Just Energy Transitions in Africa

Main report

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Disclaimer

This report was submitted as draft to the United Nations Development Programme (UNDP). Please note that the analysis and recommendations of this report do not reflect the views of UNDP. This publication is based solely on the analysis and findings of its author.

FORWORD

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LIST OF EXHIBITS AND IN-FOCUS BOXES

LIST OF ACRONYMS AND ABBREVIATIONS

AfDB	African Development Bank
AFREC	African Energy Commission
AU	African Union
BP	British Petroleum
BNEF	Bloomberg New Energy Finance
CAPP	Central African Power Pool
COMELEC	Maghreb Electric Committee
CSP	Concentrated solar power
CCS	Carbon capture and storage
CO_2	Carbon dioxide
COP	Conference of the Parties
DNV	Det Norske Veritas
DR Congo	Democratic Republic of Congo
EAC	East African Community
EAP	East African Power Pool
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
EE	Energy efficiency
EJ	Exajoule (10^{18} joules)
ERI	Electricity Regulation Index
EU	European Union
EV	Electric vehicle
FiT	Feed-in tariff
GDP	Gross domestic product
GHG	Greenhouse gas
GW	Gigawatt (billion watts)
GWh	Gigawatt-hour (billion watt-hours)
HPP	Hydropower plant
ICS	Improved cookstove
IEA	International Energy Agency
IPP	Independent power producer
IRENA	International Renewable Energy Agency
ktoe	Kiloton of oil equivalent
kton	Kiloton
LED	Light-emitting diode
mbd	Million of barrels a day
MJ	Megajoule (million = 10^6 joules)
Mton or Mt	Megaton (million tons)
MW	Megawatt (million watts)
LNG	Liquid natural gas
LPG	Liquified petroleum gas
NZE	Net Zero scenario
PES	Planned Energy Scenario
PGM	Platinum group metals
PJ	Petajoule (10^{15} joules)
PM	Particulate matter
PPA	Power purchase agreement

PPP	Public-private partnership
RE	Renewable energy
REC	Regional economic community
REmap	Renewable Energy Roadmaps
REIPPPP	Renewable Energy Independent Power Producer Procurement Program (or REI4P)
PV	Photovoltaic
RISE	Regulatory Indicators for Sustainable Energy
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SAS	Sustainable Africa scenario
SDG	Sustainable Development Goal
SDS	Sustainable Development scenario
SHS	Solar home system
STEP	Stated Policies scenario
SWH	Solar water heater
tCO_2	Ton of carbon dioxide
T&D	Transmission and distribution
TES	Transforming Energy Scenario
T&D	Transmission and distribution
TFEC	Total final energy consumption
TPES	Total primary energy supply
Toe	Ton of oil equivalent
TWh	Terawatt-hour (trillion watt-hours)
UN	United Nations
USD	United States dollar
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme
WAPP	West African Power Pool
WB	World Bank
WEO	World Energy Outlook

EXECUTIVE SUMMARY

Two energy transitions

Energy transitions are shifts in the way people produce and consume energy using different technologies and sources. The industrial revolution was driven by an energy transition from wood and other biomass to coal, followed by oil and most recently natural gas, accompanied by a rapid increase in energy consumption. Resource depletion, such as scarcity of wood and whale oil, triggered a technological innovation and shift to new energy resources.

The current transition to sustainable energy differs; it is driven by a recognition that global greenhouse gas emissions must be brought to net zero less driven rather than immediate scarcity. The Paris Agreement of 2015, to keep global warming below 1.5 °C, requires net-zero greenhouse gas emissions by 2050. Fossil fuels are the largest single source of carbon emissions (over 70% of our global greenhouse gas emissions result from the energy sector, for transport, heating, and industrial use). Thus, the low-carbon energy transition involves a shift from high-carbon energy sources (such as oil, gas and coal) to low-carbon and zero-carbon energy sources (such as renewables), within fossil fuels from coal and oil to less carbon-intensive natural gas, or from unsustainably produced biomass to other low-carbon alternatives.

One aspect of the coming global energy transition is the increasing electrification of energy demand, in particular in low-temperature heat applications in industry and buildings and the rapid penetration of electric vehicles in transport, providing from 20% in global energy consumption to 30-50% in 2050. A second important aspect is the greening of the power sector; the share of renewable energy in global electric energy production will increase from the present 25% to about 55-60% (if following a more conservative 'grey' pathway) to about 85%-90% (in 'green', net-zero emission pathways) in 2050. The role of fossil fuels in power generation will decline correspondingly, in particular coal will be phased out and replaced by natural gas and renewables. In the energy sector as a whole (electricity, heat application and motive applications), coal demand will decline, and the demand for oil products will slightly increase by 2030 and then flatten or decrease (depending on whether the world follows a grey or green pathway), while demand for natural gas will increase (and becoming the dominant carriers with fossil fuels) and slowly increase after 2030 or decrease (depending on how the decarbonization of the power sector and industry will proceed). A third aspect is formed by the new 'energy kids' on the block. In the net-zero pathway, there is an increasing role of hydrogen and derivative fuels replacing fossil fuels, while biofuels (biodiesel, syngas, synfuel, ethanol) will be emerging as fuel in transportation. Green hydrogen (made from renewable electricity) in combination with green electricity (made from solar, wind, hydro or other renewable sources) has the potential to entirely replace hydrocarbons in electricity with industrial heat, materials such as steel and fertilizer, space heating, and transport fuels as well as in the residential sector.

In 2020, 730 million of the world's people lived without access to electricity (of which three-quarters were in Sub-Saharan Africa) and about 2.4 billion had no access to clean cooking methods (with four out of ten living in Sub-Saharan Africa)[1]. The Sustainable Development Goals (SDGs) aim at providing all with access in 2030 to reliable and affordable electricity and modern cooking methods. The energy transition in Africa does, therefore, have two distinct components, one which resembles Europe's energy change during the Industrial Revolution, going from wood fuels to fossil fuels, and the other forming part of the current transition from fossil fuels to a net-zero carbon economy.

[1] Thus, more than 580 million people still lack access to electricity today and over 900 million people do not have access to clean cooking fuels (based in IEA, 2022). North Africa is different, as 95% has access to electricity and over 90% to clean cooking methods

Drivers of the future developments in Africa's energy sector

The future of Africa's energy sector will be driven by domestic and external factors. Domestic energy demand is expected to rise very rapidly in the coming decades, as a consequence of economic development, demographic changes (population growth and urbanization) and energy access expansion efforts. Concerning the latter, to meet the universal access goal, about 755 million people will need to be provided between now and 2030 with access to electricity (either by grid extension or decentralized options) and over 1.1 billion people with access to clean cooking methods (either with improved biomass stoves or non-biomass fuels).

