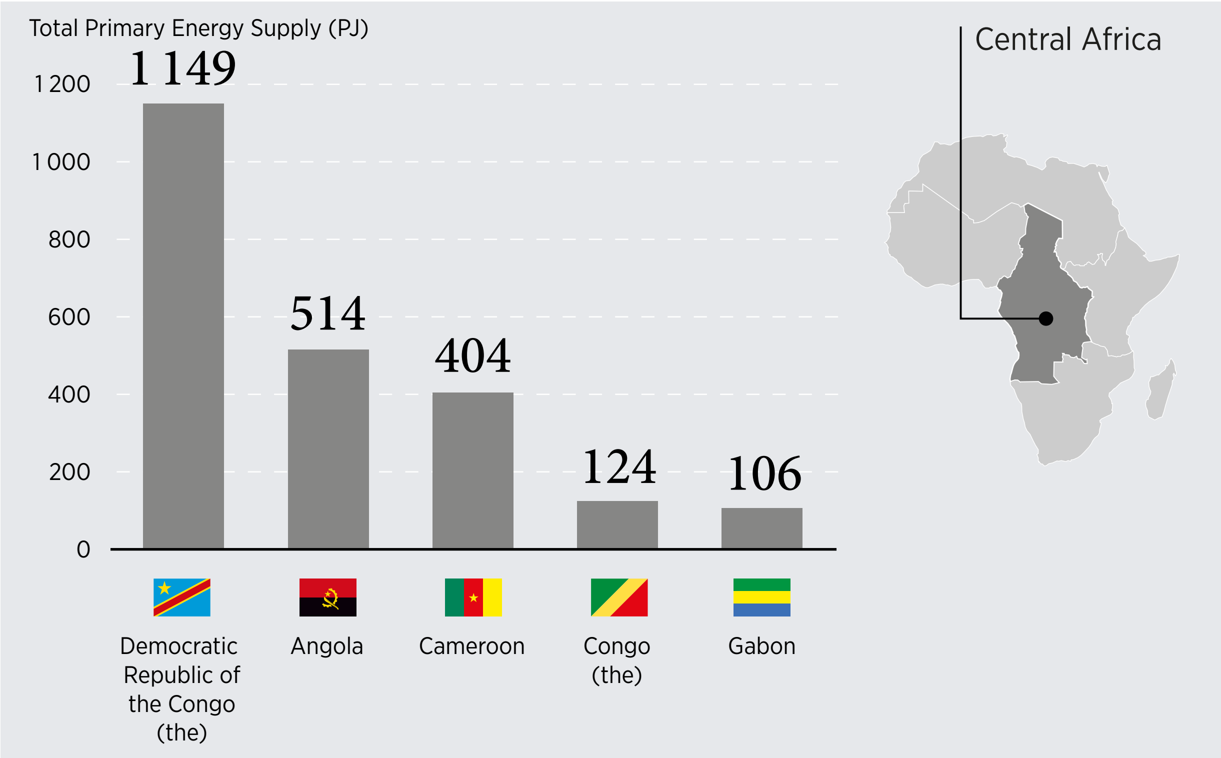
As in West and East Africa, low rates of access to modern energy in Central Africa translate into high biomass use, which remains the largest source of primary energy in the region (Figure 2.46). Hydropower contributes prominently to Central Africa's primary energy supply, accounting for almost two-thirds of the region's power generation capacity (Figures 2.47 and 2.48) and for almost one-fourth of Africa's total installed renewable hydropower generation capacity. The Democratic Republic of the Congo is traversed by the Congo River, Africa's largest, which passes through ten countries before emptying into the Atlantic Ocean. The Democratic Republic of the Congo is Central Africa's largest energy market, accounting for 46% of the region's primary energy supply (Figure 2.45).

Figure 2.44 Access to electricity and clean cooking fuels in Central Africa, 2019



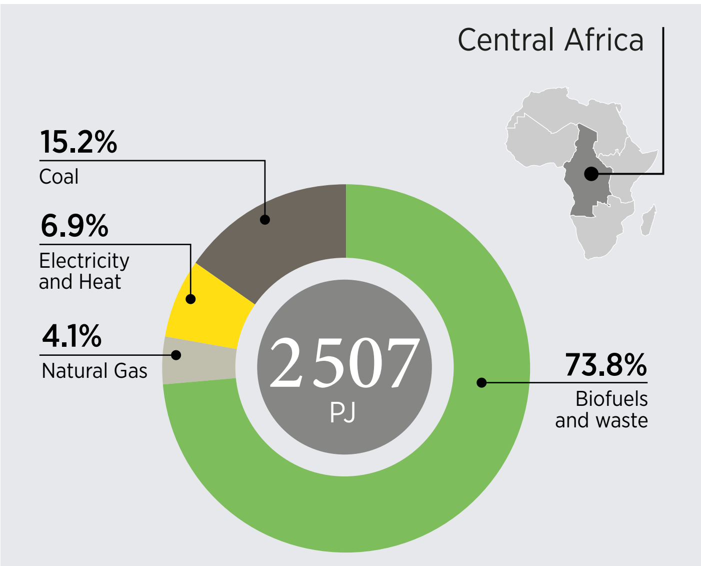
Source: World Bank, 2021; WHO, 2021.

Figure 2.45 Top five Central African countries in total primary energy supply, 2018 (PJ)



Source: UNSD, 2018.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

Figure 2.46 Total primary energy supply in Central Africa, by source, 2018



Source: UNSD, 2018.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

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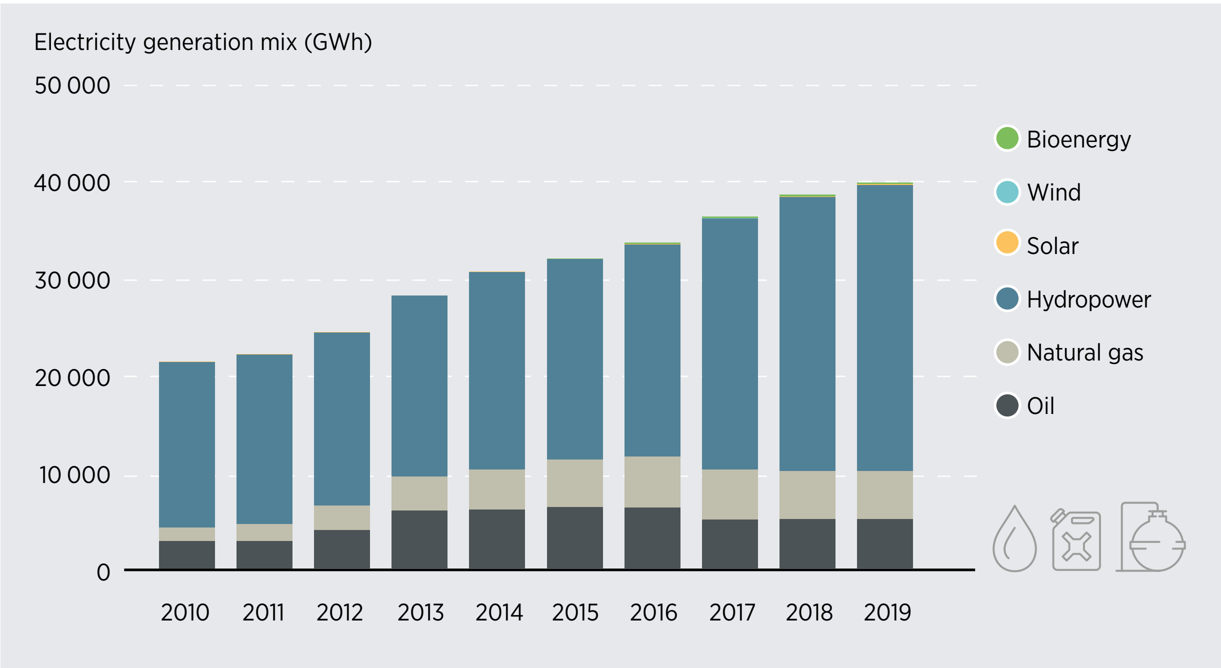
2.5.1 Electricity and renewable energy

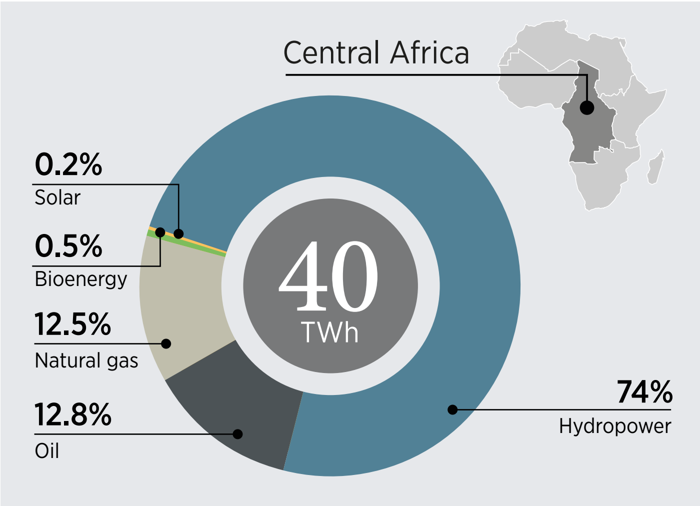
Hydropower plays a significant role in Central Africa's electricity mix. Total renewable generation capacity in Central Africa amounted to 8.1 GW, accounting for 65% of all regional generation at the end of 2020, practically all from hydropower (Figure 2.47). The high shares of added renewable capacity in 2016 (92.9%) and 2019 (95.1%) reflect the completion of the 668 MW and 334 MW Laúca hydroelectric plant units in Angola, and the 150 MW Zongo II hydropower plant in the Democratic Republic of the Congo. Solar energy additions, by contrast, amounted to just 41.1 MW from 2011 to 2020 (IRENA, 2021a). Fossil fuels are currently the main complement to hydropower in Central Africa, with oil-fired power generation accounting for more than half of electricity supply in the Central African Republic and Chad, and as much as 95% in São Tomé and Príncipe (Figure 2.49).

Figure 2.47 Central Africa's electricity generation mix, by source, 2010-2019



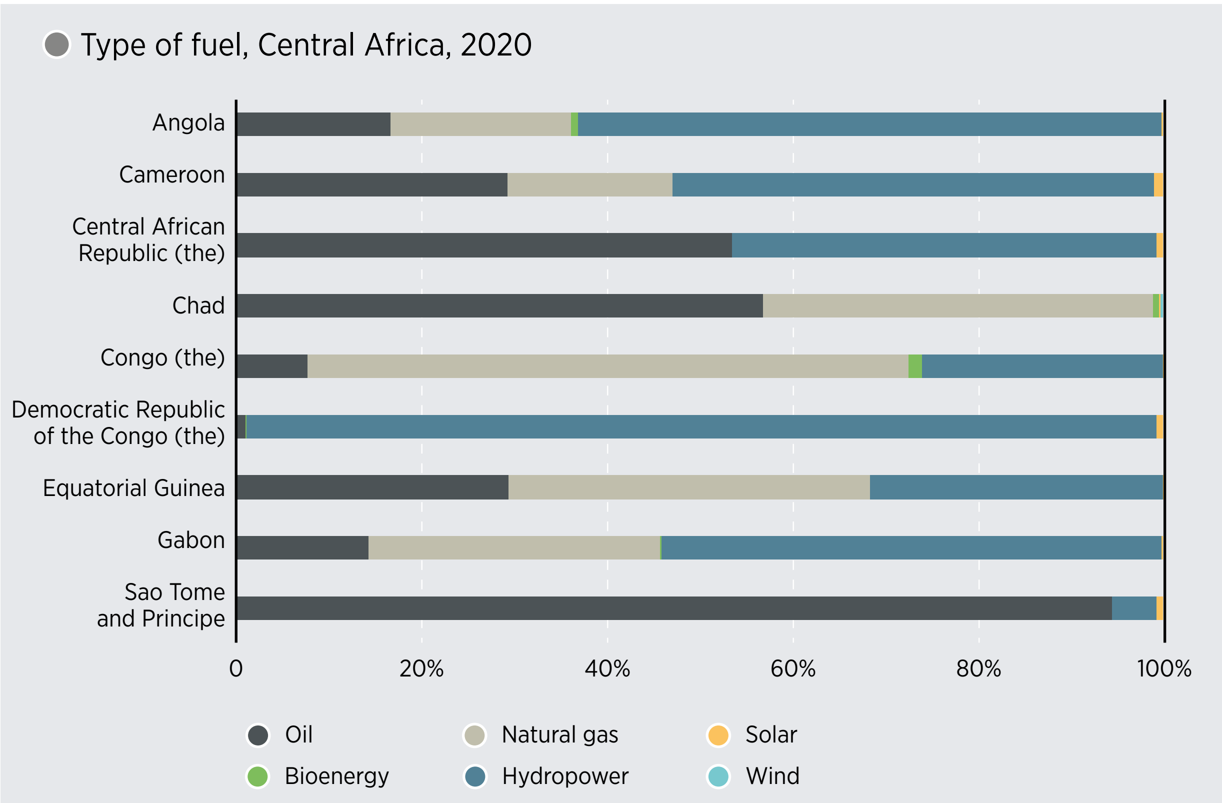
Source: IRENA, 2021a.
Note: GWh = gigawatt hour.

Figure 2.48 Electricity generation in Central Africa, by source, 2019



Source: IRENA, 2021a
Note: TWh = terawatt hour.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

Figure 2.49 Electricity generation capacity in Central Africa, by country and source, 2020



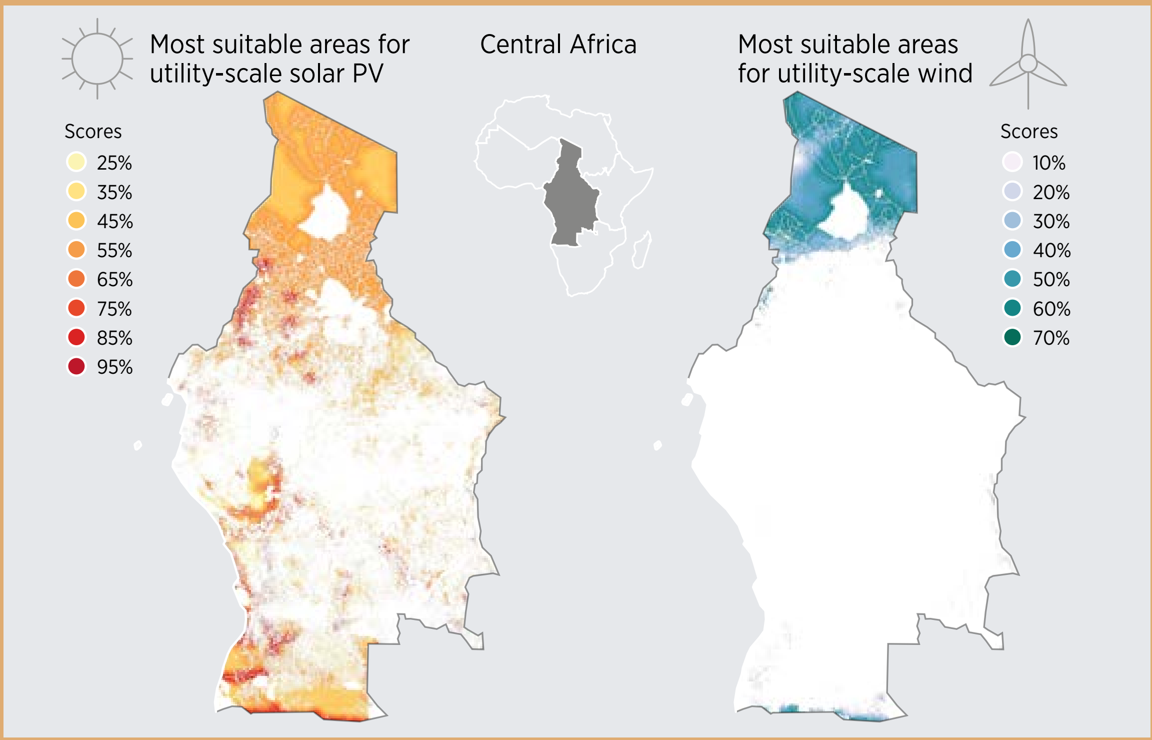
Source: IRENA, 2021a.

02

Box 2.5 Renewable energy potential in Central Africa

Central Africa has abundant renewable resources, especially solar and hydropower. The region has a high annual average solar irradiation of 2000 kilowatt hours per square metre. Wind speeds are low, averaging 4 metres per second in countries such as Angola and Chad, the only feasible locations for wind power development in Central Africa. IRENA estimates the region's technical installable capacities at 1055 gigawatts for solar and 31 for wind. The Delft University of Technology estimates the hydropower potential at 767 GW (Hoes, 2014), with peaks in Angola for solar, Chad for wind and the Democratic Republic of the Congo for hydropower. The region could benefit from further diversification from hydropower to solar and wind.

Figure 2.50 Most suitable areas in Central Africa for utility-scale solar PV and wind



Source: Suitability scoring and areas: IRENA; Base map: UN boundaries.

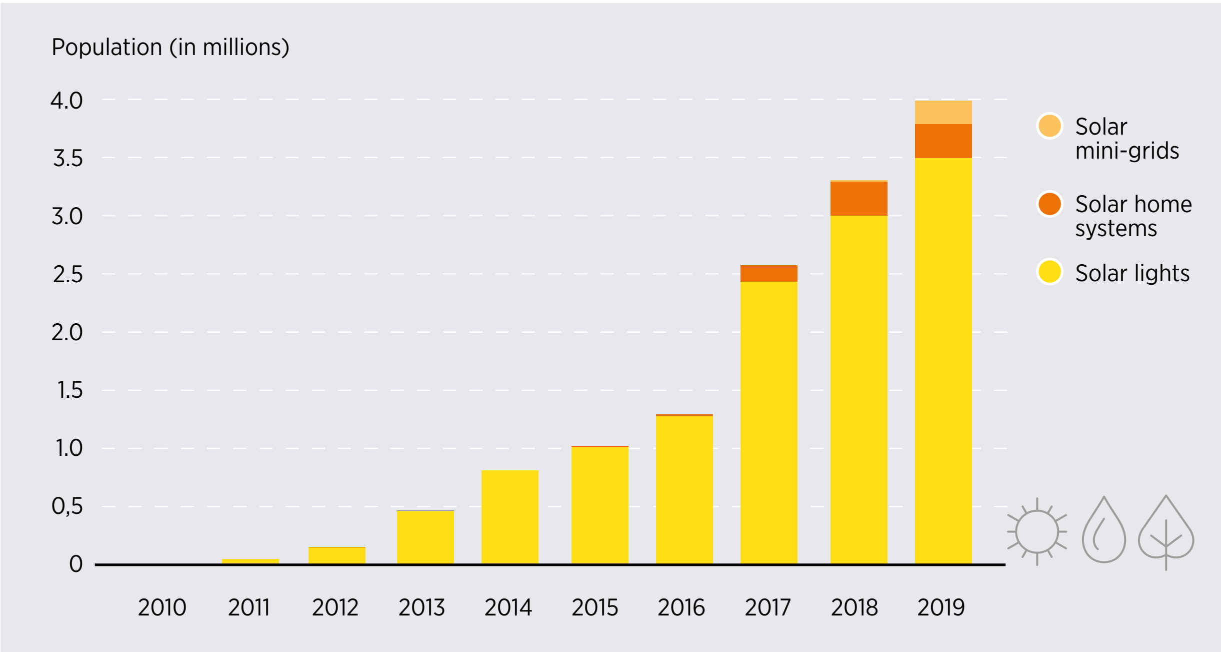
Note: PV = photovoltaic.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

2.5.2. Decentralised electricity access

Access to energy via off-grid systems has not been prevalent in Central Africa compared with other parts of the continent, despite the potential of decentralised solutions to overcome grid limitations and provide access to electricity at comparatively low cost in the Democratic Republic of the Congo and other countries with dispersed population centres (IEA, 2019a). Solar home systems did not contribute at all to energy access until 2018, when 14 300 people were recorded as being served. Solar lighting served almost 3.5 million people in 2019; 294 000 people had access to solar mini-grids in the same year (Figure 2.51).

Figure 2.51 Central African population served by off-grid renewable power, 2009–2019



Source: IRENA, 2021b.

02

2.6 SOUTHERN AFRICA

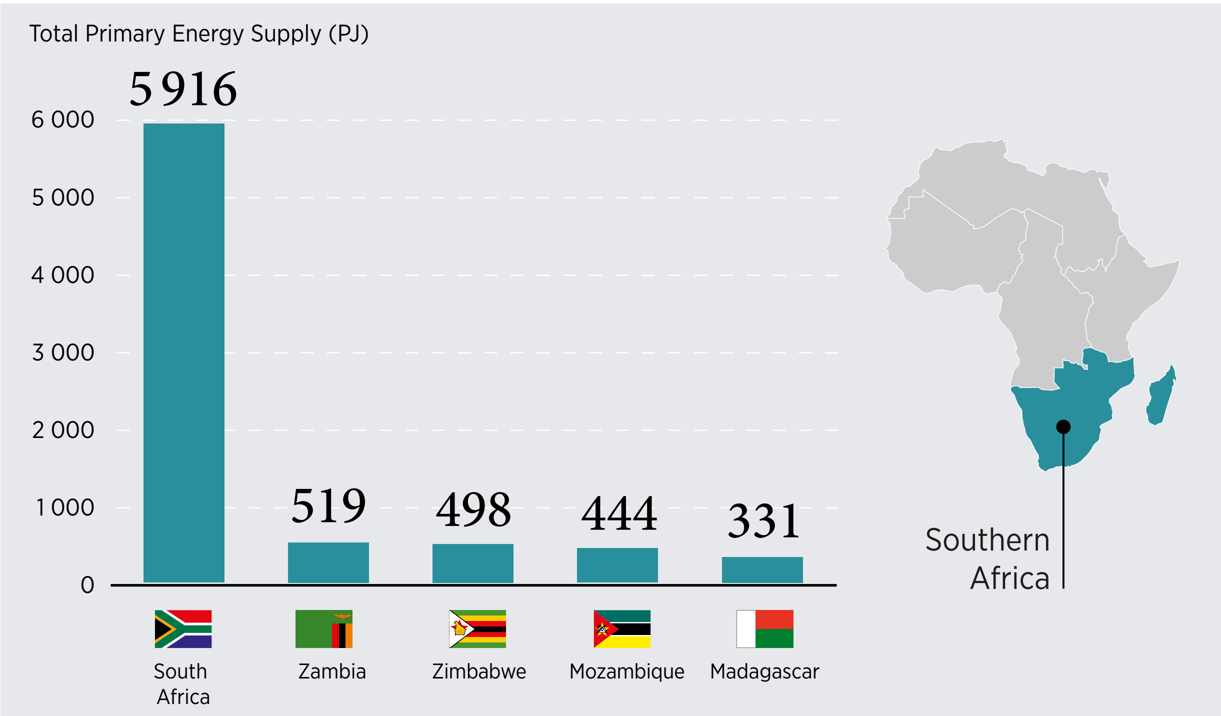
Southern Africa is Africa's third-largest energy market. Its energy landscape is distinctly different from the rest of the continent, primarily because of the overwhelming statistical weight of South Africa, whose energy sector dynamics differ substantially from those of its neighbours.

With 85% electricity access and 86% access to clean cooking, South Africa has among of the highest rates of modern energy access in Sub-Saharan Africa, and far higher than the 49% access rate of the Southern Africa region (Figure 2.53). Two other Southern African countries – Botswana and Eswatini – have achieved electricity access rates of above 70%.

Africa's third-largest economy and its sixth-most-populous country also accounts for almost three-quarters of Southern Africa's primary energy supply (Figure 2.52), and more than three quarters of the total installed electricity generation capacity in the region. South Africa also accounts for fully 73% of the electric-cooking households in Sub-Saharan Africa as a whole (World Bank, 2014). In most of the other countries of Southern Africa, biomass remains important for cooking. South Africa is also notable for having the highest use of electricity in transport, as parts of its rail network are electrified (IEA, 2019a).

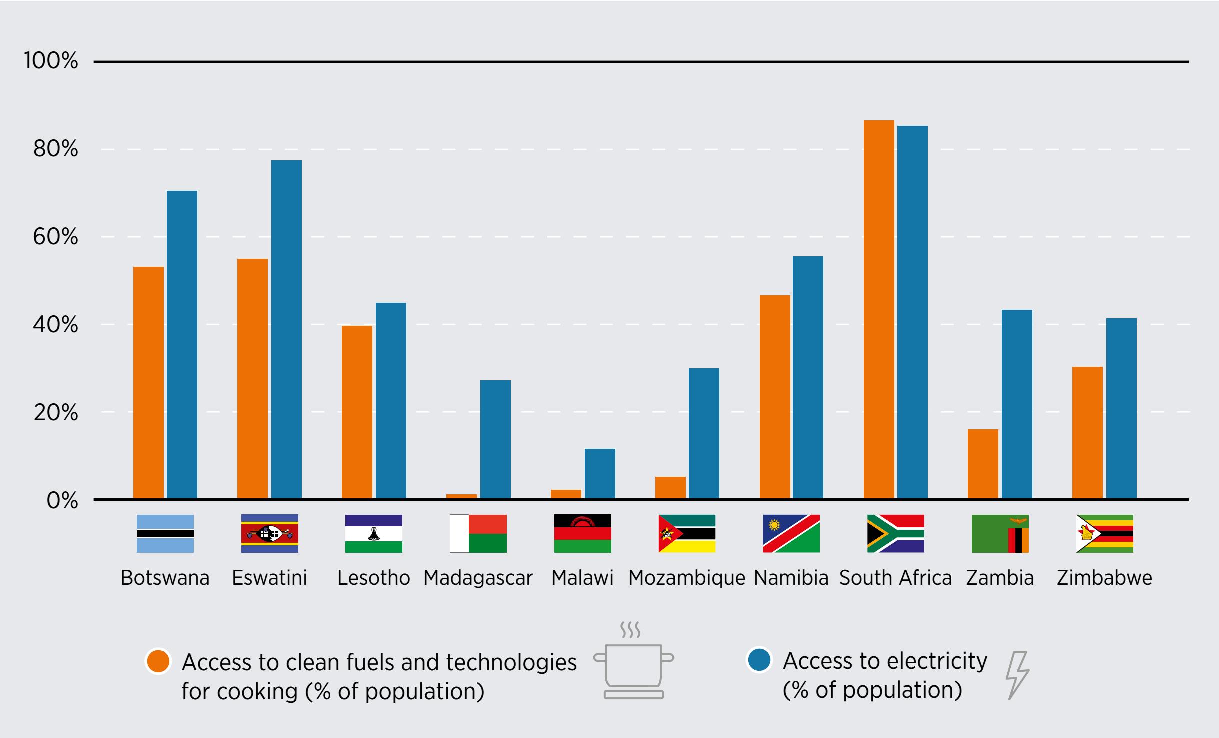
Unlike the rest of Africa, Southern Africa relies on coal as a substantial source of primary energy and electricity generation (Figures 2.54–56), with more than 70% of South Africa's and Botswana's power generation capacity based on coal (Figure 2.57). South Africa's large mines supply 96% of the region's coal. The country has experienced power crises since 2008 because of maintenance problems at power stations operated by Eskom, South Africa's public electricity utility, and underinvestment in power infrastructure. The utility has resorted to load shedding exercises since 2016, accounting for the decrease in generation (BBC, 2019).

Figure 2.52 Top five Southern African countries in total primary energy supply, 2018



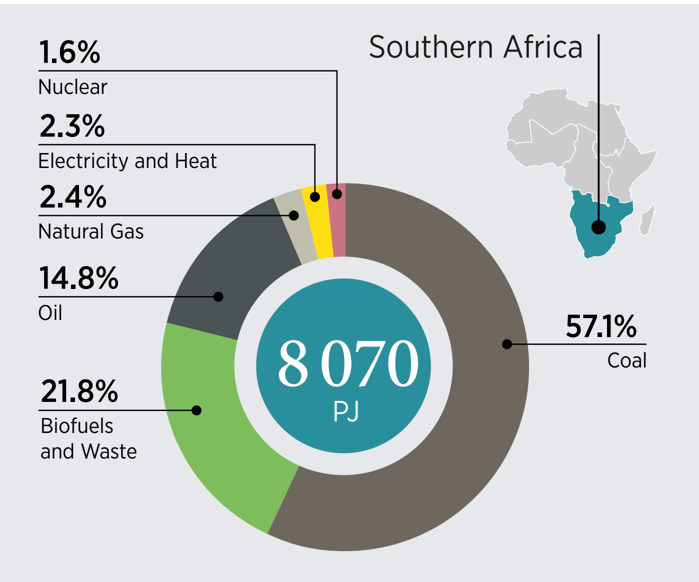
Source: UNSD, 2018.
Note: PJ = petajoule.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

Figure 2.53 Access to electricity and clean cooking fuels in Southern Africa, 2019



Source: World Bank, 2021; WHO, 2021.

Figure 2.54 Total primary energy supply in Southern Africa, by source, 2018



Source: UNSD, 2018.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

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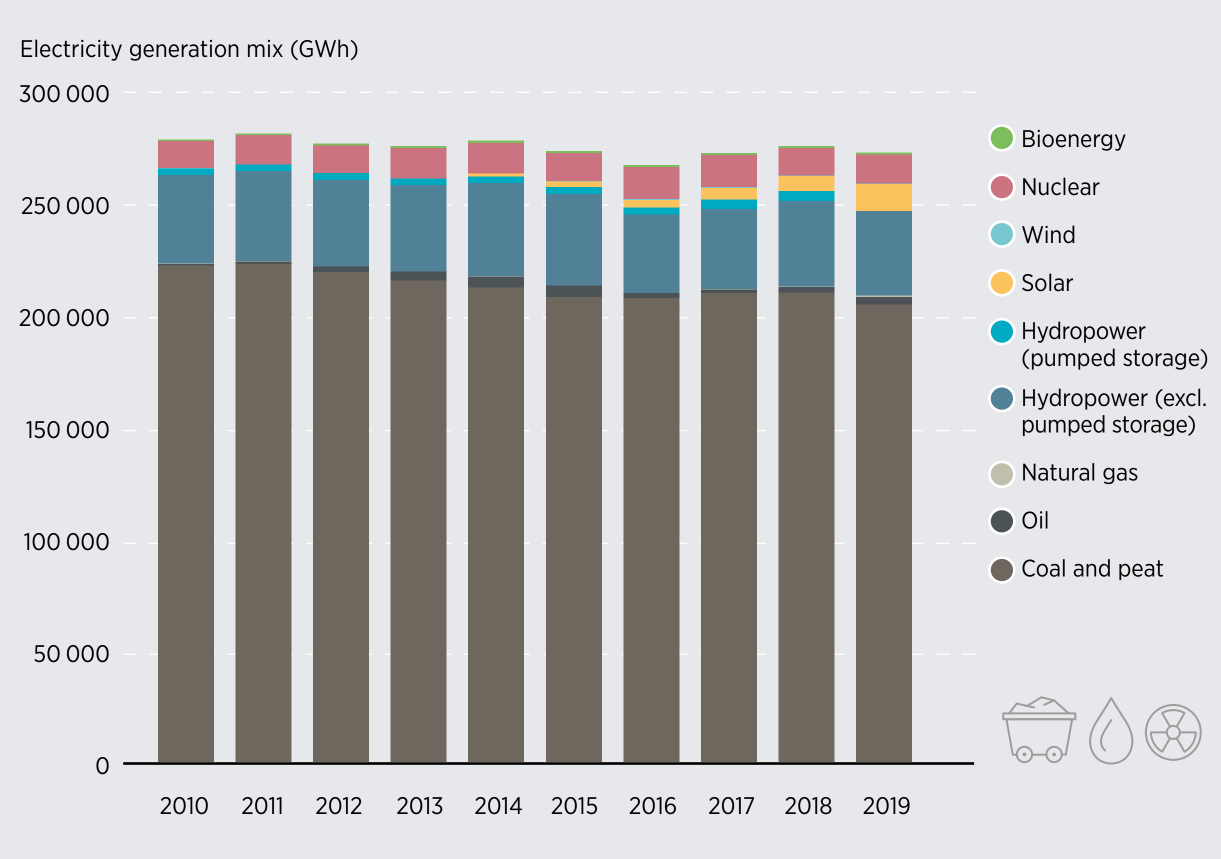
Figure 2.55 Electricity generation mix in Southern Africa, by source, 2010-2019



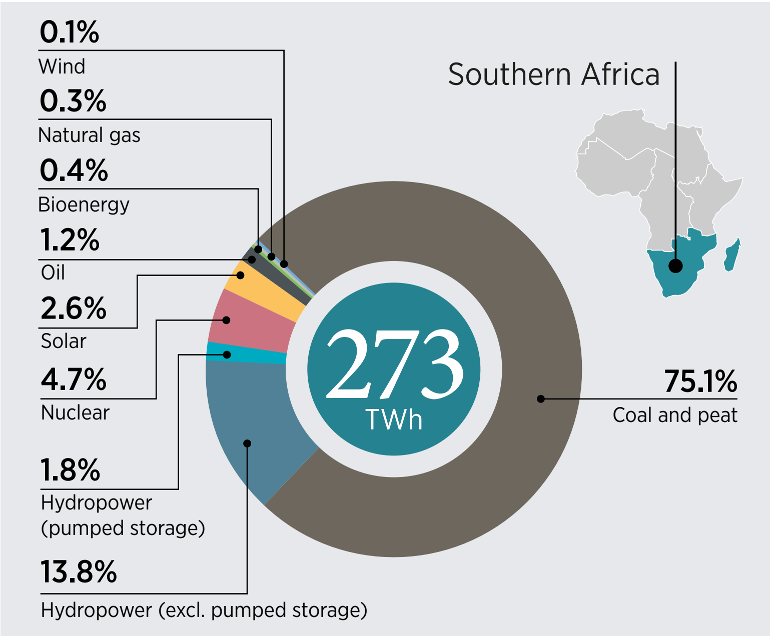
Source: IRENA, 2021a.
Note: GWh = gigawatt hour.

2.6.1 Electricity and renewable energy

Renewable energy plays a substantial role in Southern Africa in the form of household fuel (biomass) and through hydropower and solar energy for the generation of electricity. Southern Africa accounts for around a quarter of the continent's hydropower capacity, 41% of installed wind power and over 60% of the continent's grid-linked solar power generation.[5] The Zambezi River provides hydropower to Zambia, Zimbabwe and Mozambique; electricity generated on the Zambezi is also exported to South Africa. South Africa is Africa's largest solar producer, with a total capacity of 5.99 GW in 2020. It is also the only African country using nuclear energy. In total, 17% (9.6 GW) of Southern Africa's electricity generation capacity in 2020 was based on renewables, primarily solar power; this share is much higher in Lesotho, Malawi, Mozambique and Zambia than elsewhere in the region (Figure 2.57).

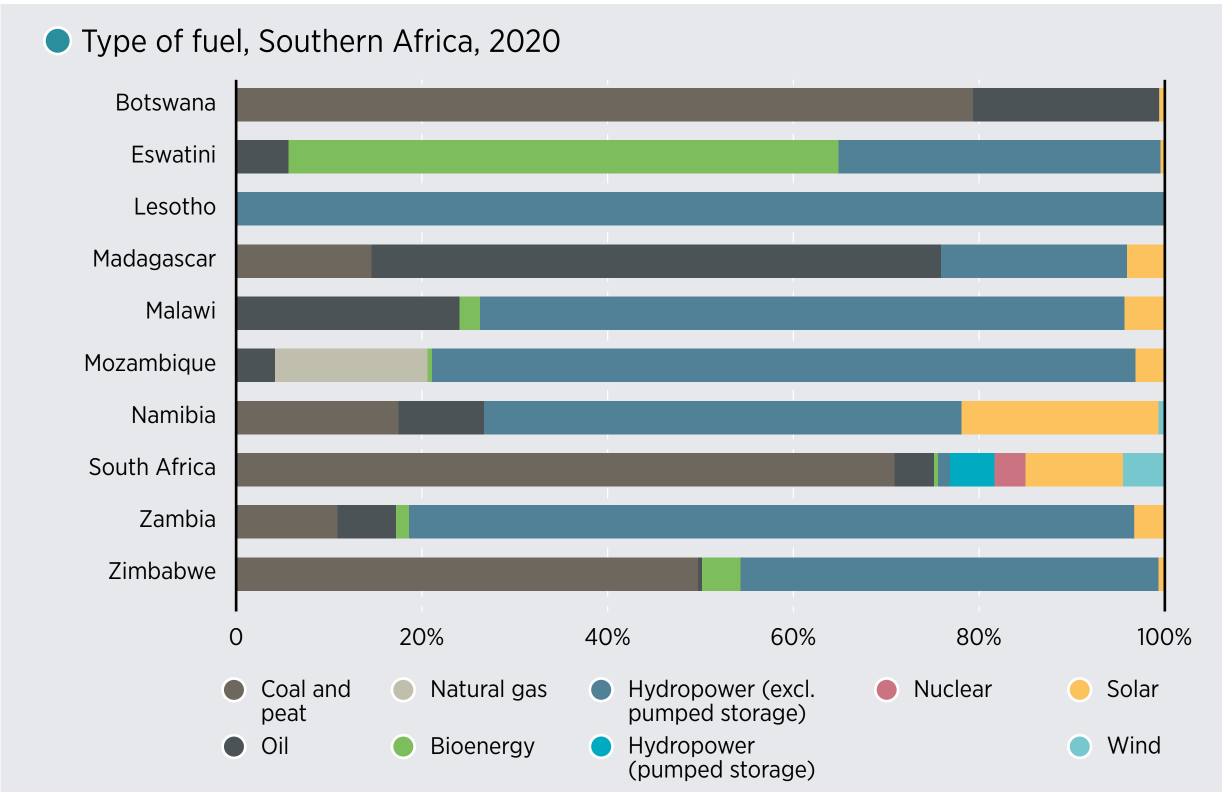
5 IRENA calculations based on data from IRENA (2021a).

Figure 2.56 Electricity generation in Southern Africa, by source, 2019



Source: IRENA, 2021a.
Note: TWh = terawatt hour.
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

Figure 2.57 Electricity generation capacity in Southern Africa, by country and source, 2020



Source: IRENA, 2021a.

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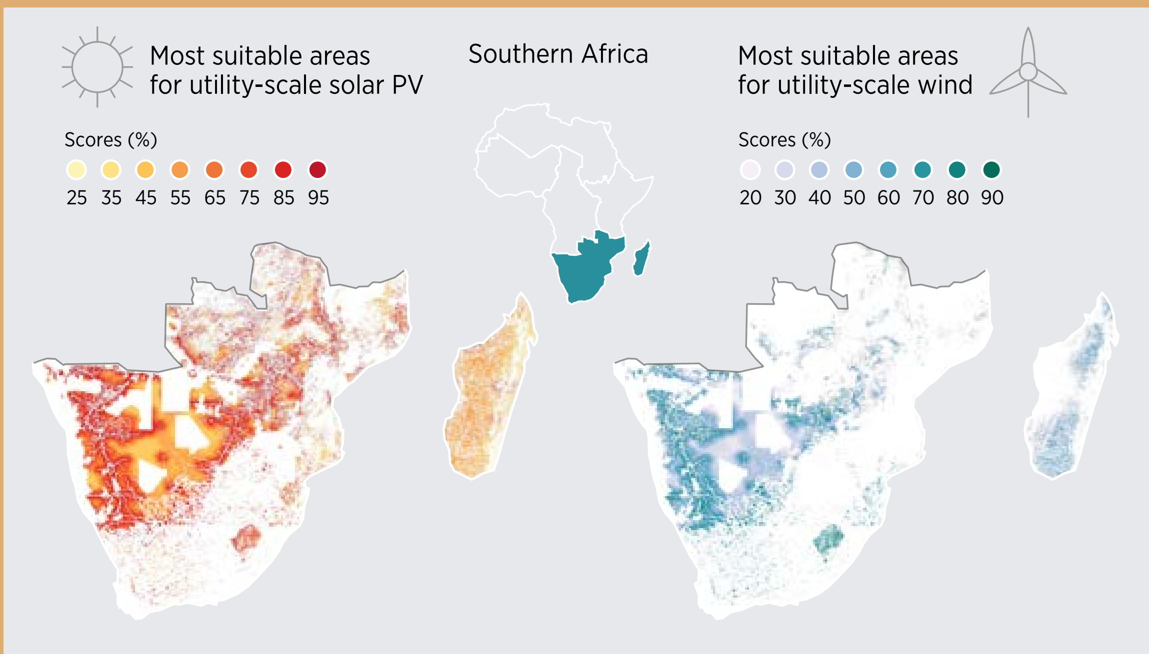
Box 2.6 Renewable energy potential in Southern Africa

Southern Africa possesses substantial renewable resources. The region has a high annual average irradiation of 2 160 kilowatt hour per square metre and moderate wind speeds averaging 6.2 metres per second – and 8.5 metres per second in Botswana and Namibia. IRENA estimates technical installable capacities of 908 gigawatts for solar and 53 for wind, assuming a 1% land-utilisation factor. The Delft University of Technology estimates the region's hydropower potential to be 447 gigawatts (Hoes, 2014), with peaks in Namibia for solar and wind, and Zambia for hydropower.

Figure 2.58 Most suitable areas in Southern Africa for utility-scale solar PV and wind



Source: Suitability scoring and areas: IRENA; Base map: UN boundaries.

Note: PV= photovoltaic.

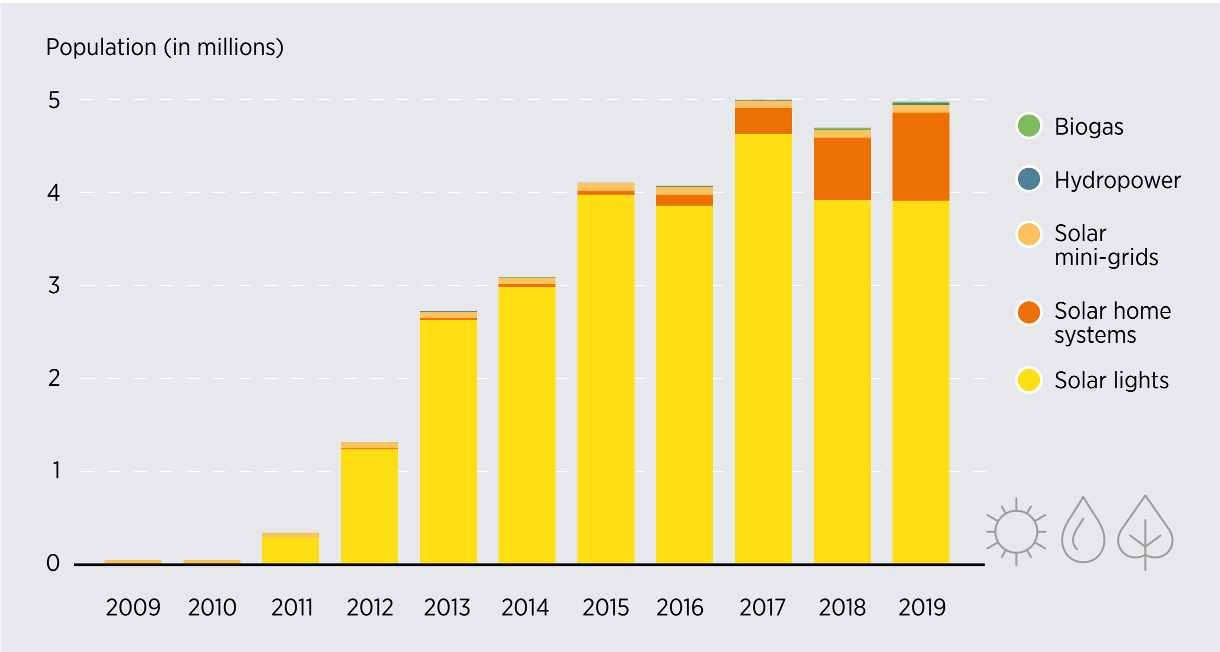
Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

Notable renewable capacity additions in recent years include the 360 MW Kariba North Bank hydropower extension (2013) in Zambia; the 999 MW Ingula 1, 2 and 4 (2016) and 333 MW Ingula 3 (2017) pumped storage facilities in South Africa; a combined total of 500 MW of concentrated solar power (2014-2019) and a combined total of 5.5 GW solar PV (2013-2020) in South Africa; and a combined total of 2.6 GW wind energy (2013-2017) in South Africa (IRENA, 2021a).

2.6.2. Decentralised electricity access

Some 5 million people in Southern Africa used decentralised systems at the end of 2019, most of them in Zambia, Malawi and Madagascar. Solar lights served 3.9 million people in 2019, fewer than in 2017. Access to solar home systems, by contrast, grew during the same period; they served 951 200 people in 2019 (Figure 2.59; IRENA, 2021b).

Figure 2.59 Southern African population served by off-grid renewable power, 2009-2019



Source: IRENA, 2021b.

02 CONCLUSION

Africa's energy needs are growing fast, raising the pressure to invest in infrastructure and energy technologies that can power social, economic and industrial growth sustainably over the coming decades. At present, among the renewable sources of energy, only hydropower has been extensively developed in Africa. At present, it remains the only low-carbon energy technology contributing significantly to electricity generation in Africa. But great potential exists for a range of renewable energy sources to power a growing share of the continent's energy needs. Solar power is already the fastest-growing renewable energy source in a continent ideally suited for solar power generation. Wind and geothermal energy resources, although more unequally distributed across the continent, can add further to the renewable energy mix in several countries, while bioenergy could also play a more significant role.

Africa's abundance of renewable resources positions it to transition successfully from non-renewable to renewable power sources. Yet despite that potential, growth in modern renewable energy supply is still far from what it could be. The following chapters explore in detail some of the factors underlying this state of affairs, as well as policies to accelerate the uptake of renewable energy uptake. Chapter 3 explores investment and finance options; Chapter 4, enabling policy environments; Chapter 5, the energy transition; and Chapter 6, the vital question of access to modern forms of energy.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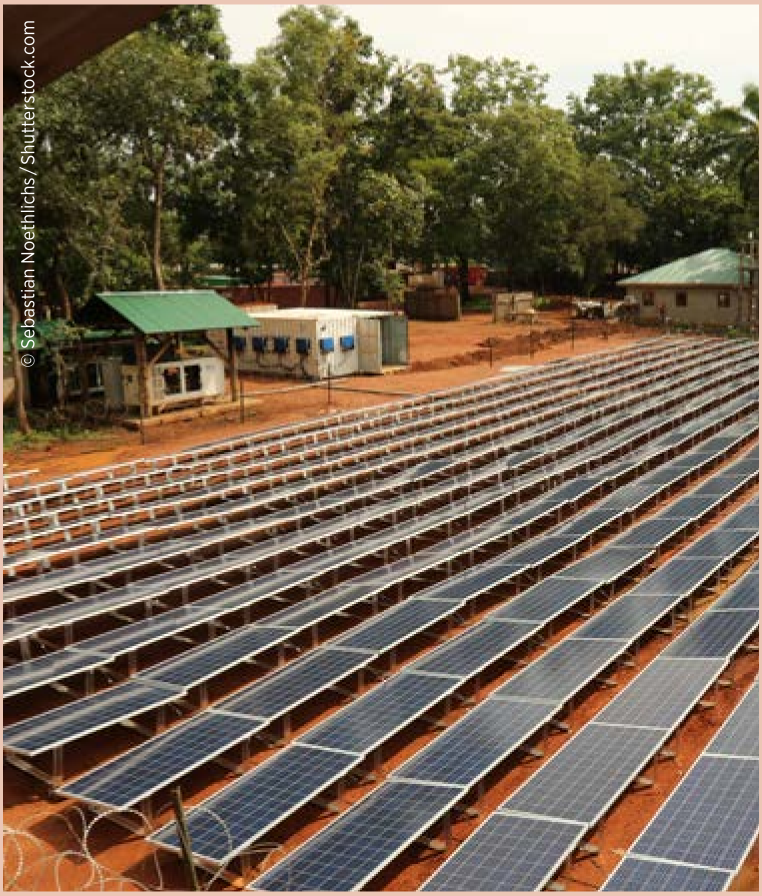
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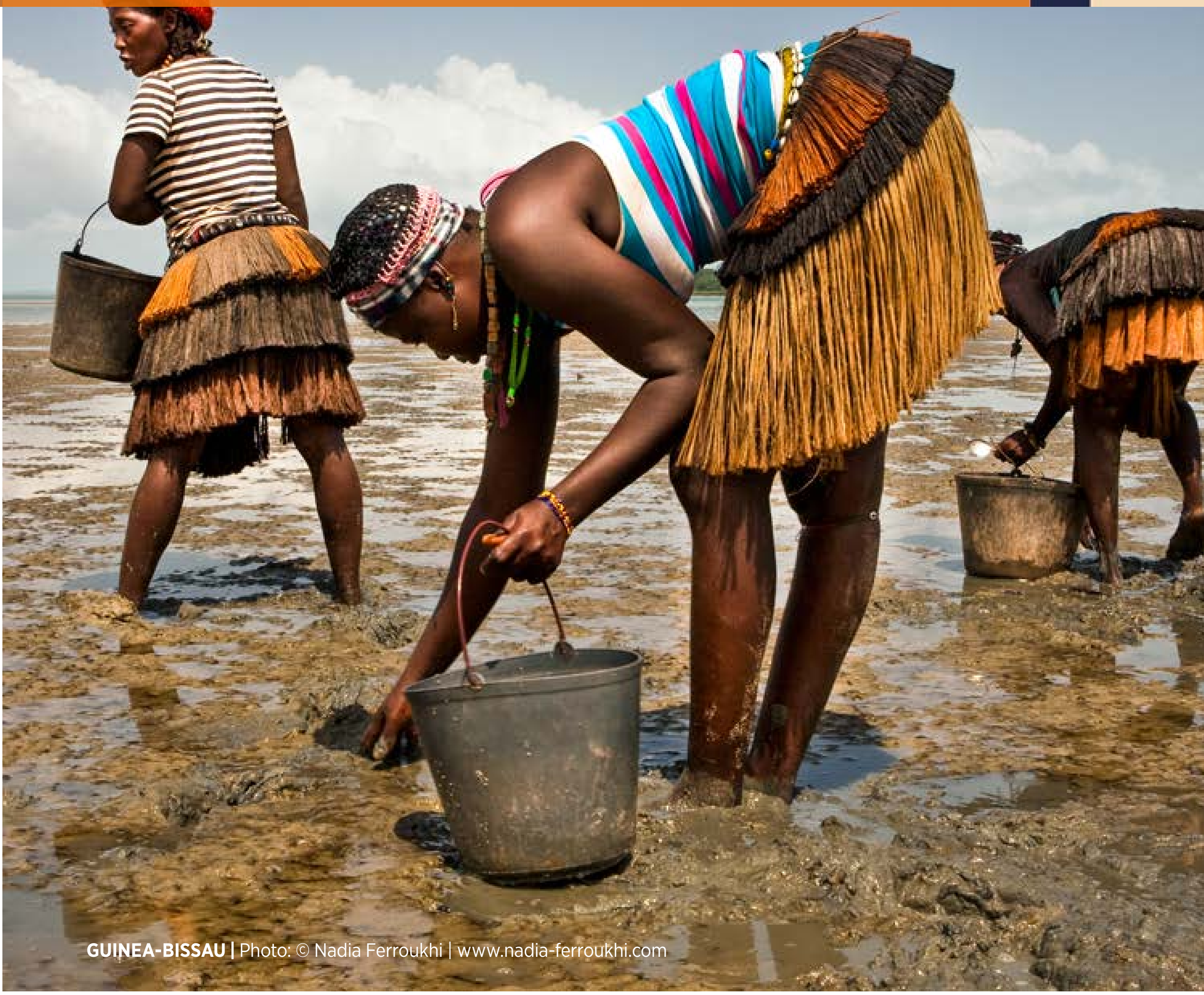
RENEWABLE ENERGY FINANCE IN AFRICA



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- **Trends** in renewable energy investment in Africa
- **Sources of funding** for renewables in Africa
- Managing risks and **mobilising capital**

Over the past two decades, investment in renewable energy grew rapidly. Yet of the USD 2.8 trillion invested globally between 2000 and 2020, only 2% went to Africa (Table 3.1), despite the continent's enormous potential to generate energy from renewable sources and its huge need to bring modern energy services to the billions of people still lacking access to electricity and clean cooking (see Chapter 6 on access). The COVID-19 pandemic could further widen the gaps in investment and access by slowing or even partially reversing the limited progress made to date. Going forward, unprecedented levels of investment will be required to put Africa on a path toward achieving the Sustainable Development Goals (SDGs), particularly SDG 7 on access to affordable, reliable, sustainable and modern energy for all. This chapter surveys trends in renewable energy investment in Africa, sources of financing in the five regions, and measures and tools to manage risks and attract further investments in all end uses.

Overall renewable energy investment – both public and private – is discussed in section 3.1. The data, which come from Bloomberg New Energy Finance (BNEF), exclude investments in large hydropower (>50 megawatts [MW]). Sources of financing are analysed in section 3.2. Public investments are covered in section 3.2.1 using data from the International Renewable Energy Agency and the Organisation for Economic Co-operation and Development (IRENA and OECD, 2021). Unlike the BNEF data, these include large hydropower, as well as capacity building, technical assistance and other non-technological investments. Investments in independent power producers (IPPs) through private sources and from development finance institutions (DFIs) are reviewed in sections 3.2.2 and 3.2.3 based on data from the Power Futures Lab (2021). Investments in off-grid renewable energy (section 3.1.2) are based on data from Wood Mackenzie (2021). Owing to the different methodologies and methods of the data providers, trends are examined without making comparisons between the various data sources.

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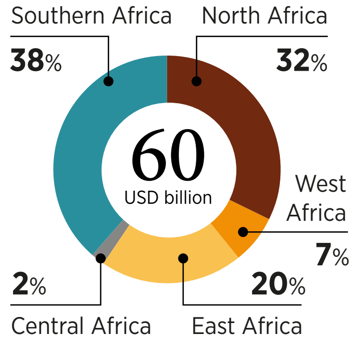
Table 3.1 Overall renewable energy investment in Africa and globally, 2000-2020

Overall renewable energy investment in Africa and globally, 2000-2020 (USD Billions, current 2020)

	2000-2009	2010-2020	Cumulative 2000-20
Global	587 USD billion	2 254 USD billion	2 841 USD billion
Africa	4.8 USD billion (0.8% of global investment)	55 USD billion (2.4% of global investment)	60 USD billion (2% of global investment)
North Africa	1.9 USD billion	17.5 USD billion	
West Africa	0.5 USD billion	3.9 USD billion	
East Africa	2.0 USD billion	9.7 USD billion	
Central Africa	0	1.3 USD billion	
Southern Africa	0.3 USD billion	22.4 USD billion	



Source: BNEF (2021c).
Note: BNEF data exclude investments in large hydropower (i.e. greater than 50 megawatts).

3.1 TRENDS IN RENEWABLE ENERGY INVESTMENT IN AFRICA

Between 2000 and 2020, Africa attracted almost USD 60 billion in investment in renewables (excluding large hydropower).[1] Over 90% (some USD 55 billion) was committed between 2010 and 2020, concentrated in a handful of countries. During this period, renewables investment in Africa grew at a remarkable average growth rate of 96% per year – compared to 15% in Asia-Oceania (excluding China and India) and 7% globally. Although investment in Africa is growing at a higher rate than in other regions, the cumulative sum of renewable energy investment makes up just 2% of global investment over the two decades.

This section starts with an overview of renewable energy investment trends in Africa between 2000 and 2020, excluding large hydropower above 50 MW. It then dives into investments in off-grid solutions, given their role in achieving universal energy access on the continent. Finally, the section analyses the impacts of COVID-19 on investments in renewables.

3.1.1 Renewable energy investment trends in Africa

Investments in the 2000s were generally flat. The 2010s, by contrast, saw increased investment driven by structured renewable energy procurement programmes in the power sector; such as feed-in

1 The analysis in this section relies on BNEF data on private and public investments in renewable energy, which exclude large hydropower above 50 MW. Investments are expressed as commitments recorded at the time of financial close.

tariffs and auctions supported by credit-enhancement structures provided by DFIs and multilateral development banks (MDBs). This is consistent with global trends, as the deployment of solar power, in particular, began to take off after 2010.

In the 2000-2009 period, renewable energy investments in Africa averaged less than USD 0.5 billion annually. In 2010-2020, the average increased ten-fold to reach USD 5 billion (Figure 3.1).

In 2010, there was an increase to around USD 3 billion/ year, mainly driven by investments in geothermal exceeding USD 1 billion in Kenya and in wind totalling USD 885 million in Egypt. After 2012, average annual investments exceeded USD 5.5 billion, as investments in solar energy started flowing, and investments in wind increased considerably, although with large fluctuations year to year (Figure 3.1).

Annual investments peaked in 2018, reaching an all-time-high of USD 10.3 billion before dropping to an annual average of USD 3.1 billion in 2019-2020. The peak in 2018 was driven by large investments in solar photovoltaic (PV), solar thermal and wind, accelerated by renewable energy procurement programmes. Solar investment in 2018 totalled USD 5.2 billion, with at least 3 gigawatts (GW) of new capacity added in 21 countries. Almost half of that investment went into Morocco (AfDB, 2019a). This geographic concentration will be examined in more detail below. Wind investments in 2018 were valued at USD 4.2 billion; 18 new windfarms totalling at least 1.3 GW were concentrated in six countries, South Africa the first among them at USD 2.6 billion. That same year, more than USD 700 million targeted geothermal in Djibouti and Kenya.

Solar thermal investments – mainly concentrated solar power (CSP) – were focused in Morocco and South Africa, especially between 2012 and 2018. They included a USD 2.4 billion investment in Morocco's Noor PV-CSP hybrid plant (about 300-390 MW in capacity) in Midelt in 2018. Previously, following the financial close of Morocco's Noor CSP project (160 MW) in Ouarzazate in 2012, the project was expanded to an additional 350 MW of generation capacity through an investment of USD 2.1 billion in 2015 (BNEF, 2021c). In the same year, South Africa's Karoshoek CSP Plant (100 MW), worth USD 1.1 billion, reached financial close (ESI Africa, 2018; BNEF, 2021c).

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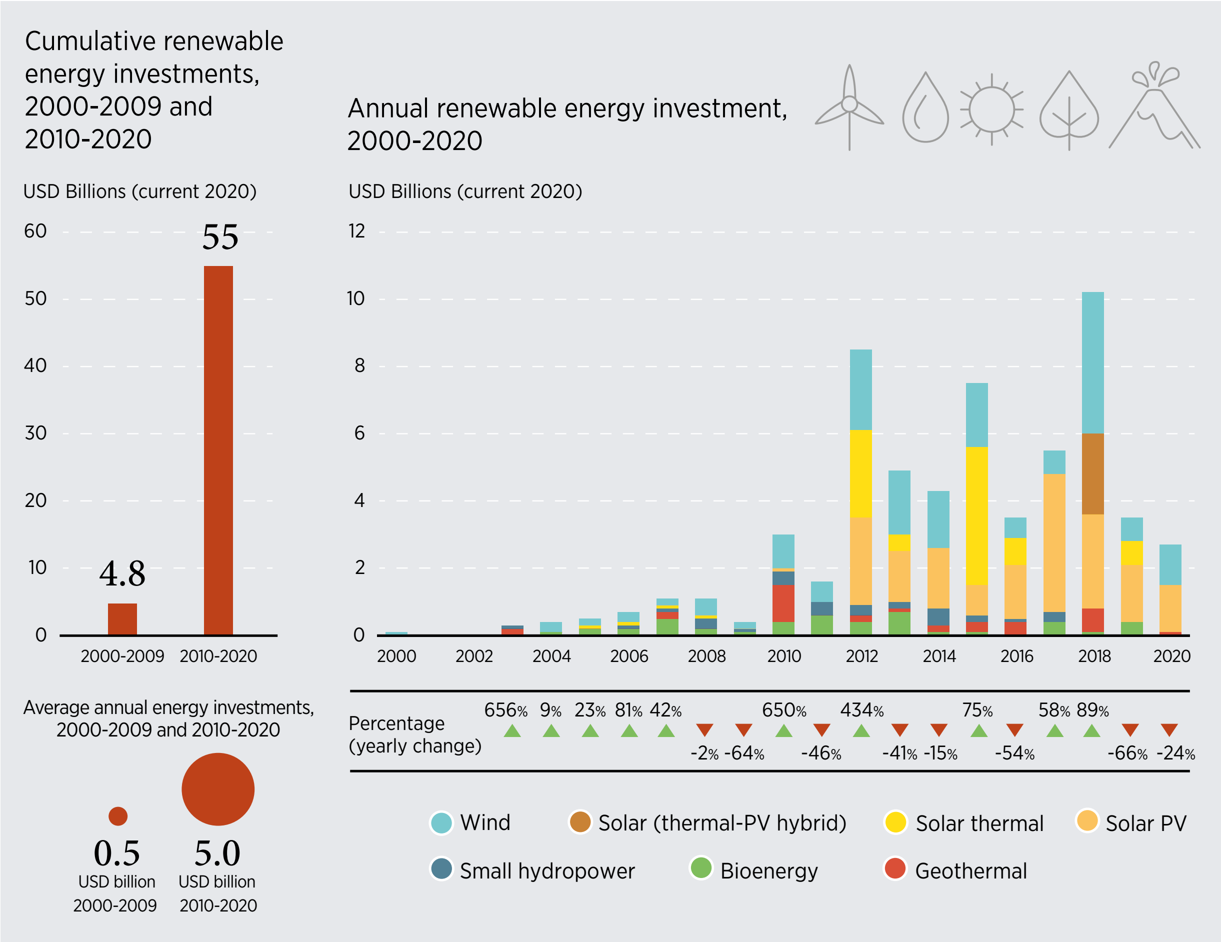
Figure 3.1 Cumulative and annual renewable energy investments in Africa by technology (excluding large hydropower), 2000-2020

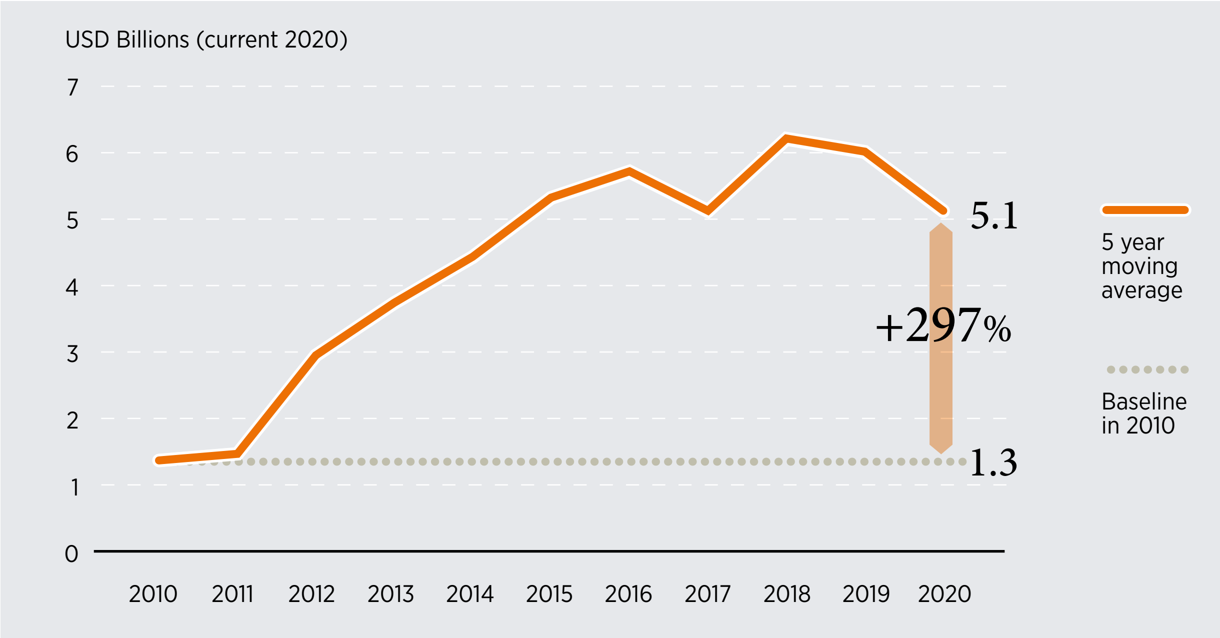


Source: Based on BNEF (2021c).
Note: BNEF data exclude investments in large hydropower (greater than 50 MW).

The decline in 2019 took the form of an 83% drop in wind and 55% drop in solar. Such dips are not uncommon, as renewable energy investments have typically followed a sinusoidal pattern (*i.e.* a repeated cycle of rising annual investments that hit a peak and fall again). The dips in 2016-2017 and 2019-2020 followed years in which one or more large projects reached financial close and had a massive impact on volume. These periods thus correspond to periods in which fewer large-scale projects contracted through structured procurement programmes were billed for financial close. The impacts of the COVID-19 pandemic on the capital market in 2020 further suppressed investments (section 3.1.3).

Nonetheless, a five-year moving average of investments, as shown in Figure 3.2 indicates an upward trend over time. Overall, average investments in the 2010s increased almost four-fold, from USD 1.3 billion to USD 5.1 billion.

Figure 3.2 Renewable energy investments in Africa based on the five-year moving average against 2010 baseline, 2010-2020



Source: Based on BNEF (2021c).
Note: BNEF data exclude investments in large hydropower (i.e. greater than 50 MW).

Investments by technology

Solar PV attracted USD 18 billion between 2010 and 2020 representing 33% of cumulative investments in Africa over that period, followed by onshore wind (31%, or USD 17 billion) and solar thermal (16%, or USD 9 billion). The share of investments going to solar technologies jumped from 2% in 2011 to 62% in 2012 and has since remained between 40% and 80%, progressively displacing bioenergy and small hydropower (Figure 3.3).

Compared with solar and onshore wind, investment in bioenergy, geothermal and small hydropower remained low, at around USD 200-300 million yearly during 2010-2020. Geothermal investments were concentrated in Kenya, with a few recent investments in Djibouti, Ethiopia and Zambia. Yet Africa accounted for 14% of global investments in geothermal during 2010-2020, as opposed to a 7% share for onshore wind and 3% for solar PV.

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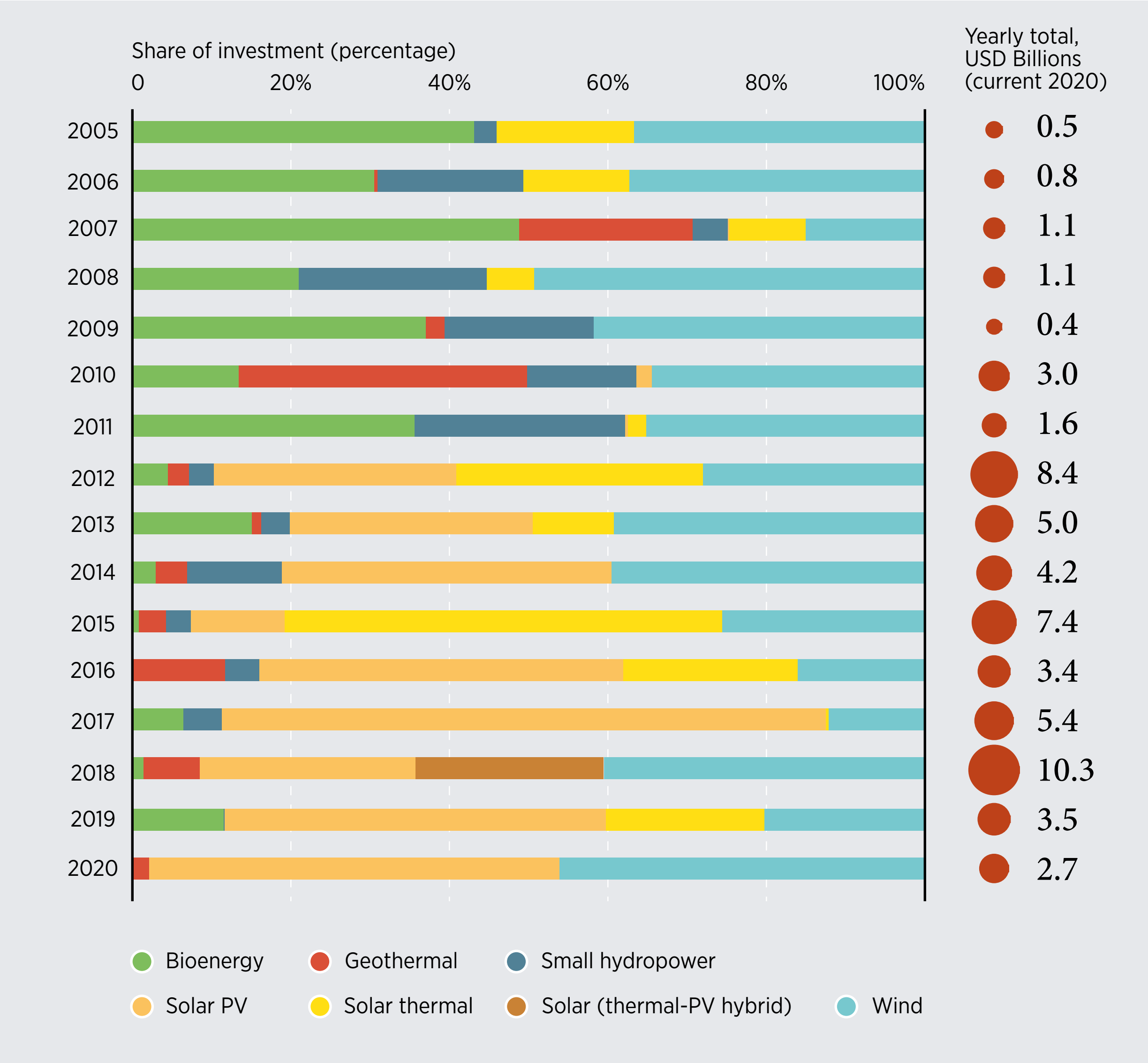
Figure 3.3 Shares of renewable energy investment in Africa by technology (excluding large hydropower), 2005-2020



Source: Based on BNEF (2021c).
Note: BNEF data exclude investments in large hydropower (i.e. greater than 50 MW).

Investments by region

Viewed by region, renewable energy investments over the period 2010-2020 were concentrated in Southern and North Africa (Table 3.1 and Figure 3.4). Within both regions, a few countries accounted for the bulk of investment.

North Africa was the second-largest recipient of renewable energy investments. During 2010-2020, the region attracted USD 17.5 billion – or 32% of the total for the decade – concentrated in Morocco (USD 9.5 billion) and Egypt (USD 8.2 billion). Over time, investments followed a steady growth trajectory, peaking at USD 4 billion in 2018 before dropping in 2019 and 2020 (Figure 3.4). Investments were concentrated in solar (PV and thermal) (67.5%) and wind (32%), with the remainder going to bioenergy and small hydropower.

West Africa attracted comparatively little investment – USD 4 billion, over the period 2010-2020. Projects in this region began receiving capital only in 2006 (Figure 3.4), initially for bioenergy during 2006-2012 and then for solar PV during 2014-2020. In the 2010-2020 period, solar PV projects accounted for 62% of renewable energy investments in the region, totalling USD 2.5 billion – twice the solar PV investment in East Africa – followed by wind at 16%, biofuels at 12% and small hydropower at 10%. Investment flows were widely distributed among countries: Nigeria accounted for 21% of the total investments, followed by relatively similar shares of 10-15% in Senegal, Mauritania, Ghana, Sierra Leone and Burkina Faso.

East Africa attracted USD 9.7 billion during 2010 2020 (or 18% of Africa's total) (Table 3.1 and Figure 3.4), with investments relatively equally distributed across technologies. Geothermal and wind projects each accounted for 30% of the total (mainly to Kenya) and bioenergy for about 20%, while solar PV and small hydropower accounted for 12% and 10%, respectively. Kenya accounted for 58% (USD 5.6 billion) of investment in the region during 2010-2020, followed by Ethiopia at 17%.

Central Africa received the least investment of all regions over the period 2010-2020. Small hydropower accounted for 50% of the regional total of USD 1.3 billion, almost exclusively in Cameroon, the Democratic Republic of the Congo and Gabon. Solar PV attracted the other half, with projects in Angola, Cameroon and Chad.

Southern Africa was the main recipient of renewable energy investment in Africa, having attracted over 40% (USD 22.4 billion) of total flows over the decade. Solar (PV and thermal) projects accounted for 60% of that investment (USD 13.5 billion) followed by wind at 35% (USD 7.8 billion). South Africa, through its Renewable Energy Independent Power Producer Procurement Programme (REI4P), took in 85% of the region's investment between 2010 and 2020. Before 2010, investments in Southern Africa had been low, averaging less than USD 50 million annually.


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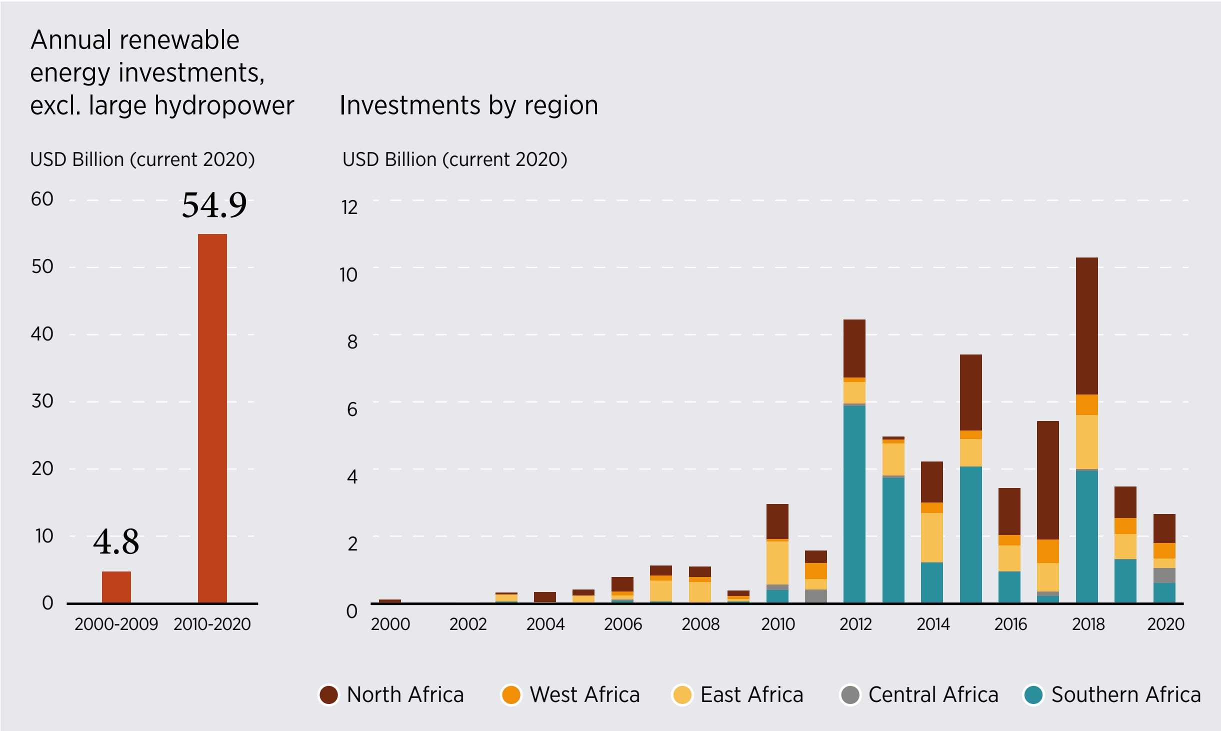
Figure 3.4 Annual renewable energy investments in Africa by region (excluding large hydropower), 2000-2020

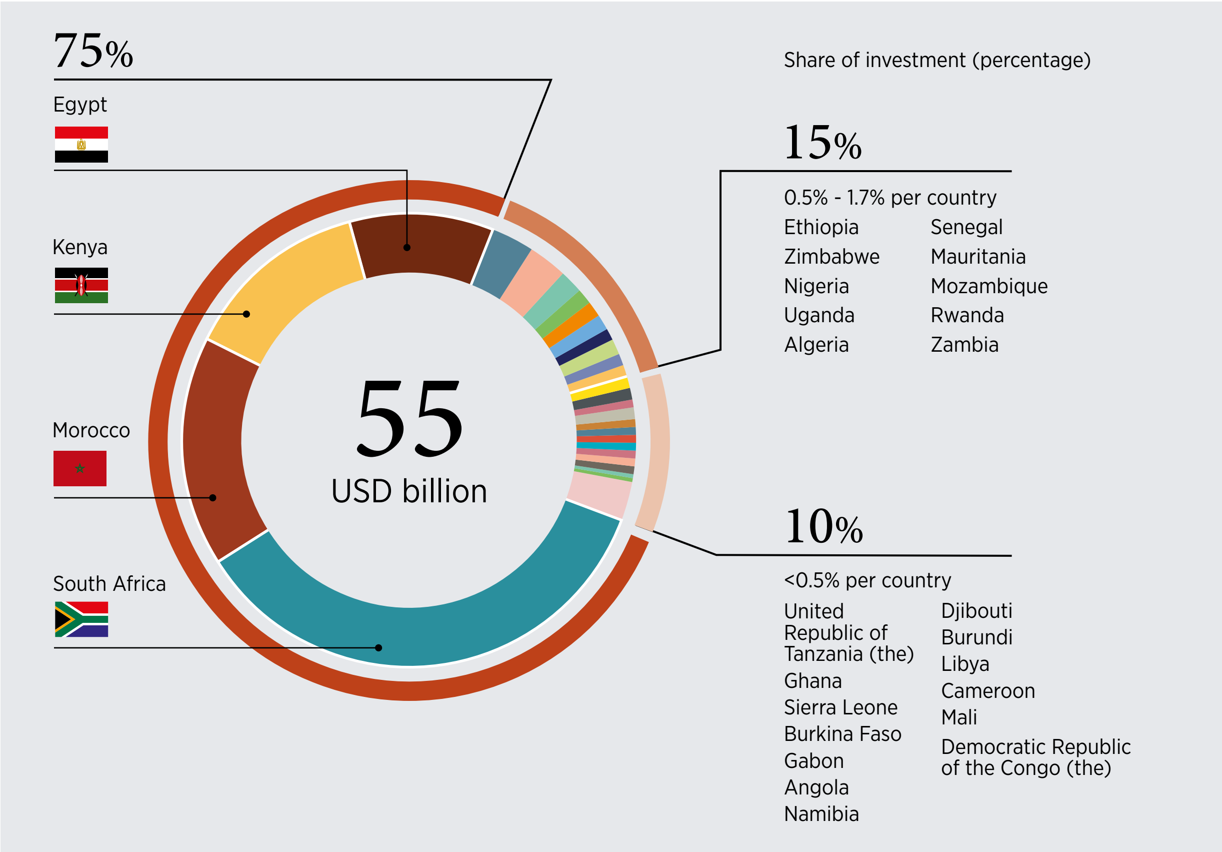


Source: Based on BNEF (2021c).
Note: BNEF data exclude investments in large hydropower (i.e. greater than 50 MW).

While investments in the region have increased and become more evenly distributed over time, they are still concentrated in a handful of countries. Looking at the period 2010-2020, 90% of all investments in renewables went to 14 of the 55 countries in Africa. Four countries alone attracted 75% of investments, namely South Africa, Morocco, Egypt and Kenya (Figure 3.5). This was mainly the result of enabling policies and financing mechanisms that were able to attract investments (Chapter 4).

The trends in these four countries show that renewable energy investments tend to flow to countries which offer higher returns and lower risks owing to their policy and institutional environment, regulations, access to finance, and market characteristics (*e.g.*, size, prospects and stability). In less-advanced economies, these enabling factors may not be as strongly present, giving rise to political, financial, legal, operational and credit risks (section 3.3). As a result of the lack of well-structured projects with attractive risk-return profiles, insufficient capital is flowing to countries that need it the most.

Figure 3.5 Top recipient countries of renewable energy investment, 2010-2020



Source: Based on BNEF (2021c).
Note: BNEF data exclude investments in large hydropower (i.e. greater than 50 MW).

3.1.2 Investments in off-grid renewable energy solutions

The world is not on track to achieve universal access to affordable, modern, and reliable energy by 2030. At the end of 2019, over 759 million people were still living without access to electricity, 75% of them in Sub-Saharan Africa (IEA, IRENA *et al.*, 2021). Decentralised renewable energy solutions, specifically standalone solar systems and mini-grids, are a cost-effective way of pursuing universal access, especially in rural areas where grid expansion may not be viable (see Chapter 6). For that reason, off-grid investments in Africa are rising exponentially and continue to show resilience despite the initial setbacks from the pandemic.

Africa accounted for 70% of global investments in the off-grid sector in the decade between 2010 and 2020, attracting USD 1.7 billion (Table 3.2). Investments grew at a cumulative annual growth rate (CAGR) of 83% which is not surprising considering that, at the end of 2019, Africa accounted for 75% of the world's population lacking access to electricity. However, the present level of investment is nowhere close to what is required to achieve universal electrification by 2030 (IEA, IRENA *et al.*, 2021).

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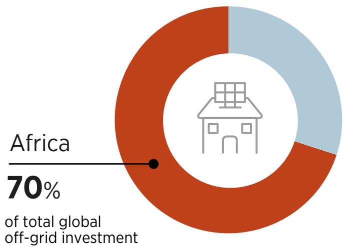
Annual commitments directed to off-grid renewables in Africa grew from just above USD 0.5 million in 2010 to more than USD 380 million in 2020 (Figure 3.6). Exceptional growth was observed in 2014, driven mainly by a surge in capital directed to four companies operating in East Africa: ZOLA Electric (Off Grid Electric), EcoZoom, M-Kopa and Mobisol (Engie Energy Access).

In 2020, amid the COVID-19 crisis, the African off-grid sector attracted a record level of commitments, 40% higher than in 2019. Several 2020 commitments were raised through crowdfunding platforms (*e.g.* Energise Africa, Trine, Lendahand) to refinance existing debt raised in earlier campaigns on the same platforms. This allowed companies to ease short-term cashflows and improve their ability to face the impacts of COVID-19 (section 3.1.3). Financing models such as crowdfunding are allowing African entrepreneurs and off-grid companies to bypass the hurdles of conventional financing.

Table 3.2 Off-grid renewable energy investment in Africa, 2010-2020

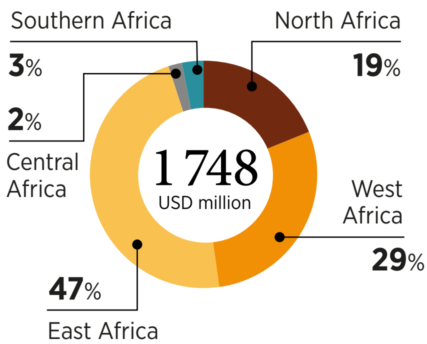
Off-grid renewable energy investment in Africa, 2010-2020
(USD Millions, constant 2019)

Global	2 485 USD million
Africa	1 748 USD million



	2010-2020
North Africa	330 USD million
West Africa	509 USD million
East Africa	822 USD million
Central Africa	36 USD million
Southern Africa	52 USD million

Share in regions (percentage)



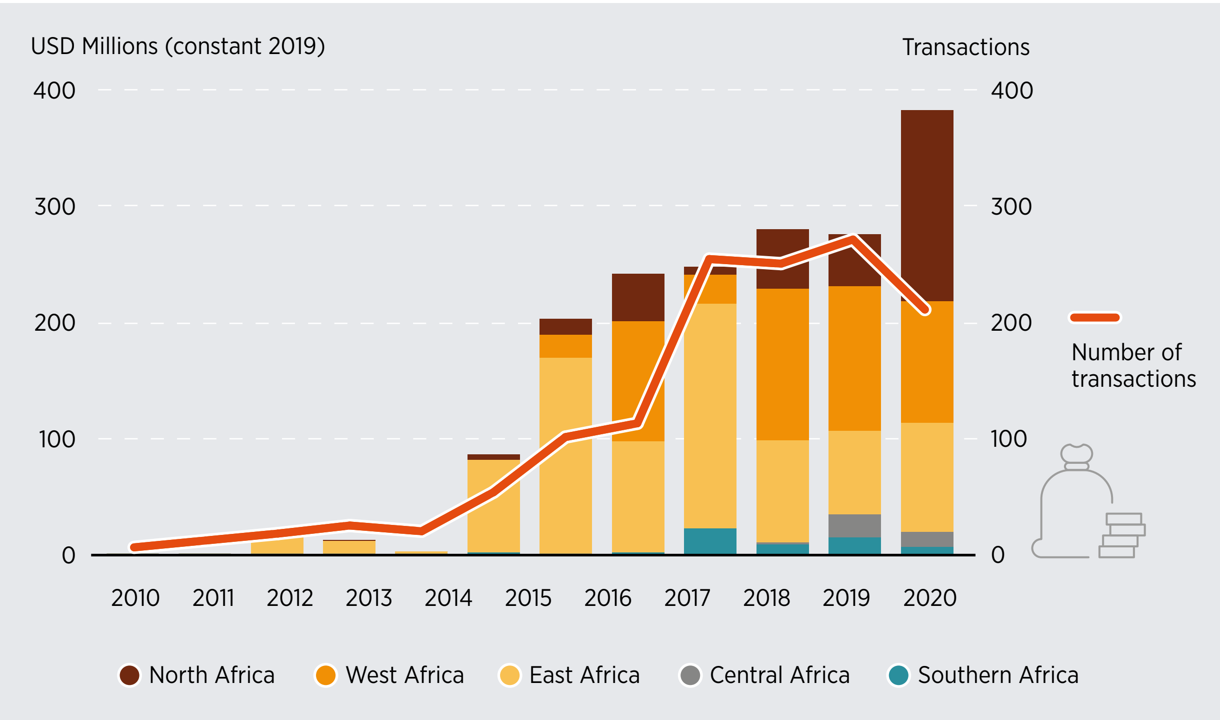
Source: Wood Mackenzie (2021)

Investments by region

Although almost one-fifth of Africa's off-grid renewable energy investments were recorded in **North Africa**, the region was not included in further analysis due to its comparatively high level of electrification.

West Africa – especially Nigeria – was Africa's second-largest recipient of off-grid renewable energy commitments during the past decade, attracting a total of USD 509 million (Table 3.2). The recent growth was largely driven by a surge in commitments (Figure 3.6), following the launch of the Regulation for Mini-Grids by the Nigerian Energy Regulation Commission in 2017, which established a clear regulatory framework for mini-grid developers in the country, addressing some of the key risks associated with licensing, tariff setting, arrival of the main grid, access to finance and quality standards (IRENA, 2018b). About half of total commitments to off-grid renewables in Africa went to **East Africa** (USD 822 million) – primarily Kenya and the United Republic of Tanzania. Investments in this region were facilitated by a well-developed mobile money industry, a necessary requirement for the adoption of pay-as-you-go (PAYG) systems (IRENA, 2017).[2] Although East Africa takes up the majority share of overall investment in the last decade, recently West Africa has taken over in terms of annual commitments to off-grid sector (Figure 3.7).

Figure 3.6 Annual commitments to off-grid renewable energy and number of annual transactions, by region, 2010-2020



Source: Based on Wood Mackenzie (2021).
Note: The figure excludes 16 commitments for which the year was not specified, representing a total of USD 730 000.

2 PAYG models are further discussed in Chapter 6 on Access.

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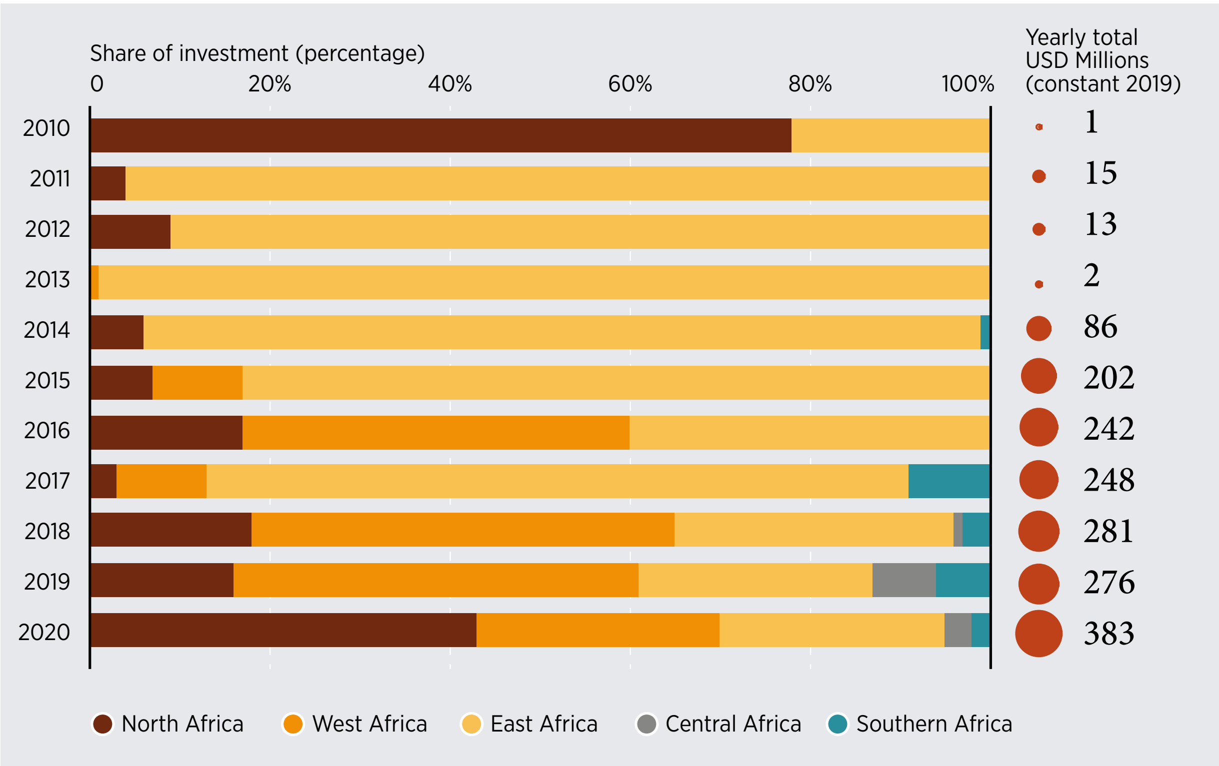
Off-grid renewables commitments remained low in **Central** and **Southern Africa**. These two regions together attracted around USD 88 million (USD 36 and 52 million, respectively) in 2010-2020, 98% of which was committed after 2016 – a sign that the sector is still at an early stage of development in these countries. Zambia and Mozambique received 65% of all commitments to Southern Africa (USD 33.6 million), while investments in Central Africa were concentrated in the Democratic Republic of the Congo (38% of the regional total), Chad (34%) and Cameroon (27%).

Over half of the total commitments to off-grid renewables in Africa – about USD 927 million during 2010-2020 – were directed towards companies or projects operating in more than one country. Most of the commitments directed to specific countries were concentrated in six countries. Nigeria was the largest single recipient, with USD 261 million in 2010-2020, followed by Kenya (USD 136 million), the United Republic of Tanzania (USD 119 million), Rwanda (USD 75 million), Côte d'Ivoire (USD 55 million) and Uganda (USD 54 million) (Wood Mackenzie, 2021). Four of these top-six recipients – Nigeria, the United Republic of Tanzania, Uganda and Kenya – are among the African countries with the largest energy deficits, representing combined 168 million people without access.

Figure 3.7 Shares of annual commitments to off-grid renewables, by region, 2010-2020



Source: Based on Wood Mackenzie (2021).

Investments by energy uses and systems

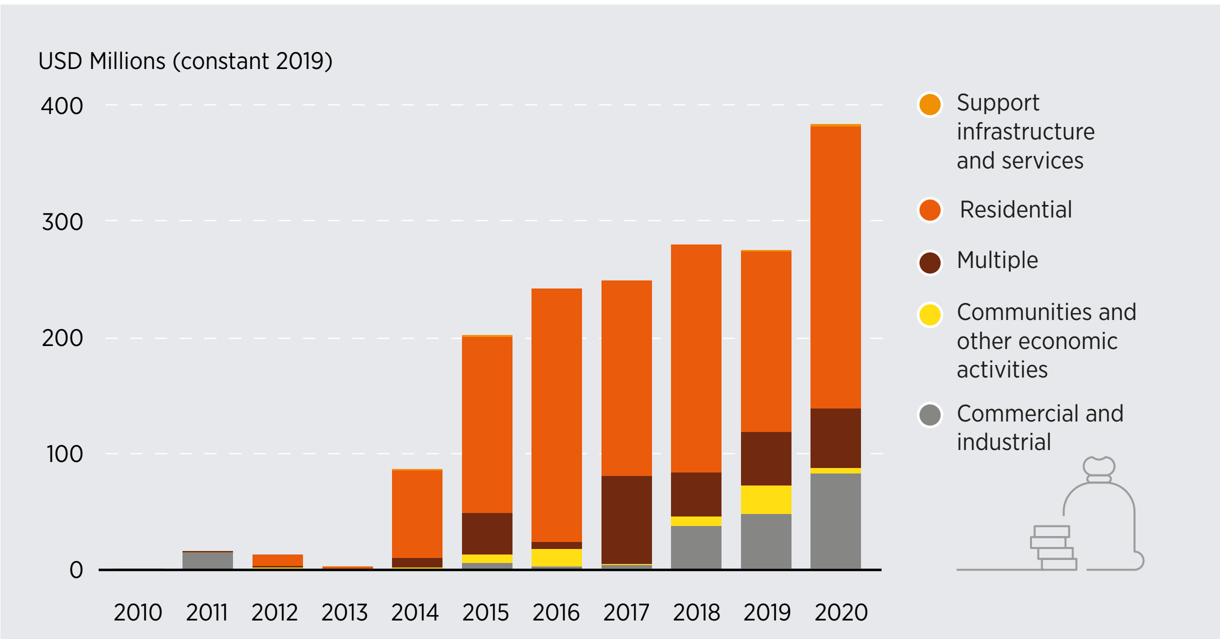
During 2010-2020, 70% (USD 1.2 billion) of off-grid renewable energy investment in Africa was directed to **residential** energy uses – that is, to provide basic energy access to households in remote areas (Figure 3.8). The priority given to residential purposes is not surprising given the large number of people still lacking access to energy. More than 40% of residential commitments went to access-deficit countries and an additional 35% targeted combinations of countries that included access-deficit countries.

Over the past three years (2018-2020) investments in off-grid renewables for **commercial and industrial** uses have surged, averaging USD 55.5 million each year (Figure 3.8). Almost half of these investments targeted West Africa, particularly Nigeria, where the regulations launched by the Nigerian Electricity Regulatory Commission (NERC) in 2017 have facilitated investments in mini-grid projects (IRENA, 2018). Investments for commercial and industrial purposes include decentralised solutions for powering small businesses in remote areas, solar pumps for irrigation and solar fishing lights. These solutions improve working conditions and promote economic growth, especially in remote areas, advancing progress towards SDG 8 on decent work and economic growth and SDG 12 on responsible consumption and production (UN, 2021c).

Commitments to off-grid renewable energy solutions for **communities and other economic activities** remained low throughout the decade, averaging just over USD 5 million per year (Figure 3.8). These include financing for streetlights as well as for decentralised systems to power hospitals and schools. In 2020, at least USD 3.9 million (or 76% of investments in this category) went to ensure reliable solar power supply for health centres in various Sub-Saharan African countries in response to the COVID-19 emergency.

Finally, investments in **support infrastructure and services**, including smart meters and voltage converters, accounted for only 0.3% of total commitments in Africa during 2010-2020 (Figure 3.8).

Figure 3.8 Annual commitments to off-grid renewables, by energy use, 2010-2020



Source: Based on Wood Mackenzie (2021).