As developing economies expand and populations grow, energy demand increases. Consumptive energy demand grows because households earn more income and choose to spend some of it on electricity and appliances. Meanwhile, productive demand in industry and agriculture increases as new businesses and light industrial activities are established and existing ones expand. All this implies rapid growth in the demand for materials to build infrastructure and increased industrialization and more transport of raw and finished goods, leading to higher demand for freight vehicles, rail, navigation and aviation.

Energy demand will not only grow rapidly, but its composition in terms of supply sources will also change. If the universal access goal of clean cooking methods will be reached, this implies a drastic decrease in the use of solid biomass (fuelwood and charcoal) and an increase in LPG consumption. The percentage share of electricity in the residential, commercial and productive sectors will also increase.

Electricity will play an important role, both as part of the universal energy access goals and of the low-carbon energy transition to be able to provide power to the fast-growing demand in the residential, commercial and industrial sectors, that get increasingly electrified. The current expansion rate of generation and transmission capacity in Sub-Saharan Africa will not be sufficient to provide sufficient, reliable and affordable energy to meet the soaring demand, while millions of new consumers in the peri-urban and rural areas will be added to the system. Demand for electricity in Sub-Saharan Africa may quadruple in the coming two decades.

Electricity will be the backbone of Africa's energy systems in the future as well, powered increasingly by renewables. Africa relies today heavily on fossil fuels) for energy consumption and its electricity generation, although with regional differences, with coal important in South Africa and oil and gas in North Africa and oil and gas producers in Sub-Saharan Africa. Hydropower is important for electricity generation in Central, East and Southern Africa. About nine countries are currently important oil and gas exporters, Nigeria, Nigeria, Egypt, Libya, Egypt, Equatorial Guinea, Angola, Congo and Gabon. A significant driver in recent years of the energy sector in Africa has been the discovery of sizeable natural gas resources across Africa, notably in Mauritania, Senegal, Tanzania and Mozambique.

Externally, exports of oil, gas or other energy carriers will be determined by a complex interplay of demand for natural gas (as a lower-carbon replacement for coal and oil), the tenacity of industrialized countries to follow a pathway towards net-zero emissions by 2050, market price development, local cost of exploration and exploitation of Africa's gas reserves and development of its renewable energy resources.

Opportunities

In Africa, the continent's industrialization will rely in part on expanding natural gas use, although in electricity generation gas will increasingly meet competition from renewable sources of energy. The position of natural gas in Africa's energy mix today varies widely across the continent. In North Africa, gas is a mainstream fuel. In much of sub-Saharan Africa, gas has been a niche fuel. Several major gas discoveries (representing over 40% of global gas discoveries between 2011 and 2018) have been made in recent years. Where resources are plentiful, it could provide the continent with additional electricity for baseload and flexibility needs, energy for industrial growth and a sizeable source of revenue. In the power sector, natural gas can help satisfy the growing appetite for baseload electricity and replace other fossil fuels in industries that are hard to electrify, while also serving as a household fuel in an increasingly urbanizing environment. Making the most of these resources would require new pipeline infrastructure, although small-scale liquefied natural gas (LNG) technologies are allowing a new approach to distributing gas to consumers. Almost all Sub-Saharan African countries could potentially use natural gas for power generation to spread electrification and/or displace oil as a generating fuel. This demand could be met by domestic gas sources where countries have significant gas reserves; imports by pipeline; imports by LNG (for those countries with coastlines) and, potentially, gas by wire (using the electricity interconnections between neighboring countries). An appropriate energy transition for African households should ensure affordable access to a much cleaner and easily access and growing urbanization suggests a growing market for cleaner cooking solutions.

The recent events in Ukraine have shown vulnerability in Europe's energy security and its lopsided dependence on Russian gas imports. The pressing search for an alternative is offering opportunities for African export through North African pipelines and LNG shipments. There is a gas transport infrastructure available between North Africa and Europe, transporting gas from Algeria and Libya to Europe via Italy and Spain. Current price surges are providing a short-term boon to African producers, with new deals signed to deliver North African gas to Europe, along with renewed momentum to develop and expand LNG terminals along the African coast.

Africa has vast resource potential in wind, solar, hydro, and geothermal energy. Hydropower is already and will remain a cornerstone of Sub-Saharan Africa's power system. Falling costs will increasingly bring solar energy almost everywhere in Africa. Wind and geothermal will be important where resources are locally available. Economies of scale, a huge domestic market and the large spectrum of renewable energy options are key drivers for building a sustainable, low-carbon, energy mix. This huge increase in renewable energy deployment will also provide unprecedented opportunities for the development of a domestic, African industry for manufacturing and assembly of energy-relevant technologies (if facilitated by the right domestic and regional policies).

Africa has abundant mineral resources essential to the production of electric batteries, wind turbines, and fuel cells, such as manganese, copper, lithium, cobalt, chromium and platinum. These form important export commodities in the global market transitioning towards zero carbon. However, the benefits Africa will derive 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 and will need improved exploration, good governance, improved transport infrastructure and a particularly strong focus on minimizing the environmental and social impacts of mining operations.

As Europe and other parts of the world move to a zero-carbon economy, the role of hydrogen will become more pronounced. This may ask for a bold strategy with an accelerated shift in the economy to a more pronounced role of green hydrogen both for export and local use. Europe has a well-developed gas grid that can be converted to accommodate hydrogen at a minimal cost. The main part of the hydrogen backbone infrastructure will consist of re-used natural gas transport pipelines with new compressors. These can eventually be converted and new pipelines added. In North Africa, the electricity production costs with solar and wind are lower than in Europe and also other regions in Africa have excellent renewable energy resources. In addition, a local green hydrogen economy can be built alongside the existing infrastructure routes of roads, railways and seaports for use in and across African regions. In most African countries the bulk of the energy infrastructure is not yet built, allowing for rapid leapfrogging to new energy systems.

Challenges

One challenge in building the new infrastructure is the substantial investment cost. Following recent energy access expansion trends, about 15-20 million people will gain electricity access, but barely enough to keep up with natural population growth. About 565 million people will still lack access to electricity in 2030 and over 1.1 billion people will not have access to clean cooking methods. This asks for a formidable effort of tripling the average number of people gaining access per year (up from about 15-20 million annually in the past years) today to over 60 million, mostly rural, people. Conventional electricity grid extension may be able to reach half of the unconnected. The other half lives in remote and or sparsely populated areas where decentralized options will be a least-cost option, in the form of minigrids serving local communities, powered by solar, hydropower or other renewable or in hybrid with diesel generators) and stand-alone options (pico-solar, solar home systems) serving individual households. At the same time, access needs to be provided to over a billion people in Sub-Saharan Africa that use wood fuels in inefficient methods by improved wood and charcoal stoves, and (when available and affordable), by non-biomass fuels, such as liquified petroleum gas (LPG) and electricity.