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In terms of energy systems, most investments were in **solar home systems** (SHSs), which attracted USD 1.3 billion during 2010-2020, or 74% of the total investment in off-grid energy (Figure 3.9). SHSs account for 95% of all commitments for residential energy uses. They are the preferred choice for providing energy access to households in remote areas (up to Tier 3[3]), enabling households to connect home appliances, such as a refrigerator and a TV. In 2020, despite the pandemic, SHSs received a record investment of USD 278 million, most of it in East and West Africa (which both experienced a 70% increase over 2019). At the same time, the investment mix changed to more debt and less equity (in both absolute and relative terms), indicating a shift in investor's preferred source of financing for the SHS sector. In addition, sales of SHSs in the two regions also remained strong, even reaching record levels in West Africa in 2020 (see section 3.1.3).

Micro- and mini-grids attracted about 16% of total commitments in 2010-2020, or USD 285 million (Figure 3.9). The level of investment in such projects increased over time, especially during 2018-2020, driven by a surge in commitments for commercial and industrial purposes. Compared to SHSs, micro- and mini-grids can provide a more advanced level of energy access (up to Tier 5) and represent the preferred option for productive energy uses, attracting three-fourths of all commercial and industrial investments during 2010-2020.

Investment in other solar applications, including solar lights, remained low over the decade, averaging USD 7 million per year (Figure 3.9). The potential for these products remains limited due to their ability to provide only a Tier 1 level of energy access, *i.e.* up to 20 MW of available peak capacity and up to four hours of electricity supply daily (USAID, 2021a).

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3.1.3 The impact of COVID-19 on renewable energy investments in Africa (including in the off-grid sector)

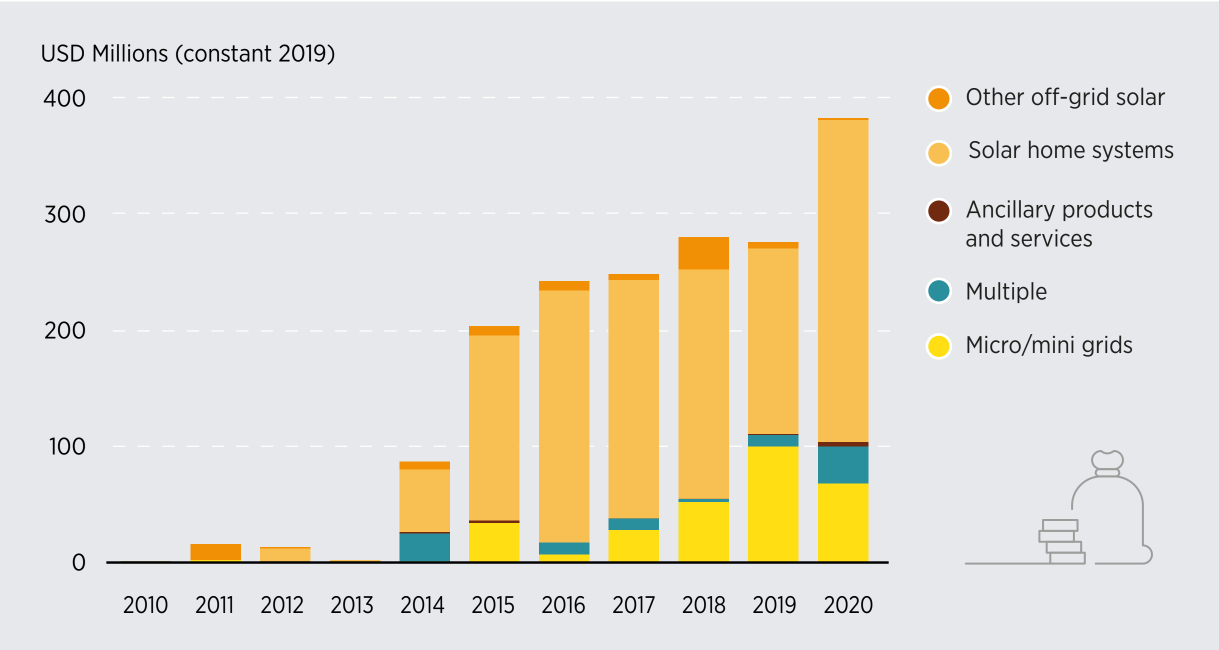
Globally, and in Africa, the pandemic has suppressed economic activity, shocked global demand and increased political turbulence. The resulting macroeconomic uncertainty translates into a more conservative investing environment (see Chapter 1). Investments in renewable energy have flattened in the face of suppressed supply chains, sharp currency depreciations, decline in energy demand and increased cost of financing.

The COVID-19 pandemic and its economic fallout risk reversing the progress made in Africa in recent years, particularly on access to energy. Early on, some countries responded to the pandemic by redirecting resources to emergency response measures. For example, Uganda halted government subsidies for its electricity access programme, while South Africa redirected funds from other sectors to health and welfare (IEA, 2020). The value of energy access was recognised, however, and in nine African countries (including Kenya, Nigeria and Uganda), off-grid solar was deemed an "essential service" during the early lockdown periods, enabling companies to continue serving their customers (GOGLA 2020a). There is evidence that many customers prioritised payments of their PAYG SHSs,[4] despite the financial burdens they faced (60 decibels, n.d.).

3 This refers to the Multi-Tier Framework developed by the World Bank, in which levels of energy access are measured in tiers ranging from Tier 0 (no access) to Tier 5 (highest level of energy access). More details are available in Chapter 6 of this report and at www.esmap.org/node/55526.

4 In a study that surveyed 50 712 people in 32 countries including the Democratic Republic of the Congo, Ghana, Kenya, Madagascar, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, the United Republic of Tanzania, Uganda and Zambia.

Figure 3.9 Annual commitments to off-grid renewables, by energy product, 2010-2020



Source: Based on Wood Mackenzie (2021).
Note: "Other off-grid solar" includes lights, kiosks, refrigerators, pumps and solar water heaters. "Multiple" denotes financial commitments that involve more than one off-grid product.

In 2020-2021, governments launched large-scale fiscal stimulus packages and expansionary monetary policies to counteract the pandemic-induced economic downturn. Several of these packages and policies centre on "green" investments, including renewable energy. Nigeria's COVID-19 economic recovery plan includes support to off-grid renewable energy (SEforAll, 2020). Senegal launched a new investment promotion strategy in 2020 that outlined ten priority areas for foreign investment, including energy (UNCTAD, 2021). The pandemic has also highlighted the nexus between health and energy. Donor agencies, such as the United States Agency for International Development (USAID), have channelled more than USD 7.2 million to support the off-grid sector in Sub-Saharan Africa, focusing on electrifying health facilities (USAID, 2021b).

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Owing to these opposing forces, the net impact of COVID-19 on renewable energy investments is poorly understood and subject to change. Although investments have dipped globally, the severity of the dip has varied significantly across geographies and subsectors. IRENA's analysis shows that in 2020 – at the onset of the pandemic – renewable energy investments in Africa fell by 24%.[5] The recovery was slow and uneven in the latter half of 2020 and into the first half of 2021 (GOGLA, 2020a, 2021). This is on the back of the pandemic triggering additional headwinds in the form of rising customer defaults and reversions to traditional fuels and cooking practices (IEA, IRENA *et al.*, 2021) (see Chapter 5). Furthermore, renewable energy investments in some regions were already dropping in the 2015-2019 period (Table 3.3).

The pandemic-related decline in renewable energy investments (excluding large hydropower) was most marked in East Africa and Southern Africa, dropping by 61% and 53%, respectively (Table 3.3). North Africa experienced a 9% decline from the previous year. Investments in West Africa declined by just 5% owing to strong investments in solar in Ghana (USD 282 million) and Burkina Faso (USD 110 million). In Central Africa the exceptionally strong growth rate of 2 461% is due to a few large projects and a negligible baseline.

Table 3.3 Net impact of the pandemic on renewable energy investment

Region	Pre-pandemic trend based on CAGR, 2015-2019	Pandemic trend based on percentage change, 2019-2020	Net trend**
North Africa	-18%	-9%	9% ◆
West Africa	13%	-5%	-18% ▼
East Africa	-19%	-61%	-42% ▼
Central Africa*	27%	2 488%	2 461% ▲
Southern Africa	-31%	-53%	-22% ▼

Source: Based on BNEF (2021c).
* *The pre-pandemic trend for Central Africa is calculated based on 2013-2019 data. The high growth rate for 2019-2020 should be interpreted with respect to a negligible 2019 baseline.*
** *These figures provide an idea of how changes in renewable energy investments during the pandemic hold when compared to pre-pandemic trends. They are not indicative of "actual impact" attributed to the pandemic, which requires more rigorous evaluations.*

5 In contrast, the off-grid sector saw record investments totalling USD 383 million (Wood Mackenzie, 2021).

Investments in 2020 also varied by type of financing. Most of the 2019-2020 drop came in the form of a decline in term loans, which shrank from USD 2.2 billion to USD 1 billion, while balance sheet financing rose by two-thirds, from USD 980 million to USD 1.6 billion. Wide fluctuations are not uncommon, but this was the first time since 2009 that term loans fell below balance sheet financing.

The pandemic also led to greater interest in clean energy investments, as oil-exporting economies were hit hard, particularly Libya, Equatorial Guinea, Algeria, Angola and Nigeria. In 2020, low demand for energy commodities and low oil prices cut export revenues and fuelled large fiscal deficits in many countries in the continent (UNECA, 2020). Expanding their clean energy investment portfolios could help oil exporters hedge their risks against fossil fuels, creating opportunities for economic growth and jobs in the short run while safeguarding long-term climate interests globally.

In the off-grid sector, private companies were exposed to a range of financial and operational risks early on. Some customers were no longer able to pay their bills and companies had to find new ways to secure cash flows while a large portion of their capital was locked in as receivables. Globally, as a result of the falling household incomes, sales of off-grid solar lighting products fell by 32% in the first half of 2020 from the second half of 2019 – with sales volumes reaching their lowest since 2014. Cash sales of SHSs also declined, with a larger share being financed through PAYG financing (GOGLA, 2020b, 2021).

However, many off-grid companies weathered the storm and continued to provide energy services to customers. Africa's off-grid sector began a quick although uneven recovery in the second half of 2020. Sales for solar lighting in Sub-Saharan Africa recovered in the second half of 2020 and were only 4% less than the second half of 2019. In South Asia, another major regional market for off grid, by contrast, the decline was 43%. At the same time, sales of off-grid appliances in Sub-Saharan Africa fell, while growing 29% in South Asia (GOGLA, 2020a).[6] Similar patterns have emerged from the latest data on the first half of 2021 (GOGLA, 2021).

West Africa experienced record sales of 148 000 SHSs in the second half of 2020 (36% higher than the second half of 2019), while **East Africa** recorded sales of 379 000 – only a slight decline from the second half of 2019. Later in the first half of 2021, SHS sales in both regions were higher than during the corresponding pre-pandemic period.[7]

Strong public support through subsidies and other government-led initiatives may have contributed to strong sales as they helped ease the burden on shrinking consumer budgets. **Rwanda** launched a nationwide subsidy worth USD 30 million for SHS products based on a successful results-based financing pilot programme. Togo had a SHS subsidy in place early on, and sales remained consistent. Other measures,

6 Appliances included TVs, fans, refrigeration units, solar water pumps, radios and "other" (agro-processing machines, air-conditioners, irons, hair clippers, stereos, sewing machines, egg incubators and other machinery) (GOGLA, 2020a).

7 Given the seasonality of off-grid sales data, comparisons with previous years were made for the corresponding period in that year (e.g. data for first half of 2021 is compared with data for first of half of 2019).

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such as debt relief funds and labelling off-grid access companies as "essential", have enabled off-grid companies to continue maintaining operations – again signalling the appeal of the off-grid sector to investors.

Despite limited available financial resources (as governments and DFIs shifted resources toward health and household consumption), investors in many countries have rallied behind the off-grid sector. Public sector investors are cognizant of the off-grid sector's importance in Africa – not only for providing basic electricity services but also to battle the pandemic, given the health-energy link. Many private investors have also remained optimistic on the long-term prospects of the market despite some of the early challenges (GOGLA, 2020b). A global coalition of 16 governments, foundations and investors has launched the USD 80 million Energy Access Relief Fund to support energy access in Sub-Saharan Africa and Asia during the pandemic (Rockefeller Foundation, 2021a).

However, COVID-19's impact has not yet fully materialised. Governments, development agencies and investors will need to be watchful of the changing environment and develop targeted approaches to support the clean energy sector.


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3.2 SOURCES OF FUNDING FOR RENEWABLES IN AFRICA

Globally, renewable energy has been financed predominantly by the private sector, with public finance accounting for just 14% of direct investments in renewable energy assets, mostly via DFIs (IRENA, 2021e). But public financing plays a more dominant role in Africa, where, except in a few countries, projects are not able to attract private capital owing to political, legal and economic risks (see section 3.3.1). Public authorities can palliate those risks and mobilise private capital through regulatory instruments, fiscal incentives, guarantees and market development (IRENA and CPI, 2020).

During the decade from 2010 to 2020, about 78% of overall financing for renewable energy in Africa came in the form of term loans ("non-recourse financing"), while 20% came from balance sheet financing ("corporate financing"). The remaining 2% was made up of bonds, development loans, construction loans, syndicated equity and tax equity. Bond financing was limited to just four solar projects in South Africa (USD 205 million) and Morocco (USD 68 million) (BNEF, 2021c). Guarantees have played an increasing role in recent years. Egypt's West Bakr Windfarm (250 MW), for example, which was funded by multiple investors, included guarantees of up to USD 122 million to help manage non-commercial risk (IFC, 2019).

This section on the sources of renewable energy investment in Africa focuses first on commitments of public funds (as opposed to disbursements, owing to the difficulty of tracking actual flows). The focus then moves to private investments, notably independent power producers (IPPs[8]), and how such investments are enabled by public investments and risk-sharing instruments, focusing particularly on the role played by DFIs. The section closes with a discussion of the sources of financing for off-grid technologies.

8 IPPs are privately developed, financed, built, owned and operated utility-scale (5 MW+) greenfield generators.

3.2.1 Public sector investments in energy, including renewables

Between 2000 and 2019, Africa received a total of USD 109 billion in public commitments in the energy sector (25% of the global total).[9] Almost USD 64 billion of that was committed to the renewable energy sector,[10] including large hydropower, of which USD 50 billion – or 78–% – was committed in the last ten years (2010-2019).[11] This is the lowest amount compared to other major developing regions such as Latin America and the Caribbean and Asia.

It is worth mentioning that these commitments go beyond investments in energy technology and include feasibility studies (*e.g.* the Kodeni and Pa Solar Power Plants in Burkina Faso), technical assistance (*e.g.* Ethiopia's Investment Advisory Facility by UK's Department for International Development) and training (*e.g.* Feasibility, pilot and training for cashew fuel for cooking in Mozambique). Most of the capital was provided by bilateral donors and DFIs using debt and grants, although the use of equity, guarantees and mezzanine financing has increased in recent years.

This section discusses public investments in the energy sector by technology, region, and source and type of financing.

Public investments by technology

Public commitments for energy took off in 2009, rising to almost USD 11 billion, from just USD 0.7 billion in 2000 (Figure 3.10). This initial increase was driven chiefly by fossil fuel investments in South Africa and hydropower investments in Ethiopia, both undertaken to help resolve the long-standing domestic energy crises (AfDB, 2009a, 2009b; Gessesse, 2021).

The year 2017 saw a record commitment to renewables, with 79% of public investment in energy going to renewables, compared with just 14% in 2000. This was driven mainly by hydropower investments totalling USD 5.4 billion (44% of the yearly total), of which USD 5 billion was for the Mambilla Hydroelectric Plant in Nigeria (IEA, IRENA, *et al.*, 2021).

Cumulative public investments in renewables rose from USD 13.7 billion in the 2000-2009 period, to USD 51 billion in 2010-2019, of which hydropower accounted for USD 23 billion (45% of the total for renewables), solar for USD 12 billion (24%), wind for USD 4 billion (8%) and geothermal for USD 2.6 billion (5%).

Over the same period, public commitments for fossil fuels more than trebled to USD 35 billion in 2010-2019, focused mainly in North, Central and Southern Africa.

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9 *Public commitments in the energy sector include renewables and non-renewables. Transmission and distribution projects are excluded. Renewables is composed of solar, wind, multiple/other (explained in Figure 3.11), geothermal and hydropower. Non-renewables encompass fossil fuels, non-renewable waste, nuclear and other (e.g. pumped storage). Commitments cover energy supply infrastructure (excluding upstream oil and gas and coal mining) and ancillary commitments to capacity-building programmes, technical assistance, and research and development.*

10 *This is in line with SDG 7 Indicator 7.A.1: international financial flows to developing countries in support of clean energy as defined in the latest edition of the Tracking SDG7: The Energy Progress Report 2021 (IEA, IRENA et al., 2021).*

11 *These figures also include large hydropower investments, which are not included in the BNEF data used in section 3.1.*

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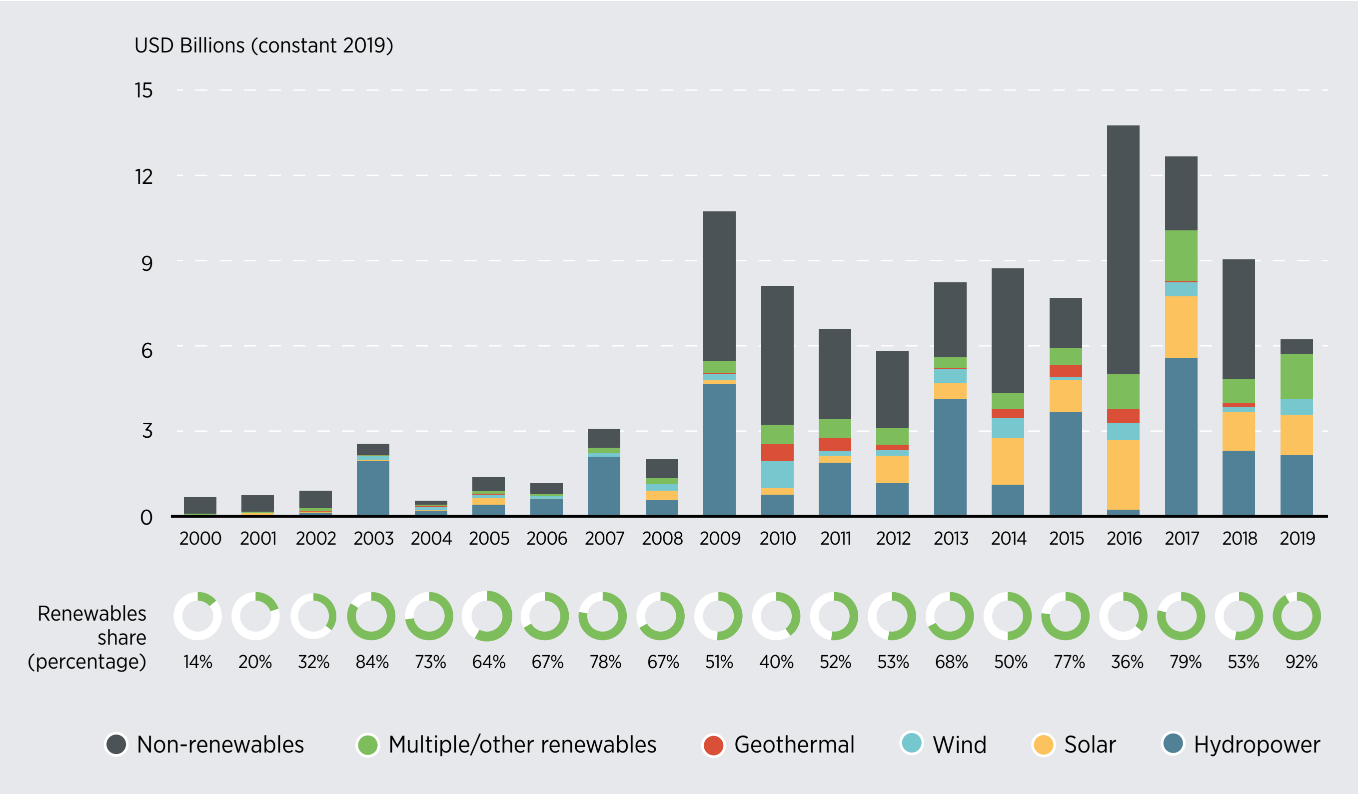
The largest investments came from China (51% of the total), the International Bank for Reconstruction and Development (14%) and the Islamic Development Bank.

Recently, the High-Level Dialogue on Energy and the United Nations Climate Change Conference (COP26) are stimulating increased pledges to renewables and net zero carbon emissions by 2050. The IKEA Foundation and the Rockefeller Foundation have announced the formation of a USD 1 billion global platform that aims to use distributed renewable energy to provide access to electricity to 1 billion people and, in so doing, cut 1 billion tonnes of greenhouse gases (Rockefeller Foundation, 2021b). Similarly, the United Arab Emirates and IRENA have announced the Energy Transition Accelerator Financing Platform which aims to mobilise more than USD 1 billion in climate finance for renewable energy in developing countries (see Box 3.3). In addition, several G20 countries, including China, have committed to stop investing in coal power plants overseas.

Public investments by destination

While investments in renewable energy have increased in Africa, they are unevenly distributed, as most tend to go to economies with relatively advanced policy, regulatory and investment frameworks and sound macroeconomic conditions. The top five recipients – South Africa, Egypt, Nigeria, Morocco and Kenya – receive more than half of all renewable investments.

Figure 3.10 Public commitments for energy in Africa, by technology and renewable share, 2000-2019



Source: Based on IRENA and OECD (2021).
Note: "Multiple/other renewables" include commitments that could not be categorised as support for a specific technology for various reasons: an unclear commitment description; commitments directed to support more than one technology; technologies receiving insignificant commitments, such as bioenergy; or multi-purpose financial instruments, such as green funds, renewable energy and electrification programmes, technical assistance activities and infrastructure supporting renewable energy.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The 33 least-developed countries (LDCs) in Africa are among the countries of the world with the greatest deficits in access to energy. Yet they received only 37% of renewable energy commitments in Africa during 2010-2019. The disparity has not improved over time.[12] These countries, which are often unable to attract private sector investments, are in dire need of international support, notably to help build an enabling policy environment, institutional capacity and effective markets, and so to attract private investors. In this way, directing financial commitments to LDC's can help foster an equitable energy transition resulting in transformative socio-economic development for underserved populations.

In **North Africa**, of the USD 18.9 billion invested in 2010-2019, about USD 10 billion (54%) went to renewables – 29% solar and 10% wind (Figure 3.11). Most of the investment went to Morocco and Egypt. However, fossil fuels continued to hold a substantial position in the investment mix, only slightly less than in the previous decade (2000-2009). The last five years have shown some positive signs, however, as solar, wind and other renewables have begun to displace fossil fuel investments.

West Africa received USD 21 billion worth of public investments in the energy sector between 2010 and 2020, of which USD 16 billion, or 75%, went to renewables (Table 3.4 and Figure 3.11). Most of the renewables share was hydropower (56%) and solar (almost 11%), followed by wind. About 85% of the investment took place in the last five years alone, owing to increased public investment in renewable energy in Ghana, Guinea and Nigeria. The comparison with the 2000-2009 period is stark: then, fossil fuels accounted for almost half of investment; in 2010-2019 that share declined to a quarter.

In **East Africa**, of the USD 11.1 billion invested in 2010-2019, renewables made up 95%. Hydropower accounted for 36% of that, followed by geothermal at 21%, wind at 14% and solar at 9%. Ethiopia, Kenya and Uganda are among some of the highest recipients. Across both decades, countries in East Africa renewables continued to dominate public investment portfolios.

In the 2010-2019 period, **Central Africa** received a total of USD 14.6 billion of which only 26% went into renewables, chiefly hydropower. Fossil fuel investments continued to dominate, although almost all of the USD 1.2 billion invested in 2017-2019 went to hydropower and solar. Cameroon has led the way in this regard, followed by smaller investments in countries such as the Central African Republic (the).

In **Southern Africa**, funding from public sources has grown, especially within the last five years. In the 2010-2019 period, the region received USD 17 billion, of which only USD 7.5 billion (44%) went into renewables, primarily hydropower (19%) and solar (14%). The investments were concentrated in four countries: South Africa, Zambia, Mozambique and Zimbabwe. Except for Zambia, the same countries also led in fossil fuel investments.

12 In making this assessment, the peak year of 2009 is also considered; in that year, 88% of investment went to the least-developed countries.

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Table 3.4 Public commitments of financing for energy, including renewable energy, in Africa, 2010-2019

Public commitments of financing for energy, including renewable energy, in Africa, 2010-2019 (USD Billions, constant 2019)

	Overall energy	Renewable energy	Renewable energy share (percentage)
Africa	83 USD billion	55[a, b] USD billion	61%
North Africa	18.9 USD billion	10.2 USD billion	54%
West Africa	21.2 USD billion	15.9 USD billion	75%
East Africa	11.2 USD billion	10.7 USD billion	95%
Central Africa	14.7 USD billion	3.9 USD billion	26%
Southern Africa	17.3 USD billion	7.6 USD billion	44%

Source: IRENA and OECD (2021).
a. Includes large hydropower and non-technological investments in capacity building, technical assistance, etc. This explains why some of the values may exceed those from the BNEF database.
b. About USD 2.8 billion was classified under "Other Africa".


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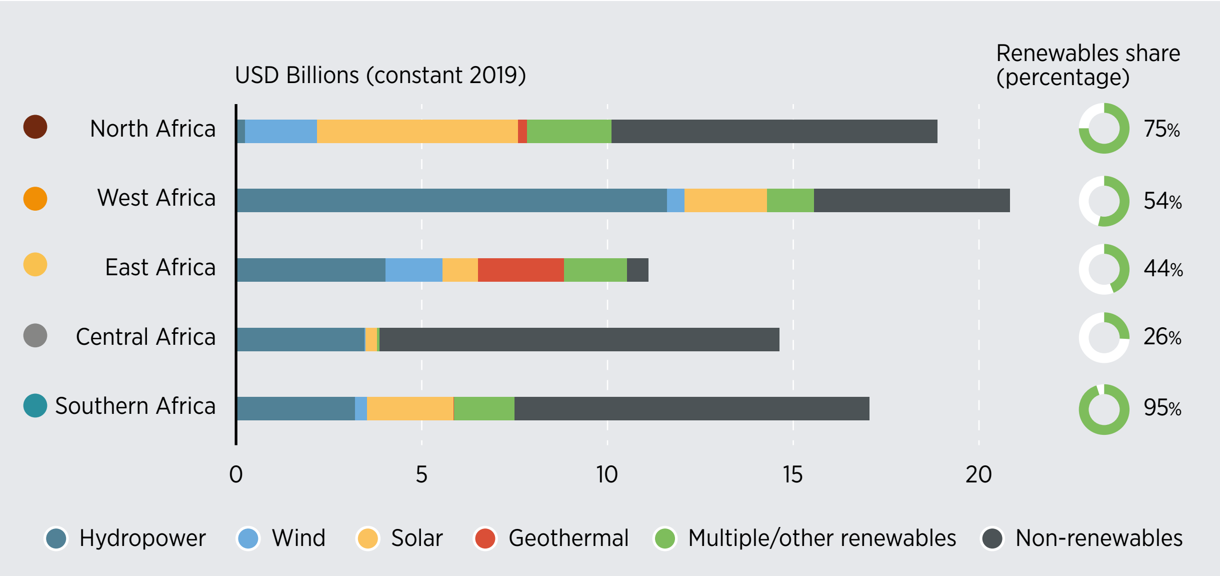
Figure 3.11 Cumulative public commitments in energy sector by region, 2010-2019



Source: Based on IRENA and OECD (2021).
Notes: This chart excludes USD 2.8 billion in 12 commitments recorded for "Other Africa".
"Multiple/other renewables" include commitments that could not be categorised as support for a specific technology for various reasons: an unclear commitment description; commitments directed to support more than one technology; technologies receiving insignificant commitments such as bioenergy or multi-purpose financial instruments such as green funds, renewable energy and electrification programmes, technical assistance activities and infrastructure supporting renewable energy.

Public investment by source and type of funding

International donors and financing institutions continue to play a key role in financing Africa's renewable energy sector, along with regional actors such as the African Development Bank (AfDB). The number of active donors increased from 27 in 2010 to 45 during the peak year (2017). Out of the 54 donors active during 2010-2019, 10 provided 85% of the public funding in Africa, equivalent to USD 43 billion. These included bilateral donors (such as China, France, Germany and the United Kingdom of Great Britain and Northern Ireland), MDBs (including the World Bank and the AfDB) and DFIs (*e.g.* FMO, KfW, Proparco) (IEA, IRENA *et al.*, 2021; IRENA and OECD, 2021). DFIs' support for Africa's renewable energy sector is discussed in more detail in section 3.2.3.

China alone provided USD 19 billion (38% of the total) for renewable energy investments (mainly hydropower) and remains a key presence in Africa. Almost the same amount went to fossil fuels – mainly coal, although the latest announcement to halt coal financing overseas could reroute investments towards renewables (BNEF, 2021a, 2021b). The AfDB still plays a small role in renewables, investing only USD 1 billion in the 2010-2019 period. While AfDB has leveraged several investments in renewable energy, including the Sustainable Energy Fund for Africa (see next section), the scale is nowhere near what is needed, and fossil fuel investments continue to receive a larger volume of financing.

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In terms of financing instruments, debt continues to be the most favoured public financing instrument across Africa. It made up 88% of all public financing in 2010-2020, followed by grants, at 10%. Within debt, standard loans have been the long-standing instrument, although concessional loans have recently begun to play a larger role, particularly in North, East and Southern Africa. Risk-mitigation instruments such as liquidity facilities and guarantees are being employed with increasing frequency in West, East and Southern Africa. In the post-pandemic world, these instruments will help reduce the cost of financing and mobilise private investment.

Although this section has focused exclusively on commitment levels, which are a reliable indicator of ambition, the commitment-disbursement gap can reveal how these commitments have translated into actual flows. Sustainable Energy for All (SEforAll) tracked this gap in 20 high-deficit countries between 2013 and 2018, 13 of which are in Africa and received a third of the committed amount. The analysis found that in the eight African countries that could be further analysed (thanks to sufficient data), approximately 51% of the projects and 64% of the financing were delayed.[13] The delays were mainly due to poor stakeholder co-ordination, policy and regulatory bottlenecks, limited access to local matching finance and technical issues related to project design (SEforAll and South Pole, 2020).

Investment funds that finance renewables in Africa

Several investment funds support renewable energy in Africa. Some are small and focused on a niche set of countries and technologies, while others are large and target a wide range of projects across the continent. The funds are often supported by governments and DFIs and have had a profound impact on the renewable energy landscape in Africa. Several examples follow.

- **The Africa Renewable Energy Fund**'s goal is to improve energy supply in Sub-Saharan Africa, excluding South Africa, by investing in renewable energy projects that deploy mature technologies with successful track records. This includes small- and medium-sized hydropower, wind, solar PV, geothermal and biomass. The fund won a cornerstone investment from the AfDB in 2015 and has so far made nine investments in six countries in Africa. The fund size is USD 200 million, and it aims to have a controlling position in projects at all development stages having installed capacity of between 5 MW and 50 MW (Berkeley Energy, 2021).
- **Beyond the Grid Fund for Africa**, established through an initiative of the Swedish International Development Cooperation Agency, aims to bring access to clean and affordable off-grid energy to 6 million people in Burkina Faso, Liberia, Mozambique, Uganda and Zambia by 2025, building on the success of an earlier pilot programme, the Beyond the Grid Fund for Zambia. The fund provides financing for companies offering off-grid solutions and offers technical assistance and capacity building for local energy authorities. It also collects market intelligence, including customers' payment history, to help de-risk future investments in the countries concerned (BGFA, 2021).
- **The Clean Technology Fund** is part of the USD 8.5 billion Climate Investment Fund (CIF) established in 2008 by 14 donor countries and implemented by six MDBs to provide financing and technical assistance for programmes in clean technology, energy access, climate resilience and sustainable forests (CIF, 2021a). The USD 5.4 billion Clean Technology Fund aims to facilitate the scaleup of low-carbon technologies that result in long-term greenhouse gas savings. Over USD 4 billion has been approved for projects in renewable energy, energy efficiency and clean transport in 19 developing countries (CIF, 2021b).

13 For reasons of data limitations, this analysis concerns only the following eight countries: the Democratic Republic of the Congo, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, the United Republic of Tanzania and Uganda.

- **The Green Climate Fund** (GCF) is the world's largest climate fund, established in 2010 within the framework of the United Nations Framework Convention on Climate Change, to help developing countries meet their Nationally Determined Contributions (NDCs) and finance climate change mitigation and adaptation. It aims for at least a 50% allocation to climate adaptation investments in least-developed countries (LDCs), small island developing states (SIDS) and African states (CIF, 2021a). As of July 2021, the fund had approved 70 projects in Africa worth USD 3.29 billion – and another USD 7.7 billion in co-financing. The fund's financial support comes in the form of equity, loans, readiness grants and guarantees (GCF, 2021).
- **The Renewable Energy Challenge Fund** is managed by the United Nations Capital Development Fund and funded by the Embassy of Sweden in Uganda. It provides co-financing for decentralised solar PV solutions in Uganda, focusing on underserved, low-income customers in rural and peri-urban areas. Its goal is to help 153 000 Ugandans transition to renewable energy, while creating 1 000 new jobs. Grants range from USD 100 000 to USD 500 000 per project (UNCDF, 2021).

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- **The Sustainable Energy Fund** for Africa is a USD 95 million fund managed by the AfDB and funded by the governments of Denmark, Italy, Norway, Spain, Sweden, the United Kingdom of Great Britain and Northern Ireland and the United States of America. Its goal is to help unlock private finance for small- to medium-scale projects in renewable energy and energy efficiency in Africa (SEFA, 2020). In addition to concessional finance, SEFA also provides technical assistance to build a robust pipeline of bankable projects. Despite the challenges caused by the COVID-19 pandemic, the fund reported a record number of transactions in 2020 and secured new commitments of USD 90 million from current and new donors, bringing the total capital raised since its inception in 2011 to USD 274 million (SEFA, 2020). That total includes a USD 20 million investment in the COVID-19 Off-Grid Recovery Platform, which will provide capital to businesses that provide decentralised energy access solutions such as SHSs, green mini-grids and clean cooking (AfDB, 2021b).

In terms of climate finance, Africa has shown some improvement in the recent past, attracting an average of USD 34 billion in global climate finance flows in 2017 and 2018 (about 6% of the global total of USD 574 billion), a major increase over the USD 8 billion yearly average in the 2015-2016 period (or about 2% of the global total of USD 463 billion). Most of the climate finance flows (about 60% in 2017-2018) are directed towards renewable energy, with low-carbon transportation in second place (24% of the total) (CPI, 2020).

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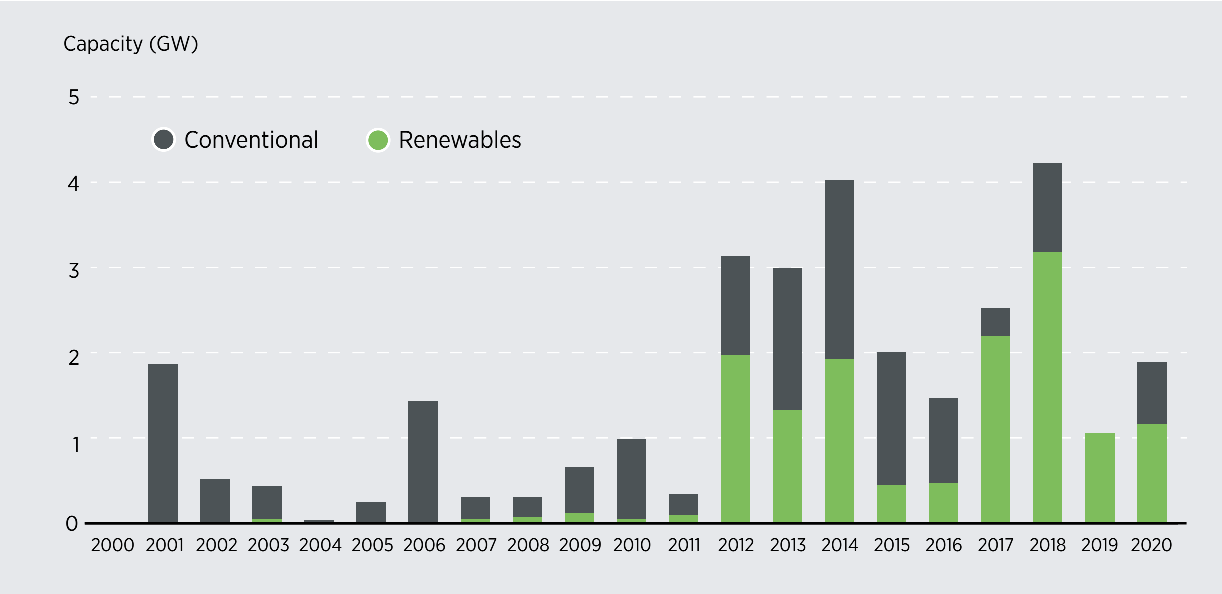
3.2.2 Private investments – focus on independent power producers

Although overall power investment levels in Africa remain below what is required to close the gap in the continent's generation capacity, there are promising signs of increased private investment, especially in renewables. IPPs – privately developed, financed, built, owned and operated utility-scale (5 MW+) greenfield generators – are now among Africa's fastest-growing sources of investment. They have gradually spread across the continent, propelled by the increasing liberalisation of electricity markets (see Chapter 4). However, major investments remain concentrated in a handful of countries. Since 2000, 340 IPPs have been operating, under construction or reached financial close in 36 countries, representing 30 GW of installed capacity (14 GW of which renewables based) and USD 61 billion of total investment.

In the 1990s and 2000s, IPP investments were generally smaller and mainly for conventional power projects. By contrast, investments in the past decade have been larger and dominated by renewable energy. The surge was spurred by the introduction of structured procurement programmes such as feed-in tariffs and auctions. As a result of these programmes, 85% of the IPPs that have reached financial close since 2010 are renewables based, amounting to more than 12 GW of installed capacity (Figure 3.12). Before 2010, renewable electricity installed capacity on the continent totalled just over 1.5 GW. The falling costs of renewable energy technologies have helped drive the trend.

Figure 3.12 IPPs in Africa: Installed capacity, 2000-2020



Source: Power Futures Lab (2021).
Note: Renewables are made up of solar PV, solar thermal, wind, geothermal, small hydropower and bioenergy. Conventional consists of open cycle gas turbine, combined cycle gas turbine, internal combustion engine, combined heat and power, fluidised bed combustion, large hydropower and coal. The annual dips since 2010 correspond to years where no projects contracted through structured procurement programmes were billed for financial close.

Private investments are concentrated in a few countries in each region. South Africa hosts 80% of the total capacity owned by IPPs in Southern Africa; Ghana, Nigeria and Côte d'Ivoire, 78% in West Africa; Egypt and Morocco, 82% in North Africa; Cameroon, 94% in Central Africa; Kenya and Uganda, 68% in East Africa (Power Futures Lab, 2021). Private investment in IPPs during the decade are broken down by region in Table 3.5.

About a third of the direct investment in IPPs comes from DFIs and MDBs such as FMO (the Dutch Entrepreneurial Development Bank); Proparco, a subsidiary of the French Development Agency; the International Finance Corporation (IFC); the European Bank for Reconstruction and Development; the European Investment Bank; and KfW, the German state-owned investment and development bank. By developing, financing and de-risking IPPs, these agencies have played an increasingly important role in mobilising investments over the past two decades (see also section 3.3).

Table 3.5 IPP investments in energy, including renewable energy, in Africa, 2010-2020

IPP investments in energy, including renewable energy, in Africa, 2010-2020 (USD Billions, current 2020)

	Overall energy	Renewable energy	Renewable energy share (percentage)
Africa	54* USD billion	35.1 USD billion	65%
North Africa	13.3 USD billion	8.9 USD billion	67%
West Africa	10.0 USD billion	1.5 USD billion	15%
East Africa	3.9 USD billion	3.2 USD billion	82%
Central Africa	1.9 USD billion	0.2 USD billion	11%
Southern Africa	24.9 USD billion	21.3 USD billion	86%

Source: Power Futures Lab (2021); World Bank (2021b).
** This corresponds to 12% of the overall IPP investments in energy globally over the 2010-2020 period.*

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3.2.3 Role of DFIs and MDBs in Africa's IPP Investments

Support for IPPs from DFIs and MDBs takes many forms, including direct investment (equity and debt), technical assistance, risk mitigation, and structured procurement programmes combining all those instruments (see section 4.2.2).

Development support in the form of loans or grants, often paired with technical assistance, can support IPPs at an early stage of development. Prominent examples are the U.S. Trade and Development Agency and the Sustainable Energy Fund for Africa (managed by AfDB); both have provided development grants, typically around USD 1 million, for many utility-scale, renewables-based IPPs. The technical and financial feasibility assessments and detailed environmental and social impact studies facilitated by development funds have been critical in developing an initial IPP pipeline to accelerate sustainable market growth.

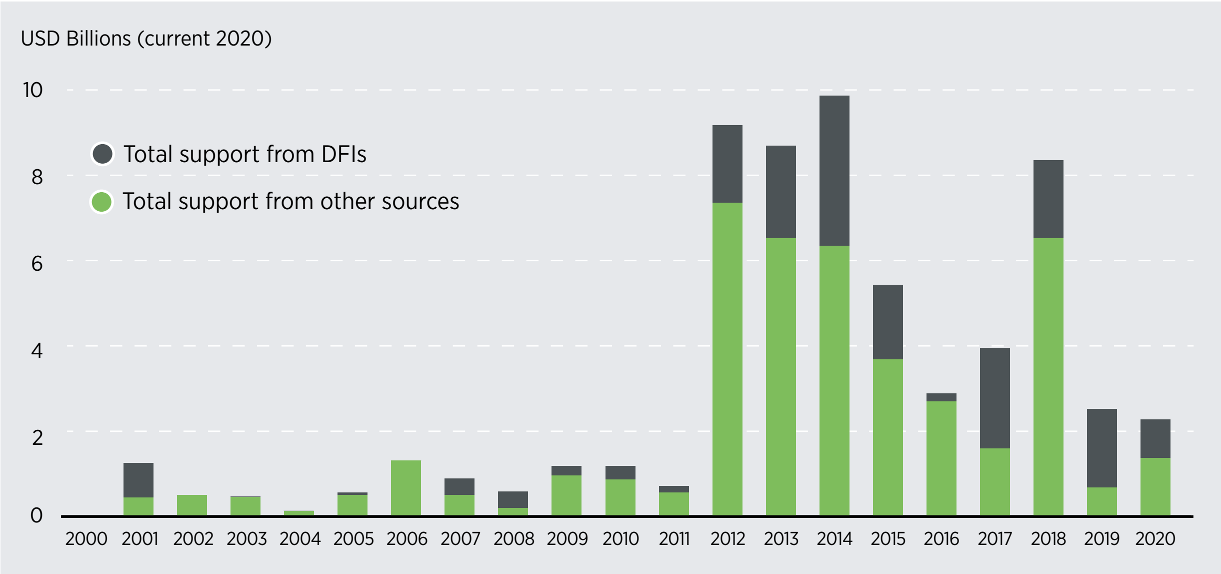
Development support can also come in the form of pure technical assistance. USAID's Power Africa programme has, for example, provided technical assistance to a host of African renewable energy projects, including the 29 MW Senergy 1 solar project in Senegal, where it supported a bankability assessment of the project finance model and power purchase agreement, and the 158.7 MW Taiba N'Daiye windfarm in the same country, where the programme provided technical assistance on financing, insurance, negotiation and land rights issues.

About 30% of the finance mobilised for African IPPs engaged in energy generation (USD 61 billion) has been contributed or arranged by DFIs in the form of direct investment (equity and debt). Over 100 IPPs (through direct negotiations and international competitive bidding) have benefitted from these funds, especially since 2012 (Figure 3.13). In this way, DFIs have been instrumental in attracting finance from private equity partners and commercial debt providers, thanks to their experience in Africa, understanding of the risks involved, access to risk-mitigation instruments and the accompanying "halo effect" that may discourage creeping expropriation and payment defaults. The past five years have seen African DFIs – in particular the AfDB and the West African Development Bank – become more prominent investors in African IPPs, providing finance to 7 of the 13 Sub-Saharan projects that reached financial close in 2020.

Although DFIs have leaned towards renewable energy investments in recent years, motivated by global climate imperatives and sustainability commitments, investments in conventional IPPs were still considerable in 2020 (Figure 3.14).

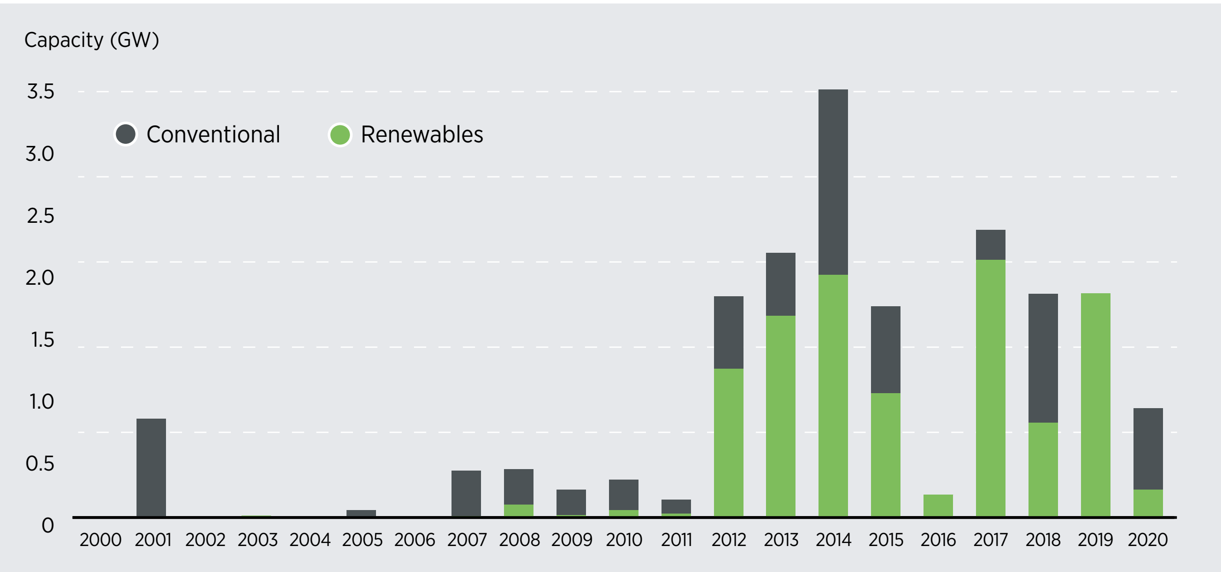
Coordinated international support with a view to further scale-up investments in renewable energy could form a key pillar for a future Green Deal for Africa – underpinning the next stage of the region's development.

Figure 3.13 DFIs' contribution to IPP energy finance, compared with other sources, 2000-2020



Source: Power Futures Lab (2021).
Note: DFI = development finance institution.

Figure 3.14 DFIs' contribution to IPP energy finance by technology, 2000-2020



Source: Power Futures Lab (2021).
Conventional technologies comprise open cycle gas turbine, combined cycle gas turbine , internal combustion engine, combined heat and power, fluidised bed combustion, large hydropower and coal. Renewables-powered technologies are solar PV, solar thermal, wind, geothermal, small hydropower and bioenergy.

DFIs sometimes provide a basket of instruments to support IPPs participating in structured procurement processes, including technical assistance, financing, and de-risking instruments. Technical assistance could be in the form of prefeasibility studies for IPPs (including site studies, resource analyses etc.) and supporting the procurement process design, and advice on proposal evaluation and contract negotiations. The provision of bespoke financing and risk mitigation packages effectively increases in the bankability of contracts in these programmes and the competitiveness of the bidding process. Examples include the FIT in Egypt (Box 4.9), the Scaling Solar and GET FiT programmes.

Scaling Solar

The World Bank Group's Scaling Solar programme was designed to accelerate private investment in Africa by effectively acting as a transnational, large-scale competitive programme, backed by a bankable contractual framework (Fergusson, *et al.*, 2015; Ahlfeldt & Attia, 2017; Kruger, *et al.*, 2019; Kruger & Eberhard, 2019). The design sought to address the main barriers identified by large developers in promising African markets, including limited market sizes, unfamiliar documentation and a range of uncertain costs and risks.

The programme was first implemented in Zambia in 2015/16, where it consisted of conducting feasibility studies, site selection and legal due diligence (supported by a USD 2 million grant from USAID's Power Africa programme); designing and managing a competitive bidding process, with IFC as transaction advisor; providing a bankable, standardized set of contractual documents; offering stapled IFC finance, as an option; and offering additional risk mitigation instruments (*e.g.* World Bank PRG, MIGA political risk insurance etc.). Together, these elements were meant to offer a standardized and replicable solar PV procurement model with significant multilateral backing that translated into low tariffs and rapid project implementation (Kruger & Eberhard, 2019; Kruger, *et al.*, 2019). The auction awarded two 50 MW solar PV projects with relatively low prices at the time, at just over USD 60/MWh and USD 78/MWh, respectively (IRENA, 2018b). A crucial component of the Scaling Solar programme – both in terms of attracting bidders and determining projects' cost of capital – was the provision of a package of risk mitigation and credit enhancement products (Box 3.1).

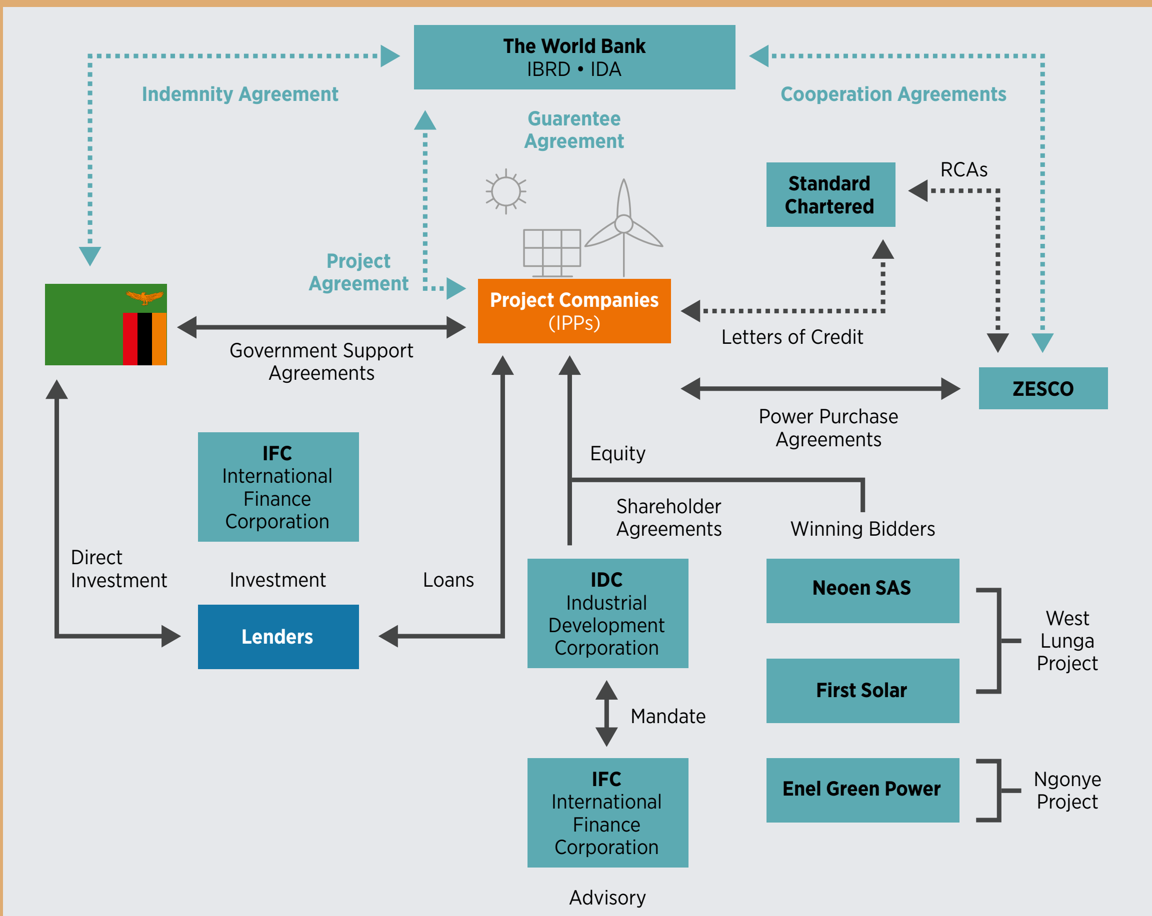
The programme has since led to the award of 60 MW at USD 40/MWh in Senegal (2018) and 250 MW in Ethiopia at USD 25/MWh in 2019. Scaling Solar projects in Zambia, Senegal are now operational. The programme is also being rolled out in Togo, Madagascar, Côte d'Ivoire, and recently Niger.

Box 3.1 Scaling Solar Programme risk mitigation and credit enhancement products

A crucial component of the Scaling Solar programme – both in terms of attracting bidders and determining projects' cost of capital - was the provision of a package of risk mitigation and credit enhancement products (Figure 3.15).

This package included a Government Support Agreement (GSA), which covered off-taker default and some force majeure risks; letters of credit covering six months of payments; and World Bank partial risk guarantees (PRGs) for payment and loans (if required by lenders). While the GSA essentially fulfilled the same role as a sovereign guarantee, it differed in the sense that the Zambian government would buy the project assets or shares in the project company at a predetermined price (covering outstanding equity, debt and associated costs) in the event of a ZESCO payment default, instead of maintaining ongoing payments to the IPP. The provision of the World Bank PRGs meant that ZESCO did not have to provide cash collateral to cover the letters of credit, since the banks were effectively providing credit to the World Bank (Kruger & Eberhard, 2019).

Figure 3.15 Scaling Solar contractual and guarantee structure in Zambia



Source: (World Bank Group, 2018).
Note: IBRD = International Bank for Reconstruction and Development; IDA = International Development Association; RCA = Reimbursement and Credit Agreement; IPPs = Independent Power Producers; ZESCO is a state-owned vertically integrated electricity utility, which generates, transmits, distributes and supplies electricity in Zambia.

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GET FiT

The Global Energy Transfer Feed-in Tariff (GET FiT) programme implemented a hybrid FiT-auction programme in Uganda in 2014 – leading to more than 20 MW of solar PV capacity (USD 164/MWh) – as well as a solar PV auction in Zambia (120 MW; USD 39 – 47/MWh).

The GET FiT programme was designed by Deutsche Bank in 2010 and its initial focus was to address primarily the investment gap between renewables and conventional energy sources. As prices of renewables (particularly solar PV and wind) started declining, the GET FiT programme shifted emphasis to technical assistance. As such, it combined technical assistance (including developing standardised, bankable documentation), viability gap funding (premium payments, financed by the United Kingdom, Norway, Germany and the European Commission) and project de-risking through the provision of liquidity and termination support.

Uganda responded positively to this model, and in 2013 Germany's development bank, KfW, and Uganda's Energy Regulatory Authority (ERA), procured 15 projects (120 MW) – mostly small hydropower, but also bagasse and biomass.[14] Projects received front-loaded premium payments – 50% of the total premium payments on reaching commercial operation, with the remaining 50% spread over the first 5 years of the project's operating life - on top of the established FiT. The contracts, tariff levels and regulatory framework has since been used to contract further small hydropower and solar PV projects outside of the GET FiT programme. Recent regulatory amendments have however indicated that all utility-scale solar projects will need to be procured competitively. A competitive round for solar PV was launched in 2014, resulting in two 10 MW projects being commissioned in 2016 (Kruger, *et al.*, 2018).

The GET FiT model was applied in Zambia in 2014, with the aim of procuring 200 MW of renewable capacity (100 MW solar PV and 100 MW small hydropower). The GET FiT Toolbox also included a debt and risk mitigation facility, viability gap funding, grid facility and technical assistance (GET FiT Zambia, n.d.). In 2019, 6 solar PV projects were awarded at prices ranging between USD 39–47/MWh. Unfortunately, due to the deteriorating financial position of ZESCO and the Zambian fiscus, these projects have not been able to proceed to financial close and commercial operation.

3.2.4 Focus on sources of investments in off-grid technologies

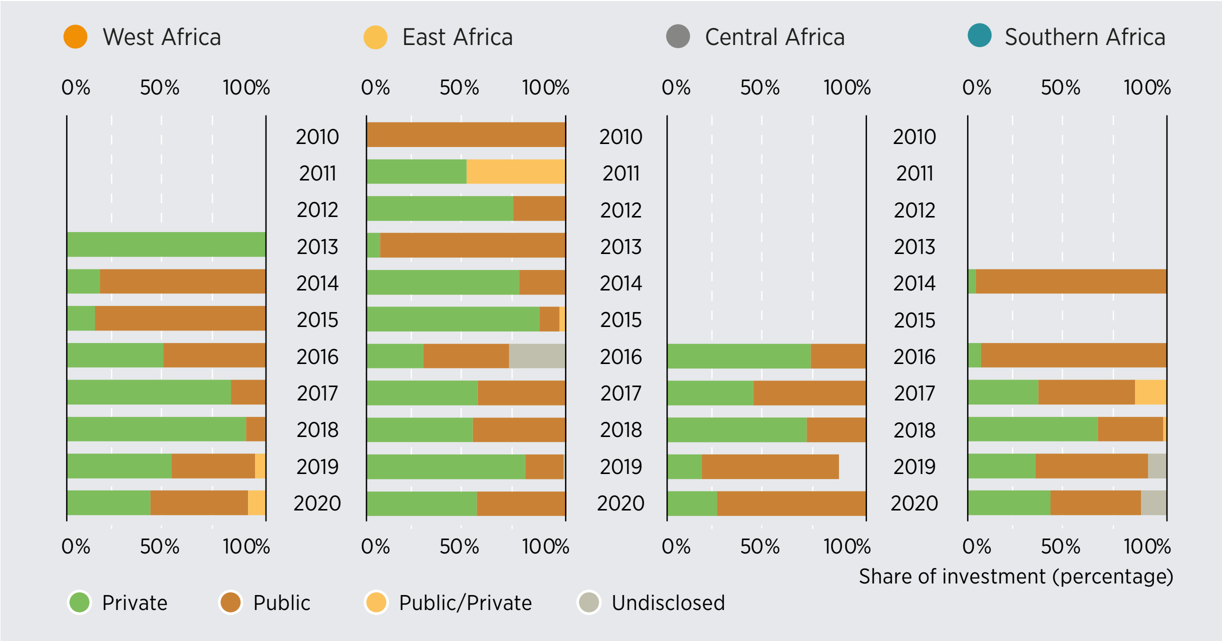
Commitments by source of capital

Over 60% of the financing directed to off-grid renewables in Africa during 2010-2020 came from the private sector, while the public sector accounted for about 34%. In 2020, 41% of commitments came from the public sector, up from 33% in 2019, signalling the need for greater support to the industry during the COVID-19 pandemic.

As the off-grid renewable energy sector advances, the purpose and share of public investment will shift, declining in some regions and increasing in others. In West and East Africa, where investments have been concentrated so far, public sector support will continue to be needed to reach remote populations and close affordability gaps. In Central and Southern Africa, where the off-grid industry is still at an early stage, public support plays an important role in catalysing the sector's growth by supporting enabling policies and regulations, and through other measures to de-risk investments and encourage market development. Public support accounted for 68% of total commitments in Central Africa in 2010-2020, and 49% in Southern Africa (Figure 3.16).

14 Some of the biomass projects were later removed due to commercial challenges.

Figure 3.16 Shares of public/private commitments to off-grid renewable energy, by region, 2010-2020



Source: Based on Wood Mackenzie (2021).

High shares of public support for the off-grid renewable energy sector in Africa are not surprising given the specific contexts in which companies must operate. Off-grid renewable energy investments typically involve small-scale companies in remote areas selling energy products or services to low-income households and small businesses with little or no credit history, circumstances that often make the companies too risky for local commercial banks and other traditional investors. In these contexts, targeted policy and regulatory support, technological innovation, capacity building and the application of tailored delivery and financing models can lower the cost of capital for both entrepreneurs and energy users (see Chapter 6).

Private investments came mainly in the form of private equity or venture capital, with just one infrastructure fund. Over 2010-2020, these investors committed USD 467 million, or 44% of total private investment in off-grid renewable energy, with shares slightly increasing over time. This is not surprising, given the appetite of equity and venture capital investors for start-ups with limited track record but high growth potential (IRENA and CPI, 2020). Institutional investors were the second-largest provider of capital in the sector, with USD 341 million committed in the same period. This group of investors consisted almost exclusively of foundations (*e.g.* Untours, David and Lucille Packard, Rockefeller) because philanthropies have a stronger interest in the social and environmental impacts of their portfolios than do other institutional investors (*e.g.* pension funds, insurance companies and sovereign wealth funds).

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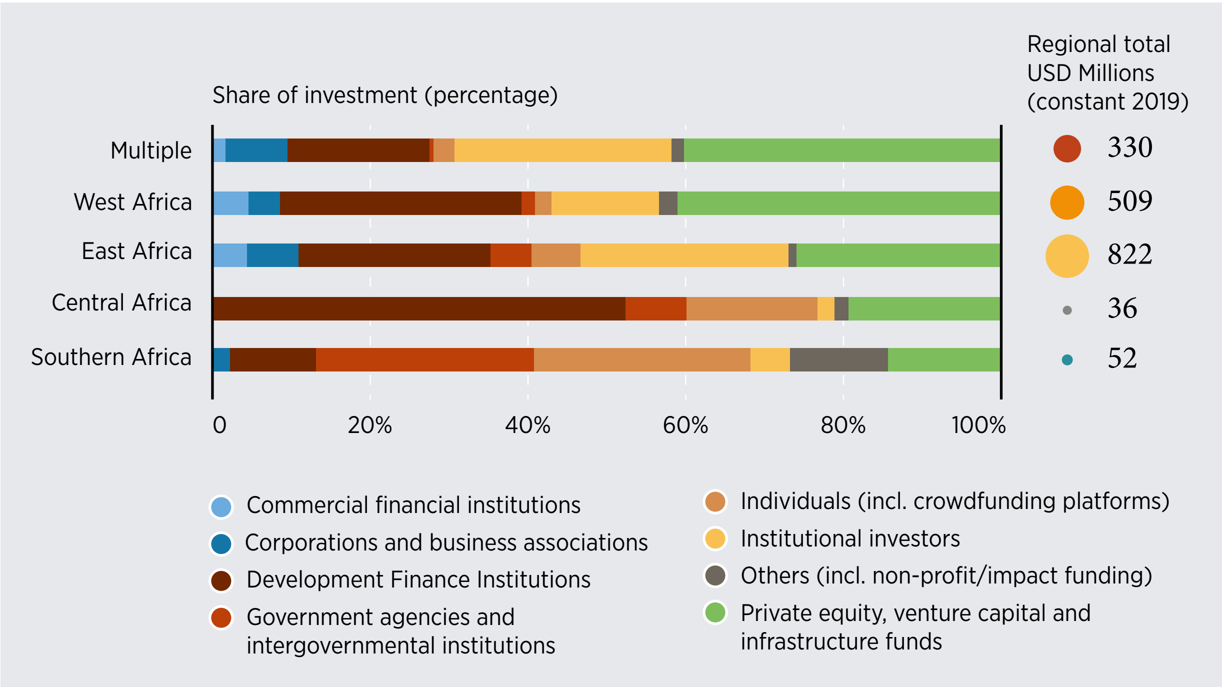
In recent years, the participation of private corporations and business associations, individuals (mainly through crowdfunding platforms) and commercial financial institutions has also increased, increasing the variety of private investors active in the sector.

Most public commitments came from DFIs, which invested USD 410 million over 2010-2020 (or 69% of total public commitments during the period). Publicly owned equity, venture capital and infrastructure funds also began investing in off-grid renewables in 2017, while the contribution of government agencies and inter-governmental institutions declined considerably over time.[15]

The varied experiences and levels of development of the off-grid renewables sector in each region attracted different types of investors. In more advanced markets, such as those of West and East, at least half of commitments came from a combination of private equity, venture capital and infrastructure funds, and institutional investors. In addition, funding from commercial financial institutions and private corporations focused almost exclusively on these two regions, demonstrating the growing commercial viability of off-grid renewables in these markets. Conversely, off-grid renewable energy companies and projects in Central and Southern Africa have relied more heavily on DFIs and government agencies and their funded programmes and partners, as well as on financing from individuals attracted through crowdfunding campaigns (Figure 3.17).

Figure 3.17 Shares of commitments to off-grid renewable energy, by type of investor and region, 2010-2020

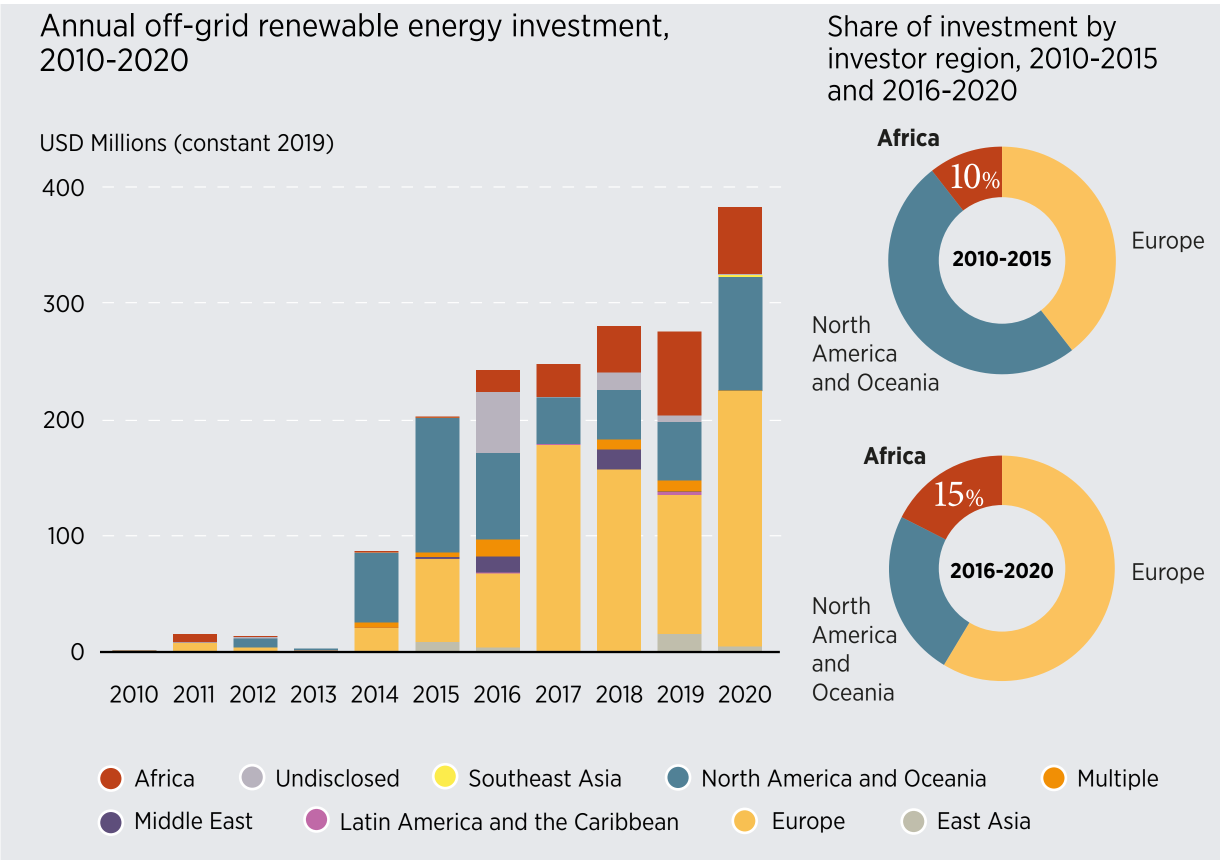


Source: IRENA analysis based on Wood Mackenzie (2021).
Note: "Multiple" denotes financial commitments that benefit more than one region simultaneously.

15 Noting that Government donors are the major funders in such agencies and intergovernmental institutions.

The lion's share of funding for off-grid renewables in Africa came from investors based in Europe, North America and Oceania. European investors accounted for almost half of the total, investing USD 841 million during 2010-2020. An additional USD 492 million came from investors based in North America and Oceania (28% of the total), though their share more than halved from an annual average of 48% in 2010-2015 to 21% in 2016-2020. Starting in 2016, investors from the African continent have played an expanding role, investing on average USD 43 million during 2016-2020, up from just USD 1.7 million in 2010-2015 (Figure 3.18).

Figure 3.18 Annual commitments to off-grid renewable energy, by investor region, 2010-2020



Source: Based on Wood Mackenzie (2021).
Note: "Multiple" denotes investors headquartered in more than one region.

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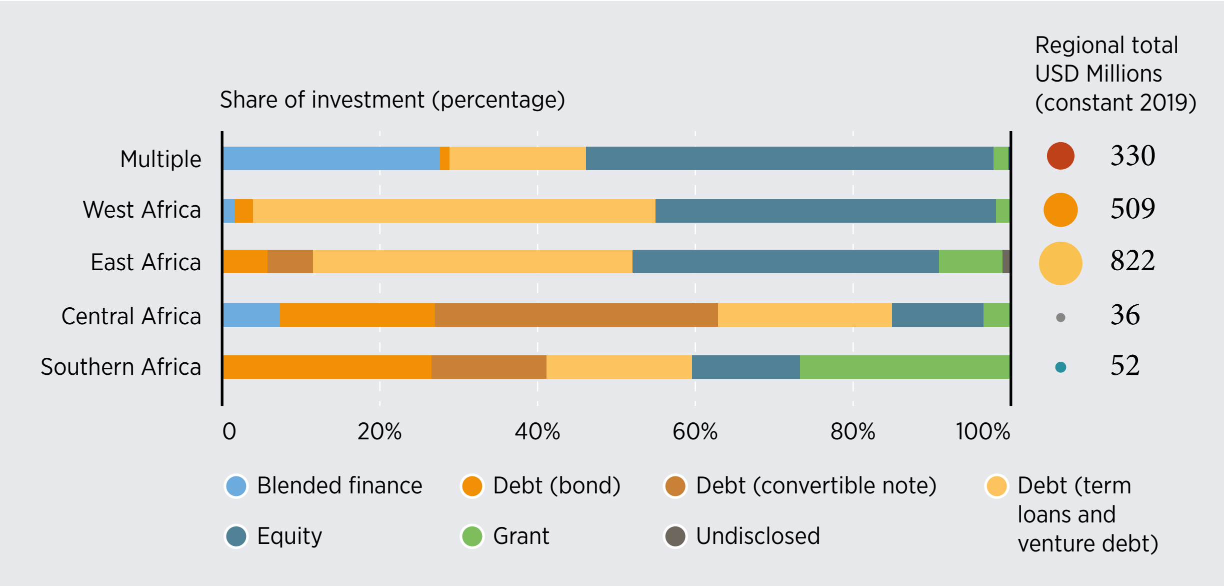
Commitments by financing instrument

Over time, as the off-grid sector matured, the variety of instruments has broadened, along with the projects they financed. Prior to 2014, financing was mainly done through grants and loans. Since 2014, equity has become the preferred instrument, followed by loans. Over the past five years (2016-2020), the share of bonds and convertible notes grew gradually. During the two decades under study, off-grid renewables in Africa were financed through a mix of equity (41%) and term loans/venture debt (38%). Other debt instruments (bonds and convertible notes[16]) accounted for 9% of total financing, while grants and blended finance each made up 6%. Transactions classified as blended finance, where public and philanthropic capital leverage private investment, remained low throughout the period 2010-2019 before peaking in 2020 following a USD 90 million commitment to Greenlight Planet Inc. to expand its operations. That single commitment has delivered over 1.3 million PAYG solar products in Kenya, the United Republic of Tanzania, Uganda and Nigeria (Business Wire, 2020).

In West and East Africa, equity, loans and grants were all used to finance off-grid renewables during 2010-2020. In Central and Southern Africa, greater use was made of convertible notes and bonds. Convertible notes, in particular, are typically used to finance early-stage start-ups. Additionally, in Southern Africa, 27% of financing came in the form of grants, suggesting a greater need for concessional funding in the region (Figure 3.19).

Figure 3.19 Shares of cumulative commitments to off-grid renewable energy, by region and financing instrument, 2010-2020



Source: Based on Wood Mackenzie (2021).
Note: "Multiple" denotes financial commitments that benefit more than one region simultaneously.

16 A convertible note is a short-term debt instrument that includes an option to convert the note into equity once a specified milestone is met, often at the valuation of a later funding round. Convertible notes are often used by angel or seed investors to finance early-stage start-ups that have not been valued explicitly.

3.3 MANAGING RISKS AND MOBILISING CAPITAL

Real or perceived risks continue to prevent many investors from committing their capital, despite the promise of the market. Mitigating solutions can help close renewable energy transactions. As shown by Moody's (2018), general project default rates in the 1983-2016 period were lower in Africa than in much of the rest of the world, including in Asia, Eastern Europe, Latin America and North America. This is likely due to the intense nature of the vetting process for projects in Africa, which have been held to a particularly high standard. Nevertheless, the low default rate also reveals a vast potential for successful transactions – if the adequate safeguards are put in place to lower risk, real and perceived.

As a result of the front-loaded and long-term nature of renewable energy projects, many barriers can block a project's initial development and funding, cause expensive delays or result in a high cost of capital that subsequently translates into high power costs for end consumers.

At the macro level, chief among the risks that investors cite are political risks (such as political stability and the rule of law), governance and safety issues, off-taker risks (some power utilities in Africa are not financially sound) and economic risks, including those linked to foreign exchange (large currency fluctuations and currency inconvertibility).

At the level of the energy industry, barriers present themselves in the form of policy-level support (or lack thereof) for the development of renewable energy, concerns about the power purchaser's creditworthiness (or consumer credit risk, particularly in the case of off-grid markets) and lack of sufficient investment in grid interconnection and transmission lines, among others. In addition, changes in legal or regulatory policies erode investor trust. Absent structural policy and regulatory reforms, private power producers might fear loss of access to the transmission grid and worry that off-takers might not be creditworthy, operationally efficient and reliable. Finally, lack of government institutional capacity and synergy in the planning, procurement and contracting processes can lead to unsustainable project development outcomes (SEforAll and South Pole, 2020).

At the transactional level, potential producers may wonder about the availability of 1) appropriate financing instruments (in particular, affordable long-term debt) in local markets; 2) matching funds and risk-mitigation tools; and 3) know-how for structuring and financing transactions. They may also be concerned about the relatively small transaction sizes.

Host governments must adopt policies and other measures to create an enabling environment that will attract local and foreign investors (see Chapter 4). The public sector can take actions to de-risk projects and mobilise private capital via blended finance initiatives (discussed in section 3.3.1) and take advantage of emerging solutions and business models (section 3.3.2).

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3.3.1 De-risking investments and mobilising capital

Credit enhancement and risk-mitigation instruments

Risk mitigation instruments can be an effective tool to lower perceived and real investment risks and, therefore, mobilise capital from private investors, especially in relatively underdeveloped markets such as in Africa. Such instruments also permit for a more efficient and leveraged use of public capital and support (including of government financing) – resources that are often constrained in the African context.

Such instruments encompass an array of solutions and tools that seek to address a host of risks including political risks (*e.g.*, war, expropriation, breach of contract), policy and regulatory risks (*e.g.*, adverse change in regulations, structural and/or sectoral reforms, taxes, incentive programmes, etc. – (see Chapter 4), economic risks including currency fluctuations and inconvertibility, off-taker non-payment risks, in addition to uncertainties linked to resource availability, and transmission and distribution capabilities, among others. Table 3.6 describes the main categories of risk a renewable transaction may encounter and common instruments to minimise, hedge or transfer them. Other risks may be present as well, including difficulties with land acquisition and rights, project permits and licences, timely completion, cost overruns and project performance.

A wide array of risk-mitigation instruments is available on the market today, provided by over a hundred institutions, public and private. These instruments are made available by host governments; multilateral, regional and national development banks; DFIs; export credit agencies; insurance companies and a host of joint initiatives. They are also typically provided on a project-by-project basis or as a bundled package for projects that are part of a structured procurement programme. DFIs, in particular, have an important role to play in supporting IPP investments in Africa by offering liquidity support, partial risk guarantees in lieu of sovereign guarantees and security packages, among other solutions. This support is critical for the bankability of projects in the region, which may be only able to sell to financially challenged power off-takers backed by fiscally constrained sovereign states. For investors – and in particular lenders – to be comfortable with the risks involved, additional credit enhancement and risk-mitigation cover is required.

Table 3.6 Key investment risks and mitigation tools to address them

Risk	Definition	Risk-mitigation tools
Policy or regulatory risk	Risks associated with changes in legal or regulatory policies that have significant, adverse impacts on project development or implementation (*e.g.*, incentive programmes, taxes, interconnection regulations, permitting processes).	Government guarantees, potentially backed by partial risk/credit guarantees, export credit guarantees and political risk insurance.
Resource risk	Risks associated with uncertainties around the availability, future price and/or supply of the renewable energy resource (*e.g.*, resource risks related to geothermal projects).	Government guarantees and grants, convertible grants, geothermal exploration insurance.
Technology risk	Risks associated with use of nascent technology or unexperienced labour deploying it.	Specialised insurance products.
Grid and transmission risk	Risks associated with limitations in interconnection, grid management and transmission infrastructure (including curtailment risk).	Government guarantees, liquidity guarantees, natural disaster insurance.
Counterparty risk (power off-taker risk)	Credit and default risk by a counterparty in a financial transaction. For renewable energy investments, this category is related to the risk of default or non-payment by the power off-taker, typically the electric utility.	Government guarantees, political risk insurance, partial risk/credit guarantees, export credit guarantees, liquidity facility, options and termination clauses in power purchase agreements.
Currency Risk	Risks associated with changing or volatile foreign exchange rates that adversely impact the value of investments and arises when there is a mismatch between assets (revenues) and liabilities (debt financing).	Government guarantees, currency risk hedging (swap, forward), loans in local currency or covered in the power purchase agreement, partial credit guarantees.
Re-financing risk	Risk that a borrower is unable to re-finance the outstanding loan during the life of the project owing to inadequate loan terms (high cost of borrowing, mismatch between loan maturity and lifetime of the asset).	Larger supply of capital market instruments for re-financing (*e.g.* green bonds/funds), partial credit guarantees.
Liquidity risk	Possibility of operational liquidity issues arising from revenue shortfalls or mismatches between the timing of cash receipts and payments.	Government guarantees, letters of credit, fully funded escrow accounts, liquidity guarantees, options.
Political risk	Risks associated with political events that adversely impact the value of investment (*e.g.*, war, civil disturbance, currency inconvertibility, breach of contract, expropriation, non-honouring of sovereignty obligations).	Government guarantees, political risk insurance, partial risk/credit guarantees.
Natural disasters	Risk that a natural disaster will affect the ability of a counterparty to fulfil its obligations (*e.g.* produce power, make payments).	Property, casualty and specialty insurance.

Source: IRENA (2020d) adapted from IRENA (2016).

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Some of these instruments may be difficult to access and sometimes expensive to buy (for example, in the case of some currency hedges). Also, guarantees, for example, are increasingly hard to obtain, as they can be considered a contingent liability that is added to the national debt burden. These difficulties often hinder a greater deployment of risk mitigation in markets such as in Africa (IRENA, 2020d, 2020e).

The World Bank and its member institutions are the most prominent providers of credit enhancement and risk-mitigation cover in Africa. AfDB and the International Development Finance Corporation (previously known as the Overseas Private Investment Corporation) are also active providers of political risk insurance. The World Bank's International Development Association's partial risk guarantees protect private lenders against debt service defaults on loans due to a host government or against the off-taker's failure to meet certain obligations. The Bank's Multilateral Investment Guarantee Agency (MIGA) guarantees IPPs against the risks of currency inconvertibility and transfer restrictions, expropriation, breach of contract, civil unrest and war. MIGA guarantees (over USD 100 million) are protecting the long-term power purchase agreements of renewable energy projects in Djibouti, Kenya, Namibia, Senegal, and South Africa (Power Futures Lab, 2021).

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Credit and political risks are also covered by joint initiatives such as the Regional Liquidity Support Facility (RLSF) launched in 2017 by the German development bank KfW and the African Trade Insurance Agency, a pan-African multilateral insurer providing credit insurance products to support investments in Africa (ATI, 2018). Recently, RLSF has supported renewable projects in Burundi (Gigawatt Global's 7.5 MW Mubuga solar plant) and in Kenya (100 MW Kipeto windfarm) by providing six months' liquidity cover for five and ten years, respectively (Alao and Kruger, 2021). Box 3.2 highlights the support of the RLSF for solar projects in Malawi. Similarly, the Africa Energy Guarantee Facility has been put in place by the European Union, KfW, the European Investment Bank, Munich Re and the ATI to provide insurance and reinsurance products for sustainable energy projects in Sub-Saharan Africa (EC, 2019).

GuarantCo, which forms part of the Private Infrastructure Development Group and is funded by the governments of Australia, Germany, the Kingdom of the Netherlands, Sweden, Switzerland and the United Kingdom of Great Britain and Northern Ireland, as well as the IFC, provides local currency liquidity support to IPPs. It is providing a USD 2.92 million loan guarantee to the Akuo Kita 50 MW solar PV Project in Mali, as well as a USD 9.3 million guarantee to the Ambatolampy 20 MW solar PV project in Madagascar (Power Futures Lab, 2021). The TCX Currency Fund also provides hedging tools for currency risks.

The U.S. International Development Finance Corporation provides similar liquidity cover, including for the 30 MW Ten Merina solar PV project in Senegal; as does France's DFI Proparco, which enabled the extension of a loan term from 8 to 15 years for a 37 MW solar PV project in Namibia by providing loan cover to a local commercial bank (Kruger, Alao and Eberhard, 2019; Power Futures Lab, 2021).

Box 3.2 Support for solar projects in Malawi from the Regional Liquidity Support Facility

With an installed power generation capacity of 439 megawatts (MW) and over 90% reliance on run-of-river hydropower, Malawi's government has been eager to grow and diversify its electricity generation capabilities. The support received from the Regional Liquidity Support Facility (RLSF) for Phase 1 of the Nkhotakota Solar Power Plant, with an installed capacity of 21 MW, and the Salima Solar PV plant, with a capacity of 60 MW will be Malawi's first to connect to the grid, serving as important catalysts for the country's clean energy goals.

The Nkhotakota and Salima facilities, currently under construction, benefitted from RLSF's revolving liquidity facility, which can be drawn upon in case of payment delays by the national off-taker, the Electricity Supply Corporation of Malawi Limited. The six month's liquidity cover provided by RLSF has a ten-year tenor for both projects and will enable USD 130 million in combined investments.

The Nkhotakota project is owned by a joint venture comprising Phanes Group (an independent power producer based in the United Arab Emirates) and responsAbility (a Swiss private equity investor). The U.S. International Development Finance Corporation is the sole debt provider.

The Salima project is owned by JCM Power (a Canadian independent power producer) and InfraCo Africa Limited (part of the Private Infrastructure Development Group funded by the governments of Australia, Germany, the Netherlands, Sweden, Switzerland and the United Kingdom of Great Britain and Northern Ireland, along with the International Finance Corporation).

Sources: Business Insider Africa (2021); Alao and Kruger (2021).

Blended finance

Often coupled with risk-mitigation instruments, blended finance encourages the sharing of risks and the know-how among transacting parties through the pooling of public and private capital. These structures have a great potential to attract private financiers to transactions which on their own might have difficulty obtaining commercial financing without the participation of the public financier (IRENA, 2016, 2020d, 2021e). Blended finance can be applied to scale up renewable energy transactions in least-developed countries. It includes an array of solutions, including 1) co-financing of projects among multiple parties; 2) on-lending transactions, whereby a DFI on-lends its low-cost capital to local institutions, and 3) the use of subordinated debt and convertible loans or grants provided by other public or philanthropic sources. Box 3.3 showcases several projects supported by the IRENA ADFD Project Facility that make use of blended finance.

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Box 3.3 IRENA ADFD Project Facility in Africa

The IRENA ADFD Project Facility is a joint initiative between IRENA and the Abu Dhabi Fund for Development (ADFD), which began in 2013. Through the facility, ADFD committed USD 350 million of concessional loans to 32 selected renewable energy projects in developing countries. The funding was provided via a co-financing structure whereby ADFD funded 50% of total project costs, with the rest of the project cost usually borne by local and/or institutional investors. In Africa, ten selected projects included a 3 megawatt (MW) community solar photovoltaic (PV) project in Burkina Faso, a 6 MW solar PV system with battery storage in six cities in Chad, a 2 MW mini hydropower project in Liberia, a 10 MW grid-connected PV system in Mauritius, a 2 MW solar PV mini-grid in Niger (the), a 2 MW solar mini-grid project in Senegal, a 1 MW solar-wind-hydropower project in Mauritania, a 4 MW decentralized solar PV mini-grid system in Mali, a 6 MW grid-connected solar PV plant in Sierra Leone and a 30 MW grid-connected solar PV plant in Togo. The IRENA ADFD Project Facility administered its last financing cycle in 2020.

At COP 26, the United Arab Emirates and IRENA launched the Energy Transition Accelerator Financing Platform, with a goal of securing at least USD 1 billion in climate finance to accelerate the transition to renewable energy in developing countries. The ADFD contributed USD 400 million towards the platform's goal.

Sources: IRENA (2020f, 2021e).

Similarly, in 2020, AfDB invested USD 54 million in seven projects, including a USD 20 million loan for the COVID-19 Off-Grid Recovery Platform, which provides capital to energy access companies. The AfDB loan will be blended and co-invested with USD 30 million of commercial funding. AfDB also awarded USD 15 million to the Africa Renewable Energy Fund II, which finances run-of-river hydropower and hybrid/storage opportunities, and acted as the anchor financier (via a USD 5 million investment) in the SPARK+ Africa Clean Cooking Ecosystem Fund, which finances clean cooking companies in Sub-Saharan Africa (SEFA, 2020).

In 2021, in response to the COVID-19 pandemic, 16 governments, foundations and investors joined together to close a USD 83 million debt fund to protect energy access for at least 20 million people in Sub-Saharan Africa and Asia. The Energy Access Relief Fund blends various types of capital, including grants, concessional and subordinated debt, and equity to offer low-interest loans and liquidity to an estimated 90 energy access companies in Sub-Saharan Africa and Asia still struggling with disruptions wrought by COVID-19.

In 2014, donors, DFIs and investors launched Climate Investor One (CI1) through the Climate Finance Lab. CI1 is a blended finance facility designed to deliver major renewable energy infrastructure projects. It employs a mix of public and private funding, as well as commitments from DFIs and guarantees from the Export Credit Agency. Public sector donors have funded the development stage of the projects, which typically cannot be financed by private investors, and played a key role in mobilising private capital during the construction stage of the project, where risks are better understood and financial returns can be achieved. Donors included the European Union, the Green Climate Fund, USAID (via PowerAfrica), the Nordic Development Fund and the Directorate General for International Cooperation within the Ministry of Foreign Affairs of the Kingdom of the Netherlands.

To make blended finance approaches more efficient and widely deployable, financial markets in the target countries must be deepened. This can be done by 1) building the capacity of local financial institutions (*e.g.* through the launch in 2021 of the GCF-AfDB Leveraging Energy Access Finance Framework); 2) mobilising local investors, including national development banks; 3) promoting greater use of local currency; 4) engaging local stakeholders to identify opportunities that meet local needs. Improved collaboration among market participants, sharing of know-how and transparent reporting of results would also help increase the number of blended transactions as well as their effectiveness in mobilising the market. Finally, blended finance packages may work best when they are part of a portfolio approach and incorporated into national sustainable development plans (OECD, 2020).

3.3.2 Emerging solutions and approaches for financing renewables

The past decade has seen the emergence of a host of new investment instruments and business models to mobilise capital towards sustainable solutions, including renewable energy. These include green bonds, contract standardisation and project bundling, which are discussed below. New financing and business models for off-grid renewables such as results-based financing, the PAYG model, and crowdfunding are discussed in Chapter 6.

Green bonds in Africa

Green bonds have proven to be a particularly successful and promising capital market instrument with an average annual growth rate of 60% over the 2015-2020 period. Total global issues reached USD 270 billion in 2020 from USD 100 billion in 2015 (Climate Bonds Initiative, 2021a). From the first issuance in 2007, global cumulative issues topped USD 1 trillion in December 2020. The potential for further growth is still very large, as the global bond market stood at USD 120 trillion at the end of 2020 (Climate Bonds Initiative, 2021a; SIFMA, 2021). Green bonds are a particularly effective tool for mobilising capital from institutional investors who prefer to invest large amounts indirectly via bonds or funds rather than directly into renewable energy projects (IRENA, 2020e).

In Africa, the green bond market is in its initial stages with only about USD 2.8 billion issued to date. Of that, South Africa alone accounted for about USD 2.2 billion (Climate Bonds Initiative, 2021b). Other African countries where green bonds have been issued include Kenya, Morocco, Namibia, Nigeria and Seychelles. Sudan (the) joined the group in May 2021, when it issued its first green sukuk bond (a bond compliant with Islamic banking principles) to finance renewable energy (Brookings, 2021; Reuters, 2021).

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Viewed globally by volume, about half of green bond issues had renewable energy as one of their use categories, while 16% were earmarked solely for renewable energy assets (IRENA, 2020g). In Africa, 19% of green bonds issuances were dedicated to renewables (IRENA, 2020g). While the role of DFIs in green bonds in the rest of the world has waned, with most issues now made by corporations and financial institutions, DFIs remain an important supporting pillar in the African market. In particular, the AfDB is estimated to have issued about 80% of the outstanding green bonds in Africa as of the end of 2018 (Tiyou, 2019).

To encourage further growth of this promising investment instrument, policy makers and regulators can work together with DFIs and green bond organisations such as the Climate Bonds Initiative to develop and adopt green taxonomies and bond issuance and rating rules; to raise awareness; to develop pertinent skills in local capital markets, as well as to support issuances and to provide seed capital and targeted grants to lower transaction costs (IRENA, 2020g). Nigeria has been taking the necessary steps and has already achieved positive results (Box 3.4).

Box 3.4 Developing the green bond market in Nigeria

Recognising the urgent need to mobilise large amounts of capital for sustainable infrastructure solutions, the Nigerian Green Bond Market Development Programme was officially launched in June 2018 through a cooperation between the FMDQ Securities exchange (Nigeria's largest securities exchange), the Climate Bonds Initiative (an international not-for-profit organisation whose goal is to mobilise capital for climate solutions) and Financial Sector Deepening Africa (a UK-funded entity that promotes financial market development in Africa). The aim of the programme is to develop the corporate green bond market in Nigeria through 1) training and capacity building in the issuance and use of green bonds; 2) risk mitigation; 3) development of a pipeline of green opportunities; and 4) collaboration among market participants. Programme parties also worked with the securities regulator, the Securities and Exchange Commission of Nigeria, to put in place the national Green Bond Issuance Rules, launched in November 2018, and to strengthen transparency and disclosure rules in the country's green bond market.

The programme has already scored several market firsts. Nigeria's first green bond was a sovereign green bond, issued by the federal government in December 2017 to fund projects that contribute to meeting the country's Nationally Determined Contributions (NDCs). Corporate issues soon followed from Access Bank PLC, raising NGN 15 billion (USD 36.5 million), and the North South Power Company Limited (NSP). raising NGN 8.5 billion (USD 20.6 million) in February 2019. The NSP bond attracted commitments from 12 institutional investors, including nine pension funds, and benefitted from a guarantee issued by the Infrastructure Credit Guarantee Company, an entity established by GuarantCo and the Nigerian Sovereign Investment Authority to provide local currency guarantees for infrastructure projects in Nigeria. The NSP issue highlights the benefits of co-operation with development banks and the importance of risk mitigation solutions that cater to institutional investors.

In addition to local issuances, in October 2019, the Nigerian Stock Exchange and the Luxembourg Stock Exchange, the largest global platform for listing of green bonds, signed a Memorandum of Understanding (MoU) to 1) promote cross-listing and trading of green bonds in Nigeria and Luxembourg, 2) share best practices, and 3) co-operate in joint initiatives. In 2020, Nigeria's Access Bank issued a first dual-listed bond on the Luxembourg Stock Exchange and the Nigerian Stock Exchange. Access Bank will be using the funds for projects in flood defence, solar generation and agriculture.

Sources: African Business, (2020); FSD Africa et al. (2019).

Contract standardisation and project bundling

Renewable energy projects, like other infrastructure projects, entail significant transaction costs stemming from the complex technical, legal and financial work required to close a transaction. When several projects can be bundled together, however, per-project transaction costs can be greatly reduced for all the participating parties, leading to faster and smoother closing, and frequently better pricing as well. Bundled projects can also help attract institutional investors.

An oft-mentioned example of a renewable energy bundled transaction is the 102 MW Seven Sisters solar PV project in Jordan led by the IFC. The transaction combined seven relatively small (10-50 MW) projects developed by seven small developers and reached financial close in 2014. Being the lead arranger and lender of record, the IFC acted as an intermediary with other lenders and service providers. All transactions were combined into one financing platform, and legal documentation was based on a common template. Transaction costs were further reduced as bulk discounts were obtained from service providers, including legal, technical and insurance advisors (IFC, 2018a). Given the success of the approach in Jordan, the IFC replicated it with the Nubian Suns project in Egypt, which reached financial close in 2017. This project is a USD 653 million, 752 MW aggregation of 13 solar PV plants near the city of Aswan, which is a part of the larger Benban Solar Park (planned to comprise 32 plants in total). The 11 financiers also included DFIs and international banks, while MIGA provided political risk insurance for 12 of the projects (IFC, 2018b). Similar DFI-led initiatives are Scaling Solar and GET FiT, both discussed in Chapter 4.

As is evident from the Seven Sisters and the Nubian Suns projects, standardisation of legal documentation is an important enabler of project bundling and the resulting economies of scale. In addition to project documentation (*e.g.*, power purchase agreement, operations and maintenance agreement, etc.), standardisation can also encompass risk mitigation instruments provided by DFIs. Documentation used for renewable energy projects is often based on documents originally developed for conventional power projects, which tend to be larger and more complex. In contrast, renewable power projects are often much simpler, smaller and more rapidly implementable. Contracts designed for fossil fuel power often do not fit well with renewables and may increase transaction time and costs unnecessarily.

In response, a great deal of work has been done to standardise renewable energy documentation at country levels, as well as globally, and market participants should take advantage to save on time and costs.

South Africa's Renewable Energy Independent Power Producer Procurement Programme, for example, contained standardised and non-negotiable power purchase agreements that were drafted in accordance with international best practices and adapted to local considerations after prior consultation with local lenders and stakeholders (Eberhard and Naude, 2017). Similarly, in efforts to attract investors to their renewable energy sectors, the governments of the United Republic of Tanzania and Uganda provide model contracts in their investment guides (McDaid and SAFCEI, 2016). In addition, IRENA and the Terrawatt Initiative have worked together with leading international law firms to draft simplified and standardised templates for solar PV documents that are publicly available. In addition to project documentation, standardisation can be applied to risk-mitigation instruments provided by DFIs. Many of these are discussed in Chapter 4.

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3.4 CONCLUSION

Renewable energy investments in Africa over the two decades from 2000 to 2020 amounted to USD 60 billion – just 2% of the global total. Conventional power still attracts more funding than renewables, owing to an established process that privileges thermal generation, which is less capital intensive than renewable energy. Yet the pace of investment in renewable energy accelerated 20-fold between 2010 and 2020, reaching USD 55 billion. Both grid and off-grid investments grew remarkably, though they are still lagging behind what is needed to meet the objectives of SDG 7.

Investments have not been distributed evenly across the African continent. Concentrations of renewable energy investments have emerged, with North and Southern Africa as the favoured destinations. West and East Africa ranked somewhat lower; Central Africa received the least amount of financing.

The distribution within regions is also unequal: South Africa, Morocco, Egypt and Kenya have attracted 75% of the overall grid-connected assets. In the off-grid sector, East Africa attracted 50% (Kenya and the United Republic of Tanzania) of all investments over the 2010-2020 period, while West Africa (mainly Nigeria) has started to receive more investment in recent years. Investment in the rest of Sub-Saharan Africa remains low and concentrated in a handful of countries.

An inclusive and just energy transition can only be achieved by bringing under-invested countries into the fold. This requires mobilization of resources on an unprecedented scale while overcoming unique contextual barriers through strong policy and institutional underpinnings – aspects that could form the key pillars for a potential Green Deal for Africa.

In terms of technology, solar PV and wind have accounted for 64% of all investments. The pace of investment slowed dramatically with the arrival of the pandemic, allowing the gap in access to electricity to continue to grow.

When it comes to the sources of funding, while North, West, and East have drawn the most public funding, North and Southern Africa have been the most significant recipients of private capital. These inter-regional differences reflect differences in the level of development of the sector, mainly in power: more mature markets attract more private funding.

Loans have been the most common instrument for funding renewable energy projects in Africa, accounting for 78% of investment. Equity has accounted for 20%. The data imply an average debt/equity ratio of 4, indicating acceptable levels of risk by lenders and equity investors. Guarantee instruments have played a key role in this achievement.

Ten investors accounted for 85% of all public commitments over the 2010-2019 period; China was the largest lender, followed by MDBs (AfDB, the World Bank Group and GCF) and DFIs. Debt remains the largest instrument in public commitments. However, commitments do not always translate into timely disbursements; in a sub-set of assessed projects during 2013-2018 in 20 access-deficit countries, almost two-thirds had late disbursements, indicating that the overall projects' development context had not been fully prepared by the time of financial closure.

The emergence of privately managed funds played a crucial role in accelerating investments, changing funding sources from public to private. More recently and although incipient, capital-market debt instruments began to replace loans once commissioning and early years of operations had been achieved, freeing capital from lenders for redeployment and further developments.

Africa's general project default rates are lower than in the rest of the world, displaying the continent as attractive and relatively safe for investment. Fiscal discipline, MDB support and guarantees have contributed to this achievement. However, policy and transaction risks remain a significant barrier to project development. MDBs, DFIs (including the export credit agencies), guarantee funds and private reinsurance have provided a plethora of risk-mitigation structures. Technological innovation and new applications of mitigation tools have increased the use of guarantees to mobilise capital towards renewable energy investments. The continent has been the stage for financial creativity – from partial risk guarantees to liquidity facilities and breach-of-contract provisions – preparing the ground for the next wave of projects.

Africa's constrained tariff context could jeopardise the bankability of projects, and international financial institutions have taken the first steps towards lowering the cost of debt and risks to enable access to pools of capital. Blended finance and green bonds have led this response, though their use remains small in scale.

COP26 shed light on some promising new initiatives: 1) standardised listed capital products (*e.g.* MOBILIST) to broaden the investor base for renewable energy; 2) the Climate Investment Fund's announcement of up to USD 700 million per annum and 3) the phase out of coal, creating a void that renewable energy could fill.

The COVID-19 recovery and COP26 have built the momentum for a new wave of renewable energy investment in Africa. This momentum could be leveraged for a future Green Deal for Africa that is underpinned by a comprehensive policy framework to drive forward the energy transition (Chapter 7), and co-ordinated assistance from donors, MDBs, DFIs, national governments and green funds, and supported by a platform for risk sharing and mitigation. Through these efforts, Africa is poised to achieve an inclusive and just transition to renewable energy in line with SDG 7 and broader socio-economic goals.

POLICY FRAMEWORK FOR THE ENERGY TRANSITION

MOROCCO | Photo: © Nadia Ferroukhi | www.nadia-ferroukhi.com

- **Enabling** policies
- **Deployment** policies
- **Integrating** policies
- **Structural policies** for a just and inclusive transition
- **Conclusions** and **recommendations**

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Africa has vast if untapped renewable energy sources. By harnessing these resources, the continent could leapfrog technology stages to create an energy system based on renewables that covers all sectors and end uses. Yet the policies and measures driving investment have for the most part focused on the power sector and rural access – electrification and clean cooking. An energy system based on renewable energy could support sustainable development, industrialisation and economic growth. To that end, a set of targeted polices and measures is needed.

This chapter sets out the International Renewable Energy Agency's (IRENA's) comprehensive policy framework for a just and inclusive energy transition (Figure 4.1). Section 4.1 covers enabling policies that support the uptake of renewable energy and energy efficiency,[1] cutting across all technological solutions. Section 4.2 discusses deployment policies specific for each solution, and section 4.3 analyses the policies to support the integration of those solutions within the energy system in Africa. Energy access specific policies are covered in chapter 6. Policies to ensure a just and inclusive transition are outlined in Section 4.4 while the need for international and South-South cooperation, anchored in an African Green Deal for social and economic development, is discussed in Chapter 7.

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1 *Energy efficiency, a primary decarbonisation route, is discussed in the report, but it is not the focus of Chapter 4.*

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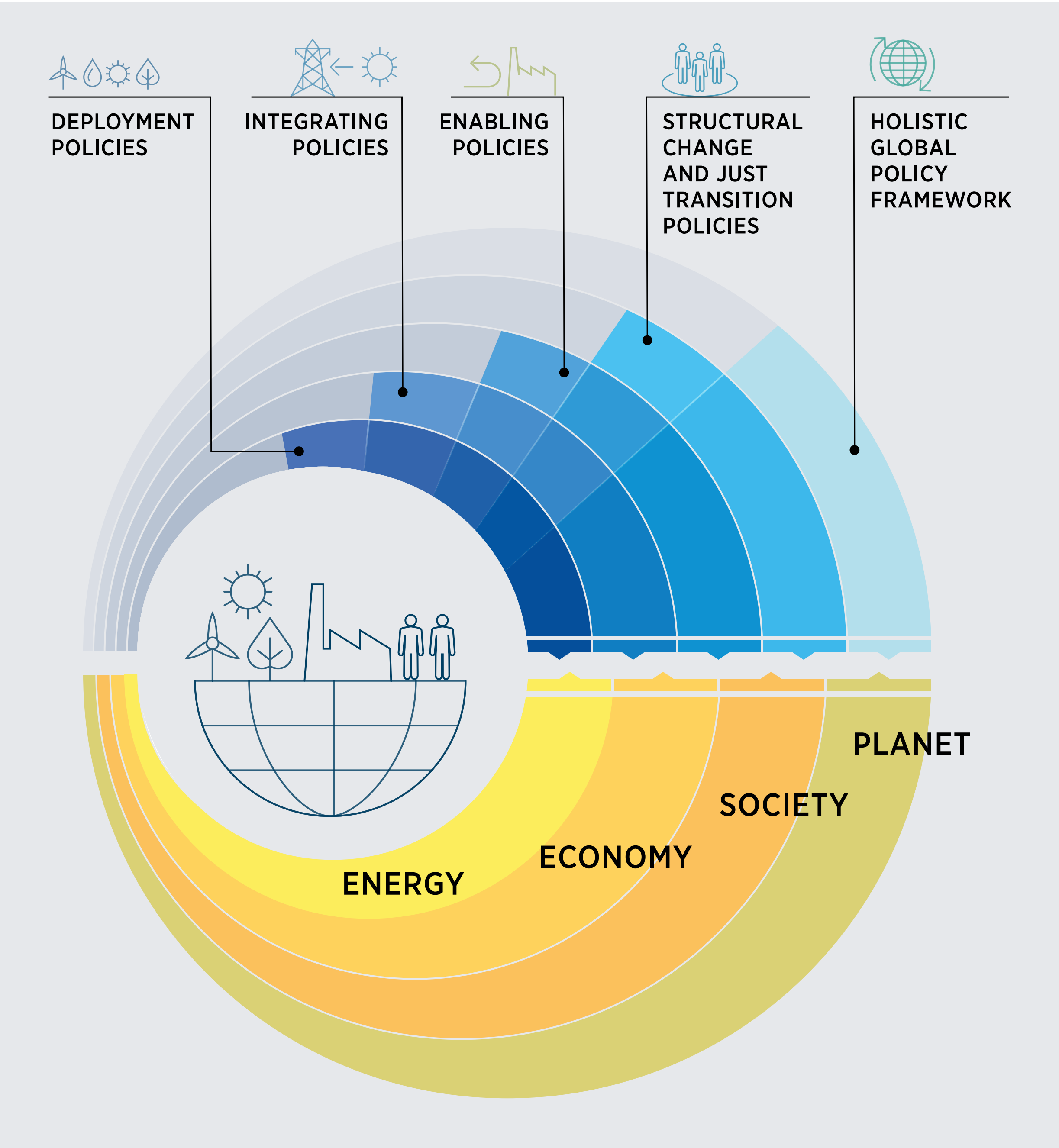
Figure 4.1 Comprehensive policy framework for a just and inclusive energy transition



Source: IRENA (2021e).

4.1. ENABLING POLICIES

A range of policies that cut across all sectors and end uses provides enabling conditions for the accelerated deployment of energy transition solutions in Africa. These include national and regional commitments to raising ambitions, such as specific renewable energy targets embedded within long-term plans; and measures that eliminate market distortions and disincentivise new investments in fossil fuel technologies, facilitate access to finance (discussed in Chapter 3), increase energy efficiency and conservation, develop the needed infrastructure, foster innovation, and raise awareness among consumers and citizens to support the uptake of transition-related technologies.

4.1.1 Commitments to renewable energy deployment

Recognising the role of renewable energy for the sustainable development and industrialisation of Africa and for achieving the potential socio-economic benefits, renewable energy commitments have been made at the regional and national levels. At the same time, commitments to support renewable energy deployment in Africa have been made by the international community, including bilateral and multilateral development institutions in the form of technology transfer, financing, policy support programmes, among others (Chapter 3 and Chapter 7). One example is the African Development Bank's New Deal on Energy for Africa (Box 4.1).

Box 4.1 The African Development Bank's (AfDB's) New Deal on Energy for Africa

Using on- and off-grid solutions, Africa aims to achieve 100% urban access and 95% access in rural areas by 2025.

African governments are partnering with bilateral and multilateral institutions, in addition to the private sector, to finance the energy sector through public-private initiatives.

The AfDB's New Deal hopes to (1) raise aspirations regarding the continent's energy challenges; (2) establish a Transformative Partnership on Energy for Africa; (3) mobilise domestic and international capital for innovative financing; (4) support African governments in strengthening energy policy, regulation and sector governance; and (5) increase the AfDB's investments in energy and climate financing.

Source: African Development Bank (2017).

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Regional plans, targets and institutions

Regional leaders have committed to inclusive, sustainable economic growth and development in Agenda 2063: The Africa We Want (IRENA, KFW and GIZ, 2021). The strategic framework highlights social and economic development, continental and regional integration, democratic governance, and peace and security among other issues (African Union Commission, 2015).

At the regional level, the twin goals of renewable energy and energy efficiency are supported through the **formation of dedicated centres** mandated to support the transition, in co-ordination with member countries, donor agencies and other international institutions. Regional centres have co-ordinated the development of energy plans and roadmaps (Table 4.1).

Renewable energy targets for West and Southern Africa focus on the power sector. West Africa targeted a 35% increase in the share of renewables in the electricity mix by 2020; for 2030 it is targeting a 48% increase. In Southern Africa, the share was set at 33% in 2020 and 39% in 2030. North African countries have joined other members of the League of Arab States in setting a target of a 12% share of renewables in generated electricity. In other sub-regions, targets remain set at the national level.

Commitments at the national level

At the national level, commitments towards renewable energy and energy efficiency are indicated in **Nationally Determined Contributions (NDCs), national energy plans and set targets.**

By mid-November 2021, 53 African countries had submitted NDCs; 38 had sent updated NDCs in 2020-2021. Of those countries submitting NDCs, around 40 included renewable energy targets, 37 of which focused on the power sector, and about 13 included targets on end uses such as heating, cooling and transport (IRENA, 2022). As in most countries in the world, pledges made in NDCs are sometimes not aligned with renewable energy targets in national energy plans.

North and West Africa are notable on the continent for having integrated **renewable energy targets into their national energy plans** mostly focused on the power sector (Table 4.2). Renewable power targets are formulated in terms of installed capacity (megawatts, MW) and the share of renewables in the electricity mix. Plans vary in ambition and target dates – for example, in 2015 Cabo Verde set a target share of 100% renewable electricity by 2030 in its national plan; in 2010 Seychelles targeted a 15% share by 2030.

As of August 2021, 28 countries had renewable energy **targets for rural electrification** in their NDCs and national plans, mostly focusing on off-grid solar photovoltaic (PV). Almost half of these countries are in West Africa, while Central Africa has the fewest countries with rural electrification plans based on renewables. When it comes to **clean cooking targets**, more than a third of African countries (20 countries) had such targets in their NDCs or national plans. Seven countries in West Africa have clean cooking targets (Table 4.2). Rural electrification and clean cooking plans and regulations are discussed in Chapter 6.

By 2021, about half of the African countries had included **energy efficiency targets** in their NDCs and national energy plans (see section 4.1.3).

Table 4.1 Renewable energy regional plans and centers

North Africa	
	**North African** countries have set targets at the national level and together with the other members of the League of Arab States, they have formed the Regional Center for Renewable Energy and Energy Efficiency (RCREEE) to support renewable energy and energy efficiency across the Arab region. The Pan-Arab Strategy for the Development of Renewable Energy 2010-2030 was expanded in 2018 to become the Pan-Arab Sustainable Energy Strategy – 2030 and include energy efficiency and energy access. The strategy aims at reaching a 12.4% share of renewables in the electricity mix, and it is presented with an implementation plan with 17 programmes (6 at the regional level and 11 at the national level) that rest on national efforts, in addition to regional and international co-operation. The strategy suggests shifting Arab electricity markets towards higher shares of renewables, ensuring the needed public and private investments, mitigating most of the risks and challenges related to grid planning, expansion and operation, and integrating smart services and quality assurance schemes. The implementation tool for renewables is the Arab Renewable Energy Framework, which offers guidelines for Arab states to develop their National Renewable Energy Action Plans based on a customised template, serves as baseline for annual progress reports (IRENA, League of Arab States and RCREEE, 2014).
West Africa	
	In **West Africa**, the Economic Community of West African States (ECOWAS) Renewable Energy Policy (EREP), adopted in July 2013 by ECOWAS heads of state and governments, aims to increase the share of renewable energy in the region's electricity mix to 35% in 2020 and 48% in 2030 (excluding large hydropower, this would be 10% and 19%, respectively). Complementing the EREP is the ECOWAS Energy Efficiency Policy, which aims to make available 2 000 megawatts of power generation capacity through efficiency gains and ultimately double the rate of improvements in energy efficiency (IRENA, n.d.a). Following the adoption of the regional policies, all ECOWAS member states developed National Renewable Energy Action Plans, National Energy Efficiency Action Plans and SEforALL Action Agendas between 2014 and 2015. As such, the aggregated targets of ECOWAS members as expressed in their Sustainable Energy Country Action Plans align with the regional targets declared in the EREP (ECREEE, 2018). The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) was established in 2010 to create favourable conditions for regional renewable energy and energy efficiency markets.
East Africa	
	In **East Africa**, the East African Community established the East African Centre of Excellence for Renewable Energy and Energy Efficiency (EACREEE) in 2016 to facilitate the creation of an enabling environment for renewable energy and energy efficiency markets and investments (EACREEE, 2020). Although all countries have set their targets at the national level, by 2021 there was no regional plan or target set.
Central Africa	
	In **Central Africa**, the 11 ministers of energy of the Economic Community of Central African States (ECCAS) approved a Renewable Energy Roadmap and the creation of the Centre for Renewable Energy and Energy Efficiency for Central Africa (CEREEAC) as a specialised institution. The Renewable Energy Roadmap for Central Africa, developed by IRENA and ECCAS, demonstrates that 77% of the electricity mix could be provided by renewable energy sources (around 25% if large hydropower is excluded) by 2030 (CEREEAC, 2021).
Southern Africa	
	In **Southern Africa**, the Southern African Development Community adopted the Renewable Energy and Energy Efficiency Strategy and Action Plan in July 2017. The regional targets are to increase the share of renewable energy in the region's electricity mix to 33% in 2020 and 39% in 2030. It also mentions increasing the off-grid share of renewable energy as per total grid electricity capacity to 5% in 2020 and 7.5% in 2030 (SACREEE, 2017). The Southern African Development Community Centre for Renewable Energy and Energy Efficiency (SACREEE) was established in 2015 to boost access to modern energy services and energy security by promoting market-based uptake of renewable energy, energy efficiency and energy services.

Disclaimer: These maps are provided for illustration purposes only. Boundaries shown on these maps do not imply any endorsement or acceptance by IRENA.

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Table 4.2 Overview of national commitments to renewable energy and energy efficiency

	RE target in NDCs/INDCs	RE target in national energy plan	RE target in rural electrification plan	Clean cooking target	EE target in NDCs/ INDCs	EE target in national energy plan
North Africa						
Algeria	Yes, focus on power	Yes, power and heating	No	No	No	Yes, power, buildings and industry
Egypt	Yes (no quantified target), focus on power and transport	Yes, focus on power	No	No	Yes (no quantified target), focus on power	Yes, lighting, power, standards and labels, and buildings
Libya	No	Yes, power and heating	No	No	No	No
Morocco	Yes, power and heating	Yes, focus on power	No	No	Yes, lighting, power, standards and labels, buildings and industry	Yes, lighting, power, standards and labels, buildings and industry
Sudan (the)	Yes, focus on power	Yes, focus on power	Yes	Yes	Yes, focus on power	No
Tunisia	Yes, power and heating	Yes, power	No	No	Yes, power, buildings and industry	Yes, power, standards and labels and buildings
West Africa						
Benin	Yes, focus on power	Yes, focus on power	Yes	Yes	Yes, lighting, power, standards and labels, buildings and industry	Yes, lighting, power, standards and labels, buildings and industry
Burkina Faso	Yes, focus on power	Yes, focus on power	Yes	Yes	Yes, focus on power	Yes, lighting, power, standards and labels, buildings and industry
Cabo Verde	Yes, focus on power	Yes, power and heating	No	No	Yes, power, buildings, and standards and labels	Yes, power, buildings, and standards and labels
Côte d'Ivoire	Yes, focus on power	Yes, focus on power	Yes	No	No	Yes, lighting, power, standards and labels, buildings and industry
Gambia (the)	Yes, power and heating	Yes, focus on power	Yes	No	Yes, focus on power	Yes, lighting, power, standards and labels, buildings and industry
Ghana	Yes, focus on power	Yes, focus on power	Yes	No	Yes, focus on power	Yes, lighting, power, standards and labels, buildings and industry
Guinea	Yes, focus on power	Yes, focus on power	No	Yes	No	Yes, focus on power
Guinea-Bissau	Yes, focus on power	Yes, power and heating	Yes	No	Yes, focus on power	Yes, lighting, power, standards and labels, buildings and industry
Liberia	Yes, power and transport	Yes, power, heating and transport	Yes	Yes	Yes, power and cooling	Yes, power, standards and labels, buildings, industry and transport
Mali	Yes, focus on power	Yes, focus on power	Yes	Yes	No	Yes, lighting, power, standards and labels, buildings and industry
Mauritania	Yes, power and heating	No	No	No	No	No

Table 4.2 Overview of national commitments to renewable energy and energy efficiency (continued)

	RE target in NDCs/INDCs	RE target in national energy plan	RE target in rural electrification plan	Clean cooking target	EE target in NDCs/ INDCs	EE target in national energy plan
West Africa (continued)						
Niger (the)	Yes, focus on power	Yes, power and heating	Yes	No	Yes, focus on power	Yes, lighting, power, standards and labels, buildings and industry
Nigeria	Yes, focus on power	Yes, power, heating and transport	Yes	Yes	Yes, focus on power	Yes, lighting, power, standards and labels, buildings and industry
Senegal	Yes, power and heating	Yes, power and heating	Yes	No	Yes, focus on power	Yes, power, standards and labels, buildings and industry
Sierra Leone	Yes, focus on power	Yes, power and heating	Yes	Yes	Yes, focus on power	Yes, lighting, power, standards and labels, buildings and industry
Togo	Yes, focus on power	Yes, focus on power	Yes	No	No	Yes, lighting, power, standards and labels, buildings and industry
East Africa						
Burundi	Yes, focus on power	No	No	No	Yes, focus on power	No
Comoros (the)	Yes, focus on power	No	No	No	No	No
Djibouti	Yes, focus on power	Yes, focus on power	No	Yes	Yes, power, buildings and cooling	No
Eritrea	Yes, focus on power	Yes, focus on power	No	Yes	Yes, focus on power	No
Ethiopia	Yes, focus on power	Yes, focus on power	Yes	Yes	No	Yes, focus on power
Kenya	Yes, focus on power (no quantified target)	Yes, focus on power and heating	Yes	Yes	Yes, focus on power	Yes, lighting, power, buildings and industry
Mauritius	Yes, focus on power (no quantified target)	Yes, focus on power	No	No	No	No
Rwanda	Yes, focus on power	No	Yes	Yes	Yes, focus on lighting, power and industry	No
Seychelles	Yes, power and transport	Yes, focus on power	No	No	Yes, lighting, power, buildings, standards and labels	Yes, power, buildings and industry
Somalia	Yes, focus on power	Yes, focus on energy access	No	No	No	No
South Sudan	Yes, focus on power	No	Yes	No	Yes, focus on power	No
Uganda	Yes, focus on power	Yes, power and heating	Yes	Yes	No	No
United Republic of Tanzania (the)	Yes (no quantified target)	Yes, focus on power	Yes	Yes	No	Yes, lighting, power, standards and labels, buildings and industry

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Table 4.2 Overview of national commitments to renewable energy and energy efficiency (continued)

	RE target in NDCs/INDCs	RE target in national energy plan	RE target in rural electrification plan	Clean cooking target	EE target in NDCs/INDCs	EE target in national energy plan
Central Africa						
Angola	Yes, focus on power	Yes, focus on power	Yes	Yes	Yes, power and buildings	Yes, power and buildings
Cameroon	Yes, focus on power	No	No	No	Yes, focus on power	Yes, power, buildings and industry
Central African Republic (the)	Yes, focus on power	No	No	No	No	No
Chad	Yes, focus on power	No	No	No	No	No
Congo (the)	Yes, focus on power	No	No	No	No	No
Democratic Republic of the Congo (the)	Yes, power, heating and transport	No	Yes	Yes	Yes, power, buildings and cooling	No
Equatorial Guinea	Yes, focus on power	No	No	No	No	No
Gabon	Yes, focus on power	Yes, focus on power	No	No	No	No
Sao Tome and Principe	Yes, focus on power	No	No	No	Yes, focus on power	No
Southern Africa						
Botswana	No	Yes, focus on power	No	No	No	Yes, lighting, power and buildings
Eswatini	Yes, power and transport	No	No	No	No	No
Lesotho	Yes, power and heating	No	No	Yes	Yes, focus on power	No
Madagascar	Yes, focus on power	Yes, focus on power	Yes	Yes	No	No
Malawi	Yes, power, heating and transport	No	Yes	Yes	No	No
Mozambique	No	Yes, power and transport	Yes	No	No	No
Namibia	Yes, power, heating and transport	Yes, power	Yes	No	No	No
South Africa	Yes, focus on power	Yes, focus on power	No	No	No	Yes, lighting, power, standards and labels, buildings and industry
Zambia	Yes (no quantified target), focus on power and transport	No	No	No	No	No
Zimbabwe	Yes, power and heating	Yes, power, heating and transport	No	No	No	Yes, focus on power

Note: EE = energy efficiency; NDC = Nationally Determined Contributions; INDC = Intended Nationally Determined Contributions; RE = renewable energy.

When it comes to translating targets into concrete action, specifically in the power sector, most African countries benefit from the fact that their power systems are fully or partially state owned (see section 4.2.2), which means that planning for additional capacity is part of central procurement processes, which could help to reach targets. Few African countries, however, have well-functioning **procurement planning processes** – where the expansion of least-cost power generation is translated into competitive procurement rounds on a timely basis – resulting in either underinvestment (most frequently) or expensive overcapacity (in a few recent cases). Some examples are outlined in Box 4.2.

4.1.2 Measures to eliminate distortions and curb investments in fossil fuels

For a sound global energy transition, countries need to eliminate market distortions that favour fossil fuels and establish a fiscal system that curbs their use (IRENA, 2021e). But such policies need to be introduced with care because some fuel subsidies help many communities meet basic energy needs. This is important in a region that hosts two-thirds of the world's most impoverished people (World Bank, 2021c), producing minimal amounts of carbon dioxide (CO_2) emissions. Sub-Saharan Africa as a whole produces only 2.4% of the global total (World Bank, 2021a).

Box 4.2 Procurement planning plans for renewable power plants

A legally binding and publicly available document, **South Africa's** Integrated Resource Plan (IRP) is updated every two years (South Africa Department of Energy, 2011). Recent experience suggests that an indicative plan for system expansion, not a prescriptive one, could better guide investment decisions. The IRP sits astride a fraught contest over the country's energy future, delaying procurement and worsening South Africa's protracted power supply crisis. The plummeting costs of renewable energy technologies, in addition to the pace of innovation, suggest that the country's plans are obsolete before they are published, further supporting a shift towards an indicative planning model.

Namibia published its national IRP in 2016, which guided recent power procurement and investment decisions (*e.g.* the Khan solar PV project) and helped sustain the country's strong renewable-energy-based investments.

Kenya's approach exemplifies this model for procurement planning, whereby an integrated national energy plan is reviewed every three years while a least-cost power development plan is updated every two years (RES4Africa Foundation, 2019). Recent years have however seen an erosion of this capability, mainly due to unrealistic power demand projections and a reversion to directly negotiated procurement processes (including as part of the FiT process) (Eberhard, Gratwick and Kariuki, 2018). The result has been expensive overcapacity in the system. A similar situation is unfolding in **Ghana**, where several power purchase agreements were signed with mostly gas-based independent power producers outside of any formal planning framework. This is triggering renegotiations of these agreements in both countries, undermining investor confidence and highlighting a procurement planning node for project sustainability.

04

Phaseout of fossil fuel subsidies

In 2019, fossil fuel subsidies in Africa were estimated at USD 36.5 billion out of a global total exceeding USD 312 billion (IEA, 2021c) and were directed mainly at the consumption and production of petroleum, including liquefied petroleum gas, for cooking, coal and electricity.[2] In 2015, Sub-Saharan Africa took in subsidies estimated at USD 26 billion – equivalent to less than 8% of the subsidies distributed globally that year,[3] although the region hosts more than 14% of the global population (World Bank, 2021f).

Even within sub-Saharan Africa, countries have wildly divergent patterns of fossil fuel subsidies. Angola,[4] Côte d'Ivoire, Mozambique, Nigeria, South Africa, the United Republic of Tanzania, Zambia and Zimbabwe receive most of them (Worrall, Whitley and Scott, 2018) – and in 2020 these countries accounted for almost 60% of the region's gross domestic product (GDP) (World Bank, 2021d). In a region that hosts 75% of the world's population without electricity access and where 910 million people still lack access to clean cooking solutions (IEA, IRENA, et al, 2021), fossil fuel subsidies are not the main impediment to renewable energy adoption, as people rely mostly on traditional biomass collected informally. As financial support is increasingly disbursed to increase electricity access, it can be channelled away from fossil fuels towards renewable energy solutions, which are already more cost competitive.

In 2020, by way of contrast, North Africa contained 3 out of the 25 countries with the highest fossil fuel subsidies globally – namely Libya, Algeria and Egypt – even after the subsidy reforms in Egypt and Morocco (Box 4.3).

Such subsidies impose hefty burdens on government budgets and point towards fraught political realities: heavy reliance on fossil fuels in energy or national development plans; lack of information about consumer and producer subsidies; weak institutions; and political capture (Worrall, Whitley and Scott, 2018).

Average subsidisation rates in Libya reached 75% in 2020, while subsidies accounted for more than 15% of the country's GDP (Table 4.3). Worse, these subsidies tend to be socially regressive. For example, estimates suggest that the poorest quintile in countries including Egypt, Mauritania, and Morocco received between 1 and 7 percent of total diesel subsidies only, while the richest quintile receive 42 to 77 percent (El-Katiri and Fattouh, 2015). By the end of 2020, several countries including Egypt, Ethiopia, Ghana, Morocco, Rwanda, and Togo had committed to fossil fuel subsidy reform in their NDCs.

Table 4.3 Energy subsidies in highest subsidising countries in Africa, 2020

	Average subsidisation rate (percent)	Subsidy per capita (USD/person)	Total subsidy as share of GDP (percent)
Libya	75	480	15.1
Angola	54	46	2.4
Algeria	52	191	5.8
Egypt	29	77	2.2

2 When accounting for externalities such as impacts on climate change and pollution, the estimated costs of fossil fuel subsidies equalled almost USD 75 billion in 2015 (Worrall, Whitley and Scott, 2018).

3 Fossil fuel subsidies distributed globally in 2015 exceeded USD 351 billion.

4 Angola is amongst the 25 countries with the highest fossil fuel subsidies globally in 2020.

However, the removal of fossil fuel subsidies can still disproportionately affect the poorest. As such, it should be done gradually, while alternative solutions are made available. Box 4.3 describes the strategies adopted by Morocco and Egypt.

Subsidies removed from fossil fuels need to be channelled towards renewable energy solutions, as that would be crucial for supporting universal and equitable access to affordable renewable energy solutions. Section 4.2.1 discusses fiscal and financial incentives and how they have improved affordability of renewable energy solutions in Africa.

To curtail the use of fossil fuels, South Africa introduced **carbon pricing**. In 2021, carbon prices in South Africa consisted of carbon taxes covering more than 41% of CO_2 emissions from energy use, up from 14.3% in 2018. Since 2018, carbon prices have decreased in South Africa. Explicit carbon prices have risen to an average of EUR 1.04 per tonne of CO_2, up by EUR 1.04 since 2018 (in real 2021 euros). In 2021, fuel excise taxes amounted to EUR 16.57 on average, down by EUR 2.32 relative to 2018 (in real 2021 euros) (OECD, 2021a).

Box 4.3 Energy subsidy reforms in Morocco and Egypt

Morocco phased in reforms over three years beginning in 2012 until full price liberalisation. The population groups that would be most affected were first identified as the government rolled out a robust communications campaign to build public acceptance. In 2013 and 2014, subsidies were removed first on products like gasoline. In 2015, the government announced prices twice a month until it deregulated prices at year's end. The reforms cut the budget deficit while protecting the most vulnerable, implementing parallel measures to expand social protection programmes. Public transport support measures offset higher fuel prices and limited fare increases (ESMAP, 2017).

Fossil fuel subsidies were a huge drain on **Egypt's** budget, making subsidy reforms a priority for the government. Energy subsidy cuts may hamper economic growth in the short term, but over the long term, household welfare improves (Breisinger et al., 2019). Through the Energy Subsidy Reform Facility of the World Bank's Energy Sector Management Assistance Program, fuel and electricity reforms were planned to occur between 2014 and 2016, covering fuel prices as well as social safety net programmes. Egypt began in 2014 with a five-year plan to remove the subsidy. In late 2016, the Egyptian pound was devalued, losing nearly half its value. In response, the Ministry of Electricity and Renewable Energy extended the five-year plan to the fiscal year 2022-2023. In the beginning of fiscal year 2019-2020, new electricity tariffs were announced. Effective July 2019, the tariff rose by around 15% (RCREEE, 2019).

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Reconsidered fossil fuel investments

A 2021 analysis of around 2 500 power plants to be built across the continent found that coal and gas will account for up to two-thirds of Africa's electricity generation by 2030. Unless countries accelerate their clean energy transitions, renewable energy will be less than 10% of the mix, excluding large hydropower (Alova, Trotter and Money, 2021). Fossil fuel power plants now risk becoming stranded assets, as renewable-based power becomes increasingly competitive, and fossil plants would be dispatched less, rendering them obsolete. Plans to develop new extraction projects in Africa – investments of USD 230 billion by 2030 and USD 1.4 trillion by 2050 – risk leaving Africans behind in the energy transition. Meanwhile 60% of projected production over the next three decades will be owned by multinational corporations. In terms of job creation and energy access, these oil and gas projects fail to deliver the benefits that renewables bring. For each dollar invested, renewable energy creates two to five times more jobs than fossil fuels do. Other investments for a green economy – like climate adaptation, conservation agriculture, public transport and energy-efficient building retrofits – provide up to 25 times more jobs than those created by fossil fuels (OCI, 2021).

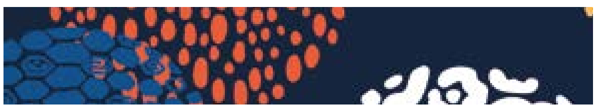
As the world embraces the energy transition, there have been concerns that investments in fossil fuels will continue to increase in Africa, especially those financed by the Belt and Road Initiative (BRI). Between 2000 and 2020, the China Development Bank and the Export-Import Bank of China alone supplied USD 6.5 billion of finance for African coal projects. By 2020, Chinese banks and companies had financed 7 coal plants, and 13 more were in the pipeline, mostly in Sub-Saharan Africa (McSweeney, 2020).

While the plants would supply energy to countries seeking to attain their development goals, they would spur greenhouse gas emissions and worsen climate risks. Several are under pressure from local campaigns calling for their cancellation (Box 4.4).

At the 2021 United Nations Climate Change Conference (COP26), Egypt and South Africa both committed to back away from coal (UNFCCC, 2021).

The international community also committed to stop financing coal plants, including in Africa. 39 signatories including several countries and MDBs agreed to end direct public support for the unabated fossil fuel energy sector by the end of 2022, complementing the agreement by representatives from nearly 200 Parties to phase down unabated coal (Conference of Parties 26, 2021; UNFCCC, 2021).

Prior to that, China had announced its support for green energy in developing countries and announced it would stop building new coal-fired power projects abroad (China Daily, 2021). As solar and wind power grew more competitive, financing costs for coal-fired power plants rose 38% over the past 10 years because of carbon pricing initiatives (Wang, 2021). In Africa, coal projects of more than USD 20 billion have either been shelved or cancelled as pressure on lenders has increased. The Industrial and Commercial Bank of China dropped a USD 3 billion coal-fired power plant in Zimbabwe following pressure from international and homegrown climate activists (Nyabiage, 2021).



Box 4.4 Local communities – a voice for cancelling coal power plants in Kenya and Ghana

In June 2019, **Kenya** revoked a licence to build a USD 2 billion coal power plant in Lamu, demonstrating that well-informed communities can help to guide environmental decisions. The success of the campaign was attributed to: 1) coordinated and combined efforts organised and directed through a campaign combining local, environmental and social groups; 2) the community campaign working with groups across various sectors that provided legal, financial and other resources while facilitating an exchange of information; 3) the development of an informative and transparent media campaign that was effective in raising awareness and gathering support; 4) communication and information sharing with those on the other side of the argument facilitated change (UNEP, 2019a).

Similarly, in 2016, the **Ghanaian** government cancelled a coal power plant and nearby shipping port. Chibeze Ezekiel led a social media campaign emphasising threats to the environment and championing the potential for job creation with a shift to renewable energy. His Children for Climate Action (C4C) engaged young people in the “no coal” debate, while exhorting neighbouring countries to resist foreign investment in coal. Coal projects have recently been shelved in Nigeria, Mozambique and Botswana (McSweeney, 2020).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4.1.3 Measures to increase energy efficiency

More energy efficiency is needed in all sectors of the African economy. It goes hand in hand with affordable and reliable access. It liberates capacity in a cost-effective manner by sidestepping costly retrofitting costs later on (Copenhagen Centre on Energy Efficiency and UNEP DTU Partnership, 2015). Clean cooking spares the environment. Energy efficiency lowers expenses for households and businesses and eases the strain of subsidies on national budgets.

By 2021, about half the countries on the continent (11 in West Africa) included **energy efficiency targets in their NDCs and national energy plans**. Southern African countries have the fewest such targets in their NDCs and national plans (Table 4.2).

In the buildings sector, energy-efficient appliances, good insulation and smart energy management will be crucial. Energy demand will rise with population growth, as standards of comfort rise alongside development. In industry, efficient industrial processes will be key in building a competitive industry fuelled by a sustainable and efficient energy system. Energy efficiency and conservation have been embraced by policy and regulatory measures, incentive schemes and voluntary initiatives.

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North African countries, and many in Sub-Saharan Africa (*e.g.*, Botswana, Cameroon, Chad, Ethiopia, Lesotho, Malawi, Mauritius, Sierra Leone, South Africa, Sudan, and Zambia), have enshrined energy efficiency policies. **Standards and labelling** have been introduced, but with relatively low implementation rates. The North African countries had an institutional framework in the Minimum Efficiency Performance Standards by 2020, and testing laboratories were established in Algeria, Egypt, Morocco and Tunisia. National authorities enforce energy efficiency regulations but face technical, financial and regulatory challenges (MEDENER and RCREEE, 2020).

South Africa has voluntary standards for appliances, while building codes are mandatory for new construction. Ghana has secured compliance rates for household appliances exceeding 97% for refrigerators and air conditioners (Isaac et al., 2021). Malawi imposed standards for charcoal cookstoves and saw efficiency improvements of 20%, a rare success. The mass roll-out of compact fluorescent lamps (CFLs) elsewhere on the continent has yielded better success rates. Legislation banning certain technologies such as incandescent lights has been passed in Algeria and Ghana. But efficient technologies are unaffordable for the poor, making these laws impracticable (Copenhagen Centre on Energy Efficiency and UNEP DTU Partnership, 2015).

Energy audit programmes, subsidised mostly by outside organisations such as the Global Environment Fund (GEF) and German Federal Ministry for Economic Cooperation and Development (BMZ), are underway in about seven countries. The Kenya Centre for Energy Efficiency and Conservation undertook 171 audits of mainstream industries, small and medium enterprises and public institutions, saving approximately 14 MW. In addition, the Government of Kenya created a Super Energy Service Company to boost energy efficiency in both the public and private sectors (UNEP DTU Partnership, 2021).

Subsidised energy audits are a popular incentive scheme, but their success has been hard to verify. A levy on electricity tariffs can also fund them. The South African Demand Side Management saved 600 MW between 2005 and 2013. Funding continuity and devising regulatory frameworks remain central to these systems (Copenhagen Centre on Energy Efficiency and UNEP DTU Partnership, 2015).

Voluntary programmes rely on end consumers with financial or moral motivations. Energy pricing is an important driver. National Cleaner Production Centres, for example, in South Africa, assist with awareness raising, capacity building and implementation of energy efficiency activities (CSIR, n.d.a). Measures to increase awareness among consumers are discussed in section 4.1.6.

4.1.4 Measures to develop needed infrastructure

To deploy renewable energy, Africa must invest in new infrastructure and update existing networks. National energy planning must guide major investments to prevent any stranded assets or plants locked into fossil fuels.

Long-term, integrated energy plans are needed to attract investment (public and private) in power grids, district heating and cooling networks, gas grids and electric charging stations. They must be based on specific needs; macro-economic conditions; availability of resources; the infrastructure already in place; and the level of development, accessibility, and cost of technologies. Such plans are necessary to coordinate the deployment of renewables-based solutions with measures to develop infrastructure, while sidestepping any collisions on different energy pathways that render assets obsolete. As shown in Table 4.2, most African countries have focused on the power sector. Cross-sectoral planning should integrate heating and cooling and transport and incorporate plans for other sectors like industry.

Measures to attract investments in power grids. To manage growing demand and flexibility needed for variable renewable energy (VRE), power grid upgrades are imminent along with new digital control and monitoring technologies for distribution networks. Smart grid technologies can supply the flexibility that sector coupling needs (IRENA, 2019b) to accommodate high shares of VRE. The decarbonisation of the continent's power sector –

where renewables will constitute 46% of total installed capacity by 2030 – will cost USD 230-310 billion through 2025, with an additional USD 190-215 billion in 2026-2030 (AfDB, 2019b) These amounts include generation capacity from mini-grids and off-grid solutions, and a considerable amount will be directed towards transmission and distribution (T&D). So far, most governments have relied on public investments, mostly from development finance institutions (DFIs) (see Chapter 3) to develop power grids. Other countries have moved towards privatising their T&D (section 4.2.2).

Measures to attract investments in district heating and cooling (DHC) networks and gas grids. Although capital-intensive, well-designed DHC networks and gas grids are among the most cost-efficient and technically feasible solutions for Africa's growing heating and cooling needs, particularly in densely populated areas with high demand.

Small-scale DHC networks are being deployed globally to service larger buildings or groups of buildings, such as university campuses or hospitals. DHC networks have great but untapped potential in Africa. The first district cooling plant was built in Cairo by GASCOOL, the Egyptian Company for Energy and Cooling (GASCOOL, 2004). As with power grids, such investments can be public, or policies can be put in place to attract private investments. IRENA's joint report with IEA and REN21 Renewable Energy Policies in a Time of Transition: Heating and Cooling discusses in detail such policies. These include ensuring the presence of sufficient anchor loads (*e.g.*, large heat consuming industries and public buildings) so that investing in the infrastructure would be seen as profitable, with connections to DHC networks or renewable gas grids (where these exist) mandated for new urban developments, public buildings and other opportune locations to ensure demand (IRENA, OECS/IEA and REN21, 2020).

Measures are also needed to expand gas grids, especially as some countries prepare for the development of green hydrogen and as others recognise the benefits of biogas and biomethane, such as improved waste management, avoided methane emissions. Some of these measures include the development of plans in the form of national strategies and roadmaps that clearly define the role of renewable gases (Section 4.2.4), harnessing the potential of existing gas network infrastructure to accommodate renewable gases, and showcasing demonstration projects (IRENA, OECD/IEA and REN21, 2020).

Measures to attract investments in electric vehicle (EV) charging stations. Depending on the electricity mix, electric mobility counts as a decarbonisation solution. Investing in EVs therefore aligns well with a renewables-based electricity mix. Charging stations are required for EVs, and governments need to attract public and private investment. So far, investment in EV infrastructure has focused on a few cities in Africa. In December 2020, the city of Cape Town (South Africa) launched the first of two solar-powered EV charging stations that will be offered free-of-charge for the first two years to the public (Pombo-van Zyl, 2020). In 2021, Nigeria commissioned its first solar-powered EV charging station at the University of Lagos (Tena, 2021a). Ghana also launched electric vehicle initiative with a number of charging stations available for the for use by POBAD International and electricity company of Ghana (see section 4.2.3).

Generally, measures to develop infrastructure are implemented at the city level. With their great energy demands and their central role in national economies, cities will be critical to the transition of Africa's energy system to one based on renewables and energy efficiency. Examples of how cities in African countries have supported such efforts are discussed in the Sidebar on Renewable Energy in Sub-Saharan African Cities and in Box 4.11.

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SIDEBAR: Renewable Energy in Sub-Saharan African Cities

Sub-Saharan Africa was home to an estimated 1.1 billion people in 2019, with around 40% of this population living in urban areas. The region also is home to the world's most rapidly urbanising cities: Africa's urban population increased more than 16-fold between 1950 and 2018, from 33 million to 548 million. Due to rising urbanisation, population growth and energy demand, the opportunities around renewable energy use in cities are increasingly recognised in Sub-Saharan Africa.

Common drivers for renewables in the region include local economic growth to reduce poverty and inequality (including by addressing energy access and energy poverty) and boosting the resilience and reliability of power systems. Cities in the region have also seen renewables as an opportunity to reduce air pollution (and thus improve public health), mitigate climate change, create more liveable urban areas and enable a better quality of life through increased access to basic services.

City governments can help to shape the energy landscape of Sub-Saharan Africa. Cities have supported local renewable energy deployment in a variety of ways: Increasingly, cities in the region set renewable energy targets and support policies, including Cape Town and Durban (both South Africa) and Kampala (Uganda). They have also facilitated collaborative projects led by national governments, development finance institutions and/or private actors. Some Sub-Saharan local governments, especially in cities where transport is responsible for a large share of energy consumption, also have entered public-private partnerships to advance e-mobility (sometimes linked to renewable electricity) at the city level. To build internal capacity and knowledge and to support renewable energy implementation, municipalities in Sub-Saharan Africa have formed partnerships with external organisations and established or joined city networks such as the Covenant of Mayors in Sub-Saharan Africa.

Cities in the region differ widely, including in terms of their national context, population size, level of urbanisation and socio-economic development, and access to energy. These factors influence their total energy demand and energy use by sector. The following case studies outline renewable energy trends in five cities.

Cape Town, South Africa

With a dedicated energy and climate change unit, Cape Town is a pioneer in providing affordable and secure energy access while tackling rapid urbanisation and associated energy poverty. The city installed solar photovoltaic (PV) on municipal buildings (alongside energy efficiency efforts) and developed tariffs and safety installations for distributed renewables on commercial and residential buildings. By 2020, the city had approved around 42 megawatts of rooftop solar PV. Similar processes, guidelines and tariffs have since been adopted in 40 other South African municipalities. In addition, the city started a roll-out of solar water heaters to low-income communities and is replacing its municipal diesel bus fleet with electric buses. The city is also preparing its power grid for high electric vehicle penetration, with electricity either to be generated by local solar PV or procured.

In a country where coal made up most of the electricity generation, the city entered into a court challenge with the national government to expand its renewable electricity supply and purchase electricity from independent power producers. In late 2020, a landmark decision amended national regulations so municipal governments can develop their own generation projects. As a result, Cape Town has begun laying the foundations for supplying renewables at scale.

Dakar, Senegal

The Senegalese capital aims to achieve 15% local electricity production from renewables by 2035, and it is looking to cut reliance on diesel power generation from 90% in 2013 to 5% in 2035. This climate plan is being developed as part of its pledge under the C40 Cities Leadership Programme to be net-zero carbon by 2050.

As in cities elsewhere, transport dominates Dakar's energy demands (accounting for 55% of total energy consumption), reflecting its deteriorating roads, inefficient public transport and ageing vehicle fleet. The city has launched an ambitious mobility and urban planning strategy to address these issues and reduce air pollution. This plan includes increasing electrification and reducing fossil fuel dependence in the transport sector as well as equipping half of municipal buildings with distributed rooftop solar PV by 2030.

Kampala, Uganda

In Kampala, the transport sector is responsible for the largest share of energy demand and consists mostly of inefficient motorcycles and private cars running on fossil fuels. In response to these challenges, the city developed its first energy and climate change action plan which aims to accelerate deployment of renewables, support a green economy and promote more environmentally friendly public transport. As part of this plan, the city is promoting electric mobility to reduce noise and air pollution, petrol demand and traffic jams and has formed public-private partnerships with start-ups. As a result, by 2020, more than 200 new and retrofitted electric motorcycles were introduced in the city (charged mostly from the hydropower-dominant grid).

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SIDEBAR: Renewable Energy in Sub-Saharan African Cities (continued)

Tsévié, Togo

This town north of the capital, Lomé, is growing at a rate of 2.8% a year and has minimal industrial activity, with its economy largely built on agricultural activities. Due to low levels of industrialisation and electricity access, traditional biomass (wood and charcoal) is the most important fuel to meet household cooking and water heating needs.

To boost local energy access and development, Tsévié introduced a three-year municipal energy programme. This aims at developing sustainable biomass use, deploying distributed rooftop solar PV, increased adoption of electric motorcycles and a gradual shift to public transport. In addition, the municipality has improved access to clean cooking facilities and has distributed 8 200 efficient stoves to reduce the use of biomass in household cooking and water heating.

Yaoundé IV, Cameroon

Yaoundé IV is one of seven communes of the Cameroonian capital, with the transport and residential sector accounting for most of the energy demand. As part of its energy and climate action plan, the city aims to reduce greenhouse gas emissions and increase energy access by 2030. As part of this plan, the city aims to increase renewable energy, such as fitting 3 000 solar streetlights, installing distributed rooftop solar PV on municipal buildings and distributing 3 600 solar kits to disadvantaged households. In addition, the municipality has rolled out a demonstration project to build nine biogas plants.

While city governments have influenced the shape of the region's energy landscape – including advancing efforts to meet renewable energy targets set at the country level – legislative, financial and technological constraints persist in many cities. These constraints include:

- Limited municipal control over energy supply, grids and infrastructure which are controlled by national governments and utilities, with an emphasis on centralised, large-scale generation.
- Weak fiscal decentralisation, few funds to invest in infrastructure grids and a lack of access to financial markets.
- Low reported data on renewables, in part due to limited capacity, funding and non-existent internet access, lack of technical equipment and absence of systematic and robust data collection. This is also a barrier for private investors.
- Human capacity constraints to take a more proactive role in renewable energy deployment.

Source: REN21 (2021a).

4.1.5 Measures to foster innovation

For Africa to fulfil its potential to leapfrog towards an energy system based on renewable energy and energy efficiency, a systemic approach is required, building on innovative solutions extending far beyond technology supply and infrastructure. Innovative financing and business models, new ways of designing and operating the power system and enabling and institutional regulatory frameworks are some of the key ways in which innovation can support the energy transition in Africa.

Innovative and inclusive solutions are also needed to address Africa's large energy access deficit and existing weak grids. Innovative policies and financing and business models such as result-based financing, crowdfunding, and the Pay as You Go (PAYG) are driving the uptake of off-grid technologies (Chapter 6), aided by digitalisation. Enabled by the penetration of mobile money in East Africa, the PAYG business model has supported the deployment of solar technologies, improving affordability and access to such solutions. In 2020, PAYG was used to purchase over 1.6 million solar systems (GOGLA, 2020c).

When it comes to power generation, **innovative policy design** can enable the deployment of technologies within specific constraints. Morocco has innovated the way solar PV is combined with concentrated solar power (CSP) in hybrid systems to support the integration of variable renewable energy into the power system. Auctions in Morocco and South Africa were designed in such a way so as to achieve the lowest price while supporting other objectives such as system integration as well as socio-economic development (Boxes 4.9 and 4.15).

Other **measures can attract investments in technology-driven innovation**. To address the issue of space limitation, Seychelles is planning the development of the first floating solar PV plant in Africa. The plant will cover 40 000 square meters (m^2) of water, will be made up of around 13 500 PV modules and will represent 2% of Seychelles' national production (5.8 MW) (Qair, 2020). Countries with considerable hydropower resources – such as Guinea, Ghana and Nigeria – can benefit from innovations in modernising hydropower facilities and operating pumped hydropower storage to integrate variable renewables and reduce the cost of the power system. South Africa is currently the only African country with operational pumped hydropower. Electrifying the transport sector through policies and measures – by using electric vehicles as well as two and three wheelers – can address pollution in densely populated African cities while also making batteries on wheels a storage solution to support distribution grids.


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When considering future economic opportunities, **policies to support the production, use and export of green hydrogen** from low-cost renewable electricity in countries with abundant resources might be an option. Countries in North Africa such as Algeria, Egypt, Morocco and Tunisia are contemplating taking advantage of geographical proximity to Europe to deliver green hydrogen to a larger market. South Africa has long-term experience in producing synthetic fuels from coal, which it can now turn to producing renewable electric fuels from green hydrogen (section 4.2.4). Using innovative solutions to increase power system flexibility and energy efficiency reduces the investment requirements and the environmental footprint of the energy transition.

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Attracting public and private investments in smart technologies such as digitalisation, smart grids, blockchain and cryptocurrency, and the Internet of Things (IoT) has been identified as a priority for African utilities. These would be crucial for demand-side management as the share of VRE increases in the electricity mix (see section 4.3 on Integrating policies). They would enable the reduction of commercial and technical losses and improvement in the quality of service, the same way the digital revolution and mobile banking have changed the business models of access to electricity with the PAYG model (IRENA, 2020h).

At the core of innovation are **public investments – local and foreign – in research and development (R&D)**. R&D spending, as a percentage of GDP, is relatively low in Africa. Many countries do not spend – or report on spending – on R&D, and those that do, spend below 1% of their GDP. The highest rate is in South Africa (at 0.83%), but even this is far below the average in the countries of the Organisation for Economic Co-operation and Development (3-5%) (World Bank, 2021g).

Nevertheless, some research institutions have been established, and have been addressing issues related to renewable energy development. For instance, the Swiss-African Research Cooperation collaborates with numerous African higher education institutions on R&D. One example is the International Institute for Water and Environmental Engineering (2iE), an international non-profit association of public utility headquartered in Burkina Faso (SARECO, n.d.). In North Africa, the renewable energy research centres are affiliated to the national research centres and national agencies. For example in Egypt, the New and Renewable Energy Authority has developed affiliations with the National Academy for Scientific Research, Ain Shams University, the British University in Egypt, the Arab Academy for Science and Technology and Maritime Transport, among others; and in Tunisia, the National Agency for Energy Conservation has affiliations with the Ecole Nationale d'Ingénieurs de Carthage and University of Sfax, among others. Moreover, the Regional Research Alliance is a collaborative partnership made up of three national research organisations – the Botswana Institute for Technology Research and Innovation (BITRI, n.d.), the Council for Scientific Research (CSIR, n.d.b) of South Africa and the Scientific and Industrial Research and Development Council (SIRDC, n.d.) of Zimbabwe. Each institution has a department conducting research in energy including renewables, and the Regional Research Alliance collaborates on several areas including renewable energy.

Table 4.4 outlines research centres which are publicly funded and focused on renewable energy technology and policy solutions based in Africa and section 4.4.2 discusses measures to support R&D and quality support for energy transition technologies.

Table 4.4 Examples of centres for research and innovation promoting renewable energy deployment in Africa

	Center	Focus
North Africa		
	Research Institute for Solar Energy and New Energies (IRESEN), Morocco.	Specialises in PV and concentrated solar power (CSP), particularly in the development of PV modules; new generation, development and testing of CSP air condensers with low water consumption; and sizing and optimisation of solar power plants. Developed a solar mapping of Morocco in particular and Africa in general.
West Africa		
	Center of Studies and Research on Renewable Energies (CERER) at the University Cheikh Anta Diop DE Dakar, Senegal	Promotes technological innovation in the field of renewable energy. Through its Solar PV Components Quality Control Laboratory, CERER ensures follow-up monitoring of PV components installed throughout the country.
	Kwame Nkrumah University of Science and Technology (KNUST), Ghana.	Focuses on PV panels, CSP and bioenergy (biogas, biodiesel and bioethanol), providing consultancy services to policy makers. Studies include one on biogas production from kitchen waste generated on the KNUST campus, and another on the technical challenges and impact of integrating high penetration PV systems into the Ghanaian transmission grid.
	International Institute for Water and Environmental Engineering (2iE), Burkina Faso	Develops academic research programmes and courses focused on strategic sectors for the social and economic development of Africa including renewable energy, water and waste treatment, mining and the production of eco-materials.
East Africa		
	Centre for Research in Energy and Energy Conservation (CREEC) at Makerere University, Uganda.	Conducts largely applied research on energy management, solar PV, pico-hydropower and biomass, with a focus on clean energy technology transfer to the business community and general public. Studies include one on small hydropower in rural Uganda, and another on solar energy kiosks.
Southern Africa		
	Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University, South Africa.	Performs state-of-the-art research on renewable-energy-related technologies and their applications. Conducts laboratory testing of renewable energy equipment to evaluate performance characteristics. Studies include one on the development of a biofuels engine testing facility, and another on the design and development of a novel wave energy converter.
	Power Futures Lab (PFL) from the University of CapeTown (UCT), South Africa.	Focuses on infrastructure investment, power sector reform and regulation in Africa. Since 2013, PFL has released at least eight studies on renewable energy auctions in Africa. The latest was titled "Counteracting Market Concentration in Renewable Energy Auctions: Lessons Learned from South Africa".

Disclaimer: These maps are provided for illustration purposes only. Boundaries shown on these maps do not imply any endorsement or acceptance by IRENA.

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4.1.6 Measures to raise awareness and confidence among consumers and citizens

Raising awareness about the negative impacts of planned fossil fuel projects, as shown in section 4.1.2, and the potential for renewable energy and energy efficiency solutions and their benefits will play a major role in increasing the uptake of renewable energy in Africa. Equally important are campaigns on the purchase and use of equipment and more importantly, the implementation of quality standards to ensure product reliability and high confidence among consumers.

Awareness raising campaigns to promote energy efficiency solutions are widespread. Examples include Egypt's programme to promote the use of CFLs in 2005, Ghana's campaign to provide information to consumers on purchasing efficient air conditioners and lighting, Mauritius's tool to assist end users carry out their own energy audits and Tunisia's energy efficiency awareness scheme in industries, which reportedly avoided 700 kilotonnes of carbon emissions (Copenhagen Centre on Energy Efficiency and UNEP DTU Partnership, 2015).

Other campaigns have taken place to support the deployment of solar water heaters (SWHs) (section 4.2.3) and distributed solar PV. Lighting Africa, a programme implemented by the World Bank, held a consumer education programme starting from 2007 to teach users about the benefits and proper usage of solar lighting and energy products and how to identify quality lanterns in Ghana and Kenya. Since then, consumer education has anchored every country programme implemented by Lighting Africa; a strong correlation can be seen between off-grid solar markets (and their sharp growth trajectories) and locales targeted by consumer education campaigns (BNEF and Lighting Global, 2016). Most off-grid consumers live in remote regions that elude traditional advertisement campaigns. So travelling roadshows enable direct communication with "last-mile" consumers, allowing them to see and test products first hand. Lighting Africa has also developed a series of posters, radio spots and TV ads that can be adapted to local audiences. Most recently,

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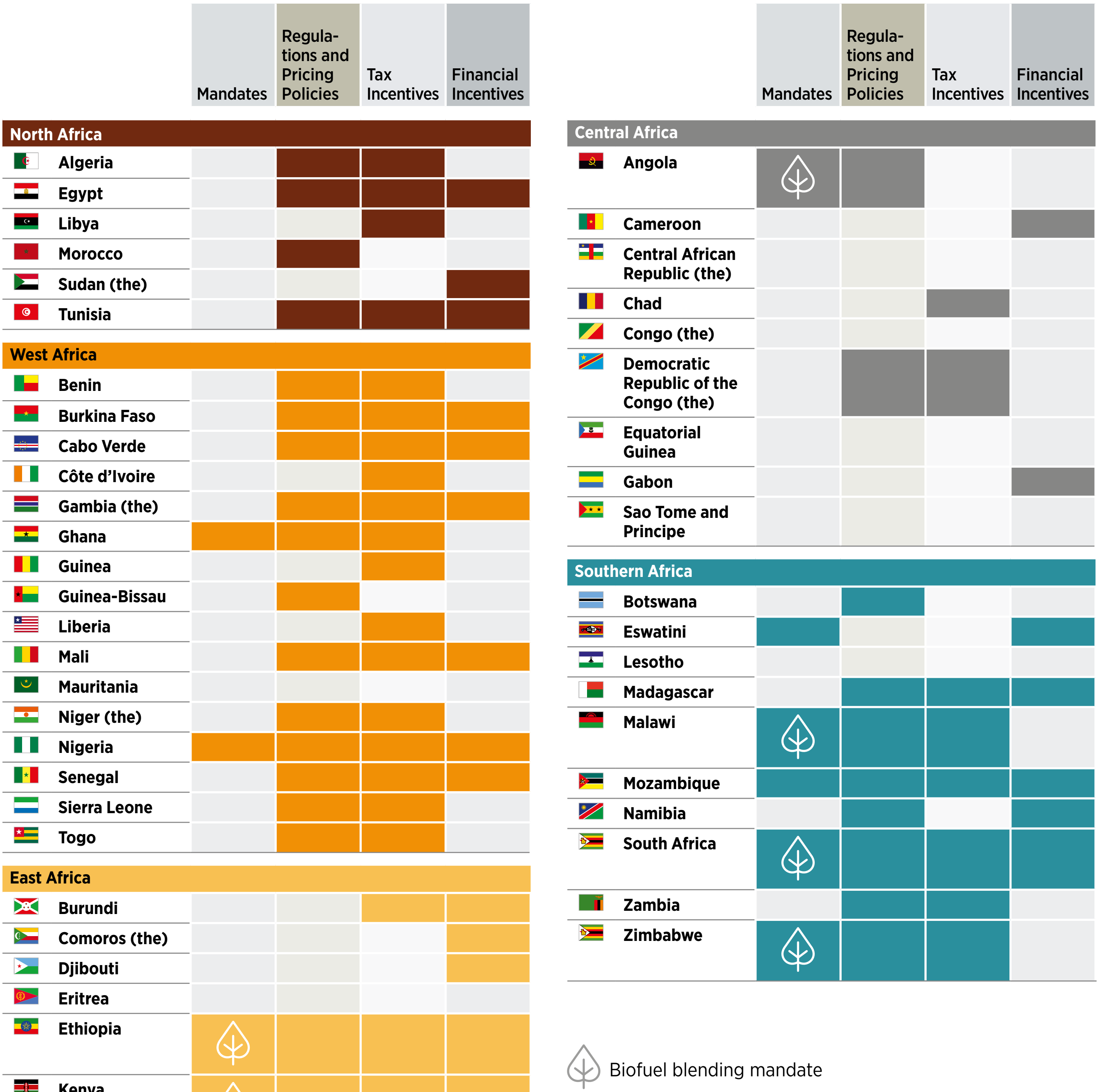
Lighting Africa developed a comic book series called "Spotlight" for young readers, teaching them about the many uses and benefits of solar lighting products (Lighting Africa, n.d.). Financial incentives, capacity building for institutions and monitoring of results would further bolster awareness-raising campaigns and voluntary initiatives.

Equally important are **measures to ensure that products on the market meet certified standards**. In Zambia and Zimbabwe, cross-sectoral policies relating to product quality have been established. As of 2017, importers of solar equipment must present the Zambia Bureau of Standards with a certification of product quality. In 2015, the Standards Association of Zimbabwe and the Zimbabwe Regulatory Authority established a solar equipment testing laboratory. These are unique cases and quality standards are not yet widely adopted.

4.2. DEPLOYMENT POLICIES

Direct deployment policies include regulatory measures that create a market for renewable energy solutions and fiscal and financial incentives that make them more affordable. Such measures are widespread in Africa, but they are deployed more often in East and West Africa; to date, few have been implemented in Central Africa (Figure 4.2).

Figure 4.2 Overview of deployment policies by region



Source: IRENA (n.d.a).

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Africa's deployment policies have focused on power, with less attention to transport and heating and cooling, even as gaps in access to cooling continue to widen, especially for the rural and urban poor (Box 4.5). In 2020, 40 African countries had regulatory and pricing policies for renewables in the power sector, compared with only 7 countries with renewable transport fuel obligations or mandates, and 2 countries with renewable heat obligations – reflecting global trends (REN21, 2021b). The power sector enjoys widespread global attention: As a mature sector, its technologies are decreasing in cost. By 2020, new solar and wind projects were undercutting even the cheapest and least sustainable of existing coal-fired power plants (IRENA, 2021g). Although the focus on power aligns with IRENA's vision of a future energy system where electricity accounts for more than half of energy consumption by 2050 (IRENA, 2021e), policies that support the direct use of renewables for heating and cooling and transport are needed to achieve industrialisation and development goals on the continent, since electricity cannot cover all end uses.

4.2.1 Fiscal and financial incentives to support renewables

Among the fiscal policies that render renewable energy more affordable are tax incentives (such as value added tax), customs and import-duty exemptions, and capital depreciation/capital allowances. These have been adopted in 21 countries, mainly in East Africa and West Africa (Figure 4.2). For example, in 2019, the Ethiopian Revenues and Customs Authority approved import tax exemptions for solar products. While the authority typically charges a 35% duty tax and up to 100% excise tax on imported products, solar products under 15 watt-peak (Wp) power and quality-certified solar home systems are tax exempt. Egypt's New Investment Law, published in 2017, provides investment incentives for renewable-energy-based projects, including a deduction of 30% of the net taxable profits for the first seven years of the project lifetime, and decreased customs duties on equipment and machinery from 5% to 2%. The project may also be eligible for an exemption from land taxes.

Box 4.5 Cooling access gaps for the rural and urban poor at highest risk in Africa

An analysis of 31 African countries with rising temperatures has found that close to 390 million of the rural and urban poor are at highest risk.

In rural areas, approximately 174 million people are at high risk through their lack of access to cooling. These account for 39% of the total rural population of Africa and 21% of the continent's total population.

An increase of 11.4 million people was observed in 2021 compared with 2020 – a larger increase than in previous years. This was in part due to the poverty brought by the COVID-19 pandemic, but it continues a trend that began in early 2020.

In cities, 215 million of the urban poor are at highest risk for lacking access to cooling – an increase of 8.0 million compared with 2020. More than 70% of the urban populations in 16 countries are at high risk: Angola, Benin, Burkina Faso, Chad, the Congo, Guinea-Bissau, Liberia, Malawi, Mali, Mozambique, Niger, Nigeria, South Sudan, Sudan, Togo and Uganda.

People in the lower-middle-income group will soon be able to purchase the most affordable air conditioner or refrigerator on the market, a growing trend in Africa, increasing by 43 million people since 2018. Between these three groups, approximately 776 million people across the 31 high-impact countries in Africa, or 93% of their total population, face cooling access challenges.

Source: SEforAll (2021a).

Financial incentives (subsidies and grants) focus on East and West Africa (Figure 4.2). Djibouti, for example, provides subsidies for household renewable energy applications. In Namibia, the Solar Revolving Fund provides low-interest loans for the purchase of solar energy technologies including solar home systems, SWHs and solar pumps.

4.2.2 Policies for electrification and renewable power

Electricity tariffs remain generally high across the continent, especially when compared with other developing regions. Together with poor reliability, tariffs remain one of the main barriers to higher consumption (Trimble *et al.*, 2016). Most of Africa's public utilities are in financial distress. As they struggle to cover their operational costs, the utilities cannot finance the required renewable energy projects or maintain and operate electricity infrastructure. This forces them to rely on public subsidies (RES4Africa Foundation, 2021). All these factors impede development and economic growth.


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Power sector reforms

Over the past decades, several African countries have adopted electricity sector reforms with the intention of improving performance and attracting foreign investments. Going back as far as the 1990s, multilateral development banks and development finance institutions (DFIs) – particularly the World Bank and International Monetary Fund – offered loans subject to structural reforms embracing the "one-size-fits-all" model of economywide liberalisation. Other reforms promoted by multilateral development banks and DFIs included commercialising electricity utilities; vertically unbundling national monopolies into separate generation, transmission, and distribution companies; horizontally unbundling generation and retail, by splitting the generators and suppliers into multiple companies to kickstart competition; allowing private sector participation; and introducing market competition through large-scale power contracting. Most African utilities remain vertically integrated monopolies and these sectoral reforms have for the most part been implemented only partially and to address specific issues across varying contexts: Nigeria and Uganda have instituted structural reforms to improve operational efficiency and electricity access. South Africa permitted private investment in independent power producers (IPPs) but ignored broad structural reforms to address energy security (AfDB, 2019c).


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These reforms allowed private investment into the generation side of the power system, especially through IPPs. Now present in about 30 countries, the IPPs represent more than 20 gigawatts (GW) installed capacity and USD 45.5 billion total investment. Regional IPP investment trends show power investments track resource potential. For instance, West and North Africa have the greatest proven gas reserves and the most gas-fired IPPs by installed capacity. Compared with other regions, East and Southern Africa have done more to develop their solar PV and wind resources. East African countries, especially Kenya and Ethiopia, have tapped into their geothermal resources. Central Africa's private investment has gone into hydropower, such as Cameroon's 420 MW Nachtigal hydropower plant, the largest privately owned project on the continent. Central Africa has not, however, been able to attract sufficient investment despite its huge reserves of hydropower. Lack of institutional capacity, the poor financial condition of off-takers and the risk profiles of the countries are all thought to be at work.

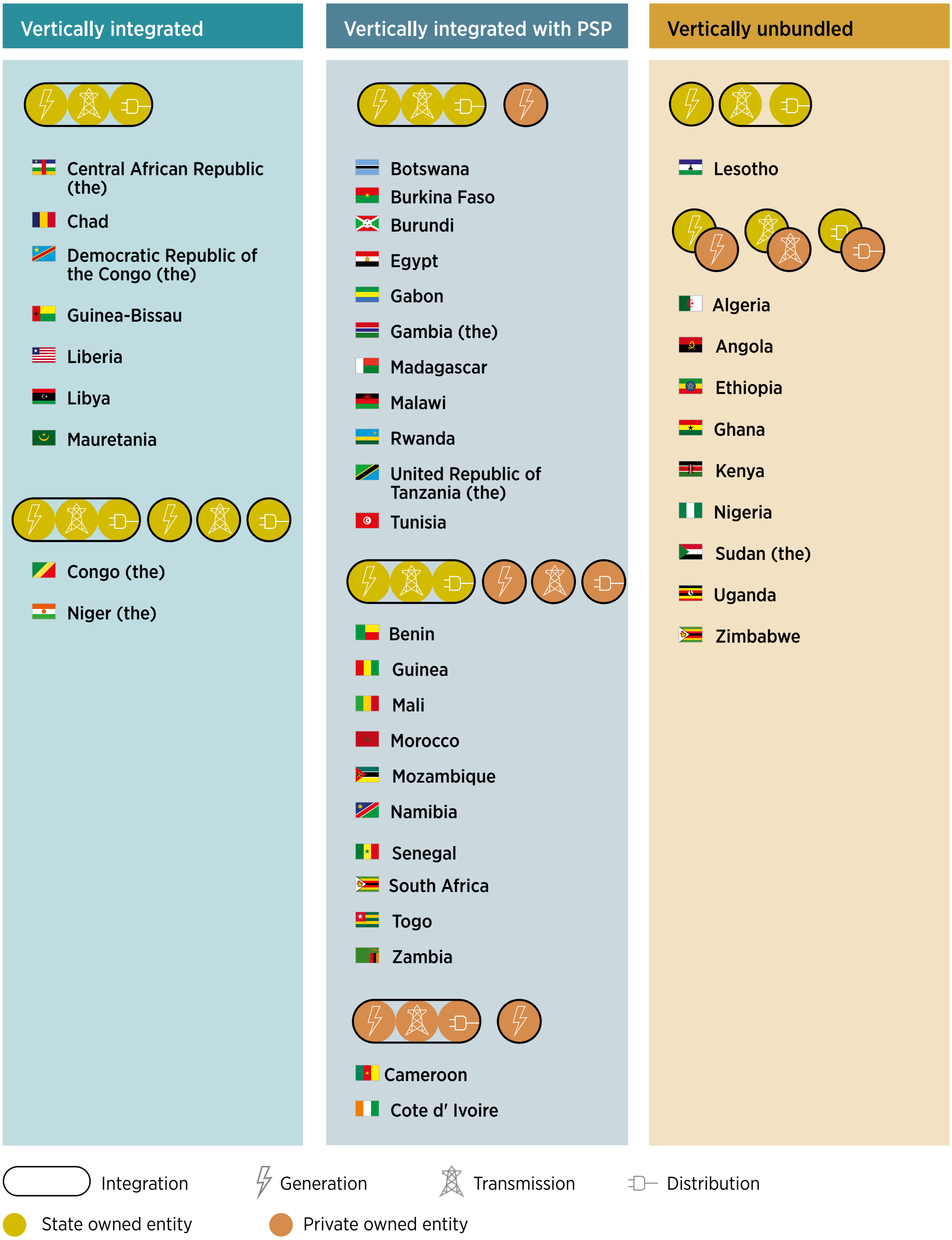
The diffusion of IPPs across the continent has led to more renewable electricity projects. Since 2010, around 70% of IPPs that have reached financial close are based on renewable energy, including solar PV and wind (Power Futures Lab, 2021). Private sector participation in T&D remains scarce (Figure 4.3).

The participation of IPPs has shown to increase renewable energy penetration (Doumbia, 2021), and improve technical performance and power generation investment levels (Urpelainen and Yang, 2016) in hybrid markets. The top IPP investment destinations in Sub-Saharan Africa – Uganda, Kenya, Namibia, Ghana and Nigeria – have all moved towards vertically integrated utilities with private sector participation or vertical unbundling of their utilities. South Africa is in the process of establishing an independent, state-owned transmission and system operator to remove the conflicts of interest currently in the system that have hampered the roll-out of renewable energy IPPs over the past five years.[5]

As for the structure of the power system, there has been a rethinking regarding the prescriptions of the 1990s reform model of market liberalisation, which should be factored into the plans of African countries, as they move towards designing power systems based on renewables. By the early 2000s, it had become clear that the liberalisation model was developed around centralised infrastructure designed to reap economies of scale and achieve simultaneous balancing of supply and demand through the one-way flow of power to passive consumers. First, it was not universally applicable, and by 2020, there was enough empirical evidence to show the practical difficulties encountered with the application of the model in developing power markets. Second, and most importantly, this model did not align with local concerns, visions and needs and was not compatible with the significant changes in policy objectives, mainly of a just and inclusive energy transition. At the same time, the development of disruptive technologies including decentralised renewable energy, battery storage and digitalisation has raised questions about how the recommendations of the 1990s model may need to be adapted going forward (Foster and Rana, 2020). IRENA's study on the "Organisational Structure of Power Systems for the Renewable Energy Era" shows the need for a new power system organisational structure that can support the energy transition and the power systems of the future while avoiding potential misalignments (Box 4.6), whether in liberalised or regulated power systems. The analysis shows that instruments that have proved capable to support the energy transition are already available, including bankable power purchase agreements (PPAs) which have proven suitable for supporting the deployment of capital-intensive renewable power plants, minimising the cost of procuring renewable power by keeping finance costs low.

5 Recent developments include the plans to unbundle Eskom, the national power utility, and increase the threshold of distributed generation capacity from 1 MW to 100 MW without need for a generation licence (simplified procedures).

Figure 4.3 Power sector structures in Africa



Source: AfDB (2019c).
Note: PSP = Private sector participation.

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Box 4.6 Organisational structure of power systems for the renewable energy era

A smooth energy transition comprises a technological transition, systemic changes and the reorganisation of the power system. While the technological transition and systemic changes are relatively well understood, the reorganisation of the power system lags behind, held back by implicit assumptions that current organisational structures are appropriate for the renewable energy era.

Power system organisational structures were designed with the blueprint of fossil fuel technologies. But the energy transition is transforming the way electricity is produced, transmitted and consumed. Consequently, the interactions between the different elements of the power system (organisational structures, technologies and policies) and with the wider energy, socio-economic and planetary systems are also changing. Both regulated and liberalised power systems face similar transition-related challenges. Merely adjusting and fixing, bit by bit, the organisational structures of current power systems will not suffice and might in fact lead to additional misalignments producing unwanted effects which can slow or derail the energy transition.

This is not new. Energy systems are set up to provide energy services to society, but in delivering those services, undesirable impacts on societies have been produced. Important misalignments have, for instance, led to climate change and air pollution. This results from the organisational structures of the fossil fuel era not properly aligning the costs, price and value dimensions of energy. While the energy transition itself is expected to mitigate both climate change and air pollution, as the transition progresses, new fundamental misalignments arise, with potentially severe consequences, if unaddressed. IRENA's report on the "Organisational Structure of Power Systems for the Renewable Energy Era" highlights the need for a more comprehensive rethinking of power system structures, to avoid misalignments that create barriers that could delay or even endanger the energy transition.

Source: IRENA (2022 Forthcoming-b).


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Planning, procurement and contracting frameworks, together with the financial stability of the sector, are central considerations for IPP development in Africa. More than 12 countries have developed model PPAs for renewable energy, including 5 countries with technology-specific contracts (AfDB, 2020c). To ease this process and streamline project development, IRENA and the Terrawatt Initiative (TWI) launched the Open Solar Contracts, an initiative that provides simple, universally applicable legal agreements to reduce the time and cost associated with the contracting process (IRENA and TWI, n.d.) (Box 4.7).

Box 4.7 Open Solar Contracts

In 2020, IRENA and the Terrawatt Initiative jointly launched the Open Solar Contracts initiative, which offers standardised, simplified and publicly available documentation for solar photovoltaic projects. The documents were developed in close collaboration with a dozen leading international law firms. In addition to simplicity, the solar contracts seek to balance risk allocation and universal applicability, lowering time and costs for the transacting parties.

The documentation set includes a power purchase agreement, implementation agreement, operation and maintenance agreement, supply agreement, installation agreement, finance facility term sheet, along with implementation guidelines. Also benefiting from an extensive public consultation process, the documents are freely available on the Open Solar Contracts website (www.opensolarcontract.org).

Standardised contracts and PPAs must be accompanied by financial stability of the sector, and particularly the financial stability of the project off-taker. By 2016, only three electricity utilities in Sub-Saharan Africa had an investment-grade credit rating: Namibia, Uganda and Seychelles. Most African utilities are not able to charge cost-reflective tariffs (with the exception of these three). This is often compounded by low tariff collection rates, high technical and non-technical losses, and poor financial and technical management. As a result, most African utilities are dependent on bailouts and subsidies from the state, representing considerable quasi-fiscal liabilities (Trimble et al, 2016). Because most jurisdictions allow projects to sell power only to these utilities, projects often need sovereign guarantees (Chapter 3). In many cases, these guarantees are also backstopped by further multilateral cover because of the host states' difficult fiscal positions. These guarantees present further contingent liabilities to host country treasuries, constraining their ability to raise finance at competitive rates.

Historically, most utility-scale (5 MW+) IPPs in Africa, especially in Sub-Saharan Africa, have been procured using direct negotiation. These projects were often initiated in emergency power supply contexts through unsolicited proposals, with limited transparency and drawn-out negotiation processes. Recent years have seen a shift towards structured procurement programmes – both auctions and, to a lesser extent, feed-in tariffs (Figure 4.4). This procurement shift coincided with increased investment in renewables, largely because these instruments set out a clear, more transparent and predictable route to market. In addition, they require that the procuring government thinks through its power needs, and the necessary steps required before going to market (Alao and Kruger, 2020a; Power Futures Lab, 2021).

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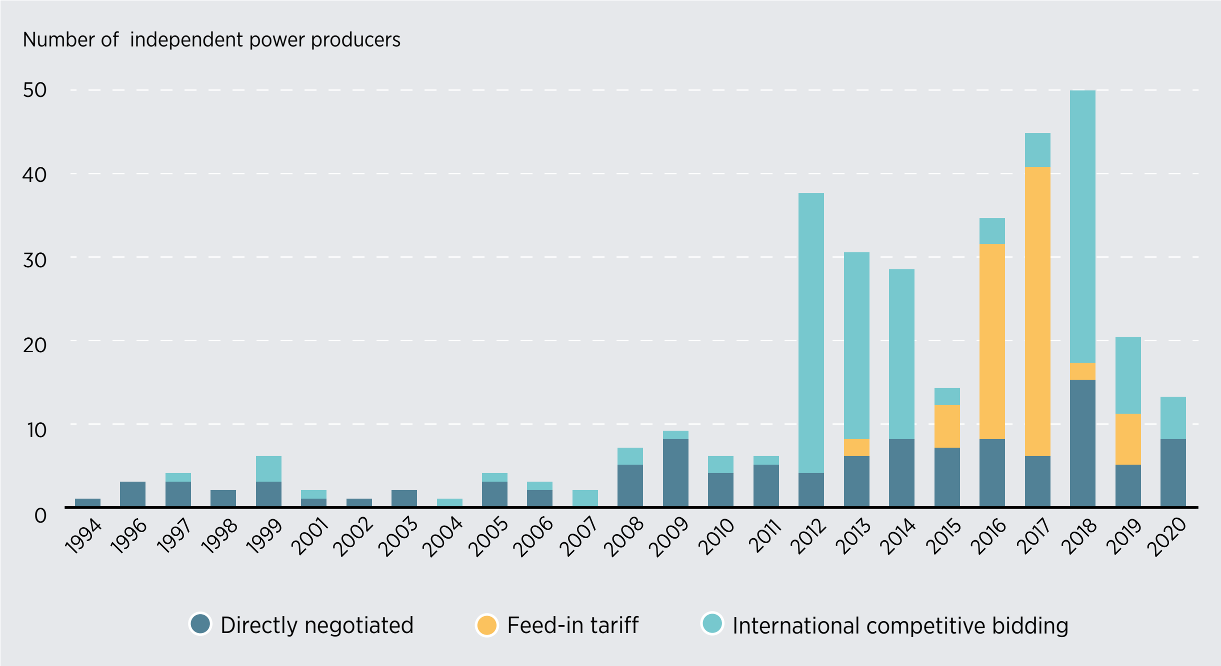
Figure 4.4 Number of IPPs in Africa by procurement method and year of financial close



Source: Power Futures Lab (2021).

Structured procurement products

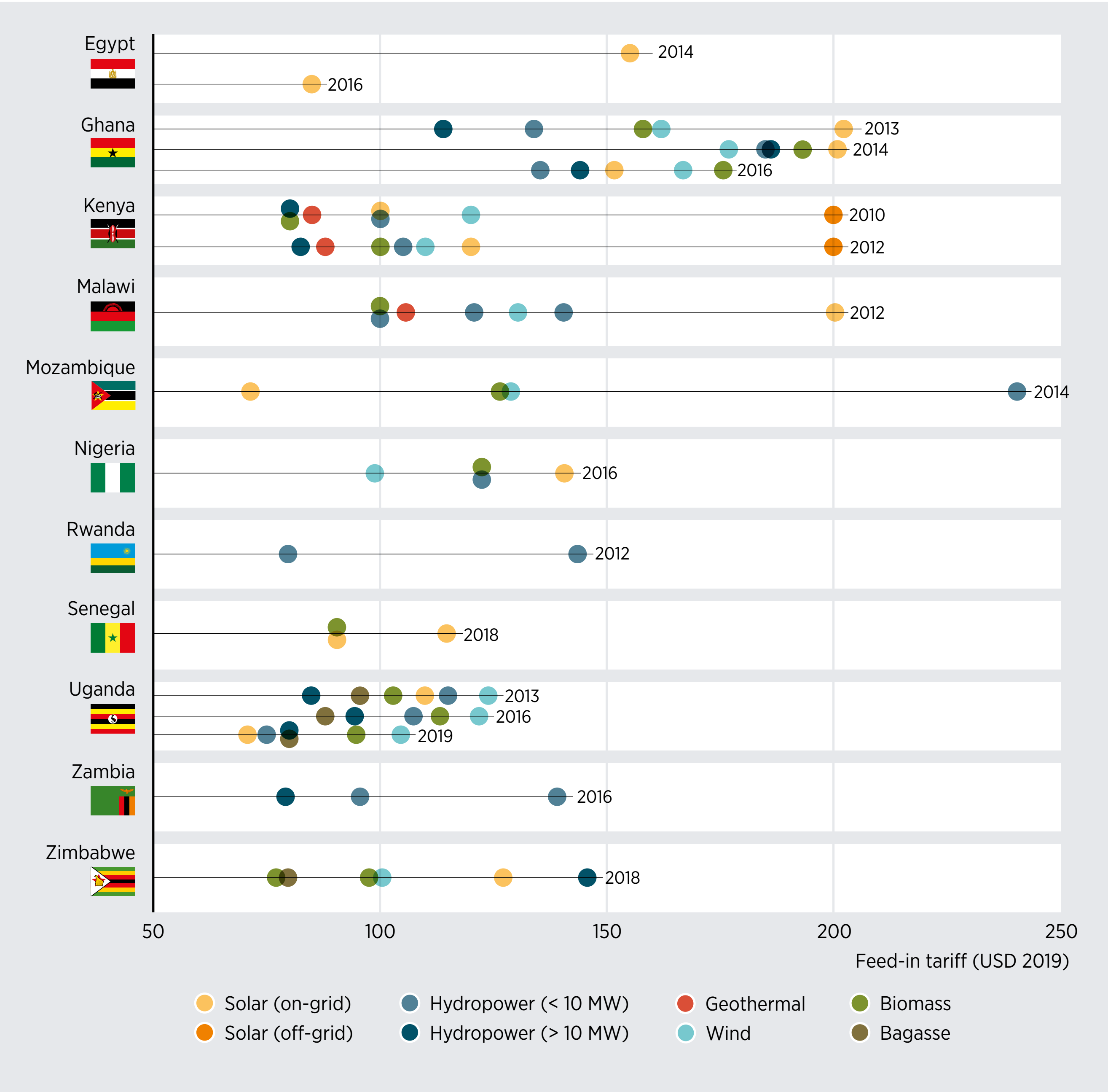
Feed-in tariffs

Feed-in tariffs (FiTs) are not widely implemented in Africa – they have only been adopted in about 14 countries and they have resulted in meaningful utility-scale investments in only 4 countries (Egypt, Kenya, Namibia and Uganda), for a total of around 2 GW[6] from solar PV, onshore wind, biomass and small hydropower . All four countries have transitioned or will be transitioning to competitive procurement methods for future projects, aiming for lower tariffs. Figure 4.5 shows the tariffs offered in Africa between 2010 and 2020 for various technologies. In general, FiTs have failed to deliver much investment as they are often not supported by the necessary regulatory and policy reforms or backed by bankable contractual frameworks. Countries like Angola, Malawi, Mozambique,[7] Ghana and Zimbabwe have had FiT policies on their books for close to a decade but have no operating FiT projects to show for it. Box 4.8 illustrates the experiences of Egypt, Ghana (albeit not very successful), Kenya and Namibia with FiTs.

6 This excludes the 60 MW Kinangop project in Kenya, which – despite reaching financial close in 2013 – failed to be constructed due to conflicts with the local community.

7 A scheme was adopted in Mozambique in 2014, but the country still lacks the regulatory framework to allow power to be injected into the grid, hindering its implementation.

Figure 4.5 Renewable energy feed-in tariff prices in African countries



Source: IRENA (n.d.a).

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Box 4.8 Experience with feed-in tariffs in Egypt, Namibia, Uganda, Kenya and Ghana

Egypt's feed-in tariff (FiT) programme can be considered the most successful on the continent based on the number of developed projects and total installed capacity. Despite Egypt's enormous renewable potential, its electricity mix had been dependent on fossil fuels for several decades. The launch of the Nubian Suns renewable energy feed-in tariff (REFiT) programme in 2014, ratified to advance the Benban Solar Park development – one of the largest solar complexes in the world – represented a turning point for the country's electricity sector. The USD 4 billion Benban Solar Park, located in the Aswan governorate, constitutes 41 solar photovoltaic (PV) installations as well as several small solar farms (IFC, 2021). In 2017, all project developers allotted utility-scale solar capacity in the programme signed their power purchase agreements (PPAs) with the government at a firm tariff of USD 8.4/kilowatt hour. All the projects reached financial close in the same year, commencing commercial operations two years later. The programme was backed by the Egyptian government and several development finance institutions including the International Finance Corporation, the Multilateral Investment Guarantee Agency and the European Bank for Reconstruction and Development. Nine international banks, led by the International Finance Corporation, provided construction loans for the projects, totalling USD 653 million. The European Bank for Reconstruction and Development also provided similar loans to the tune of around USD 650 million. The Multilateral Investment Guarantee Agency issued USD 210 million worth of political risk insurance protection to the projects' sponsors and lenders. The government provided the land for the mega project and built the transmission line linking the park to the grid in a timely manner (IFC, 2021). The success of Egypt's REFiT programme underscores the importance of regulatory and policy reforms and bankable contractual frameworks in attracting investments, which was unavailable in most other REFiT schemes in Africa.

Ghana initially implemented a FiT strategy in 2011 which did not attract investors – due in part to a 10-year limit on FiT contracts, as well as caps on project capacity, implemented to maintain grid stability. In 2016, Ghana made efforts to improve its strategy, increasing the contract limit to 20 years and relaxing capacity constraints. However, unsolicited and negotiated PPAs were the preferred option over FiTs and they have resulted in a high-cost, overcapacity system. Therefore, as of 2020, Ghana placed a moratorium on new PPAs until a more sustainable contracting system is developed. Moreover, FiTs increased nominally between 2013 and 2016 (although they still fell when adjusted for inflation and power purchase parity), reaching between GHS 529.4/megawatt hour (MWh) and GHS 691.2/MWh (USD_{2019} 607.6/MWh and USD_{2019} 793.3/MWh, respectively) – significantly higher than the FiTs found in many other countries. Going forward, Ghana must focus on financially sustainable renewables deployment – for example, through auctions, which when designed for that purpose have the ability to discover real prices (IRENA and GIZ, 2021).

Box 4.8 Experience with feed-in tariffs in Egypt, Namibia, Uganda, Kenya and Ghana (continued)

Kenya's experience with FiTs has been mixed. The policy was first promulgated in 2008, with revisions in 2010 and 2012. The FiT policy differs in that the published tariff levels act as tariff ceilings or caps rather than being guaranteed for approved projects. Final project tariff levels therefore still need to be negotiated and approved – which to a large extent negates many of the advantages (predictability, transparency) associated with FiT policies. By 2018, investors had expressed interest in developing more than 4 000 MW under the policy, including 104 small hydropower projects (578 MW total capacity), 19 wind projects (898 MW total capacity), six biomass/biogas projects (496 MW total capacity), 2 519 MW of solar projects and 15 MW of geothermal projects (Republic of Kenya Ministry of Energy, 2018). Nevertheless, only 8 projects (representing 361 MW – biomass, solar PV, onshore wind and small hydropower) have managed to reach financial close.[8] Most projects are stuck at the feasibility study stage,[9] while existing projects (or projects with signed PPAs) are facing the threat of tariff and dispatchability renegotiations based on overcapacity in the system. The country now plans to move towards an auction system for renewable energy, as recommended in the 2018 version of their national energy policy (Republic of Kenya Ministry of Energy, 2018), though this shift has yet to be fully realised.

Namibia is another successful case. Prior to 2015, the country had no private power generation investment; it imported close to 50% of its annual power demand from neighbouring South Africa. An interim FiT programme was announced in September 2015, which aimed at increasing investment from non-hydro sources. FiT levels were based – in part – on prices achieved in South Africa's Renewable Energy Independent Power Producer Procurement Programme (REI4P), but were still considered attractive[10] and managed to attract substantial local and international interest. Prior to the launch of the FiT programme, Namibia's energy regulator (Electricity Control Board) had granted 27 provisional licenses to renewable energy projects, all of which had failed to secure financing in the absence of a structured procurement process. These projects were invited to participate in the REFiT programme and given six months to submit all documentation to NamPower – the country's state-owned electricity utility. Fourteen projects rated at 5 MW (13 solar PV, 1 onshore wind) were awarded on a "first come, first to meet the requirements" basis. All facilities reached commercial operation within 12 to 24 months from award, fundamentally changing the structure and composition of the country's power sector. Namibia's experience with auctions (2016) ultimately ended the FiT programme as it became clear that the project prices achieved through competition were much more attractive.

8 One of these being the aborted 60 MW Kinangop wind project.

9 Many are also held up by a lack of clear guidelines for PPA negotiations.

10 Tariffs were in local currency and indexed to local inflation levels for a period of 20 years.

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Auctions

Since 2010, auctions have been announced in at least 25 African countries, representing more than 22 GW of auctioned capacity, out of which more than 13 GW have been awarded. This is considerable given that Africa currently has 147 GW of installed capacity and about half of the countries have power systems smaller than 500 MW. This section discusses the implementation of auctions in Africa, presents the volumes of renewable capacity awarded through auctions, as well as the prices achieved. It highlights how auctions have been designed to achieve objectives beyond price in the region, namely socio-economic development goals, and system integration as the share of variable renewable energy increased. It also discusses the performance of auctions in the region, presenting the share of auctioned volume that has reached financial close, and projects delayed or cancelled.

Auctions are now prevalent in all regions in Africa

Auctions are now prevalent in all regions in Africa, with more than half of the countries in each region (except Central Africa[11]) hosting or at least announcing an auction. Most of the procured capacity is concentrated in Southern Africa, due to South Africa's large power system and economy, as well as the success of its Renewable Energy Independent Power Producer Procurement Programme (REI4P).

The capacity awarded in Africa has exceeded 13 GW – with more capacity scheduled to be announced in the short to medium term.

Most of the awarded capacity pertains to solar PV projects, although onshore wind, geothermal, concentrated solar, landfill gas, biomass and small hydropower projects have also been awarded. Figure 4.6 illustrates the volumes awarded in Africa between 2010 and 2020.

Recent years have seen record-breaking prices being announced in West, East, Southern and North Africa

The competition in auctions has brought down prices. Solar auctions have realised prices that have repeatedly broken the continent's solar PV price record. In August 2019, Tunisia's Tatouine solar PV farm was awarded at USD 25.34/MWh (in 2018, the global weighted average of solar PV auctions was USD 56/MWh). Later the same year, Ethiopia's Gad and Dicheto solar PV farms broke this record after being contracted at USD.25.26/MWh (IRENA, n.d.b).

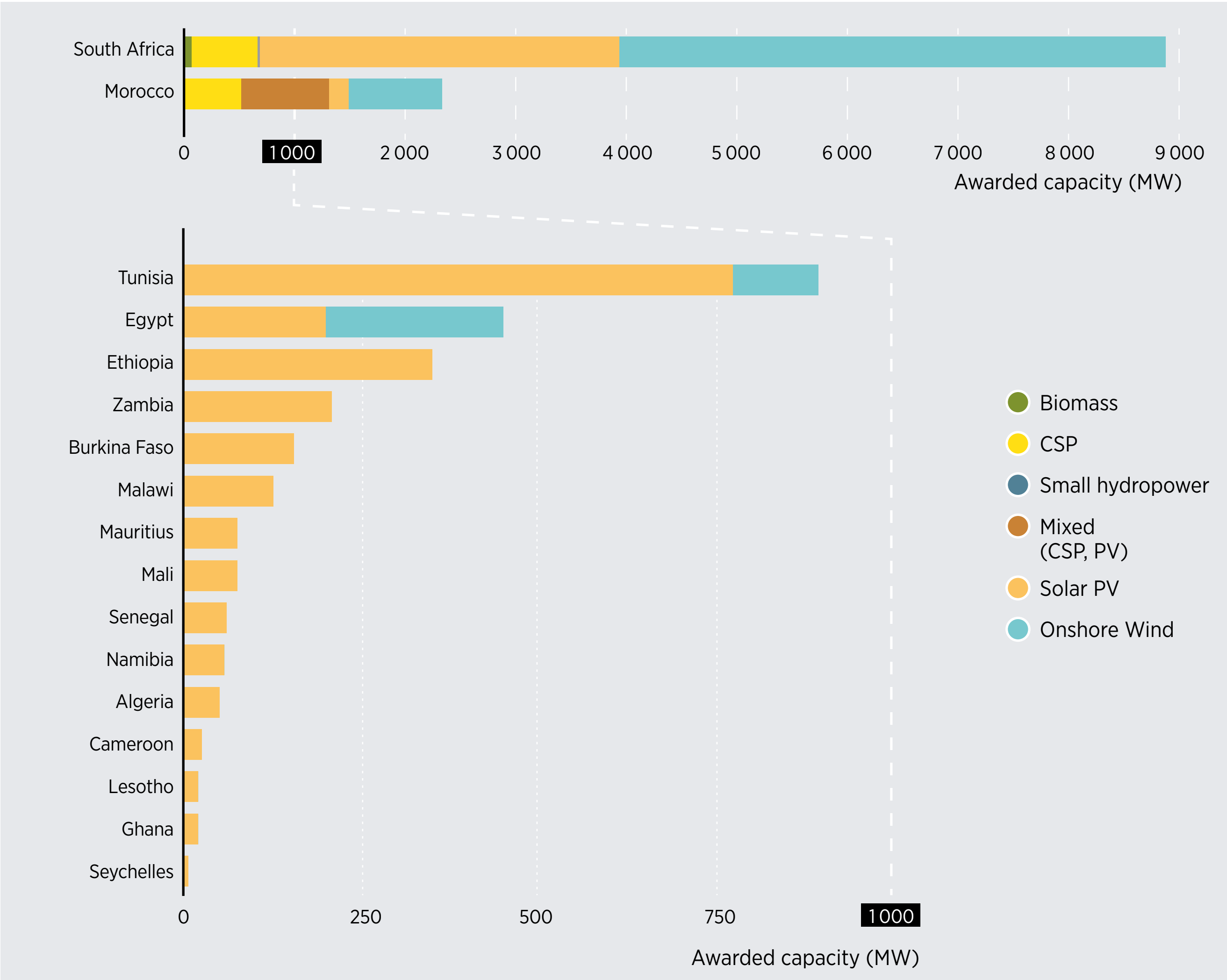
Wind power auctions have yet to gain as much attention as solar PV. To date, only South Africa, Morocco, Egypt and Tunisia have contracted onshore wind IPPs following an auction. In South Africa, the price reduction realised is remarkable: from a tariff of USD 140/MWh for the 139 MW Cookhouse wind farm awarded in the REI4P Bid Window 1 (BW1) (2011) to an average price of USD 32/MWh for the 1 608 MW onshore wind awarded in the fifth round in 2021 (IRENA, n.d.b).