The investment cost to achieve universal access is large, about USD 40-50 billion a year. Even when achieving universal access for all by 2030, the effort of providing access does not stop in 2030. Population growth means that new connections will need to be provided annually (although at a smaller scale), while people will aspire to climb up the energy ladder from the low-energy level supplied by stand-alone solutions to the higher levels of electricity consumption that a full grid connection can provide, or from improved biomass stoves to LPG or electric cooking.

To meet future demand, Africa will need to upgrade and expand its power system significantly. At present, the systems face a significant deficit in electricity supply and reliability, particularly in Sub-Saharan Africa. The transmission and distribution losses in Sub-Saharan Africa (excluding South Africa) are about 23%. Reducing transmission and distribution losses by modernizing and rehabilitating grid infrastructure will significantly lower electricity supply needs. Public utilities will be responsible for much of the investment in upgrading the electricity systems across the African continent. This is not an easy task given the perilous financial state of main utilities today. Only a few countries have fully cost-reflective electricity tariffs, while some countries employ tariffs that recover less than 50% of the total cost of supply. Expanding and modernizing Africa's electricity infrastructure requires a radical improvement in the financial health of many utilities to be brought about by better governance and regulatory reforms, in particular, by having cost-of-service electricity tariffs.

Apart from improving efficiency in the power system, energy end-use efficiency will help temper demand growth, reduces fuel imports and reduces the strain on an already overstretched power system. Saving a kilowatt-hour is often cheaper than generating one, and reducing investment in power generation and transport will keep consumer bills affordable.

Energy trade within Africa remains marginal, reflecting the low rate of Africa's economic integration. Regional power pool interconnections, with hydropower and natural gas as base load, will provide the flexibility to the African power systems to be able to integrate the variable sources of renewable energy, solar and wind, on a large scale.

Despite the large natural gas reserves, there has been low penetration of natural gas in Sub-Saharan Africa. In many cases, there is a considerable distance between production (in a few countries) and the main consumption centers. Probably the biggest barrier to the expansion of gas use across Africa is the lack of infrastructure on a large-scale throughout the continent. North Africa is quite well connected from a main hub in Algeria with pipelines connecting Algeria to Morocco and Tunisia as well as through to Europe. However, in the other African regions, there are only a few operational cross-border gas pipelines (such as the West African Gas Pipeline from Nigeria to Benin, Togo and Ghana and the pipeline from Mozambique to South Africa).

Production of oil and gas remains important to African economic and social development, but the focus will shift to meeting domestic demand. As current refining capacity is limited in size, this means that increasingly, Africa will have to rely on imports of oil products. This would justify investing in new refineries in the region, but mobilizing the huge investment required to build new capacity is a daunting task given the difficult business environment for investors, and the availability of ample refining capacity elsewhere in the world. Also, foreign investors may feel that projects that are now under construction or planned in the natural gas industry are not consistent with the "net-zero" emission pathways.

Africa has been and will remain a minor contributor to global emissions, so it is hypocritical that it is denied funds for developing a local infrastructure by investors and donors from countries whose industrialization has been largely fossil-fuel-based. Despite technological advances, traditional fossil fuels such as gas remain the least-cost approach to providing the stable power that businesses need in many countries. Expecting African countries to prioritize the reduction of carbon emissions above domestic competitiveness is unrealistic. If industrialized countries limit development opportunities (for example, by ceasing funding for LPG or LNG infrastructure without making provisions for equally affordable alternatives they risk limiting the countries' development; such an approach is counterproductive and likely to push African countries to identify alternative finance partners, who could turn a blind eye to damaging environmental impacts.

However, it does raise questions about the future use of gas infrastructure and the risks associated with investments in natural gas. The typically long lead time in the development of gas projects risks failing to recover their upfront costs. These could become stranded assets with high costs to decommission fossil fuel infrastructure. Maybe, rather than focusing investment on the short-term profit offered by gas (and oil) exports to Europe, whose revenues will decline in the future, it is better to realize the longer-term opportunity of investing in oil and gas infrastructure to serve local demand. As with the power sector, Africa will need to develop a well-functioning infrastructure within Africa, refinery as well as storage and distribution infrastructure, to meet future domestic demand. This does not mean that natural investment for domestic and export markets exclude each other. It makes sense to focus on export (during the transition period) for foreign exchange earnings while creating a modern, smart increasingly renewables-based system domestically. In the long run, the reuse of the gas infrastructure for green gas, such as carbon-free hydrogen and biomethane, thus offers a strategy for helping to avoid stranding assets while also accelerating greenhouse gas mitigation.

Africa spent about USD 25-30 billion on the power sector. Investments in the power sector need to increase significantly, in the order of USD 70-135 billion (of which 60-105 billion in Sub-Saharan Africa) annually to invest in the expansion of generation capacity; grid expansion, maintenance and enforcement; interregional connections; and to in decentralized options (minigrids and stand-alone systems). The energy sector as a whole may need investments in the order of USD 150-200 billion if the continent (of which USD 100-150 billion in Sub-Saharan Africa), depending on the pathway to follow in the global transition, 'grey' (with a reduced role of oil but a larger role of natural gas), 'green' (with a large but smaller role of natural gas and increased role of renewables, in particular, solar and wind energy) or 'net-zero' (with a more important role of biofuels and entering into the global hydrogen economy).

One question is if Africa has to go through the similar transition from wood fuels through fossil fuels to renewable energy as the industrialized world has done, or is there a way to leapfrog into the modern low-carbon economy, building a home-grown energy industry?

Whatever the pathway, a substantial increase in investment in the energy sector is needed in accordance with Africa's population size. While Africa accounts for almost one-fifth of the world's population, it at present attracts less than 5% of global energy investment. This is spread unevenly across the continent. Ten countries accounted for 90% of private investment in energy and electricity infrastructure on the continent over the last ten years, South Africa alone accounting for nearly 40% (IEA, 2022). Average annual investments in renewable energy grew tenfold from less than USD 0.5 billion in the 2000-2009 period to USD 5 billion in 2010-2020. Nonetheless, only 2% of global investments in renewable energy in the last two decades were made in Africa.

Impacts of the low-carbon energy transition

While the transition generates challenges, it also generates opportunities for achieving both environmental goals and socio-economic objectives. A recent IRENA study shows that an energy transition under a 1.5°C climate-compatible scenario offers Africa the possibility of an average 6.4% higher GDP in the period 2021 to 2050 and an overall 3.5% increase in employment (in comparison with the reference 'policy-as-usual' scenario). New jobs will be in new industries that require skills development, partly replacing dangerous and unhealthy jobs (e.g., in mines) with new and safer employment. African economies are mainly connected to global value chains as suppliers of raw materials or other low-end products. A wider energy transition provides the opportunity to add value to products and start production lines in Africa for regional and global value chains. Getting energy access and climbing up the energy ladder will empower communities.

Although not a major emitter, Africa is on the front line of the effects of a changing climate. Energy infrastructure planning must be climate-resilient. Increased frequency and intensity of extreme weather events such as droughts and floods are set to lead to more variability in the generation of hydropower and affect bioenergy production.

The impacts of global warming will not only affect us all but especially the poorest and most vulnerable in society, of which millions live in Africa, as they are the least able to adapt. Thus, the transitions must start now everywhere.

Just energy transition

In the energy transition, there will be winners and losers. Energy transition will impact differently, varying from region to region, country to country, community to community and from person to person. For example, jobs will be lost in the coal and (informal) charcoal sectors that currently provide a livelihood for millions. Some communities are already suffering from the unchecked expansion of raw material extraction to fuel the transition to renewable energies.

Certain regions and countries will benefit, while other regions and countries will see an economic and social decline. The net wealth created may concentrate in the hands of the happy few and increase the gap between the wealthy and the poor, between those who have jobs and those that have been left out, and between those who can afford to pay and those who cannot. 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.

Some may argue that responsibility for climate change must implement such transitions from fossil fuels, away from coal, oil and later gas, while the possible socio-economic inequalities in applying such a transition in Africa are seen as an excuse to delay the transition needed. Failing to address these potential injustices will leave the sustainable development goals unfulfilled, generate widespread suffering, and even risk derailing the transition through widespread resistance. The sometimes-violent protests of coal communities around the world when coal mines are shut, leaving many without alternative means, are a clear example.

Hence, the Paris Agreement calls for "just transitions", i.e., transitions to environmentally sustainable societies in which no one is left behind. The ILO[2] defines a 'just transition' as "greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind." A "just energy transition" can be defined as a negotiated vision and process centered on dialogue, supported by a set of guiding principles, to shift practices in energy production and consumption. It aims to minimize negative impacts on workers, communities and regions with stakes in high-carbon sectors that will wind down, and maximize positive opportunities. It strives to ensure that the costs and benefits of the transition are equitably shared and a fair as possible, leaving no-one behind[3].

To avoid perpetuating injustices from the conventional energy, system or creating new inequities, a wide set of just transition policies at the national, regional and global levels, are needed that are aligned with the broader systemic transformation needed for long-term sustainability. Just energy transitions will be guided by, contribute to and deliver on the Sustainable Development Goals.

Towards a just low-carbon energy transition

The energy transition in electricity, heating and cooling, and transport will not accelerate by itself. This requires systematic changes to current policies, institutions, and societal systems using an intersectoral approach. At the country level, this requires long-term strategic planning toward smart, inclusive, decarbonization of the economy. Such strategies should include the integration of access to affordable and reliable electricity and clean cooking as a central pillar in any just energy -transition strategies). Access to electricity will be provided by both grid extension and distributed, decentralized energy production, linked with local economic development and environmentally sustainable industrialization. Clean cooking methods will include the efficient use of solid biomass and non-biomass fuels.

Energy policy must not only narrowly look at the power sector but embrace fuels in an integrated way looking at power, heating and cooling uses in residential and industrial sectors as part of integrated energy resource and demand plans that have targets for energy access, the share of renewable energy and indicating the role of natural

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2 https://www.ilo.org/global/topics/green-jobs/WCMS_824102/lang--en/index.htm

3 Definition adapted from IISD

gas in the transition process. Energy efficiency is an important component of this strategic objective. Not only has energy efficiency an important impact on climate change but it also brings significant economic and social benefits, because investments in this area are usually highly cost-effective.

New jobs created in, for example, clean energy will not necessarily be available to those who will be impacted negatively in the energy transition, in particular, those working informally in wood fuels supply and charcoal production and formally in the coal sector. Consequently, skills development is central to supporting a just transition. This means reskilling opportunities (according to the needs of the emerging sustainable economy) for existing workers in activities and industries that are being phased out, while figuring out how to bring more informally employed in the formal sectors.

Investing in regions according to region-specific plans for sustainable development to promote economic growth is important as a means of channeling capital to areas that are especially impacted by the low-carbon transition. Some regions risk being left behind as the competitiveness of certain practices, industries, and businesses is eroded, leading to acute challenges in terms of employment, wealth, and social well-being. A growing number of public and private investors aim to counteract this problem by helping affected regions develop in the framework of regional development plans. Opportunities for economic diversification in the areas affected by transitions need to be identified and supported, such as investing in clean energy technologies or other, non-energy, commercial and productive activities.

The upstream planning for a just transition needs to involve multiple agencies, government departments, and stakeholders at the local, national, and regional levels. The focus needs to not just be on specific projects, but a cohesive plan at the programmatic level that takes into account macro-economic, multi-sectoral and social implications of the transition. Systems-level modeling on the role of renewable energy, gas and new technologies (such as hydrogen) and related economy analysis as described above can help inform decisions on who needs to be involved in transition planning dialogues.

While governments will play a crucial role in promoting energy transition, they cannot achieve this outcome alone. A right balance between the public and private sectors will need to be struck in policy formulation, while the involvement of local communities and civil-led initiatives should be encouraged to increase the uptake and support by communities. Making these planning processes transparent and participatory, with special emphasis on creating opportunities to empower marginalized groups (including, but not limited to, informal workers, local communities, indigenous peoples, and migrant workers) to voice their concerns and solutions in upstream planning, can substantially help a just transition. Most countries lack platforms to allow such collaborative and transformative planning to take place across ministries, actors and sectors. Complex and uncertain transition processes require multiple levels of stakeholders working together to ensure just processes and outcomes during the planning phase and throughout implementation. Local- and national-level platforms that foster social inclusion are critical. Failure to do so can result in resistance and delays in response to potential overlooked negative impacts on local jobs and livelihoods. Strengthen multi-stakeholder partnerships to leverage the transformational potential of energy for enabling the SDGs. Such partnerships should encourage action at the global, regional, national, and local levels, and also facilitate coordination among a variety of stakeholders, including governments, financial institutions, businesses, and civil society, as well as impacted and vulnerable communities.

African countries will on the other hand also benefit from the development of enhanced webs of electricity integration. Power pools, of which Africa has five, are also crucial for system integration. They exploit synergies among multiple energy sources and demand profiles across the continent. Regional power integration offers several opportunities, including lowering electricity procurement costs; benefit from pan-continental domestic energy resources, in particular gas and renewables; allowing power producers to sell surplus power and generate additional income; and reaching economies of scale to attract large amounts of private capital. The continent has a unique opportunity to design integrated power systems in the regional market that generates a larger balancing area, able to accommodate high shares of variable renewables (solar, wind). This will require pan-African institutions to develop a common approach to power pools and cross-border interconnections and strengthen existing regional institutions for effective intra- and inter-regional integration.