These low prices, compared to the continent's average generation tariff of USD 180/MWh (not accounting for externalities), indicate the success of renewable auctions in achieving affordable and sustainable electricity. Figure 4.7 shows the results of selected auctions in Africa, with global weighted average prices resulting from auctions between 2010 and 2020, for onshore wind and solar PV. It shows that auctions have been relatively successful in driving down prices in several countries. This is due to their design flexibility and their ability to cater to specific challenges and circumstances, such as high-risk environments, typical of most African countries.[12]

11 In Central Africa, only the Democratic Republic of the Congo has hosted an auction.

12 The design of auctions for high-risk environments is the focus of IRENA's upcoming report from the series on Renewable Energy Auctions that started in 2013.

Figure 4.6 Renewable capacity awarded through auctions in Africa, 2010-2020



Source: IRENA (n.d.b); Power Futures Lab (2021).
Note: CSP = concentrated solar power; MW = megawatt; PV = photovoltaic.

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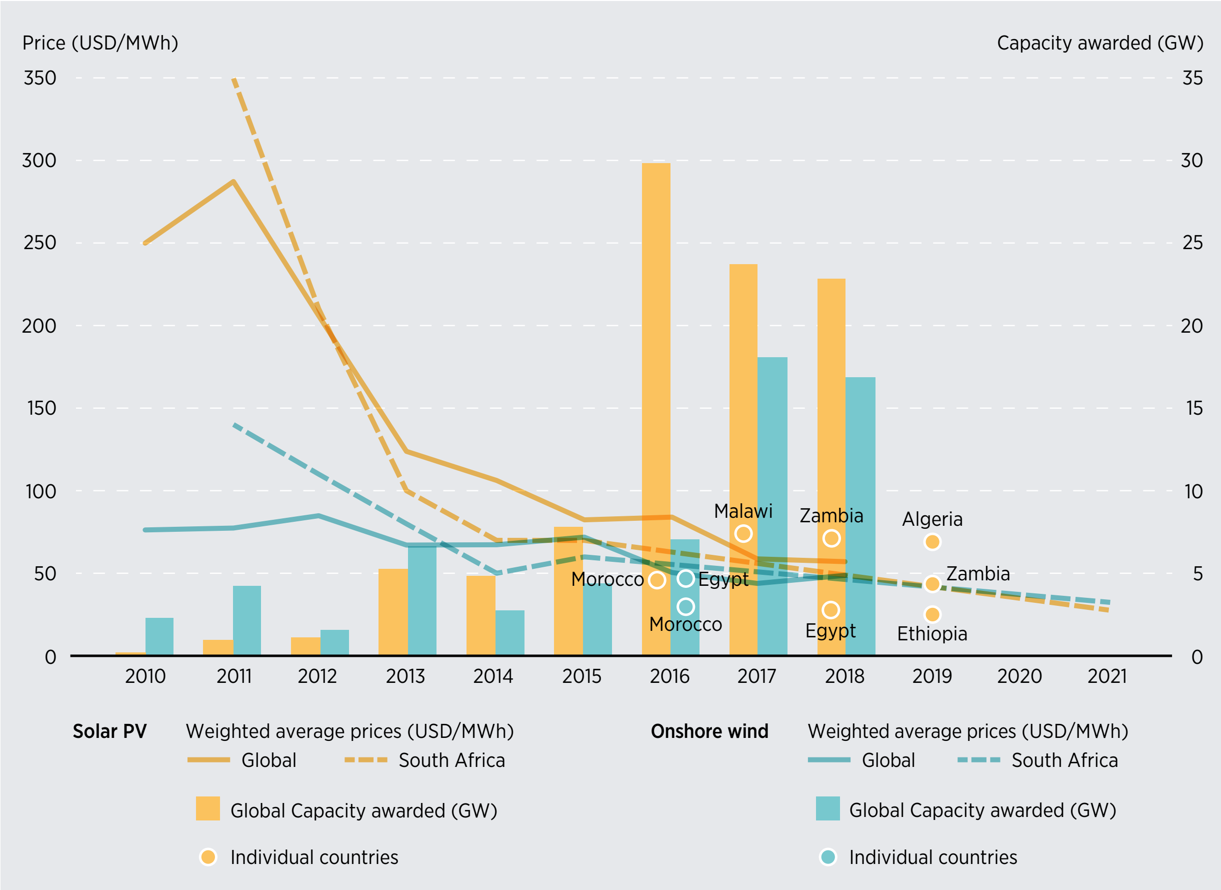
Figure 4.7 Results of selected auctions in Africa, and global weighted average prices resulting from auctions, 2010-2020



Source: IRENA (n.d.-b).

Auctions have also been designed to achieve objectives beyond price

Another strength of auctions, and important in Africa, is their ability to achieve objectives beyond price. Paramount are socio-economic development goals with extensively reported experiences from Morocco (Box 4.9) and South Africa (Box 4.15). Another objective of growing importance for the region is system integration as the share of VRE increases. Design elements include hybrid renewable auctions for dispatchable capacity. These produced the Midelt project in Morocco (Box 4.9) combining CSP and PV; the Golomoti project in Malawi linking PV and a lithium-ion battery; and zone-specific auctions as seen in South Africa (IRENA, 2019d).

The volume cancelled or delayed in Africa is almost 40% of what has been auctioned

Another objective of auctions that is crucial for Africa as many of its countries battle with undercapacity, is ensuring timely project completion. IRENA identifies key stages where auctions can underperform, starting with the announcement of the auction and extending through the processes of bidding, awarding, contracting, constructing and operating the assets specified in the PPA. Design elements to ensure performance at each of those stages are detailed in IRENA (2019d).

Box 4.9 Auctions in Morocco designed for socio-economic goals and system integration

Morocco's Noor Power Station was the first complex to combine hybrid solar photovoltaic (PV) and concentrated solar power (CSP) to use concentrated solar's storage capacity and support system integration. The complex was auctioned in four rounds. The first three rounds for CSP totalled 510 MW: the 160 MW Noor I and 200 MW Noor II projects use the parabolic trough technology with storage capacity of three and seven hours, respectively, and Noor III, a 150 MW solar tower, has seven hours of storage capacity. These were followed by a fourth round of PV with 72 MW.

The 510 MW of CSP resulting from the first three rounds were supported by the Climate Investment Funds with USD 435 million, the African Development Bank and World Bank with an investment of about USD 700 million, part of foreign and multilateral investments that exceeded USD 3 billion. The support of both banks and the Climate Investment Funds was critical in driving down the cost of CSP in Morocco (CIF, n.d.).

The auction for the Noor-Ouarzazate solar complex sought to develop a domestic industry and create economic opportunities for local communities. People in neighbouring villages benefitted from the project, including women and children. Cash compensation for the land would have benefitted landowners, who are men. Therefore, the community opted for investments in amenities and social services like drainage, irrigation channels and community centres. The complex has offered employment opportunities to women.

Local labour and materials were encouraged in the four rounds. Commitments presented in bids for each of the phases were higher than the thresholds specified in the auction. And they doubled the threshold at the fourth phase, bringing employment to 6 430 Moroccans (70% of the total employed), sourcing a third of the jobs to the Ouarzazate region.

In May 2019, Morocco auctioned the world's first advanced CSP-PV hybrid. The 800 MW CSP-PV Noor Midelt provides dispatchable solar energy during the day and for five hours after sunset for a record-low tariff at peak hours of MAD 0.68/kWh (USD 70.3/MWh).[13] This will greatly support the integration of variable renewable energy into the system.

Source: IRENA (2019b).

13 USD 1 = MAD 9.6743 in May 2019.

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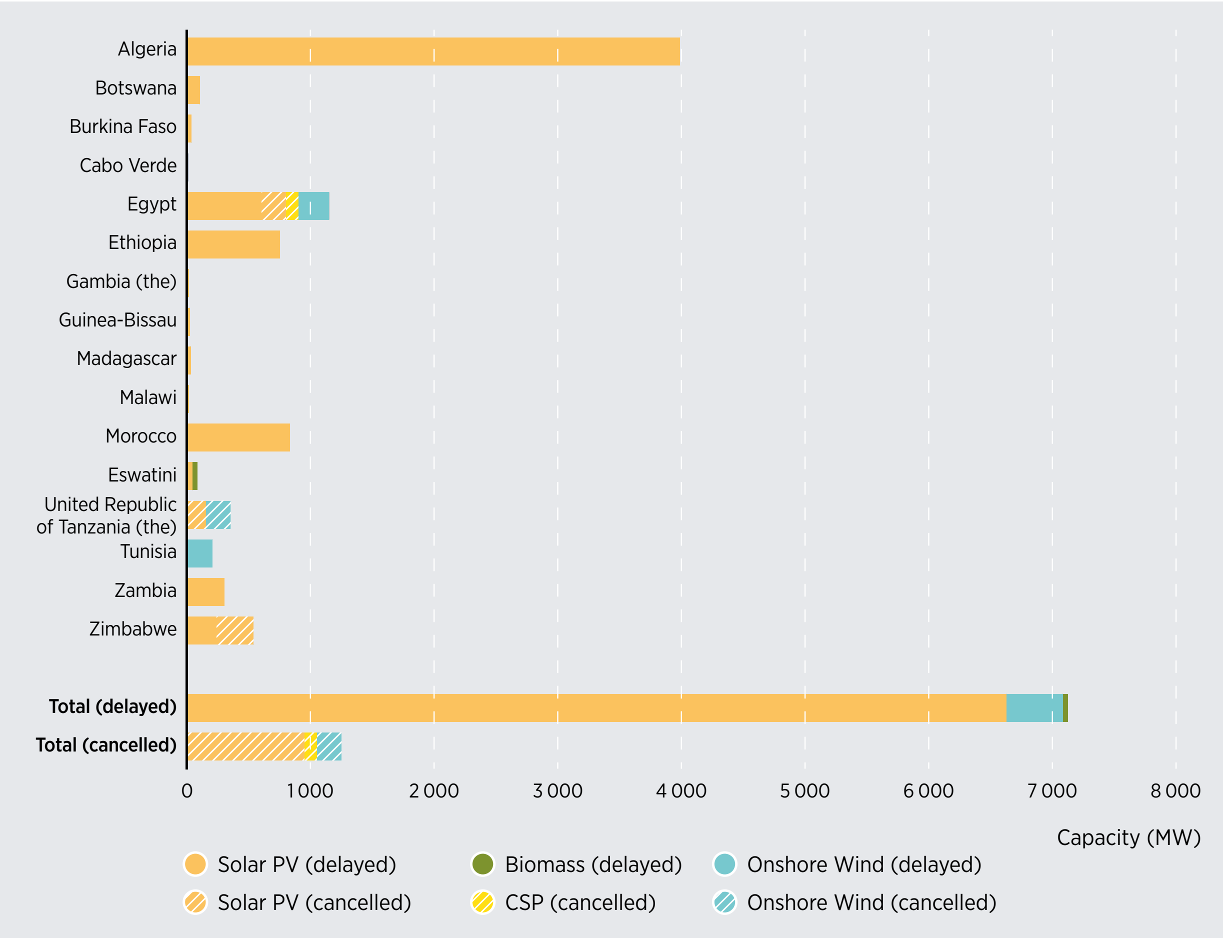
In the bidding and awarding stage, many auctions have experienced delays or cancellations, equivalent to almost 8.5 GW. Out of this volume, a total of 1.25 GW has been cancelled (Figure 4.8). There are also some examples of awarded projects that have failed to or are struggling to reach financial close in the contracting stage, undermining investor confidence, affecting competition levels and the cost of capital, and ultimately resulting in higher power prices. From the volume awarded, as of 2020, projects representing more than 7 GW of capacity have reached financial close and moved to construction and commercial operation, equivalent to more than 60% of the volume awarded. Box 4.10 presents some highlights of auction completion rates in Africa.

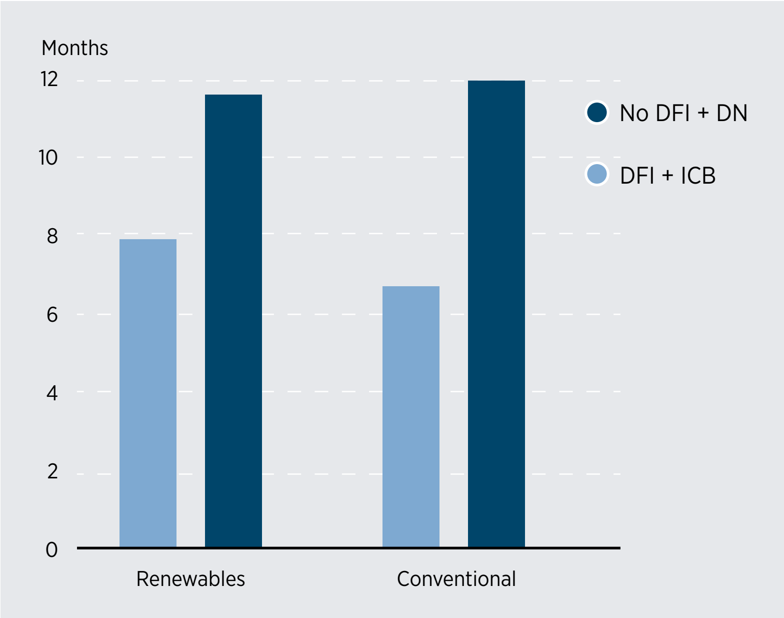
In the construction phase, the structured nature of auctions, especially those supported by DFIs, seems to have a ripple effect on every aspect of the development of renewable energy projects. Notably, projects that enjoyed some form of DFI support and were contracted through an auction were built quicker (within around eight months of reaching financial close) than those without DFI support and procured following direct negotiations (almost one year) (Figure 4.9).

Figure 4.8 Auctions in Africa cancelled or delayed, 2010-2020



Source: IRENA (n.d.b).
Note: CSP = concentrated solar power; MW = megawatt; PV = photovoltaic.

Figure 4.9 Average years taken for an IPP to come online after financial close



Source: Power Futures Lab (2021).
Note: DFI = development finance institution; DN = direct negotiation; ICB = international competitive bidding.
Note: DFI + ICB = projects that enjoyed support from development finance institutions and that and were contracted through international competitive bidding; No DFI + DN = projects without support from development finance institutions and procured following direct negotiations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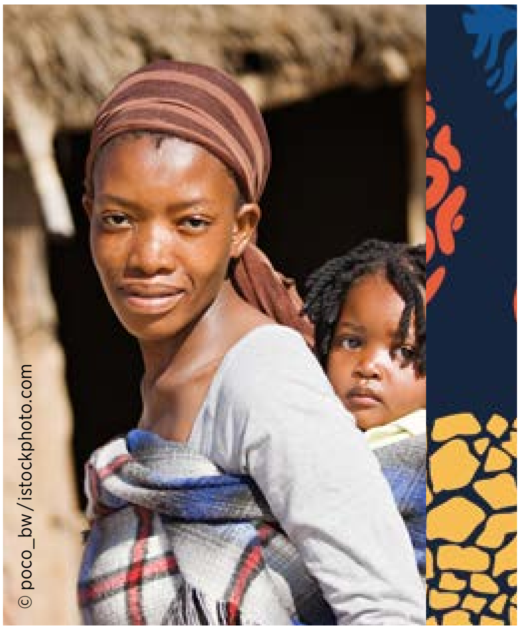
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Box 4.10 Auction completion rates in Africa – highlights from selected countries

South Africa was the first Sub-Saharan country to embark on a renewable energy auction programme in 2011, called the Renewable Energy Independent Power Producer Procurement Programme (REI4P). Four rounds of procurement, as well as an additional round for concentrated solar power (CSP), were held between 2011 and 2015, resulting in 92 projects being awarded (mostly solar photovoltaic [PV] and onshore wind) representing more than 6.3 GW of capacity, out of which 4.5 GW was online by September 2020. The auction was structured as a single-stage, pay-as-bid, sealed bid tendering process – with dedicated demand bands for each technology: solar PV, onshore wind, small hydropower, biomass, landfill gas and CSP. An additional Small Independent Power Producer (IPP) Procurement Programme was launched in 2014 to provide opportunities for smaller, local developers and investors, for 20 x 5 megawatt (MW) projects.

Competition was fierce, with more than 390 bids submitted over the four rounds, which drove down the prices with each bidding window (BW), from just over USD 350/megawatt hour (MWh) and USD 140/MWh for solar PV and onshore wind respectively in BW1 to just over USD 50/MWh and USD 70/MWh in BW4 (considering a blended, weighted average of all technologies). As a result, solar PV and wind technologies are now the established least-cost capacity expansion options for the country. In 2021, the results of BW5 were announced. More than 100 bids were received and solar PV and onshore wind were awarded at an average price of USD 28/MWh and USD 32/MWh respectively.

In 2015, an impasse between the REI4P and South Africa's state-owned monopoly power utility, Eskom, resulted in a three-year delay in the signing of power purchase agreements for projects awarded in BW4,[14] as well as a hiatus in the procurement programme. As a result, the country is currently experiencing its worst power crisis to date.

South Africa also launched a controversial 2 GW "technology-neutral" Risk Mitigation IPP Procurement Programme for dispatchable capacity in late 2020, which awarded 776 MW to projects that combined solar PV, wind, storage and gas-fired or diesel generation.[15]

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Namibia awarded a 37 megawatt-peak (MWp) solar PV IPP in 2016 for USD 63/MWh.[16] Competition was intense among the 13 bids. The project began commercial operations a mere 13 months afterwards and has a capacity factors of 35%. In early 2020, NamPower again awarded another 20 MWp solar PV IPP (Khan) at USD 29/MWh.[17] These projects proved the competitiveness of renewable energy technologies for the country and played an important part in Namibia's recently announced ambitious green hydrogen strategy. What makes these projects more remarkable, for the region, is that they are being paid in local currency, with no sovereign guarantee or other risk mitigation measures backing NamPower's offtake obligations thanks to the utility's financial health.

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Tunisia has also had notable success with auctions. In 2019, the Ministry of Energy, Mines and Renewable Energies awarded 500 MW of solar PV to three companies for several projects, with the lowest bid coming in at TND 71.83 (USD 25.30/MWh[18]) and the highest bid at TND 97.92/MWh (USD 34.51/MWh) (Bellini, 2019). Seychelles also awarded its first utility-scale IPP and the region's first floating (4 MW) solar PV project through an auction in 2020, at USD 95/MWh.

Other countries that have seen competitively awarded renewable energy projects reach financial close include: **Burkina Faso** (60 MW solar PV, USD 90/MWh, 2021); **Egypt** (200 MW solar PV, USD 28/MWh, 2021; 250 MW onshore wind, USD 47/MWh, 2017); **Malawi** (66 MW solar PV; USD 74/MWh, 2020-2021); **Mauritius** (75 MW solar PV, USD 62/MWh 2018-2019); **Morocco** (177 MW solar PV, USD 46/MWh, 2017; 510 MW CSP, 2013-2015; 270 MW wind, 2018-2019); **Senegal** (20 MW solar PV, 2016; 60 MW solar PV, USD 40/MWh, 2019); **Tunisia** (10 MW solar PV, 2019; 30 MW onshore wind, 2019) and **Zambia** (40 MW solar PV, USD 60.2/MWh, 2017; 40 MW solar PV, USD 78.4/MWh, 2018).[19]

14 The small IPP projects' off-take agreements have still not been signed, despite the country's power crisis.

15 The remainder was awarded to power ships using liquefied natural gas. It is at this stage unclear whether these projects will reach financial close due to permitting issues and legal challenges.

16 USD 1 = NAD 14.7129 in 2016 (average).

17 USD 1 = NAD 16.58 in 2020 (average); 16 bids submitted.

18 USD 1 = TND 2.8377 on 20 December 2019.

19 The awarded projects in Zambia have not been able to reach financial close due to the rapidly deteriorating financial position of ZESCO – the off-taker – and the dire fiscal state of the Zambian economy, which is in default on some of its major loans.

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A key feature of several successful auctions in Africa has been the notable presence and support of international and multilateral development partners. The impact of this support was also seen in feed-in tariffs (see section 3.2.3).

Grid access, priority dispatch and other forms of generation/consumption

To support renewable energy deployment, open and non-discriminatory access is required to promote the injection of renewable electricity into the grid. This is usually required by law (often referred to as "obligation to take") in most countries around the world. Initially, this provision was included in regulations to support renewables and eliminate relevant risks. However, as costs of renewables have declined and grid operators are less concerned about integrating renewables into the grid, there is broad recognition that renewables need to be dispatched first as they have near-zero variable costs. That said, technical standards for grid connection should be communicated clearly and transparently to generators and enforced by system operators to avoid synchronisation and system balancing issues in the future.

Ethiopia has introduced several regulatory reforms in order to attract private investment in renewable energy. Among them, the Energy Proclamation, adopted in 2013, introduced a licensing regime and rules for operators. However, the licensing application procedures and timelines remain unclear. Further, a transmission grid code was drafted in 2018, establishing the right to non-discriminatory access to the national transmission network, but has yet to be officially adopted. Similarly, **Ghana** adopted a national grid code for transmission services in 2009, and also dedicated T&D grid sub-codes for renewables. The codes include technical and performance requirements, as well as grid connection procedures and cost allocation. However, there remains room for improvement as regulations regarding priority dispatch and curtailment compensation are not included (RES4Africa Foundation, 2019).

Indeed, providing priority dispatch or preferential access to the grid can support renewable energy development. Although implementation of this measure is not yet common in Africa, regulations supporting grid access are present in a few countries. For example, in 2020, Niger implemented new measures making renewable energy sources "self-dispatching" – meaning that renewable energy projects are connected to the distribution network and are automatically synchronised, if the appropriate grid voltage is available. This guarantees grid access and priority dispatch for renewables. The **Madagascar** Electricity Code, established in 2017, provides a framework for priority grid connection and dispatch of renewables. **South Africa**'s grid code also includes provisions for priority dispatch of renewables, curtailment compensation and coverage from imbalance risk (RES4Africa Foundation, 2019). However, it should be noted that in 2020, the state utility Eskom, curtailed power from wind generators owing to depressed demand in the system due to lockdowns implemented in response to the COVID-19 pandemic.

Clear rules for self-consumption can also promote renewable energy development. For example, in **Tunisia**, producers have the right to sell excess renewable electricity generated for the purposes of self-consumption to the Tunisian Electricity, Gas and Renewable Energies Company. **Morocco** has also implemented specific regulations for self-consumption, allowing for the sale of surplus electricity to the national utility as well as allowing self-generators access to the transmission network to transport electricity generated for the purposes of self-consumption from a production site to a consumption site. Distributed generation can also be supported by net metering.

South Africa recently announced that projects up to 100 MW will be exempt from needing to secure a generation license from the regulator, which has been a main bottleneck.

Net metering

Several African countries are incentivising self-generation through net-metering regulations applied at the national level, including Botswana, Egypt, Mauritius, Morocco, Namibia, Rwanda, Senegal, the United Republic of Tanzania and Tunisia. Some municipalities in South Africa have put up financial, regulatory and policy barriers to net metering schemes. In fact, city governance is crucial for renewable energy deployment in all end uses (Sidebar on Cities and Box 4.11).

In South Africa, most municipalities add a huge markup to Eskom electricity, creating a fund that constitutes more than half their revenues. If not properly designed, then, net metering represents a direct financial threat. Most South African municipalities with net-metering policies pay only what they would pay Eskom as a bulk tariff. In addition, net metering that compensates power fed back into the grid does not cover the cost of T&D. The unbundling of tariffs would be one step towards a cost-reflective net-metering policy. Finally, to support more cost-reflective electricity tariffs, effective implementation would minimise price distortions to protect the very poor (AfDB, 2019b).

Box 4.11 The role of cities in renewable energy deployment in Kasese (Uganda)

Kasese's district government has focused on renewable energy deployment as a means to improve health, education and poverty reduction (KDLG, 2013).

- A **Kasese District Renewable Energy Strategy** is setting ambitious targets by increasing the number of institutions using renewable energy and growing the number of renewable energy enterprises by 20%; households and local industries using renewable energy will each commit to increase their use of renewables by 10%.
- Kasese is also undertaking a pilot project supported by IRENA, the **solar city simulator**, which optimises photovoltaic installations through homeowner assessments of viability and affordability; commercial entities and municipal authorities can also conduct these assessments.
- The municipality is supporting an initiative inspired by the **Supporting African Municipalities in Sustainable Energy Transition** project. It helped Kasese fill data gaps in the energy sector, built capacity through courses in professional development and broadened Kasese's network locally and internationally with funding from the United Kingdom.
- The municipality also took part in the **Solar Loan Programme** run by a government agency which facilitates investments and credit support for renewable projects in Uganda. The municipality helped to train workers in installing, maintaining and distributing renewable energy technologies, and fostered partnerships between local businesses and non-governmental organisations (NGOs). Kasese's Conservation and Development Agency, a local NGO, arranged financing schemes for solar photovoltaic and improved cookstoves and trained local producers of briquettes and local arborists and their tree nurseries. Finally, national research institutions provided data and analysis.

Source: IRENA (2021h).


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4.2.3 Policies for the direct use of renewables: Heating and cooling and transport

Heating and cooling

In the heating and cooling sector, African policies are focused on clean cooking and water heating. To take full advantage of its vast potential in solar, geothermal and bioenergy resources, Africa will need to do much more so that it can fuel productive uses such as agriculture and industrial processes.

Policies to promote solar water heating are common in East Africa (Kenya, Mauritius and Rwanda), North Africa (Morocco, Tunisia, Egypt and Libya) and Southern Africa (Zimbabwe, South Africa and Eswatini). Typically, these policies offer subsidies to support SWHs; Tunisia's PROSOL programme was more comprehensive, however. Consumers could purchase SWHs at lower up-front costs through investment subsidies on a five-year loan. Working alongside banks, the programme reduced risks by making the electricity utility the debt collector and increasing the supply of finance available for the systems (Innovation for Sustainable Development Network, 2019). South Africa's state-owned utility, Eskom, implemented a SWH rebate programme in two phases, 2008-2013 and 2010-2015. In 2011, Rwanda rolled out its flagship programme, SolaRwanda, which provided grants and loans for residential SWHs. By 2018, 3 400 units had been installed (Solar Thermal World, 2018).

In Kenya, a building regulation mandated that at least 60% of the hot water supplied be heated using solar thermal systems. This regulation applies to new, expanded or renovated commercial and residential buildings that use more than 100 litres of hot water per day (REN21, 2019). A privately owned equity bank collaborated with companies to provide preferential loans with longer tenures to small-scale residential SWH users (Hakeenah, 2018).

In Zimbabwe, incentives for SWHs are considered alongside regulations restricting the installation of electric heaters. In 2019, a regulation banned the installation of new electric heaters (geysers), subject to certain exemptions (for example, if the premises use electricity generated by renewable energy and divert excess electricity to heat water). SWH systems are to be used instead of electric heaters. The regulations also regulate the licensing, operation, repair, maintenance, retrofit and upgrade of these SWH systems.

Innovative methods are used to **cool buildings**. In Mauritius, a Deep Ocean Water Applications project proposes to air condition buildings in Port Louise with seawater captured at the coldest depths of the Indian Ocean.

In **agriculture**, in Sub-Saharan Africa alone, Kenya is tapping geothermal energy for commercial agriculture. A world leader in the development of geothermal resources, Kenya has two power plants. The plant in Oserian, near Lake Naivasha, uses geothermal steam to warm greenhouses and generate electricity (Yee, 2018). Kenya's success in leveraging its rich geothermal resources for direct heating and productive use is attributed to:

- Integrated geothermal energy and rural development plans;
- Active engagement with local actors and promotion of partnerships;
- Assessment of specific productive-use activities in the early stage; and
- A strong focus on capacity building for end users.

In **industry**, bioenergy has been used in co-generation. In the city of Lugazi (Uganda), where many households make a living in agriculture, crop residues and farm waste play a huge role in energy generation (Mboowa *et al.*, 2017; BDLG 2016). Lugazi's largest industry, the Sugar Corporation of Uganda, has established a bagasse-fired co-generation plant with a capacity of 9.5 MW (MEMD, 2015). Eco-Fuel Africa is converting farm and municipal waste into briquettes and biochar fertiliser with simple, low-cost technologies that draw on local fuel usage (Gebrezgabher and Niwagaba, 2018).

Transport

Renewable energy use in Africa's transportation sector lags behind electricity, with scant progress in recent years. Policies focus on **biofuel blending**. Currently, 7 out of 54 countries have some form of biofuel blending mandate (Figure 4.2).

The gap between regulation and implementation means many mandates go unenforced, mostly because of insufficient local supply. Senegal and Uganda have biofuel laws regulating blending, but no mandates.

Few countries in Africa have implemented policies or projects for **electric mobility**. This is hardly surprising as most African countries still have an electricity deficit and electric vehicles are generally not affordable. Although the degree to which electric mobility counts as a decarbonisation solution depends on the electricity mix, investing in electric vehicles as most countries start expanding their fleets could align well with a future electricity mix based on renewables.

Ghana has launched an electric vehicle initiative with a number of charging stations available for the for use by POBAD International and electricity company of Ghana (Box 4.12).

Box 4.12 The deployment of electric vehicles (EVs) in Ghana

Ghana's Energy Commission launched the Drive Electric Initiative in 2019. EVs can help take up some of Ghana's excess electricity generation capacity. At the end of 2019, the country's installed generation capacity was about 5 000 megawatts, whereas peak load was 2 612 MW. Ghana moved from a deficit to excess generation capacity in just a short period of time after a rush of independent power producers moved in to address the deficit. "Take or pay" clauses in their contracts mean that excess electricity is paid for. The country is paying more than USD 500 million annually for unused power generation capacity.

Ghana's EV market is getting traction through start-ups like SolarTaxi and Accraine Ghana, which are leasing EVs, EV accessories and used EVs imported from Europe. POBAD International has partnered with the national power utility to install EV charging stations across the country. In the first phase of the project, POBAD will install a total of 200 chargers across southern Ghana.

Source: Kuhudzai (2020).

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In 2020, the **Seychelles** Ministry of Environment, Energy and Climate Change, launched an electric mobility project with the Department of Land Transport. Its pilot phase involves the introduction of two electric public transport buses and is to start in 2021. **Cabo Verde** adopted an electric mobility policy charter whose goal is to replace internal combustion engine vehicles with electric vehicles – a 100% EV fleet for public administration by 2030 and 100% electrification by 2050.

South Africa has ambitious targets for EVs. The country's Green Transport Strategy 2018-2050 proposes a 5% emission reduction goal in the transport sector by 2050. Investment in biogas filling stations and electric car charging points is also highlighted in the strategy (DoT, 2018). South Africa has included commitments on transport in its NDC, targeting 20% of hybrid EVs by 2030 and more than 2.9 million electric cars on the road by 2050. These will require around ZAR 6.5 trillion (USD 440 billion) of new investment in the EV industry over the next four decades (Grabosch, 2018). Nearby **Namibia** aims to have 10 000 EVs by 2030 (SLOCAT, 2021). In 2016, South African Airways became the first airline on the continent that powers commercial flights with biofuel produced locally and certified by the Roundtable on Sustainable Biomaterials (Biofuels International, 2019).

Some countries and cities have adopted fiscal incentives and demonstrations.

To encourage EVs in the market, **Egypt** has been exempting imported, used EVs from customs duties since March 2018. In 2020, it announced customs tariff discounts on imported components for EV charging stations. Locally manufacturing passenger EVs are set to commercialise in 2022 (Al Bawaba, 2021). Egypt has also vastly expanded its electric public transportation system. The first electric bus line in Cairo was launched in 2019; a USD 4.5 billion contract was signed for the country's first high-speed electrified rail line (Takouleu, 2019; Bailey, 2021).

In **Mauritius**, the government has halved exercise duties, road taxes and registration fees for electric cars and hybrid vehicles since 2009 to promote the development of low-carbon transport (GFPN, 2017).

The **Rwandan** government approved a new set of incentives to catalyse the adoption of EVs. The incentives include a preferential corporate income tax rate of 15% for e-mobility investors, half of the 30% standard tax rate (MININFRA, 2021). Other policies include reduced electricity tariffs at the industrial level and rent-free land for the installation of charging infrastructure in some cases (GGGI, 2021).

City-level demonstration projects are underway in **Cape Town** (South Africa), with two electric buses for daily public transport operations after a 12-month testing period (ESI Africa, 2021). **Addis Ababa** (Ethiopia) has a pilot project for electric buses (Endale, 2020).

Renewable energy deployment and supporting policies for other forms of transport, such as railway, maritime and aviation, remain very limited. In 2016, the South African Airway became the first African airline to operate commercial flights powered by

biofuels produced locally in South Africa and certified by the Roundtable on Sustainable Biomaterials (Biofuels International, 2019).

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4.2.4 Green hydrogen

Green hydrogen can link renewable electricity generation with hard-to-electrify sectors. Hydrogen is a suitable energy carrier for remote areas, far from electricity grids, or that require a high energy density. Green hydrogen can also serve as a feedstock for chemical reactions to produce a range of synthetic fuels and feedstocks.

Africa has abundant renewable resources and demonstrated potential for production at globally competitive costs. Several European countries are looking into investing in Africa's green hydrogen production and transport infrastructure (mostly ships).

On the one hand, it is difficult to endorse the idea of generating renewable electricity at a large scale to produce and export green hydrogen when the continent cannot even support universal access. Indeed, any green hydrogen producer should adhere to the principle of "additionality". This principle holds that if any electricity from renewable sources has other productive uses, then it should not be converted into green hydrogen. As it stands, European regulation already prohibits green hydrogen that has "additionality" attributes.

On the other hand, green hydrogen could support a leapfrogging strategy, whereby green industry and sustainable, long-distance exports are unconstrained by fears of large-scale devaluations or stranded assets. Unlike Europe and other parts of the developed world, many African economies are not trapped in established industries. Green hydrogen could absorb both excess renewable electricity and overcapacities (such as those discussed in Ghana in Box 4.12). Other benefits of green hydrogen include greater energy security and socio-economic gains with potential for job creation.

To this end, Africa has undertaken several green hydrogen initiatives:

- The African Hydrogen Partnership is a continentwide trade association dedicated to the deployment of green hydrogen and fuel-cell technologies. Its vision is to construct renewable energy hubs – large-scale power-to-gas plants – located in metropolitan areas, ports and mining centres along trans-African highways (Clifford Chance, 2021).
- H2 Power-Africa is a green hydrogen initiative sponsored by the German Federal Ministry of Education and Research (BMBF) and the countries of the Southern African Development Community and the Economic Community of West African States (ECOWAS). The purpose of the initiative is to explore renewable energy potential in Southern and West Africa (Clifford Chance, 2021; GUI, n.d.; BMBF, 2021).
- The Global PtX Atlas also covers the regional potential for green hydrogen (Fraunhoefer-IEE, n.d.).
- The ECOWAS Centre for Renewable Energy and Energy Efficiency, in collaboration with the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), is preparing a request for proposals on green hydrogen policy for the ECOWAS region (GN-SEC, 2021).

Other agreements include the Germany-Niger hydrogen projects (Wehrmann, 2020); West Africa is investigating possible deals (Fuel Cells Works, 2020), while Mauritania is entertaining an agreement from CWP Global to develop a 30 GW project (AHP, n.d.).

The following initiatives have taken off:

Egypt introduced green hydrogen in its 2035 energy strategy. Egypt's Sovereign Fund, the Norwegian company Scatec and Fertiglobe (a leading ammonia producer) signed an agreement to produce green hydrogen in quantities ranging from 50 to 100 MW, as a feedstock to produce green ammonia (Zawya, 2021).

The government of **Mauritania** has signed a memorandum of understanding on Project Nour, a green hydrogen development of up to 10 GW. In an onshore and offshore area of approximately 14 400 km^2, Project Nour could also generate solar and wind power (Power Engineering International, 2021).

With its plentiful renewable energy sources, **Morocco** could position itself as a global energy hub. A tender for a 100 MW green hydrogen electrolyser project is planned for 2022, and a project to produce 183 000 tonnes of green ammonia by 2026 – with a production capacity of 31 000 tonnes of green hydrogen a year – has been announced (Technical Review Middle East, 2021).

Through its initiative Hydrogen South Africa (HySA), the **South African** government is working to expand local knowledge and innovation to create tangible local benefits through job creation and increased wealth. Fuel cells could expand clean energy provision to remote communities, reducing energy poverty.

Nigeria has also expressed interest in hydrogen energy to meet energy demand. Its National Energy Policy 2018 details short-, medium- and long-term strategies on incorporating hydrogen energy. Public-private partnerships ensure the provision of green hydrogen to underserved communities. **Uganda's** Rural Electrification Agency partnered with Tiger Power, a Belgian company, to supply solar power to three villages in the Kyenjojo District. Using hydrogen batteries, the project stores excess solar energy from the day to power villages through the night.

Namibia is planning to publish a green hydrogen strategy in 2021 after announcing a cooperation with Germany (for export) (Radowitz, 2021).

As revealed by IRENA analysis, the pillars of green hydrogen policy making are outlined in Box 4.13. Although it helps decarbonise energy sectors, green hydrogen is not a priority in Africa. Renewable energy projects will address power shortages for some time to come.

Box 4.13 Key pillars of green hydrogen policy making

IRENA has identified the following key pillars of green hydrogen policy making:

Set policy priorities. Green hydrogen can support a wide range of end uses. Policy makers should identify and focus on applications that provide the highest value.

Establish a national hydrogen strategy. Each country needs to define its level of ambition for hydrogen, outline the amount of support required and provide a reference on hydrogen development for private investment and finance.

Introduce guarantees of origin. Carbon emissions should be reflected over the whole life cycle of hydrogen. Origin schemes need to include clear labels for hydrogen and hydrogen products to increase consumer awareness and facilitate claims of incentives.

Adopt a governance system and enabling policies. As green hydrogen becomes mainstream, policies should cover its integration into the broader energy system. Civil society and industry must be involved to maximise the benefits.

Source: IRENA (2020i).

4.3. INTEGRATING POLICIES

Renewable energy sources and their integration are central in the global energy transition. Secure supply by power grids requires a continuous balancing of supply and demand. Yet the presence of VRE like solar and wind power, whose feed-in depends on meteorological conditions like solar irradiation and wind speed, can pose challenges to grid operation. Given the relatively low base of installed capacity in Africa and the continent's steep growth in demand, many African countries face a dual challenge: growing renewables while growing the system itself. The continent has a unique opportunity to design power systems able to accommodate high shares of variable renewables (Sterl, 2021). The integration of renewables can be facilitated through the formation of power pools in Africa which provide a framework for regional and cross-national planning.

Africa has five power pools[20] that could integrate renewables into the energy system (Chapter 2). As of 2017, all but three member states of the Southern African Development Community – Angola, Malawi and the United Republic of Tanzania – were connected through the Southern African Power Pool (SAPP), able to trade electricity with member states and to bolster energy security in the region (AfDB, 2019c).

Markets operating at the power-pool level support VRE by harnessing a region's "spatiotemporal synergies". These are complementary dynamics between renewable energy sources and demand profiles (IRENA, 2018d, 2021i). Hydropower in the rainy mountains and solar/wind power in low-lying deserts is one kind of synergy (*e.g.* Ethiopia and Sudan; Guinea and Senegal) that creates pronounced temporal synergies on seasonal timescales, especially in regions with strong monsoons. An adequate power pool infrastructure could make investments in VRE projects more attractive, since it may lower the costs of grid integration. The substantial power grid created by regional markets generates a larger balancing area, which if well designed can moderate VRE curtailments and reserve requirements.

On the technological side, power pools require large-scale transmission interconnectors and adapted operation of various power plants. Most recently, large-scale transmission interconnectors have started construction in West Africa.[21] Hydropower plants may have to ramp up (or down) more often to accommodate VRE infeed from solar and wind power generated elsewhere in the pool. Older hydropower plants may require refurbishment to meet the required ramp rates. Flexibility provisions may be required in other types of power plants, like solar CSP with thermal storage and biomass plants. Gas-fired power plants will have an important role until they are phased out in compliance with the Paris Agreement.

After flexibility provisions, storage-based technologies could also accommodate variable renewables in Africa's power pools. Currently, South Africa and Morocco are the only countries using pumped-storage hydropower. But this mature technology also holds promise for hydro-rich countries like Egypt and Ethiopia (Hunt *et al.*, 2020). Over the next decades, large-scale battery storage could accommodate the integration of renewables to decarbonise electricity systems across Africa – particularly to balance the diurnal nature of solar PV (Barasa *et al.*, 2018). For seasonal storage, power-to-gas technologies (*e.g.* green hydrogen) could play important roles (IRENA and GIZ, 2021).

On the policy side, integrating renewables into the energy system requires that the power system have a conducive organisational structure, as discussed in Box 4.6, together with sector coupling policies to support the electrification of end uses. Those include enabling electricity tariff structures, such as time-of-use tariffs and other innovative solutions to support demand side management (Section 4.1.5). Forward-looking plans are also needed, to integrate the additional renewable electricity and address the load imposed by the electrification of end uses through grid expansion and strengthening (IRENA, 2021e).

20 The Southern African Power Pool, Eastern Africa Power Pool, Central Africa Power Pool, the West African Power Pool and North African Power Pool, also known as the Maghreb Electricity Committee (COMELEC).

21 These are: the coastal transmission backbone (Ghana, Togo, Benin and Nigeria), the Côte d'Ivoire, Liberia, Sierra Leone and Guinea interconnector, the North core (Nigeria, The Niger, Benin and Burkina Faso), the OMVG loop (Senegal, The Gambia, Guinea-Bissau, Guinea). Others are under development, such as the median backbone (Nigeria, Benin, Togo, Ghana and Côte d'Ivoire), the GBM (Ghana, Burkina Faso and Mali), the Sahel Backbone (Mauritania, Mali, Burkina Faso, Niger and Chad).

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On the economic side, regional markets rely on appropriate transmission infrastructure, co-ordination rules and consistent regulatory frameworks. Unfortunately, in practice, cross-border collaboration within African power pools has been hindered by a lack of aligned national policies and regulations, as well as inadequate funding and investment in infrastructure. Apart from the SAPP, most of the power pools are relatively young. Therefore, the ability of these power pools to achieve targets remains limited (AfDB, 2019c; IRENA, 2019d). Innovative practices may need scaling up over the coming years. For instance, the SAPP makes it possible for initiatives to set up investment-grade intermediary off-taker agreements, which can then trade on the pool to improve the bankability of renewable energy projects that would normally have been able to only sell to low-rated state-owned utilities. Africa GreenCo is an example of such an initiative.

Recent analyses have emphasised the importance of the procurement planning nexus for accelerating power investment in Africa, including renewables (Eberhard *et al.*, 2016). Dynamic, frequently updated power system expansion plans need to ensure that projected electricity demand will be met by a least-cost mix of technologies. In the African context, this least-cost mix is most often dominated by renewable energy resources in the long term (IRENA, KFW and GIZ, 2021), but this is likely to require near-term policy support to drive renewables' deployment and cancel fossil fuel projects in the pipeline, without which the energy transition may fail (Alova *et al.*, 2021). A recent IRENA analysis, for instance, showed that unless generation capabilities in East and Southern Africa are reviewed and reconsidered, the region is on track to construct more than 100 GW of new coal-fired power until 2040, leading to a substantial increase in CO_2 emission levels (IRENA, 2021i).

Such plans should ideally also stipulate which projects will be built by the public sector utility, and which by the private sector based on clear criteria. For these plans to lead to sustainable, increasing investment levels, they need to be translated into internationally competitive bidding rounds on a regular, predictable basis. This predictability stimulates project pipeline development, leading to increased investment volumes, improved project quality and higher levels of competition in bidding programmes (resulting in lower project prices). It also allows for better alignment with grid infrastructure plans.

For the plans to function as guides for investment decision making, it is of paramount importance that institutional capacity be established to effectively govern the process of planning. Critical aspects of an effective planning process include ownership of the planning process, the ability to update plans as needed, transparency of the process and stakeholder participation (IRENA, 2018e; EEG, 2021). To support this effort, IRENA has undertaken a range of capacity-building initiatives to inform energy/capacity expansion planning, both on a country level as well as on a power pool level (Box 4.14). Examples include country-level support to Eswatini, Sierra Leone and Cameroon as well as power pool level analyses for the Central Africa Power Pool and the Eastern and Southern African Power Pools, together known as the African Clean Energy Corridor.

Box 4.14 IRENA's Prospects and Planning for Renewable Power in Africa series – informing capacity building and long term planning

Since 2012, IRENA has published five reports in the "Prospects and Planning for Renewable Power in Africa" series (IRENA, 2021i, 2018d, 2015, 2013a, 2013b). These use System Planning Test (SPLAT) models to assess the continent's renewable power generation prospects through 2030 and 2040. The models span nearly 50 countries across the continent's five power pools.

MESSAGE software allows national energy planners to assess least-cost supply scenarios and call on IRENA's databases on technology costs and resource availabilities. As of 2021, IRENA had set up ready-to-run SPLAT-MESSAGE models for 49 African countries covering all power pools.

All SPLAT-MESSAGE models will converge into a single, all-Africa model that displays supply and deficit electricity generation regions. These models will inform debates on transmission infrastructure and variable renewable energy integration under the African Single Electricity Market launched in February 2021. This market links power sector strategies, harmonises regulatory frameworks and integrates energy generation, transmission and distribution. It would support the five power pools and boost Africa's energy transition (EU, 2021). IRENA's work on model supply regions, together with its database on hydropower availability in Africa, has allowed renewable electricity generation to be represented at a higher spatiotemporal resolution than before.


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4.4. STRUCTURAL POLICIES FOR A JUST AND INCLUSIVE TRANSITION

The energy transition in Africa promises benefits related to GDP, jobs and welfare (Chapter 5). Furthermore, given the connections between development and political stability, the energy transition can support efforts to strengthen sustainable peace in a continent which faces a range of security risks and threats including armed conflict and incidents of terrorism. The mounting climate crisis and the ongoing COVID pandemic further exacerbate existing vulnerabilities. Platforms such as the Aswan Forum for Sustainable Peace and Development have recognised the key contribution of sustainable energy in improving Africa's resilience and the enabling environment for advancing peace in the context of interlinkages between peace, security and sustainable development (Aswan Forum, 2021).

At the same time, challenges and misalignments may arise, as the energy transition will influence how citizens consume, produce, travel and commute and it will introduce changes to local and regional economies.. Impacts vary across regions and countries, reflecting the respective socio-economic contexts and different starting points, development priorities and capabilities.

Policies for structural change and just transition are needed to address potential challenges (Figure 4.10), and they need to consider the capabilities of countries, as well as their dependence on resources, commodity trade and other economic characteristics.

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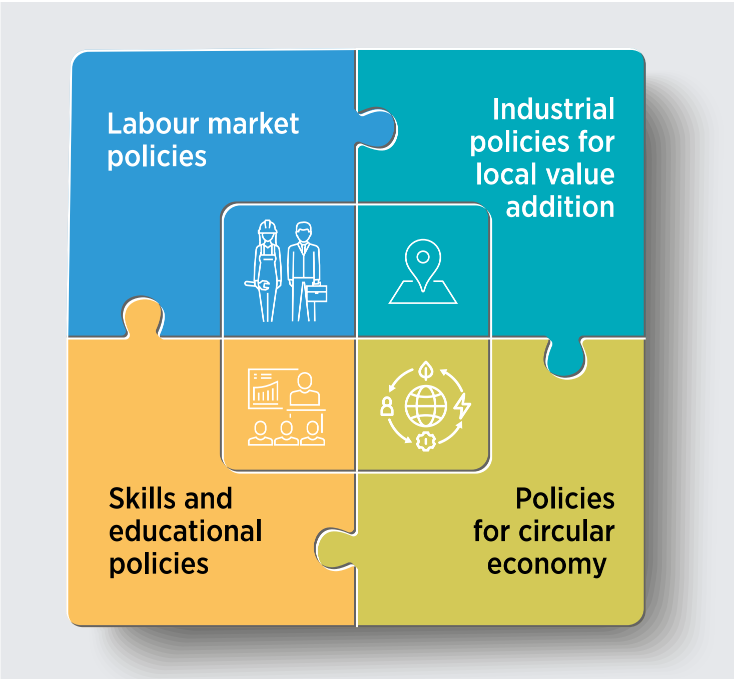
Figure 4.10 Overview of structural change policies



This section discusses policies needed to address potential labour market misalignments (section 4.4.1); support the development of local value chains by leveraging and enhancing domestic capacities (section 4.4.2); offer education and build capacity (section 4.4.3). To ensure the sustainability of the energy transition, polices to support the circular economy are also needed (section 4.4.4).

4.4.1 Labour market policies

Labour market policies are critical tools to help African countries address potential labour market misalignments related to time, when job losses precede job gains at a larger scale; space, when new jobs are emerging in communities or regions other than those that lose jobs; education, when the skills levels or the occupations required were not developed or needed under the previous energy system; and sector, because of changing value chains and supply chains under the energy transition (IRENA, 2021e).

Addressing these misalignments is of high political relevance in Africa, which faces many long-term challenges such as increasing economic and demographic pressures, coupled with the more immediate effects from the pandemic and financial crisis. In addition, addressing spatial and sectoral misalignments enables women to cross into male dominated sectors such as the energy sector, as in Uganda, leading to three times higher earnings than in typically female-dominated industries (Campos *et al.* 2016).

Labour market policies to address these misalignments and encourage or facilitate more and better jobs in energy transition-related fields in Africa involve vocational training (discussed in section 4.4.3), employment and wage subsidies, in addition to measures that boost information and transparency.

Active labour market policies **support firms in dealing with regulations and labour laws**. Successful programmes in South Africa have trained firms in labour law, facilitating job creation (Bertrand and Crépon, 2016). Measures that provide information about employment opportunities in different locations, or subsidise relocation or travel, can help address spacial misalignments.

Regulatory barriers can be major obstacles for formal firms. Many are pushed into the informal economy, especially micro and small enterprises. **Employment policies can support formal employment** in newer sectors, shifting labour shift from less productive, obsolete sectors (African Development Bank 2021c). Encouraging the formalisation of small enterprises, including those in the renewable energy value chain, involves lowering the barriers; increasing access to information, banking and small loans; improving access to energy and digital products; and offering fiscal incentives. Morocco has created a legal "self-employer" status that supports entrepreneurs through reduced taxes when annual sales fall below a threshold and access to social protection and financing.

Policies targeting transition-related sectors in Africa could include a leave-of-absence policy for government employees who are starting a new business. This ameliorates the risks of entrepreneurship and reduces dependence on government jobs. Measures can be implemented to ease bureaucratic hurdles, encourage tax breaks and equip young people to start their own businesses and venture into agri-businesses and climate-smart agriculture along with renewable energy. Labour movement restrictions for highly skilled workers could be eased, where applicable, affording "champion firms" access to a larger pool of workers, while encouraging nationals to become more competitive.

Stepping up social security systems is particularly relevant in countries largely dependent on fossil fuels, such as Algeria and Nigeria, which could invest more systematically in transition-related funds that re-channel fossil fuel revenues into social protection and labour training and reskilling as part of a just transition.

Social protections go hand-in-hand with resilience planning. In view of the energy transition, South Africa is establishing resilience plans to "protect vulnerable groups that may lose their jobs or livelihoods as a result of climate change impacts".

4.4.2 Industrial policies for local value addition

For African nations to maximise the socio-economic benefits of the global energy transition, far-sighted **industrial policies** will be necessary. Africa's narrow industrial base has meant that industrialisation is still seen as the road to development (Newfarmer, Page and Tarp, 2018; Morris *et al.*, 2012). In view of the need to combine industrialisation with sustainable environmental management, the structural transformation of African economies will need to align with the energy transition.

The energy transition could promote industrialisation and helping countries leave the commodity dependence trap behind, by fostering the so-called "industries without smokestacks" and integrating renewable energy, energy efficiency and energy access into industrial activities. Industrial policies – including investing in infrastructure, digitalisation and R&D; providing access to electricity, roads, telecommunication, finance and information; building local capacity; and introducing local content incentives – are central to drive the structural transformation towards a more sustainable and greener economic system (Anzolin and Lebdioui, 2021; Aiginger 2015; Hallegatte *et al.* 2013; Lütkenhorst *et al.* 2014; Rodrik 2014).

Ambitious industrial policies that add value to the renewable energy sector can be found in Morocco (Box 4.9) and South Africa (Box 4.15). Egypt, Ethiopia and Kenya have also shown commitment towards maximising socio-economic benefits. Countries such as the Democratic Republic of Congo, Zambia and Zimbabwe also hold large reserves of minerals that are essential to the clean energy transition. The use of industrial policies will be critical in ensuring value addition and the integration of local firms in higher value-added segments of renewable energy value chains.

Because African economies present limited markets, economies of scale in the renewable energy sector can be achieved only through regional and regional co-operation. This section outlines policy interventions required to sustain accumulated industrial capabilities for a just and developmental energy transition in Africa (Figure 4.11).

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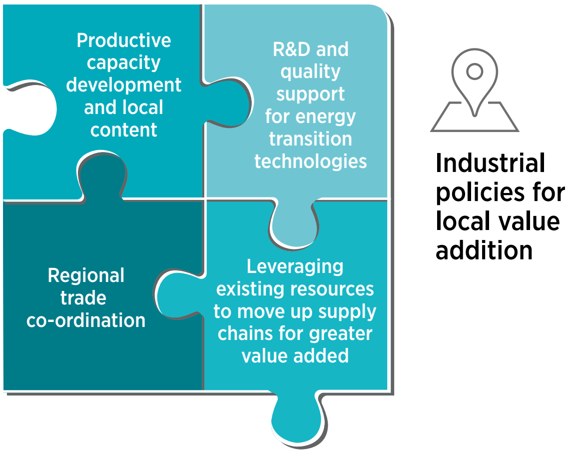
Figure 4.11 Industrial policies for local value addition

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Productive capacity development and local content

Local content requirements (LCRs) and incentives can leverage the energy transition for industrial development and job creation by ensuring a demand for domestic products and services. Such measures can help local firms to learn-by-doing and promote incremental innovation in the face of consolidated supply chains that present high barriers to entry. Because renewable energy in most markets maintains a newcomer status, it offers favourable prospects for LCRs in the low- and medium-skilled work segments (IRENA, 2021e).

In the past, LCRs have violated World Trade Organization rules (WTO, 2018), but the paradigms seem to have shifted in the "just transition" debate given the urgency of climate change. The post-COVID-19 recovery provides an opportunity to rethink world trade rules and perhaps carve out policy space for LCRs – granting special status, for example, for renewable energy technologies.

Some countries adopted measures to support value creation from fossil fuels, including Angola, Cameroon, Chad, the Congo, Equatorial Guinea, Gabon and Nigeria. Dependent on their fossil fuel sectors, these countries have sought to localise jobs along the fossil fuel value chain (Bond and Fajgenbaum, 2014; Ovadia, 2018; UNCTAD, 2018). In many cases, local content policies have strengthened the skills and capacities both of workers and of small- and medium-scale enterprises. They have expanded the roles of national industries in the oil and gas industry. Nigeria has created competitive firms in oil logistics, maintenance and related services, some of which started as subsidiaries of international firms and others as local start-ups (Bond and Fajgenbaum, 2014). These clusters provide employment, create world-class capacity and possess strong links to the rest of the economy, and could inspire copycats in the renewable energy sector.

As part of its Economic Sustainability Plan (IRENA, 2021g), the Government of Nigeria launched a Solar Power Naija project in December 2020 to expand energy access to 25 million people. Pre-qualified solar home system distributors and mini-grid developers are to receive long-term, low-interest credit, along with manufacturers and assemblers of solar components. More local content in solar manufacturing and assembly, with import substitution, is possibly worth USD 10 million per year. The government hopes to incentivise the creation of 250 000 jobs (Bungane, 2020).

LCRs are not a panacea, however, and they do not by themselves build productive capabilities (Lebdioui, 2019). Quotas that are too high can scare off investors. Those that are too broad allow investors to exploit ambiguities. More important, governments tend to enforce local content quotas without investing in capabilities accumulation, leading to a costly trade-off between local content and competitiveness.

Box 4.15 Supporting the development of local content in South Africa

In South Africa's Renewable Energy Independent Power Producer Procurement Programme (REI4P), bids are evaluated by criteria stipulating local content and job creation. There is a required minimum threshold for local content spending in addition to targets that bidders must achieve. As the bidding rounds progress, local content requirements rise. By 2020, the ZAR 58.5 billion local content spending reported by active REI4Ps was 89% of the ZAR 66 billion expected (Republic of South Africa, 2021).

The job creation criterion targets disadvantaged communities and racial groups to ensure that local employment is at the core of the REI4P. By March 2021, the programme had created 59 071 job years – or about two-thirds of total jobs held in the coal sector (Republic of South Africa, 2021; SEI *et al.*, 2020). Socio-economic benefits linked to the REI4P are:

- **Direct employment:** Cumulative job-years rose from 31 207 in 2016-2017 to 59 071 by March 2021; more than 15 000 job-years benefit those in communities near IPP projects. Construction accounts for 80% of jobs, which tend to be short term. More permanent occupation is seen at the operational phases; these account for the remainder of job-years created (around 11 000). Women have held only 10% of jobs created so far.
- **Ownership:** South Africans own on average 48% equity in all IPPs, with local communities' equity averaging 10%.
- **Local content:** Procured projects committed about ZAR 67.1 billion (USD 4.7 billion) to local content,[21] or 45% of total project value. Local manufacturing rose, while imports of solar PV and wind turbine components declined since 2012. Now a small export industry is starting to develop.
- **Socio-economic development:** As of June 2018, ZAR 640 million (USD 45 million) was invested in socio-economic development, including education and skills development. This represents 1.2% of project revenue and falls within the 1.0-1.5% range of commitments.
- **Enterprise development:** As of June 2018, ZAR 6.4 billion (USD 450 million) of project revenue (or 0.4%) was invested in enterprise development, below the 0.6% commitment (Republic of South Africa, 2021).

Three wind tower manufacturing plants have been built under this procurement programme. Besides the wind energy sector, the solar sector in South Africa has seen a number of new manufacturing and assembly facilities. Special Economic Zones (SEZs) have attracted component manufacturers, especially of wind towers (Larsen and Hansen, 2020). Yet, despite SEZs, the minimal scale of local component manufacturing reflects the absence of a green industrial policy (Baker and Sovacool, 2017). In addition, local content objectives are measured purely in terms of local spending, which skews local content away from value-added activities like post-project planning services, critical manufactured items or technology acquisition. These items in the supply chain have the greatest domestic industrial impact (Morris *et al.*, 2020). Inadequate policies on local content allow solar PV developers to sidestep rules through something called "transfer pricing" (Baker and Sovacool, 2017: 9). As a consequence, less than 2% of their production capacity comprises local orders (Baker and Sovacool, 2017).

The REI4P was to ensure continuous job creation. So local supplier development needs to be strategic – with a more protracted horizon for implementation. Development of local small and medium enterprises is both time consuming and specific to each project's economic conditions. Nevertheless, asset management and the 20- to 25-year operation and maintenance phase provide notable opportunities for business.

21 At mid-2019 exchange rates; 1 South African Rand (ZAR) equals USD 0.071.

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The integration of renewable energy supply chains into productive capabilities relies on human resource development commensurate with local content goals. For instance, **supplier development programmes** could boost the capabilities of local suppliers by creating more stable intra-industry relationships, modelling best practices and quality standards and communicating information about the requirements of a changing market.

Price control mechanisms are industrial policy tools that signal beneficial socio-economic outcomes. For instance, fiscal incentives encourage companies and suppliers to contribute to the local economy through industrial linkages and knowledge transfer. Strict performance requirements are imposed on local suppliers in exchange for government support, such as subsidies and tax breaks. In addition, the government can send market signals by making alternatives more costly. Besides carbon taxes, a progressive phaseout of fossil fuel subsidies could encourage local consumers and firms to shift to renewables. Private firms could exploit this new mass market with scale economies to produce goods at lower cost.

Enhancing and leveraging domestic capabilities requires carefully crafted incentives and rules, business incubation initiatives, supplier-development programmes, support for small and medium enterprises and promotion of industrial clusters. A holistic approach to local content in the renewable energy sector builds capacity. Meanwhile, local capabilities develop the scale and capacity to meet the demand for sophisticated inputs and services in green technology manufacturing. This strategic, holistic approach builds a competitive supplier base that does not require industry protection. It also allows African countries to integrate renewable value chains without slowing the global energy transition.

Regional trade co-ordination

Regional trade co-ordination among African countries could help fill the basket of policy solutions to create more localised industries. Market integration and cross-border collaboration are relevant given the limited markets in most African countries, which hinder productivity gains. Larger market access, regional clustering and the consequent ability to localise more of Africa's industrial value chains could drive down costs and boost productivity (Lebdioui and Morales, 2021).

For local firms to gain productivity and avoid duplication of effort, regional synergies around the supply of renewables will be vital. Regional co-operation will also improve quality standards and technology impact. The African Continental Free Trade Area is one such device able to boost intra-regional trade and local production of renewables (Box 4.16).

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Box 4.16 Implications of the African Continental Free Trade Area for the renewable energy sector in Africa

The African Continental Free Trade Area (AfCFTA) came into effect on 1 January 2021. Years in the making, the trade area is part of a continentwide vision articulated in the African Union's Agenda 2063. Given the centrality of energy to economic activity and social welfare, AfCFTA will have ramifications for the sector, both renewable and non-renewable, and, more particularly, for renewable energy access and industrial opportunities along the related value chains.

Renewable energy access. The AfCFTA is expected to expand access to cheaper sources of electricity and more secure energy supply (Pendame, 2020; Peterson, 2019; Africa Oil & Power, 2020) through:

- Integrated electricity grids and installed capacity (Adeniran and Onyekwana, 2020; Pendame, 2020; Papaefstratiou, 2019).
- Liberalised cross-border trade in electricity and reduced tariffs (Adeniran and Onyekwana, 2020), which will benefit both consumers and energy-intensive industries that stand to gain from increased security and diversification of supply, as well as reduced energy costs (UNECA, 2020).

Renewable energy value chains and related industrial development. AfCFTA's impact on renewable energy value chains is hard to determine at this juncture. Negotiations for phase 2 of the agreement are still incomplete. AfCFTA will open up a larger export market (Komane, 2018) and is set to lead to better movement of labour, which makes skilled labour more available for the green energy transition (Adeniran and Onyekwana, 2020), and to expand knowledge sharing across the continent.

Africa has diverse levels of industrial and economic capacity. So as AfCFTA liberalises trade, the countries that shed industrial capabilities may benefit far more from upgrades in the renewable energy value chain.

R&D and quality support for energy transition technologies

R&D could become an essential tool during the energy transition, especially for African nations wanting to shift from mere technology consumers to producers and innovators. Measures to foster innovation are discussed in section 4.1.5. Business activities like in-house R&D, quality certification, incubation, technology transfer and diffusion are needed not only for functioning national renewable energy markets but also for creating new jobs (Anadon *et al.*, 2016; Barrett, 2009; Conchado *et al.*, 2016; Mercure *et al.*, 2016).

Governments have several tools at their disposal to stimulate low-carbon, green technology development. These include long-term, patient capital and non-repayable R&D funding, which is vital for early research and development. Few green financing programmes exist in Africa to date.

To promote technology diffusion, African governments could establish industry clusters for emerging technologies related to the energy transition. Several renewable energy technologies – such as onshore wind and solar PV, the least costly technologies for power generation (IRENA, 2021e) – have reached market maturity. But a vast array of other technologies (ranging from battery storage and hydrogen technologies to EVs and tidal power) are not yet cost competitive but will be crucial for the energy transition over the long term. By adopting national and regional strategies, African countries should be able to localise the expected socio-economic benefits of industry development and jobs creation.

Quality control and assurance are key to the energy transition, but they should be an entry point, not a barrier to the markets. Easy access to standardisation procedures, including training and skills formation, can reduce entry barriers for local firms seeking access to value chains (see section 4.4.3).

Leveraging existing resources to move up supply chains for greater value added

Copper, lithium and cobalt: Central and Southern Africa have abundant mineral resources essential to the production of electric batteries, wind turbines and other low-carbon technologies. Considering its cobalt stores, the Democratic Republic of the Congo could be a leader in the global energy transition. Yet, minerals critical to the clean energy industry are bound to be affected by commodity price cycles. To avoid commodity dependencies, critical mineral producers might leverage the energy transition to move into higher value-added segments of the renewable energy supply chains, leapfrogging into processing rather than exporting its valuable raw materials. The mining industry could share its experience with a view to maximising local value.

4.4.3 Skills and educational policies

A just and inclusive transition in Africa hinges on human resources at the local level – capacity required to develop, install and maintain renewable energy projects. Policies and measures that educate and train pertinent segments of the workforce will be vital. Better local capacities will reduce reliance on imported expertise. Reskilling energy sector workers is an important part of leaving no one behind in the energy transition. Think of coal, gas and oil workers in North, West and Southern Africa. Key education and skilling priorities for Africa include the puzzle pieces depicted in Figure 4.12.

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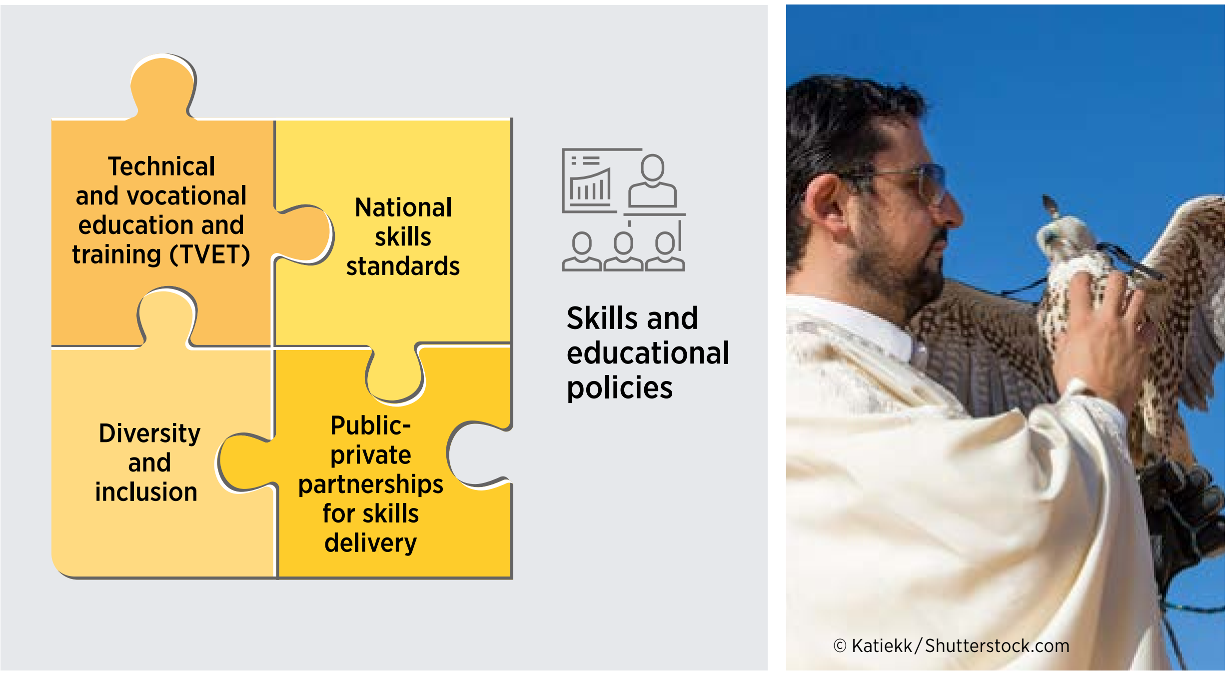
Figure 4.12 Key education and skilling priorities



Note: TVET = technical and vocational education and training.

Technical and vocational education and training (TVET)

During the energy transition, governments need to address the mismatch of skills supply and demand. TVET systems need to be responsive to development priorities. An initiative led by the International Institute for Educational Planning of the United Nations Educational, Scientific and Cultural Organization (IIEP-UNESCO) exemplifies this approach. With funding from the French Development Agency, the Platform of Expertise in Vocational Training provides support to a number of countries through an exchange of good practices and experiences (IIEP-UNESCO, n.d.). Zambia's Green enterPRIZE Innovation and Development project is another initiative that builds worker competences in a range of solar and biogas installations, sales and marketing (ILO, 2021).

Local capacity around renewable energy installations ensures the distribution of benefits and opportunities. In South Africa, the Department of Energy established a community programme near a CSP PV facility (CPV1) (Touwsrivier SE.ED, 2017). The Socio-economic and Enterprise Development programme (SE.ED) includes skill and enterprise development initiatives that build the capabilities of the local residents, particularly youth, in order to improve particpants employability and establish an industrial hub as illustrated in Figure 4.12. Similarly, the Umoya wind energy farm included the Home Improvement Programme which initially worked to improve the energy efficiency of low-cost homes but in the second phase was expanded to include skill development for unemployed residents of Hopefield (AIIM, 2018).

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Figure 4.13 SE.ED initiatives in support of youth employment and skills development

COMMUNITY JOBS FUND	Aims to create temporary work opportunities for unemployed local youth, with a specific focus on (re) integrating single mothers into the job market.
EXPERIENCE WORK	Aims to boost skills needed locally through work placement and on-the-job training to improve longer term employability of trainees.
BURSARY FUND	Aims to generate technical skills base through comprehensive tertiary education funding for studies in scarce technical skills.
STARTER PACK	Accredited programme for aspiring entrepreneurs that teaches basic business development skills and allows for piloting of ideas.
ENTERPRISE STARTER PACK	Supports youth with business ideas through entrepreneurship programme.
ENTERPRISE 4 SOUTH AFRICA	Aims to grow locally-owned businesses through a mentorship programme that draws on business consultants for individualised support.
BUY LOCAL INITIATIVE	Loyalty programme that rewards individuals employed through one of the SE.ED initiatives for purchasing goods and services locally.
INDUSTRIAL DEVELOPMENT	Establishment of a green industrial zone attracting manufacturing businesses including incentives for local employment.

Public-private partnerships for skills delivery

Many countries are establishing new public-private mechanisms to deliver sectoral TVET programmes.

Morocco uses public-private partnerships to train workers through Delegated Management Institutes (IGDs). The costs of specialised training courses are covered by the state while management is led by the private sector (World Bank, 2020c). Of the ten IGDs established to date, three train for the renewable energy sector with IGDs located near large installations in Oujda, Tangier and Ouarzazate.

SMEs deliver energy services across Africa. To strengthen their capacity, IRENA and the ECOWAS Centre for Renewable Energy and Energy Efficiency established a support facility in 2015 offering mentorship and advice on technical guidance, business management and operations. They enhance project proposals and launch innovative new initiatives (ECREEE, n.d.a). In Mauritania, a framework for stakeholders would address skills shortages in the electricity and energy sectors with a public-private partnership forming a consultative group of training institutions, government actors and private sector leaders (IIEP-UNESCO, 2021).

National skills standards

Many African countries face untrained technicians who install and maintain renewable energy plants. Expanding energy access however, such as solar home systems, depends on local capacity not only to install projects but also to maintain them. National curriculum standards and the accreditation of training courses would greatly strengthen energy sector workers and promote the long-term reliability and sustainability of installations. Introducing and developing national standards requires industry to co-operate with educational institutions, labour associations and governments. Curriculum standards along with accreditation of training institutions ensure that they can train workers and issue standardised assessments and certifications.

Egypt launched such a training centre to build national expertise, including a stronger energy-engineering curricula, sponsoring joint research and establishing scholarships and internships (USAID, 2021c). USAID also partnered with the Egyptian government to develop a renewable energy curriculum for technical schools training young people for work in the solar and wind sectors (Farouk, 2018). In Kenya, the Energy Regulatory Commission (2012) launched the Energy Solar Photovoltaic System Regulation in 2012, requiring that all solar technicians be licensed only for the system on which they had been qualified. Regulations like these reduce low-quality installations and maintenance and professionalise the renewable energy sector.

Diversity and inclusion

While the renewable energy sector does better on gender equality than its predecessor, the fossil fuel sector, much remains to be done. Programmes that target skill building across population segments will ease energy transitions that are just, so women, youth and older workers, minorities, low-income persons and those with disabilities are included. In some cases, renewables can lean on policies in conventional power generation. Targeted education and training will diversify the talent pool and improve representation. Scholarships and other funded training, as well as programmes for women, will be vital. Nearly 60% of the population in Africa is under the age of 25 (compared to 40% globally), so youth training programmes will be needed (UN, 2019).

A number of African countries have used targeted training to address gender imbalances in the energy workforce. The Ethiopian Electric Utility (EEU) set a goal for 2023 to expand the number of women in its workforce to 30%, up from 19.2% in 2019 (WRI, 2021). To this end, the EEU has partnered with the Ministry of Science and Higher Education and 12 universities to deliver STEM courses to women; it is offering scholarships to women on staff for graduate studies and technical training. Only 9% of managers are women, so EEU is developing leadership training to augment managerial positions with more women.

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Targeted internships to female STEM graduate students have also been used to provide practical experience, with the opportunity for a permanent job if requirements are met. These initiatives are funded with earmarked allocations to gender equity and citizen engagement within the budget of the Ethiopia Electrification Program (WRI, 2021; IRENA, 2021e).

In Gambia, Fandema, a women's development centre, is training women in the design, installation and maintenance of standalone power systems. Funded by the Global Environment Facility and implemented by the United Nations Industrial Development Organization, the project took a training-of-trainers approach, equipping graduates of the centre to become trainers in a later phase (UNIDO, 2017).

Funding for renewable energy training and education will be a priority. Most training markets are financed through student fees. Having in place a range of funding mechanisms will enable training facilities to deliver high-quality courses to a diverse population. These include payroll levies, tax incentives, scholarships, donations, vouchers and student loans (Dunbar, 2013). Dedicated "transition training funds" are already helping training markets impart skills for energy transition jobs, and there is scope to adapt this model to the African context. The use of these funds depends on national priorities but could cover disbursements to institutions training key demographics or funding to employers offering more on-the-job training.


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4.4.4. Policies for circular economy

Global demand places inordinate pressure on existing resources and how they are processed and used. With its vast resources, the African continent is no exception. A circular economy is in sync with traditional indigenous and ingenious African approaches, keeping scarce materials in circulation. The Suame-Kumasi vehicle cluster in Ghana and the Kihamba Forest garden in the United Republic of Tanzania are two circular economy examples collected in a mapping exercise (Footprints Africa, 2021). Since Africa is both the source for raw materials and a repository for discarded plastics, clothing and cars, a non-linear economy seems indicated.

Rapid urbanisation on the continent, however, requires countries to shrink their environmental footprints rather than stepping up consumption. Africa's megacities could foster circular economic activity, creating jobs in collecting, separating and recycling. With worker safety measures in place, such jobs could lead to formal employment in a developing circular economy (SAP, 2020).

The mapping exercise mentioned above analysed 23 case studies on the continent. Most of the enterprises regarded waste as a resource, then rethink the business model to close loops and chains.

Waste includes e-waste, biomass from food production, agricultural residues, plastics and construction waste. In Africa, organic material makes up to 60% of municipal waste flows. So the biowaste sector presents huge opportunities projected to double over time (EMF, 2021). Treated organic waste can be used energetically, in the form of biogas, and can also produce fertiliser and animal feed from cities to the rural areas and to agriculture. Chanzi, a start-up in the United Republic of Tanzania, has created modular insect farming boxes with local equipment and materials. The relatively easy insect farms generate biogas and rich bio-fertiliser (EMF, 2021). Units have been piloted in South Africa and Liberia.

The energy transition itself should apply the principles of the circular economy as it progresses. One neglected socio-cultural and political dimension to the rapid diffusion of solar power in Sub-Saharan Africa is the question of what happens when things fall apart (Cross and Murray, 2018). Off-grid solutions in particular need to address the environmental consequences and to show approaches based on traditions, cultures and economies of repair.

Globally, the turnover of off-grid devices approaches hundreds of million dollars, as tens of millions of small PV devices reach the end of their life each year. A large share of this takes place in Africa and hence on the continent new solutions to handle this amount of material and not to let it simply go to waste need to be developed soon. Suggestions range from supporting the recyclability and repairability of systems, to creating new business opportunities in collecting used systems and feeding them into upgrading and recycling mechanisms, to creating awareness of how solar panels become e-waste at the end of their life, as do phones and other electronics devices.

In Kenya, for instance, according to a survey of solar users, nearly one-fifth of solar products in Kenya stop working within 18 months of purchase. A survey of small-scale solar users showed that people keep solar devices even after they cease using them. But small-town repair clinics can fix these items for reuse, or repurpose them; company workshops can also replace, return and store these things. Some of these phases of the afterlife value chain need to be properly addressed and supported by future policies.

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4.5 CONCLUSIONS AND RECOMMENDATIONS

African leaders have committed to inclusive, sustainable economic growth and development in *Agenda 2063: The Africa We Want*. Regional and national commitments to renewable energy have been made, anchoring sustainable development and industrialisation for the continent. At the regional level, dedicated centres are mandated to support the transition in co-ordination with member countries, donor agencies and other international institutions. At the national level, **commitments to renewable energy and energy efficiency** are indicated in Nationally Determined Contributions, national energy plans and set targets. These have so far focused on the power sector and would need to increasingly cover end uses such as heating and cooling – including for buildings, industry and agriculture – and transport, that will be vital for economic development and industrialisation. Stronger commitment to Africa's just energy transition from the international community, including bilateral and multilateral development institutions, in the form of technology exchange, financing and policy support, would be needed and would form one of the main building blocks of an African Green Deal (Chapter 7).

Commitments are already materialising into action. At COP26, Egypt and South Africa committed to moving away from coal and the international community announced it will halt funding for coal power plants in Africa, paving the way for a clean and sustainable energy system where renewables are already cost-competitive. In Kenya and Ghana, local communities have led successful campaigns to cancel coal power plants. Measures to eliminate market distortions that favour fossil fuels have been introduced, including subsidy reforms in Egypt and Morocco and carbon pricing in South Africa. Such measures must be implemented carefully so as not to impede access to basic energy needs.

Energy efficiency and conservation go hand in hand with energy access, affordability and reliability goals. Support to date has come in the form of policy and regulatory measures (*e.g.* minimum efficiency performance standards in North African countries), subsidies for energy audits (as in Kenya), and voluntary initiatives that rely on end consumers with financial or moral motivations (as in South Africa). Continued awareness-raising regarding the potential for energy efficiency and renewable energy solutions and their benefits will play a major role in Africa's energy transition. Equally important are quality standards to ensure product reliability and high confidence among consumers.

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The continued uptake of renewable energy will require **deployment policies** such as fiscal measures and financial incentives (*e.g.*, subsidies and grants) that help make renewable energy technologies more affordable. These have been mostly adopted in East and West Africa. Structured procurement mechanisms such as FiTs and auctions have been instrumental in attracting private investments in renewable power in some countries, especially when implemented as part of a basket of instruments together with financing, risk mitigation and technical assistance. The Scaling Solar programme in Ethiopia, Senegal and Zambia, for example, was innovative in its ability to mitigate risks. Increasingly, auctions are designed to achieve objectives beyond price discovery. Morocco and South Africa were pioneers in auction design to achieve socio-economic development and VRE integration. But in some cases, structured procurement mechanisms were not as successful. In Angola, Malawi, Mozambique, Ghana and Zimbabwe, FiTs were often not supported by the necessary regulatory and policy reforms or backed by bankable contractual frameworks, and they have failed to attract much investment. Across the continent, about 40% of the volume auctioned was cancelled or delayed, mainly due to institutional barriers or high off-take risks.

Similar to global trends, policies in Africa have focused on the **power sector**, while renewable energy policies for heating and cooling and transport have lagged. Policies to support renewable energy for heating and cooling have so far focused on clean cooking and water heating. More will be needed for the continent to take full advantage of its vast renewables potential, to fuel productive uses in agriculture and industry. In transport, at least 7 countries have introduced some form of biofuel blending mandate, and a handful of countries have implemented policies or projects for electric mobility. In Ghana, EVs can help take up excess electricity generation which is paid for due to the "take or pay" clauses in IPP contracts.

For **hard-to-electrify sectors**, Egypt, Mauritania, Morocco, Namibia, Nigeria and South Africa have developed green hydrogen strategies with demonstrated potential for production at globally competitive costs. Because many African economies are not trapped into established industries built on fossil fuels, they can leapfrog into an economy based on sustainable energy. Green hydrogen could help make that a reality while absorbing excess renewable electricity and overcapacity. But green hydrogen production should adhere to the principle of additionality. If electricity from renewable sources has other uses (such as providing access to electricity), it should not be converted into green hydrogen.

Green hydrogen can also support system integration through, for example, seasonal storage. Storage-based technologies offer flexibility which is crucial to accommodate VRE. Currently, South Africa and Morocco are the only countries using pumped-storage hydropower, a mature technology that also holds promise for hydro-rich countries like Egypt and Ethiopia. Over the next decades, large-scale battery storage could play a big role, particularly by balancing the diurnal nature of solar PV. **Power pools** – of which Africa has five – are also crucial for system integration. They exploit synergies among multiple renewable energy sources and demand profiles across the continent. Pan-African power pools and cross-border interconnections will require a broad range of co-operation and investment to evolve successfully. To date, cross-border collaboration within African power pools has been hindered by a lack of aligned national policies and regulations, as well as inadequate funding and investment in infrastructure.

04

Major investments in new **infrastructure** and in upgrading existing networks will be needed, ideally guided by long-term national energy planning to ensure that they do not result in stranded assets or lock-ins to fossil fuels. Forward-looking plans are also needed to address the load imposed by the electrification of end uses through grid expansion and strengthening.

Integrating renewables into the energy system also requires a conducive **organisational structure of the power sector**, together with sector-coupling policies to support the electrification of end uses. These policies and arrangements include appropriate electricity tariff structures, such as time-of-use tariffs and other innovative solutions to support demand-side management.

The energy transition in Africa will change the way citizens consume, produce and travel, impacting local and regional economies. Policies that promote **structural change** are needed and they must consider how regions depend on resources, commodity trade and other economic characteristics. Such policies should emphasise local value and labour, regional trade opportunities, and shared research and development, to expand the economic value of the energy transition. Communities and businesses must be part of the process.

On the **labour** side, there are opportunities to build a skilled and diverse workforce and advance entrepreneurship. This will require vocational training, employment and wage improvements, recruitment of women into the energy sector, and better communications and transparency about opportunities. Policies must also address potential misalignments that may emerge as old fossil fuel industries and jobs fall by the wayside and new ones in renewables and related industries appear.

Far-sighted **industrial policies** will be necessary to achieve the full potential for socio-economic benefits. These include appropriately designed local content requirements (LCRs) and incentives, business incubation initiatives, supplier-development programmes, support measures for small and medium enterprises, and promotion of industrial clusters.

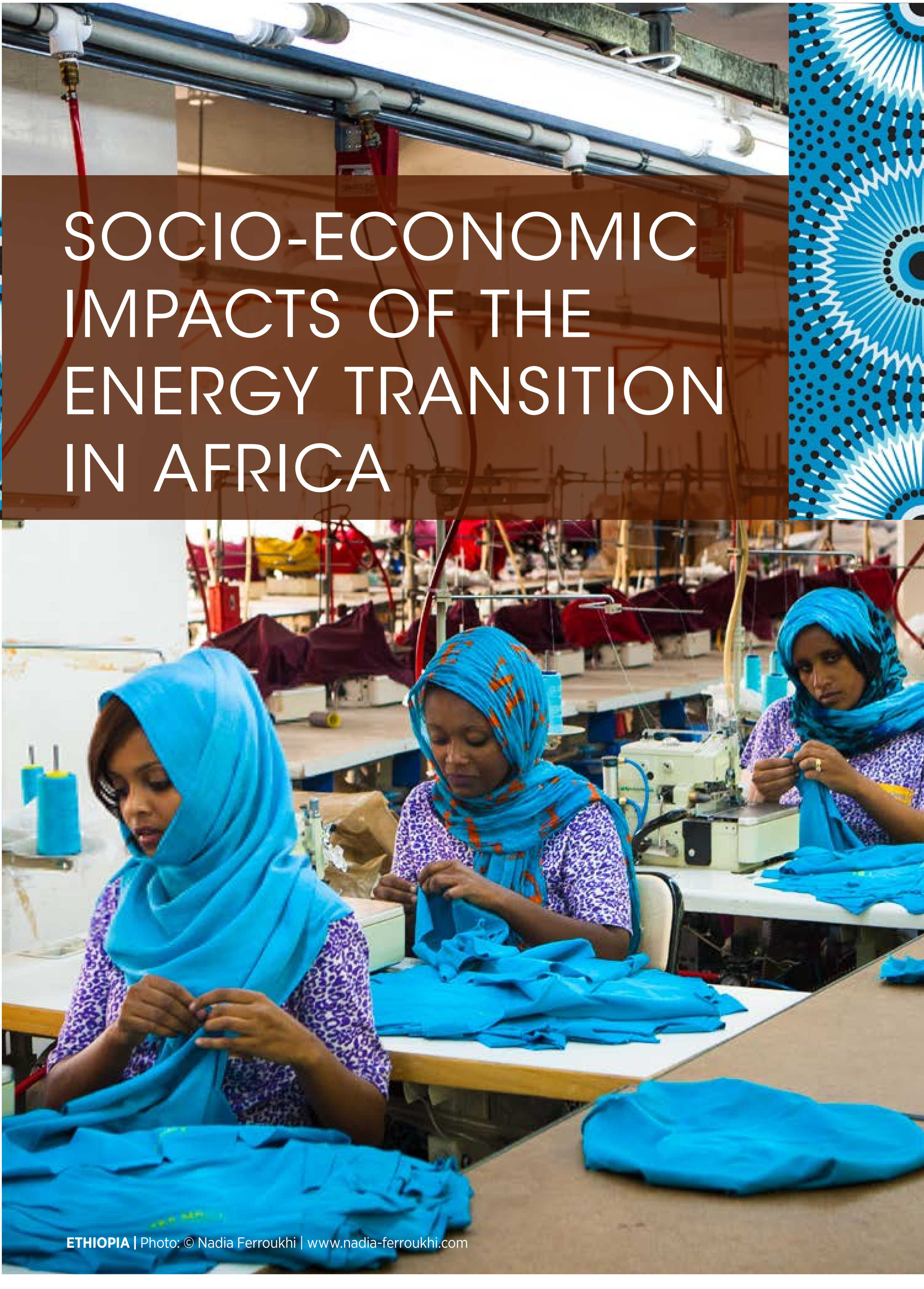
In the past, some LCRs have been judged to violate World Trade Organization rules but the paradigms seem to have shifted in context of the "just transition" debate and given the urgency of climate change. LCRs and incentives can leverage the energy transition for industrial development and job creation by ensuring demand for domestic products and services. In the face of the high barriers to entry presented by consolidated global supply chains, such measures help local firms

learn (and innovate) by doing. Egypt had adopted a 30% local content target for wind farms which went up to 70%, and a 50% goal for concentrated solar power plants. South Africa included requirements in its auctions to develop a local industry for solar PV, ratcheting them up over time. Local content requirements spur efforts to source inputs locally, helping to develop local industrial capacities and leverage existing resources including minerals.

Central and Southern Africa have abundant **mineral resources** essential to the production of electric batteries, wind turbines, and other low-carbon technologies. Yet minerals critical to the clean energy industry are bound to be affected by commodity price cycles. To avoid commodity dependencies, critical mineral producers need to leverage the energy transition to move into higher value-added segments of the renewable energy supply chains such as processing rather than merely exporting valuable raw materials.

Regional trade co-ordination among African countries could help fill the basket of policy solutions to create more localised industries. Market integration and cross-border collaboration are important given the limited markets that hinder productivity gains in most African countries. Larger market access, regional clustering and the consequent ability to localise more of Africa's industrial value chains could drive down costs and boost productivity. For local firms to gain productivity and avoid duplication of effort, regional synergies around the supply of renewables will be vital. Regional co-operation will also improve quality standards and technology impact. The African Continental Free Trade Area is one such device able to boost intra-regional trade and local production of renewables.

SOCIO-ECONOMIC IMPACTS OF THE ENERGY TRANSITION IN AFRICA



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- Impacts on **GDP under 1.5-S**
- Impacts on **jobs under 1.5-S**
- **Welfare** effects

The energy transition, with its systematic shift to renewable energy, holds vast potential to improve livelihoods across Africa in ways that transcend purely economic benefits. These improvements loom large for a continent that, despite its minimal emissions of greenhouse gases, is vulnerable to the depredations of climate change.[1] These effects may include disruptions to the continent's farming and agricultural systems, already strained by limited water availability, and to health systems (Niang *et al.*, 2014). Disruptions may also extend to modern energy in parts of Africa (Chapter 2), to livelihoods and to cultural identity. Climate change also threatens global commodity markets and supply chains as the energy transition, vital for most of the continent, ramps up.

This chapter provides an overview of IRENA's latest modelling results showing how the energy transition benefits Africa's economies and people – beyond emissions reductions – through 2050. Two scenarios are modelled: 1) an ambitious energy transition scenario (1.5-S) that aims to reach the global 1.5°C goal; and 2) a scenario based on current plans. The latter is dubbed the Planned Energy Scenario (PES).

Results are presented for Africa and its five regions (North, West, East, Central, and Southern Africa).

Section 5.1 of the chapter focuses on impacts of the transition on GDP and the economy. Job creation is the focus of Section 5.2. Wider welfare benefits are discussed in Section 5.3.

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1 *The share of Africa in global emissions was only 4% in 2020, and 3% in historical terms (Mashishi, 2021)*

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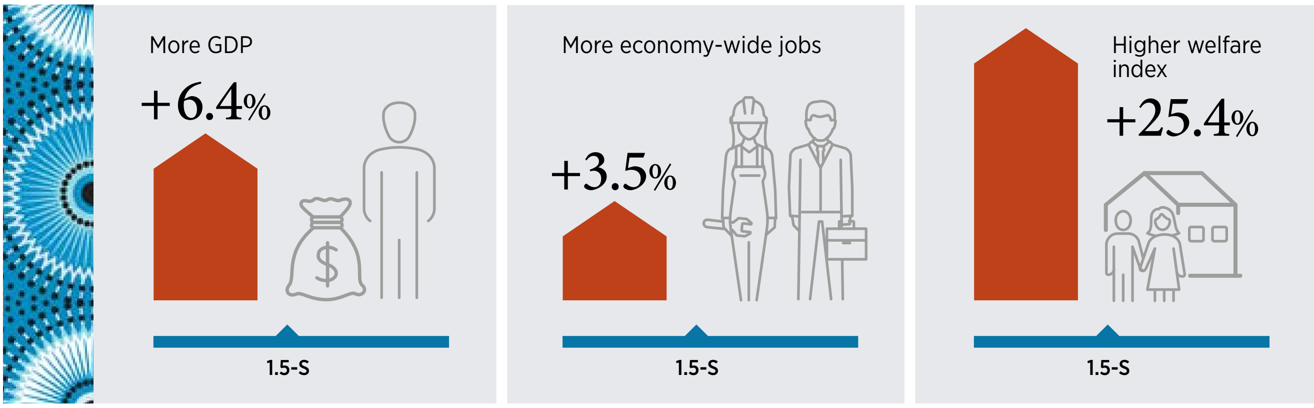
The modelling reveals that, despite the difficult shift away from carbon-intensive energy sources, the energy transition holds huge promise for Africa. On average over the period 1.5-S predicts 6.4% higher GDP across Africa than that realised under the status quo, and a net balance of 3.5% more jobs than those predicted under current policies. In addition to structural benefits, IRENA analysis shows Africa prospering from a diversified economy, industrial development and innovation, energy access, and profound benefits for the environment, all of which are critical to more equitable socio-economic development across the continent. The energy transition is bolstered by public and private investment and targeted climate policies in addition to International co-operation, South-South co-operation, industrial policy, and the exchange of technological know-how.

The modelling presented here builds on IRENA's previous work, which provides an increasingly granular picture of the manifold economic and social responses to the energy transition (IRENA, 2016b, 2017b, 2018c, 2019a, 2020h, 2021e). IRENA's latest global scenario, published as the World Energy Transitions Outlook (IRENA 2021e), has been downscaled to inform the 1.5°C scenario used in this chapter. For an overview of the IRENA's modelling framework for WETO, see Box 5.1.

Average differences between 1.5-S and PES in the 2021-2050 period:



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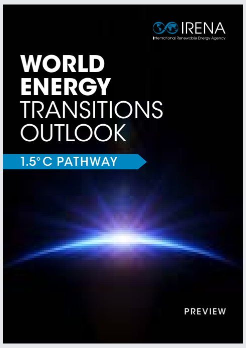
Box 5.1 IRENA's World Energy Transitions Outlook (WETO)

IRENA's *World Energy Transitions Outlook (WETO)* is a 1.5°C-compatible, global pathway guided by the UN's Agenda for Sustainable Development and the Paris Agreement on Climate Change. It also examines full socio-economic and policy implications and provides insights on structural changes and finance.

The scenario called 1.5-S makes several assumptions. First, it assumes systematic support of emerging technologies likeliest to be competitive in the short term and best at lowering emissions over the long term. Other assumptions: limited investment in oil and gas; phase-outs of coal and fossil fuel subsidies; adapted market structures and policies promoting resilience, inclusion, and equity; and measures protecting transition-affected workers and communities.

Among other things, this implies that under the global 1.5°C trajectory by 2050, electricity will be the main energy carrier, with hydrogen and derivatives accounting for 12% of final energy, and bioenergy for 18%. This will require an additional investment of USD 1.1 trillion in renewables, efficiency, and electrification per year to move from PES to 1.5-S. Total cumulative investments from today until 2050 will then amount to USD 131 trillion.

IRENA's PES and 1.5°C Scenarios



The **Planned Energy Scenario (PES)** is the primary reference case for this study, providing a perspective on energy system developments based on governments' current energy plans and other planned targets and policies (as of 2019), including Nationally Determined Contributions (NDCs) under the Paris Agreement.

PES

The **1.5°C Scenario (1.5-S)** describes an energy transition pathway aligned with the 1.5°C climate ambition – that is, to limit global average temperature increase by the end of the present century to 1.5°C, relative to pre-industrial levels. It prioritises readily available technology solutions including all sources of renewable energy, electrification measures and energy efficiency, which can be scaled up at the necessary pace for the 1.5°C goal. The 1.5-S is not limited exclusively to these technologies. It also accounts for innovation and emerging solutions, especially in the coming decades.