Much of the natural gas is currently exported either through gas pipelines linking North Africa to Europe or as LNG. Regional gas pipelines have also been deployed in West Africa and North Africa. Such infrastructure and trade developments underline the potential of natural gas interconnections as part of the energy mix during the transition. It will be an important strategic consideration for African countries to determine to what extent it makes sense to, during the transition period towards full decarbonization in line with the Paris agreement, unlock Africa's natural gas potential and enhance interconnections of African countries through gas pipeline networks. Whether natural gas production and consumption will increase depends on strategic choices relating to overall energy planning, short- versus longer-term supply and investment considerations for other energy sources such as renewables, investment risk assessments and climate concerns. These issues are best discussed at the pan-African level to derive a common approach.

Whichever way the energy transition pathway will be followed, grey, green or net-zero, a lot more capital will be required in the energy sector to ensure that the energy supply is both reliable and adequate to meet future demand. The financing must be able to support a doubling in investment by 2030 and even larger investments to make the clean energy transition happen thereafter.

The majority of the continent's infrastructure is funded through government budget allocation and state-owned enterprises. However, limited governmental capacity translates to a substantial financing gap remaining. The first step is to make more government resources available. Phasing out fossil fuel subsidies will provide important fiscal space for sustainable energy and to address other social and development objectives (regional and sectoral disparities in economy and employment). For example, the amount of fossil fuel subsidy spent is in the same order as the annual investments needed to achieve universal energy access by 2030 in Sub-Saharan Africa, about USD 40 million annually. Often, subsidies benefit the rich more in absolute terms than the poor. In many cases, fossil fuel subsidies persist even when their original rationale or justification has ceased to exist and the original policy objectives have been achieved. Subsidies that were intended to be temporary often eventually become permanent. Governments face several barriers to implementing subsidy reform. Foremost is garnering public support in the face of often fierce opposition from those who stand to lose the subsidy. Cheap energy is critically important for household welfare, particularly among poorer families. Gradual removal is better than shock therapy. Thus, fossil fuel subsidy reforms need to include compensatory measures that target the poorest and most affected households.

Even when government revenues are increased and the financial position of utilities improved, private sector investment and lending, as well as private-public partnerships, are needed as the means to bridge the current and future infrastructure financing gap. Sustainable energy policy in the energy transition must be flanked by a wide range of accompanying measures in order to mobilize much larger amounts of private capital. These include building a sound legal-regulatory framework with measures that create a market for private energy providers and renewable energy investors (such as transparent procurement and contracting, as well as fiscal and financial incentives).

A supportive, and committed government, well-governed energy institutions and utilities, together with the financial stability of the sector, are indispensable to the success of any form of private involvement. The global investment needs are huge, but not unsurmountable, if all actors involved, government and utilities, private developers and investors, financial institutions and international development partners, will make a concerted effort.

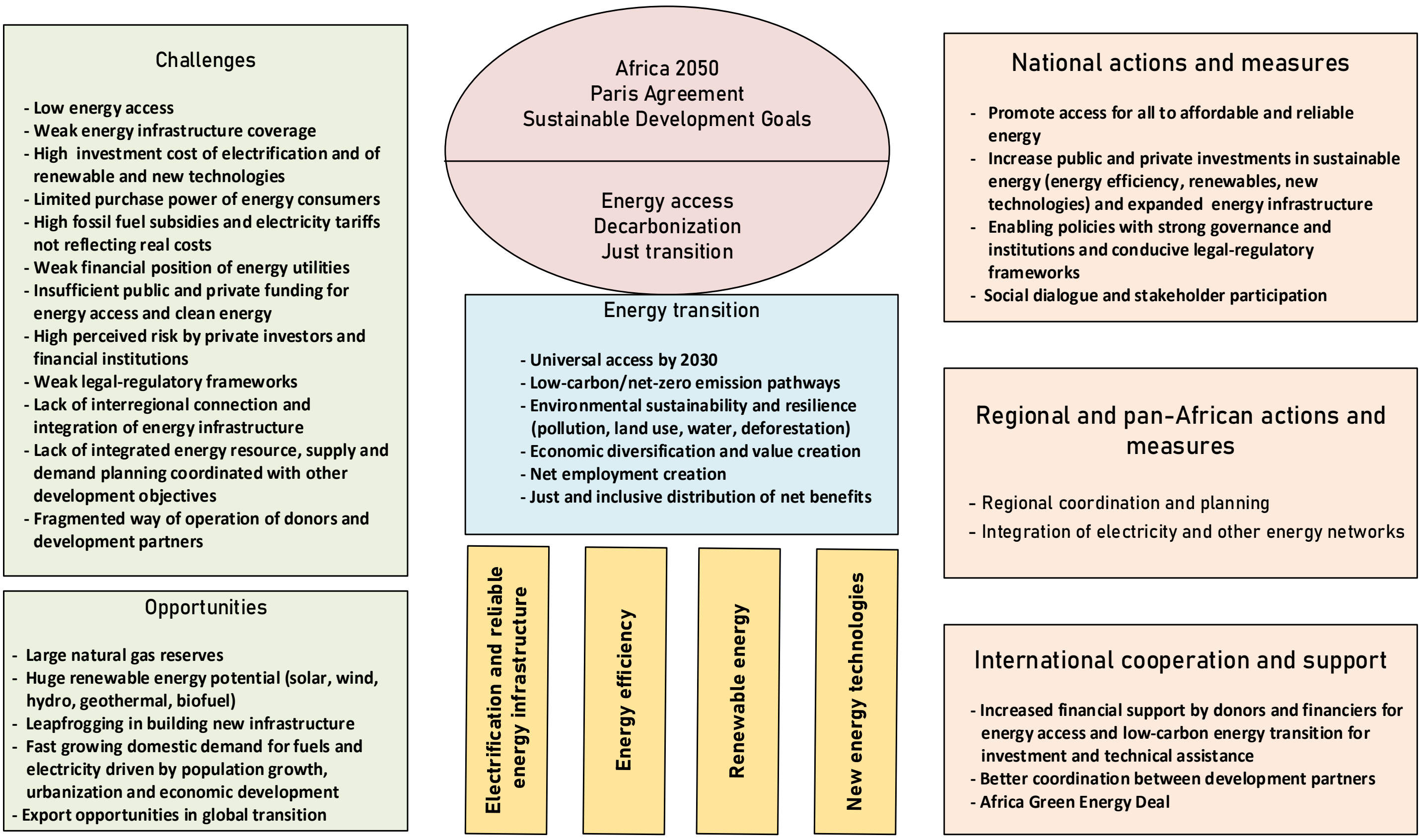
International support

International financial support needs to be increased significantly. International climate change finance also needs to address just transition in developing countries and hence on the African continent. To turn energy transition into a means for development, international finance needs to go into energy access and social development, renewable energy deployment, energy efficiency, and addressing overall energy infrastructure gaps. Development finance institutions (DFIs) can help by acting as a catalyst, for example by providing guarantees, refinancing or on-lending. DFIs can strengthen the role of local banks and help enterprises access cheaper and longer-term finance.

They are well-positioned to initiate and support inclusive cross-sectoral dialogues at the local, national, and international levels and to provide technical assistance to build country-level capacity and develop transition plans.

The European Green Deal aims to make the European Union climate-neutral by 2050 and includes setting up funds to make the energy transition a just transition. An African Green Deal could build on this concept and its ideas but be designed specifically around the continent's own needs and circumstances and could provide the institutional and programmatic framework needed to mobilize resources and policy action at the appropriate scale. It would combine the objectives of achieving climate goals, fostering economic development and job creation, and guaranteeing social equity, environmental safeguard and welfare for society as a whole. Such an African Green Deal can 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.

Challenges and opportunities, goals and main elements in the energy transition and needed actions



1. INTRODUCTION

1.1 Context

In Paris in 2015, signatories to the United Nations Convention on Climate Change (UNFCCC) agreed to pursue efforts to keep the rise in global temperatures to well below 2°C and try to limit the temperature increase to 1.5°C above pre-industrial levels by 2050. The Sustainable Development Goals 7 (SDG 7) in support of the 2030 Agenda aims at universal energy access in 2030. The United Nations Global Roadmap for Accelerated SDG7 Action in Support of the 2030 Agenda for Sustainable Development (2021) commits to transformative action to address the twin energy challenges: ensuring access to clean and affordable energy services for all by 2030 and accelerating the energy transition towards net-zero emissions by 2050.

The transition will also bring many challenges. Given current trends, African regions, except North Africa, are unlikely to meet the SDG 7 targets, let alone 'net zero'. The expansion of generation capacity (and of the transmission and distribution systems) is not sufficient to provide reliable and affordable electricity. Taking a faster penetration of renewables and/or off-grid options, maintaining affordable energy for al will already require billions of dollars of investments per year. This raises the question of how financing way above the current levels can be mobilized. Urgent attention must also be given to innovative financing mechanisms that mobilize private sector investment and financing in addition to increased public and international financing *and* much more will be needed to achieve the goal of 'net zero by 2050).

The energy transition towards also offers opportunities. Africa has vast resource potential in wind, solar, hydro, and geothermal energy. Africa also has abundant mineral resources essential to the production of electric batteries, wind turbines, and fuel cells, such as manganese, copper, lithium, cobalt, chromium and platinum. If realized, the energy transition may bring net economic growth and employment benefits.

In the energy transition, there will be winners and losers. The changes in the energy system will impact differently, varying from region to region, country to country, community to community and from person to person. The winners are those that will benefit from cleaner sources of energy, reduced emissions from the removal of fossil fuels, and the employment and innovation opportunities that accompany this transition. The losers are those that will bear the burden or lack access to the opportunities. Failing to address potential injustices that will arise will leave the sustainable development goals unfulfilled, generate widespread suffering, and even risk derailing the transition through widespread resistance. Energy justice is centered around the notion that all individuals should have access to energy that is affordable, safe, equitable sustainable and able to sustain a decent lifestyle, as well as the opportunity to participate in and lead energy decision-making processes throughout the life-cycle of energy resources from extraction to production to consumption to waste[4].

To avoid perpetuating inequalities in the current energy system or creating new inequities, a wide set of just transition policies at the national, regional and global levels are needed that are aligned with the broader societal transformation needed for long-term sustainability. Such 'just energy transitions' will be guided by, contribute to and deliver on the Sustainable Development Goals (SDGs). These will require systematic changes to current policies, institutions, and societal systems using an integrated approach that involves multi-stakeholder partnerships. Such partnerships should encourage action at the global, regional, national, and local levels, and also facilitate coordination among a variety of stakeholders, including governments, financial institutions, businesses, and civil society, as well as impacted and vulnerable communities.

A "just energy transition" can be defined as a negotiated vision and process centered on dialogue, supported by a set of guiding principles, to shift practices in energy production and consumption. It aims to minimize negative impacts on workers, communities and regions with stakes in high-carbon sectors that will wind down, and

[4] Adapted from texts in Carley & Konisky (2020)

maximize positive opportunities. It strives to ensure that the costs and benefits of the transition are equitably shared and a fair as possible, leaving no-one behind[5]. A set of such guiding principles have been formulated by the Alliance for Just Energy Transformation (see Exhibit 1)

Africa's just energy transition will be coming, in one way or another, integrated into the global trend towards a carbon-neutral future; it is not just an option. African governments and their development partners must therefore prepare, by bringing in new investment to boost energy supply and improve local reliability and access. This implies step up the efforts to provide the right incentives for investors in an appropriate enabling regulatory ecosystem to expedite this transition.

1.2 Overview of the report

The reports highlight the rationale for "Just Energy Transitions" in Africa, following the commitments and conclusions from the COP 26, concluded in 2021. It will elaborate strategies to ensure a transition towards more planet-friendly energy options for domestic, transport and industrial purposes across the continent with a focus on strategies that utilize the continent's resource endowment to ensure that Africa attains the universal energy goals in 2030, while embarking on pathway towards 'net zero' greenhouse gas emission goals by 2050. Success will be built around creating a connected set of proposals that, if well supported, can trigger viable transformation in the thinking and practice of the financing, design and implementation of sustainable energy options for Africa.

The report seeks to achieve the following results:

- Expand and enhance the research relating to sustainable energy transitions in Africa, by solidifying the literature review, validating the empirical research, and examining illustrative country case studies;
- Organize the data and country profiles relating to the sources and use of energy demand and supply in Africa. This includes tables graphs with historical trends and future scenarios;
- Construct a narrative which quantifies the challenges and opportunities of alternative options for African countries, with a view to attaining the 2050 net-zero targets, and
- Assess realistic alternatives for African countries that highlight the continent's comparative advantage in attaining sustainable pathways for transition, in accordance with the Paris Agreement and the AU's Agenda 2063. Based on the principle of 'leaving no one behind', assess how the energy transition can be just and inclusive, and catalyze transformational co-benefits for the achievement of the SDGs
- Highlight investment needs and sustainable financing challenges as well as the role of public and private stakeholders, development partners and multilateral organizations

The first chapter, "Energy in Africa today", provides an overview of access to energy, the sources (fossil fuels and renewable) and uses (domestic, transport and industrial) of energy in Africa; over recent decades, and discusses the key drivers of and challenges in the future development of the energy sector.