1.5-S

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Box 5.1 IRENA's World Energy Transitions Outlook (WETO) (continued)

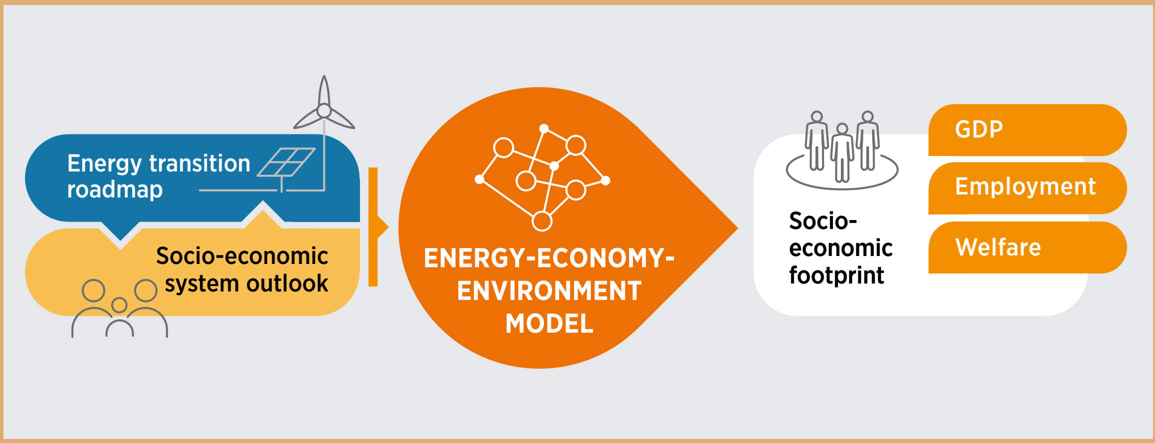
IRENA measures the impacts of transition scenarios and their accompanying policy baskets through the evaluation of their socio-economic footprint, which includes GDP, employment and welfare (Figure 5.1).

The climate policy basket accompanying the energy transition roadmap has a strong impact on the resulting socio-economic footprint, highlighting the relevance of appropriate policy making for a successful transition.

The WETO analysis (IRENA 2021e), like IRENA's former socio-economic footprint analyses, has shown that even when a given policy basket produces positive overall results, significant differences in socio-economic performance may show up across countries, particularly between developed and developing countries. The difference is shaped, among other factors, by the degree of fossil fuel dependence of their economies.

Two of the main elements of climate policy baskets are carbon pricing and international co-operation. To improve the socio-economic footprint of those countries shown in previous analyses to derive less benefit from the energy transition, the policy basket applied in the present analysis modifies that used for WETO in two key and complementary aspects: by reducing carbon prices to mitigate their regressive impact and increasing international co-operation to enlarge the fiscal space available to developing and fossil fuel-dependent countries, thus allowing them to better address their energy and socio-economic challenges.

Figure 5.1 Measuring the socio-economic footprint of the energy transition



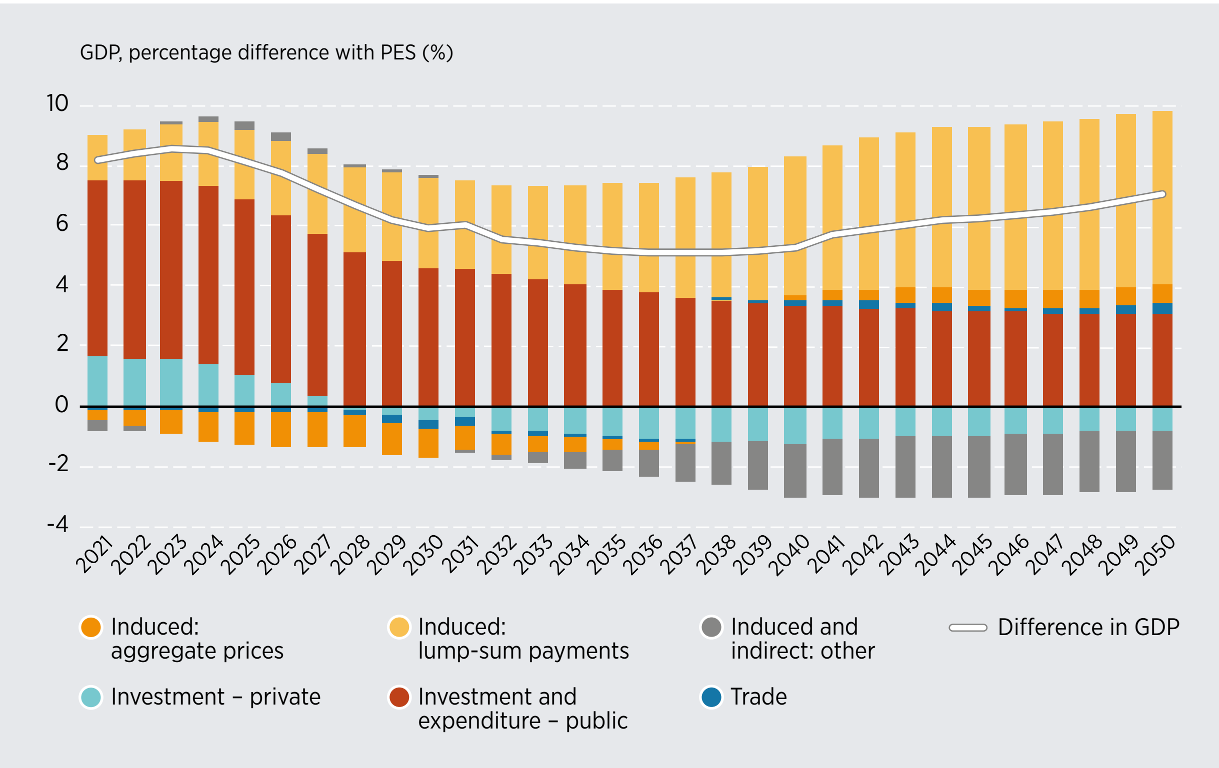
Source: IRENA.

5.1 IMPACTS ON GDP UNDER 1.5-S

This section presents energy transition impacts on aggregate economic activity (as measured by GDP) in Africa and its regions. These results are reviewed at the end of the section in light of the climate change damages wrought on the economy under both PES and 1.5-S.

The energy transition under IRENA's 1.5-S pathway boosts Africa's GDP throughout the entire outlook period up to 2050, compared with PES. On average, GDP is 7.5% higher in the first decade, and 6.4% higher over the nearly three decades until 2050. Figure 5.2 shows relative differences between the scenarios, in percentages. The relative difference for total GDP, for instance, in the year 2030 means that the energy transition under 1.5-S yields a GDP 5.9% higher in that year than under PES.

Figure 5.2 Comparison of 1.5-S and PES and their drivers: Effects on African GDP, 2021-2050



Source: IRENA.

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Benefits to GDP in Africa stem from factors that favour a fair and equitable energy transition, as described below and illustrated in Figure 5.2.

- **Public investment and expenditure**, comprising additional public investment in renewable energy, energy efficiency, power grids and flexibility, green hydrogen, electrification and other transition-related investments, subsidies and finance, as well as additional social spending and investment.
- **Private investment**, including additional investment in the energy transition across all technologies and less investment in fossil fuel–related industries (such as exploration and production, refining, logistics and crowding out effects in the private sector).
- **Differences in net trade**, primarily through reductions in hydrocarbon imports and exports.
- **Climate change mitigation policies**, including fiscal tools, such as carbon prices, energy taxes or reduced fossil fuel subsidies; and regulatory tools, such as efficiency standards.
- **Induced lump-sum payments**, that is government recycling of fiscal surpluses in the form of lump-sum payments for lower income groups to support living standards.
- **Aggregated prices**, reflect the effects of the energy transition on the price level. Prices can be higher or lower than under a less-ambitious scenario because of the aggregate effect of factors such as carbon prices, the evolution of wages, and the transition to less expensive fuels.

Public investment and expenditure appear to exert a major influence on the economic outcome of the energy transition, contributing more than half of the overall positive effects in the first decade and more than one-third in later decades. A pivotal role in enabling public investment and expenditure in Africa is international co-operation and climate finance, which enable countries to boost spending on clean energy technologies, and on areas critical to the transition, including health, education, social security and support for a just transition. Figure 5.2 also shows that with the right environment in place, the **private sector** in Africa can shift its activities and investments towards the energy transition, with net gains across the continent during the first decade. Additional policies would be needed to expand its contribution from 2030 onwards.

The effects from **changes to net trade** at the continental level are small. The losses in fossil fuel trade for energy exporting countries are balanced by gains for importing economies. For energy importers, reducing imports frees resources for other purposes and reduces the burden that dependence on imports imposes, including the exposure to volatile prices on global markets. Figure 5.2 shows that these positive effects prevail in the final two decades of the period.

Some **fiscal and regulatory policies** supporting the energy transition can have regressive effects in income terms because higher costs affect those with small disposable income ranges proportionally more than those with higher incomes. To alleviate and even reverse these effects and hence lower barriers and social costs, the 1.5-S climate policy basket includes transition-related subsidies and progressive revenue recycling in the form of **lump-sum payments**. By reducing inequality and raising consumption among lower income groups, these payments provide high social value. The lump-sum payments are the second-largest driver for GDP – after public investment and expenditure – growing more relevant over time to become the dominant driver in the final decade of the analysis. Ripple effects include more demand for a wider range of products, which boosts economic activity and living standards.

Aggregate prices have a slight negative impact on overall African GDP up to 2035, reflecting among other things the move from subsidised fossil fuels to renewables and the consequences of carbon pricing. However, the reduced carbon pricing applied in the 1.5-S policy basket alleviates this effect on GDP. In several African countries, oil and gas royalties play an important role in governments' budgets. As global demand for fossil resources gradually declines, other sources of revenue, such as income taxes need to be levied or increased. The negative effects on consumption are reflected in the induced-effect categories, together with other indirect and induced effects that grow more relevant over time.

Box 5.2 International co-operation

IRENA has analysed the welfare impact of the energy transition for many years (IRENA, 2016b, 2017b, 2018c, 2019a, 2020h, 2021e). It has found that mitigation policies targeting only the energy sector bring only slight social and equity improvements (IRENA, 2021e). Gaining traction in recent years is the idea of a socio-economic transition to accompany the energy shift.

International co-operation enables developing countries, including those in Africa, to implement policy frameworks that tie the energy transition to more equitable access to resources and economic opportunities.

At the 2009 meeting of COP15, developed countries pledged USD 100 billion/year in climate finance by 2020; COP21 extended the time frame through the 2020-2025 period. Current climate-finance estimates range from USD 80 billion per year to USD 20 billion (OECD 2021b; Oxfam, 2020). Aid volumes aside, the implementation of the USD 100 billion/year pledge poses substantial challenges – including transparency and accountability, the shares to be devoted to mitigation and adaptation, and the amount to be allocated to the most vulnerable developing countries. But the needs of developing countries to successfully address the climate challenge are very great indeed. A recent report from the UNCC Standing Committee on Finance states that developing countries will need more than USD 650 billion/year through 2030 just to cover 40% of their Nationally Determined Contributions (SCF, 2021). For Africa alone, the African Group of Negotiators on Climate Change has tabled a figure of USD 1.3 trillion/year from 2025 (Ainger, 2021).

Moreover, climate finance is just one of the components needed for a socio-economic transition. Existing economic and social systemic challenges, such as structural dependencies, inequality and institutional constraints, are fundamental barriers to trigger the collaborative framework needed to address the climate challenge. Unmitigated climate change will exacerbate these problems, highlighting the need to support developing countries in and outside Africa with sufficient means. ▶


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Box 5.2 International co-operation (continued)

▶ For the WETO analysis (IRENA, 2021e) the climate policy basket for 1.5-S included relatively high carbon pricing (aligned with the 1.5°C climate goal), and an international co-operation flow of some USD 290 billion/year (about three times current pledges) through 2050. Because of concerns about general price effects and their regressive effects in some developing countries, the 1.5-S climate policy basket in the current analysis implements lower carbon pricing (half the WETO value), differentiated by per capita country income. To preserve governments' fiscal space and encourage needed policies, the climate policy basket for 1.5-S now assumes international co-operation flows equal to 0.7% share of global GDP through 2050.[a]

The international flows are relevant to an enabling and social pillar reflecting countries' position on the Human Development Index, a justice pillar ensuring the energy transition is just and inclusive for fossil fuel–dependent economies, and an equity pillar to ensure that the energy transition contributes to a fairer world. Government revenues are earmarked for transition-related investment and additional social spending.

IRENA analysis shows that 1.5-S, with its respective policy basket, yields positive results for the African continent and all its regions. Compared with PES, 1.5-S leads to more economic activity and additional employment. Welfare also improves overall along the various dimensions.

Compared with the policy basket used in WETO (higher carbon taxes and lower international co-operation transfers), the policy package used for 1.5-S in this analysis significantly improves the outcome in terms of additional GDP, employment and welfare for many countries, especially developing countries and emerging economies with high fossil fuel dependence. Small, industrialised economies with high fossil fuel use may experience slightly poorer economic performance than under policy baskets with higher carbon pricing (such as that used in WETO) because of lower recycling of government revenues. Large industrialised economies with well-developed carbon tax frameworks, well-integrated renewable energy value chains and large domestic investment and value creation do not see their aggregated economic performance significantly affected by the upgraded policy basket. When the effects of climate damages on economic activity are factored in, industrialised countries are much better off by contributing to the international co-operation fund and thereby facilitating a more ambitious transition.

a. This is in line with the 2021 report of the UN's Inter-agency Task Force on Financing for Sustainable Development, which calls for the international community to respond to the Covid pandemic by "scaling up and meeting their commitments of 0.7 percent of official development assistance (ODA) as a share of gross national income. Grant finance rather than loans should be prioritised for vulnerable countries, such as least developed countries and small island developing states, while the decline in ODA to health should be reversed"(United Nations, 2021d).

5.1.1 GDP impacts by sector

The energy transition can contribute to diversifying economies, by boosting demand for new product ranges and services, and promoting innovation in new technologies and knowledge-based products. African economies can leverage on domestic strengths, increasingly addressing the value chain of manufacturing in domestic industrialisation. Using the energy transition as a boost to more diversified economies across Africa will require a variety of skills, developed through more and better education and training opportunities.

Figure 5.3 shows the difference between the scenarios in economic activity by sector for selected years in Africa. Manufacturing and engineering-related economic activities gain from the energy transition, and this effect increases over time. Additional output needs additional intermediate inputs for production and hence services, retail, and transport also gain. By contrast, fossil fuel industries (coal, oil and natural gas) stand to lose under the energy transition, as do respective utilities. Since 1.5-S is based on a high level of electrification throughout the economy, electricity suppliers also gain. It should be noted, though, that reaching 100% energy access often involves off-grid solutions, which do not fall under this category. The difference in output in the electricity sector between 1.5-S and PES is therefore slightly underestimated in Figure 5.3.

The global energy transition will be metal and mineral intensive, as clean energy technologies (for example, battery storage and EV manufacturing) require these materials. The World Bank estimates that the transition could boost global production of cobalt, lithium, or graphite by nearly 500% by 2050 (World Bank, 2020d). The African countries already producing and exporting these minerals and metals could benefit from increased demand. DRC, Zambia and Madagascar, for example, are important cobalt producers, while Zimbabwe and Namibia have significant lithium reserves. IRENA's analysis shows that the front-loaded global investment stimulus associated with the energy transition can increase yearly output from African mining and extraction activities (excluding those related to fossil fuels) by an average of 10% in the decade until 2030. If combined with policies to deepen, strengthen and lengthen domestic and regional supply chains, these industries could contribute toward longer term added value and economic diversification (IISD, 2018, see also Chapter 4).

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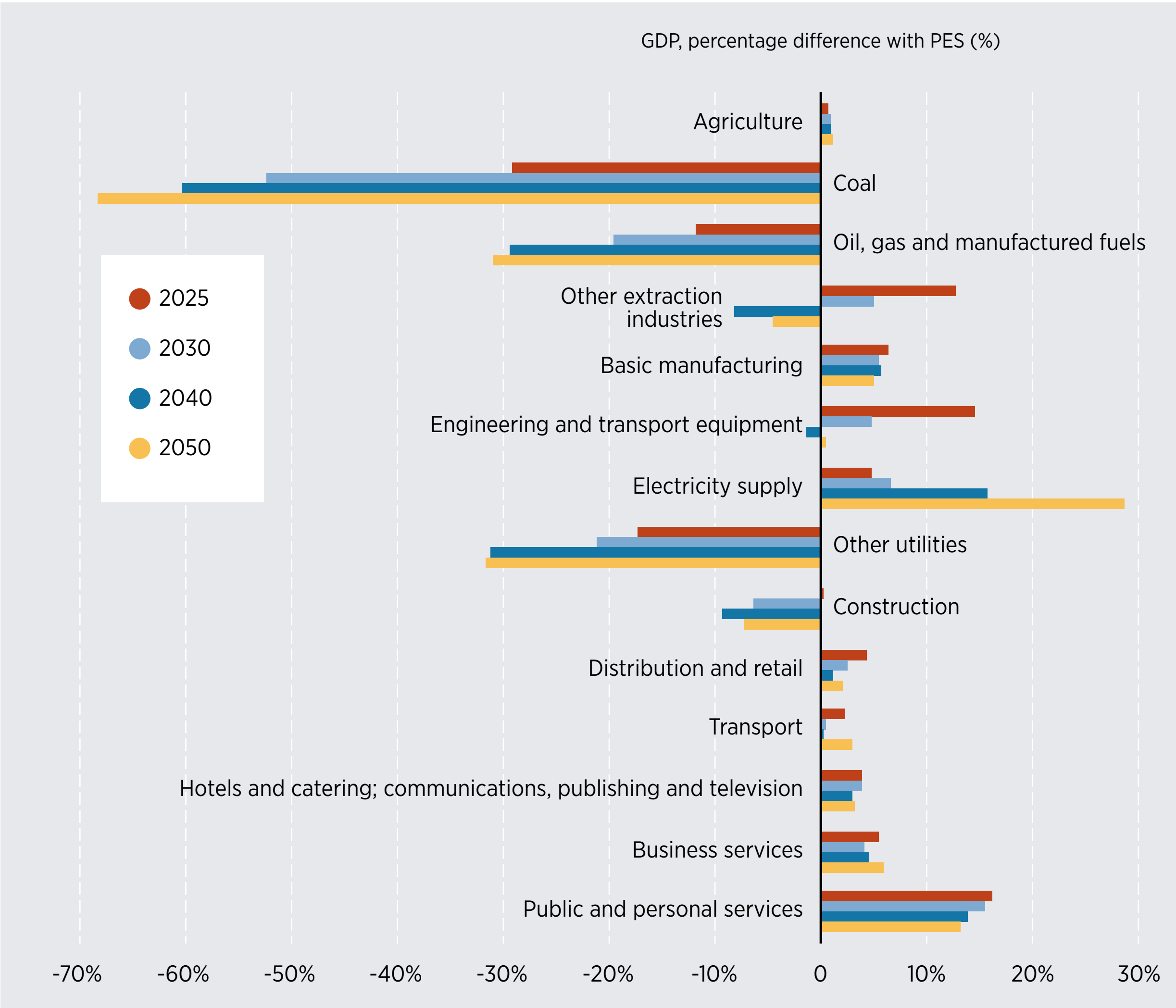
5.1.2 GDP impacts at the regional level

The effect of the energy transition on economic activity naturally differs across Africa, based on existing economic structure, and the availability of economic, financial, and institutional factors and the presence and potential for the development of transition-related skills. IRENA disaggregates its findings by region across the African continent.

Figure 5.4 presents average GDP differences between 1.5-S and PES for Africa and its regions. It should be noted that at the regional level, too, differences between countries, such as fossil fuel producers versus fuel importers and small economies versus large economies, are masked by the average, meaning that within one region there may be countries with substantially different results. A key takeaway from the data is, however, that all African regions benefit from the transition in GDP terms, ranging from a high of additional 15.4% in Central Africa to a low of additional 1.6% in West Africa (Figure 5.4), in terms of the average difference from PES. Figure 5.5 presents the role that GDP drivers play in each African region over time.

Figure 5.3 Effects on output by sector in Africa, percentage difference between 1.5-S and PES, selected years



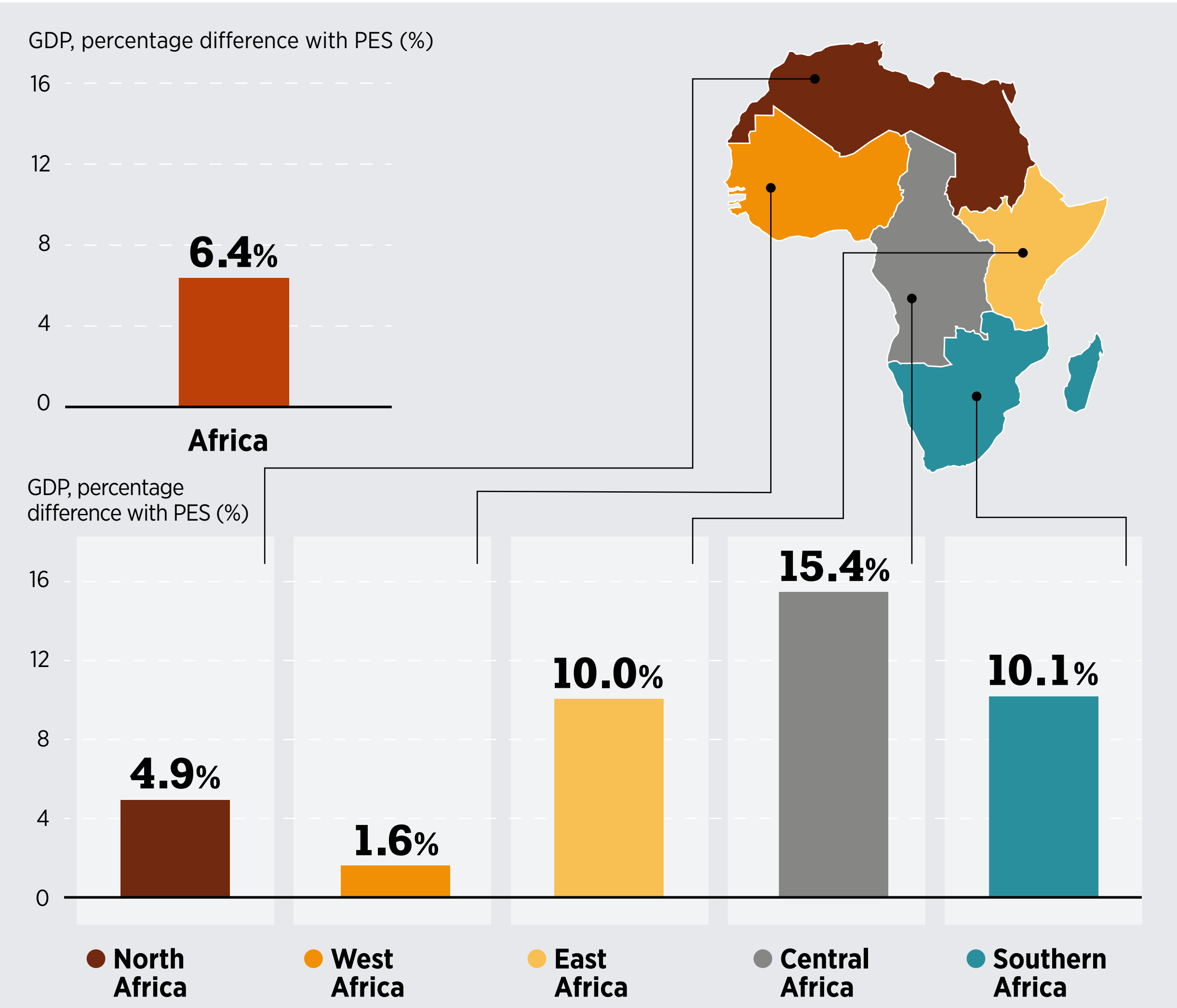
Source: IRENA.

North Africa

Under 1.5-S, GDP in North Africa would be 4.9% higher, on average, than under the less-ambitious PES. Despite its heavy dependence on fossil fuels, a 1.5-S pathway accompanied by appropriate policies would produce net benefits for regional GDP. But country effects differ notably. Egypt, the largest economy in the region, is one of the countries that benefit from the energy transition's effect on **net trade** because it has become a net natural gas and oil importer.

By contrast, in Algeria and Libya, which are net oil and gas exporters, the changes in **net trade** will cause GDP to drop. The trade effects will spread through the economy as indirect and induced effects, and taxes will rise to compensate for losses in oil and gas royalties. Even here, however, climate policies that support a just transition through measures such as public investment and spending to diversity the economy, improve education and training, provide social security, and fund lump-sum payments to people in the lower income quintiles, can neutralise the negative GDP impacts.

Figure 5.4 GDP percentage difference between 1.5-S and PES for Africa and its regions (2021-2050 average)



Source: IRENA.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

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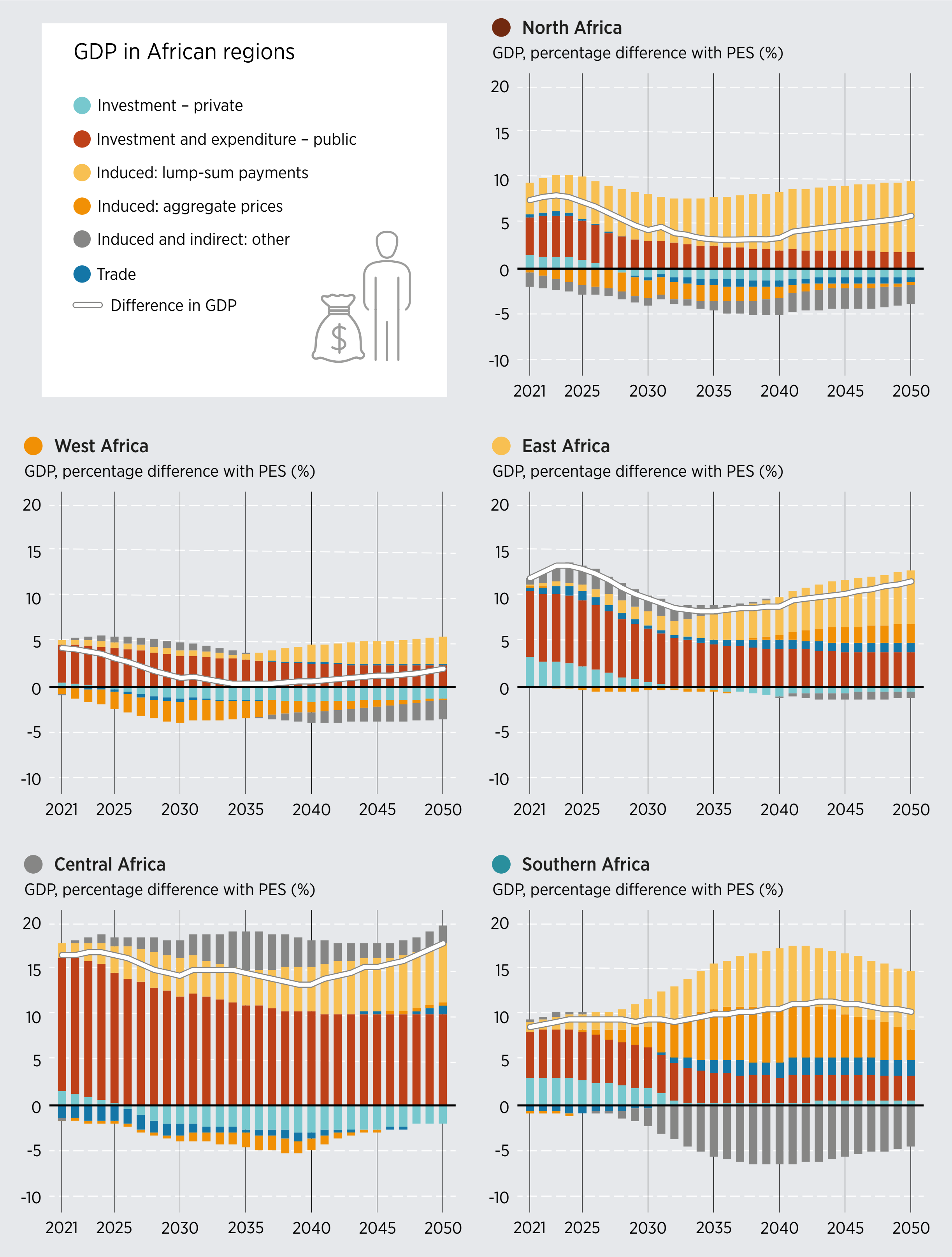
Figure 5.5 GDP in African regions, percentage difference between 1.5-S and PES by driver, 2021-2050



Source: IRENA.

Public investment and expenditure, and induced effects from **lump-sum payments**, drive the positive GDP difference over PES in North Africa (see Figure 5.5). After 2025 these payments become the dominant driver sustaining the favourable trend. While public investment in North Africa targets renewable energy deployment and efficiency gains in the first decade, lump-sum transfers contribute more and more over time to aggregate economic activity and reduced inequality, as governments' capacity to invest and spend increases from revenues derived from carbon prices and international co-operation. Compared with PES, the adverse effects of higher prices diminish after 2030 as carbon pricing impacts on households reduce because of the gradual substitution of fossil fuels.

East Africa

East Africa is a highly diverse region, benefiting largely from the energy transition under 1.5-S. The region is home to Somalia and South Sudan; both among the least-developed countries, and to Djibouti and the United Republic of Tanzania, whose development over the past few decades has been significant (see also Chapter 1). East Africa produces fossil fuels, but many countries in the region are net importers of oil, oil products, and in some cases coal. On average, East Africa sees 10.0% higher GDP levels under 1.5-S, a substantial boost for national economies.

The largest contribution to this additional GDP comes as a result of **public investment and expenditure** in the first two decades of the transition (2021-2041). Consumption, with induced effects from **lump-sum payments**, gradually becomes more important in the last two decades (see Figure 5.5). The benefits from **net trade**, mainly due to falling fossil fuel imports, would persist until 2050. Over time, costs of living will fall to levels below those under PES, mainly due to the shift towards lower-cost renewable energy. **Private investment** also contributes to the transition, but its net effect on GDP is lessened by a reduction in fossil fuel–related investment (such as the exploration of newly discovered reserves and the construction of new pipelines) compared with PES.

Kenya, one of East Africa's largest economies, shows a GDP 7.6% higher under 1.5-S than under PES, on average. The impact of drivers is similar to the overall in East Africa, although with a less predominant role of the public investment and expenditure driver.

West Africa

With the WETO policy basket, West Africa would see a net decline in GDP of -1.05% under 1.5-S compared with PES. The policy basket refined for use in this report averts this decline, and boosts GDP by 1.6%. The role of policies to accompany the transition roadmap is fundamental in West Africa. Heavy fossil fuel dependence in some of the region's main economies will make the energy transition a challenge, reflected in the comparably small but positive net effect on regional GDP. A case in point is Nigeria, where the policy basket reduces but cannot completely reverse its lower GDP compared with PES.

The main negative drivers of the GDP difference are private investment and aggregate price effects (Figure 5.5). **Heavy private investment** in fossil fuel under PES does not occur under 1.5-S. As in other parts of Africa, industrial diversification policies are needed to facilitate structural changes in the economy and prevent stranded assets. The negative contribution from **aggregate price effects** stems in part from carbon pricing and, although still relevant (Figure 5.5), has been attenuated by the lower carbon prices applied from the policy basket.

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These negative effects are surmounted by a proactive climate policy, in particular **public investment** and **lump-sum payments** (Figure 5.5). Lump-sum payments to lower income groups, besides directly addressing the welfare distributional dimension, protect incomes and hence spending, including on products and services from other sectors that are critical to driving tax revenue and economic activity throughout the outlook period.

Central Africa

Central Africa is one of the regions that stands to gain the most from the energy transition. On average, GDP under 1.5-S exceeds that under PES by 15.4 %, implying the energy transition holds major opportunities for structural economic development in Central Africa. Over the coming decades the region's highly vulnerable countries such as – Chad and the Central African Republic, which witness political instability, – would be further disrupted by climate change in the absence of an effective and ambitious transition (WMO, 2021; see Box 5.3).

Under 1.5-S, Central Africa will see enormous benefits from international co-operation – benefits that redound as well to fossil fuel–exporting economies such as Chad, Equatorial Guinea and Angola – to foster much-needed structural change and economic diversification. **Public investment and expenditure** – and increasingly over time, induced effects due to lump-sum payments to lower income residents share of the population and other induced effects associated with greater economic activity – help drive these hugely beneficial structural changes. **Net trade** exerts a slight downward pressure on additional GDP, because of losses from exports of fossil fuels, as does less private investment in this sector. But on the approach to 2050, net trade effects turn positive, owing to increasingly large savings in net importing countries balancing the losses of the net exporters.

In the Democratic Republic of the Congo the drivers play a similar role as in the whole of Central Africa, but with a smaller relative impact of the public investment and expenditure and lump-sum payments drivers, with 1.5-S's average GDP improvement over PES reaching 8.1%.

Southern Africa

Southern Africa benefits greatly from the energy transition, with regional GDP under 1.5-S 10% higher than GDP under PES, on average. **Private investment** in the energy transition and **public investment and spending** drive the difference, before additional effects induced by lump-sum payments from revenue recycling come to play a larger role the last decade of the period. Reduced inflationary pressure owing in part to reduced oil imports also has positive effects during the last two decades.

South Africa, the largest economy in Southern Africa, gains an additional 7.8% GDP than it would have under PES, on average. The country's economic structure and the level of development provide an excellent starting point. But spatial misalignments in addition to the need for education, skilling, and training will need to be addressed (see Chapter 4).

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5.1.3 The effects of climate damages

Climate change can have significant, detrimental effects in Africa. Land temperatures are expected to rise faster than the global average, with temperature increases between 3°C and 6°C by the end of the century; in fact, warming is already occurring (Niang *et al.*, 2014). Damages brought by climate change, and its effect on GDP, is not included in the GDP results shown above. But it is affecting economic activity even now and could continue to do so, depending on the region and the emissions pathway.

IRENA started exploring the implications of climate damages on overall economic activity in *Global Energy Transformation* (IRENA, 2019a). Subsequently, the agency published global results incorporating updates to the methodology, including additional data on the impact of temperature changes on economic performance (IRENA, 2021e).[2] The estimate is considered conservative because some effects are not yet prominent or measurable in historic data, such as the intensification of extreme events (wildfires, flooding, and tropical storms), sea level rise, tipping points, trade disruptions and knock-on political and social effects (for example, mass migration) (IRENA, 2019a).

Climate change will damage aggregate economic activity in both the 1.5°C Scenario and PES, but to a lesser degree according to their respective cumulative CO_2 emissions during this century. Climate damages will vary across regions. Figure 5.6 presents how the difference in GDP develops over time for PES, globally, in Africa and for the individual regions. Climate damages in Africa and its regions are expected to be greater than the global average. Extensive climate damages can be expected under PES. By 2100 it could reduce GDP by 55%-65% (compared to GDP estimates that do not account for climate damages), implying that unmitigated climate change will have a highly damaging impact on the African continent.

2 The methodology is based on a statistical analysis to derive a non-linear damage function that maps temperature changes to economic losses, providing geographical details of climate damage (Burke, Davis and Diffenbaugh, 2018; Burke, Burke, Hsiang and Miguel, 2015). The work was informed by an extended dataset at a subnational level involving over 11,000 districts (Burke and Tanutama, 2019).

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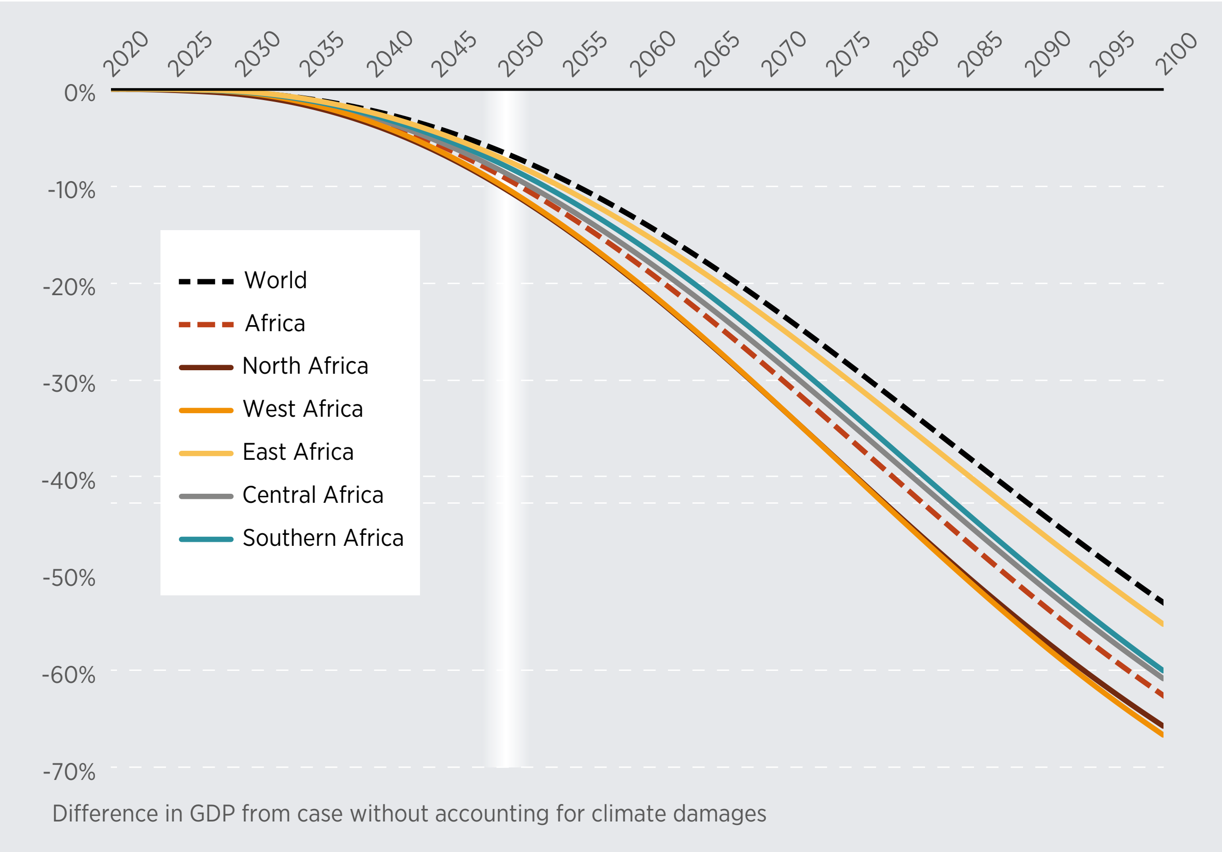
Figure 5.6 Climate damages on GDP under PES: World, Africa, and African regions, 2020-2100

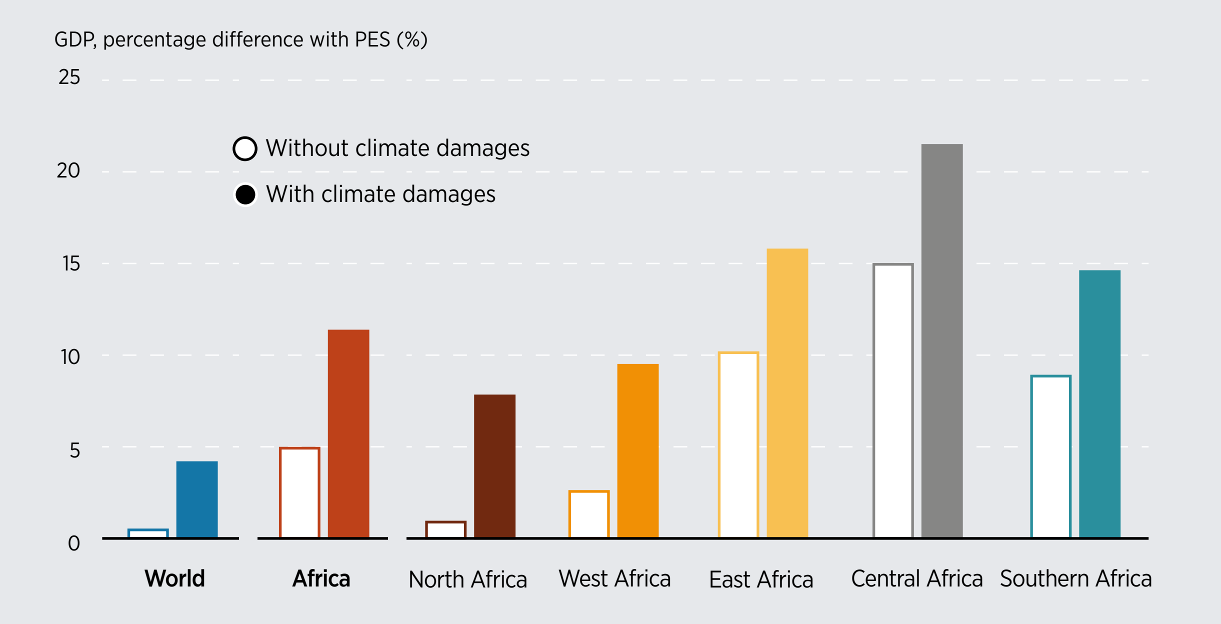


Source: IRENA.

Although both scenarios entail negative impacts, the much lower cumulative emissions under 1.5-S imply fewer climate-related damages and support the case for a swift clean-energy transition.

Figure 5.7 compares the GDP differences between 1.5-S and PES by 2050, both accounting for and disregarding climate damages. Under the first case, GDP benefits magnify the importance of transitioning in all regions. For Africa, the benefit measured by additional GDP more than doubles from 5.0% to 11.5% when accounting for climate damages. North Africa and West Africa both experience an even higher relative difference of GDP with climate damages factored in. This underlines the strong case for economic benefit arising from the energy transition, highlighting the opportunities involved and the risks associated with continuing with business as usual.

Figure 5.7 GDP percentage difference between 1.5-S and PES in 2050, with and without climate damages



Source: IRENA.

Box 5.3 The need for adaptation on the African continent – one more role for renewable energy

Africa is at a tipping point, a reality that is placing recent and hard-won progress at risk (UNDP, 2018). Changes in rainfall patterns and droughts threaten rain-fed agricultural production and promise to dry up reservoirs, thereby cutting electricity generation from existing hydropower. The prospect has induced some countries to envision an *increase* in the share of fossil fuels in their energy mix. Vulnerable populations with little resilience will be particularly affected by flooding and extreme weather. The need for policy to enhance resilience, prepare people and economies for the onslaught of climate change, and address gaps in financing, institutional and knowledge has become impossible to ignore.

National adaptation plans – a process first established in 2010 under the Cancun framework – could be used to identify needs and strategies in Africa. A majority of African countries embarked on a national adaptation plan in March 2021, but only six have finalised theirs (UNFCC, 2021).

Renewable energy has a largely unacknowledged role to play in adaptation. Most energy transition solutions involve high shares of renewables (IRENA, 2021e), yet their role in adaptation measures is still meagre. In the process of setting Nationally Determined Contributions under the 2015 Paris Agreement on Climate Change, few countries have made renewable energy part of their contributions.

The opportunities for renewable energy in adaptation are nevertheless significant (IRENA, 2021). Risk mitigation through renewable energy in adaptation will need to assess the impact on vulnerability and exposure to identify the many opportunities for renewable (IRENA, forthcoming-c).

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5.2 IMPACTS ON JOBS UNDER 1.5-S

With around 420 million people ages 15 to 35, Africa is a demographically young continent. Its population is expected to double by 2050 (AfDB, 2016; ILO, 2020; see also Chapter 1). The African Development Bank (AfDB) estimates that each year more than 10 million youth enter the workforce, yet only 3 million new jobs are created. This disparity leaves vast numbers of youth unemployed or in unstable and informal employment. The energy transition can become one of the drivers of jobs for Africa's young population over the coming decades, across different sectors and value chains, supporting goals to promote more diversified economies that are based on skills, knowledge and fair wages. IRENA's analysis shows that renewables and other energy transition–related technologies have already created 1.9 million jobs across Africa, a number that will grow substantially as countries invest further in the energy transition.

This next subsection provides insights on economy-wide employment, then it focuses on energy sector jobs. Finally, it looks at renewable energy employment, considering the skills required to enable such a transition.

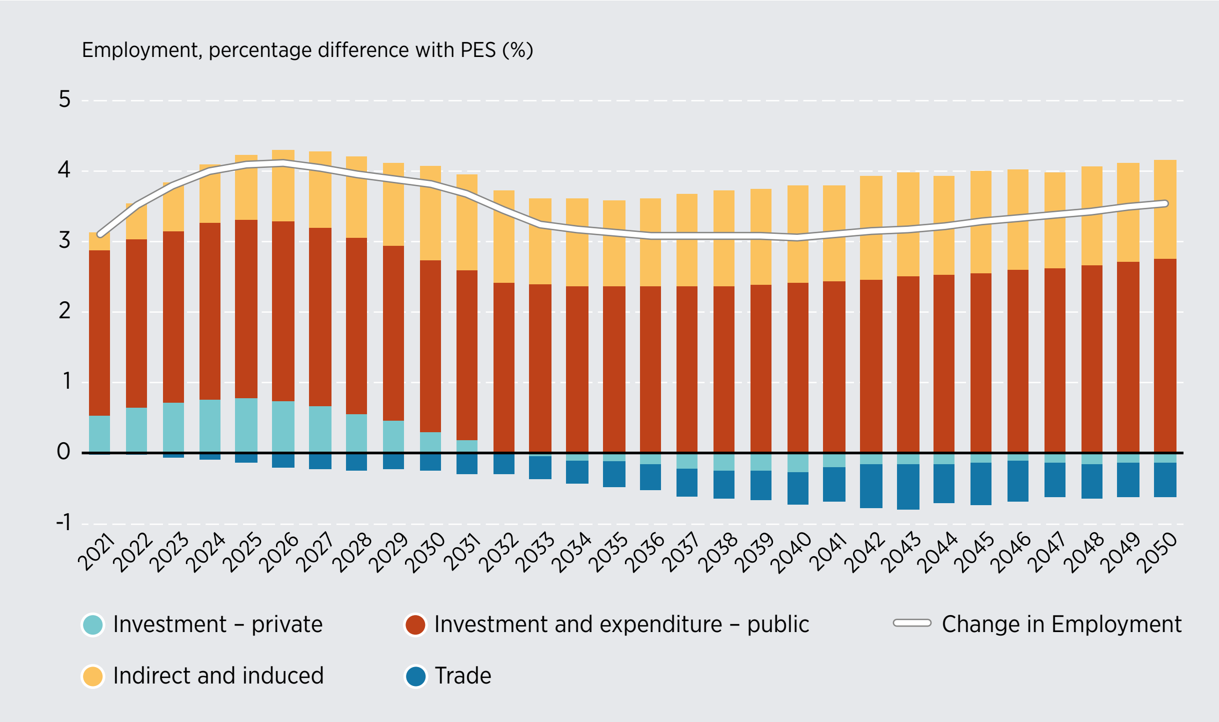
5.2.1 Economy-wide jobs

The energy transition's positive impact on GDP is reflected in Africa's job markets as well. Economy-wide employment on the continent is 3.8% higher in 2030, and 3.6% higher in 2050, than under PES (Figure 5.8), suggesting substantial ripple effects of transition-related economic changes across sectors and beyond energy. However, and especially in Africa, the policy basket accompanying the energy transition roadmap has a strong influence on what employment benefits are achievable. Policies aimed at the socio-economic system play a strong role in addressing the employment gap. For instance, the policy basket used for the WETO report (IRENA, 2021e) would make a difference in economy-wide employment (compared with PES) of around 7 million jobs by 2050, while the 1.5-S policy basket in this analysis produces a difference of 26 million.

In the first few years up to 2030, the main driver of additional jobs is additional **government spending** on public services (*e.g.* health, education) that is partly funded by international co-operation. The second driver for additional employment during these few years is front-loaded **investment, both public and private**, in upfront capital-intensive transition technologies, notably energy efficiency, and renewables. But soon after the first decade, this effect dissipates as front-loaded investment tapers off. **Induced and indirect effects** in turn become more important during the 2030s, mainly from more spending by low-income households that have received lump-sum payments disbursed to counter regressive effects (for example, existing structures, climate change impacts and carbon pricing). As such, in 2050 the main contributors to the 3.6% difference in economy-wide employment compared with PES are additional **public spending** and **induced and indirect effects**, in that order (see Figure 5.8).

Trade tends to have a negative effect in economy-wide employment: this is mostly because of reductions in exports of labour-intensive fossil energy commodities under 1.5-S compared with PES, leading to lower employment in these and associated industries.

Figure 5.8 Economy-wide employment in Africa under 1.5-S and PES, 2021-2050



Source: IRENA.

These trends are also reflected at the subcontinental level, which reconfirms the centrality of international co-operation to support African countries in their energy transition pathways (Figure 5.9). The key role of **induced and indirect** effects is particularly pronounced in Southern Africa (in the first half of the study horizon), and Central Africa (towards the end). Furthermore, regional results confirm the front-loaded nature of public and private investment effects on job creation across most regions, as with GDP. The negative effects on jobs in fossil fuel-related industries (through both trade and investment channels) are acute in the two regions where producers are concentrated: North Africa and Southern Africa. The economy-wide employment effects in each region are further described below.

North Africa

In North Africa, labour markets experience profound, structural change owing to the diversification of economic activity. Net trade effects, driven by reduced trade in fossil fuels, produce a marked reduction in employment that grows over the outlook period as fossil fuels are phased out globally. However, thanks to the upgraded policy basket, **public investment** in transition-related technologies and sectors, as well as greater **social spending** linked to international co-operation, help create substantial new employment across the region's economies in comparison with PES, increasingly aided by induced and indirect effects. This means that in spite of job losses in fossil fuel industries, North Africa benefits from 3.0% more jobs under 1.5-S by 2030, and 1.4% in 2050, when compared with PES, for an average of 2.2% across the outlook period.

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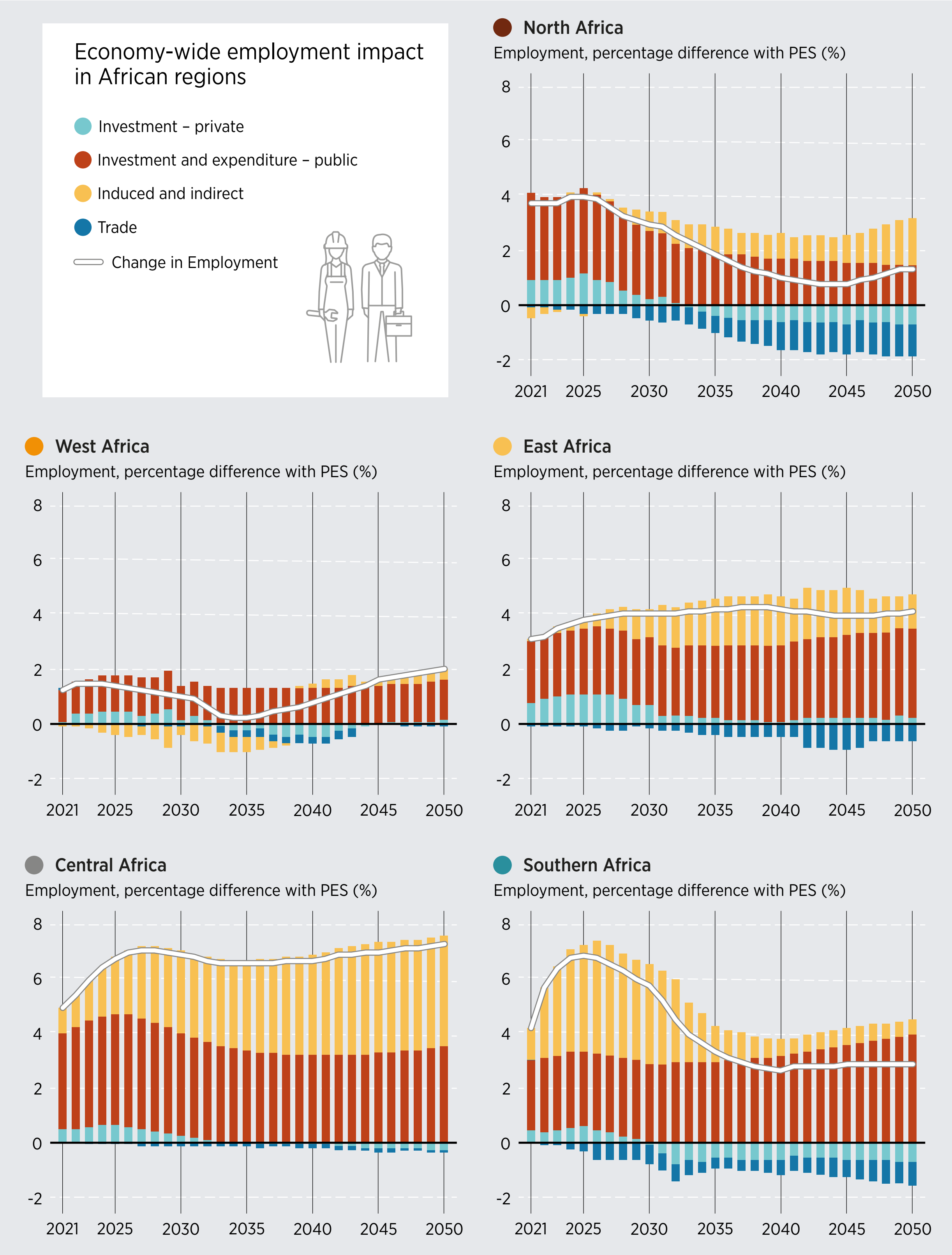
Figure 5.9 Economy-wide employment impact of 1.5-S and PES in African regions, by driver, 2021-2050



Source: IRENA.

West Africa

West Africa, another region producing and exporting fossil fuels, sees a similar pattern: employment reductions in fossil fuel–associated sectors that are offset through **social spending** and ripple effects from energy transition–related **investments**. The net effect between 1.5-S and PES is +1.0% in 2030, 2.0% in 2050 and an average of 1.1% over the entire period.

East Africa

East Africa is less dependent on fossil fuel industries to start with. As a consequence, the job creation potential of the energy transition is larger than in North Africa, at a solid +4.1% more employment under 1.5-S compared with PES both by 2030 and 2050. **Net trade** effects of lessened reliance on fossil fuels, while boosting GDP (shown above), creates a negative effect on jobs, though in reverse fashion to that seen in exporting regions; job losses in East Africa related to fossil fuel industries occur along the import value chain. The main drivers for employment gains in East Africa are **induced and indirect** effects, especially the ripple effects caused by additional spending supported by international co-operation.

Central Africa

The greatest benefits of international co-operation in economy-wide employment across Africa are seen in Central Africa. Here, the energy transition and climate policies result in an average of 6.7% more job creation over the period under 1.5-S than under PES, a substantial gain in socio-economic welfare. Along with Southern Africa, Central Africa sees the largest contributions from **induced and indirect** employment, but instead of concentrated at the beginning of the study horizon, they are more evenly spread.

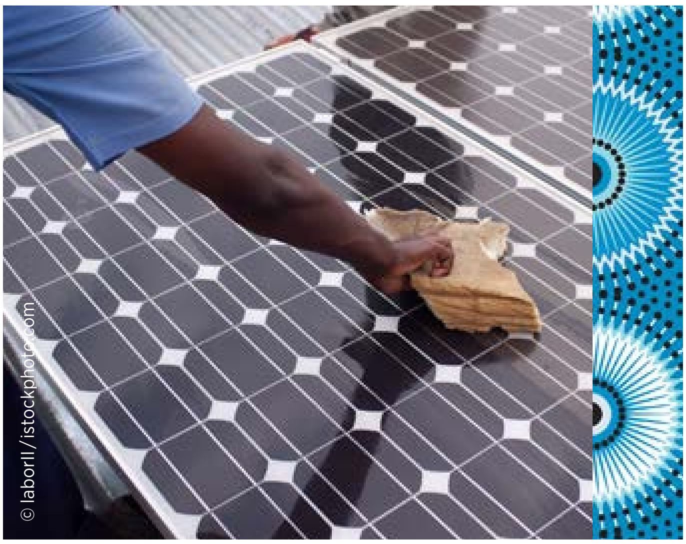
Southern Africa

Southern Africa also sees substantial job creation as a result of the energy transition and transition-linked policies. Jobs are up 5.7% in 2030 and 2.9% in 2050 under 1.5-S compared with PES, for an average of 4.1% across the outlook period, among the highest rates outside Central Africa. Public investment and additional social spending, together with induced ripple effects throughout the economy, signal that job losses in the fossil fuel sector are being met by significantly more job creation in other sectors.

These results for all five African regions highlight the potential for gains not only in overall economic output, but also in job creation and thus socio-economic opportunities in Africa as a result of the energy transition, when they are supported by the policy baskets that can make the energy transition a social and economic one.

5.2.2 Energy sector jobs

The energy transition would also significantly benefit job creation in Africa's energy sector, with the potential to create more than 9 million additional jobs between 2019 and 2030, and an additional 3 million jobs by 2050. Most of these jobs will be in renewables, energy efficiency, electricity grids and flexibility.[3] For comparison, the African Development Bank targets the creation of 14 million new jobs related to industrialisation, or 25 million jobs for young people, between 2016 and 2025 (AfDB, 2016). Job creation in the energy sector over the next decade could contribute greatly to this goal.



3 Mainly smart meters and energy storage (pumped hydropower, batteries and hydrogen-based seasonal storage).

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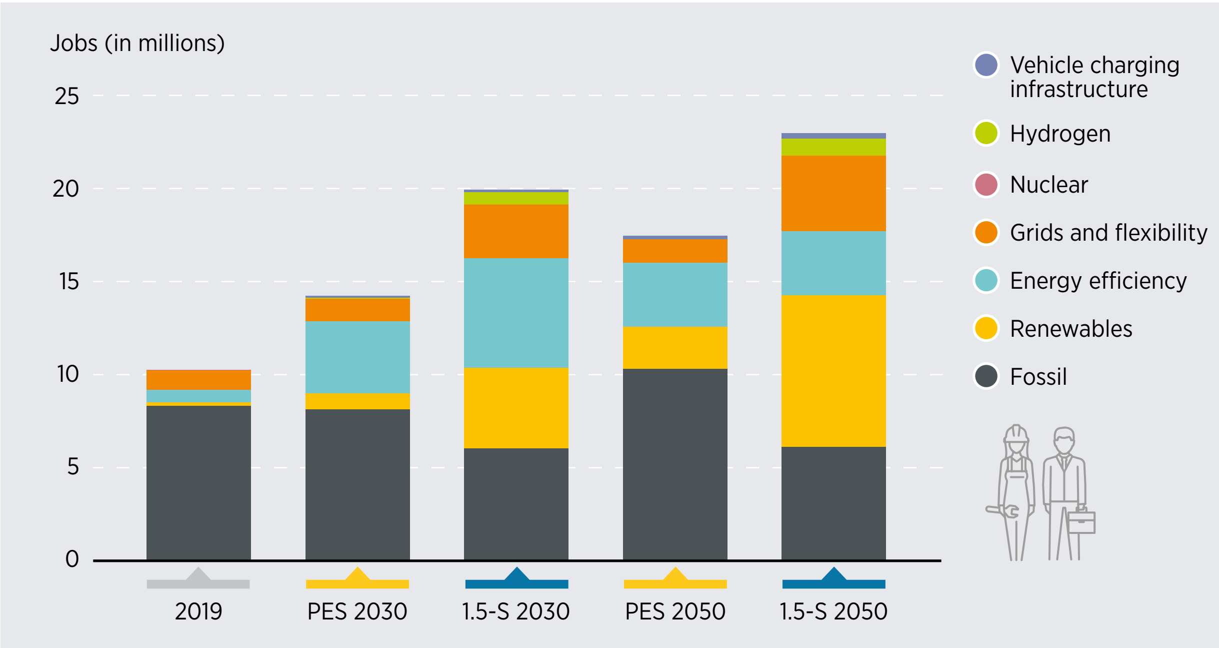
Most affected in the energy sector from job losses will undoubtedly be the fossil fuel industry and related value chains, including mining, extraction, refining, distribution/logistics and power generation with fossil fuel sources. Under 1.5-S, the fossil fuel sector would employ 2.1 million people less in 2030 and 4.2 million less in 2050 than under PES (Figure 5.10).

On the flip side, transition-related sectors more than offset these losses and provide many more alternative job opportunities than under PES. Energy-efficiency investments have particular potential to create more than 5.2 million jobs between 2019 and 2030. In subsequent decades, large-scale renewable energy deployment in increasingly electrified economies take over as the main booster of job creation in the sector. The resulting net gain in employment is notable: across Africa, the energy sector as a whole employs around 5.5 million more people both in 2030 and 2050 under 1.5-S when compared with PES, highlighting the sector's potential for job creation, if accompanied by proactive deployment policies, investment, and education and training opportunities to support the transition and allow for labour market mobility (see Chapter 4 and IRENA and ILO, 2021).

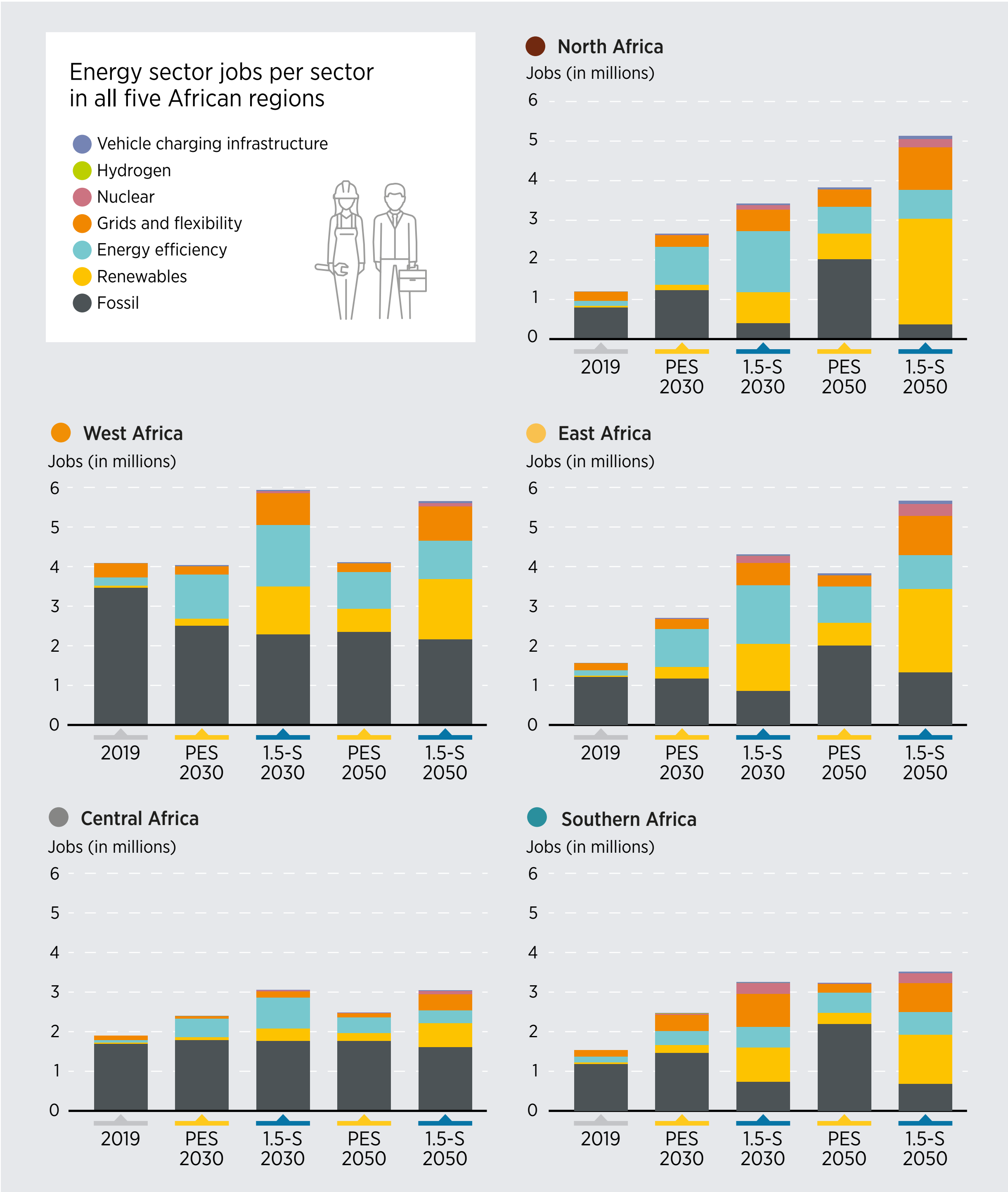
The net positive effect of the transition on energy sector jobs in Africa can be observed across all five African regions. Renewables, energy efficiency, power grids and flexibility are the main drivers of job creation across the continent. The most difficult, and hence politically challenging, transitions occur in countries and regions that are highly dependent on fossil fuels. There is a concomitant public perception that the fossil fuel sector is a major employer in countries with high existing unemployment. This is true for North and Southern Africa, highlighting the need for governments to plan, implement and monitor policies that accommodate the transition and strengthen transparency and access to information and job opportunities for those most directly affected by job losses in these industries. At the same time, these regions benefit substantially from a more diversified job market within the energy sector by 2050 if accompanying policies support this development (Figure 5.11).

Figure 5.10 Overview of energy sector jobs in Africa under 1.5-S and PES, by sector, 2019-2050



Source: IRENA.

Figure 5.11 Energy jobs by sector in African regions, 2019-2050



Source: IRENA.

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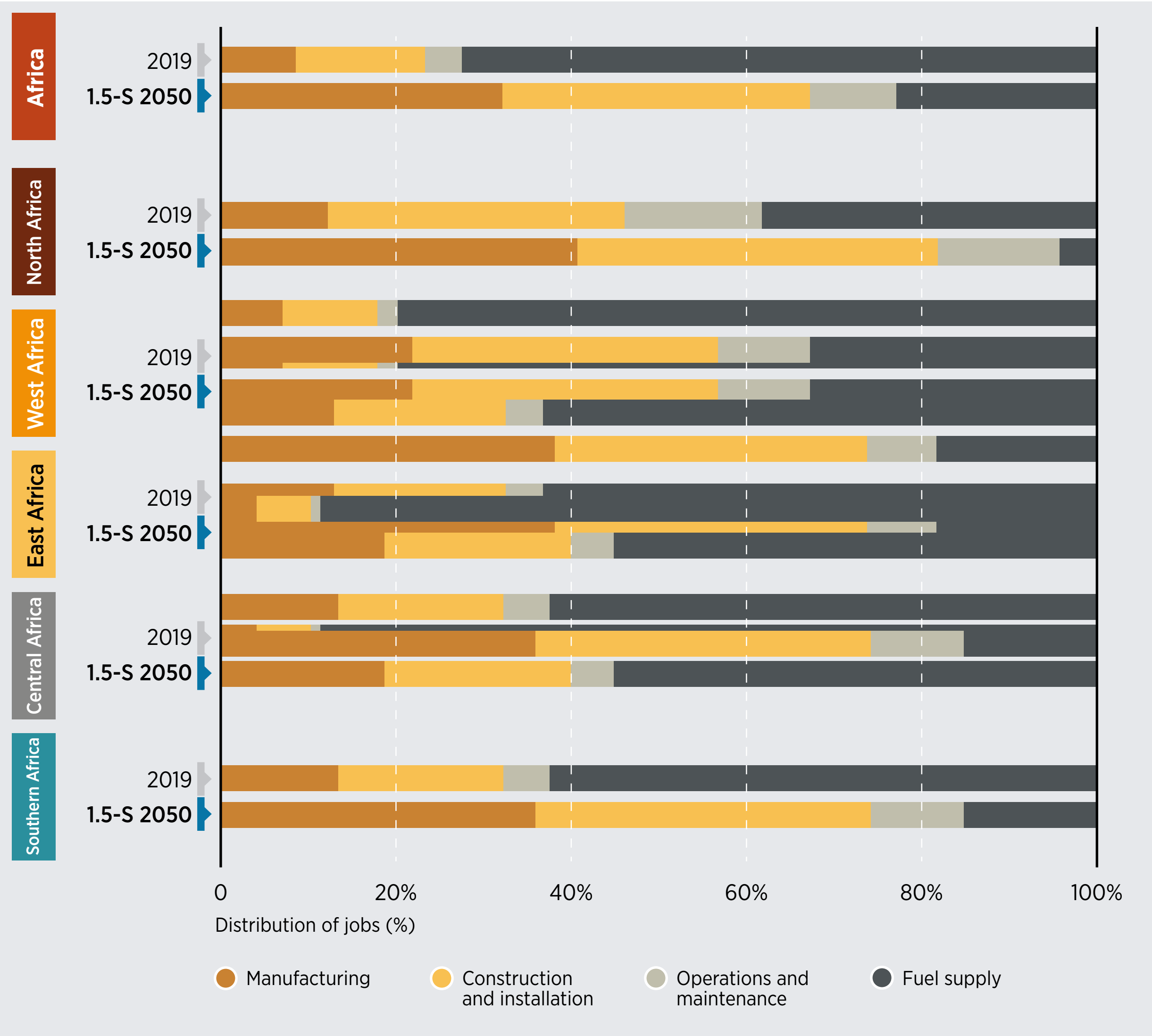
Within the energy sector, the transition will redistribute the relative importance of different segments of the value chains in job creation. Manufacturing, construction and installation, and operation and maintenance jobs all increase their share in employment creation from around 35% at the beginning of the 2020s to almost 70% by 2050. Meanwhile, the relative importance of fuel supply-related sectors falls from 65% today to around 30% in 2050 (Figure 5.12). This difference is dominated by fossil fuel supply and partly offset by additional employment in bioenergy supply.

Figure 5.12 Evolution of energy sector jobs Africa and its five regions by segment of the value chain and transition scenario, 2019-2050

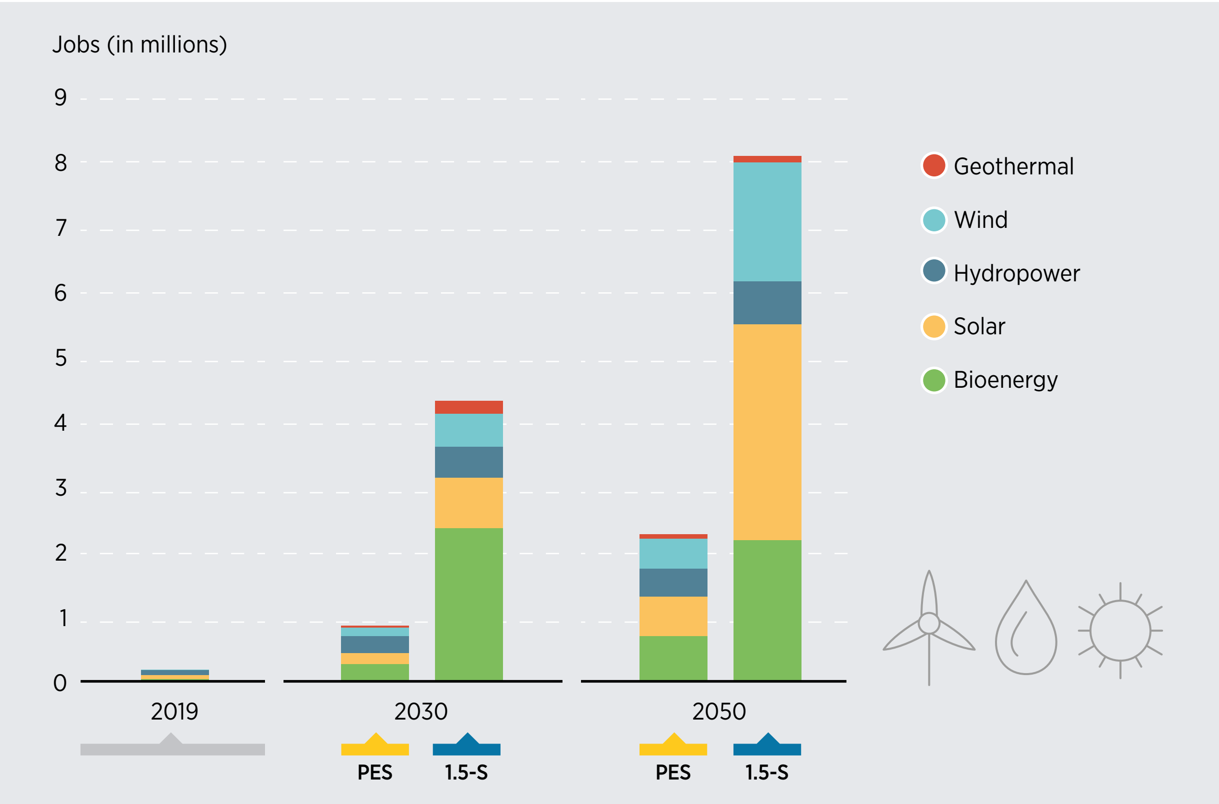


Source: IRENA.

5.2.3 Jobs in renewable energy

Renewable energy is one of the most important sectors gaining in job creation potential over the outlook period. The energy transition has the potential to boost employment in the renewable energy sector substantially in Africa, up from around 0.35 million in 2020[4] to over 4 million by 2030 and over 8 million by 2050 under 1.5-S. This is a 20-fold increase by 2050 from today's values, and four times as many jobs as without the energy transition. Indeed, PES sees a moderate increase to under 0.9 million jobs by 2030, and 2 million by 2050, as renewable technology becomes more cost efficient and (delayed) climate change responses keep driving deployment. Many of the renewable energy jobs in 1.5-S are in solar, bioenergy, wind and hydropower (Figure 5.13). From a global viewpoint, the African renewable energy sector has a higher job-creation potential: global renewable energy jobs in 2050 under 1.5-S are double than those in PES (49 million vs 25 million), while in Africa the multiple is 4 (8 vs 2 million).

Figure 5.13 Evolution of renewable energy sector jobs in Africa under 1.5-S and PES, by technology, 2019-2050



Source: IRENA.

4 IRENA's Annual Review on Renewable Energy and Jobs is based on regions' and countries' reporting as well as IRENA estimations, hence it has some technological and geographical data gaps. The simulation results reported here bridge these gaps analytically. The 2020 renewable jobs figure reported here corresponds to the renewable energy jobs monitored by IRENA and presented in its latest jobs report (IRENA, 2021e). The modelling exercise done to analyse the socio-economic footprint of the energy transition in Africa used IRENA's renewable jobs monitoring in 2019 (IRENA, 2020h) for initial model calibration; it then proceeded to fill the gaps (technological and geographical) in the monitoring exercise using on modelled results.

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Solar energy[5] is a key driver of job creation in the renewables sector over the outlook period. IRENA estimates that the African solar sector could employ 3.3 million people by 2050, driven by investment and deployment, as costs for solar technologies fall and make them in many cases one of the most price-competitive energy options, both in the on- and off-grid sectors. By 2050 most jobs in the solar industry are found in construction and installation (42%) and manufacturing (35%), but also in operations and maintenance (23%). Furthermore, the distributed nature of a large proportion of solar deployed in Africa to address the energy access challenge makes solar energy in Africa potentially more labour-intensive than suggested by these estimates, in particular in the construction and installation phases.

Sustainable bioenergy is another main contributor to job creation in 1.5-S, providing jobs to over 2 million people in both 2030 and 2050 – a large figure explained by the comparably labour-intensive nature of bio-fuels production. Viewed by segment of the value chain, bioenergy jobs are expected to be concentrated in fuel production, with fewer jobs in manufacturing, construction, installation or operation and management of bio-based power plants and other bioenergy facilities (for example, biomass boilers, clean cooking devices or biogas digesters).

The third major technology providing jobs in the African renewable energy sector is **wind energy**, which will employ more than 1.8 million people by 2050. Most jobs are in manufacturing of hardware components and in labour-intensive construction and installation.

Hydropower is one of the most important renewable energy sources today in Africa, but its job creation potential is more limited, with jobs around the hydropower value chain stagnating around 0.7 million until the end of the study horizon. There is mounting pressure to balance the energy generation objectives of large-scale hydropower with competing uses of water and land, labour protection, environmental standards and community land rights.

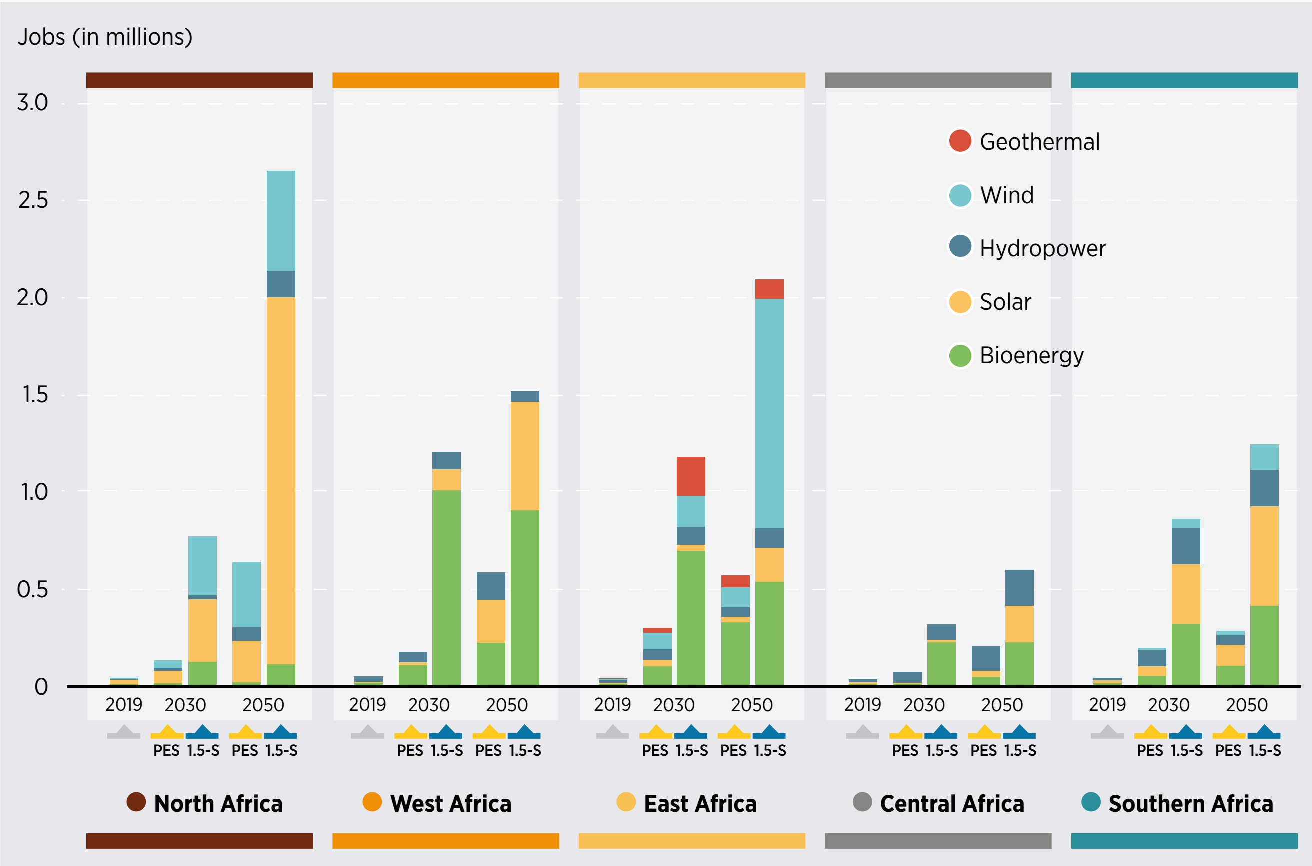
Regional dynamics reveal that potential job creation along the renewable energy value chain differs substantially across Africa, owing to differences in technology potential and skills. The single largest beneficiary of renewables-based job creation is North Africa, which alone could see close to 2.7 million jobs in renewable energy by 2050 under 1.5-S. This alone is higher than all renewable energy job creation potential across Africa by this time under PES (2.3 million). Another 2.1 million renewable energy jobs could be created in East Africa by 2050. A sizeable share of bioenergy jobs is concentrated in West Africa, and jobs in geothermal energy in East Africa with a few hundred thousand employees in the transition scenario (Figure 5.14).

5.2.4 Job impacts by skill level

For the energy transition to contribute to employment in Africa, the workforce needs to be trained with the adequate skills and ready to take the occupations that will be required. In addition to training new workers, the renewable energy sector can also draw on skilled workers in other industries. Many skills are not highly specific or exclusive to a particular industry and can thus be applied cross-sectorally to some extent, though typically some adaptation and reorientation will be needed. Thus, countries and firms can try to leverage existing skills, particularly in industries that have occupational profiles comparable to that of the renewables value chain. Given the long lead times and

5 Including all PV, CSP and SWH.

Figure 5.14 Evolution of renewable energy sector jobs in African regions under 1.5-S and PES, by technology, 2019-2050



Source: IRENA.

inertias in the education and training systems, planning in this field is one of the most immediate steps that policy makers can take in the context of the transition (see Chapter 4 and IRENA and ILO, 2021). Figure 5.15 shows the number of energy sector jobs in Africa per educational level until 2050 in the two scenarios. Most of the labour force expansion will draw from workers with primary education:[6] more than a tripling, from close to 4 million today to 12 million by 2050 in 1.5-S.

Early investment, planning and deployment of transition-related energy infrastructure (such as energy efficiency and renewables), requires more secondary education, later on operations and maintenance require more people with primary education. The peak in the need for tertiary-educated workers by 2030 represents a critical barrier for many low-income countries where currently high-level skills and university-trained professionals tend to be scarce (IRENA and ILO 2021).

These varying trends call for 1) co-ordinating energy sector demand with educational institutions; 2) anticipating skill needs; 3) implementing an integrated approach to labour and educational policy and planning, and 4) better integrating the educational requirements in the energy sector with those of other sectors.

6 'Educational levels are based on the International Standard Classification of Education: Primary education level comprises ISCED levels 0-2 (childhood, primary and lower secondary education); secondary education level includes ISCED levels 3-4 (upper secondary, post-secondary non-tertiary education), such as vocational qualifications and specialisations; tertiary education level comprises ISCED levels 5-8 (short-cycle tertiary education, bachelor's, master's and doctoral levels).

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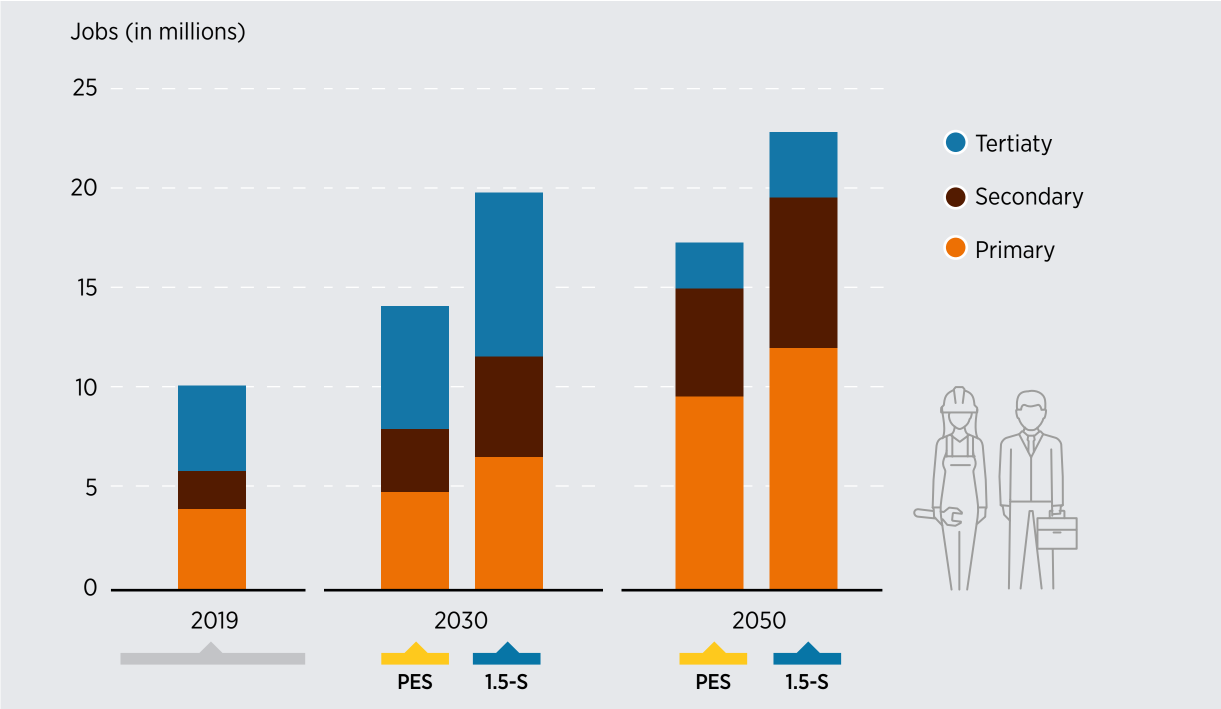
Figure 5.15 Energy sector jobs in Africa by educational requirements: PES and 1.5-S compared over time



Source: IRENA.

Furthermore, analysing specific occupations is also required. As seen in Figure 5.12 above, jobs shift from fuel supply to manufacturing, construction and installation, and operation and maintenance. IRENA and ILO analysis shows that to have workers follow this shift, they will need to acquire the necessary practical skills or expand on skills used in manufacturing, transport, metal, machinery, or electrical work (IRENA and ILO, 2021). There will be a need to enable workers to move from jobs in a declining sector to new jobs in rising sectors. While overlaps in needed skills may exist, there will also be a need for reskilling, reorientation, and recertification of skills. For instance, synergies may exist between coal and solar PV skills: more than 40% of coal power plant workers in the United States could transition to solar PV without additional training, while 30–35% of jobs are specific to coal mining and would require reskilling (Louie and Pearce, 2016). Similarly, significant synergies exist between offshore wind and offshore oil and gas skills (IRENA, 2018c).

All in all, IRENA's analysis shows a positive overall employment impact of the energy transition for Africa. Economy-wide jobs will be increased by a few percentage points when compared with PES, and the energy sector will employ more people than without the energy transition (job losses in fossil fuel industries are more than offset by job gains in renewables, energy efficiency, electricity grids and flexibility). But this positive picture at a macro level can hide challenges at a micro level, in specific industries, locations or periods where job losses are a reality. Transition-related employment opportunities will take place where new installations and infrastructures are located, where relevant technologies are produced, and where supply chains are located. A wide range of policies needs to address the potential job misalignments (temporal, educational and geographic). These policies are further discussed in Chapter 4.

Table 5.1 presents a high-level summary of some of the key job figures obtained by IRENA's analysis.

Table 5.1 Key figures on jobs in Africa, 2030 and 2050

	By 2030	By 2050
Relative difference between 1.5S and PES in total economy-wide employment	3.5% higher on average throughout 2021-2050	
Total energy sector jobs, absolute difference between 1.5S and PES	5.7 million	5.5 million
Total jobs in transition-related technologies under 1.5S	13.9 million	16.8 million
Total renewable energy sector jobs under 1.5S	4.3 million	8.1 million
of which solar	0.8 million	3.3 million
bioenergy	2.4 million	2.2 million
wind	0.5 million	1.8 million
hydropower	0.5 million	0.7 million

Source: IRENA.

5.3 WELFARE EFFECTS

The energy transition also has huge potential to improve welfare in Africa. IRENA quantifies the impact of the energy transition through its Welfare Index (IRENA, 2016b, 2017b, 2018c, 2019a, 2020h, 2021e). The index captures five welfare dimensions: economic, social, environmental, distributional and energy access (see Box 5.4).

Both the absolute indices per scenario and the percentage differences among the scenarios tell a story about welfare gains under the energy transition. Figure 5.17 presents the relative difference in welfare indices between PES and 1.5-S, by 2050, for Africa and each of its five regions, and illustrate how each dimension contributes. The welfare improvement for the African continent under 1.5C-S over PES reaches 24.3% by 2050, ranging from 14.6% in North Africa to 39.6% in Southern Africa. Although the relative contribution of the various dimensions differs across African regions, all benefit. These significant improvements in welfare are even greater than those seen for GDP (7.1% improvement over PES by 2050) and economy-wide employment (3.6% improvement over PES by 2050), highlighting the value of the transition for Africa over and above purely economic benefits.

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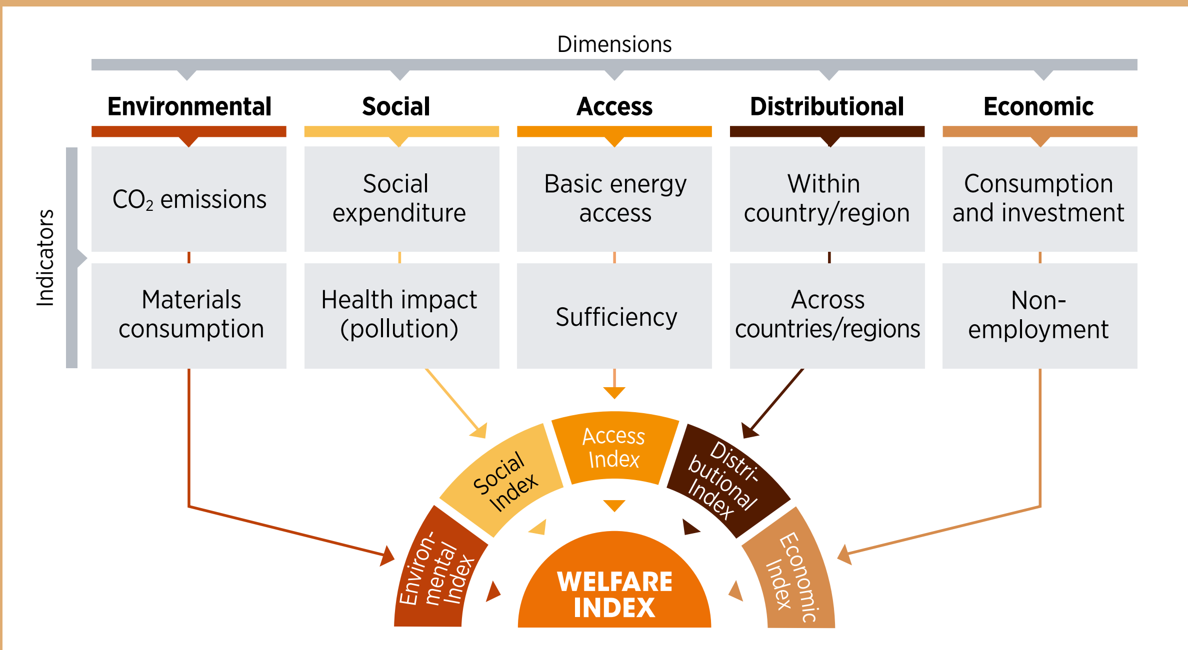
Box 5.4 IRENA's energy transition welfare index

Welfare is a multidimensional concept. In its socio-economic footprint analysis, IRENA measures welfare through a normalised index comprising the economic, social, environmental, distributional and energy access dimensions. Each dimension aggregates two indicators into its index (Figure 5.16).

The **environmental dimension** addresses the interactions of the socio-economic system with planetary boundaries, and its welfare implications. Two indicators are used to inform this dimension:

- ***Cumulative global CO_2 emissions*** are used to evaluate the climate implications of the proposed transition pathway. The index includes a vulnerability factor that accounts for the climate vulnerability of different countries/regions, in such a way that the higher the climate vulnerability the lower the corresponding index.
- ***Per capita materials consumption*** besides making direct reference to the sustainability boundary acknowledging that resources are finite, it is also used as a proxy of the impacts of human activities on biodiversity because of the high correlation between material throughput and ecological impacts. In Africa's context, however, starting from very low values of materials consumption owing to the developing country status of many African countries, increased consumption of materials may add to welfare while remaining below sustainability limits. To acknowledge this reality the index implements a development allowance limit such that material consumption below it does not affect the overall welfare index.

Figure 5.16 Structure of IRENA's Energy Transition Welfare Index



Source: IRENA.

Box 5.4 IRENA's energy transition welfare index (continued)

The **social dimension** aims at capturing social elements of welfare, and is informed by two indicators:

- ***Per capita social expenditure*** addresses public spending for improving social welfare, and includes spending in education and health, as well as other public spending and investment with social value.
- ***Per capita health impacts*** pertain to energy-system-related air pollution (indoor and outdoor).

The **access dimension** evaluates the evolution of energy access, and includes two indicators:

- ***Basic access*** is measured by the share of population without access to modern, sustainable energy. Access to clean cooking, the most restrictive indicator, is used here as a proxy for overall energy access.
- ***Evolution along the energy access ladder*** is measured in terms of per capita total final energy consumption. The corresponding index includes a sufficiency limit, after which additional final energy consumption does not contribute further to welfare. To account for the fact that as efficiency is deployed the amount of final energy required for a given energy service reduces, the sufficiency limit is modulated by the evolution of efficiency deployment (*e.g.* the sufficiency limit reduces with efficiency deployment).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The **distributional dimension** addresses the impacts of inequality on welfare, and is informed by two sets of indicators:

- ***Intra inequality*** uses two indicators to measure inequality within countries or regions: one on income and one on wealth.
- ***Inter inequality*** also uses two indicators to measure inequality between countries or regions: one on income and another on wealth.

The **economic dimension** is meant to measure the welfare implications of economic activity, and is informed by two indicators:

- ***Per capita consumption and investment*** are used as a proxy for the positive impact of private economic activity associated with the transition. The Welfare Index uses a logarithmic scale to acknowledge the decreasing marginal welfare benefit from increasing consumption and investment, as well as an overall sufficiency limit and a minimum aspirational goal (to recognise that consumption and investment in countries with low levels must increase).
- ***Non-employment*** indicates the participation of the working-age population in the economy. Non-employment is evaluated as the share of the working age population not employed subtracting the youth population enrolled in an educational institution.

The indicators are assembled in an index, which is normalised to 1, to ensure comparability of the different dimensions. Welfare improves as the index increases. The goalposts used for normalisation address sufficiency conditions, aspirational goals, development allowances and planetary boundaries.

For a further technical discussion of the results of IRENA's Welfare Index for Africa, see IRENA (2021e).

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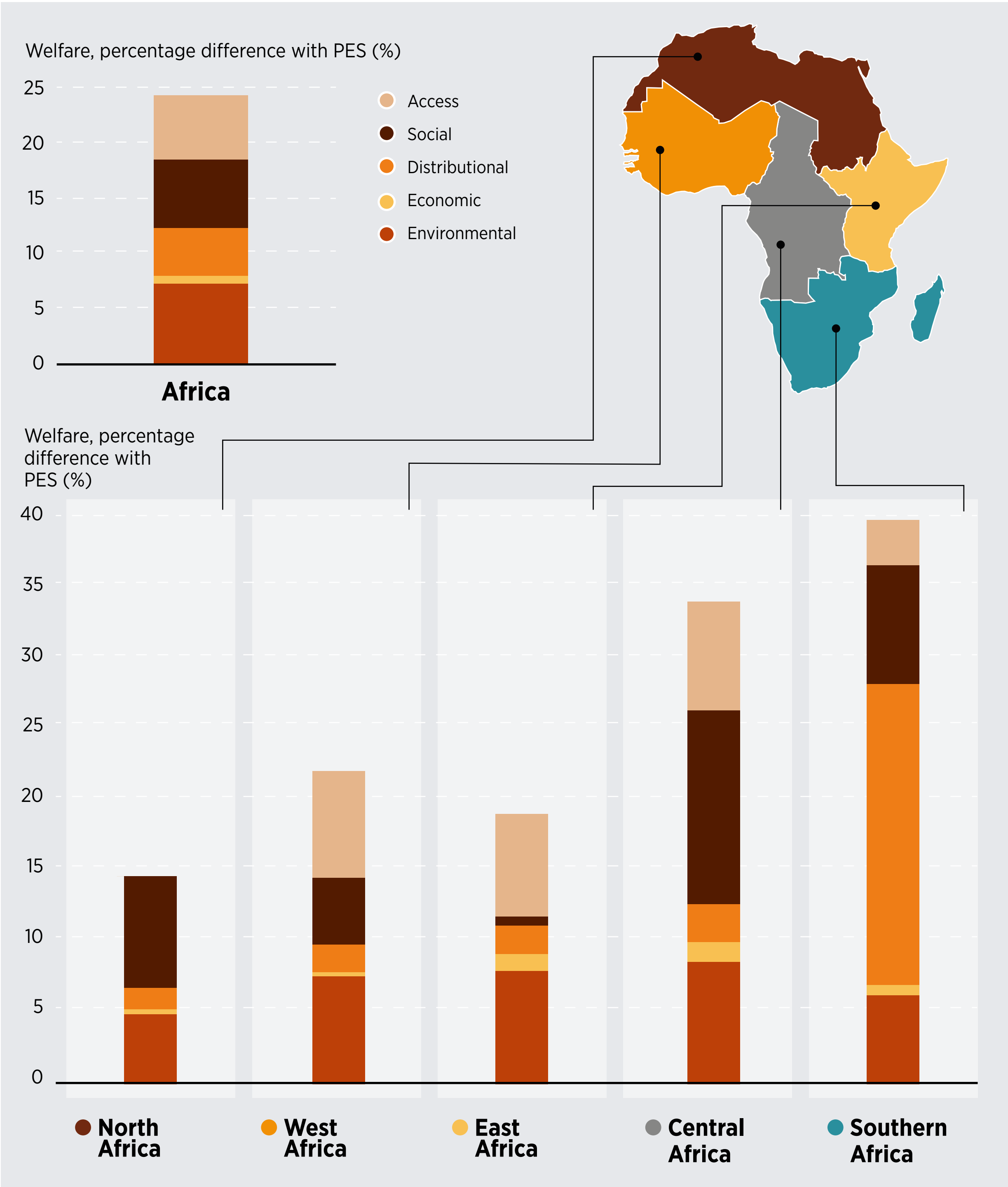
Figure 5.17 Welfare Index percentage difference between 1.5-S and PES for Africa and its regions by 2050



Source: IRENA.

Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by IRENA.

Environmental welfare constitutes the most significant advancement for Africa under 1.5-S. With a difference of over 37% compared with PES, the energy transition holds vast promise for Africa. Key to these welfare improvements is the global mitigation of CO_2 emissions under 1.5-S, which promises massive benefits for Africa, whose climate vulnerability is much greater than the global average. Materials consumption increases over time driven by increased economic activity under both 1.5-S and PES but remains within sustainable levels owing to the low per capita consumption of materials in Africa.[7]

Significant benefits are also seen in terms of **social welfare** improvements across Africa under the energy transition. At 32%, the difference in the social index between 1.5-S and PES is large, suggesting the energy transition improves quality of life across Africa. While social spending remains low in Africa under all scenarios owing to the continent's low starting values (USD 144 per capita in Africa vs USD 1 284 per capita globally in 2021), the policy basket for 1.5-S improves social spending more than PES. At the same time, 1.5-S has notable public health benefits for Africa, in particular through reduced indoor air pollution, a co-benefit of better energy access (clean cooking). The continent as a whole stands to benefit from these social index improvements brought about by the energy transition.

Under 1.5-S, the energy transition expands welfare in Africa through increased **energy access**, as spelled out in Sustainable Development Goal (SDG) 7 on universal access to modern energy by 2030. PES, by contrast, is based on current policies and does not reach universal energy access, even by 2050. Moreover, basic energy access is just the first step in the progression, and 1.5-S expands the options users have with the energy they may be able to afford by 2050. This progression differs substantially among African regions, but all see advances both in basic energy access and in progress along the energy access ladder. The energy access index is almost 30% greater by 2050 under 1.5-S than under PES.

An additional channel through which 1.5-S and the energy transition improve welfare in Africa is the **distributional dimension**. At about a 22% difference from PES by 2050, distributional impacts are relevant under 1.5-S, with particularly large gains in Southern Africa (see discussion below). The climate policy basket implemented with 1.5-S has specific items targeting inequality, such as international transfers and lump-sum payments to recirculate additional government revenues to the lower income quintiles.

Africa's economies can expect to benefit from the energy transition through enhanced **economic welfare**: a boost in disposable incomes creates more consumption and investment; and employment opportunities increase. Since African countries start from modest levels of consumption and investment (reflecting their status as mostly low- or lower-middle-income countries), a boost to consumption and investment is linked to necessary and important progress on basic living standards that provide important welfare benefits even if the overall improvement over PES is relatively modest (3.8% for Africa as a whole; see Table 5.2). The economic index improves in all African regions when moving from PES to 1.5-S and has a rather balanced contribution of its two indicators (consumption and investment, non-employment), although in North Africa consumption and investment has a higher contribution to the economic index while in Central and East Africa the key driver is non-employment.

Table 5.2 summarises the relative differences discussed above and gives the welfare and dimensional indices for 1.5-S for all African regions, Africa and the world.

7 The materials index has a value of 1 under both PES and 1.5-S for Africa and most African regions.

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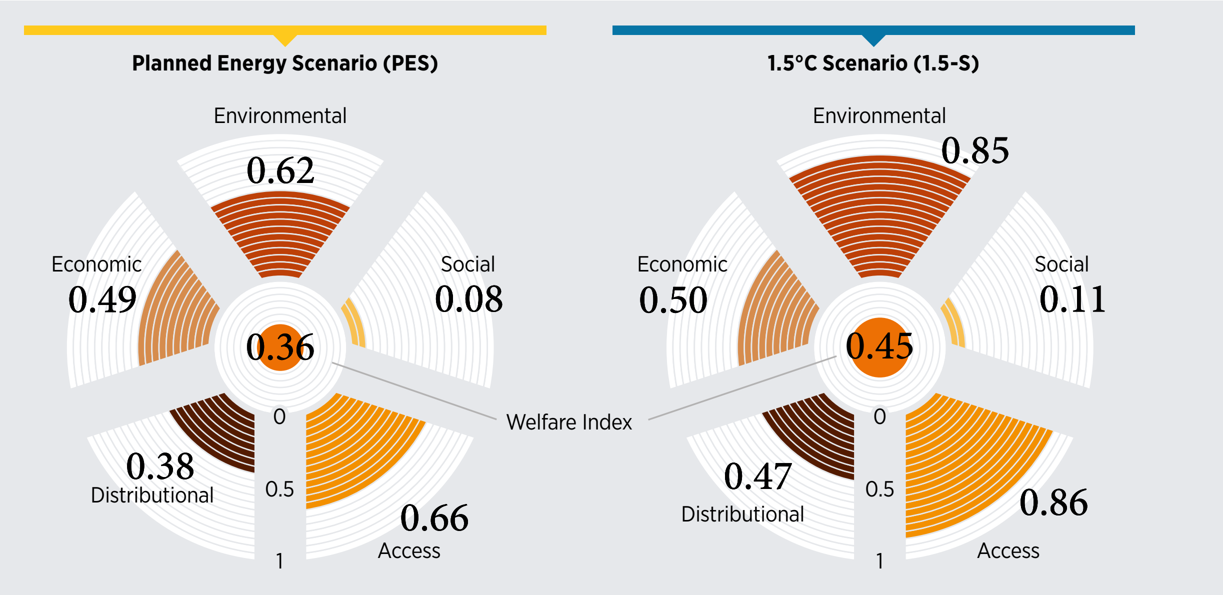
Figure 5.18 Welfare and dimensional indices for 1.5-S and PES in Africa by 2050



Source: IRENA.

Table 5.2 Welfare and dimensional indices for 1.5-S, and differences with PES, in 2050

Relative difference in indices [1.5-S – PES]							
	Global	Africa	North Africa	West Africa	East Africa	Central Africa	Southern Africa
Environmental	26.1%	37.6%	26.9%	39.8%	41.9%	46.0%	35.2%
Social	26.6%	32.0%	42.9%	24.7%	3.5%	73.1%	47.1%
Access	6.7%	29.8%	0.0%	39.3%	37.9%	40.9%	17.9%
Distributional	19.5%	22.3%	8.2%	10.1%	10.5%	14.3%	119.1%
Economic	0.9%	3.8%	2.0%	1.5%	6.3%	7.5%	4.0%
Welfare	**15.4%**	**24.3%**	**14.6%**	**22.0%**	**19.0%**	**33.8%**	**39.6%**

indices for 1.5-S							
	Global	Africa	North Africa	West Africa	East Africa	Central Africa	Southern Africa
Environmental	0.62	0.85	0.88	0.85	0.84	0.84	0.83
Social	0.28	0.11	0.11	0.09	0.07	0.11	0.16
Access	1.0	0.86	1.0	0.87	0.69	0.68	1.0
Distributional	0.36	0.47	0.51	0.50	0.50	0.48	0.64
Economic	0.70	0.50	0.48	0.40	0.49	0.48	0.55
Welfare	**0.53**	**0.45**	**0.48**	**0.43**	**0.40**	**0.43**	**0.55**

Source: IRENA.

In absolute terms, as shown in the Indices for 1.5-S in the table, the relevance of the different dimensions becomes clear. For 1.5-S, the highest dimensional indices in Africa are access (0.86) and environmental (0.85), while the lowest dimensional index is social (0.11), indicating a lot of room for improvement in this welfare dimension despite the social components introduced in the 1.5-S climate policy basket (the global value for the social index is 0.28 in 1.5-S). The economic and distributional dimension have intermediate index values in 1.5-S (0.50 and 0.47 respectively). Africa's environmental index value under 1.5-S (0.85) is significantly higher than the global value (0.62) because of its much lower materials consumption, and despite its higher climate vulnerability. Figure 5.18 depicts the resulting absolute indices for Africa in 2050 for both PES and 1.5-S, with the value for the overall index in the centre and the dimensional values along the blades.

Also in absolute terms, the regions differ. **North Africa's** overall welfare index is below the global average. Access contributes extensively to welfare; it is the highest dimensional index under 1.5-S at 1.0, followed by environmental dimension (0.88). Social spending remains low in North Africa throughout both scenarios, dragging down the social index in absolute terms and indicating more scope beyond the 1.5-S policy basket to improve social welfare (see Box 5.5 for further discussion). North Africa's overall welfare index by 2050 is 0.42 and 0.48 under PES and 1.5-S, respectively.

In **West Africa**, the highest indices reached under 1.5-S are access (0.87) and environmental (0.85), while the lowest is the social (0.09), the second-lowest value across African regions, indicating ample scope for further social policy beyond the 1.5-S climate policy basket. West Africa's economic index is 0.4 in 2050 under 1.5-S, the lowest in Africa, but its difference with PES remains positive. By 2050, the welfare index in West Africa is 0.35 and 0.43 under PES and 1.5-S, respectively.

Under 1.5-S, **East Africa** by 2050 has the highest absolute environmental dimension (at 0.84) in its indices. This is followed by access (0.69) and the distributional dimension (0.50). Contributing to the high environmental dimension index value in East Africa are materials consumption (because per capita consumption remains below the developmental allowance, the index reaches its maximum value) and CO_2 mitigation. The access index in East Africa (0.69) is the second lowest among African regions (Africa overall is 0.86), indicating that progress along the energy access ladder lags significantly behind (full basic access is reached already in 2030). Social welfare only improves marginally compared with PES, suggesting more is required than the 1.5-S policy basket to make a substantial difference in this dimension. Overall, East Africa's welfare index by 2050 is 0.33 and 0.40 under PES and 1.5-S respectively.

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Central Africa also has as highest dimensional indices under 1.5-S by 2050 the environmental (0.84) and access (0.68) dimensions. Still, Central Africa has the lowest access index of all African regions, indicating that progress along the energy access ladder lags significantly behind (full basic energy access is reached by 2030). The distributional index in Central Africa (0.48) is also the lowest among all African regions, suggesting much more will need to be done to address inequality. By 2050, Central Africa's welfare index is 0.32 and 0.43 under PES and 1.5-S respectively.

Southern Africa has the continent's highest welfare index in absolute terms – at 0.55 under 1.5-S, compared with 0.39 under PES. The highest dimensional indices in Southern Africa by 2050 are environmental (0.83) and access (1.0), with Southern Africa having reached sufficiency in energy access (both under PES and 1.5-S) by this date.

Addressing global challenges such as climate change requires a shared collaborative framework. An ambitious energy transition is a must to avoid the worst impacts of climate change and requires all countries to contribute. Effective policy action for a successful transition needs insight on the wider socio-economic implications of implementing energy transition roadmaps. Moreover, policy baskets accompanying

Box 5.5 Fiscal balances and their welfare impact under 1.5-S

Improvements in welfare, employment and GDP from the energy transition depend on proactive government policy and available fiscal space. This is why, under 1.5-S, the climate policy basket includes elements that support governments' ability to spend and invest, both in people and in the wider economy. Under 1.5-S, despite the reduction in fossil fuel royalties due to the lower role of fossil fuels in the global and African energy balances, government revenues are increased through two main elements of the climate policy basket: carbon pricing and international collaboration transfers.

Carbon pricing in the implemented policy basket for 1.5-S in Africa is enough to make up for the revenue lost because of lower oil royalties. But the price has deliberately been set as low as possible to mitigate any negative (regressive) socio-economic impacts from the transition. This means that the implemented policy basket in this analysis uses carbon prices that in general are 50% of the values used in WETO (IRENA, 2021e). On top of that, the current analysis differentiates carbon pricing by income group, and because all African countries fall under the middle- and low-income groups, the applied carbon prices are much lower than in high-income groups.

International collaboration transfers are therefore critical for closing the gap in revenues due to low carbon pricing. Key to the transition's political feasibility is a socio-economic transition along with the energy shift. Pairing social gains with the energy transition empowers African countries. To enable transition policies, the climate policy basket offered here structures international collaboration transfers around three pillars:

1. enabling and social (allocated as per the Human Development Index)
2. international justice (allocated as per fossil fuel dependence modulated by economic capacity)
3. international equity (allocated as per the fair share of carbon budget).

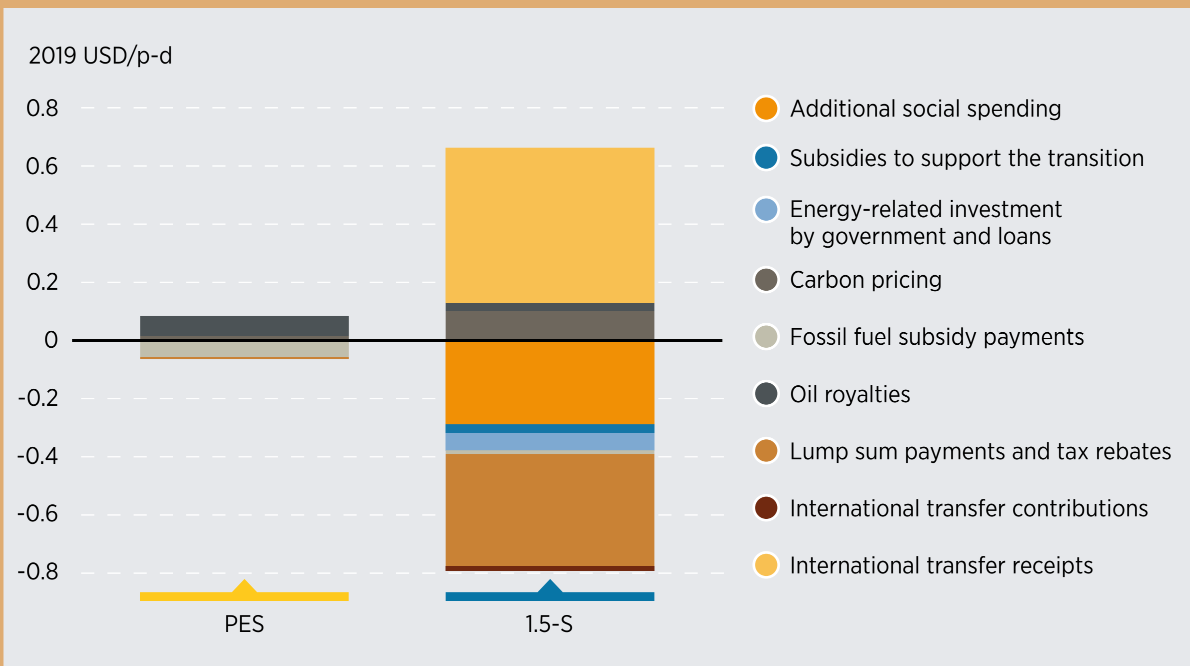
International transfer receipts dominate Africa's transition-related revenues, although receipts from international collaboration per capita are still modest (USD 0.54/person-day on average over the 2021-2050 period; see Figure 5.19).

the energy transition may themselves have a huge impact on the viability to realise transition roadmaps, facilitating the required collaborative framework and preventing barriers.

IRENA's socio-economic footprint analysis for Africa shows that with an appropriate climate policy basket the continent and its regions would benefit from an ambitious transition, with significant improvements in aggregated economic activity, jobs and welfare. International co-operation plays an important role in enabling these positive socio-economic footprint results and hence in facilitating a favourable collaborative framework for a successful global transition.

Box 5.5 Fiscal balances and their welfare impact under 1.5-S (continued)

Figure 5.19 Transition-related per capita fiscal flows in Africa: PES and 1.5-S, 2021-2050



Source: IRENA.

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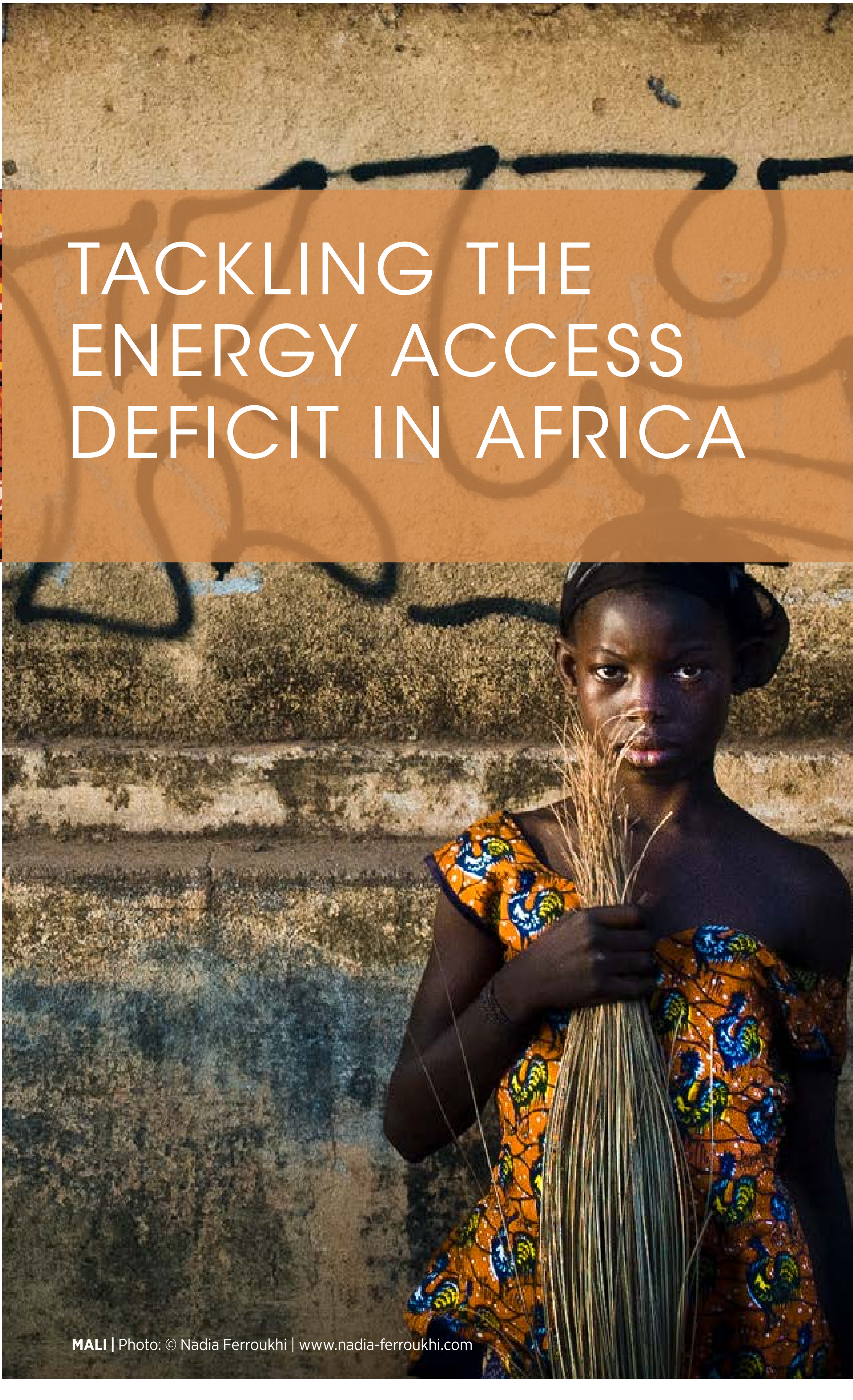
Table 5.3 Main Socio-economic indicators for Africa and its regions

			Africa	North Africa	West Africa	East Africa	Central Africa	Southern Africa
GDP	**GDP 2030** (in trillion USD 2019)	PES	3.9	1.3	1.1	0.4	0.4	0.7
		1.5-S	4.1	1.3	1.1	0.5	0.4	0.8
	GDP 2050 (in trillion USD 2019)	PES	9.7	3.4	2.8	1.2	0.8	1.5
		1.5-S	10.4	3.6	2.8	1.3	1.0	1.6
	GDP (% difference with PES)	2030	5.9%	4.3%	1.0%	9.4%	14.4%	9.4%
		2050	7.1%	5.6%	2.0%	11.2%	18.0%	10.3%
		average 2021-2050	6.4%	4.9%	1.6%	10.0%	15.4%	10.1%
Jobs Economy-wide employment	**Jobs 2030** (in millions)	PES	548	76	137	174	80	81
		1.5-S	569	79	139	182	85	85
	Jobs 2050 (in millions)	PES	722	91	175	242	107	106
		1.5-S	747	92	179	252	115	109
	Jobs (difference with PES in millions)	2030	20.9	2.3	1.4	7.2	5.5	4.6
		2050	25.7	1.3	3.5	10.0	7.8	3.1
	Jobs (% difference with PES)	2030	3.8%	3.0%	1.0%	4.1%	6.9%	5.7%
		2050	3.6%	1.4%	2.0%	4.1%	7.3%	2.9%
		average 2021-2050	3.5%	2.2%	1.1%	4.0%	6.7%	4.1%
Energy sector jobs, total	**2030** (in millions)	PES	14.3	2.7	4.0	2.7	2.4	2.5
		1.5-S	20.0	3.4	5.9	4.3	3.1	3.2
	2050 (in millions)	PES	17.5	3.8	4.1	3.8	2.5	3.2
		1.5-S	23.0	5.1	5.6	5.7	3.0	3.5
	Jobs (difference with PES in millions)	2030	5.7	0.8	1.9	1.6	0.7	0.8
		2050	5.5	1.3	1.5	1.8	0.6	0.3
Energy sector jobs, fossil fuels	**2030** (in millions)	PES	8.2	1.2	2.5	1.2	1.8	1.5
		1.5-S	6.1	0.4	2.3	0.9	1.8	0.7
	2050 (in millions)	PES	10.3	2.0	2.3	2.0	1.8	2.2
		1.5-S	6.2	0.4	2.2	1.3	1.6	0.7
	Jobs (difference with PES in millions)	2030	-2.1	-0.8	-0.2	-0.3	0.0	-0.7
		2050	-4.2	-1.6	-0.2	-0.7	-0.2	-1.5

Table 5.3 Main Socio-economic indicators for Africa and its regions (continued)

			Africa	North Africa	West Africa	East Africa	Central Africa	Southern Africa
Energy sector jobs, transition-related	**2030** (in millions)	PES	6.1	1.4	1.5	1.5	0.6	1.0
		1.5-S	13.9	3.0	3.6	3.4	1.3	2.5
	2050 (in millions)	PES	7.1	1.8	1.8	1.8	0.7	1.0
		1.5-S	16.8	4.8	3.5	4.3	1.4	2.8
	Jobs (difference with PES in millions)	2030	7.8	1.6	2.1	1.9	0.7	1.5
		2050	9.7	2.9	1.7	2.5	0.7	1.8
Energy sector jobs, renewables	**2030** (in millions)	PES	0.9	0.1	0.2	0.3	0.1	0.2
		1.5-S	4.3	0.8	1.2	1.2	0.3	0.9
	2050 (in millions)	PES	2.3	0.6	0.6	0.6	0.2	0.3
		1.5-S	8.1	2.7	1.5	2.1	0.6	1.2
	Jobs (difference with PES in millions)	2030	3.5	0.6	1.0	0.9	0.2	0.7
		2050	5.9	2.0	0.9	1.5	0.4	1.0
Welfare 2050 (% difference with PES)	**Environmental**		37.6%	26.9%	39.8%	41.9%	46.0%	35.2%
	Social		32.0%	42.9%	24.7%	3.5%	73.1%	47.1%
	Access		29.8%	0.0%	39.3%	37.9%	40.9%	17.9%
	Distributional		22.3%	8.2%	10.1%	10.5%	14.3%	119.1%
	Economic		3.8%	2.0%	1.5%	6.3%	7.5%	4.0%
	Overall welfare		**24.3%**	**14.6%**	**22.0%**	**19.0%**	**33.8%**	**39.6%**
Welfare 2050 (Index for PES)	**Environmental**		0.62	0.69	0.61	0.59	0.57	0.62
	Social		0.08	0.08	0.08	0.06	0.07	0.11
	Access		0.66	1.00	0.62	0.50	0.48	0.85
	Distributional		0.38	0.47	0.46	0.46	0.42	0.29
	Economic		0.49	0.47	0.39	0.46	0.45	0.53
	Overall welfare		**0.36**	**0.42**	**0.35**	**0.34**	**0.32**	**0.39**
Welfare 2050 (Index for 1.5-S)	**Environmental**		0.85	0.88	0.85	0.84	0.84	0.83
	Social		0.11	0.11	0.09	0.07	0.11	0.16
	Access		0.86	1.00	0.87	0.69	0.68	1.00
	Distributional		0.47	0.51	0.50	0.50	0.48	0.64
	Economic		0.50	0.48	0.40	0.49	0.48	0.55
	Overall welfare		**0.45**	**0.48**	**0.43**	**0.40**	**0.43**	**0.55**

TACKLING THE ENERGY ACCESS DEFICIT IN AFRICA



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- The energy access deficit: **A closer look**
- Raising access to electricity using **distributed renewables**
- **Clean cooking** with renewable energy solutions
- **Priority action areas** to reach universal access to modern energy

06

A key pillar of Africa's energy future involves expanding access to reliable, affordable and sufficient electricity and clean cooking fuels and technologies for the hundreds of millions of people who presently lack it. An estimated 592 million Africans were living without electricity in 2019; 927 million had no access to clean cooking fuels and technologies (IEA, IRENA, *et al.*, 2021). The access deficit is particularly acute in rural areas of Sub-Saharan Africa, with average rates of 25% for electricity and only 4% for clean cooking. Of the world's 3.5 billion people living without reliable access to electricity, the majority are found in Sub-Saharan Africa (Ayaburi *et al.*, 2020).

The full impact of the COVID-19 pandemic on access is not yet known, but it has been estimated that in Sub-Saharan Africa 17 million people lost the ability to afford an essential bundle of electricity services, while nearly 25 million might be at risk of reverting to traditional fuels and technologies, such as candles and kerosene for lighting and wood for cooking (IEA, IRENA, *et al.*, 2021; IEA, 2020b). Even before COVID-19, the achievement of universal access by 2030 – as targeted by Sustainable Development Goal (SDG) 7.1 – had become increasingly unlikely. The energy access trajectory presents a bleak picture for the African continent, as population growth and slow progress over the past decade has resulted in limited reductions in the absolute numbers of people without access. By 2030, around 560 million and 1 billion people in Sub-Saharan Africa are still expected to be without electricity and clean cooking fuel access, respectively (IEA, 2020c).

Achieving universal access to modern forms of energy influences each one of Africa's social, economic and environmental goals. It is central to meeting several of the SDGs and must be a key pillar of an African Green Deal that advances a sustainable, just and inclusive energy transition. The COVID-19 crisis has been a sobering reminder of the critical role energy plays in health care, sanitation, telecommunications and resilient livelihoods.

This chapter delves deeper into the complexities of the energy access deficit before examining the role of renewables in expanding access to electricity and clean cooking. It then highlights key recommendations to scale up the adoption of renewables so as to accelerate progress towards universal access and the SDGs.

06

6.1 THE ENERGY ACCESS DEFICIT: A CLOSER LOOK

Chapter 2 provided an in-depth assessment of Africa's energy access landscape. Countries in North Africa have the continent's highest rates of electrification and access to clean cooking fuels and technologies, whereas the deficit is greatest in West Africa. Nigeria, the Democratic Republic of Congo and Ethiopia have the largest populations living without energy access – about 218 million for electricity access and 349 million for clean cooking. In terms of population shares, South Sudan, Chad, Malawi and Burkina Faso had the lowest rates of electricity access in 2019, at 7%, 8%, 11% and 18%, respectively. For clean cooking, rates are even lower, with six African countries (Burundi, the Central African Republic, Liberia, Sierra Leone, South Sudan and Uganda) having rates below 1% (IEA, IRENA, et al., 2021).

Beyond traditional binary metrics (*e.g.* "connected" or "not connected" for electricity), energy access is increasingly seen as multi-dimensional to fully capture the quantitative and qualitative aspects of access for households, public buildings and enterprises. The Energy Sector Management Assistance Program's (ESMAP's) Multi-Tier Framework for Energy Access has introduced additional attributes of energy access: availability, reliability, quality and affordability for electricity access; cookstove efficiency, convenience, affordability and fuel availability for clean cooking (ESMAP, 2015a). Gathering country-level data across these different attributes provides greater insights into the landscape of energy access and makes it possible to set targets and track progress towards "meaningful" access for all. This section discusses selected attributes of energy access, drawing on available data and information.

6.1.1 Affordability

The affordability of access to energy has several different aspects, including the cost of subsistence consumption as a proportion of gross household incomes, the affordability of connection fees and clean cookstoves, and the existence of lifeline tariffs. While consumer affordability has improved in recent years, the pandemic-related economic shock is likely to widen the affordability gap (IEA, IRENA, *et al.*, 2021). In Africa, the number of people without electricity increased in 2020 for the first time in six years and basic electricity services became increasingly unaffordable for millions of people who had previously gained access (UNSD, 2021).

Many countries in Africa already have among the highest energy costs globally. The unit cost of electricity to consumers in many countries is more than double that in high-income countries (*e.g.* USD 0.12/kilowatt hour [kWh] in the United States) and higher than in many emerging economies (*e.g.* USD 0.08/kWh in India) (Blimpo and Cosgrove-Davies, 2019). In many countries, it would cost more than 10 percent of per capita gross domestic product to power a refrigerator for a year. For many African households, 7% of household spending goes for lighting and cooking energy. The number can be as high as 15-20% for the poor in urban areas using high-cost cooking fuels such as charcoal (World Bank, 2014). Clean cooking solutions often have much higher capital costs than traditional stoves, particularly when the costs associated with appliances and replacement are counted. Unsubsidised capital costs of biogas digesters range from USD 500 to 1 500, while biomass gasifier stoves can cost between USD 75 and 100 (ESMAP, 2020a). These costs are usually unaffordable for low-income consumers and financing options are rarely available. Non-residential consumers, too, face high energy costs, affecting profitability and competitiveness. The aggregate price per unit of electricity for commercial and industrial customers can vary by a factor of 20 across Sub-Saharan Africa, ranging from USD 0.02/kWh (in Ethiopia) to over USD 0.5/kWh (in Cabo Verde and Liberia) (Barasa, 2021; Kojima and Han, 2017).

Tackling the affordability challenge requires a range of context-specific measures, including demand-side subsidies, fiscal incentives (*e.g.* reduction in value-added tax and import duties) and tailored consumer financing. Demand-side subsidies are increasingly relevant to ensure that energy access efforts leave no one behind. Such subsidies can be designed in various ways – as grants to cover connection costs for grid-based and distributed solutions, or as incentives for enterprises to reach households faced with the affordability challenge. However designed, they must be targeted, progressive and accompanied by suitable regulations (IEA, IRENA, *et al.*, 2021).

In Rwanda, demand-side subsidies have been introduced alongside supply-side incentives to support adoption of solar home systems and clean cooking solutions among low-income consumers. In 2014, a supply-side subsidy in the form of results-based financing (RBF)[1] led to the adoption of over 140 000 solar home systems. Nevertheless, a large segment of the population was unable to afford the systems. In 2019, as a pilot programme in partnership with EnDev, the Rwandan government launched a demand-side subsidy programme, driving adoption among 31 000 households that had been unable to afford under the initial programme (ACE, Tetra Tech and UKAID, 2020; GOGLA, 2021a) (see also Box 4).


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6.1.2 Reliability and availability

Reliability of electricity supply is a major constraint in Africa. In Ethiopia, for instance, almost 60% of grid-connected households face 4-14 disruptions a week, and 3% face more than 14 disruptions a week (World Bank, 2018a). The proportion of firms experiencing outages is higher than in any other region, forcing enterprises to use generators and pushing up their operating costs. In 25 of the 29 countries in Africa, fewer than one-third of firms had reliable access to electricity (Blimpo and Cosgrove-Davies, 2019). In Kenya, 65% of enterprises report having 4-14 service interruptions a week, with quality of service (low or fluctuating voltage) a constraint for about 20% (IEA, IRENA, *et al.*, 2021).

The lack of reliable supply makes it challenging for households, enterprises and public infrastructure (*e.g.* schools and clinics) to fully exploit the opportunities offered by modern energy, holding back socio-economic development. Closely linked to reliability are availability considerations, *i.e.* the ability to draw energy or fuels when needed for use. In the case of electricity, for instance, availability of supply is often more important during the evenings (particularly for households), while for enterprises reliability is most important during the day. Availability challenges may also emerge with distributed renewables as a result of supply chain interruptions, and the lack of sufficient inventory owing to limited access to working capital.


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1 RBF is a type of development assistance that links funds to predefined, measurable and verifiable outcomes. Payments are triggered once certain results are achieved and verified (Vivid Economics, 2013). These can include instruments such as subsidies, grants and cash transfers (GPOBA, 2018; Urban Institute, 2016). RBF is increasingly used in developing countries to finance infrastructure and public goods and services – particularly in the health, transport, energy, and information and communications sectors.

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6.1.3 Accessibility

Solutions that enable access to energy, at least in theory, are not always accessible for various social and consumer groups because of the absence of requisite infrastructure or of opportunities to take advantage of that infrastructure. In Rwanda, for example, high connection fees keep many households from taking advantage of access to the grid (World Bank, 2018b). In Kenya, electricity access rates for formal enterprises is close to 100%, while the same for informal enterprises is estimated at 90%. The disparity is found to be even larger in São Tomé and Príncipe (84% for formal and 37% for informal) (IEA, IRENA, *et al.*, 2021). The lack of connectivity infrastructure (*e.g.*, road access in remote areas) and distribution channels for products and fuels can also present accessibility challenges.

Gender also strongly shapes accessibility. Women-owned households and enterprises find it harder to access modern energy. In Rwanda, female-headed households have lower access rates for both grid and off-grid electricity: 20% of female-headed households have access to electricity, compared with 31% of male-headed households. Also, more female-headed households (60%) than male-headed households (52%) use a three-stone open fire as their primary stove (World Bank, 2018b). A study based in five African countries (Ethiopia, Ghana, Kenya, the United Republic of Tanzania and Zambia) indicates that electricity connections for women-headed businesses are generally delayed when compared to their male counterparts (Banerjee, 2019). Alongside the traditional distribution of roles, differences in access to finance is one of the reasons for gender disparities. Schemes for financing connections that take gender into account have been known to significantly increase overall connection rates (World Bank, 2017).

Refugees and internally displaced persons also have challenges with accessibility. Sub-Saharan Africa hosts more than a quarter of the world's refugees, with most of them living in rural areas with limited access to reliable and sustainable sources of energy for electricity, space heating and cooking. In fact, access rates for refugee sites are found to be drastically lower than for host communities (Box 6.1).

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Measuring energy access demands a multi-dimensional approach that goes beyond a supply-side perspective to look closely at end users' needs and the qualitative aspects of services delivered. This applies equally to centralised and distributed solutions, with both potentially playing complementary roles to strengthen access (*e.g.* interconnected mini-grids to improve the quality of supply, as discussed later). Given their inherently decentralised characteristics, stand-alone systems and mini-grids are well positioned to deliver tailored energy services and are beginning to play an important role in accelerating energy access in Africa, as discussed in Chapter 2.

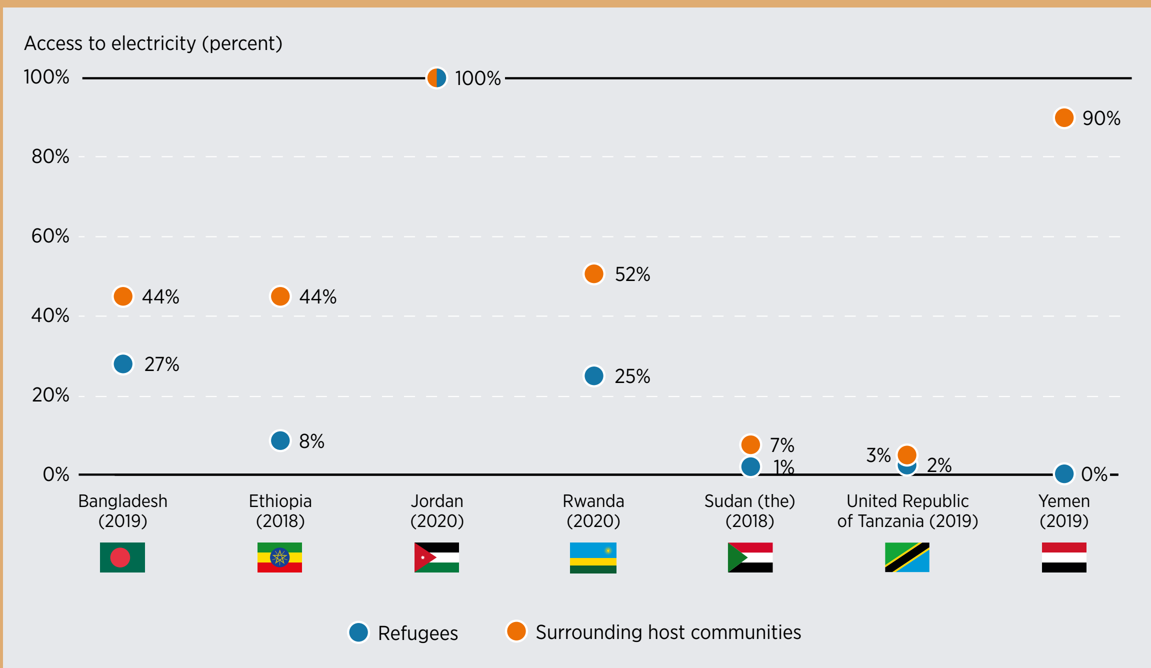
The remainder of this chapter discusses measures to scale up distributed renewable energy solutions to expand access to reliable and affordable electricity. It also examines how such solutions are being leveraged to improve health care and support livelihoods to maximise socio-economic benefits. The chapter then tackles the critical issue of clean cooking, an area where progress has lagged and in the absence of urgent action, the human, economic and environmental costs of cooking with traditional fuels continues to mount. The chapter concludes by identifying priority actions for achieving universal access to energy in Africa.

Box 6.1 Access to energy at refugee sites and near host communities

Data gathered by the United Nations High Commissioner for Refugees across 18 countries suggests that, on average, surrounding host communities have twice the access rates of the forcibly displaced. The assessment found that refugees in Ethiopia (27 sites), the Sudan (4 sites) and the United Republic of Tanzania (3 sites) suffered from far lower electricity coverage than in other countries (Figure 6.1).

Renewable energy solutions are increasingly being deployed to increase access to electricity and clean cooking energy within refugee camps (IRENA, 2019a). In the Dollo Ado region of Ethiopia, five camps have been powered since 2018 by solar mini-grids managed by co-operatives. The mini-grids power households, along with health facilities, food distribution centres and new businesses (UNHCR, 2021b). In the Sudan, over 800 refugee families in two camps in White Nile State have gained access to ethanol fuel from a sugar-producing company to reduce their reliance on fuelwood requiring day-long trips to gather and causing widespread deforestation (UNHCR, 2021c).

Figure 6.1 Access to electricity for refugee sites and nearby host communities



Source: UNHCR, 2021a.

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6.2 RAISING ACCESS TO ELECTRICITY USING DISTRIBUTED RENEWABLES

Distributed renewable energy solutions play a steadily growing role in expanding electricity access in off-grid areas and strengthening supply in already connected areas in Africa.[2] In the off-grid context, renewables-based stand-alone systems (*e.g.* solar lights, home systems) and mini-grids have spread in recent years, driven by improving technology, falling costs and favourable policy and regulatory environments. With the active participation of the private sector and facilitated by context-specific local conditions (*e.g.* mobile payments in East Africa), these solutions have quickly come to complement electrification through grid extension.

At the same time, grid-interactive distributed renewables are also increasingly being considered to raise the quality and reliability of supply in connected areas, particularly for commercial and industrial consumers.

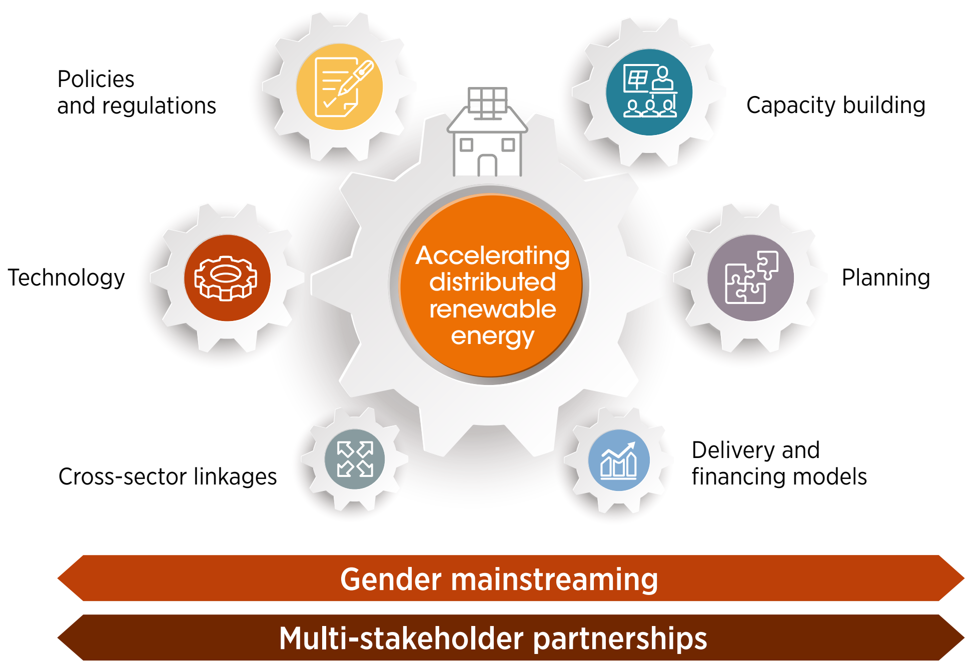
Distributed renewables are also increasingly deployed to support the delivery of public services such as health care and education. Linking electricity supply with income-generating activities and public services is crucial to maximising socio-economic benefits and making progress on multiple SDGs.

This section discusses all three contexts.

6.2.1 Expanding new connections

Scaling up the adoption of distributed renewable energy solutions requires an enabling environment that hinges on integrated planning; dedicated policies and regulations; tailored institutional, delivery and financing models; capacity building; technology innovation; and cross-sector linkages (Figure 6.2). Gender mainstreaming and multi-stakeholder partnerships are common elements across each of the components.

Figure 6.2 Components of an enabling environment for distributed renewable energy solutions



Source: IRENA.

2 Centralised grid-based solutions will continue to play a fundamental role in expanding electricity access through grid extension and densification. The associated implications for expansion in generation capacity and investments in transmission and distribution infrastructure are broadly covered in earlier chapters of this report.

Electrification planning

With the advent of distributed renewables, integrated electrification plans have become a cornerstone for addressing the institutional, technical and financial aspects of electrification in a coordinated manner (SEforAll, 2019a). Such plans are necessary to guide adequate public and private investments across a range of electrification solutions that sum up to at least a pre-determined level of access for all *i.e.*, leaving-no-one-behind. It offers visibility to stakeholders across sectors (including consumers and industry), allows progress tracking and importantly provides a framework for dynamic interactions between centralised and distributed solutions as consumption patterns evolve and dedicated regulations are designed to strengthen interoperability and safeguard infrastructure investments.

Several countries on the African continent have taken steps to develop and implement integrated electrification plans, although their scope varies. Electrification plans that incorporate distributed renewables are found in at least 15 countries across Africa, most in West Africa (7) and East Africa (6). The subregions with the largest electricity deficit – Southern Africa and Central Africa – are also ones with the fewest electrification plans in place. Countries with highest RISE (Regulatory Indicators for Sustainable Energy) scores for electrification planning[3] are Rwanda, South Africa, the United Republic of Tanzania, Ghana, Uganda, Angola, Ethiopia, Kenya and Malawi. In Rwanda, the Energy Sector Strategic Plan includes a target to achieve 100% electricity access for households by 2024. A National Electrification Plan is in place with allocation of areas to be electrified by deploying distributed systems and extending the grid (RURA, n.d.).

Increasingly, electrification plans also integrate the volume of capital investment needed across the power sector – in generation, transmission, distribution and operations – over time, as well as the affordability gap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3 *Indicators used by RISE for electrification planning include the existence of a plan, its public availability, targets and implementation and setting of an institutional landscape for implementation (https://rise.worldbank.org/scores).*

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to provide guidance on the magnitude and nature of financing required. Kenya's National Electrification Strategy, launched in 2019, utilised least-cost geospatial planning to assess the viability of various supply options (grid extension, grid intensification and densification,[4] mini-grids and stand-alone systems) to connect households, small businesses and public facilities as yet unserved. The plan presented a five-year investment plan for implementation, totalling about USD 2.7 billion (World Bank, 2018c).

Reaching universal electricity access in Uganda by 2030 will require connecting approximately 6.1 million new customers between 2019 and 2030 and a minimum of USD 5.5 billion of investment for both on- and off-grid connections (GCEEP, 2020). Beyond capital investments, public funding is also necessary to bridge the affordability gap. In Uganda's case, an affordability gap of USD 329 million for Tier 1 solar home systems has been estimated over ten years (SEforAll, 2019b). Integrated plans can also identify priority areas for matching energy supply with demand for productive uses and for expanding the use of electricity for cooking.

Several technical assistance programmes now focus on integrated electrification planning. ESMAP's Sustainable Energy for All Technical Assistance programme has supported the preparation of least-cost plans in nine Sub-Saharan African countries (Burkina Faso, Eritrea, Kenya, Madagascar, Malawi, Mozambique, the Republic of Congo, Uganda and Zambia). Least-cost plans are expected to be completed by 2022 in another eight countries (Angola, Benin, Chad, Liberia, Mauritania, Namibia, Somalia and Zimbabwe) (World Bank, 2020a). SEforAll's integrated energy planning programme is also offering support to Malawi, Nigeria and Rwanda to update and enhance their national plans. Greater availability of data, analytics and tools – including machine learning – now provide new opportunities to further enhance electrification planning through better estimates of demand, and more intelligent integration of available technologies and business models to reach all user segments in the most efficient and inclusive manner.

Policies and regulations

Holistic and integrated energy access strategies must be backed by dedicated policies and regulations designed for distributed solutions such as mini-grids and stand-alone systems. An adequate and stable regulatory framework is necessary to attract private investment in all areas of the sector where public funding falls short (Blimpo and Cosgrove-Davies, 2019). Developing such an enabling framework requires co-ordination between institutions across sectors, including energy, finance, agriculture, health and environment/forestry.

In the specific case of **stand-alone systems**, fiscal incentives, such as exemptions from import duties and value added taxes, are often introduced to incentivise market development and make stand-alone systems more affordable. At least 26 countries in Africa have introduced fiscal incentives for distributed renewable energy solutions, mostly in West Africa (12), followed by East Africa (8) and Southern Africa (4). The stability of such measures is important. In Kenya, one of the largest markets in the region for stand-alone solar systems, a value added tax was reintroduced in 2020 (GOGLA, 2020b), only to be rolled back in 2021 (GOGLA, 2021b). The lack of clear and coherent guidance on exemptions, delays in clearing consignments, and misclassification of solar products also pose challenges (UNREEEA, KEREA and USEA, 2020). Other supportive measures include levelling the playing field (*e.g.*, eliminating fossil fuel subsidies), raising public awareness and introducing quality standards. With the growth in the adoption of stand-alone systems, countries are also looking to increase local manufacturing and assembly of systems through a variety of policy measures and financial incentives (Box 6.2).

Scaling up renewable energy mini-grids requires dedicated policies and regulations to address licensing and permitting requirements (including quality standards), tariff-setting frameworks, the implications of arrival of the main grid, and the distinctive aspects of mini-grid public financing (IRENA, 2016a). A growing number of countries in Africa have introduced dedicated mini-grid policies (UNIDO, 2020).

4 Grid densification is achieved by installing additional transformers on existing medium-voltage lines to connect housing clusters within a predefined distance from existing distribution transformers. Grid intensification is achieved by extending short medium-voltage lines and additional transformers to connect more consumers. Embedded generation assets may also be included where central supply is deemed insufficient or too expensive.

Box 6.2 Policies to support local manufacturing of stand-alone solar solutions

At present, stand-alone systems are largely imported, with extensive back-end supply chains. Governments have been employing a variety of policy instruments – including faster processing of business applications and infrastructure and fiscal incentives – to promote manufacturing. Yet, only a few countries have made progress in this direction, mainly involving the assembly of solar modules, light-emitting diodes, solar televisions and pico solar products, or the manufacturing of batteries. Rwanda, for instance, has attracted foreign direct investment in assembly operations through policies that assure offtake of the production. The government offered a contract to purchase 100 000 solar home systems manufactured within the first two years of operation to stimulate investment in local manufacturing and assembly. In Nigeria, the Economic Sustainability Plan (2020) includes a goal to electrify 5 million households with solar and a phased increase in value chain localisation, including 100% local assembly and increasing the local manufacturing to a 15% share by 2022. An economic model for the localisation of the solar value chain in Nigeria has been developed to better understand impacts on socio-economic indicators, including on product price and employment generation.

Some of the challenges facing local manufacturing relate to import tariff regimes covering complete systems and subcomponents; the lack of quality standards; and the lack of incentives and uncertainty in long-term demand for products.

Source: ACE-TAF, 2021; SEforAll, 2020a.

In ***West Africa***, Senegal and Mali have seen the largest number of mini-grids installed as a result of dedicated programmes offering 10-15 year concession contracts to mini-grid developers and operators. Sierra Leone adopted mini-grid regulations in 2019 with support from the Rural Renewable Energy Project, which offered guidance on licensing procedures, consumer service, grid interconnection and tariff setting (SEforAll, UNOPS and FCDO, 2021). Beginning with the installation of solar systems at 54 community health centres across 12 districts of the country, the project widened electricity access through 50 independent mini-grids with capacities of between 16 and 36 kilowatts peak. In a subsequent phase, an additional 44 mini-grids were developed through public-private partnerships; capacities range from 36 to 200 kilowatts peak. Nigeria's advanced regulatory framework for mini-grids was enacted in 2016. By the end of 2019, Nigeria's estimated installed mini-grid capacity was about 2.8 megawatts, with 59 projects serving rural consumers. The regulations have further evolved to cover emerging applications including interconnected mini-grids (see below).

In ***East Africa***, countries such as Kenya and the United Republic of Tanzania have had a long record of mini-grid deployment through dedicated policies and regulations. The foundations for the United Republic of Tanzania's Small Power Producer framework were laid in the early 2000s with successive iterations issued by the Electricity and Water Utility Regulatory Authority to improve the enabling environment for mini-grids (IRENA, 2018a). The United Republic of Tanzania is estimated to have over 209 mini-grids, mostly renewables powered (*e.g.* hydro, biomass and solar/solar-hybrid) (SEforAll, 2020b). More recently, revised regulations for mini-grids have been introduced in Kenya (Box 6.3).

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Box 6.3 Renewable energy mini-grid regulations in Kenya

Mini-grids are anticipated to play an important role in helping Kenya meet the objective of universal electricity access by 2022. It is expected that over 280 mini-grids will be built and commissioned before 2022 under the National Electrification Strategy, raising the total number of operational mini-grids from 106 in 2018 to 391 in 2022 (EPRA, 2021). In 2018, dedicated guidelines for mini-grids were published under the provisions of the 2006 Energy Act. After revision of the act in 2019, draft regulations were published in May 2021 to facilitate investments in mini-grids of up to 1 megawatt. The new regulations cover aspects such as tariff approval, licensing requirements, interconnection arrangements, technical guidelines and performance and reporting guidelines.

Source: EPRA, 2021

In ***Southern*** and ***Central Africa***, dedicated mini-grid regulations have been less prevalent. In September 2021, Mozambique approved its Off-grid Energy Regulation to encourage the private sector to invest in distributed solutions, including mini-grids, by providing explicit guidance on permitting processes and tariff setting, among other aspects (SNV, 2021a). In Zambia, the national utility, ZESCO, operates several (fossil fuel-powered mini-grids (~8 MW in total) and is now looking to hybridise or replace them with renewable energy-based options, particularly solar and hydro (ENEA, 2016). In addition, at least five solar-based mini-grids have been developed mainly by the Rural Electrification Authority, the private sector and several foundations. In 2020, Zambia's Energy Regulation Board approved a regulatory framework for mini-grids (Bumbarger, 2021).

National regulatory frameworks guiding mini-grid development usually tend to focus on primary measures that directly impact project development and operation, notably legal and licensing provisions, tariff regulation, and the implications of arrival of the main grid (IRENA, 2016a, 2018a; UNIDO, 2020).

Legal and licensing provisions provide the legal framework for mini-grids to generate, distribute and retail electricity in a defined area. They are necessary to attract long-term investments in the sector. Largely administrative, they can involve transaction costs that may be significant for mini-grid projects. Dedicated mini-grid regulations increasingly impose simpler licensing requirements. In Nigeria, for instance, mini-grids under 100 kW are exempted from licensing requirements, though developers can voluntarily apply in order to reduce operational risks. To streamline processes, countries are digitising and exploring portfolio-based licensing regimes (*e.g.* in Sierra Leone, Uganda and Zambia) to ensure regulatory compliance and consumer safety. One of the key risks in the legal and licensing phase remains the stage at which developers can apply. Under proposed regulations in Kenya, for instance, developers cannot apply for licensing until after tariff approval and completion of construction, posing investment risks.

Tariff regulation is central to the viability of any mini-grid business model, steeped as it is in local political considerations. Given the higher cost of supply of isolated mini-grids compared to the national grid, the tariff setting process must balance cost recovery with consumers' ability to pay. Early mini-grid regulations embodied a "willing-buyer, willing-seller" approach to tariff setting for mini-grids of predefined system sizes. A drawback of that approach has been the risk of communities withdrawing consent during the operational phase. Where regulators were required to approve tariffs, steps were taken, for instance in Nigeria, to develop transparent, standardised tariff calculation methodologies that developers can use. Preferable is a cost-of-service approach to tariff setting that takes financial support (*e.g.* capital subsidies and RBF) into consideration (UNIDO, 2020). To support scale, portfolio-level tariff approvals are also increasingly recommended as they allow developers to cross-subsidise across their portfolio. Where national uniform tariffs are applicable or regulators determine retail tariffs, adequate subsidy mechanisms are needed to bridge the gap between the cost of service and tariff revenue.

Arrival of the main grid is a major risk for isolated mini-grid investments. Mini-grid regulations, including those in Kenya, Nigeria and the United Republic of Tanzania, have attempted to address this risk through integrated planning and earmarking options for operators. These generally include compensation (based on a predefined depreciation schedule and business value estimation) and conversion to the status of small power producers or distributors. In each case, the regulatory guidance must be clear, transparent and reliable, given the significant risk of stranded assets.

In addition to the primary measures just discussed, secondary and tertiary measures are also needed to sustain mini-grid projects. Implementation of such measures typically rests with institutions outside the energy sector (Figure 6.3). Secondary measures include policies related to land rights and use, banking, and company formation. Tertiary measures cover access to local statistics, technical assistance and capacity building (*e.g.* to support local enterprise development).

Secondary and tertiary measures also influence the adoption of stand-alone systems. In Nigeria, for instance, the Rural Electrification Agency has developed the Nigerian Energy Database (https://database.rea.gov.ng/) to provide community-level data on mini-grids and stand-alone systems, distribution infrastructure, the road network, and locations of health care centres and schools. The data are meant to strengthen the information base guiding investments.


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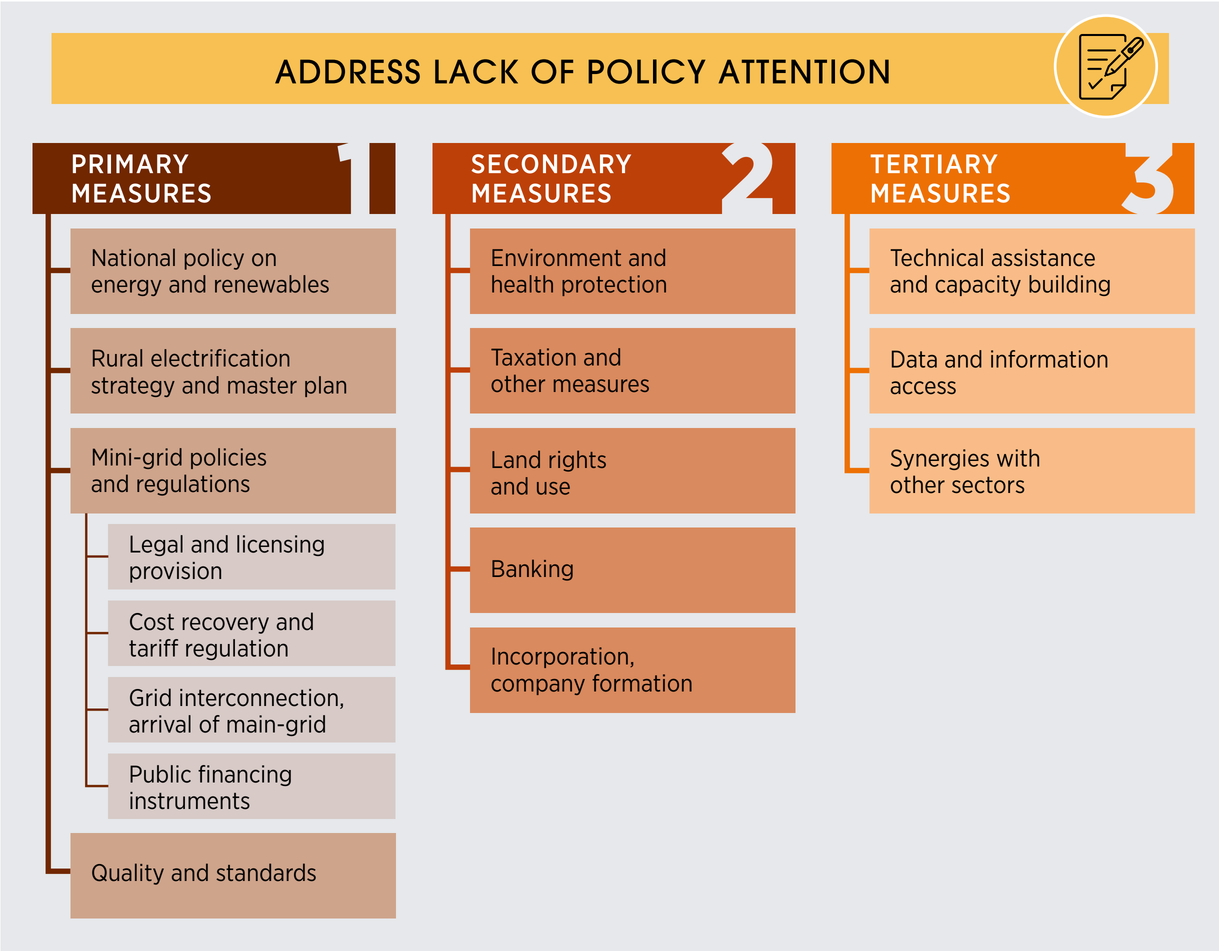
Figure 6.3 Overview of measures to scale up renewable energy mini-grids



Source: IRENA, 2018a.

Delivery and financing models

Innovations in delivery and financing models for distributed renewable energy solutions have made them more accessible and affordable for millions of people in the last decade. Chapter 3 provided a detailed analysis of the trends in investment in distributed renewables in Africa, highlighting two key challenges that deserve further attention.

First, there exists a significant gap in the magnitude of investment being mobilised for energy access. Despite the significant growth observed between 2010 and 2020, investments in distributed solutions represented less than 1% of overall financing for energy access, with the remainder being invested in grid-connected generation, transmission and distribution (SEforAll and CPI, 2020).

Second, over the 2010-2020 period, about half of total commitments to distributed renewables in Africa went to East Africa (USD 822 million) – primarily Kenya and the United Republic of Tanzania. West Africa – mainly Nigeria – represented the second-largest destination for investments, with USD 356 million. Commitments remained alarmingly low in Southern and Central Africa, which contain four of the nine largest access-deficit countries in Africa. Greater efforts are needed to scale up finance flows to ensure equitable access, particularly in countries where access deficits are the largest and progress remains slow.

In Sub-Saharan Africa, "North-South" investments – from developed countries to developing and emerging markets – continue to dominate, accounting for 85% of commitments (IRENA and CPI, 2020), highlighting also the importance of mobilising local capital – both debt and equity – to support the scaleup of distributed renewables in Africa. Among the barriers to unlocking local financing are poor understanding of the sector (which has inhibited assessment of risks and collateral requirements), the high cost of capital and unfavourable terms (*e.g.* tenor of financing).

Financing needs also vary greatly by solution and region. Sales of **stand-alone systems**, such as solar home systems, are heavily dependent on access to consumer financing. In the second half of 2020, over 40% of off-grid solar lighting sales were based on pay-as-you-go (PAYG)[5] sales, with the remainder being cash sales. In East Africa, which has by far the highest number of off-grid solar sales, cash sales dominate, except in Kenya, which has a mature PAYG ecosystem. In West Africa, PAYG and cash sales each account for about half of sales, but in Benin and Senegal, PAYG dominates (GOGLA, 2020a). The PAYG business model – now increasingly adopted for both consumer and productive appliances (IRENA, 2018b) – requires access to affordable capital for enterprises to sustainably scale-up, complementing by additional incentives to address affordability challenges to "leave no one behind".

In Rwanda, even with PAYG, the lowest-priced solar home systems cost households USD 3-4 per month, whereas their pre-existing expenditures were less than USD 1 for basic lighting and phone charging (USAID, 2020). Under an RBF scheme, partnering enterprises were able to offer solar home systems at a reduced price, receiving a subsidy once the transaction was verified. From January 2020 to March 2021, more than 22 000 Rwandan households opted to acquire the solar home system through this programme, with lower default rates. The government conducted a nationwide roll-out of the subsidy based on the "pro-poor" RBF structure in 2020.

At the enterprise level, significant gaps remain in accessing early-stage equity and grants for market entry. To address enterprises' need for affordable capital, some dedicated funding facilities, capitalised with both public and private monies, are now available and need to be scaled-up. For instance, the Trade and Development Bank is launching a USD 75 million SME Off-Grid Facility to facilitate access to debt financing for small and medium enterprises, primarily targeting the off-grid energy sector, as well as those in the broader infrastructure value chain (FW Africa, 2021).

In Madagascar, the Off-grid Market Development Fund is providing RBF to enterprises, in particular solar distributors, to test delivery models to make stand-alone systems more affordable for customers. It also offers credit lines to cover consumer financing, working capital and inventory costs (Pothering, 2021). RBF support is also being offered to enterprises to encourage uptake of efficient appliances. The Global LEAP RBF offers off-grid solar companies incentives to deploy energy-efficient appliances, including refrigerators and solar water pumps, having catalysed the procurement of over 230 000 systems in Kenya, Rwanda, Uganda and the United Republic of Tanzania. Financial support is increasingly being delivered through competitive processes, including minimum subsidy tenders (*e.g.* in Nigeria) and a fixed grant per connection (*e.g.* Nigeria and the United Republic of Tanzania).

Multiple forms of financing are being offered to make **mini-grids** more viable commonly involving a blend of grants (upfront or results-based) and equity (balance sheet, private equity or venture capital). These range from upfront capital subsidies increasingly disbursed through minimum subsidy tenders (since 2019, eight countries[6] in Africa have launched mini-grid tenders) (SEforAll, 2020b) to RBF-based support (*e.g.* on the basis of verified connections). A dedicated RBF

5 A typical PAYG structure involves the purchase of a system through an initial down payment followed by periodic payments. The arrangement can take the form of a perpetual lease or lead to ownership after a defined period. Payments are collected through mobile payment platforms, while smart meters and data analytics facilitate operation, monitoring and other after-sales services.

6 These include Mali, Nigeria, Senegal, Sierra Leone, Burkina Faso, Togo, Algeria, Ethiopia and Madagascar.

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facility – Universal Energy Facility – was launched in October 2020, opening first for mini-grid projects in Sierra Leone, Madagascar, followed by Benin. Offering USD 433 per connection in each country, the Universal Energy Facility aspires to be a USD 500 million facility by 2023 (SEforAll, 2020c, 2021a). Experience from Nigeria – which hosts both a minimum subsidy tender and RBF facility – suggests that implementation of RBF can be simpler and faster (SEforAll, 2020b); however, the private sector will still require an upfront funding mechanism to meet initial capital needs (SEforAll, 2021b), as also seen through EnDev's experience in Rwanda and Kenya (EnDev, 2021a). In this context, the participation of local financing institutions, particularly commercial banks, remains crucial for the scale-up of the mini-grid sector. At present, local lending is limited due to high perceived risks, lack of understanding of the sector and shorter-term loan tenors.

Early signs of access to long-term financing are emerging, including debt, which is crucial for scaleup. Cross Boundary Energy Access (CBEA) is an Africa-focused blended finance facility for mini-grids offering long-term infrastructure financing (equity and debt). In Nigeria, 28 mini-grid systems will be developed with construction financing from Oikocredit, Triodos IM and EDFI ElectriFI, with CBEA purchasing the portfolio once operational and a private sector entity taking over operation and maintenance (Tena, 2021). Another private entity has secured international debt funding for 49 mini-grid projects in Sierra Leone and Uganda (Hall, 2021).

Efforts are also being made to aggregate demand for distributed renewable energy technologies to achieve economies of scale and drive down costs. The International Solar Alliance, for instance, has aggregated demand for over 270 000 solar pumps across 22 countries (SEforAll, 2020a). Dedicated financing is also being channelled to help enterprises cope with the disruptions caused by the COVID-19 pandemic (Box 6.4), and to support deployment in challenging contexts such as refugee settlements. In 2019, USD 1.8 million was committed (mainly by government agencies and inter-governmental institutions) to distributed renewable energy solutions for refugee settlements in Kenya and Uganda (IRENA analysis based on Wood Mackenzie, 2020).

Crowdfunding has also emerged as an important tool to finance small-scale renewable energy projects. IRENA's analysis shows that since 2014 more than USD 58 million has been raised through crowdfunding for various off-grid technologies, particularly in East, Southern and West Africa.[7] By 2018, about 45 different platforms had raised funds for at least 4 800 renewable energy campaigns in emerging and developing countries (IRENA and CPI, 2020). As the funds are not tied to geographical boundaries, campaign proponents can access a significantly broader pool of investors, which in turn lowers the overall cost of capital. Financing goals can be reached within a matter of days or weeks as opposed to months or years.

7 Based on data from Wood Mackenzie. Data are collected from a variety of sources including the Cambridge Centre for Alternative Finance, Crowdsurfer and platform partners to the Crowd Power programme, i.e. Kiva, Bettervest, Indiegogo, Lendahand, GlobalGiving, Trine, Crowdcube, Pozible and M-Changa.

Box 6.4 COVID-19 relief funding for the distributed renewable energy sector

COVID-19–related disruptions and income shocks have hit energy access enterprises hard, creating problems with supply chains, customer service, tariff recovery and expanding the consumer base. With distributed renewables providing critical energy services for hundreds of millions of people, dedicated funding facilities have been developed to offer short-term support for enterprises in the sector.

The Energy Access Relief Fund is a partnership of 16 governments, foundations and investors formed to offer financial support to energy access enterprises affected by disruptions related to COVID-19. The USD 80 million fund aims to provide short-term loans to an estimated 90 companies in Sub-Saharan Africa and Asia.

In Uganda, a EUR 1 million COVID-19 Economic Relief Fund was set up by EnDev in co-operation with the Ugandan Ministry for Energy and Mineral Development and with support from the German Federal Ministry for Economic Cooperation and Development. The fund targets the solar and cookstove sectors, with 26 enterprises receiving funds to cover training, inventory, payment of staff salaries, defaulted customer payments and digitisation of operations. A similar fund was introduced in Mozambique as the Relief Scheme for Companies Vulnerable to Increased Default of Payments (COVID-PAY), offering PAYG companies EUR 10 in financial support per customer per month for a maximum of six months. So far, almost 125 000 customers have benefited from the scheme.

Source: EnDev, 2021b; Acumen Fund, 2021.

Technology innovation

Technology innovation has played a key role in reducing costs, improving reliability and making renewable energy available and accessible for various end-use applications in Africa. The innovation process encompasses generation technologies (*e.g.* solar modules, micro-hydro turbines), balance-of-system components (*e.g.* inverters, electronic load controllers, smart meters), control systems, appliances (*e.g.* energy-efficient pumps, televisions, processing equipment) and enabling infrastructure (*e.g.* digital payments). To support a further scaleup in distributed renewables, the innovation process will have to focus more closely on adapting to local conditions and needs, and on developing high-quality infrastructure.

Linking technology innovation with livelihood development and public services has emerged as an important frontier for distributed renewables (discussed further in section 3.3). To exploit this link, technology solutions will have to be tailored to specific productive end uses and segments of the value chain in sectors such as textiles, agriculture and animal husbandry, as well as cottage industries. Special emphasis must be placed on improving the energy efficiency of appliances for productive end use (*e.g.* milling machines) and for public services (*e.g.* health equipment) to lower the costs of integrating them with distributed renewables.

Across Africa, several examples of efforts in this direction are emerging through partnerships between development institutions, academia, the private sector and governments. The Africa Centre of Excellence for Sustainable Cooling and Cold-Chain (ACES), for example, was established in 2020 by the governments of Rwanda and the United Kingdom, the United Nations Environment Programme's United for Efficiency initiative, the Centre for Sustainable Cooling, and a range of academic institutions (United for Efficiency, 2020). ACES aims to tackle the challenge of high postharvest losses resulting from the lack of

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cold-chain infrastructure. Key areas of focus include technology demonstration and capacity building, data acquisition and use, a business incubator and research on future-proof, localised solutions for reducing food losses and increasing farmers' incomes.

The Efficiency for Access coalition has been established to convene development agencies and foundations to support and promote high-performing appliances that contribute to energy access. Its programmes fund design challenges, research and development, and market scaleup (Efficiency for Access, 2021). The Global LEAP awards, for instance, use competition to drive innovation in off-grid appliances and accelerate market development. Since 2014, Global LEAP has supported off-grid products including televisions, fans, refrigerators, solar water pumps, cold storage and electric pressure cookers. To strengthen the adoption of supported technologies, partnerships with results-based programmes have also been established in Kenya, Uganda, the United Republic of Tanzania, Senegal and Zambia (Efficiency for Access, 2021).

Smart metering technologies are also improving access to, and management of, consumer-level data, while also unlocking functionalities associated with remote management, flexible pricing, theft detection and prevention, and demand data for investors (UKAID, Shell Foundation and USAID, 2020). These functionalities are increasingly needed to manage large numbers of distributed energy assets while keeping metering, billing and collection costs low.

"Quality infrastructure" (QI) is an umbrella term covering the varied services, regulations and institutions required to ensure the quality of a system or product. Through comprehensive standards, testing, certification and accreditation, inspection and monitoring, and metrology, QI can lower costs by reducing legal, regulatory and performance uncertainty associated with distributed renewable energy development (IRENA, 2020a). A comprehensive, system-level approach to the development of QI requires cost-effective testing methods, integration of QI into policy frameworks, and adaptation to changing market conditions.

Several countries, including Nigeria and the United Republic of Tanzania have introduced technical regulations for mini-grids based on International Electrotechnical Commission standards. Regional standardisation efforts are also underway. Quality standards and testing methods developed under the Lighting Africa programme for solar lanterns have been adopted by the International Electrotechnical Commission as a reference for off-grid lighting products, and by national governments such as Kenya, the United Republic of Tanzania and Ethiopia (Lighting Africa, 2021). In some countries, such as Liberia, quality-verified products are a necessary pre-requisite for accessing public financing.

Training and skills development

A variety of actors in the distributed renewable energy market – including end users, financing institutions, local entrepreneurs, governments, standardisation agencies and the private sector – could benefit from enhanced skills; indeed, skills development and training are essential for the long-term sustainability of the sector. Several national and regional programmes have been launched to bridge the skills gap. In Nigeria, several solar training institutes and centres now offer a wide range of technical and non-technical courses. Technical institutes are also offering follow-on business training. The Renewable Energy Technology Training Institute in Lagos, for instance, supports graduates, through its Growth Support Plan, helping them establish and manage enterprises in the renewable energy sector (Olisa, 2020). In Sierra Leone, an off-grid agro-solar academy has been established to help graduates of vocational training programmes apply renewables in agriculture.

Across West Africa, the Regional Centre for Renewable Energy and Energy Efficiency (ECREEE) of the Economic Community of West African States (ECOWAS) launched a regional certification scheme with support from IRENA, GIZ and the World Bank. The aim of the scheme, known as ECOWAS Certification of Sustainable Energy Skills, is to promote professional competency and address quality assurance gaps in the renewable energy and energy efficiency value chain. The scheme is based on a job-task analysis developed by IRENA in co-ordination with ECOWAS member states. ECREEE aligns all certification systems to the requirements of ISO/IEC 17024:2012 ("conformity assessment general requirements for bodies performing certification of persons"). This facilitates regional and international recognition of sustainable energy professionals' credentials. At the moment, the scheme covers technicians focused on off-grid solar photovoltaic systems (ECREEE, 2019).

In East Africa, several training institutes are now developing skills needed for the sector. In Kenya, Renewable Energy Solutions for Africa (RES4Africa) has established the MicroGrid Academy with local partners, including the Institute of Energy Studies and Research, the University of Strathmore, St Kizito Vocational Training Institute, and AVSI, a non-governmental organization. In the United Republic of Tanzania, the Kilimanjaro International Institute for Telecommunications, Electronics and Computers offers a professional development course for solar mini-grid installers, operators and site managers. In Uganda, the Centre for Research in Energy and Energy Conservation supports research on rural electrification, productive use of energy and energy entrepreneurship (Energy4Impact and Inensus, 2018).

Beyond technical skills, local entrepreneurs also benefit from capacity building to support enterprise development and access to financing. Several regional and national facilities now assist local private sectors in securing enterprise development grants and assistance. The ECOWAS Renewable Energy Entrepreneurship Support Facility was established in 2015 by IRENA, ECREEE and the International Institute for Water and Environmental Engineering (2ie). The facility has supported over 80 enterprises in the 15 ECOWAS countries through training courses, advisory assistance, networking and matchmaking with financial institutions (IRENA, 2020b). IRENA set up a similar facility in southern Africa in 2017 in partnership with the Southern African Development Community's (SADC) Centre for Renewable Energy and Energy Efficiency. Since the launch, nine partners – funding institutions, business incubation centres and technical training centres – have joined the facility (IRENA, 2020b). Under SADC's Entrepreneurship Support Facility, over 70 small and medium enterprises in the region have received support on business management and the technicalities of renewable energy systems. Some have also benefitted from mentoring. Financial institutions in the region have been trained on the evaluation and appraisal of renewable energy projects.

A key area of concern remains equitable access of under-represented groups to capacity-building opportunities (IRENA, 2019b). To tackle this, some training sessions backed by development partners require a minimum enrolment of women (*e.g.* GIZ has targeted 30% in its recent initiatives) (Sharma and Trace, 2021).

6.2.2 Improving quality of supply in grid-connected areas

Distributed renewables are increasingly seen as a tool to improve the reliability of electricity services in grid-connected areas, and to support grid densification and intensification. Most distribution utilities across the African continent are presently under-recovering costs and find it challenging to raise capital to upgrade distribution infrastructure and thereby expand access. This results in unreliable electricity services, often leading to reliance on fossil fuel-based backup generators, particularly among commercial

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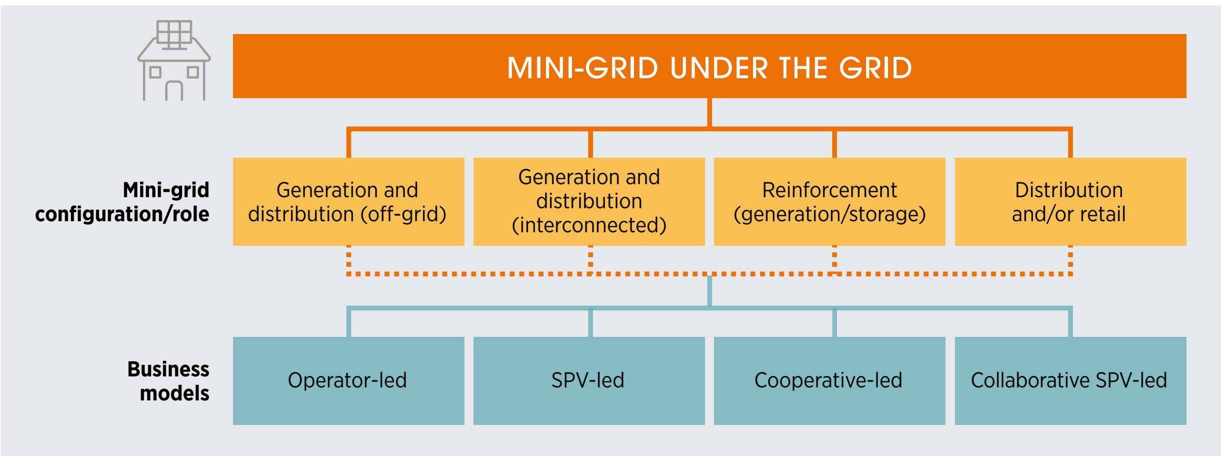
and industrial consumers. With the increasing cost competitiveness of distributed renewables (*e.g.* rooftop solar), large consumers are shifting towards investments in captive distributed renewable energy systems to meet all or part of their electricity needs. However, this trend exacerbates the problems of distribution utilities, as high-paying commercial and industrial consumers, which traditionally cross-subsidise residential users, reduce their reliance on the grid.

To improve the quality of electricity supply and attract investments in distribution infrastructure, distribution utilities are beginning to integrate distributed renewables into their business models (Mahomed *et al.*, 2020). Various configurations of such models are possible (Figure 6.4) depending on the range of services a mini-grid provides (*e.g.* generation, distribution, retail) and the nature of involvement of the private sector and communities. Whatever the configuration, mini-grids operating "under the grid" offer the opportunity to improve services for parts of a distribution licensees' coverage area by making investments in networks, generation assets and metering, as well as through enhanced customer engagement. Two prominent examples are emerging – in Uganda and Nigeria.

In Uganda, the Utilities 2.0 initiative is a partnership between the privately-owned distribution utility (Umeme), a private developer (Equatorial Power), Power for All, EnerGrow and the Rockefeller Foundation. It aims to strengthen collaboration between existing distribution utilities and private renewables-based mini-grid developers. In this case, the private sector owns and operates the mini-grid and connects to the network offered by the existing distribution utility. The first pilot mini-grid under the programme – comprising 40 kW of solar and a 140 kWh battery – was commissioned in Kiwumu. It supplies 300 households along with local enterprises. The anchor load for the mini-grid is a containerised milling and dryer unit consuming about a quarter of the power generated (Cohn, 2021).

In Nigeria, the regulatory framework for interconnected mini-grids was recently strengthened. In March 2020, the Nigerian Electricity Regulatory Commission approved a sub-concession agreement between a distribution licensee (Kaduna Electricity Distribution Company) and a new private sector entity, Konexa. The agreement allows Konexa to provide electricity services in selected parts of the Kaduna's franchise area using an integrated approach involving the use

Figure 6.4 Overview of "mini-grid under the grid" configurations



Source: Rocky Mountain Institute, 2019; MIT Energy Initiative, 2020.
Note: SPV = special purpose vehicle.

of stand-alone systems and mini-grids. One of the most appealing features for Konexa is the ability to carve out special purpose vehicles containing utility assets that allow infrastructure investors to come in without taking on the risk of the incumbent utilities' financial condition (Miller, 2019). The Abuja Electricity Distribution Company has also developed a distributed energy solutions strategy to strengthen the development of embedded and interconnected mini-grids (Perez-Arriaga and Stoner, 2020). The first interconnected mini-grid in Abuja was set up to cater to the 5 000 traders in the Wuse market (Box 6.5).

6.2.3 Linking electricity supply with public services and livelihood applications

There is growing recognition that efforts to increase electricity access must be more strongly linked to income-generating activities and public services. Targeted measures to link electricity access programmes with such end uses can improve the sustainability of distributed renewables by stimulating demand and raising consumers' ability to pay, as well as propel progress towards several SDGs. The emphasis on linking electricity supply with livelihoods and public services has grown in the context of the COVID-19

Box 6.5 Interconnected mini-grids in Nigeria: The case of Wuse Market

The Energizing Economies Initiative incentivises the deployment of mini-grids to support micro, small and medium-sized enterprises in economic clusters, including markets, shopping complexes, and agricultural and industrial areas. The Wuse Market interconnected mini-grid in Abuja is the first interconnected mini-grid to address the need for reliable electricity supply and reduce dependence on expensive fossil fuel-based generators.

The initiative involved a tripartite agreement between the distribution utility (Abuja Electricity Distribution Company), a private sector developer (Green Village Electricity) and the Wuse Market Traders Association for development and operation of a 1 megawatt (MW) mini-grid system. The project will supply round-the-clock electricity for over 2 150 shops with 5 000 traders, while cutting down the use of some 3 000 fossil fuel-based power generating sets.

The private sector developer is responsible for investments in generation and distribution assets, including operation and distribution activities such as metering, billing and collection. The distribution company owns the existing distribution assets and provides electricity supply at the point of interconnection. The Traders Association has played an instrumental role in organising consumers for the project. Customers were able to negotiate a lower tariff payment (N 55/hr or USD 0.13/hour) in comparison to what they had been spending on fuel/diesel generators and the grid-connected electricity supply (a monthly average of N 12 592 or USD 30.45).

The Wuse Market project has paved the way for future projects that utilise interconnected mini-grids to power economic clusters under the Energizing Economies Initiative. The Rural Electrification Agency undertakes feasibility assessments, including energy audits, to identify such clusters.

Source: SD Strategies, 2021; Rockefeller Foundation, 2020.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response (*e.g.* for the delivery of health care and the vaccine supply chain) and enhancing resilience of rural livelihoods to future shocks (IRENA, 2020c).

The SADC Centre for Renewable Energy and Energy Efficiency, for instance, is implementing a project on "Improvement of Livelihoods in SADC Member States through the Adoption of Distributed Renewable Energy for Productive Use." The project aims to promote a water-energy-food nexus approach through which renewables will be deployed to improve livelihoods (SACREEE, n.d.).

Distributed renewable energy solutions are ideal for providing tailored energy services to support livelihood activities. There are differences between a technology-centred approach (*i.e.* one that aims to accelerate the deployment of mini-grids, solar home systems or another technology) and one that is centred on end users' livelihoods or services. To work, the latter approach requires certain additional factors to be in place, including market linkages, sector-specific skills and energy efficient appliances (Figure 6.5) (IRENA and SELCO Foundation, 2021). In the United Republic of Tanzania, for instance, measures to support solar irrigation solutions are being combined with efforts to engage suppliers of agricultural inputs and extension services, as well as companies that source fresh organic vegetables and green beans, to improve market linkages for smallholder farmers (Elico Foundation, 2020).

This section discusses two cases, one linking renewable energy with livelihoods in the agriculture sector, and the other the delivery of health services which has gained relevance in the context of COVID-19 response.

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In focus: Renewables and agriculture

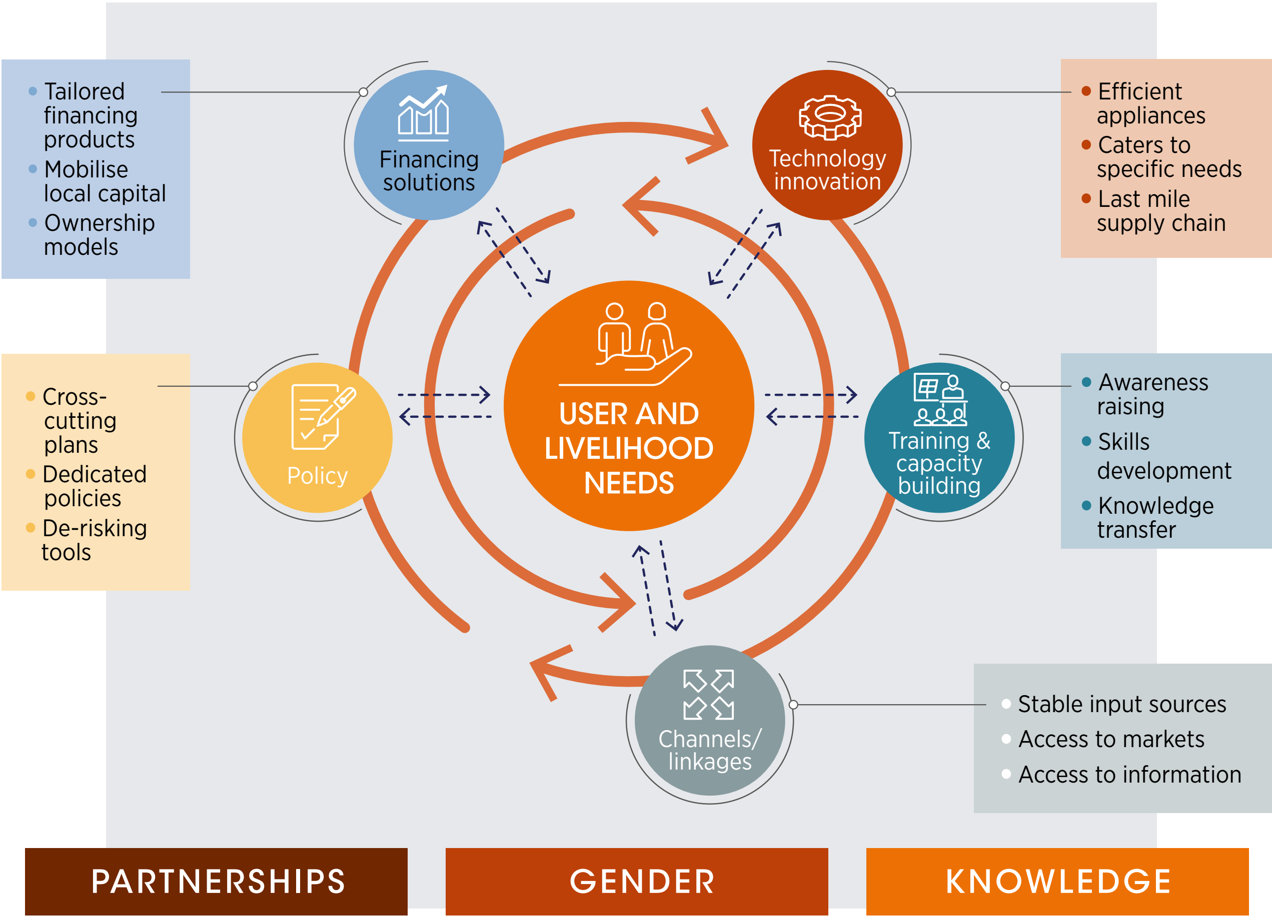
Agriculture accounts for the largest number of jobs (mostly informal) on the continent, as discussed in Chapter 1. Energy is a crucial input at each step of agricultural value chains, from primary production to processing, storage and cooking. But although Africa has a sixth of the world's population, energy consumption in its agriculture sector was just 4% of agricultural energy use worldwide. That figure has remained largely constant over the past decade despite growing food demand from a growing population. The large energy gap will need to be met to raise productivity, strengthen supply chains, reduce food losses and improve food security. At the same time, continuing to meet energy needs through fossil fuels poses challenges in terms of accessibility, affordability, resilience to supply and price shocks, and environmental protection, especially related climate change (IRENA and FAO, 2021).

Distributed renewable energy solutions can play a central role in bridging the energy gap at every step of the agri-food value chain.

In the primary production stage, renewables-powered irrigation is increasing yields and reducing reliance on erratic rains (IRENA, 2016b). The technical potential for solar water pumps on smallholder farms (less than 1 hectare) is at least 130 million systems across West, Central and East Africa (GOGLA, 2020c). In Rwanda, smallholder farmers using solar irrigation pumps improved their yields by about a third. Many were able to grow crops in the dry season for the first time (Energy4Impact, 2021). Integrating the water-energy-food nexus into planning the deployment of solar irrigation solutions can maximise benefits while ensuring resource sustainability (*e.g.* by avoiding groundwater overextraction).

In the processing stage, depending on the value chain being considered, renewables can power milling, threshing machines, chillers and dryers to increase value and reduce losses for local farmers and agri-enterprises (IRENA, 2016c). The potential for solar mills and threshers is especially large – 940 000 units in Sub-Saharan Africa alone (IFC, 2020). Beyond solar milling, specialised applications can

Figure 6.5 Ecosystem for linking electricity access with livelihood applications



Source: IRENA and SELCO Foundation, 2022 (forthcoming).

also be found in the value chains of oil, poultry, dairy and coffee. In Sierra Leone, for example, a 250-kW hydro-based mini-grid powers a palm oil pressing plant, which also improves the financial case for the mini-grid, as the plant buys a third of the electricity generated (Power for All, 2020). In Kenya, pilot projects have been launched to use geothermal heat to pasteurise milk, heat aquaculture ponds and dry grain. Substantial potential exists in meat and honey processing, as well, and in postharvest crop preservation (IRENA, 2019c).

Demonstration projects are under way to create renewables-powered agro-processing hubs in rural areas. In the Kamwenge district of Uganda, a biomass gasification plant produces electricity and heat for a hub to which farmers bring their produce for sorting, drying and processing. Residues are then used as fuel. The electricity thus produced powers further agro-processing and other local economic activities, as well as local households (EEP Africa, 2018). Renewables-based cold storage is helping to maintain the quality of produce, reduce losses and enhance market access (IRENA and FAO, 2021).

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For end users, renewables-based clean cooking using solid biomass, biogas or electricity reduces dependence on traditional firewood, sparing households and communities the negative health and environmental impacts of burning firewood (discussed further in Section 4).

Closely linking the development of energy and agriculture infrastructure promises significant socio-economic benefits. In Ethiopia, electrification of agricultural activities could save fuel costs or enable significant new revenue generation for rural smallholder farmers and small and medium agricultural enterprises. Analysis of six value chain opportunities covering grains, high-value crops and the dairy sector finds that these could generate revenue streams worth USD 4 billion between 2020 and 2025 (Borgstein, Wade and Mekonnen, 2020). They would also be likely to create thousands of new jobs along the value chains of various agri-commodities (Box 6.6). The Ministry of Water, Irrigation and Energy is leading a collaboration to assess the economic viability of 285 potential mini-grid sites, with a focus on the agricultural commercialization clusters (Ethiopia Job Creations Commission, 2021).

Scaling up the use of renewable energy in food systems to jointly advance energy and food-security goals requires coordination across sectors by decision makers in government, the private sector, international organisations, financing institutions, academia and nongovernmental organisations. Box 6.7 summarises key actions areas to facilitate deployment of renewables in food systems.

Box 6.6 Job creation through off-grid energy access in agriculture: Insights from Ethiopia

Ethiopia is one of the largest economies in Africa, with a large youth population. Over half of young adults are unemployed or underemployed, with 600 000 new workers entering the labour force each year. Solar-powered solutions for micro, small and medium enterprise in agriculture, trade and industry offers significant untapped potential for job creation.

Across three value chains – horticulture, wheat and milk – technologies to stimulate productive end uses could create about 190 000 jobs by mechanizing tasks and expanding production capacity.

In the horticulture value chain, solar water pumps could meet irrigation needs, helping create approximately 130 000 new jobs across the value chain from sales to processing as production increases. In wheat, renewables-based technologies could solve the problems of unreliable electricity faced by micro, small and medium enterprises, creating an estimated 50 000 jobs at various stages of the value chain. Dairy farmers produce about 4 billion litres of milk a year in Ethiopia, however 20-35% of that production is lost, primarily for lack of cooling. Milk chilling from source to retail could reduce spoilage and wastage, creating an estimated 11 000 jobs.

Source: Ethiopia Jobs Creation Commission, 2021.

Box 6.7 Scaling-up renewable energy use in agriculture

A joint report published by IRENA and the Food and Agriculture Organization of the United Nations, *Renewable energy for agri-food systems: Towards the Sustainable Development Goals and the Paris Agreement*, presents an action agenda to accelerate the deployment of renewables in the agri-food systems. It includes efforts to 1) improve data and information to guide investments; 2) enhance access to financing for end-users, enterprises and intermediaries; 3) advance holistic approaches in national strategies and policies to transform energy and agriculture sectors; 4) facilitate energy efficient appliances and greater awareness; and 5) mainstream the water-energy-food nexus approach to minimise competition and leverage synergies in water-in and land-use.

Source: IRENA and FAO, 2021.

In focus: Renewables and health care

Access to reliable and sufficient energy is essential for the proper functioning of healthcare facilities. A complete picture of energy access in such facilities remains elusive owing to data limitations, but evidence points to significant gaps. A survey of over 4 000 clinics and hospitals in 11 countries of Sub-Saharan Africa found that about one in four has no access to electricity and most of those that do have access have an unreliable supply (WHO, 2014). Wide disparities exist between countries. In Ethiopia, over 40% of health institutions are estimated to have no access to electricity, while 25% rely on off-grid solutions (IEA, IRENA, *et al.*, 2020). In Niger, the figures are 28% with no access and more than half relying on off-grid systems. In Kenya, 77% of health facilities receive electricity from the grid, though reliability is a concern (IEA, IRENA, *et al.*, 2021).

Distributed renewable energy solutions offer a reliable, affordable and rapidly deployable ways to address these deficits, particularly in rural areas with low resources. As an integral part of the COVID-19 response, several countries on the continent have rolled out programmes to deploy mini-grids and stand-alone systems to power


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remote clinics, quarantine centres and testing facilities. Nigeria's Rural Electrification Agency has already deployed solar-hybrid mini-grids to improve electricity services to healthcare centres, including some 200 offering primary care (REA, 2020; Takouleu, 2021). The United States Agency for International Development's Power Africa Off-grid Project has provided financing for the electrification of 300 healthcare facilities in Africa using solar-based solutions (Power Africa, 2020).

To guide investments and facilitate resource mobilisation into projects at the energy-health nexus, IRENA supports member countries in undertaking comprehensive assessments of energy needs in rural health care. In partnership with local stakeholders and using primary data, the assessments identify optimised renewables-based technical solutions that can serve as a blueprint for replication within the country and provide recommendations for implementation looking into policy, resource mobilisation, institutional oversight. The first of the assessments, done in Burkina Faso in co-ordination with the nation's energy and health ministries, is nearing completion (Box 6.8). Similar assessments have begun in Mali and São Tomé and Príncipe, and talks are under way with Cameroon and Mozambique. This workstream is included in a multi-partner Energy Compact on Health Facilities Electrification that aims to ensure 1) that 25 000 health facilities are sustainably equipped with robust, clean and reliable power solutions, and 2) that detailed country assessments for electrification of health facilities are carried out in up to 20 countries with large energy access gaps. Among the partners in the compact are USAID, Power Africa, SEforAll, IRENA, the United Nations Children's Fund, Gavi (Global Vaccine Alliance) and the SELCO Foundation. The compact is also endorsed by the Clinton Health Access Initiative and the Health and Energy Platform for Action led by the World Health Organization.