The second chapter, "Towards the global energy transition", describes the diverse pathways in the global energy transition that will shape Africa's trajectory. It describes the options for Africa's energy transition the challenges faced, advantages and disadvantages and investment cost of moving away from traditional biomass and fossil fuel

The third chapter, "Elements of a just energy transition', examines the position of the energy transition within the overall development by looking at the environmental, socio-economic and distribution impacts of changes in the energy system to derive at a conclusion on how to make the energy transition just and inclusive

The last part, "Enabling the just energy transition", discuss the various actions and interventions needed to be undertaken by the range of stakeholders involved, government and government agencies, private sector investors

[5] Definition adapted from IISD

and developers, public and private financial institutions, and development partners as well as pan-African and regional organisations. It highlights the role of different financing sources and ends with a recommendation that a continent-wide concerted approach of these stakeholders is needed as part of an integrated African Green Deal to avoid duplication and leaving gaps in the efforts of supporting Africa attaining universal energy access by 2030 and net zero goals by 2050.

Exhibit 1 Eight core principles of a Just Energy Transition

The Alliance for Just Energy Transformation is a voluntary initiative that aims to catalyse a shared understanding and transformative action towards and successful implementation of Just Transition policies worldwide. It has formulated eight principles for a 'just energy transition':

1. **Be guided by science and understand** the urgency to reduce emissions in line with the goals set out by the Paris Agreement.
2. **Be fair and uphold the rights, needs and values of everyone** - no single group should be privileged over others and the upfront costs must not fall on those with the least responsibility for climate change or ability to bear them.
3. **Be sustainable, ambitious and consistent** with wider, holistic strategies that contribute to the energy transition needed to limit global temperature increase to 1.5°C, or well under 2°C.
4. **Be comprehensive, transparent and inclusive**, which requires that just transition strategies developed at the national level to be co-designed and implemented at the local level.
5. **Ensure clearly-defined, robust and meaningful stakeholder engagement and social dialogue**, including a specific focus on social protection and gender equality policies to promote equitable access to benefits.
6. **Be centred on climate justice** so that the burdens of climate change, as well as the costs of avoiding it, are shared fairly; both internationally and inter-generationally. Implementation of the transition must support jobs, local communities and improve human wellbeing in the developing world.
7. **Recognize energy access as an essential contributor** for social wellbeing, economic growth, enabler of sustainable development and improved livelihoods and transformation of energy systems must enable large scale access to clean, safe and reliable energy to meet developmental needs of all.
8. **Ensure access to justice, decision-making and information**: A common approach to investment which upholds indigenous and local community rights. Recognition and implementation of the right to meaningful participation in energy transition decision-making processes for all stakeholders, acknowledging and compensating for differences in resources and capacity to engage.

The Alliance was launched at CO27 (Sharm el Sheikh, 2022). Member of the Alliance are UNDP, REN21, KPMG, WWF, Gridworks and the Environment Defense Fund (EDF).

2. ENERGY IN AFRICA TODAY: SITUATION AND TRENDS

This Chapter provides a description of the current state of affairs in the energy sector. An important starting point is the realization that about half of Sub-Saharan Africa's population has no access to electricity and about 80% cooks with wood fuels using energy-inefficient methods. If the access rate does not rapidly increase above natural population growth levels, achieving universal access by 2030 will be an ambition on paper only.

The energy sector has a vital role to play in Africa's future. Growing urban populations imply rapid growth in material demand to build infrastructure, expansion of industrial and agricultural production, and increased mobility of people and goods, boosting energy demand. Universal access to clean cooking methods does not only mean more households using improved biomass stoves but an increasing number of people gaining access to modern fuels, such as liquified petroleum gas (LPG), natural gas or electricity. The less polluting the cooking method, the more health and other benefits for women and children will be.

Average energy and electricity consumption per capita in most African countries is well below the world average. In the coming decades, electricity demand will rapidly increase, pushed up by the ambition to achieve universal access to electricity, population growth and urbanization and accelerated economic development, and electrification of energy demand in certain sectors. Keeping up with soaring electricity demand, the supply will have to expand speedily. The expansion of transmission and distribution (T&D) of the main national grids may not be sufficient to provide reliable access for all. Therefore, non-grid solutions, minigrids and stand-alone systems, mostly based on renewable energy, are seen as essential to achieving universal energy access.

The needed generation capacity expansion of the main grid networks will be fueled by renewable energy and natural gas. The future of natural gas in Africa is at an important juncture. The prospects for gas depend upon the ability to bring the discoveries into production and build infrastructure to deliver gas for power production, to local consumers and for export at competitive prices. Exporting natural gas or electricity generated from gas provides an opportunity for countries to switch away from a high dependence on coal and oil and help reduce CO_2 emissions, especially in the coming decade. Thereafter, the changing global energy dynamics toward a net-zero emission economy are likely to put further pressure on foreign investment in all hydrocarbon-based energy systems, including natural gas.

Africa has not been a significant contributor to global greenhouse gas (GHG) emissions since the start of global Industrialization, contributing less than 4% of historic global emissions. From a climate justice point of view, it seems wrong to punish Africa by not allowing it to take full advantage of the revenues of its hydrocarbon resources as other parts of the world have done since the onset of the Industrial Revolution and continue to do so.