Box 6.8 IRENA energy assessment for healthcare facilities: The case of Burkina Faso

In 2020, in partnership with the Ministry of Energy and the Ministry of Health, IRENA launched the Sector Assessment for the Electrification of Primary Health Care Facilities in Burkina Faso. With the SELCO Foundation, the project involves an analysis of the rural health sector focusing on policy, financial, technical and institutional gaps. It is evaluating energy needs across the rural medical value chain, assessing appliance use, energy efficiency and building design using an ecosystem approach. The resulting sector assessment report will include optimised technical designs and cost estimates for rural healthcare facilities. The assessment is being carried out in three phases:

- **Pre-assessment.** The phase began with an effort to understand priorities, baselines, gaps and needs to undertake an analysis of the health-energy landscape in the country and selecting sample facilities and local partners for the detailed assessment performed in phase 2.
- **Assessment.** Phase 2 involved a series of workshops, bilateral meetings and collections of primary data from a sample of 50 health facilities (out of a total of a total of around 1 800 facilities) across five geographic regions of the country. The goal was to assess the technological, institutional, financial and policy aspects of electrification of rural health facilities of Burkina Faso.
- **Post-assessment.** IRENA and the Burkina Faso ministries of energy and health are developing recommendations and a way forward on technical design of solutions for the un- and under-electrified rural healthcare facilities (existing and future). Financial, capacity-building, policy and programme design aspects will be weighed.

Preliminary results are currently being substantiated with primary data and will be validated by a wider network of local and regional stakeholders from the energy and health communities.

6.3 CLEAN COOKING WITH RENEWABLE ENERGY SOLUTIONS

Access to clean cooking solutions is a central pillar of the just energy transition in Africa. In North Africa, more than 90% of the population has access to clean cooking, compared with just 17% in Sub-Saharan Africa. At 4%, rural access rates are even lower. Low rates of access to clean cooking are found across all regions of Sub-Saharan Africa. Even in Southern Africa, where Angola, Botswana, Eswatini and South Africa have rates above 50%, Malawi and Mozambique are at only 2% and 5%, respectively. Sub-Saharan Africa is the only region in the world where the number of people without access to clean cooking has increased over the last decade, from 746 million in 2010 to 906 million in 2019 (IEA, IRENA, *et al.*, 2021). This deteriorating situation has been caused by a lack of progress in implementing clean cooking solutions, combined with rapid population growth.

Most households have little choice but to burn biomass fuels (mostly firewood and charcoal) on open fires or in inefficient stoves. The social, economic and environmental costs of this are immense. Almost 700 000 Africans, most of them women, die prematurely every year due to household air pollution linked mainly to cooking (Fisher *et al.*, 2021). In rural areas, women and children often spend many hours collecting firewood, hours that could instead be used for other productive activities, education or leisure. Firewood collection and charcoal production also contribute to deforestation and degradation, which has severe local impacts (*e.g.* on water cycles, in turn affecting agricultural livelihoods), while contributing to global climate change. Solid fuel cooking in Sub-Saharan Africa has been estimated to account for 6% of global black carbon emissions and 1.2% of global carbon dioxide emissions (UNEP, 2019). Overall, the external cost of inaction on clean cooking, driven by negative externalities for health, gender and climate, is estimated to be in the order of USD 330 billion per year in Sub-Saharan Africa (ESMAP, 2020a).

Where there has been progress on clean cooking in Africa, it has been achieved largely in urban areas through use of liquid petroleum gas (LPG) and electricity, although not necessarily renewables-based electricity (ESMAP, 2020a). However, overall cooking across Sub-Saharan Africa remains highly dependent on biomass. In urban areas, charcoal is the most common fuel, while in rural areas firewood prevails. In 2019, Africa accounted for 65% of the world's charcoal production, with production increasing by 22% between 2010 and 2019 – from 28.45 million tonnes to 34.7 million tonnes. The 2019 figure is 2.6 times the amount of charcoal produced in Asia (FAO, 2021a). Africa is the only continent where charcoal production is still increasing.

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Over the next two to three decades, Africa will need to shift to renewable cooking options. This will involve both cleaner bioenergy solutions (including biogas and bioethanol) and renewables-based electric cooking.

6.3.1 Improved solid biomass cooking

Considering the large reliance on and the lack of alternatives to solid biomass in many (especially rural) areas, it is likely to continue playing an important role in cooking in Africa for some time. The socio-economic aspects of wood fuel production and use are complex. For many people in the poorest communities, cooking on inefficient three-stone fires or basic stoves with "free" firewood collected locally is the only available or affordable option. Where fuel is bought, it often constitutes a significant part of a household's budget – between 5% and 10% of household income in rural areas of Nigeria, Ethiopia and the Niger (ESMAP, 2020a). At the same time, wood fuel value chains have economic importance, with charcoal production being an important part of the informal economy, employing an estimated 7 million people in Sub-Saharan Africa (UNEP, 2019). Culturally, cooking with wood fuels is deeply ingrained and would require a radical shift, which is unlikely in the short-to-medium term. Even where households have access to modern fuels, traditional or minimally-improved biomass stoves are widely used in parallel with the modern alternatives (World Bank, 2014). Biomass solutions that can improve efficiencies, cut indoor air pollution, reduce drudgery but still maintain employment in the cooking value chain are therefore likely to play an important role in Africa's clean cooking pathways.

In principle, biomass cooking can be a renewable solution, provided the fuel is harvested sustainably and is used efficiently in low-emission stoves, thus also reducing the health impacts. However, in Sub-Saharan Africa, this is generally not the case. Population pressure combined with inefficient fuel use in basic cookstoves or three stone fires, has contributed to deforestation across much of the continent. It has been estimated that 90% of all wood removals in Africa are for fuelwood (Forest Research, 2019). However, opportunities exist to make solid biomass cooking more sustainable through changes to the fuels used and improvements to cookstoves.

On the fuel side, the options include briquettes made from agricultural waste, improved carbonisation efficiencies for charcoal, and efficient pellets made from plantations or invasive species (Box 6.9). Improved biomass fuels not only reduce the pressure on forests but can also burn more cleanly and be cheaper than traditional fuels. In rural areas, where fuelwood is often collected for free, the economic case for improved fuels is more difficult to establish.

Efforts to improve the efficiency of cookstoves go back to the 1980s and have received attention from many development projects and programmes over the years (Stevens *et al.*, 2020). A range of improved stoves are now available, from basic models that provide efficiency improvements of 20-35% to intermediate ones that improve fuel efficiency by to two-thirds (World Bank, 2014). These types of stoves can help reduce fuelwood use and the associated problems of drudgery and deforestation. However, very few biomass stoves meet high standards for household emission performance. Some advanced stoves (*e.g.* updraft gasifier stoves) can meet Tier 4 standards.[8] But these stoves require electricity (typically from a small solar panel which can also be used for phone charging) to operate an internal fan and are often used with processed biomass such as wood pellets.

Data on the take-up of improved biomass cookstoves across Africa are scant, but there is evidence that the lower-tier improved stoves (such as the Kenya Ceramic Jiko charcoal stove) have reached some scale and a good level of market development in several countries, especially for urban charcoal users (ESMAP, 2015b). BURN manufacturing of Kenya has sold over

8 The International Organisation for Standardisation (ISO) has published voluntary performance targets for cookstoves based on efficiency, efficiency, safety and durability. The scale runs from Tiers 0 to Tier 5. The emission rates of Tier 5 align with the World Health Organization's guidelines for indoor air quality. https://www.cleancookingalliance.org/technology-and-fuels/standards/iwa-tiers-of-performance.html.


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1 million locally manufactured improved stoves for use in household and institutional settings (Burn Stoves, 2021). In Ghana, the Gyapa, a stove similar to the Kenyan Jiko, has seen sales of almost 1.5 million to date (Climate Care, 2021).

It has been more difficult to find a successful business model for the most advanced stoves, which require pellets as fuel. The costs of the stove and fuel combined can be unaffordable. Inyenyeri, a Rwandan-based company, failed in 2020 despite significant donor and investor interest. In Zambia, SupaMoto is trying out a PAYG model for the same stove as used by Inyenyeri, fuelled by pellets produced from sawdust and

Box 6.9 Improved solid biomass fuels

Carbonised **briquettes** are increasingly being used as alternative cooking fuels. Briquetting is a technique that converts residues with a low heating value to high density fuels. A range of agricultural wastes, saw dust or forestry trimmings can be used for briquetting, providing an alternative to traditional charcoal.

Examples include Kenya's Acacia Innovation which produces sugarcane briquettes that provide savings of 50% compared to charcoal and 35% compared to fuelwood where this has to be purchased (SEforAll, 2020d). In Uganda, Green Charcoal Uganda produces briquettes by using agricultural waste like rice husks and palm kernel husks, combined with more efficient charcoal kilns. The resulting fuel is more carbon-dense and burns for longer (Torvaney, 2021). In Mali, AFOvert produces charcoal briquettes from charcoal dust (OPEC Fund, 2017), thus improving one part of the very wasteful charcoal supply chain.

Traditional charcoal kilns are only between 8-15% efficient (UNEP, 2019). There are a number of **improved kiln technologies**, such as the Casamance kiln which was first developed in Senegal. It has efficiencies of up to 30%, produces higher quality charcoal and can be constructed at fairly low cost (Schure *et al.*, 2019). In Kenya, a pilot project in Baringo county aims to improve the sustainability of charcoal by using an invasive species (Prosopis juliflora) combined with greater kiln efficiencies (GBEP, 2020). However, the adoption of such improved technologies has been low in sub-Saharan Africa due to challenges associated with affordability, consumer awareness and end-user preferences.

Another option for agricultural waste, sawmill residues or invasive species is to produce energy-dense **pellets**. They are particularly suitable for use in gasifier stoves, potentially providing a low emission cooking solution. Pellets are still a niche cooking fuel in Africa, but a few examples exist. Abellon CleanEnergy, who pioneered biomass pellet-based cooking in India, has expanded into Africa and in 2015 built a pellet factory in Ghana operating on wood waste (Abellon, 2021). In Zambia, Emerging Cooking Solutions produces SupaMoto branded pellets from sawdust from pine and eucalyptus plantations. It has sold pellets and cookstoves to 20 000 households. Costs are 30-40% lower than charcoal (SupaMoto, 2021a).

agricultural waste. The company has been selected to join the Clean Cooking Alliance Venture catalyst, which will provide business development support to enable investment and growth (SupaMoto, 2021b).

Improved biomass cookstoves continue to be supported across Sub-Saharan Africa by governments, donor programmes and carbon finance in recognition of their climate benefits. Voluntary carbon finance based on offsetting emissions from charcoal, firewood and, in some cases, LPG is an important source of funding for improved cookstove programmes. The Green Climate Fund includes in its portfolio a USD 27.6 million improved cookstove programme in Kenya and Senegal (GCF, 2019). Reflecting the complexity of the biomass cooking supply chain, support programmes target a variety of aspects such as product innovation, business development, marketing and end-user subsidies. However, these types of programmes remain a drop in the ocean; Africa has a long way to go before biomass cooking improves widely enough that it can be considered a truly renewable and sustainable solution.

6.3.2 Biogas for cooking

Biogas is one of the cleanest cooking options, producing very low indoor emissions and bringing multiple environmental and social benefits (IRENA, 2017). It can play an important role in rural Africa, where it can also contribute to poverty reduction. Many of Africa's poor are smallholder farmers, most of whom keep livestock. Their manure and other agricultural waste can be used as feedstock for biogas production; digestate, a by-product of the process, can be used as fertiliser. There is also scope for larger-scale biogas production in Africa to deal with urban organic waste. If improved, sewage infrastructure and urban waste management in many African countries could provide opportunities for biogas production (Austin and Morris, 2012).

Several African countries have implemented market-oriented biogas programmes over the past two decades. These have encountered challenging conditions, leading to the under-delivery of targets. For example, in Senegal, a government biogas programme established under phase I of the Africa

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Biogas Partnership Programme (Box 6.10) had aimed at installing 8 000 digesters between 2009 and 2013. However, fewer than 600 units were installed, and the country was dropped from the ABPP owing to poor performance of the implementing agency (Fair & Sustainable Consulting, 2019). The ABPP overall had targeted 100 000 digesters in its second phase (2014-2019), yet by 2019 it had delivered only 38 000. Rwanda's biogas programme, introduced in the mid-2000s, had an initial target of 15 000 household biogas plants by 2011. The target was downscaled twice, and by the target date fewer than 2 500 digesters had been installed, many of them non-functioning (FAO, 2021b).

Notwithstanding this under-performance, the number of Africans cooking with biogas increased to 410 000 by 2019. However, this represents less than 0.5% of Africa's biogas potential. There may be scope for deploying digesters in 18.5 million households (World Bank, 2019). Challenges related to technology and quality of installations, capital costs and access to affordable financing were evident in the early Senegal and Rwandan programmes and continue to limit uptake across the continent. A recent analysis of the Rwanda situation suggests that biogas systems must be designed based on a better understanding of key parameters, such as manure production rates, water access rates, livestock numbers and demand for cooking energy (FAO, 2021b). Affordability remains a major challenge, as it is with other clean cooking solutions. Biogas systems are capital intensive, and the upfront investment is beyond the reach of many rural households. A lack of awareness of the existence and benefits of biodigesters is also a key barrier, as is the absence of guiding policies and a supportive regulatory framework (World Bank, 2019).

Some countries that encountered early problems have been successful in attracting new funding. For example, Senegal set up a new National Domestic Biogas Programme in 2019; in 2021, the Swiss government announced its support for the programme's aim to develop 60 000 biodigesters

Box 6.10 Africa Biogas Partnership Programme

The African Biogas Partnership Programme (ABPP) was established in 2009 with Dutch aid to create viable biodigester markets in Sub-Saharan Africa. The programme was implemented in two phases by development organisations Hivos and SNV. Phase I operated from 2009 to 2013, initially in Burkina Faso, Ethiopia, Kenya, Senegal, the United Republic of Tanzania and Uganda. Phase II (2014-2019) excluded Senegal. Phase I focused on building technical and institutional capacity. Ambitious biodigester targets were set but not achieved owing to challenging conditions. In Burkina Faso, only 44% of the target was achieved in the face of a lack of expertise, a weak private sector and difficult climate conditions (Fair & Sustainable Consulting, 2019).

ABPP shifted its focus in Phase II, adding incentives targeting producers and other upstream actors instead of consumers (Clemens *et al.*, 2018). More than 38 000 biogas digesters were installed during Phase II (REN 21, 2021). While well below the targeted 100 000 installations, the programme did make some progress towards commercially viable biogas markets, especially in Kenya. A follow-up programme, the African Biodigester Component, has received funding from the Dutch government for 2021-2025. It is being implemented by the Netherlands Enterprise Agency in partnership with EnDev in Burkina Faso, Kenya, Uganda, Mali and the Niger. The goal is to deliver 50 000 small digesters by 2025, in part by improving access to finance and strengthening biogas enterprises.

Sources: Clemens et al., 2021; Fair & Sustainable Consulting, 2019; REN 21, 2021; RVO, 2021.

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from cattle dung and faecal sludge (Magoum, 2021). Senegal is also one of eight founding nations in the Biodigester Alliance of West and Central Africa, the aim of which is to accelerate the use of biogas in the region (AB-AOC, 2021). The Alliance is now being supported by the Dutch-funded African BioDigester Component (see Box 6.6). In Ethiopia, the European Union and the Ethiopian government–funded Biogas Dissemination Scale-Up Programme (NBPE+) had delivered 13 000 household and 8 large-scale digesters by April 2021. It has also pioneered a large-scale biodigester for on-farm electricity generation (SNV, 2021b).

A major development in recent years has been the entry of companies selling prefabricated modular systems in East African markets, particularly Kenya. One of them, the Mexican social enterprise Sistema.bio, has sold more than 4 000 biodigesters, also offering finance, after-sale service and training. In 2019, Sistema.bio raised USD 12 million of venture capital, followed in 2020 by a EUR 387 000 grant from EEP Africa, a clean energy financing facility managed by the Nordic Development Fund. The aim is to install 4 000 biodigesters, focusing on women as sales agents and beneficiaries (EEP Africa, 2021).

These developments show that biogas can make progress in Sub-Saharan Africa. It has reached a high level of acceptability in several countries and attracted private sector players. But scaling up biogas across more countries will require supportive policy and regulatory frameworks that link agricultural policy with energy policy. In the short-to-medium term, some financial support will be needed to improve viability for end users, strengthen biogas companies and build markets.

6.3.3 Renewables-powered electric cooking

Electricity has to date played a very limited role in providing access to clean cooking in Africa. In only a few countries where grid electricity access is high, notably South Africa, has electric cooking gained a foothold. However, South Africa's grid is mainly coal-based, with only 10% of electricity generated from renewables (Malinga, 2021). In some countries with a well-developed grid, unreliable supply has actually forced a return to solid biomass cooking. For example, in Zimbabwe, as power cuts have become more frequent since 2019, people have increasingly gone back to charcoal cooking (Ngezi, 2019).

Sub-Saharan Africa's widespread lack of access to electricity, combined with the inefficiency of available appliances (such as hot plates) to prevent electric cooking from being seen as a viable solution. In particular, off-grid electric cooking with solar photovoltaic (PV) has been considered unrealistically expensive. However, with the decline of solar PV and battery costs, electric cooking has become more affordable in certain settings. Since 2016, the cost of solar modules and lithium-ion batteries

has decreased by 30-50%, and electric cooking appliances have become more efficient (Efficiency for Access, 2019; Couture and Jacobs, 2019).

The expansion of mini-grids in several African countries also offers opportunities to expand electric cooking. Solar mini-grids are often under-used; expanding household consumption to cooking offers an opportunity to make better use of available power (Onjala, 2020). However, to date there is limited experience with mini-grid e-cooking in Africa (Blair, 2020). One reason for the under-use is that mini-grids tend to have relatively high tariffs, because, unlike national grids, they are not subsidised. Not surprisingly, the price of electricity is a major determinant of use of electric cooking appliances (Kweka *et al.*, 2021).

Electric cooking on AC (alternating current) grids is already cheaper than cooking with charcoal in some urban centres in Africa (World Bank, 2020b). To make renewables-based electric cooking more widely affordable and feasible, efficient appliances, especially in off-grid settings, are needed. Electric pressure cookers are the focus of a number of pilot projects but their high up-front costs (typically up to USD100) remain a key challenge. Many of the poorest households are not able to afford the upfront costs and their access to finance tends to be very limited (MECS, 2021). This is the same problem as for other modern cooking solutions such as gasifier stoves or biodigesters.

Additionally, the use of electric pressure cookers leads to a very different type of cooking, requiring behavioural changes. However, at the same time there can be benefits such as time saving for some dishes (Leary *et al.*, 2021). Increased convenience could become a driver for uptake as urbanisation continues to increase across Africa and lifestyles change (Leary *et al.*, 2021). Pilot programmes for electric cooking in Kenya have tried to create awareness about the benefits of e-cooking, with a focus on local dishes (Box 6.11).

Box 6.11 Promoting electric cooking in Kenya

For the last few years, Kenya has had underutilised power capacity, with supply outstripping demand. Power reliability has improved considerably and in 2019, 89% of the country's generation was from renewable sources. In principle, this provides good conditions for electric cooking but currently only 3% of Kenyan households own an electric cooking appliance.

Kenya Power and Lighting Company (KPLC) launched its Pika na Power (Cook with Electricity) campaign in 2017 to encourage its customers to cook with electricity as a means to stimulate demand for surplus power on the national grid. The campaign promoted electric cooking on national TV and social media, using celebrities to demonstrate how easy it is to cook Kenyan meals with electric cooking appliances. They also ran bi-weekly cooking classes.

Electric Pressure Cookers were virtually unknown in Kenya until recently but have been promoted under the UK-aid funded Modern Energy Cooking Services (MECS) programme. KPLC teamed up with MECS to demonstrate the use of pressure cookers. MECS has also produced an e-cookery book for traditional Kenyan dishes.

As the upfront costs of EPCs are still unaffordable to many consumers in Kenya, financial incentive mechanisms are important. Global Leap, with support from EnDev, ran an initial pilot RBF pilot programme in 2020 and announced a second round in October 2021. KPLC are also considering extending their 'stima loan' (electricity loan) concept from connection fees to ecooking appliances.

Source: Leary, Kalyonge and Kalyonge, 2019; Byrne, et. al., 2020; Leary, Menyeh, Chapungu and Troncoso, 2021.

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While interest in renewables-based electric cooking has increased significantly, it remains a distant solution for most African countries. In a recent global market assessment, Algeria and Kenya were the only African countries to score in the top 20 of countries with the greatest potential for a scaleup of electric cooking (MECS, 2021). A few other African countries scored well for specific opportunities in mini-grid cooking (Algeria, South Africa and Nigeria) or for stand-alone off-grid cooking (Kenya, Morocco, Nigeria, Rwanda, South Africa and Uganda). The assessment found that in Sub-Saharan Africa, the viability of a scaleup of electric cooking is most significantly hindered by the absence of energy infrastructure, a well-developed clean cooking market and other enabling factors (MECS, 2021). Affordability of appliances and electricity, resistance to new cooking methods and the lack of overall consumer awareness also hinder further development.

6.3.4 Creating an enabling policy framework for clean cooking

The barriers to adoption of renewables-based solutions to the clean cooking deficit in Africa include the lack of policy attention, cost and financing constraints, appliance and fuel standards, quality and skills, unreliable supply chains, cultural barriers, and limited awareness in local communities (IRENA, IEA and REN21, 2020). A comprehensive policy framework adapted to individual countries' circumstances can address these barriers. Key elements of such a framework are shown in Table 6.1

While there are many examples of individual policy measures to promote clean cooking in African countries, Sub-Saharan Africa scores below the global average for clean cooking policy frameworks, as measured by its score on the RISE index (ESMAP, 2020b). Out of 35 African clean cooking-deficit countries reported in the RISE clean cooking

Table 6.1 Clean cooking policy framework – key aspects

ADDRESS LACK OF POLICY ATTENTION	TACKLE COST AND FINANCE BARRIERS	BOLSTER SUSTAINABILITY AND SUPPLY CHAINS	CREATE AWARENESS ABOUT IMPACTS AND SOLUTIONS
• Prioritisation of clean cooking • Clean cooking strategies (inter-national and national) • Integrated energy planning, including grid, off-grid and clean cooking • Cross-ministerial approaches (including energy, health, agriculture and forestry)	• Financial support (e.g., results-based finance, direct consumer subsidies, low interest loans) • Fiscal measures (e.g., reduced VAT and import duties)	• Regulation and equipment standards • Licensing and certification • Fiscal measures • Training (e.g., business skills, installation and maintenance) • Enable access to early stage/growth capital	• Data collection on what works • Education, information and awareness programmes • Gender-inclusive policies and programmes

indicators,[9] only Ethiopia, Kenya and Uganda had advanced clean cooking frameworks. Meanwhile, almost all the lowest-scoring countries (*e.g.* Burundi, the Central African Republic, the Republic of Congo, Guinea and South Sudan) have close to zero per cent clean cooking access. With no or few plans and measures in place, these countries have little hope of making progress on the SDG 7 target related to clean fuels and technology.

Kenya is one of the countries with the largest improvements in RISE scores over recent years. Currently wood fuel is the primary fuel in 75% of Kenyan households but in 2019 the Kenyan government set a target for universal access to clean cooking by 2028. A range of policy measures and programmes are in place across various policy spheres – including health, forestry and gender. While some of these promote LPG cooking, others focus on renewables, including a bioenergy strategy and measures to promote biogas and bioethanol (New Climate Institute and EED Advisory, 2021).

Despite some progress in Kenya and a few other countries, clean cooking remains a major challenge for policy makers across Sub-Saharan Africa. Finance and other support continue to be lacking, with most multilateral and bilateral programmes continuing to focus on access to electricity. At the same time, the socio-cultural obstacles to advancing clean cooking remain complex and more attention needs to be given to cultural and behavioural issues, particular related to gender.

9 RISE indicators for clean cooking include planning (e.g. the existence of a plan, tracking), scope of planning (e.g. measures to involve women, targeting the most vulnerable groups), standards and labelling, incentives and attributes (https://rise.worldbank.org/

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6.4 PRIORITY ACTION AREAS TO REACH UNIVERSAL ACCESS TO MODERN FORMS OF ENERGY

Universal access to modern energy must be a cornerstone of Africa's energy transition. Without reliable, affordable and sustainable modern energy for every household, farm, enterprise, school and clinic, the continent's socio-economic development objectives will be difficult to attain. In addition to being a dedicated target of SDG 7, modern energy access in Africa is a matter of energy justice. A just and inclusive energy transition – an increasingly prominent goal in international discourse – will not be possible without addressing the problem of access on the continent with the lowest per capita energy consumption of all world regions and the largest energy deficit.

Alongside cost-competitive utility-scale renewables, distributed energy systems are now recognised by national governments and other public and private actors as key to expanding access to electricity and clean cooking in a timely and environmentally sustainable manner. Despite some progress in their adoption (as discussed in Chapter 2), distributed renewable electricity and clean cooking solutions must be scaled up significantly if the continent is to have a shot at reaching the 2030 target of universal access. The necessary scaleup will require concerted action by development partners, financing institutions, the local and international private sector, civil society, and academia, led by bold, ambitious action by national and local governments. In this context, this final section brings to the fore several priorities as efforts ramp up.

6.4.1 Energy access as a national and regional priority

Given its centrality for achieving socio-economic development goals, universal access must be a central national, regional and continental priority, as well as a key pillar of the region's COVID-19 recovery plans. "Light Up Africa" is one of the African Development Bank's "High 5" priority areas. Nigeria and a few other countries have integrated renewables-based access targets into their COVID-19 recovery plans. But only about 20 countries on the continent have a clean cooking target and fewer than 30 have a renewables target in their electrification plans (as discussed

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in Chapter 4). Besides setting ambitious targets, integrated access plans that consider both centralised and distributed renewables in a co-ordinated manner offer good opportunities to identify cost-effective pathways to universal access in a time-bound and transparent manner, while demonstrating political commitment and leadership. Such plans should clarify the investments needed and affordability gaps to implement the strategies they propose, while aligning actions in pursuit of those strategies. Designing and implementing integrated plans will require agencies of the government – from energy to health, agriculture to finance – to work in tandem. The private sector, too, has an important role to play. Ensuring that no one is left behind will require strong government commitment reflected in target setting, planning, policies, and public financing.

6.4.2 Greater ambition and investments in renewables-based clean cooking

When population growth is factored in, access to clean cooking has dropped in Africa. This poses human, economic and environmental costs that fall disproportionately on women and children. It is becoming increasingly clear that without a quantum shift in commitments and actions, limited progress will be made toward the 2030 clean cooking target. As discussed in this chapter, a range of renewables-based clean cooking solutions are available that can play a role in the transition away from the inefficient use of traditional fuels for cooking and heating. Several co-benefits can also be realised, including waste management and production of biofertilisers (in the case of biogas systems), and demand stimulation for utilities and mini-grid operators (in the case of renewables-powered electric cooking). Given the value they bring in long-term sustainability and development goals, renewables-based solutions must figure prominently in the integrated frameworks countries devise to expand clean cooking access. Dedicated programmes and financing incentives will have to be introduced 1) to support the adoption of renewables-based clean cooking solutions adapted to the local context, 2) to raise awareness and 3) to create robust supply chains to support access and maintenance.

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6.4.3 Stronger policy and regulatory frameworks

Significant progress has been made over the past decade in the policy and regulatory framework guiding investments in energy access. Dedicated policies and regulations for distributed renewables, particularly mini-grids and stand-alone solar systems, complemented by regional programmes and donor-led initiatives, has driven recent growth in deployment, as seen in Chapter 2. Yet large gaps remain, with several countries on the continent having no dedicated policies for distributed renewables, and others needing adaptations to support the dynamic nature of electrification processes.

Regulatory frameworks – covering licensing provisions, tariff setting, main grid arrival and public financing – must provide an enabling framework for investments in renewable energy mini-grids. At the same time, those frameworks must evolve in response to new applications in grid-connected areas (*e.g.* interconnected mini-grids). Scaling up mini-grids in Africa will require the application of

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cost-of-service principles, support to bridge the viability gap, and co-ordination and partnerships among stakeholders in the distributed renewables sector, including utilities (UNIDO, 2020). Examples of such partnerships are emerging in Nigeria, Uganda and several other countries; they should be emulated based on lessons learnt with due attention to local context. Stability in policy support and adequate quality and standards framework guiding investments in both stand-alone systems and mini-grids are equally necessary to sustain local markets and maintain delivery of energy services.

6.4.4 Ramped-up investment for energy access

Present levels of financing for energy access are not enough to achieve universal access by 2030. Both public and private financing will need to be multiplied to reach the funding levels needed to reach universal access. Enterprises, including technology providers and distributors of appliances for both electricity access and clean cooking solutions, require high-risk capital to engage in the research and development required to adapt products to end-user needs, as well as equity and working capital to scale up distribution and offer consumer financing. Particular emphasis is needed on closing the end-user affordability gap to ensure that energy – centralised or distributed – is accessible to all. Closing that gap calls for suitably designed and targeted public financing.

Existing investments in energy access are largely concentrated in East and West Africa, with Southern and Central Africa receiving a fraction of financing commitments. Specific efforts are needed to strengthen the investment framework in countries with low financing flows, including the use of multilateral development funds, climate finance and philanthropic capital to support market development. Local enterprises continue to face challenges in accessing financing, with investments concentrated in a small number of companies. Over the long term, unlocking domestic capital, including local-currency debt, through risk-mitigation instruments and on-lending facilities for commercial banks and intermediaries should be a priority. Funding support is also needed for investments in non-tangible assets, including training and skills development, planning, and awareness raising, which are essential for long-term market development.

6.4.5 Stronger links between energy access, livelihoods and public services

Linking energy supply with income-generating activities and public services, such as health care, education and water supply, can maximise the socio-economic benefits of access while contributing to multiple SDGs. Achieving this requires specific efforts: 1) to improve the data and information base available to guide decision-making on nexus solutions (*e.g.* mapping energy use in specific agri-food value chains, healthcare facilities); 2) to facilitate financing for the development and uptake of efficient appliances and productive end uses; 3) to enhance market access; and 4) to build cross-sectoral skills. Cross-sectoral perspectives must also be integrated within energy access strategies, including national policies and Nationally Determined Contributions, as well as sector-transformation plans (*e.g.* for agriculture). Here the importance of partnerships cannot be understated. As discussed in section 3.3, action-oriented partnerships that convene stakeholders across sectors are key for scaling up the use of distributed renewables to strengthen delivery of public services and livelihoods. Two such partnerships are one joining IRENA and the Food and Agriculture Organization on agriculture, and another bringing together IRENA, SEforAll, the World Health Organization and the World Bank on health.

6.4.6 Inclusive approaches to energy access

The active engagement and involvement of women, youth and marginalised communities are important in defining successful energy access plans at the national level. As beneficiaries of energy access, women, youth and marginalised communities can be persuasive agents of change in delivering renewable energy services, creating local jobs and catalysing rural economies (IUCN, 2018). As women become engaged, they take on more active roles in their communities and thereby facilitate a gradual shift in the social and cultural norms that previously acted as barriers to their agency (IRENA, 2019b). Women's entrepreneurship should be encouraged through tailored financing for women-led energy enterprises and equitable access to training and skills development opportunities (UN, 2021; IRENA, 2019b).

Gender-responsive policy and regulatory reforms must also address women's needs and priorities, and close gender gaps and inequalities in the energy sector. Important steps have been taken in this direction.

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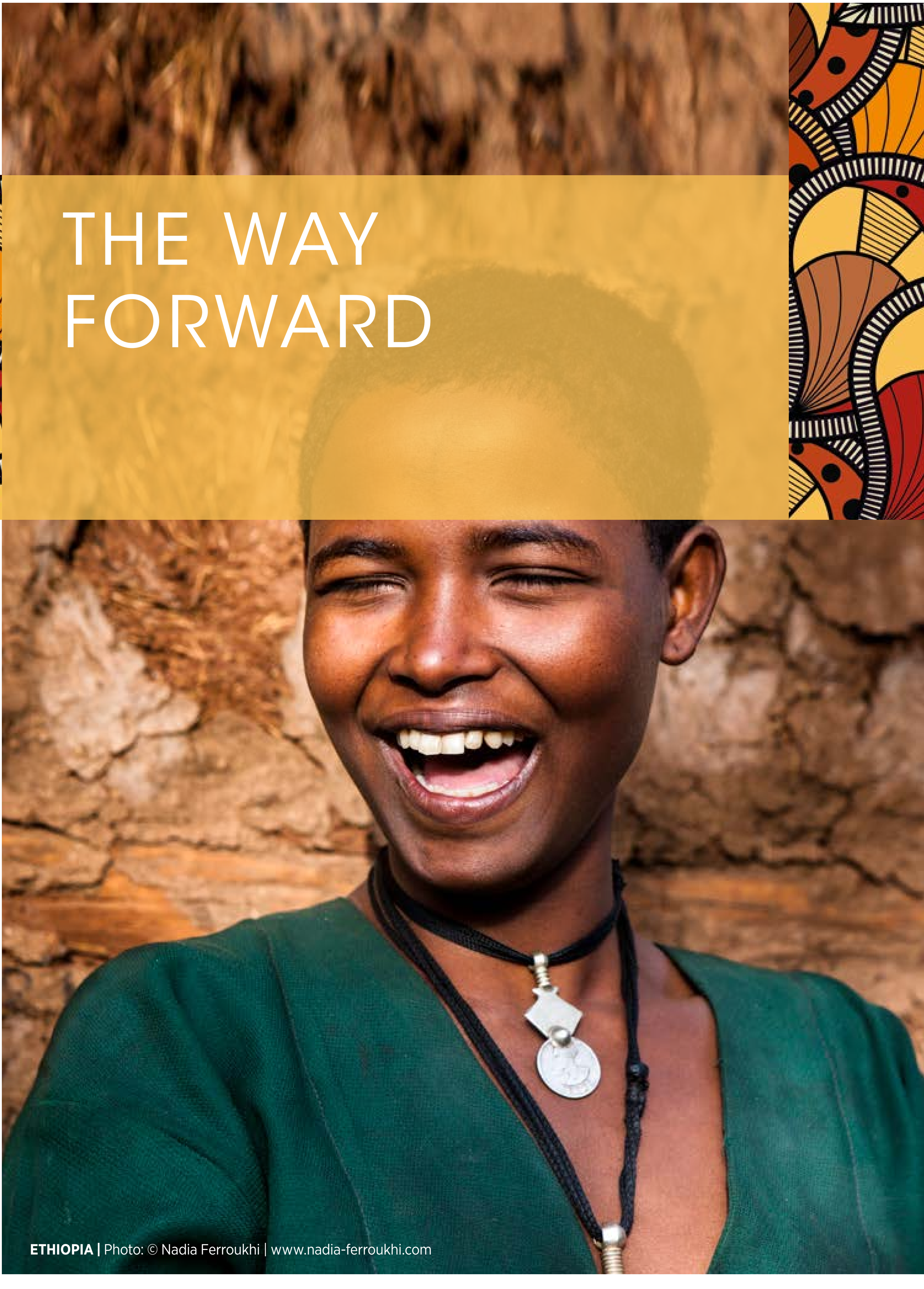
Kenya launched the continent's first gender policy for the energy sector (ENERGIA, 2019; Ministry of Energy, 2019). At a regional level, the ECOWAS Programme on Gender Mainstreaming in Energy Access was established to factor in the differing needs of men and women in the planning and implementation of energy access interventions in West Africa (ECREEE, n.d.). Gender audits, as tools, can ensure due consideration of the known gender differences in household decision making, preferences and priorities. Audits have been used in Botswana and Senegal, among other countries, to support the integration of gender into energy access projects (IRENA, 2019b).

Gender-disaggregated data related to energy access remain sparse, making it difficult to monitor gender gaps in access and to assess the effects of limited access on women's lives and livelihoods (UN, 2021). Specific efforts are needed to gather gender-disaggregated data for all countries by scaling up the use of methodologies such as the Multi-Tier Framework.

A just and inclusive energy transition underpinning Africa's socio-economic development goals will be incomplete without tackling the widespread access deficit. This chapter presented the steps needed to accelerate renewables adoption to end energy poverty on the continent. A concerted focus - as part of an African Green Deal - must now be on mobilising political commitment, policy action and investments at the levels needed to urgently address the electricity and clean cooking gap.

THE WAY FORWARD



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- The opportunities inherent in **the energy transition**
- The power of comprehensive policy
- **Scaling up finance**
- Bridging the gap in **access to modern energy**
- The promise of an **African Green Deal**

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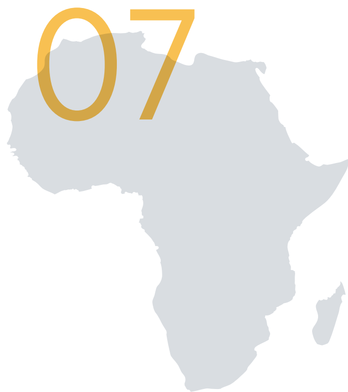

As governments and other actors in Africa contemplate the energy transition, the continent finds itself at a crossroads. Common threads running through its many development challenges are bolstering its defences against climate change, improving access to clean and affordable energy for the millions of Africans who still lack it and making a resilient recovery from the COVID-19 pandemic. Policy choices must be made against the backdrop of a population expected to almost double from today's 1.4 billion people to 2.5 billion by 2050.

African countries are among the most vulnerable to the negative consequences of climate change, even though most contribute only marginally to greenhouse gas emissions. Climate change already imposes considerable economic costs on the continent. African nations suffered economic losses of USD 38 billion in 2020 alone from effects such as desertification and mass displacements (WMO, 2021). Mitigating climate change and adapting to it will cost billions each year. The risk is that extreme climate vulnerability may compromise the social and economic achievements that Africa's economies and people have made to date, while clouding the prospects for sustainable development.

The interplay of these factors demands a comprehensive approach to making policy for the energy transition. That approach might take shape under a framework such as an African Green Deal. The systemic character of "green deals" is what has made the concept attractive in places like the United States and the European Union. The latter has advanced a comprehensive regional plan along these lines. A similar framework for Africa could draw on Europe's example, with appropriate modifications to suit the continent's particular energy challenges and opportunities, including those linked to the current global economic system.

This chapter first considers Africa's energy transition opportunities. It then affirms the importance of policies to facilitate the shift to a renewables-based energy system, as well as industrial policies and other measures to strengthen the continent's industrial base and diversify its economies. Following a discussion of the importance of overcoming financing constraints, the chapter focuses on improving energy access. It concludes with a discussion of the demands and the promise of an African Green Deal.

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7.1 THE OPPORTUNITIES INHERENT IN THE ENERGY TRANSITION

Because most African countries do not have a fossil fuel infrastructure as extensive as Europe's or North America's, they are in a better position to leapfrog to an economy centred on renewable energy. Achieving that depends on putting in place structures and institutions to strengthen supply chains, shore up the skills base, and allow greater local value creation to benefit the local population. All of these measures require adequate financial means. Beyond mobilising domestic funds, the climate policy basket proposed in this report's socio-economic analysis envisions a strong element of international cooperation to that end.

Renewable energy use in Africa has historically been centred on the traditional use of biomass for cooking, which remains a mainstay of energy supply for many millions of households (and provides millions of livelihoods in the charcoal and wood fuel economy), and on hydropower for electricity. In more recent years, modern renewable energy deployment has grown, with the biggest additions coming from solar energy. Africa's vast solar energy potential makes the continent exceptionally well positioned to transition away from traditional power sources. This is in addition to other renewable energy resources, whose development still significantly lags behind potential.

The energy transition in Africa, as elsewhere, will have marked impacts, notably by altering international demand for goods and services in the energy sector.

African producers of fossil fuels will be required to adapt to the prospect of reduced global demand – and hence a drop in exports, with implications for jobs. On the other hand, the build up of renewable energy sources such as wind, solar, bioenergy, hydro and geothermal energy capacities will create greater employment and generate economic activity in construction, installation, operations and maintenance. Local manufacturing of equipment like wind turbines and solar panels may be less prominent until African countries can develop suitable industrial policies, support skill-building and find ways to localise value creation domestically or regionally. Expanded access to decentralised (off-grid) energy will support local livelihoods in agriculture, commerce, education and communications.

Global demand for metals and minerals needed for renewable energy and other transition technologies is already rising fast and will soon snowball. Several African countries are rich in such resources. The degree to which they will benefit from this emerging demand – ensuring that they are more than mere providers of raw materials to be processed elsewhere – depends on systemic, structural changes in the global economy.


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For now, commodities – agricultural, mineral, and energy – remain the primary export product of many African countries. Government revenues and public budgets are exceptionally dependent on global markets for these commodities. The lack of substantial local processing and manufacturing capacities means that the continent's high commodity-dependence is a source of socio-economic vulnerability in the face of variable, and sometimes volatile, commodity prices.

Modelling highlights the value of a successful energy transition for African countries. IRENA's 1.5°C Scenario, which lays out a global pathway guided by the United Nations' 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change, implies major benefits to Africa over a less-ambitious pathway based on current commitments (IRENA Planned Energy Scenario). The benefits include a 6.4% increment in GDP and a 3.5% increment in jobs. The energy transition also promises significant welfare benefits (*e.g.* employment, public health, environment) as measured by IRENA's Energy Transition Welfare Index, discussed in Chapter 5. Translating these model results into reality will require a host of ambitious and comprehensive policies, sketched below.


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7.2 THE POWER OF COMPREHENSIVE POLICY

Africa has a wide range of different geographies, development experiences, socio-demographic patterns and institutional capacities (see Chapter 1). Each country embarks on the energy transition from its own starting point, implying different sets of strengths and weaknesses. Policy making at the national level must be tailored to these conditions. Here, the intent is to highlight broad principles for the way forward.

To harness the vast potential of renewable energy, African countries can adopt a broad set of **deployment policies**, together with measures to support the integration of renewable energy technologies into grids and other energy delivery systems (see Chapter 2). They start with plans and **targets** for renewables and greater energy efficiency set at either the national or regional level. Those policies must be flanked by a wide range of **accompanying measures** to avoid being locked onto a path of continued fossil fuel dependence. They include a phase-out of fossil fuel subsidies and a move away from further investments in coal or oil and gas. To replace fossil fuel-based energy systems, policy makers must mobilise public and private investments in new or upgraded energy infrastructure (power grids, district heating and cooling networks, electric charging stations) and foster innovation, and assess what measures are needed to make energy affordable for people. In this context, efforts to raise public awareness of renewable energy solutions and their benefits will be central to ensuring popular acceptance and support for the energy transition.

Direct deployment policies include regulatory measures that create a market for renewable energy, along with changes in the power sector pertaining to grid access and priority dispatch, among other issues; fiscal measures (tax incentives and capital depreciation/capital allowances); and financial incentives (subsidies and grants). Power sector restructuring and structured procurement mechanisms (feed-in tariffs and auctions) have

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enabled private investment in renewable-based power generation, especially through independent power producers. Such mechanisms are increasingly being introduced as part of a basket of instruments offered by multilateral development banks and development financing institutions, together with financing mechanisms (*e.g.* concessional loans) and de-risking instruments, which are key to unlocking investments.

To date, deployment policies in Africa have focused on the power sector and, within it, on large, centralised facilities and associated grids. Mini-grids and other decentralised renewables offer additional options. However, energy policy must also embrace other end uses including transport, heating and cooling, and clean cooking. Solar water heating programmes are in place in some countries, including regulations and incentives. But transport-related measures are still scarce, focusing mostly on biofuel blending mandates. In the future the focus must shift to electric mobility. Green hydrogen can provide a link between growing and sustainable renewable electricity generation and sectors that are hard to electrify.

To realise the socio-economic benefits of the energy transition, far-sighted policies will be necessary to broaden and strengthen Africa's currently limited industrial base as part of a broader effort to diversify economies and reduce dependence on the export of unprocessed commodities.

Agriculture is another priority area, given the sector's huge importance for GDP and employment. Renewable energy has the potential to revolutionise agriculture through applications in water pumping, food processing and storage, and other uses. Policymaking accordingly needs to focus not only on the deployment of decentralised renewables but also on the productive uses of energy and how this can transform rural economies.

While Africa is endowed with many of the minerals that are essential inputs for sustainable energy and low-carbon technologies like electric batteries and wind turbines, the benefits that can be derived from that endowment will depend on the extent to which countries can develop processing capacity further up the value chain. What is needed are **industrial policies**

– a set of incentives and rules, business incubation initiatives, supplier-development programmes, support measures for small and medium enterprises, and promotion of industrial clusters that bundle innovation. Together, they can create the structural underpinnings for viable local supply chains. This will require infrastructure spending (for basic public goods such as electricity, roads, and telecommunications); programmes to bolster local firms' access to finance and information and boost their capacities along the value chain; and finely tuned local content incentives and requirements (to facilitate spill-over effects and support local value creation).

Industrial policy design must be based on better data and empirical analysis of each country's economic structures. The first step is to understand how existing capabilities can be leveraged and enhanced. In the longer term, the objective shifts to creating new capabilities in industries related to renewable energy with the help of well-crafted technology transfer policies aligned with education and training strategies.

Considering the limited domestic market of most African economies, regional value chains will be required to achieve needed economies of scale in renewable energy and associated industries. Integrating local suppliers in regional supply chains can enhance their productivity and avoid fragmented industries. Local content policies might be more effective if formulated in the context of an intra-regional trade and industrial strategy in Africa.

Labour markets are another important area.[1] The energy transition will create many new jobs, surpassing the number lost in the conventional energy sector. This may open opportunities for women, youth and members of marginalised communities to gain employment. But labour market policies will have to address the misalignments that may emerge during the energy transition as old fossil fuel industries and jobs fall by the wayside and new ones appear in renewables and related industries. The misalignments can occur in *time* (if new jobs are not created as quickly as old ones disappear); in *space* (new jobs may be created in locations different from old ones); in *education* (the energy transition may require different skill sets); and in *economic structures* (the transition may feature different sectors and supply chains than those prominent under the old energy economy).

In Africa, one challenge is that much of the workforce is not in the formal sector of the economy. At present, many states lack the financial wherewithal and institutional capacity to carry out labour market interventions or to offer social protection programmes related to health insurance, old-age pensions and unemployment support. The specific challenges vary considerably by region and country, but bringing large portions of the workforce into the formal economy (*i.e.*, with its regulations and protections) is a core challenge.

7.3 SCALING UP FINANCE

Large-scale investment will be required to support an energy transition in line with the Sustainable Development Goals. Financing will be needed to build renewable energy capacity, to create economic structures capable of sustaining the transition and securing associated development benefits, and to meet the climate challenge.[2] The financial resources that were mobilised to address the social and economic repercussions of the COVID-19 pandemic have altered perceptions of what governments can and must do. The costs of inaction dwarf those required for successful action.

However, access to climate financing remains a key obstacle for African countries, and current investments in power generation in the region remain among the lowest in the world. One way to boost spending in Africa is to ensure that public sector investment decisions clearly prioritise renewables over fossil fuel projects. Green financing programmes managed by national development banks could improve access to credit for industrial activities that feed into renewable energy value chains. (Several examples of such programmes exist in Europe, North America and South America; significant African versions have yet to emerge.) Continued support from development finance institutions (including export credit agencies, multilateral development banks and guarantee funds) will be needed to mobilise additional amounts of capital. All relevant actors need to make good on their promises and pledges, whether offered in pursuit of COVID-19 recovery packages, in the context of climate and SDG commitments or in other frameworks.

1 *Labour market policies are state interventions that aim to increase the employability of workers through vocational training; reduce labour costs with employment subsidies; provide information to facilitate matching labour supply and demand (and thereby avoiding skills mismatches); support re-entry of the long-term unemployed; facilitate reskilling and moving workers from one sector of the economy to another; or support firms to grow and provide more job opportunities.*

2 *In Africa, considerable resources are required to adapt to and mitigate the effects of climate change. For example, one study estimated the cost of mitigating heat stress caused by the energy sector at USD 51 billion by 2035 and USD 487 billion by 2076 (Parkes et al., 2017). Estimates of the total cost to electrify the entire African continent range from USD 160 billion to USD 547 billion (AfDB, 2008; World Bank 2006; Rosnes and Vennemo 2012), depending on what measures are included. The annual cost may be in the range of USD 20-25 billion, for a period of 12 to 25 years.*

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Targeted bilateral and multilateral initiatives can make a difference. For example, the International Just Energy Transition Partnership between South Africa and France, Germany, the United Kingdom, the United States and the European Union, announced at COP26, provides a mechanism for supporting energy transitions in South Africa. As part of the Partnership, USD 8.5 billion will be mobilised in the first phase of financing to support "low emissions and climate resilient development, to accelerate the just transition and the decarbonisation of the electricity system, and to develop new economic opportunities such as green hydrogen and electric vehicles."[3]

Money must flow not just to power sector projects, but also to transport and to heating and cooling.

7.4 BRIDGING THE GAP IN ACCESS TO MODERN ENERGY

A just and inclusive energy transition will be incomplete without tackling widespread energy poverty on the continent. Africa's energy future includes universal access to reliable, affordable and sufficient electricity and clean cooking (see Chapter 6).

Yet current ambitions and efforts fall well short of what is needed to reach universal access by 2030. Despite growing commitments from governments and the international community, investment flows into both electrification and clean cooking solutions remain insufficient.

Fortunately, lower costs, an improving policy environment and increasing involvement of the private sector make it possible to rapidly expand access to distributed renewables, including stand-alone systems and mini-grids. The number of people who enjoy access to some form of electricity from distributed renewables has already jumped eight-fold to 176 million since 2011 (IRENA (2021b), and distributed solutions are now recognised as a key solution to expand modern energy access to electricity and clean cooking in a timely and environmentally sustainable manner. Energy access must be mainstreamed as a national and regional priority backed by ambitious targets and an action plan. Implementation will require a concerted effort by all stakeholders, including development partners, financing institutions, the private sector, civil society and academia.

Limited progress on clean cooking has been achieved mostly through liquid petroleum gas and electricity – although not necessarily renewables-based. Most households have little choice but to burn biomass fuels (mostly firewood and charcoal) in open fires or inefficient stoves. The social, economic and environmental costs of this are immense. Almost 700 000 die prematurely every year due to household air pollution linked to cooking (Fisher *et al.*, 2021). Charcoal remains the most common fuel in urban areas, while in rural areas the use of firewood prevails. Any energy transition strategy must reckon with the socio-economic aspect of charcoal. Though unsustainable, the sector provides livelihoods for many millions of Africans; policy makers must therefore focus on

3 https://ec.europa.eu/commission/presscorner/detail/en/IP_21_5768 creating countervailing employment opportunities in renewable energy and productive uses of energy.

Renewable cooking options involve both cleaner bioenergy solutions (including biogas and bioethanol) and renewables-based electric cooking. A comprehensive policy framework adapted to individual country circumstances is needed to overcome barriers to their more widespread adoption, notably cost constraints; problems related to appliance and fuel standards; skills needs; supply chains; cultural barriers; and a lack of awareness in local communities (IRENA, IEA, REN21, 2020).

Until reliable, affordable and sustainable modern energy reaches every household, farm, enterprise, school and clinic in Africa, the continent's socio-economic development objectives will remain unfulfilled.

7.5 THE PROMISE OF AN AFRICAN GREEN DEAL

The multifaceted nature of the policies required to promote a just and development-oriented energy transition in Africa calls for a comprehensive, coordinated and regionally nuanced approach. A "green deal" tailored to the African context could provide the institutional and programmatic framework needed to mobilise resources and policy action at the appropriate scale. It would combine the objectives of achieving climate goals, fostering economic development and jobs creation, and guaranteeing social equity and welfare for society as a whole.

The concept is inspired by the massive mobilisation of resources led by President Franklin D. Roosevelt in the United States in the 1930s. Roosevelt's New Deal entailed fiscal, monetary and banking reforms, public works and other programmes, and new regulatory measures in response to the devastating financial crisis known as the Great Depression. Over 70 years later, in the aftermath of the Great Recession of 2007-2008, proposals for another new, Green Deal emerged (Benedick, 2001; Friedman; 2007; New Economics Foundation, 2008; UNEP 2009), amid growing acknowledgment of the close connections between socio-economic and environmental concerns.

In the context of the COVID-19 pandemic and the increasingly urgent climate crisis, the concept has been revived and updated in a transformational blueprint for Europe's decarbonisation and in legislative proposals in the United States. Green Deal proposals have several characteristics in common. They:

- acknowledge the need for unprecedented action and call for mobilisation of resources on a scale commensurate with an existential crisis
- either explicitly endorse or imply the need for greater state intervention, based on the realisation that market-driven approaches alone will not suffice to promote a just energy transition, and that strong public policy tools are needed to reach emissions reduction targets in a timely fashion
- imply that in order to address the root causes of the crisis the connections between low-carbon consumption, production and innovation must be understood
- emphasise the opportunities to simultaneously resolve other pressing societal problems (in public health, biodiversity protection, and economic resilience)
- regard a just transition for workers and communities affected by the needed economic restructuring as an essential component.

Green Deal proposals to date have been framed in the context of advanced economies, and discussions have focused on strategies to develop the productive and innovative capabilities of domestic firms in those countries, with little attention given to impacts on developing countries. An African Green Deal could build on existing concepts and ideas but be designed specifically around the continent's own needs and circumstances.

The European Green Deal aims to make the European Union climate neutral by 2050 (see Box 7.1).

While the European Green Deal is specific to Europe's own needs and opportunities, it could be a source of inspiration for African countries, demonstrating that bold policy proposals can be translated into

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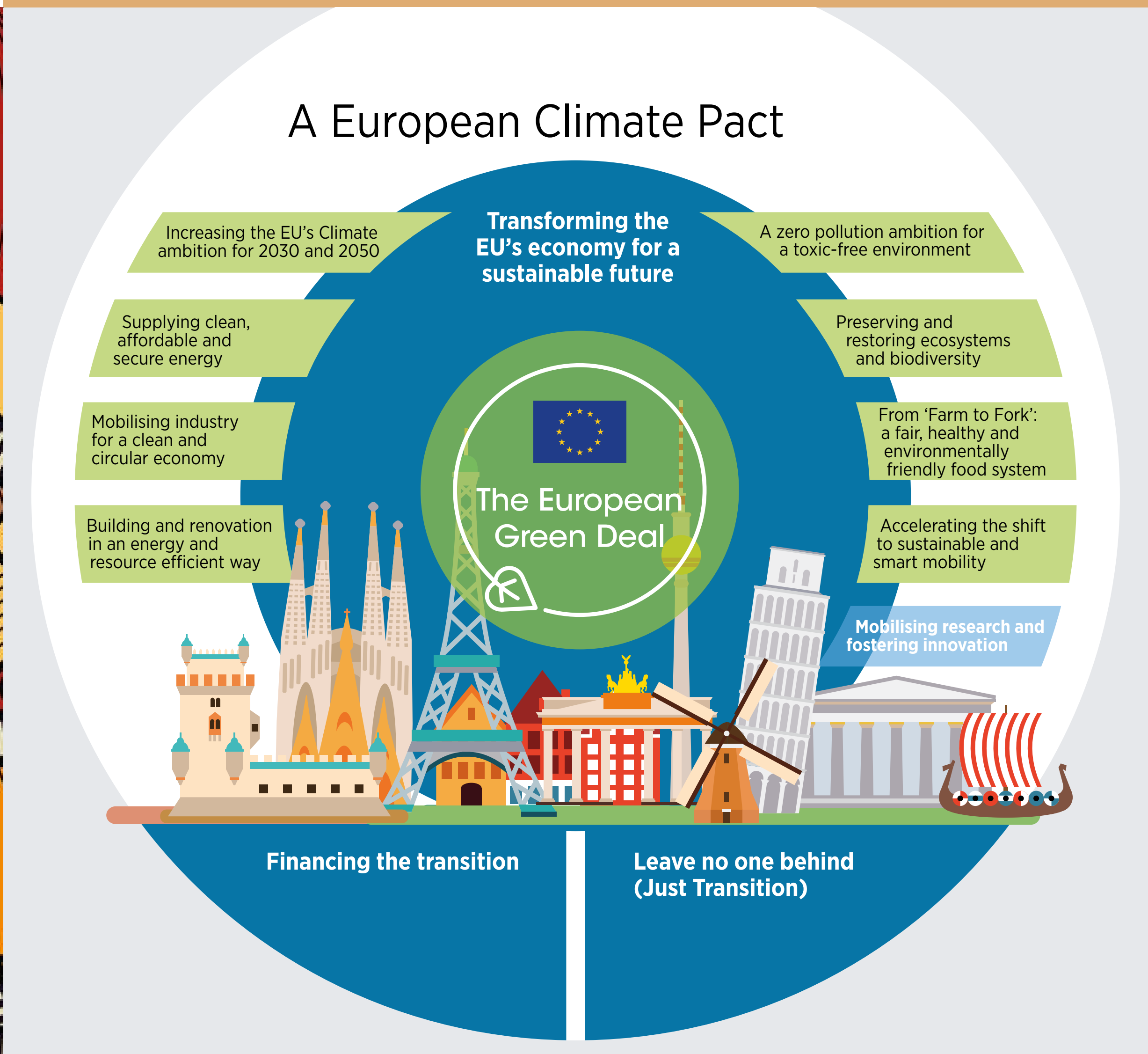
Box 7.1 The European Green Deal

The Deal was initially presented in December 2019, with specific proposals and strategies elaborated subsequently (see Figure 7.1). For example, the European Industrial Strategy was adopted in March 2020; it featured a new circular economy action plan. Strategies for energy system integration and hydrogen were adopted in July 2020. In December 2020, the European Climate Pact was launched. In July 2021, the Commission presented the "Fit for 55" package, which entailed a series of legislative proposals to achieve the EU Green Deal (Simon, 2019; Heinrich Böll Stiftung, 2021).

Figure 7.1 Components of the European Green Deal



Source: European Commission, 2019.

Box 7.1 The European Green Deal (continued

The European Green Deal Investment Plan includes the mobilisation of at least EUR 1 trillion of sustainable investments over the next decade; incentives for public and private investment; and practical support to public authorities and others in planning, designing and executing sustainable projects.

The Just Transition Mechanism provides support to mobilise at least EUR 100 billion in 2021-2027 for the EU's most affected regions in order to alleviate the energy transition's socio-economic impacts and help workers and communities dependent on the fossil fuel value chain. Three sources of financing have been identified.

One is the Just Transition Fund, consisting of EUR 7.5 billion in new EU funds; member states are expected to match Fund flows with money from the European Regional Development Fund, the European Social Fund Plus, and national resources, for a total of EUR 30-50 billion. The second source is a just transition scheme under InvestEU to mobilise EUR 45 billion in public and private investment in sustainable energy and transport. The third is a European Investment Bank loan facility backed by the EU budget to mobilise between EUR 25 and EUR 30 billion in investment.

The Just Transition Mechanism is not only about financial flows. It also provides technical assistance and a strong governance framework (European Commission, 2020).

policy action and suggesting specific measures that might be undertaken. In April 2021 the President of the European Commission, Ursula von der Leyen, suggested the creation of an African Green Deal similar to the European Green Deal as the "linchpin" for the economic recovery, as part of a vision of mutually beneficial cooperation and fostering of synergies (Portuguese Presidency, 2021).

Beyond serving as an example, however, the European Green Deal, along with other net-zero climate strategies adopted across the globe, has considerable practical implications for Africa's resource-rich economies. For one, it will induce a decline in demand for fossil fuels from Africa, leading to reduced revenues and job losses. At the same time, it will increase the demand for minerals such as cobalt, copper and lithium that are critical for the energy transition, promising greater revenues, job gains and other socio-economic benefits. Structural changes in African economies and trade relations should be encouraged to avoid a situation in which African economies continue to serve primarily as providers of unprocessed resources, dependent on cyclical swings in other parts of the world and unable to reap the full benefits of the energy transition (Usman *et al.*, 2021).

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African leaders must clearly articulate, map and assert their own climate transition and development agendas. Regional coordination is needed to foster synergies among various countries and regions, expand economies of scale, and promote the development of resilient regional supply chains. The creation of regional clusters and supply chains in the renewable energy sector offers the potential of leveraging local capabilities and setting local firms on a path to competitiveness through economies of scale and cost reductions. Integrating local suppliers into regional or other supranational supply chains can enhance their productivity.

Similarly, promoting industrial complementarity can prevent duplication of efforts in the same activities and avoid the fallacy of assuming that something that is true in one country is also true in neighbouring countries operating in the same regional markets. It can also make local content policies more efficient and effective.

Intraregional specialisation in different segments of the renewable energy value chain can exploit complementarity of assets across the region. African regions have complementary strengths, from critical minerals abundance, to manufacturing capacity, as well as proximity to important trade routes. Such an approach would support the acquisition of new comparative advantages and provide opportunities for economic diversification across Africa.


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A key debate in development economics has been whether countries, within the context of their resource potential, should be *complying with* or *defying* their existing comparative advantages (see, for example, Lin and Chang, 2009). The question holds important implications because several African countries do not yet have a comparative advantage in the provision of renewables-related goods and services.

Two observations are pertinent. First, some of the key drivers of comparative advantage, such as human, institutional and technological capabilities, are policy-induced (Chang, 2009; Lebdioui 2019c, Lebdioui 2020b). Current comparative advantages (or lack thereof) thus reflect proactive policies that underpin factor productivity and institutional arrangements relative to those of other countries (Diestsche, 2018). Second, some resource-dependent African countries already face the imperative of diversifying their productive structures to avoid the hazards of commodity dependence and vulnerability to climate change (see Chapter 1). Conforming to their existing comparative advantage would be a mistake for countries that need to steer their economies away from volatile commodities and generate employment outside of fossil fuels (Lebdioui, 2019b).

In contrast to approaches based on established capabilities and static views of comparative advantage, approaches that aim to *acquire* comparative advantage by charting a new path can greatly enhance developing countries' ability to accumulate productive capabilities and achieve the dual objective of expanding renewable energy and transforming economic structures.

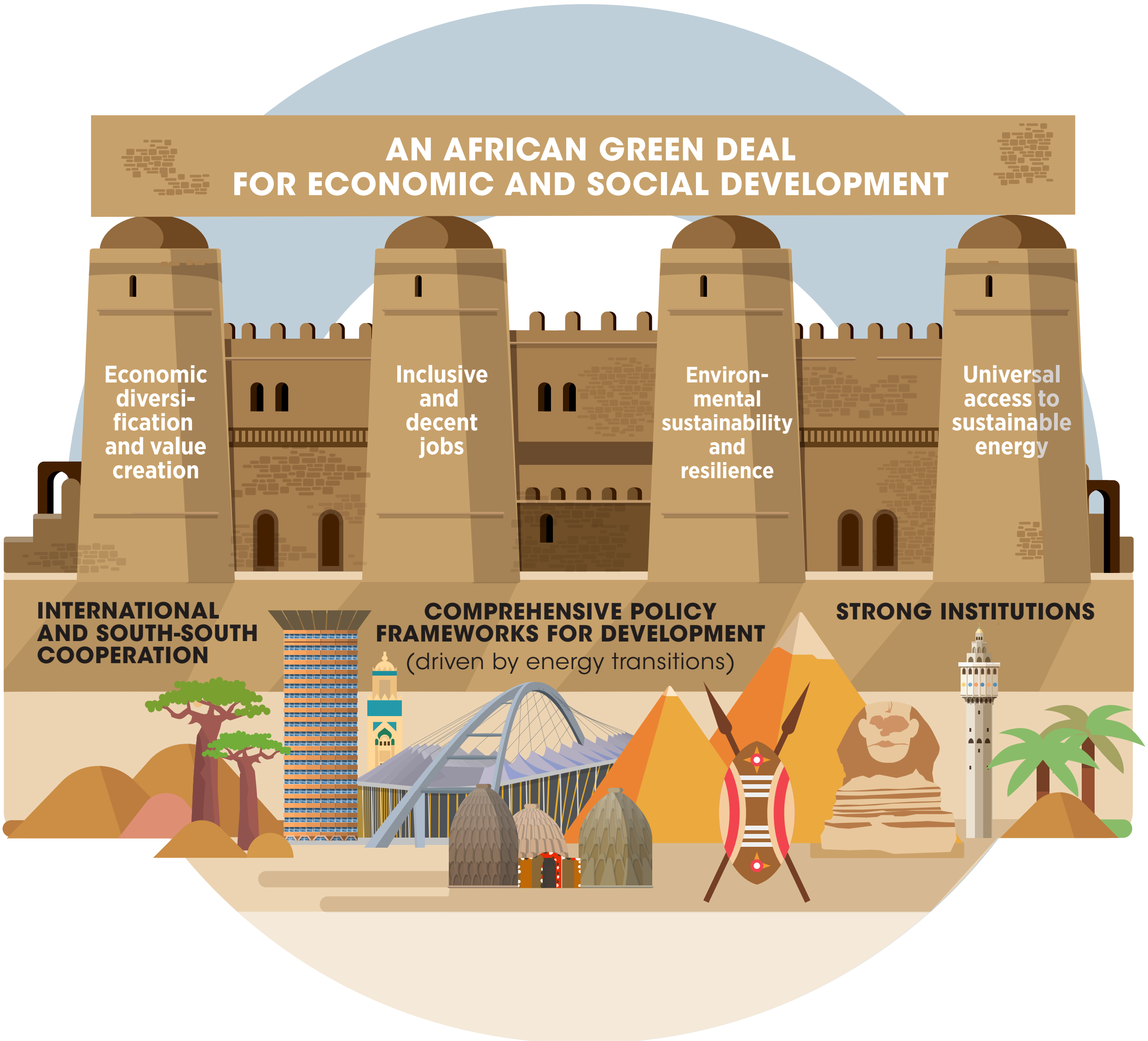
A successful strategy to promote regional supply chains around renewable energy should include a forum within which governments and firms can tackle issues of regional integration (*e.g.* a coordinated local content policy), promoting in the process economically sustainable market opportunities all along the value chain.

An African Green Deal with renewable energy at the heart of economic transformation should include a far-reaching set of complementary interventions on the demand and supply sides. It should be driven by a comprehensive policy package (see Chapter 4), strong institutions, and international co-operation (including South-South). A Green Deal on this scale holds the potential to produce positive effects across a wide array of social, economic and sustainability imperatives, as Figure 7.2 indicates. They include economic diversification and value creation; inclusive and decent jobs; environmental stewardship and climate resilience; and universal access to affordable, reliable, sustainable and modern energy.

Coordination around an African Green Deal can capitalise on existing institutions and initiatives at both the continental and regional levels. Leaders have made clear their commitment to inclusive and sustainable economic growth and development in the African Union's *Agenda 2063: The Africa We Want (African Union Commission, 2015).*

This blueprint and master plan for transforming the continent into a global powerhouse (IRENA, KFW

Figure 7.2 Pillars and desired outcomes of an African Green Deal



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and GIZ, 2021) establishes the links between energy and industrialisation. In addition to the African Development Bank's New Deal on Energy for Africa, which sets out to achieve universal access to energy in Africa by 2025, several other initiatives now promote renewable energy deployment: the Africa Renewable Energy Initiative; the Africa Power Vision; the African Clean Energy Corridor and the Desert to Power initiative for the 11 countries of the Sahel. Most recently, the African Union launched a new African Single Electricity Market (see Box 7-2).

The commitment of members of African regional communities to renewable energy and energy efficiency has already been demonstrated through the formation of dedicated centres that have developed energy plans and roadmaps at the regional level (see Chapter 4). The development of clean energy has also been incorporated into several regional development strategies and programmes.[4]

Cooperation mechanisms related to clean energy and industrial development therefore exist both at the continental and regional levels, and a Green Deal programme could integrate them into an ambitious policy package. The first contribution of the nascent Green Deal might be to provide a forum within which key regional actors – the African Union, governments, multilateral institutions, the private sector and other development partners – could build consensus, identify credible regional targets, identify and exploit synergies among different national and regional energy transition strategies, and plan next steps. Under the umbrella of an African Green Deal, regional alliances can be created to coordinate the research, production and deployment of specific renewable energy technologies.

The COVID-19 pandemic has underlined in dramatic fashion that no country is an island unto itself, and that global solidarity is key. Resolving the climate crisis and ensuring inclusive development will require international co-operation even more strongly.

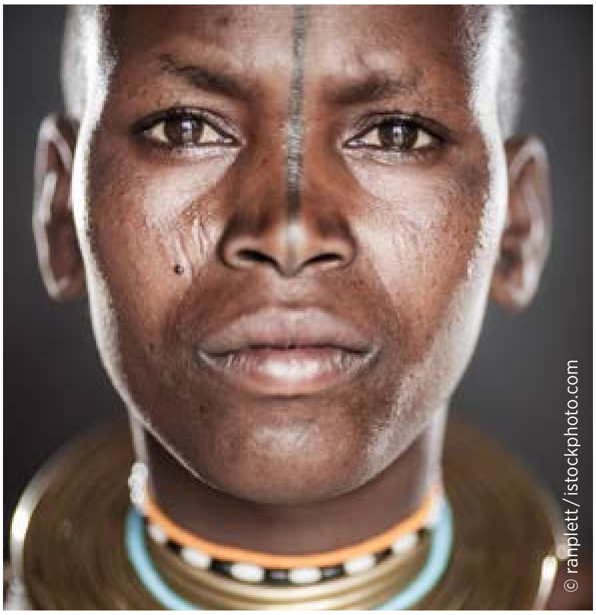
Box 7.2 The African Single Electricity Market

Initiated in early 2021, the African Single Electricity Market (AfSEM) is intended to connect energy strategies and action plans on the African continent through a harmonisation of regulatory frameworks and by integrating national generation, transmission, and distribution master plans. AfSEM will be the largest single electricity market in the world, serving a population of over 1.3 billion people in 55 countries. It can facilitate a realisation of the continent's renewable energy potential, with the aim to reach 100% access to electricity (African Union, 2021).

4 *Those regional development strategies and programmes are the East African Community Industrialisation Policy 2012-2032; the COMESA Industrialisation Strategy; the West African Common Industrial Policy, which is championed by ECOWAS, and the Southern African Development Community Industrialisation Strategy and Roadmap 2015-2063.*

Beyond intra-African co-operation, Africa can benefit from a vigorous multilateral approach. For example, the Africa-EU Partnership is an effort to strengthen economic cooperation around shared issues of interest such as climate and the sustainable development goals. Such specific forms of cooperation can draw on the experiences of countries around the world; provide promised climate mitigation and adaptation funding; and ensure that lessons and solutions are shared across regions, countries and communities.

As this discussion has indicated, a holistic vision along with strong political commitment is necessary for success. A comprehensive approach requires strategic vision, a broad policy framework, financial resources on a large scale, and institutional capacities to carry out the strategy. As important as the implementation of any specific measure are an inspiring articulation of policies, broad public awareness and the inclusion of diverse communities and stakeholders.



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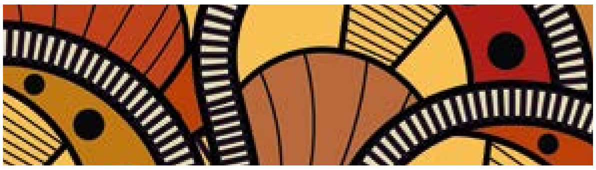

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REFERENCES

AB-AOC (Alliance pour le Biodigesteur en Afrique de l'Ouest et du Centre) (2021), "Alliance pour le Biodigesteur en Afrique de l'Ouest et du Centre", www.ab-aoc.org/?fbclid=IwAR0-ubdyXdMyN7DEDHYOKbUSDgZNzcp4YN46neP_wraokm7DYOIMx8WTPSU#objectifs.

Abellon (2021), "Presentation on pellet production in Ghana", www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/2021_events/Online_Bioenergy_Week/PPTs_17_March/LC_R/17_March_LC_R_Mishra_Abellon_Clean_Energy.pdf.

ACE-TAF (Africa Clean Energy Technical Assistance Facility) (2021), *Assessment of Local Manufacturing of Off-Grid Solar in Sub-Saharan Africa*, Africa Clean Energy Technical Assistance Facility, Nairobi, Kenya, www.ace-taf.org/wp-content/uploads/2021/04/Assessment-of-Local-Manufacturing-of-Off-Grid-Solar-in-Sub-Saharan-Africa-1.pdf.

ACE, Tetra Tech and UKAID (2020), *Demand-Side Subsidies in Off-Grid Solar: A Tool for Achieving Universal Energy Access in Sustainable Markets*, Africa Clean Energy, Tetra Tech International Development, Nairobi, Kenya, www.ace-taf.org/wp-content/uploads/2020/09/Demand-Side-Subsidies-in-Off-Grid-Solar-A-Tool-for-Achieving-Universal-Energy-Access-and-Sustainable-Markets.pdf.

ACPC (2013), *Vulnerability to climate change in Africa: Challenges and recommendations for Africa*, Policy Brief 2, African Climate Policy Centre, https://archive.uneca.org/sites/default/files/PublicationFiles/policy_brief_2_vulnerability_to_climate_change_in_africa_challenges_and_recommendations_for_africa.pdf.

Acumen Fund (2021), "Global coalition launched $80 million relief fund to protect energy access in vulnerable communities from COVID-19 fallout", 1 September, https://acumen.org/blog/coalition-launches-energy-access-relief-fund/.

Adeniran, A. and Onyekwena, C. (2020), *Acceleration Green Energy Transition in Africa Through Regional Integration*, South African Institute of International Affairs, https://saiia.org.za/research/accelerating-green-energy-transition-in-africa-through-regional-integration/.

African Business (2020), "Green bonds revolution for Africa's exchanges", https://african.business/2020/02/economy/green-bonds-revolution-for-africas-exchanges/.

AfDB (African Development Bank) (2021a), *African Economic Outlook 2021*, African Development Bank, Abidjan, Côte d'Ivoire.

AfDB (2021b), "African Development Bank COVID-19 Off-Grid Recovery Platform reaches financial close for $20 million SEFA investment", African Development Bank, Abidjan, Côte d'Ivoire, www.afdb.org/en/news-and-events/press-releases/african-development-bank-covid-19-grid-recovery-platform-reaches-financial-close-20-million-sefa-investment-45139.

AfDB (2021c), *Desert to Power*, African Development Bank, Abidjan, Côte d'Ivoire https://www.afdb.org/sites/default/files/news_documents/dtp-brochure-2021.pdf.

AfDB (2020a), *African Economic Outlook 2020*, African Development Bank, Abidjan.

AfDB (2020b), "Africa's energy masterplan takes shape as African Development Bank and AUDA-NEPAD release key report", African Development Bank, 30 October, www.afdb.org/en/news-and-events/press-releases/africas-energy-masterplan-takes-shape-african-development-bank-and-auda-nepad-release-key-report-38576.

AfDB (2020c), *Electricity Regulatory Index for Africa 2020*, African Development Bank, Abidjan, Côte d'Ivoire, www.afdb.org/en/documents/electricity-regulatory-index-africa-2020.

AfDB (2019a), *NOOR Midelt Solar Complex Project: Phase I (NOORM I AND NOORM II Solar Plants): Morocco: Project Appraisal Report*, African Development Bank, Abidjan, Côte d'Ivoire, www.afdb.org/en/documents/document/morocco-noor-midelt-solar-complex-project-phase-i-noorm-i-and-noorm-ii-solar-plants-appraisal-report-109576.

AfDB (2019b), *Estimating Investment Needs for the Power Sector in Africa 2016-2025*, African Development Bank, Abidjan, Côte d'Ivoire, www.afdb.org/en/documents/estimating-investment-needs-power-sector-africa-2016-2025.

AfDB (2019c), *Revisiting Reforms in the Power Sector in Africa*, African Development Bank, Abidjan, Côte d'Ivoire, www.afdb.org/en/documents/revisiting-reforms-power-sector-africaGroup.

AfDB (2017), *The Bank Group's Strategy for the New Deal on Energy for Africa 2016-2025*, African Development Bank, Abidjan, Côte d'Ivoire, www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Bank_s_strategy_for_New_Energy_on_Energy_for_Africa_EN.pdf.

AfDB (2016), "Jobs for Youth in Africa. Catalyzing youth opportunity across Africa", African Development Bank, Abidjan, March 2016.

AfDB (2009a), "AfDB helps South Africa tackle energy crisis – approves €1.86 billion loan for Medupi Power Project", African Development Bank, Tunis, www.afdb.org/en/news-and-events/afdb-helps-south-africa-tackle-energy-crisis-approves-eur1-86-billion-loan-for-medupi-power-project-5421.

AfDB (2009b), *Medupi Power Project: Republic of South Africa: Project Appraisal Report*, African Development Bank, Abidjan, Côte d'Ivoire, www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/South_Africa_-_Medupi_Power_Project_-_Appraisal_Report.pdf.

Africa Oil & Power (2020), "Here's to a Modern Africa of Continental Free Trade and Energy Access", 20 October, https://www.africaoilandpower.com/2020/10/20/heres-to-a-modern-africa-of-continental-free-trade-and-energy-access/.

African Union (2021a), "Agenda 2063: The Africa we want", https://au.int/en/agenda2063/overview

African Union (2021b), "African Union Launches World's Largest Single Electricity Market (AFSEM)", 4 June, https://au.int/en/pressreleases/20210604/african-union-launches-worlds-largest-single-electricity-market-afsem.

African Union Commission (2015), "Agenda 2063 – The Africa We Want", https://au.int/en/agenda2063/overview.

AHP (n.d.), "The AHP", African Hydrogen Partnership, www.afr-h2-p.com/#:~:text=The%20African%20Hydrogen%20Partnership%20Trade,related%20business%20opportunities%20in%20Africa.

Aiginger, K. (2015), "Industrial Policy for a Sustainable Growth Path', in D. Bailey, K. Cowling, and P. Tomlinson (eds), New Perspectives on Industrial Policy for a Modern Britain, 365–94. Oxford: Oxford University Press.

Ainger, J. (2021), "Africa Wants $1.3 Trillion Annual Climate Finance as Rich Nations Miss Target", Bloomberg, 4 November, https://www.bloomberg.com/news/articles/2021-11-04/africa-wants-climate-finance-boost-as-rich-nations-miss-target#:~:text=The%20African%20Group%20of%20Negotiators,but%20has%20been%20repeatedly%20missed.

AIIM (2018), *Case study: Umoya energy wind farm (Umoya)*, aiim_case-study_umoya-windfarm_06072018.pdf (aiimafrica.com).

ALB (2020), "Is the Covid-19 pandemic fuelling the energy transition in Africa?", African Law and Business, 08 December, www.iclg.com/alb/15182-is-the-covid-19-pandemic-fuelling-the-energy-transition-in-africa (accessed 03 December 2021).

Al Bawaba (2021), "Egypt tests Chinese EVs ahead of local production", www.albawaba.com/business/egypt-tests-chinese-evs-ahead-local-production-1443691#:~:text=Egypt%20has%20begun%20testing%20China,Manufacturing%20Company%20starting%20mid%2D2022.

Alao, O. and Kruger, W. (2021), *Review of Private Power Investment in sub-Saharan Africa: 2020*, https://www.gsb.uct.ac.za/files/2020_SSA_Investment_Report_PFL.pdf.

Alova, G., Trotter, P. A. and Money, A. (2021), *A machine-learning approach to predicting Africa's electricity mix based on planned power plants and their chances of success*, Nature Energy, Vol. 6, pp. 158-166.

Anadon, L. D., Chan, G., Harley, A. G., Matus, K., Moon, S., Murthy, S. L. and Clark, W. C. (2016), *Making technological innovation work for sustainable development*, Proceedings of the National Academy of Sciences, 113(35), 9682-9690.

Anzolin, G. and Lebdioui, A. (2021), *Three dimensions of green industrial policy in the context of climate change and sustainable development*, The European Journal of Development Research, 33(2), 371-405.

Aswan Forum (2021), "The Aswan Conclusions on Sustainable Peace and Development in Africa – Second Edition", www.aswanforum.org/img-uploads/6825_18030149.pdf.

ATI (African Trade Insurance Agnecy) (2018), *The Regional Liquidity Support Facility (RLSF) for Sub-Saharan African independent power producers*, African Trade Insurance Agency, Nairobi, Kenya, www.ati-aca.org/wp-content/uploads/2018/04/RLSF-Teaser.pdf.

Ayaburi, J., Bazilian, M., Kincer, J. and Moss, T. (2020), "Measuring 'reasonably reliable' access to electricity services", *The Electricity Journal*, Vol. 33/7, 106828, pp. 1040-6190, https://doi.org/10.1016/j.tej.2020.106828.

Austin, G. and Morris, G. (2012), "Biogas production in Africa", in *Bioenergy for Sustainable Development in Africa*, Janssen, R. and Rutz, D. (eds), pp. 103-115, Springer, Dordrecht, https://doi.org/10.1007/978-94-007-2181-4_10.

Bailey, S. (2021), "Egypt is building a $4.5 billion high-speed rail line", CNN Travel, 17 December, https://edition.cnn.com/travel/article/egypt-high-speed-train-spc-intl/index.html.

Baker, L. and Sovacool, B. K. (2017), *The political economy of technological capabilities and global production networks in South Africa's wind and solar photovoltaic (PV) industries*, Political Geography, 60, 1-12.

Banerjee, M. (2019), "Gender neutral ways of ensuring universal electricity access in Sub-Saharan Africa", www.orfonline.org/expert-speak/gender-neutral-ways-ensuring-universal-electricity-access-sub-saharan-africa-51872/.

Barasa, M. (2021), "Counting the cost: Is electricity affordable for Africa's non-residential consumers?", www.energyforgrowth.org/memo/counting-the-cost-is-electricity-affordable-for-africas-non-residential-consumers/.

Barasa, M., Bogdanov, D., Oyewo, A. and Breyer, C. (2018), *A cost optimal resolution for Sub-Saharan Africa powered by 100% renewables in 2030*, Renewable and Sustainable Energy Reviews, Vol. 92, pp. 440-457.

Barrett, S. (2009), *The coming global climate-technology revolution*, Journal of Economic Perspectives, Vol.23, No.2, pp.53-75.

BBC (2019), "Eskom crisis: Why the lights keep going out in South Africa", BBC News, 16 February, www.bbc.com/news/world-africa-47232268 (accessed 11 January 2021).

BDLG (Buikwe District Local Government) (2016). "Buikwe District Local Government: Profile", Buikwe District Local Government, Uganda https://buikwe. go.ug/sites/default/files/District%20Profile%202016%20 Buikwe%20final.pdf.

Bellini, E. (2019), "Winners and prices of Tunisia's 500 MW PV tender", PV Magazine, www.pv-magazine.com/2019/12/20/winners-and-prices-of-tunisias-500-mw-pv-tender/.

Benedick, R.E. (2001), *Striking a new deal on climate change, Issues in Science and Technology*, Vol. 18(1), 71-76.

Berkeley Energy (2021), "Berkeley Energy Funds: The Africa Renewable Energy Fund (AREF)", www.berkeley-energy.com/energy-funds/.

Bertrand, M., and Crepon, B. (2016), "Teaching Labor Laws: Results from a Randomized Control Trial in South Africa." Centre de Recherche en Economie et Statistique.

BGFA (Beyond the Grid Fund for Africa) (2021), "About BGFA", Beyond the Grid Fund for Africa, https://beyondthegrid.africa/about-bgfa/.

BGR (Bundesanstalt fur Geowissenschaften und Rohstoffe) (2016), "Regional Project: Geothermal Energy – East Africa", Bundesanstalt fur Geowissenschaften und Rohstoffe (BGR), www.bgr.bund.de/EN/Themen/Zusammenarbeit/TechnZusammenarb/Projekte/Abgeschlossen/Afrika/2029_2016-2066-5_RegionalOstafrika_Geothermie_en.html?nn=1548118 (accessed 03 December 2021).

Biofuels International (2019), "South Africa's OR Tambo airport to introduce biodiesel into operations", https://biofuels-news.com/news/south-africas-or-tambo-airport-to-introduce-biodiesel-into-operations/.

BITRI (Botswana Institute for Technology Research and Innovation) (n.d.), "Energy division", www.bitri.co.bw/energy-division/.

Barasa, M. (2021), "Counting the cost: Is electricity affordable for Africa's non-residential consumers?", www.energyforgrowth.org/memo/counting-the-cost-is-electricity-affordable-for-africas-non-residential-consumers/.

Blimpo, M. P. and Cosgrove-Davies, M. (2019), *Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact*, Africa Development Forum series, World Bank, Washington, DC, doi:10.1596/978-1-4648-1361-0.

BMBF (Federal Ministry of Education and Research) (2021), "West Africa can become the climate-friendly energy powerhouse of the world", Federal Ministry of Education and Research, Bonn, Germany, www.bmbf.de/bmbf/en/home/_documents/west-africa-can-become-the-cli-energy-powerhouse-of-the-world.html.

BNEF (Bloomberg New Energy finance) (2021a), "China to stop building new coal-fired power projects abroad", Bloomberg News, Bloomberg New Energy Finance, www.bnef.com/news/963179 (subscription required).

BNEF (2021b), "China avoids coal projects in belt and road for first time", Bloomberg News, Bloomberg New Energy Finance, www.bnef.com/news/943935 (subscription required).

BNEF (2021c), "Renewable assets" (database), Bloomberg New Energy Finance, www.bnef.com/projects/search (subscription required).

BNEF and Lighting Global (2016), *Off-Grid Solar Market Trends Report 2016*, Bloomberg New Energy Finance, London and Lighting Global, Washington, DC in cooperation with the Global Off-Grid Lighting Association (GOGLA), the Netherlands, www.lightingglobal.org/wp-content/uploads/2016/03/20160301_OffGridSolarTrendsReport-1.pdf.

Bond, J. and Fajgenbaum, J. (2014), *Harnessing natural resources for diversification*, Global Journal of Emerging Market Economies, 6 (2), 119–143, https://doi.org/10.1177/0974910114525536.

Borgstein, E., Wade, K. and Mekonnen, D. (2020), "Capturing the productive use dividend: Valuing the synergies between rural electrification and smallholder agriculture in Ethiopia", Rocky Mountain Institute, www.rmi.org/insight/ethiopia-productive-use/.

Breisinger, C., Mukashov, A., Raoufa, M., and Wiebelt, M. (2019), Energy subsidy reform for growth and equity in Egypt: The approach matters, Energy Policy, Vol. 129, pp. 661-671.

Brookings (2021), "Africa's green bond market trails behind other regions", www.brookings.edu/blog/africa-in-focus/2021/03/26/africas-green-bond-market-trails-behind-other-regions/.

Bumbarger, S. (2021), "Powering small-scale renewable electrification in rural Zambia", https://dt-global.com/es/company/blog/april-29th-2021/mini-grids/.

Bungane (2020), "Nigeria announces new energy access project 'Solar Power Naija'", ESI Africa, 7 December, https://www.esi-africa.com/renewable-energy/nigeria-announces-new-energy-access-project-solar-power-naija/

Burke, M., Hsiang, S. and Miguel, E. (2015), Global non-linear effect of temperature on economic production, Nature, https://www.nature.com/articles/nature15725.

Burke M., Matthew Davis, W. and Diffenbaugh N. (2018), "Large potential reduction in economic damages under UN mitigation targets", Nature, https://www.nature.com/articles/s41586-018-0071-9.

Burke M. and Tanutama V. (2019), "Climatic Constraints on Aggregate Economic Output", Working Paper No. 1044, National Bureau of Economic Research.

Burn Stoves (2021), "Impact", https://burnstoves.com/impact/our-impact.

Business Insider Africa (2021), "African Trade Insurance Agency (ATI) steps in to provide liquidity cover for the 60 MW JCM Salima Solar PV – the second project in Malawi to benefit from the Regional Liquidity Support Facility (RLSF)", https://africa.businessinsider.com/apo/african-trade-insurance-agency-ati-steps-in-to-provide-liquidity-cover-for-the-60-mw/c47v2zk.

Business Wire (2020), "Greenlight Planet, solar pay-as-you-go market leader secures 90 million investment", www.businesswire.com/news/home/20200922005395/en/Greenlight-Planet-Solar-Pay-As-You-Go-Market-Leader-Secures-90-Million-Investment.

Byrne, R., Onsongo, E., Onjala, B., Chengo, V., Todd, J. F., Ockwell, D. and Atela, J. (2020), "Electric cooking in Kenya: An actor-network map and analysis of a nascent socio-technical innovation system", https://mecs.org.uk/wp-content/uploads/2020/12/Byrne-et-al-2020-Kenya-ISM-MECS-format-200809-1.pdf.

Campos, F., Goldstein, M., McGorman, L., Munoz Boudet, A.M., and Pimhidzai, O. (2016), "Breaking the Metal Ceiling Female Entrepreneurs Who Succeed in Male-Dominated Sectors", https://openknowledge.worldbank.org/bitstream/handle/10986/23469/Breaking0the0m0le0dominated0sectors.pdf?sequence=1&isAllowed=y

CEREEAC (Centre for Renewable Energy and Energy Efficiency for Central Africa) (2021), "ECCAS Centre for Sustainable Energy", Centre for Renewable Energy and Energy Efficiency for Central Africa, Gabon, www.gn-sec.net/content/eccas-centre-sustainable-energy.

Chang, H.J. (2013), "Comments on 'Comparative Advantage: The Silver Bullet of Industrial Policy' by Justin Lin and Célestin Monga", *The Industrial Policy Revolution I* (pp. 39-42). Palgrave Macmillan, London.

China Daily (2021), "China to stop building new coal-fired power projects abroad: Xi", www.chinadaily.com.cn/a/202109/22/WS614a3c0aa310cdd39bc6a863.html.

CIF (Climate Investment Funds) (2021a), "Climate Investment Funds: Donors & MDBs", Climate Investment Funds, www.climateinvestmentfunds.org/finances.

CIF (2021b), "Clean Technology Fund", Climate Investment Funds, www.climateinvestmentfunds.org/topics/clean-technologies.

CIF (n.d.), "Ouarzazate: Lighting up the sky", Climate Investment Funds, www.climateinvestmentfunds.org/CIF10/morocco/ouarzazate.

Cilliers, J., and S. Kwasi (2021), "Strategies for preserving gains in human development in Africa in the time of COVID", Brookings, January, https://www.brookings.edu/essay/human-development-protecting-vulnerable-populations/.

Cimoli, M., G. Dosi and J.E. Stiglitz (2009), *The political economy of capabilities accumulation: The past and future of policies for industrial development*. Oxford University Press.

Clemens, H., Bailis, R., Nyambane, A. and Ndung'u, V. (2018), "Africa Biogas Partnership Program: A review of clean cooking implementation through market development in East Africa", *Energy for Sustainable Development*, Vol. 46/ October, pp. 23-31, https://doi.org/10.1016/j.esd.2018.05.012.

Clements, R. (2009), *The Economic Cost of Climate Change in Africa*. Pan-African Climate Justice Alliance.

Clifford Chance (2021), "Focus on hydrogen: A new energy frontier for Africa", www.cliffordchance.com/content/dam/cliffordchance/briefings/2021/01/focus-on-hydrogen-a-new-energy-frontier-for-africa.pdf.

Climate Bonds Initiative (2021a), "Record $269.5bn green issuance for 2020: Late surge sees pandemic year pip 2019 total by $3bn", www.climatebonds.net/2021/01/record-2695bn-green-issuance-2020-late-surge-sees-pandemic-year-pip-2019-total-3bn.

Climate Bonds Initiative (2021b), "Climate Bonds Initiative and FSD Africa launch Africa Green Bonds Toolkit: A practical guide for African markets", www.climatebonds.net/2020/09/climate-bonds-initiative-and-fsd-africa-launch-africa-green-bonds-toolkit-practical-guide.

Climate Care (2021), "Gyapa stoves in Ghana", www.climatecare.org/projects/project-map/gyapa-stoves-in-ghana/.

Cohn, L. (2021), "Will utility partnerships in minigrid projects help overcome electrification barriers in Uganda?", https://microgridknowledge.com/uganda-minigrid/.

Conchado, A., Díaz Anadón, L., Linares Llamas, P. and López-Peña Fernández, Á. (2016), "Benefits of investing in energy R&D and portfolio optimization: the case of Spain", EAERE-FEEM-VIU European Summer School on Uncertainty, Innovation and Climate Change, Venice (Italy).

Conference of Parties 26 (2021), "Statement on International Public Support for the Clean Energy Transition", 4 November, https://ukcop26.org/statement-on-international-public-support-forthe-clean-energy-transition/.

Copenhagen Centre on Energy Efficiency and UNEP DTU Partnership (2015), *Accelerating Energy Efficiency: Initiatives and Opportunities – Africa, Copenhagen Centre on Energy Efficiency* (SE4ALL Energy Efficiency Hub), Copenhagen, Denmark, https://unepdtu.org/wp-content/uploads/2015/08/african-regional-report.pdf.

Couture, T. and Jacobs, D. (2019), *Beyond Fire: How to Achieve Electric Cooking*, World Future Council, Hamburg, Germany, www.worldfuturecouncil.org/wp-content/uploads/2019/05/Beyond-Fire_-How-to-achieve-electric-cooking.pdf

CPI (Climate Policy Initiative) (2020), *Updated View on the 2019 Global Landscape of Climate Finance*, Climate Policy Initiative, London, www.climatepolicyinitiative.org/publication/updated-view-on-the-global-landscape-of-climate-finance-2019/.

Cronk, R. and Bartram, J. (2018), *Environmental conditions in health care facilities in low and middle-income countries: Coverage and inequalities*, International Journal of Hygiene and Environmental Health, Vol. 221/3, pp. 409 422.

Cross, J. and Murray, D. (2018), *The afterlives of solar power: Waste and repair off the grid in Kenya*, Energy Research & Social Science, Vol. 44, pp. 100-109, https://reader.elsevier.com/reader/sd/pii/S2214629618304055?token=51EB3DC7DBEE752B4566F6C76DC63CC45CCAE0A45069471ABDDA3BE5A214218BEE140691222FC1A15603A50C05D6C4AA&originRegion=eu-west-1&originCreation=20210914101349.

CSIR (Council for Scientific and Industrial Research) (n.d.a), "National Cleaner Production Centre of South Africa", Council for Scientific and Industrial Research, www.csir.co.za/national-cleaner-production-centre-south-africa (accessed November 2021).

CSIR (n.d.b), "Energy Research Centre", Council for Scientific and Industrial Research, www.csir.co.za/energy-research-centre.

Dalberg (2018), *Cleaning up cooking in urban Kenya with LPG and bio-ethanol*, Dalberg, www.dalberg.com/our-ideas/cleaning-cooking-urban-kenya-lpg-and-bio-ethanol/.

Diestche, E. (2018), "New industrial policy and the extractive industries", in A. Addison and A. Roe (eds) *Extractive Industries: The Management of Resources as a Driver of Sustainable Development*, 137-160, Oxford University Press.

DoT (2018), *Green Transport Strategy for South Africa: (2018-2050)*, Department of Transport, South Africa, Pretoria, www.transport.gov.za/documents/11623/89294/Green_Transport_Strategy_2018_2050_onlineversion.pdf/71e19f1d-259e-4c55-9b27-30db418f105a.

Doumbia, D. (2021), "Power market sophistication and sector outcomes: A focus on social performance, electricity reliability, and renewable energy penetration", https://openknowledge.worldbank.org/bitstream/handle/10986/35293/Power-Market-Sophistication-and-Sector-Outcomes-A-Focus-on-Social-Performance-Electricity-Reliability-and-Renewable-Energy-Penetration.pdf?sequence=1&isAllowed=y.

DTU (Technical University of Denmark) (2015), "Global wind atlas", DTU, Lyngby (Denmark), https://science.globalwindatlas.info/#/map.

Dunbar, M. (2013), "Engaging the private sector in skills development", www.norrag.org/fileadmin/Events/Oxford/OxCon_2013_Dunbar.pdf.

EACREEE (East African Centre for Renewable Energy and Energy) (2020), *Business Plan 2020-2024*, East African Centre for Renewable Energy and Energy Efficiency, Uganda, www.eacreee.org/sites/default/files/documents/files/31.07.2020_EACREEE_business_plan_FINAL_VERSION.pdf.

Eberhard, A., Gratwick, K. and Kariuki, L. (2018), *Lessons from two decades of experience with independent power producers*, Utilities Policy, Vol. 52, pp. 37-49.

Eberhard, A. and Naude, R. (2017), *The South African Renewable Energy IPP Procurement Programme: Review, Lessons Learned & Proposals to Reduce Transaction Costs*, Graduate School of Business, University of Cape Town, www.gsb.uct.ac.za/files/EberhardNaude_REIPPPPReview_2017_1_1.pdf.

Eberhard, A., Gratwick, K., Morella, E. and Antmann, P. (2016), *Independent Power Projects in Sub-Saharan Africa: Lessons from Five Key Countries*, Directions in Development, World Bank, Washington, DC, https://openknowledge.worldbank.org/handle/10986/23970.

EC (European Commission) (2019), "African Energy Guarantee Facility (AEGF)", European Commission, https://ec.europa.eu/eu-external-investment-plan/projects/african-energy-guarantee-facility-aegf_en.

ECREEE (ECOWAS Centre for Renewable Energy and Energy Efficiency) (2020), "West African Clean Cooking Alliance (WACCA)", ECOWAS (Economic Community of West African States) Centre for Renewable Energy and Energy Efficiency, Praia, www.ecreee.org/Project/wacca (accessed 21 August 2021).

ECREEE (2019), "ECOWAS Certification of Sustainable Energy Skills (ECSES) scheme", ECOWAS Centre for Renewable Energy and Energy Efficiency, https://drive.google.com/file/d/1avv0zrS1YbqleRtoal-OCBaQ0cHj6lPg/view.

ECREEE (2018), *Regional Progress Report on Renewable Energy, Energy Efficiency and Energy Access in ECOWAS Region: Monitoring Year: 2016*, ECOWAS Centre for Renewable Energy and Energy Efficiency, Cabo Verde, www.ecreee.org/system/files/ecreee_report_-_regional_monitoring_framework_2016_0.pdf.

ECREEE (n.d.a), "ECOWAS Renewable Energy Entrepreneurship Support Facility", ECOWAS Centre for Renewable Energy and Energy Efficiency, www.ecreee.org/page/ecowas-renewable-energy-entrepreneurship-support-facility (accessed 9 September 2021).

ECREEE (n.d.b), "ECOWAS Program on Gender Mainstreaming in Energy Access (ECOWGEN)", ECOWAS Centre for Renewable Energy and Energy Efficiency, www.ecreee.org/page/ecowas-program-gender-mainstreaming-energy-access-ecowgen.

EEG (2021), *Key principles for improving the support to strategic energy planning in developing and emerging economies*, The Applied Research Programme on Energy and Economic Growth, www.energyeconomicgrowth.org/publication/key-principles-improving-support-strategic-energy-planning-developing-and-emerging.

EEP Africa (2021), "Biogas by women for women", https://eepafrica.org/wp-content/uploads/2021/08/KEN15050_Sistema.bio_.pdf.

EEP Africa (2018), *Opportunities and Challenges in the Mini-Grid Sector in Africa*, EEP Africa, Hatfield, South Africa, https://eepafrica.org/wp-content/uploads/2019/11/EEP_MiniGrids_Study_DigitalVersion.pdf.

Efficiency for Access (2021), "Global LEAP Awards", https://efficiencyforaccess.org/global-leap-awards-2.

Efficiency for Access (2019), *Solar Water Pump Outlook 2019: Global Trends and Market Opportunities*, https://efficiencyforaccess.org/publications/solar-water-pump-outlook-2019-global-trends-and-market-opportunities.

EIA (Energy Information Administration) (2019), "Background Reference: Angola", U.S. Energy Information Administration, Washington, DC, www.eia.gov/international/content/analysis/countries_long/Angola/background.htm#:~:text=Angola%20does%20not%20have%20a,%2C%20Central%2C%20and%20Southern%20systems (accessed 15 January 2021).

Elico Foundation (2020), "Solar-powered irrigation systems transforming smallholders farming practices in rural Tanzania", https://elicofoundation.org/solar-powered-irrigation-systems-transforming-smallholders-farming-practices-in-rural-tanzania/.

El-Katiri, L. and Fattouh, B. (2015), *A brief political economy of energy subsidies in the Middle East and North Africa*, Oxford Institute for Energy Studies, Oxford, UK, www.oxfordenergy.org/wpcms/wp-content/uploads/2015/02/MEP-11.pdf.

EMF (Ellen Macarthur Foundation) (2021), "Circular economy in Africa: examples and opportunities", https://ellenmacarthurfoundation.org/circular-economy-in-africa/overview

Endale, A. (2020), "Addis Ababa to board electric buses", https://ethiopianbusinessreview.net/addis-ababa-to-board-electric-buses/.

EnDev (2021a), *Transforming Energy Access Markets with Results-Based Financing*, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn and Eschborn, Germany, https://endev.info/wp-content/uploads/2021/08/EnDev_RBF-Lessons-Learnt-Report_2021.pdf.

EnDev (2021b), "EnDev Uganda's COVID-19 relief fund for the solar and cookstove sector", https://endev.info/endev-ugandas-covid-19-relief-fund-for-the-solar-and-cookstove-sector/.

ENEA (National Agency for New Technologies, Energy and Sustainable Economic Development) (2016), *Developing Mini-Grids in Zambia: How to Build Sustainable and Scalable Business Models?* ENEA, Paris, www.club-er.org/files/fichiers/photo251118214434.pdf.

ENERGIA (2019), "Kenyan Ministry of Energy launches first national gender policy in the energy sector ever", www.energia.org/kenyan-ministry-of-energy-launches-first-national-gender-policy-in-the-energy-sector-ever/.

Energy4Impact (2021), "Solar irrigation Rwanda: Developing a new market for smallholder farmers", https://energy4impact.org/news/solar-irrigation-rwanda-%E2%80%93-developing-new-market-smallholder-farmers.

Energy4Impact and Inensus (2018), *Mini-Grid Training Needs Assessment: Gap Analysis for Developers*, https://energy4impact.org/file/2085/download?token=DoEEe2rq.

Energy and Petroleum Regulatory Authority of Kenya (2012), "The energy (solar photovoltaic systems) regulations, 2012", https://eregulations.invest.go.ke/media/THE%20ENERGY%20_SOLAR%20PHOTOVOLTAIC%20SYSTEMS_%20REGULATIONS%202012.pdf.

EPRA (2021), "The draft energy (mini-grid) regulations", Energy and Petroleum Regulatory Authority, Nairobi, Kenya, www.epra.go.ke/wp-content/uploads/2021/05/MINIGRID-REGULATIONS-REGULATORY-IMPACT-STATEMENT-FINAL-1.pdf.

ESI Africa (2021), "South Africa launches their first electric bus in Cape Town", www.esi-africa.com/industry-sectors/future-energy/south-africa-launches-their-first-electric-bus-in-cape-town/.

ESI Africa (2018), "S. Africa: 100MW Karoshoek Solar One project goes live", www.esi-africa.com/resources/press-releases/s-africa-100mw-karoshoek-solar-one-project-goes-live/.

ESMAP (Energy Sector Management Assistance Program) (2020a), *The State of Access to Modern Energy Cooking Services*, Energy Sector Management Assistance Program, World Bank, Washington, DC, https://documents1.worldbank.org/curated/en/937141600195758792/pdf/The-State-of-Access-to-Modern-Energy-Cooking-Services.pdf.

ESMAP (2020b), *Regulatory Indicators for Sustainable Energy (RISE): Sustaining the Momentum*, Energy Sector Management Assistance Program, Washington, DC: World Bank. http://hdl.handle.net/10986/34937.

ESMAP (2019a), *Mini-Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers*, Energy Sector Management Assistance Program, World Bank, Washington, DC, https://esmap.org/mini_grids_for_half_a_billion_people.

ESMAP (2019b), "Global solar atlas", World Bank, Washington, DC, https://globalsolaratlas.info/map.

ESMAP (2017), "A phased approach to energy subsidy reform: Morocco experience", Energy Sector Management Assistance Program, Washington, DC, www.esmap.org/node/140726.

ESMAP (2015a), *Beyond Connections: Energy Access Redefined*, Energy Sector Management Assistance Program, World Bank, Washington, DC, https://mtfenergyaccess.esmap.org/data/files/download-documents/full_report_beyond_connection.pdf.

ESMAP (2015b), *The State of the Global Clean and Improved Cooking Sector*, Energy Sector Management Assistance Program, World Bank, Washington, DC, www.esmap.org/sites/esmap.org/files/DocumentLibrary/ESMAP_State_of_Globa_Clean_Improved_Cooking_sector_Optimized.pdf.

Ethiopia Job Creation Commission (2021), *Ethiopia Job Creation through Off-Grid Energy Access*, Ethiopia Job Creation Commission, Addis Ababa, Ethiopia, www.ace-taf.org/wp-content/uploads/2021/08/Jobs-and-Energy-Report_Ethiopia-_August_2021.pdf.

EU (European Union) (2021), "African leaders launch the 'African Single Electricity Market (AfSEM)'", EEAS - European Commission.

European Commission (2020), "Financing the green transition: The European Green Deal Investment Plan and Just Transition Mechanism", 14 January, https://ec.europa.eu/commission/presscorner/detail/en/ip_20_17.

European Commission (2019), *The European Green Deal COM(2019) 640 final*, European Commission, Brussels, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en.

FAO (Food and Agriculture Organization) (2021a), "Forestry production and trade", Food and Agriculture Organization, Rome, www.fao.org/faostat/en/#data/FO.

FAO (2021b), "Biogas systems in Rwanda – A critical review", Food and Agriculture Organization, Rome, Italy, www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1393280/.

Fair & Sustainable Consulting (2019), *Africa Biogas Partnership Programme (ABPP): Phase 2 Effect Evaluation: Final Report*, Fair & Sustainable Consulting, Utrecht, The Netherlands, www.government.nl/binaries/government/documents/reports/2019/05/13/africa-biogas-partnership-programme-abpp-phase-2---effect-evaluation/Africa+Biogas+Partnership+Programme.pdf.

Farouk, M. (2018), "Egypt launches renewable energy curriculum to boost promising sector", www.al-monitor.com/originals/2018/02/egypt-launches-renewable-energy-curriculum.html#ixzz5FfXczpH1 (accessed 14 September 2021).

Fisher, S. *et al.* (2021), "Air pollution and development in Africa: impacts on health, the economy, and human capital", The Lancet, Vol. 5, October, e681-e688.

Footprints Africa (2021), "On a mission to prove business can be a force for good at scale", www.footprintsafrica.co/.

Forest Research (2019), "Wood removals", www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2019/international-forestry/wood-removals/.

Foster, V. and Rana, A. (2020), *Rethinking Power Sector Reform in the Developing World*, World Bank, Washington, DC, https://openknowledge.worldbank.org/handle/10986/32335.

FSD Africa *et al.* (2019), *State of the Market Report: The Nigerian Green Bond Market Development Programme*, Financial Sector Deepening Africa, UK Aid, FMDQ Securities Exchange and Climate Bonds Initiative, www.climatebonds.net/files/reports/nigerian-green-bond-market-development-programme-state-of-the-market-final.pdf.

Fuel Cells Works (2020), "Germany: Hydrogen partnership with Africa begins", https://fuelcellsworks.com/news/germany-hydrogen-partnership-with-africa-begins/.

FW Africa (2021), "Trade and Development Bank launches US$75m SME off-grid facility ", https://africaincmag.com/trade-and-development-bank-launches-us75m-sme-off-grid-facility/.

Garrett-Peltier, H. (2017), *Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model*, Economic Modelling, Vol. 61, February, pages 439-447.

GASCOOL (2004), "GASCOOL district cooling/heating plant at smart village", Egyptian Company for Energy and Cooling Projects, Egypt, www.gascool-eg.com/index.php/en/projects-en/dcps/45-project1-en#.

GBEP (Global Bioenergy Partnership) (2020), *Collection of Examples: Positive Relationships between Sustainable Wood Energy and Forest Landscape Restoration*, Global Bioenergy Partnership, Rome, Italy, www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/AG4/AG4_Collection_of_examples_links_sust._wood_energy_and_FLR_June2020.pdf.

GCEEP (Global Commission to End Energy Poverty) (2020), *Global Commission to End Energy Poverty: 2020 Report Electricity Access*, Global Commission to End Energy Poverty, www.rockefellerfoundation.org/wp-content/uploads/2020/12/GCEEP-ALLReports-FullComp11b.pdf.

GCF (Green Climate Fund) (2021), "GCF Spotlight: Africa (as of 1 July, 2021)", Green Climate Fund, www.greenclimate.fund/sites/default/files/document/gcf-spotlight-africa-jul2021_1.pdf.

GCF (2019), *Promotion of Climate-Friendly Cooking: Kenya and Senegal*, Green Climate Fund, www.greenclimate.fund/document/promotion-climate-friendly-cooking-kenya-and-senegal.

Gebrezgabher, S. and Niwagaba, C. B. (2018). *Briquettes from agro-waste and municipal solid waste* (EcoFuel Africa, Uganda) – case study, Taylro & Francis, https://wle.cgiar.org/briquettes-agro-waste-and-municipal-solid-waste-eco-fuel-africa-uganda-case-study.

Gessesse, A. (2021), "The benefits of big hydro in Ethiopia", Stantec, www.stantec.com/en/ideas/the-benefits-of-big-hydro-in-ethiopia.

GFPN (Green Fiscal Policy Network) (2017), "Mauritius – Country profile", Green Fiscal Policy Network, Bonn, Germany, https://greenfiscalpolicy.org/policy_briefs/mauritius-country-profile/.

GGGI (Global Green Growth Institute) (2021), "Rwanda aims to have 20% of all buses transition to electric by 2030", Global Green Growth Institute, Kigali, Rwanda, https://gggi.org/rwanda-aims-to-have-20-of-all-buses-transition-to-electric-by-2030/.

GN-SEC (Global Network of Regional Sustainable Energy Centers) (2021), "Consultancy services to develop ECOWAS green hydrogen policy", Global Network of Regional Sustainable Energy Centers, www.gn-sec.net/procurement/consultancy-services-develop-ecowas-green-hydrogen-policy.

GOGLA (2021a), *Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data: January-June 2021 public report*, Global Association for the Off-grid Solar Energy Industry, Amsterdam, The Netherlands, www.gogla.org/sites/default/files/resource_docs/global_off_grid_solar_market_report_h1_2021.pdf.

GOGLA (2021b), *Discussion paper: How end-user subsidies can help achieve universal energy access*, Global Association for the Off-grid Solar Energy Industry, Amsterdam, www.gogla.org/sites/default/files/resource_docs/gogla_discussion-paper-subsidies_def_2.pdf.

GOGLA (2021c), "A big win for Kenya: Government reinstates VAT exemption on renewable energy products", www.gogla.org/news/a-big-win-for-kenya-government-reinstates-vat-exemption-on-renewable-energy-products.

GOGLA (2020a), *Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data: July-December 2020 public report*, Global Association for the Off-grid Solar Energy Industry, Amsterdam, The Netherlands, www.gogla.org/sites/default/files/resource_docs/global_off-grid_solar_market_report_h2_2020.pdf.

GOGLA (2020b), "Committed investors keep the funds flowing for off-grid solar", Global Association for the Off-grid Solar Energy Industry, Amsterdam, The Netherlands, www.gogla.org/about-us/blogs/committed-investors-keep-the-funds-flowing-for-off-grid-solar.

GOGLA (2020c), *Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data: January-June 2020*, Global Off-Grid Lighting Association, Amsterdam, The Netherlands, www.gogla.org/sites/default/files/resource_docs/global_off_grid_solar_market_report_h1_2020.pdf.

GOGLA (2020d), "Policy alert: Kenya introduces VAT on off-grid solar products", www.gogla.org/news/policy-alert-kenya-introduces-vat-on-off-grid-solar-products.

GOGLA (2020e), "Productive use of off-grid solar: Appliances and solar water pumps as drivers of growth", www.gogla.org/sites/default/files/resource_docs/gogla_pb_use-of-off-grid-solar_def.pdf.

Government of Mozambique (2019), *Mozambique Cyclone Idai: Post Disaster Needs Assessment*, https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_704473.pdf.

GPOBA (Global Partnership on Output-Based Aid) (2018), *A Guide for Effective Results-Based Financing Strategies*, Global Partnership on Output-Based Aid, World Bank, Washington, DC, http://gpoba.org/sites/gpoba.org/files/publication/downloads/2018-11/Guide_for_Effective_RBF_Strategies.pdf.

Grabosch, M. (2018), *EV readiness: Assessment*, Urban Electric Mobility Initiative (UEMI) Secretariat, Berlin, www.uemi.net/uploads/4/8/9/5/48950199/uemi_ev_readiness_sa-small.pdf.

FZ- Jülich (Forschungszentrum Jülich GmbH) (n.d), *H2 ATLAS-AFRICA Atlas of Green Hydrogen Generation Potentials in Africa: A technological, environmental and socioeconomic feasibility assessment*, Forschungszentrum Jülich GmbH, https://www.sasscal.org/wp-content/uploads/2020/04/updated-h2-atlas-project-flier.pdf

Hakeenah (2018), "Equity Bank, Orb Energy partner to give builders solar water heating loans and systems", www. theexchange.africa/tech-business/equity-bank-orb-energypartner-to-give-builders-solar-water-heating-loans-and-syst.

Hall, M. (2021), "Finance for 49 mini grids in Sierra Leone and Uganda", PV Magazine, 18 February, www.pv-magazine.com/2021/02/18/finance-for-49-mini-grids-in-sierra-leone-and-uganda/.

Hallegatte, S., Fay, M., and Vogt-Schilb, A. (2013), *Green Industrial Policy: When and How*, World Bank Policy Research Working Paper No. 6677. Washington, DC: World Bank.

Heinrich Böll Stiftung (2021), "The EU's Fit-for-55 package", https://eu.boell.org/en/fit-for-55.

Hoes (2014), "Global potential hydropower locations", 4TU.ResearchData, Dataset, https://doi.org/10.4121/uuid:99b42e30-5a69-4a53-8e77-c954f11dbc76.

Hunt, J., Byers, E., Wada, Y., Parkinson, S., Gernaat, D., Langan, S., van Vuuren, D. P., and Riahi, K. (2020), "Global resource potential of seasonal pumped hydropower storage for energy and water storage", Nature Communications, Vol. 11, Article 947.

ICRC (International Committee of Red Cross) (2020), *When Rain Turns to Dust: Understanding and Responding to the Combined Impact of Armed Conflicts and the Climate on Environment Crisis on People's Lives*, International Committee of the Red Cross, Geneva, https://www.icrc.org/sites/default/files/topic/file_plus_list/rain_turns_to_dust_climate_change_conflict.pdf.

IEA (International Energy Agency) (2021a), *World Energy Balances*, International Energy Agency, Paris, www.iea.org/reports/world-energy-balances-overview.

IEA (2021b), *Access to Electricity*, International Energy Agency, Paris, www.iea.org/reports/sdg7-data-and-projections/access-to-electricity (accessed 30 August 2021).

IEA (2021c), "IEA fossil fuel subsidies database", International Energy Agency, Paris, www.iea.org/topics/energy-subsidies.

IEA (2020a), "The COVID-19 crisis is reversing progress on energy access in Africa", International Energy Agency, www.iea.org/articles/the-covid-19-crisis-is-reversing-progress-on-energy-access-in-africa

IEA (2020b), *World Energy Outlook 2020*, International Energy Agency, Paris, www.iea.org/reports/world-energy-outlook-2020.

IEA (2020c), "Access to clean cooking and premature deaths from household air pollution in Sub-Saharan Africa and Asia, 2010-2018", International Energy Agency, Paris, www.iea.org/data-and-statistics/charts/access-to-clean-cooking-and-premature-deaths-from-household-air-pollution-in-sub-saharan-africa-and-asia-2010-2018

IEA (2019a), *Africa Energy Outlook 2019*, International Energy Agency, Paris, www.iea.org/reports/africa-energy-outlook-2019.

IEA (2019b), *Nigeria Energy Outlook: Analysis from Africa Energy Outlook 2019*, International Energy Agency, Paris, www.iea.org/articles/nigeria-energy-outlook.

IEA, IRENA, UNSD (United Nations Statistics Division), World Bank and WHO (World Health Organization) (2021), *Tracking SDG 7: The Energy Progress Report*, World Bank, Washington, DC, https://trackingsdg7.esmap.org/data/files/download-documents/2021_tracking_sdg7_report.pdf.

IFC (International Finance Corporation) (2021), "A new solar park shines a light on Egypt's energy potential", International Finance Corporation, Washington, DC, www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/cm-stories/benban-solar-park-egypt.

IFC (2020), *Off-Grid Solar Market Trends Report 2020*, International Finance Corporation, Washington, DC, www.lightingglobal.org/wp-content/uploads/2020/03/VIVID%20OCA_2020_Off_Grid_Solar_Market_Trends_Report_Full_High.pdf.

IFC (2019), "IFC and MIGA to support landmark wind farm on Egypt's Gulf of Suez", International Finance Corporation, Cairo, Egypt, https://pressroom.ifc.org/all/pages/PressDetail.aspx?ID=18488.

IFC (2018a), *Seven Sisters (Jordan): Amplifying the voice of developers*, International Finance Corporation, Washington, DC, www.ifc.org/wps/wcm/connect/a3e81cb4-a73d-422e-9700-ae369b56f4d8/scaling-infra-jordan-10.pdf?MOD=AJPERES&CVID=mSCZig6#:~:text=Jordan's%20%E2%80%9CSeven%20Sisters%E2%80%9D%20are%20a,Government%20of%20Jordan%20in%202011.

IFC (2018b), *Nubian Suns (Egypt): Scale at speed*, International Finance Corporation, Washington, DC, www.ifc.org/wps/wcm/connect/9ed0cd1e-f9b0-4f55-b5c2-c7741f2af162/scaling-infra-egypt-10.pdf?MOD=AJPERES&CVID=mSCOjq2.

IHA (International Hydropower Association) (2020), *2020 Hydropower Status Report: Sector Trends and Insights*, International Hydropower Association, London.

IIEP-UNESCO (2021), "Establishment of a sectoral partnership framework for the electricity and energy sector (CSP-2E) in Mauritania", International Institute for Educational Planning-United Nations Educational, Scientific and Cultural Organization, Paris, https://pefop.iiep.unesco.org/en/activities/establishment-sectoral-partnership-framework-electricity-and-energy-sector-csp-2e (accessed 10 September 2021).

IIEP-UNESCO (n.d.), "Pefop: development of specialized expertise for TVET in Africa", International Institute for Educational Planning-United Nations Educational, Scientific and Cultural Organization, Paris, France, https://pefop.iiep.unesco.org/en/activities/establishment-sectoral-partnership-framework-electricity-and-energy-sector-csp-2e (accessed 11 September 2021).

IISD (2018), *Green Conflict Minerals: The fuels of conflict in the transition to a low-carbon economy*, International Institute for Sustainable Development, Canada.

ILO (International Labor Organization) (2021), "Green enterPRIZE innovation & development in Zimbabwe", International Labour Organization, Geneva, Switzerland, www.ilo.org/africa/countries-covered/zimbabwe/WCMS_623951/lang--en/index.htm (accessed 9 September 2021).

ILO (2020), *Report on Employment in Africa (Re-Africa)*, International Labour Organization, Geneva.

ILO (2019), *Advancing social justice: Shaping the future of work in Africa*, International Labour Organization, Geneva.

ILO (2018), *World Employment and Social Outlook: Trends 2018*, International Labour Organization, Geneva.

ILO (2013), *Resolution concerning statistics of work, employment and labour underutilization adopted by the 19th International Conference of Labour Statisticians*, Geneva, October 2013, www.ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/normativeinstrument/wcms_230304.pdf.

IMF (International Monetary Fund) (2021), *Regional Economic Outlook for Sub-Saharan Africa: Navigating a Long Pandemic*, International Monetary Fund, Washington, DC.

IMF (2019), *Sub-Saharan Africa Regional Economic Outlook: Recovery amid Elevated Uncertainty*, International Monetary Fund, Washington, DC.

Innovation for Sustainable Development Network (2019), "PROSOL: Financing solar water heating in Tunisia", www.inno4sd.net/prosol-financing-solar-water-heating-in-tunisia-454.

IRENA (2022), *NDCs and renewable energy targets in 2021: Are we on the right path to a climate-safe future?*, International Renewable Energy Agency, Abu Dhabi.

IRENA (forthcoming-a), *The AfREP database for hydropower (IRENA's African Renewable Electricity Profiles for Energy Modelling series)*, International Renewable Energy Agency, Abu Dhabi.

IRENA (forthcoming-b), REorganising the power systems, International Renewable Energy Agency, Abu Dhabi.

IRENA (forthcoming c), *Renewable Energy in Adaptation: Methods and Metrics*, International Renewable Energy Agency, Abu Dhabi

IRENA (2021a), *IRENA Statistics Database*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2021b), *IRENA Off-Grid Statistics Database*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2021c), "IRENA and IAEA to help African Union develop continental power master plan with EU support", 1 September, https://irena.org/newsroom/articles/2021/Sep/IRENA-and-IAEA-Selected-to-Help-African-Union-Develop-Continental-Power-Master-Plan-with-EU-support.

IRENA (2021d), "Global Atlas for Renewable Energy (web platform)", International Renewable Energy Agency, Abu Dhabi, https://globalatlas.irena.org/workspace.

IRENA (2021e), *World Energy Transitions Outlook: 1.5°C Pathway*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2021f), "UAE and IRENA launch USD 1 billion global finance platform to accelerate renewable energy", International Renewable Energy Agency, Glasgow, www.irena.org/newsroom/pressreleases/2021/Nov/UAE-and-IRENA-Launch-USD1-billion-Global-Finance-Platform-to-Accelerate-Renewable-Energy.

IRENA (2021g), *Renewable Power Generation Costs in 2020*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_Power_Generation_Costs_2020.pdf.

IRENA (2021h), *Renewable Energy Policies for Cities: Experiences in China, Uganda and Costa Rica*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/May/IRENA_Policies_for_Cities_2021-V2.pdf.

IRENA (2021i), *Planning and Prospects for Renewable Power: Eastern and Southern Africa*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Apr/IRENA_Planning_Prospects_Africa_2021.pdf.

IRENA (2021j), "IRENA and IAEA to help African Union develop continental power master plan with EU support", International Renewable Energy Agency, Abu Dhabi, https://irena.org/newsroom/articles/2021/Sep/IRENA-and-IAEA-Selected-to-Help-African-Union-Develop-Continental-Power-Master-Plan-with-EU-support.

IRENA (2021k), "Renewable Energy and Jobs - Annual Review 2021", International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2021/Oct/Renewable-Energy-and-Jobs-Annual-Review-2021

IRENA (2021l), *Bracing for climate impact: Renewables as a climate change adaptation strategy*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2020a), *Post-COVID Recovery: An Agenda for Resilience, Development and Equality*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2020b), "Bioenergy", www.irena.org/bioenergy.

IRENA (2020c), *Circular Carbon Economy Report 05*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2020d), *Mobilising Institutional Capital for Renewable Energy*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2020e), *Renewable energy finance: Sovereign guarantees*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2020f), *Advancing Renewables in Developing Countries: Progress of Projects Supported through the IRENA/ADFD Project Facility*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2020g), *Renewable energy finance: Green bonds*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2020h), *Global Renewables Outlook: Energy transformation 2050 (Edition: 2020)*, International Renewable Energy Agency, Abu Dhabi

IRENA (2020h), "Energy innovation for a green recovery in Africa", International Renewable Energy Agency, Abu Dhabi, www.irena.org/newsroom/articles/2020/Sep/Energy-Innovation-for-a-Green-Recovery-in-Africa.

IRENA (2020i), *Green Hydrogen: A Guide to Policy Making*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2020j), *Quality Infrastructure for Smart Mini-Grids*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2020k), *Scaling Up Renewable Energy Deployment in Africa: Detailed Overview of IRENA's Engagement and Impact*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Feb/IRENA_Africa_Impact_Report_2020.pdf?la=en&hash=B1AD828DFD77D6430B93185EC90A0D1B72D452CC.

IRENA (2019a), *Global energy transformation: A roadmap to 2050 (2019 edition)*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2019b), *Innovation Landscape for a Renewable-Powered Future: Solutions to Integrate Variable Renewables*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2019c), *Renewable energy auctions: Status and trends beyond price*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2019d), *Regional markets: Innovation landscape brief*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2019e), *Renewables Solutions for Refugee Settlements: Sustainable Energy Access in Humanitarian Situations*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2019f), *Renewable Energy: A Gender Perspective*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2019/Jan/Renewable-Energy-A-Gender-Perspective.

IRENA (2019g), *Accelerating Geothermal Heat Adoption in the Agri-Food Sector: Key Lessons and Recommendations*, International Renewable Energy Agency, Abu Dhabi, https://irena.org/publications/2019/Jan/Accelerating-geothermal-heat-adoption-in-the-agri-food-sector.

IRENA (2018a), *Sustainable Rural Bioenergy Solutions in Sub-Saharan Africa: A Collection of Good Practices*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2018b), *Policies and Regulations for Renewable Energy Mini-Grids*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2018c), *Global Energy Transformation: A roadmap to 2050*, International Renewable Energy Agency', Abu Dhabi.

IRENA (2018d), *Planning and Prospects for Renewable Power: West Africa*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2018e), *Insights on Planning for Power System Regulators*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2018f), *Renewable Energy Benefits: Leveraging Local Capacity for Offshore Wind*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2018g), *Off-grid renewable energy solutions: Global and regional status and trends*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2017a), *Accelerating the Global Energy Transformation*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2017b), *Biogas for domestic cooking: Technology brief*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2016a), *Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2016b), *Renewable Energy Benefits: Measuring the Economics*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2016c), *Policies and Regulations for Private Sector Renewable Energy Mini-Grids*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2016d), *Solar pumping for irrigation: Improving livelihoods and sustainability*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2016e), *Renewable energy benefits: Decentralised solutions in the agri-food chain*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2015), *Africa Power Sector: Planning and Prospects for Renewable Energy (synthesis report)*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2013a), *Southern African Power Pool: Planning and Prospects for Renewable Energy*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2013b), *West African Power Pool: Planning and Prospects for Renewable Energy*, International Renewable Energy Agency, Abu Dhabi.

IRENA (n.d.a), *IRENA's policy and measures database*, International Renewable Energy Agency, Abu Dhabi

IRENA (n.d.b), *IRENA's repository of knowledge: RE Auctions (quantitative)*, International Renewable Energy Agency, Abu Dhabi.

IRENA (n.d.c), "West Africa Clean Energy Corridor", www.irena.org/cleanenergycorridors/West-Africa-Clean-Energy-Corridor (accessed Nov 2021).

IRENA and CPI (2020), *Global Landscape of Renewable Energy Finance 2020*, International Renewable Energy Agency and Climate Policy Initiative, Abu Dhabi.

IRENA and FAO (2021), *Renewable Energy and Agri-food Systems: Advancing Energy and Food Security Towards the Sustainable Development Goals and Paris Agreement.* International Renewable Energy Agency, Abu Dhabi.

IRENA and GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) (2021), *The Renewable Energy Transition in Africa: Country Studies for Côte d'ivoire, Ghana, South Africa, Morocco and Rwanda*, International Renewable Energy Agency, Abu Dhabi.

IRENA, IEA and REN21 (2020). *Renewable energy policies in a time of transition*, www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_IEA_REN21_Policies_Heating_Cooling_2020.pdf.

IRENA and IEA (2017), *Perspectives for the energy transition – investment needs for a low-carbon energy system*, International Renewable Energy Agency, Abu Dhabi.

IRENA and ILO (2021), *Renewable Energy and Jobs – Annual Review 2021. Special Edition: Labour and Policy Perspectives*, International Renewable Energy Agency, Abu Dhabi.

IRENA, KFW and GIZ (2021), *The Renewable Energy Transition in Africa Powering Access, Resilience and Prosperity*, International Renewable Energy Agency, Abu Dhabi.

IRENA, League of Arab States and RCREEE (Regional Center for Renewable Energy and Energy Efficiency) (2014), *Pan-Arab Renewable Energy Strategy 2030*, Regional Center for Renewable Energy and Energy Efficiency and International Renewable Energy Agency, Abu Dhabi.

IRENA and OECD (Organisation for Economic Co-operation and Development) (2021), "Renewable Energy Public Investments Database (based on OECD and IRENA data)", International Renewable Energy, Abu Dhabi, www.irena.org/Statistics/ View-Data-by-Topic/ Finance-awww.irena.org/Statistics/ View-Data-by-Topic/ Finance-and-Investment/Renewable-Energy-Finance-Flowsnd-Investment/Renewable-Energy-Finance-Flows.

IRENA, OECD/IEA and REN21 (2020), *Renewable Energy Policies in a Time of Transition: Heating and Cooling*, International Renewable Energy Agency, Abu Dhabi.

IRENA and SELCO Foundation (2021). *Fostering Livelihoods with Decentralised Renewable Energy: An Ecosystems Approach*, International Renewable Energy Agency, Abu Dhabi.

IRENA and TWI (Terrawatt Initiative) (n.d.), "Open Solar Contracts", https://opensolarcontracts.org/Terms.

Isaac, S. H., Li, W., and Justice, G. (2021), *Unveiling the consumers' taste attributed to energy efficient labelled appliances: Evidence from energy efficiency 2019 appliance compliance monitoring report*, International Journal of Advanced Engineering Research and Science (IJAERS), Vol. 8/4, pp. 64-78.

IUCN (International Union for Conservation) (2018), "Energizing equality: Sub-Saharan Africa's integration of gender equality principles in national energy policies and frameworks", International Union for Conservation, Washington, D.C., https://portals.iucn.org/union/sites/union/files/doc/iucn-egi-ssa-web-final.pdf.

KDLG (Kasese District Local Government) (2013), *Kasese District Renewable Energy Strategy*, Kasese District Local Government, Kasese.

Kelton, S. (2020), *The Deficit Myth: Modern Monetary Theory and the Birth of the People's Economy*, John Murray.

Kumi, E. N. (2017), *The electricity situation in Ghana: Challenges and opportunities, CGD Policy Paper 109*, Center for Global Development, Washington, DC.

Kojima, M. and Han, J. (2017), "Electricity tariffs for nonresidential customers in Sub-Saharan Africa", Live Wire 2017/77, World Bank, Washington, DC, https://openknowledge.worldbank.org/handle/10986/26571?locale-attribute=es.

Komane, N. (2018), "South African Trade and the African Continental Free Trade Agreement (AfCFTA)", https://www.igd.org.za/infocus/12122-south-african-trade-and-the-african-continental-free-trade-agreement-afcfta.

Kruger, W., Alao, O., and Eberhard, A. (2019), *Namibia Country Report*, Power Futures Lab, University of Cape Town, www.gsb.uct.ac.za/files/Namibia_Country_Report_1.pdf.

Kuhudzai, R. J. (2020), "The Electricity Company of Ghana & POBAD International partner to install EV charging stations in Ghana", CleanTechnica, 8 December, https://cleantechnica.com/2020/12/08/the-electricity-company-of-ghana-pobad-international-partner-to-install-ev-charging-stations-in-ghana/.

Kweka, A., Clements, A., Bomba, M., Schurhoff, N., Bundala, J., Mgonda, E., Nilsson, M., Avila, E. and Scott, N. (2021), "Tracking the adoption of electric pressure cookers among mini-grid customers in Tanzania", Energies, Vol. 14/15, pp. 4574, www.mdpi.com/1996-1073/14/15/4574/pdf.

Larsen, T. and Hansen, U. (2020), *Sustainable industrialization in Africa: the localization of wind-turbine component production in South Africa*, Innovation and Development, DOI: 10.1080/2157930X.2020.1720937.

Leary, J., Kalyonge, A. and Kalyonge, M. (2019), "Electric pressure cookers (EPCs) in Kenya: A huge untapped opportunity", Modern Energy Cooking Services blog, 1 September, https://mecs.org.uk/blog/ecps-in-kenya-a-huge-almost-completely-untapped-opportunity/.

Leary, J., Menyeh, B., Chapungu, V. and Troncosco, K. (2021), "eCooking: Challenges and opportunities from a consumer behaviour perspective", *Energies*, Vol. 14/14, pp. 4345, https://doi.org/10.3390/en14144345.

Lebdioui, A. (2020a), "The case for a green recovery in post-covid Latin America", LSE Latin America and Caribbean Blog, 1 September, https://blogs.lse.ac.uk/latamcaribbean/2020/09/01/the-case-for-a-green-recovery-in-post-covid-latin-america/.

Lebdioui, A. (2020b), "The political economy of moving up in global value chains: how Malaysia added value to its natural resources through industrial policy". *Review of International Political Economy*, 1-34.

Lebdioui, A. (2019a), *Local content in extractive industries: Evidence and lessons from Chile's copper sector and Malaysia's petroleum sector*, The Extractive Industries and Society, 7(2), 341-352.

Lebdioui, A. (2019b), "Economic diversification and development in resource-dependent economies: Lessons from Chile and Malaysia", Doctoral dissertation, University of Cambridge.

Lebdioui, A. (2019c), "Chile's export diversification since 1960: A free market miracle or mirage?" *Development and Change*, Vol. 50(6), 1624-1663.

Lebdioui, A. and Morales, M. (2021), *The Latin American Experience in Designing Local Content Policies in the Oil and Gas Sectors: Strengths, Limitations, and Future Perspectives*, in Olawuyi, Damilola S., ed. Local Content and Sustainable Development in Global Energy Markets. Cambridge University Press.

Lighting Africa (2021), "Quality assurance", www.lightingafrica.org/what-we-do/quality-assurance/.

Lighting Africa (n.d.), "Consumer education", www.lightingafrica.org/what-we-do/consumer-education/.

Lin, J. and H.J. Chang (2009), "Should industrial policy in developing countries conform to comparative advantage or defy it? A debate between Justin Lin and Ha-Joon Chang". *Development Policy Review*, Vol. 27(5), 483-502.

Louie, E. P. and Pearce, J. M. (2016), *Retraining investment for U.S. transition from coal to solar photovoltaic employment*, Energy Economics, Vol. 57/ June, pp. 295 302, doi:10.1016/j.eneco.2016.05.016.

Lütkenhorst, W., Altenburg, T., Pegels, A., and Vidican, G. (2014), *Green Industrial Policy: Managing Transformation under Uncertainty*, DIE Discussion Paper, Deutsches Institute für Entwicklungspolitik, Bonn.

Magoum, I. (2021), "Senegal: 60,000 biodigesters to produce biogas from faecal sludge", Afrik21, 15 July, www.afrik21.africa/en/senegal-60000-biodigesters-to-produce-biogas-from-faecal-sludge/.

Mahler, D. G., Lakner, C., Castaneda Aguilar, R. A., and Wu, H. (2020), "The impact of COVID-19 (Coronavirus) on global poverty: Why Sub-Saharan Africa might be the region hardest hit", World Bank Blogs, 20 April, www.blogs.worldbank.org/opendata/impact-covid-19-coronavirus-global-poverty-why-sub-saharanafrica-might-be-region-hardest.

Mahomed, S., Shirley, R., Tice, D. and Phillips, J. (2020), "Business model innovations for utility and mini-grid integration: Insights from the Utilities 2.0 initiative in Uganda", https://energyeconomicgrowth.org/index.php/publication/business-model-innovations-utility-and-mini-grid-integration-insights-utilities-20.

Malinga, S. (2021), "Renewable energy contributed 10% to SA's grid in 2020", IT Web, 15 March, www.itweb.co.za/content/lLn14Mmjog6qJ6Aa.

Mashishi, N. (2021) "Factsheet: Understanding greenhouse gas emissions, and how Africa compares with the rest of the world", Africa Check.

Mboowa, D., Kabenge, I., Banadda, N., and Kiggundu, N. (2017). "Energy Potential of Municipal Solid Waste in Kampala, a Case Study of Kiteezi Landfill Site" African Journal of Environmental and Waste Management, Vol.4 (1), pp.190-194.

McDaid, L. and SAFCEI (Southern African Faith Communities' Environment Institute) (2016), "Opportunities for Investing in Renewable Energy Sector in Africa", Norwegian Church Aid, April 2016, www.kirkensnodhjelp.no/contentassets/c1403acd5da84d39a120090004899173/briefing-paper-2016-opportunities-for-investing-in-renwable-energy-sector-in-africa.pdf.

McSweeney, E. (2020), "Activists are fighting for a renewable future in Sub-Saharan Africa. Chinese coal projects threaten to dirty those plans", https://edition.cnn.com/2020/12/09/business/africa-coal-energy-goldman-prize-dst-hnk-intl/index.html.

MECS (Modern Energy Cooking Services) (2021), *Clean Cooking: Financing Appliances for End Users*, Modern Energy Cooking Services,

MEDENER (Mediterranean Association of the National Agencies for Energy Management) and RCREEE (Regional Centre for Renewable Energy and Energy Efficiency) (2020), *Assessment of Appliances Share of the Total Energy Consumptions in the SEMCs – Special Focus on Air Conditioning Appliances*, European Union, Brussels, https://docs.google.com/viewerng/viewer?url=https://www.rcreee.org/sites/default/files/02_a33_appliancesshare_final.pdf.

MEMD (Ministry of Energy and Mineral Development) (2015), *Sector Development Plan: 2015/16 – 2019/20*, Ministry of Energy and Mineral Development, Uganda, http:// npa.go.ug/wp-content/uploads/2018/01/Energy-SectorDevelopment-plan-Final.pdf.

Mercure, J., Knobloch, F., Pollitt, H., Lewney, R., Rademakers, K., Eichler, L., Laan, J. V. D., and Leonidas Paroussos (2016), *Policy-induced energy technological innovation and finance for low-carbon economic growth. Study on the macroeconomics of energy and climate policies*, European Commission, Brussels.

Miller, E. (2019), "Konexa: Seeding the integrated utility future", Power for All, 19 August, www.powerforall.org/news-media/articles/konexa-seeding-integrated-utility-future.

MININFRA (Ministry of Infrastructure) (2021), "Rwanda has awesome new incentives for electric vehicles", Ministry of Infrastructure, Republic of Rwanda, www.mininfra.gov.rw/updates/news-details/rwanda-has-awesome-new-incentives-for-electric-vehicles.

Ministry of Energy (2019), *Gender Policy*, Ministry of Energy, Nairobi, Kenya, https://energy.go.ke/wp-content/uploads/2019/10/Gender-Policy-in-Energy.pdf.

MIT Energy Initiative (2020), "Towards actionable electrification frameworks: Mini-grids under the grid", working paper, MIT Energy Initiative, www.endenergypoverty.org/s/2020-towards-actionable-electrification-grid.pdf.

Monnier, O. (2021), "A ticket to recovery: Reinventing Africa's tourism industry", International Finance Corporation, https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/reinventing-africa-tourism.

Moody's (2018), "Project finance bank loan default rates by region, 1983-2016", Moody's Investor Service, www.moodys.com/research/Moodys-Default-and-recovery-rates-for-project-finance-bank-loans--PR_380331.

Morris, M., Robbins, G., Hansen, U. E., and Nygaard, I. (2020). Energy and Industrial Policy Failure in the South African Wind Renewable Energy Global Value Chain: The Political Economy Dynamics Driving a Stuttering Localisation Process. University of Cape Town, South Africa.

Morris, M., Kaplinsky, R., and Kaplan, D., (2012). One Thing Leads to Another: Promoting Industrialization by Making the Most of the Commodity Boom in Sub-saharan Africa. Accessible at. http://tinyurl.com/CommoditiesBook.

Moyer, Jonathan D., Abigail Kabandula, David K. Bohl, Vivian Yang, Kaylin McNeil, Yutang Xiong, Ibrahim Mayaki, Martin Bwalya, George Murumba and Bernice Mclean (2021), COVID-19: The Future of African Development Systems, Frederick S. Pardee Center for International Futures, Denver, CO/AUDA-NEPAD, Johannesburg, South Africa.

Naudé, W. (2011), *Climate Change and Industrial Policy, Sustainability*, Vol. 3, pp. 1003-1021.

New Climate Institute and EED Advisory (2021). *The Kenyan Cooking Sector – Opportunities for Climate Action and Sustainable Development*, https://ambitiontoaction.net/wp-content/uploads/2021/07/A2A_Kenya_CleanCookingStudy_July2021.pdf.

Newfarmer, R. S., Page, J. and Tarp, F. (2018), *Industries without smokestacks and structural transformation in Africa: Overview*, Oxford University Press, 2018.

Ngezi, M. (2019), "Zimbabwe turns to charcoal for cooking as power outage bites", France24, 26 November, www.france24.com/en/20191126-zimbabwe-turns-to-charcoal-for-cooking-as-power-outages-bite.

Niang, I., Ruppel, O.C., Abdrado, M. A., Urquhart, P. (2014), "Africa". In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, ed. Barros, V.R., C.B. Field, D.J. Dokken ... and L.L. White. Cambridge University Press, Cambridge, United Kingdom and New York, NY, pp. 1199-1265. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap22_FINAL.pdf.

Nyabiage, J. (2021), "Are China's banks going cool on coal power plants in Africa?" www.scmp.com/news/china/diplomacy/article/3139791/are-chinas-banks-going-cool-coal-power-plants-africa.

OCI (Oil Change International) (2021), *The Sky's Limit Africa: The Case for a Just Energy Transition from Fossil Fuel Production in Africa*, Oil Change International, Washington, DC, https://priceofoil.org/2021/10/14/the-skys-limit-africa/.

OECD (2021a), "Carbon pricing in times of COVID-19", Organisation for Economic Co-operation and Development, Paris, www.oecd.org/tax/tax-policy/carbon-pricing-south-africa.pdf.

OECD (2021b), *Climate Finance Provided and Mobilised by Developed Countries: Aggregate trends updated with 2019 data, Climate Finance and the USD 100 Billion Goal*, OECD Publishing, Paris

OECD (2020), *Blended Finance in the Least Developed Countries 2020: Supporting a Resilient COVID-19 Recovery*, Organisation for Economic Cooperation and Development, Paris, www.oecd-ilibrary.org/development/blended-finance-in-the-least-developed-countries_57620d04-en.

Olisa, P. (2020), "Renewable energy education fast changing Nigeria's employment landscape", PV Magazine, 14 October, www.pv-magazine.com/2020/10/14/renewable-energy-education-fast-changing-nigerias-employment-landscape/.

Onjala, B. (2020), "Opportunities for electric cooking in mini grids", Modern Energy Cooking Services, 3 June, https://mecs.org.uk/opportunities-for-electric-cooking-in-mini-grids/.

OPEC Fund (2017), "Today, we are the only producer of green charcoal briquettes in Mali", https://opecfund.org/news/today-we-are-the-only-producer-of-green-charcoal-briquettes-in-mali.

Ovadia, J. S. (2016), *Local content policies and petro-development in Sub-Saharan Africa: A comparative analysis*, Resources Policy, 49, 20-30.

Oxfam (2020), *Climate Finance Shadow Report: Assessing progress towards the $100 billion commitment*, Oxfam GB for Oxfam International, ISBN 978-1-78748-662-1.

Papaefstratiou, D. (2019), "What the AfCFTA means for the energy sector", https://www.miningreview.com/energy/african-continental-free-trade-area-energy-sector/

Parkes, B., J. Cronin, O. Dessens and B. Sultan, B. (2019), *Climate change in Africa: costs of mitigating heat stress.* Climatic Change, 154(3), 461-476.

Pendame, S. (2020), "Covid 19 and Beyond-Solar Energy in Africa: Powering Responses, Accelerating Inclusive and Sustainable Development. African Economic Conference", https://aec.afdb.org/en/papers/covid-19-and-beyond-solar-energy-africa-powering-responses-accelerating-inclusive-and-sustainable-development-422.

Perez-Arriaga, I. and Stoner, R. (2020), "Abuja Electric's proposed sub-franchising model: DESSA", https://static1.squarespace.com/static/5d371cb401986300013881d3/t/5fc7c8498927470b95c5b39d/1606928457976/2020-abuja-electric-proposed-model-DESSA-2.pdf.

Peterson, R. (2019), "Can AfCFTA solve Africa's energy challenge?", https://www.dlapiper.com/en/uk/insights/publications/2019/11/africa-connected-issue-3/can-afcfta-solve-africas-energy-challenge/.

Pombo-van Zyl , N. (2020), "Free public electric vehicle charging station launched in Cape Town", ESI Africa, 3 December, www.esi-africa.com/industry-sectors/future-energy/free-public-electric-vehicle-charging-station-launched-in-cape-town/.

Portuguese Presidency of the Council of the European Union (2021), "A 'Green Deal' for Africa to recover from the crisis and 'reduce inequalities': High-Level EU-Africa Green Investment Forum", 23 April. www.2021portugal.eu/en/news/a-green-deal-for-africa-to-recover-from-the-crisis-and-reduce-inequalities/

Pothering, J. (2021), "Off-Grid Market Development Fund offers results-based financing for solar access in Madagascar", https://impactalpha.com/off-grid-market-development-fund-offers-results-based-financing-for-solar-access-in-madagascar/.

Power Africa (2020), "USAID/ Power Africa announces $2.6 million in healthcare electrification grants to solar energy companies in nine countries in Sub-Saharan Africa", 22 September, https://powerafrica.medium.com/usaid-power-africa-announces-2-6-c003fa75f004.

Power Engineering International (2021), "Mauritania advances 10GW green hydrogen project", 6 December, www.powerengineeringint.com/hydrogen/mauritania-advances-10gw-green-hydrogen-project/.

Power Futures Lab (2021), "Private Database", Power Futures Lab, University of Cape Town.

Power for All (2020), "Mini-grids productive use of energy (PUE) in agriculture", Fact Sheet, www.powerforall.org/application/files/9615/9302/4971/FS_Mini-grids_productive_use_of_energy_PUE_in_agriculture3.pdf.

Fraunhofer IEE (n.d.), "Welcome to the global Power-to-X potential atlas of the Fraunhofer IEE", Fraunhofer IEE, https://maps.iee.fraunhofer.de/ptx-atlas/.

Qair (2020), "The Seychellois Minister of the Environment, the French Ambassador and the Secretary of State Jean-Baptiste Lemoyne visit the future construction site of Qair floating PV plant", Qair, 23 March, www.qair.energy/en/the-seychellois-minister-of-the-environment-the-french-ambassador-and-the-secretary-of-state-jean-baptiste-lemoyne-visit-the-future-construction-site-of-qair-floating-pv-plant/.

Radowitz, B. (2021), "Germany eyes world's cheapest green hydrogen from Namibia amid global 'race for best sites'", Recharge News, www.rechargenews.com/energy-transition/germany-eyes-worlds-cheapest-green-hydrogen-from-namibia-amid-global-race-for-best-sites/2-1-1057335.

RCREEE (2019), *Arab Future Energy Index*, Regional Center for Renewable Energy and Energy Efficiency, Cairo, www.rcreee.org/sites/default/files/final_afex_re_2019_final_version-1.pdf.

REA (2020), "REA electrifies four COVID-19 health facilities with solar hybrid mini grids", press release, Rural Electrification Agency, 15 April, https://rea.gov.ng/press-release-rea-electrifies-four-covid-19-health-facilities-solar-hybrid-mini-grids/.

REN21 (2021a), *Renewables in Cities: 2021 Global Status Report*, Renewable Energy Policy Network for the 21st Century Secretariat, Paris, www.ren21.net/wp-content/uploads/2019/05/REC_2021_full-report_en.pdf.

REN21 (2021b), *Renewables 2021 Global Status Report*, Renewable Energy Policy Network for the 21st Century Secretariat, Paris, www.ren21.net/wp-content/uploads/2019/05/GSR2021_Full_Report.

REN21 (2019), *Renewables 2019 Global Status Report*, Renewable Energy Policy Network for the 21st Century Secretariat, Paris, www.ren21.net/gsr-2019/

Republic of Kenya Ministry of Energy (2018), *National Energy Policy*, Ministry of Energy, Republic of Kenya, https://kplc.co.ke/img/full/BL4PdOqKtxFT_National%20Energy%20Policy%20October%20%202018.pdf

Republic of South Africa (Departments of Energy and Treasury, and Development Bank of Southern Africa) (2021), "Independent Power Producers Procurement Programme (IPPPP): An Overview as at 31 March 2021", https://www.ipp-projects.co.za/Publications.

RES4Africa Foundation (2021), *Scaling up Africa's Renewable Power*, RES4Africa Foundation, Rome, Italy, https://nul-erc.s3.amazonaws.com/public/documents/reports/scaling-up-africas-renewable-power-the-need-for-de-risking-investments-and-the-case-for-renewafrica-1611474193.pdf.

RES4Africa Foundation (2019), "What does it take to accelerate renewable energy investments in Africa?", RES4Africa Foundation, Rome, Italy, www.res4med.org/wp-content/uploads/2019/06/What-does-it-take.pdf.

Reuters (2021), "Sudanese bank launches first green sukuk for renewable energy", www.reuters.com/article/sudan-energy-idUKL5N2NI1R6.

Rockefeller Foundation (2020), "Grid connected mini-grid in an urban market", www.rockefellerfoundation.org/wp-content/uploads/2020/10/EE-Download-Solutions-CaseStudies-Urban-grid-connected-system.pdf.

Rocky Mountain Institute (2019), *Electrifying The Underserved: Collaborative Business Models for Developing Mini-grids under the Grid*, Rocky Mountain Institute, Basalt, CO, https://rmi.org/insight/under-the-grid/.

Rodrik, D. (2021), "Poor Countries' Technology Dilemma. Project Syndicate", 8 February, https://www.project-syndicate.org/commentary/poor-countries-technology-dilemma-by-dani-rodrik-2021-02

Rodrik D. (2014), "Green Industrial Policy", Oxford Review of Economic Policy, Vol. 30, Issue (3), pp.469–491.

Rosnes, O. and H. Vennemo (2012), "The cost of providing electricity to Africa". *Energy Economics*, Vol. 34(5), 1318-1328.

RURA (Rwanda Utilities Regulatory Authority) (n.d.), "Electricity", Rwanda Utilities Regulatory Authority, Kigali, Rwanda, https://rura.rw/index.php?id=65.

RVO (Netherlands Enterprise Agency) (2021), "African Biodigester Component – ABC", Netherlands Enterprise Agency, https://english.rvo.nl/subsidies-programmes/african-biodigester-component-abc.

SACREEE (SADC Centre for Renewable Energy and Energy Efficiency) (2017), *Renewable Energy and Energy Efficiency Strategy and Action Plan (REEESAP 2016-2030)*, SADC Centre for Renewable Energy and Energy Efficiency (SACREEE), Botswana.

SACREEE (n.d.), "Improvement of Livelihoods in SADC members states through the adoption of distributed renewable energy (DRE) for productive use", SADC Centre for Renewable Energy and Energy Efficiency, Windhoek, Namibia, www.sacreee.org/content/improvement-livelihoods-sadc-members-states-through-adoption-distributed-renewable-energy.

SAP (2020), "Ghana's ambitious plan to minimize plastic waste", SAP News Center, 29 October, https://news.sap.com/2020/10/minimize-plastic-waste-in-ghana-domestic-recycling/#:~:text=Waste%20picking%20is%20a%20means%20of%20survival%20for,12%20percent%20of%20the%20total%20plastic%20waste%20generated.

SARECO (Swiss-African Research Cooperation) (n.d.), "2IE – International Institute for Water and Environmental Engineering", Swiss-African Research Cooperation, www.sareco.org/institution/2ie-international-institute-for-water-and-environmental-engineering/.

Schlag, N. and Zuzarte, F. (2008), "Market barriers to clean cooking fuels in Sub-Saharan Africa: A review of literature", Stockholm Environment Institute, Stockholm, www.sei.org/publications/market-barriers-clean-cooking-fuels-sub-saharan-africa-review-literature/.

Schure, J., Pinta, F., Cerutti, P. and Kasereka-Muvatsi, L. (2019), "Efficiency of charcoal production in Sub-Saharan Africa: Solutions beyond the kiln", www.cifor.org/publications/pdf_files/articles/ASchure1902.pdf.

SD Strategies (2021), "Case study: The interconnected mini-grid of Wuse Market, Abuja", https://sd-strategies.com/wp-content/uploads/2021/05/SD_Strategies_DREI_Wuse_Case_Study_Final.pdf.

SEFA (Sustainable Energy Fund for Africa) (2020), Annual Report, Sustainable Energy Fund for Africa, AfDB, Abidjan, Côte d'Ivoire, www.afdb.org/en/documents/sefa-annual-report-2020.

SEforAll (Sustainable Energy for All) (2021a), "Tracking global access to cooling in 2021", Sustainable Energy for All, Vienna, www.seforall.org/chilling-prospects-2021/global-access-to-cooling.

SEforAll (2021b), "Universal Energy Facility opens for mini-grid projects in Benin", Sustainable Energy for All, www.seforall.org/news/universal-energy-facility-opens-for-mini-grid-projects-in-benin.

SEforAll (2021c), *Increasing Energy Access in Sierra Leone: Mini-Grid Survey Analysis on Tariffs, Subsidies and Productive Use*, Sustainable Energy for All, www.seforall.org/system/files/2021-05/Energy-Access-SierraLeone-SEforAll.pdf.

SEforAll (2020a), "How Nigeria is using the pandemic to build a sustainable energy future", Sustainable Energy for All, Vienna, www.seforall.org/news/damilola-ogunbiyi-how-nigeria-is-using-the-pandemic.

SEforAll (2020b), "Project: Achieving economies of scale in the Nigerian solar value chain", www.seforall.org/policy-and-regulatory-frameworks/project-nigerian-solar-value-chain.

SEforAll (2020c), *State of the Global Mini-Grids Market: Report 2020*, Sustainable Energy for All, www.seforall.org/system/files/2020-06/MGP-2020-SEforAll.pdf.

SEforAll (2020d), "Universal Energy Facility opens for mini-grid projects in Sierra Leone and Madagascar", www.seforall.org/news/universal-energy-facility-opens-for-mini-grid-projects.

SEforAll (2020e), "Acacia innovations provides clean cooking for schools in Kenya", www.seforall.org/stories-of-success/acacia-innovations-provides-clean-cooking-for-schools-in-kenya.

SEforAll (2019a), "Integrated electrification pathways for universal access to electricity: A primer", www.seforall.org/system/files/2019-06/SEforAll_IEP_2019.pdf.

SEforAll (2019b), "Energizing finance: Taking the pulse 2019 – Madagascar, the Philippines and Uganda", www.seforall.org/publications/energizing-finance-taking-the-pulse-2019.

SEforAll (2015), "Action agenda for Sustainable Energy for All", Washington, DC, https://www.se4all-africa.org/fileadmin/uploads/se4all/Documents/Country_AAs/Action_Agenda_Sustainable_Energy_4_All_SE4ALL_CBV_-_Eng.pdf.

SEforAll and CPI (2020), *Energizing Finance: Understanding the Landscape 2020*, Sustainable Energy for All, Vienna, www.seforall.org/system/files/2020-11/EF-2020-UL-SEforALL_0.pdf.

SIFMA (Securities Industry and Financial Markets Association) (2021), *Capital Markets Fact Book, 2021*, Securities Industry and Financial Markets Association, New York, www.sifma.org/resources/research/fact-book/.

SEforAll and South Pole (2020). *Energizing Finance: Missing the Mark 2020*, Sustainable Energy for All, Vienna, www.seforall.org/system/files/2020-11/EF-2020-MM-SEforALL.pdf.

SEforAll, UNOPS and FCDO (2021), *Increasing Energy Access in Sierra Leone: Mini-Grid Survey Analysis on Tariffs, Subsidies and Productive Use*, Sustainable Energy for All, United Nations Office for Project Services and Foreign, Commonwealth and Development Office, www.seforall.org/system/files/2021-05/Energy-Access-SierraLeone-SEforAll.pdf.

SEI (Stockholm Environment Institute), IISD, ODI (Overseas Development Institute), E3G and UNEP (United Nations Environment Programme) (2020), *The Production Gap: 2020 Special Report*, Stockholm Environment Institute, https://productiongap.org/wp-content/uploads/2020/12/PGR2020_FullRprt_web.pdf.

Simon, F. (2019), "EU Commission unveils 'European Green Deal': The key points", Euractiv, 11 December, www.euractiv.com/section/energy-environment/news/eu-commission-unveils-european-green-deal-the-key-points/.

SIRDC (Scientific and Industrial Research & Development Centre) (n.d.), "Energy Technology Institute (ETI)", Scientific and Industrial Research & Development Centre, www.sirdc.ac.zw/institutes/energy-technology/.

SLOCAT (Partnership on Sustainable, Low Carbon Transport) (2021), "E-mobility trends and targets", https://slocat.net/e-mobility/.

SNV (2021a), "Government of Mozambique approves off grid energy regulation taking a key step towards universal access", SNV Netherlands, 15 September, https://snv.org/update/government-mozambique-approves-grid-energy-regulation-taking-key-step-towards-universal.

SNV (2021b), "Pioneering green electricity bio-digesters in Ethiopia", SNV Netherlands, June, https://snv.org/update/pioneering-green-electricity-bio-digesters-ethiopia.

Solar Thermal World (2018), "Rwanda looks forward to second phase of SolaRwanda", www.solarthermalworld.org/news/rwanda-looks-forward-second-phase-solarwanda.

South Africa Department of Energy (2011), Integrated Resource Plan, South Africa Department of Energy.

SCF (Standing Committee on Finance) (2021), *First report on the determination of the needs of developing country Parties related to implementing the Convention and the Paris Agreement, FCCC/CP/2021/10/Add.2–FCCC/PA/CMA/2021/7/Add.2*, United Nations Framework Convention on Climate Change.

Sterl, S. (2021), "A grid for all seasons: Enhancing the integration of variable solar and wind power in electricity systems across Africa", Current Sustainable/Renewable Energy Reports, Vol. 8, pp. 274-281.

Sterl S., Devillers, A., Chawanda, C. J., van Griensven, A., Thiery, W. and Russo, D. (2021), A spatiotemporal atlas of hydropower in Africa for energy modelling purposes, Open Research Europe, Vol. 1/29, https://doi.org/10.12688/openreseurope.13392.1

SupaMoto (2021a), "SupaMoto Clean Cooking", www.supamoto.co.zm/clean-cooking/.

SupaMoto (2021b), "FAQs", www.supamoto.co.zm/faq/.

Sustainable Development Goals Center for Africa (2019), *2019 Africa: SDG Index and Dashboards Report, Sustainable Development Goals Center for Africa*, Kigali, Rwanda, https://sdgcafrica.org/wp-content/uploads/2019/06/SDGS_INDEX_REPORT_2019WEB.pdf.

Tait, L., Merven, B. and Senatla, M. (2013), *Investigating the current and future roles of paraffin in South Africa*, Energy Research Centre, University of Cape Town, https://media.africaportal.org/documents/13Tait-etal_Paraffin_in_SA.pdf.

Takouleu, J. M. (2019), "Egypt: Government launches first electric bus service", Afrik 2114 November, www.afrik21.africa/en/egypt-government-launches-first-electric-bus-service/.

Takouleu, J. (2021), "Nigeria: Federal government to solarise 304 hospitals and schools", www.afrik21.africa/en/nigeria-federal-government-to-solarise-304-hospitals-and-schools/

Technical Review Middle East (2021), "Morocco aims to tender green hydrogen project in 2022", 9 December, www.technicalreviewmiddleeast.com/power-a-water/renewables/morocco-aims-to-tender-green-hydrogen-project-in-2022

Tena, N. (2021a), "Nigeria commissions first solar-powered electric vehicle charging station", ESI Africa, 19 July, www.esi-africa.com/industry-sectors/smart-technologies/nigeria-commissions-first-solar-powered-electric-vehicle-charging-station/.

Tena, N. (2021b), "Innovative financing secures 28 new minigrids in Nigeria", Power Engineering International, www.powerengineeringint.com/news/innovative-financing-secures-28-new-minigrids-in-nigeria/.

The Rockefeller Foundation (2021a), "Global coalition launched $80 million relief fund to protect energy access in vulnerable communities from COVID-19 fallout", www.rockefellerfoundation.org/news/global-coalition-launched-80-million-relief-fund-to-protect-energy-access-in-vulnerable-communities-from-covid-19-fallout/.

The Rockefeller Foundation (2021b), "Ikea Foundation and the Rockefeller Foundation join forces to set up a historic $1 billion initiative to catalyze investments in distributed renewable energy", www.rockefellerfoundation.org/news/ikea-foundation-and-the-rockefeller-foundation-join-forces-to-set-up-1-billion-dollar-initiative-in-distributed-renewable-energy/.

Touwsrivier SE.ED (Touwsrivier socio-economic and enterprise development) (2017), "Touwsrivier socio-economic and enterprise development (SE.ED)", www.touwsrivierseed.co.za/index.html (accessed 14 September 2021).

Trimble, C., Kojima, M., Perez Arroyo, I. and Mohammadzadeh, F. (2016), *Financial viability of electricity sectors in Sub-Saharan Africa*, World Bank, Washington, D.C., https://openknowledge.worldbank.org/bitstream/handle/10986/24869/WPS7788.pdf?sequence=4&isAllowed=y.

Tsagas, I. (2019), "Spain's third interconnection with Morocco could be Europe's chance for African PV – or a boost for coal", PV Magazine, 20 February, www.pv-magazine.com/2019/02/20/spains-third-interconnection-with-morocco-could-be-europes-chance-for-african-pv-or-a-boost-for-coal/.

Tiyou, T. (2019), "Can Africa Green Bonds be the future of funding? Climate Bonds Initiative expert tells us all," www.renewablesinafrica.com/can-africa-green-bonds-be-the-future-of-funding-climate-bonds-initiative-expert-tells-us-all/.

UKAID, Shell Foundation and USAID (2020), *Off-Grid Utilities Report: Bridging the Rural Energy Gap in Emerging Markets*, Shell Foundation shellfoundation.org/app/uploads/2020/02/Shell-Foundation-Bridging-the-Gap-DCU-report.pdf.

UNCDF (United Nations Capital Development Fund) (2021), "Calls for Applications: RfP: Renewable Energy Challenge Fund Uganda – Solar Window", United Nations Capital Development Fund, New York, www.uncdf.org/article/2726/rfp-renewable-energy-challenge-fund-uganda-solar-window.

UNCTAD (United Nations Commission on Trade and Development) (2021), *World Investment Report 2021: Investing in Sustainable Recovery*, United Nations Commission on Trade and Development, New York, https://unctad.org/system/files/official-document/wir2021_en.pdf.

UNCTAD (2019), *State of Commodity Dependence*, United Nations Conference on Trade and Development, Geneva.

UNCTAD (2018), *Overview of Local content regulatory frameworks in selected ECCAS countries*, United Nations Conference on Trade and Development, Geneva.

UNDP (2018) "Climate Change Adaptation in Africa: UNDP Synthesis of Experiences and Recommendations 2000-2015". United Nations Development Programme

UNDP (United Nations Development Programe) (n.d.), "Planetary pressures–adjusted Human Development Index (PHDI)", http://www.hdr.undp.org/en/content/planetary-pressures–adjusted-human-development-index-phdi.

UNECA (United Nations Economic Commission for Africa) (2020), "The Impact of Covid-19 on Africa's energy sector and the role of renewable energy to empower a long term and sustainable recovery", United Nations Economic Commission for Africa, Addis Ababa, Ethiopia, www.uneca.org/impact-covid-19-africa%E2%80%99s-energy-sector-and-role-renewable-energy-empower-long-term-and-sustainable.

UNFCCC (2021), "National Adaptation Plans", United Nations Framework Convention on Climate Change, https://unfccc.int/topics/adaptation-and-resilience/workstreams/national-adaptation-plans (accessed in October 2021).

UNECA (2017), *Impact of Climate Change on Agricultural Trade Flows and Food Security in the Economic Community of West African States*, United Nations Economic Commission for Africa, Addis Ababa, Ethiopia, https://archive.uneca.org/sites/default/files/PublicationFiles/impact_of_climate_change_on_agricultural_trade_flows_and_food_security_in_the_economic_community_of_west_african.pdf.

UNEP (United Nations Environment Programme) (2019a), "Lamu coal plant case reveals tips for other community-led campaigns", United Nations Environment Programme, Nairobi, Kenya, www.unep.org/news-and-stories/story/lamu-coal-plant-case-reveals-tips-other-community-led-campaigns.

UNEP (2019b), *Review of Woodfuel Biomass Production and Utilization in Africa: A Desk Study*, United Nations Environment Programme, Nairobi, Kenya, wedocs.unep.org/bitstream/handle/20.500.11822/28515/WoodfuelRpt.pdf?sequence=1&isAllowed=y.

UNEP (2009), "Global Green New Deal policy brief". http://go.nature.com/Vy5zDt

UNEP-DTU Partnerhship (2021), "Kenya kickstarts a super ESCO for boosting energy efficiency", Copenhagen, Denmark, https://unepdtu.org/kenya-kickstarts-a-super-esco-for-boosting-energy-efficiency/

UNFCCC (United Nations Framework Convention on Climate Change) (2021), "End of coal in sight at COP26", United Nations Framework Convention on Climate Change, https://unfccc.int/news/end-of-coal-in-sight-at-cop26 (accessed 4 Nov 2021).

UNHCR (2021a) "Integrated Refugee and Forcibly Displaced Energy Information System", United Nations High Commissioner for Refugees, https://eis.unhcr.org/home.

UNHCR (2021b), "Solar cooperatives give refugees and locals in Ethiopia clean energy and livelihoods", United Nations High Commissioner for Refugees, www.unhcr.org/news/stories/2021/6/60b8c9874/solar-cooperatives-give-refugees-locals-ethiopia-clean-energy-livelihoods.html.

UNHCR (2021c), "Refugees in Sudan reap benefits of clean cooking energy", United Nations High Commissioner for Refugees, www.unhcr.org/news/stories/2021/2/6038cc6b4/refugees-sudan-reap-benefits-clean-cooking-energy.html.

UNIDO (United Nations Industrial Development Organization) (2020a), Industrialization as the Driver of Sustained Prosperity, United Nations Industrial Development Organization, Vienna, https://www.unido.org/industrialization-driver-sustained-prosperity.

UNIDO (2020b), Clean-Energy Mini-Grid Policy Development Guide, United Nations Industrial Development Organization, www.unido.org/sites/default/files/files/2021-03/CEMG_Development_Guide_EN.pdf.

UNIDO (2017), "Empowering young women through renewable energy training", United Nations Industrial Development Organization, Vienna, Austria, www.unido.org/stories/empowering-young-women-through-renewable-energy-training (accessed 14 September 2021).

United for Efficiency (2020), "Africa Centre of Excellence for Sustainable Cooling and Cold-chain: Food saved is as important as food produced", https://united4efficiency.org/wp-content/uploads/2020/10/Africa-Centre-of-Excellence-20210219.pdf.

United Nations (2021a), Leveraging Energy Action for Advancing the Sustainable Development Goals: Policy Briefs in Support of the High-Level Political Forum, United Nations, New York, https://sdgs.un.org/publications/policy-briefs-support-high-level-political-forum-33303.

United Nations (2021b), "UN Comtrade Database", https://comtrade.un.org/data/dev/portal/.

United Nations (2021c), "SDG Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all", United Nations, New York, www.un.org/sustainabledevelopment/economic-growth/.

United Nations (2021d), "Financing for Sustainable Development Report 2021", Inter-agency Task Force on Financing for Development, United Nations, New York, https://developmentnance.un.org/fsdr2021.

United Nations (2021e), *Leveraging Energy Action for Advancing the Sustainable Development Goals: Policy Briefs in Support of the High-Level Political Forum*, United Nations, New York, https://sdgs.un.org/sites/default/files/2021-06/2021-UN_POLICY%20BRIEFS-063021.pdf.

United Nations (2020), *Accelerating SDG7 Achievement in the Time of COVID-19: Policy Briefs in Support of the High-Level Political Forum 2020*, United Nations, New York, https://sustainabledevelopment.un.org/content/documents/26235UNFINALFINAL.pdf.

United Nations (2019a), *Accelerating SDG7 Achievement: SDG7 Policy Briefs in Support of the High-Level Political Forum 2019*, United Nations, New York, https://sustainabledevelopment.un.org/content/documents/22877UN_FINAL_ONLINE_20190523.pdf.

United Nations (2019b), "World population prospects 2019", United Nations, https://population.un.org/wpp/Download/Standard/Population/ (accessed 14 September 2021). https://united4efficiency.org/wp-content/uploads/2020/10/Africa-Centre-of-Excellence-20210219.pdf.

UNREEEA (Uganda National Renewable Energy), KEREA (Kenya Renewable Energy Association) and USEA (Uganda Solar Energy Association) (2020), The East African Handbook on Solar Taxation, VeraSol, https://verasol.org/publications/east-africa-regional-solar-taxation-handbook.

UNPD (United Nations Population Division) (2019). World Population Prospects 2019. United Nations Population Division, New York.

UNSD (2021), *Ensure Access to Affordable, Reliable, Sustainable and Modern Energy for All*, United Nations Statistics Division, New York, https://unstats.un.org/sdgs/report/2021/goal-07/.

Urban Institute (2016), "Results-based financing approaches", www.urban.org/sites/default/files/publication/85601/results-based-financing-approaches_1.pdf.

UNSD (2018), *2018 Energy Balances*, United Nations Statistics Division, United Nations, New York.

USAID (United States Agency for International Development) (2021a), "Multi-tier framework for measuring household electricity access", United States Agency for International Development, Washington, DC, www.usaid.gov/energy/mini-grids/economics/cost-effectiveness/tiers-of-service/.

USAID (2021b), "Power Africa COVID-19 response", United States Agency for International Development, Washington, DC, www.usaid.gov/sites/default/files/documents/Power-Africa-COVID-19-Fact-Sheet-August-2021.pdf.

USAID (2021c), "Center of Excellence for Energy", United States Agency for International Development, Washington, DC, www.usaid.gov/egypt/higher-education/center-excellence-energy (accessed 14 September 2021).

USAID (2020), "Pro poor results-based financing: Increasing off-grid access to electricity in Rwanda", United States Agency for International Development, www.usaid.gov/sites/default/files/documents/Power-Africa-Rwanda-Pro-Poor-Report.pdf.

Usman, Z., O. Abimbola and I. Ituen (2021), *What Does the European Green Deal Mean for Africa?* Carnegie Endowment for International Peace, Washington, D.C., https://carnegieendowment.org/2021/10/18/what-does-european-green-deal-mean-for-africa-pub-85570#:~:text=The%20European%20Green%20Deal%20provides,Related%20Media%20and%20Tools.

Urpelainen, J. and Yang, J. (2016), "Policy reform and the problem of private investment: Evidence from the power sector", Journal of Policy Analysis and Management, Vol. 36/1, pp. 38-64.

Vivid Economics (2013), *Results-Based Financing in the Energy Sector: An Analytical Guide*, Energy Sector Management Assistance Program Technical report 004/13, World Bank, Washington, DC, https://openknowledge.worldbank.org/handle/10986/17481.

Wang, C. N. (2021), "Brief: Coal phase-out in the Belt and Road Initiative (BRI): An analysis of Chinese-backed coal power from 2014-2020", https://green-bri.org/coal-phase-out-in-the-belt-and-road-initiative-bri-an-analysis-of-chinese-backed-coal-power-from-2014-2020/.

Wehrmann, B. (2020), "'Tomorrow's oil': Germany seeks hydrogen export deal with West African states", Clean Energy Wire, www.cleanenergywire.org/news/tomorrows-oil-germany-seeks-hydrogen-export-deal-west-african-states.

Whiteman, A., Broadhead, J. and Bahdon, J. (2002), "The revision of woodfuel estimates in FAOSTAT", An International Journal of Forestry and Forest Industries, Vol. 53/4, www.fao.org/3/y4450e/y4450e00.htm#Contents.

WHO (2021), "Global Health Observatory data repository", World Health Organization, Geneva, Switzerland, https://apps.who.int/gho/data/view.main.HHAIRFUELSCLEANCOUNTRYv (accessed 23 August 2021).

WHO (2014), "Harnessing Africa's untapped solar energy potential for health", World Health Organization, Washington, DC, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3949541/.

WMO (World Meteorological Organization (2021), *State of the Climate in Africa 2020*, WMO-No. 1275, World Meteorological Organization, Geneva.

Wood Mackenzie (2021), "Off-Grid Renewable Investment (database)", https://datahub.woodmac.com/app/main#/dashboards/5d3a1511d249d18c0f001758 (subscription required).

Wood Mackenzie (2020), Off-grid renewable investment (database), Wood Mackenzie, https://datahub.woodmac.com/app/main#/dashboards/5d3a1511d249d18c0f001758 (subscription required).

World Bank (2021a), "World development indicators", https://databank.worldbank.org/source/world-development-indicators.

World Bank (2021b), "Private Participation in Infrastructure (PPI) Project Database", World Bank Group, https://ppi.worldbank.org/en/ppidata.

World Bank (2021c), "CO_2 emissions (kt) – Sub-Saharan Africa", https://data.worldbank.org/indicator/EN.ATM.CO2E.KT?end=2018&locations=ZG&start=1960&view=chart.ac

World Bank (2021d), "GDP", https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=ZG.

World Bank (2021e), "Poverty", https://data.worldbank.org/topic/poverty?locations=ZG.

World Bank (2021f), "Sub-Saharan Africa", https://data.worldbank.org/country/ZG

World Bank (2021g), "Research and development expenditure (% GDP)", https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS

World Bank (2020a), *Poverty and Shared Prosperity 2020: Reversals of Fortune*, World Bank, Washington, D.C., https://www.worldbank.org/en/publication/poverty-and-shared-prosperity

World Bank (2020b), *The African Continental Free Trade Area: Economic and Distributional Effects*, World Bank, Washington, D.C., https://openknowledge.worldbank.org/handle/10986/34139.

World Bank (2020c), *Morocco Skills Development for Employment: The Role of Technical and Vocational Education and Training*, World Bank, Washington, D.C., https://documents1.worldbank.org/curated/en/919151593565793405/pdf/Morocco-Skills-Development-for-Employment-The-Role-of-Technical-and-Vocational-Education-and-Training.pdf.

World Bank (2020d), *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition*, Climate-Smart Mining Facility, The World Bank, Washington, D.C., https://pubdocs.worldbank.org/en/961711588875536384/Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf.

World Bank (2020e), "Integrated electrification planning accelerating progress towards SDG7: Focus on low access countries in Sub-Saharan Africa", www.worldbank.org/en/results/2020/11/10/integrated-electrification-planning-accelerating-progress-towards-sdg7-focus-on-low-access-countries-in-sub-saharan-africa.

World Bank (2020f), *Cooking with Electricity: A Cost Perspective*, Energy Sector Management Assistance Program, World Bank, Washington, D.C., https://openknowledge.worldbank.org/handle/10986/34566.

World Bank (2019), *The Power of Dung: Lessons Learned from On-Farm Biodigester Programs in Africa*, World Bank, Washington, DC, http://documents1.worldbank.org/curated/en/468451557843529960/pdf/The-Power-of-Dung-Lessons-Learned-from-On-Farm-Biodigester-Programs-in-Africa.pdf.

World Bank (2018a), *Ethiopia: Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework*, World Bank, Washington, DC, https://mtfenergyaccess.esmap.org/data/files/download-documents/mtf-energy-access-country-diagnostic-report_ethiopia_6.2018.pdf.

World Bank (2018b), *Rwanda: Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework*, World Bank, Washington, DC, https://mtfenergyaccess.esmap.org/data/files/download-documents/mtf-energy-access-country-diagnostic-report_rwanda_6.2018.pdf.

World Bank (2018c), "Kenya National Electrification Strategy: Key highlights", http://pubdocs.worldbank.org/en/413001554284496731/Kenya-National-Electrification-Strategy-KNES-Key-Highlights-2018.pdf.

World Bank Group (2018), *Zambia Scaling Solar*, World Bank Group, Washington, D.C., https://thedocs.worldbank.org/en/doc/208821518200595153-0100022018/original/BriefsGuaranteesZambiaScalingSolar.pdf.

World Bank (2017), "Energy Access and Gender: Getting the Right Balance", https://documents1.worldbank.org/curated/en/463071494925985630/pdf/115066-BRI-P148200-PUBLIC-FINALSEARSFGenderweb.pdf.

World Bank (2014), *Clean and Improved Cooking in Sub-Saharan Africa*, World Bank, Washington, DC, https://documents1.worldbank.org/curated/en/164241468178757464/pdf/98664-REVISED-WP-P146621-PUBLIC-Box393185B.pdf.

World Food Programme (2021), *Food Security and Livelihoods under a Changing Climate in Mozambique*, World Food Programme, Rome, https://reliefweb.int/sites/reliefweb.int/files/resources/C_ADAPT_Food_security_Mozambique_14april-compressed.pdf.

Worrall, L., Whitley, S. and Scott, A. (2018), "Reforming Africa's fossil fuel subsidies", www.sun-connect-news.org/de/articles/business/details/reforming-africas-fossil-fuel-subsidies/.

WRI (World Resources Institute) (2021), "Ethiopia: Expanding opportunities for women in the electricity sector", World Resources Institute, Washington, DC, www.wri.org/just-transitions/ethiopia (accessed 5 September 2021).

WTO (World Trade Organization) (2018), *India – Certain Measures Relating to Solar Cells and Solar Modules*, World Trade Organization, Geneva, https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds456_e.htm.

WTTC (World Travel and Tourism Council) (2020), "Urgent appeal to international community to support African travel and tourism sector", World Travel and Tourism Council, https://wttc.org/News-Article/Urgent-Appeal-to-International-Community-to-Support-African-Travel-and-Tourism-Sector.

Yee, A. (2018), "How Kenya is harnessing geothermal energy to power its growing economy", Independent, www.independent.co.uk/news/long_reads/geothermal-kenya-africa-green-energy-environmentally-friendly-un-development-expansion-a8228821.html.

Zawya (2021), "Egypt introduces green hydrogen in 2035 Energy Strategy", 24 October, www.zawya.com/mena/en/business/story/Egypt_introduces_green_hydrogen_in_2035_Energy_Strategy-SNG_254912502/.

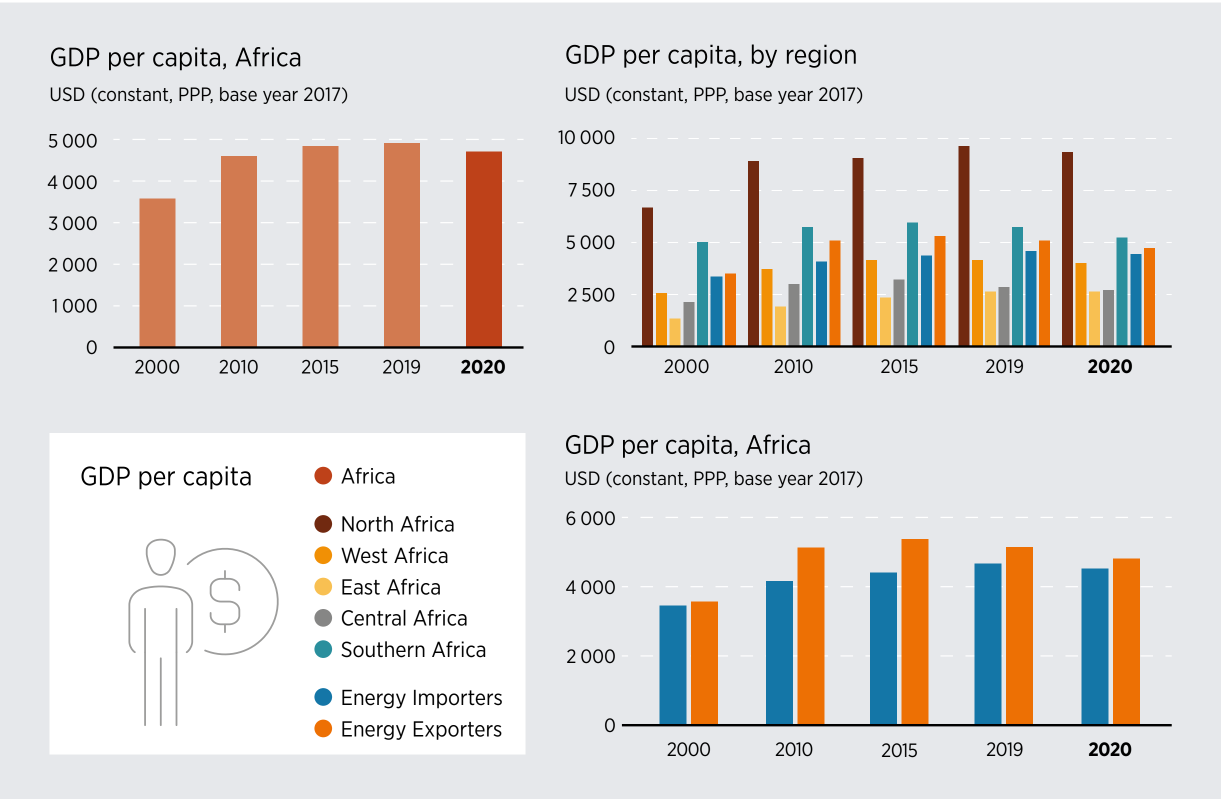
60 Decibels (n.d.), "Listening in the time of COVID-19", https://app.60decibels.com/covid-19#explore.

ANNEX

ANNEX A
Additional economic indicators for Africa by region and country

A

Figure A.1 Purchasing Power Parity (PPP) indicators for GDP per capita in Africa



A

Table A1 Africa country classifications and basic indicators, 2019

	Population (total)	GDP (constant 2015 US$)	GDP per capita (constant 2015 US$)	Access to electricity (% of population)	Oil rents (% of GDP)	Natural gas rents (% of GDP)	Coal rents (% of GDP)
North Africa							
Algeria	43 053 054	177 004 287 500	4 111	100	14.4	1.9	0
Egypt	100 388 076	398 037 429 250	3 965	100	4.0	0.8	0
Libya	6 777 453	40 473 930 299	5 972	69	43.9	0.7	0
Morocco	36 471 766	112 681 944 402	3 408	100	0	0	0
Sudan (the)	42 813 237	70 899 185 365	2 018	54	3.6	0	0
Tunisia	11 694 721	46 215 187 210	3 952	100	1.7	0.2	0
West Africa							
Benin	11 801 151	14 179 807 375	1 202	40	0.1	0	0
Burkina Faso	20 321 383	15 021 062 489	739	18	0	0	0
Cabo Verde	549 936	1 915 123 783	3 482	96	0	0	0
Côte d'Ivoire	25 716 554	59 861 589 343	2 328	69	1	0.3	0
Gambia (the)	2 347 696	1 674 917 282	713	60	0	0	0
Ghana	30 417 858	60 053 814 796	1 974	84	4.7	0.2	0
Guinea	12 771 246	12 078 653 012	946	42	0	0	0
Guinea-Bissau	1 920 917	1 248 729 328	650	31	0	0	0
Liberia	4 937 374	3 168 645 098	642	28	0	0	0
Mali	19 658 023	16 030 225 229	815	48	0	0	0
Mauritania	4 525 698	6 991 169 072	1 545	46	0	0	0
Niger (the)	23 310 719	12 206 862 618	524	19	1.3	0	0
Nigeria	200 963 603	502 942 019 448	2 503	55	7.4	1	0
Senegal	16 296 362	22 515 082 955	1 382	70	0	0	0
Sierra Leone	7 813 207	5 093 411 985	652	23	0	0	0
Togo	8 082 359	5 098 275 352	631	52	0	0	0
East Africa							
Burundi	11 530 577	3 209 182 873	278	11	0	0	0
Comoros (the)	850 891	1 093 028 518	1 285	84	0	0	0
Djibouti	973 557	3 191 851 222	3 279	61	0	0	0
Eritrea	n.a.	n.a.	n.a.	50	n.a.	n.a.	n.a.
Ethiopia	112 078 727	89 640 020 508	800	48	0	0	0
Kenya	52 573 967	79 567 400 860	1 513	70	0	0	0
Mauritius	1 265 711	13 472 250 306	10 644	100	0	0	0
Rwanda	12 626 938	11 182 411 389	886	38	0	0	0
Seychelles	97 625	1 553 582 269	15 914	100	0	0	0
Somalia	15 442 906	4 467 302 097	289	36	n.a.	n.a.	n.a.
South Sudan	11 062 114	n.a.	n.a.	7	n.a.	n.a.	n.a.
Uganda	44 269 587	39 772 129 636	898	41	0	0	0
United Republic of Tanzania (the)	58 005 461	60 313 624 453	985	38	0	0.2	0

Table A.1 Africa country classifications and basic indicators, 2019 (continued)

	Population (total)	GDP (constant 2015 US$)	GDP per capita (constant 2015 US$)	Access to electricity (% of population)	Oil rents (% of GDP)	Natural gas rents (% of GDP)	Coal rents (% of GDP)
Central Africa							
Angola	31 825 299	110 072 586 683	3 459	46	25.1	0.7	0
Cameroon	25 876 387	36 174 281 281	1 398	63	2.8	0.4	0
Central African Republic (the)	4 745 179	1 984 982 179	418	14	0	0	0
Chad	15 946 882	10 526 057 266	660	8	17.8	0	0
Congo (the)	5 380 504	9 679 884 326	1 799	48	43.4	1.2	0
Democratic Republic of the Congo (the)	86 790 568	44 487 649 198	513	19	0.7	0	0
Equatorial Guinea	1 355 982	9 998 462 338	7 374	67	22.3	6.9	0
Gabon	2 172 578	15 464 604 555	7 118	91	18.8	0.1	0
Sao Tome and Principe	215 048	359 752 972	1 673	75	0	0	0
Southern Africa							
Botswana	2 303 703	16 660 581 829	7 232	70	0	0	0.3
Eswatini	1 148 133	4 386 267 606	3 820	77	0	0	0.1
Lesotho	2 125 267	2 329 753 749	1 096	45	0	0	0
Madagascar	26 969 306	13 185 667 410	489	27	0.1	0	0
Malawi	18 628 749	7 498 874 534	403	11	0	0	0
Mozambique	30 366 043	18 179 703 970	599	30	0.1	2.3	3.4
Namibia	30 366 043	18 179 703 970	599	30	0.1	2.3	3.4
South Africa	58 558 267	326 441 485 337	5 575	85	0	0	1.9
Zambia	17 861 034	24 089 948 504	1 349	43	0	0	0
Zimbabwe	14 645 473	20 030 275 330	1 368	41	0	0	0.4

B

ANNEX B
Basic energy indicators for Africa by region and country

Table B.1 Installed electricity-generating capacity, by source, 2020 (MW)

	Coal and peat	Oil	Natural gas	Gas/Oil hybrid	Bioenergy	Geothermal	Hydropower (excl. Pumped Storage)	Hydropower (Pumped Storage)	Solar	Wind	Total
North Africa											
Algeria	0	175	23 903	0	0	0	228	0	448	10	**24 764**
Egypt	0	937	20 718	31 793	79	0	2 832	0	1 680	1 380	**59 420**
Libya	0	4 045	9 682	0	0	0	0	0	5	0	**13 732**
Morocco	4 116	1 640	920	0	7	0	1 306	464	734	1 405	**10 592**
Sudan (the)	0	2 013	0	0	199	0	1 907	0	18	0	**4 137**
Tunisia	0	92	6 180	0	0	0	62	0	95	244	**6 673**
Total	**4 116**	**8 902**	**61 403**	**31 793**	**285**	**0**	**6 335**	**464**	**2 980**	**3039**	**119 317**
West Africa											
Benin	0	174	127	0	0	0	1	0	3	0	**304**
Burkina Faso	0	339	0	0	1	0	35	0	62	0	**437**
Cabo Verde	0	141	0	0	0	0	0	0	8	28	**176**
Côte d'Ivoire	0	328	1 012	0	0	0	879	0	13	0	**2 232**
Gambia (the)	0	102	0	0	0	0	0	0	2	1	**105**
Ghana	0	992	2 673	0	8	0	1 584	0	94	0	**5 351**
Guinea	0	0	254	0	0	0	368	0	13	0	**636**
Guinea-Bissau	0	28	0	0	0	0	0	0	1	0	**29**
Liberia	0	98	0	0	0	0	92	0	3	0	**193**
Mali	0	459	0	0	40	0	315	0	70	0	**884**
Mauritania	0	465	0	0	0	0	0	0	88	34	**587**
Niger (the)	38	294	21	0	0	0	0	0	27	0	**380**
Nigeria	0	43	10 959	0	10	0	2 111	0	28	3	**13 154**
Senegal	0	556	163	0	25	0	0	0	171	50	**965**
Sierra Leone	0	139	0	0	34	0	61	0	4	0	**238**
Togo	0	52	20	100	0	0	67	0	6	0	**245**
Total	**38**	**4 210**	**15 229**	**100**	**118**	**0**	**5 512**	**0**	**593**	**117**	**25 916**

Table B.1 Installed electricity-generating capacity, by source, 2020 (MW) (continued)

	Coal and peat	Oil	Natural gas	Gas/Oil hybrid	Bioenergy	Geothermal	Hydropower (excl. Pumped Storage)	Hydropower (Pumped Storage)	Solar	Wind	Total
East Africa											
Burundi	0	51	0	0	4	0	48	0	5	0	108
Comoros (the)	0	22	0	0	0	0	1	0	0	0	23
Djibouti	0	123	0	0	0	0	0	0	0	0	123
Eritrea	0	205	0	0	0	0	0	0	22	1	228
Ethiopia	0	104	0	0	290	7	4 071	0	20	324	4 817
Kenya	0	750	57	0	88	824	837	0	106	336	2 998
Mauritius	188	438	0	0	97	0	61	0	83	11	877
Rwanda	15	74	25	0	1	0	110	0	31	0	256
Seychelles	0	116	0	0	0	0	0	0	4	6	126
Somalia	0	100	0	0	0	0	0	0	23	4	126
South Sudan	0	174	0	0	0	0	0	0	1	0	175
Uganda	0	103	0	0	96	0	1 011	0	77	0	1 287
United Republic of Tanzania (the)	0	344	974	0	70	0	589	0	24	0	2 000
Total	**203**	**2 604**	**1 056**	**0**	**646**	**831**	**6 728**	**0**	**396**	**681**	**13 144**
Central Africa											
Angola	0	991	1 146	0	51	0	3 729	0	13	0	5931
Cameroon	0	437	268	0	0	0	777	0	14	0	1 497
Central African Republic (the)	0	22	0	0	0	0	19	0	0	0	41
Chad	0	162	120	0	2	0	0	0	0	1	285
Congo (the)	0	63	534	0	12	0	214	0	1	0	823
Democratic Republic of the Congo (the)	0	29	0	0	3	0	2 750	0	20	0	2 802
Equatorial Guinea	0	118	156	0	0	0	127	0	0	0	401
Gabon	0	87	192	0	1	0	330	0	1	0	612
Sao Tome and Principe	0	45	0	0	0	0	2	0	0	0	48
Total	**0**	**1 954**	**2 416**	**0**	**69**	**0**	**7 949**	**0**	**51**	**1**	**12 439**
Southern Africa											
Botswana	732	185	0	0	0	0	0	0	6	0	923
Eswatini	0	10	0	0	106	0	62	0	1	0	179
Lesotho	0	0	0	0	0	0	75	0	0	0	75
Madagascar	120	502	0	0	0	0	164	0	33	0	819
Malawi	0	130	0	11	12	0	374	0	24	0	551
Mozambique	0	125	478	0	14	0	2 204	0	95	0	2915
Namibia	120	63	0	0	0	0	351	0	145	5	684
South Africa	40 686	2 440	0	0	265	0	747	2 732	5 990	2 636	55 496
Zambia	330	195	0	0	43	0	2 399	0	99	0	3 066
Zimbabwe	1 190	10	0	0	100	0	1 081	0	17	0	2 398
Total	**4 3178**	**3 660**	**478**	**11**	**540**	**0**	**7 457**	**2 732**	**6 410**	**2 641**	**67 107**

RENEWABLE ENERGY MARKET ANALYSIS

AFRICA AND ITS REGIONS

IN COLLABORATION WITH

AFRICAN DEVELOPMENT BANK GROUP

IRENA
International Renewable Energy Agency