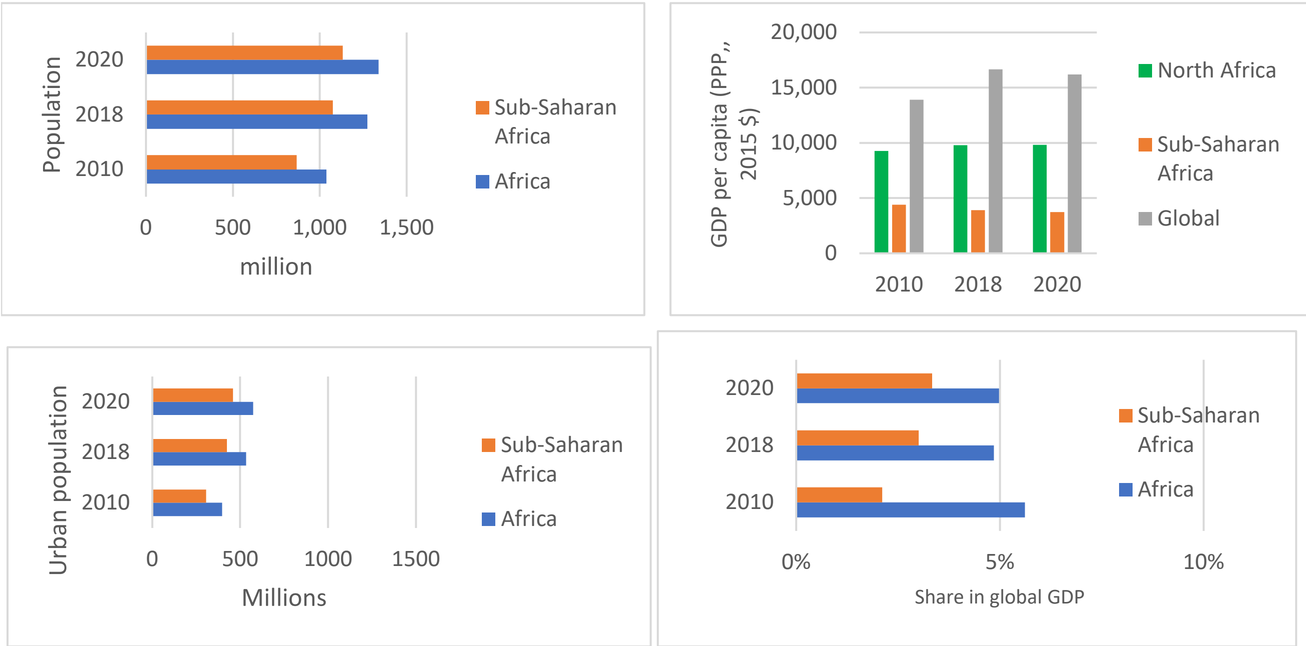
On the other hand, Africa has plentiful renewable energy resources and its economic potential is substantially larger than the energy consumption of the continent. Bioenergy, hydropower, solar and wind power account for the bulk of the resources, while East Africa also has rich geothermal resources. Last, but not least, Africa is home to many of the minerals that will be essential in the global low-carbon energy transition. Thanks to technology improvements and resource endowments, Africa has the opportunity to pursue a much less carbon-intensive model of development by phasing out the inefficient combustion of biomass and much stronger shares of natural gas and, increasingly, renewables.

2.1 Economy and population

Economy

Africa's gross domestic product (GDP) in PPP (in 2015 USD) was USD 5.49 trillion, about 4% of the world's total of USD 125.65 trillion. Its GDP per capita (PPP, 2015 USD) was USD 4,382, about a quarter of the global value of USD 16,192. Africa has experienced relatively low gross domestic product (GDP) growth in the period 2010-2020, an

Exhibit 2 Africa's share in population and economic indicators



Own elaboration, using data from World Bank's World Indicators, UN Population statistics

average of 2.5%, similar to the global average of 2.5%. The African economy was actually growing close to 3% until 2019 until the COVID-19 pandemic[6].

Projections done before 2020 by World Bank and IMF see the continent with 3.1-3.5% annually. In reality, GDP in Africa contracted in 2020 by 2.3% due to events in the last two years. The COVID-19 pandemic destabilized the global economy during 2020-2021 and continues still to cause supply chain disruptions. Second, the Russian Federation's invasion of Ukraine in February 2022 sent global food and fuel prices soaring. The two events have hit entire economies as well as individual households and industries. The impact is felt everywhere, as evidenced by the swelling inflation figures in Europe and North America, but is most severely felt in the developing countries in Africa, where people are least able to cope with soaring prices of imports of goods, fuels, materials and products.

Many countries have depleted their fiscal reserves, drained by emergency support, and measures to make fuel and food more affordable. While IMF and World Bank predict economic growth figures to recover after 2022-2024, the economic crises have already had an impact on the energy sector. On one hand, oil and gas exports have profited from higher prices. But, on the other hand, grid expansion and energy access projects have been delayed; fuel price increases imply lower affordability of fuel and electricity. The IEA estimates that the number of people without access in sub-Saharan Africa has increased by 4% in 2021 relative to 2019, thus effectively reversing gains made in previous years[7]. Expansion and upgrades in electricity and infrastructure are meeting delays. Persistent underinvestment and maintenance issues will mean many that many African facilities will struggle to ramp up production to meet their domestic demand, let alone take advantage of the demand for natural gas in Europe after the start of the Russia-Ukraine conflict.

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6 IEA (2022) and data.worldbank.org

7 IEA (2021)

Distribution of wealth and income

Growth, however, has not always delivered higher standards of living for most Africans. For example, nearly 40% of the population in Sub-Saharan Africa still live in extreme poverty[8]. While in relative terms, the share has been dropping steadily (from 58% in 2000 and 45% in 2020), in absolute terms the number of people in extreme poverty has increased from 360 million in 2000 to 422 in 2019. In contrast, in 2021, the wealthiest 10% of Africans owned 71% of the continent's wealth[9].

Of the global population of 7.76 billion in 2020, Africa had 16.1% (1.359 billion), of which 14.6% were in Sub-Saharan Africa (1.152 billion). With over 40% of the continent's population under the age of 15, it also has the world's youngest population. Africa has the world's fastest-growing population; one in three people born today are African (IEA 2022) and one-in-two people added to the world population in the period to 2050 will be African[10]. The population of Sub-Saharan Africa is expected to reach 1.47 billion in 2030 (1.71 billion for the continent as a whole) and to double by 2050 (to 2.19 billion and to 2.48 billion, including North Africa)[11].

The last decade has seen the number of people living in cities increase by 50%, and this trend is set to accelerate over the next two decades. By 2030, urban people in Africa will total about 807 million. By 2050, an estimated 1.47 billion Africans will be city-dwellers. In other words, this is an unprecedented pace of urbanisation of about 86% in the next 3 decades. (IEA, 2019).[12]

2.2 Energy access: electricity and clean cooking

Electricity

In 2020, 733 million of the world's people lived without access to electricity, down from 1.2 billion in 2010. From 2010 to 2018, 130 million people gained access to electricity each year, on average. Between 2018 and 2020, influenced by the complexity of last-mile connectivity, and aggravated by the COVID pandemic, energy access has only increased modestly with about 50 million a year[13].

The global electricity access deficit remains concentrated in Sub-Saharan Africa. Out of every four persons without electricity access three lives in Sub-Saharan Africa in 2020. Access did increase from 290 million people in 2010 to 552 million people in 2020. The number without access peaked around 2013 (about 610 million) and declined slowly to 595 million in 2018, 572 million in 2019 and 558 million in 2020[14].

Since 2012, on average 26 million people gained access annually, slowing down to some 20 billion annually in 2019-2020. This does mean that more people in Sub-Saharan Africa gained access annually than non-connected people added by population growth but the difference between the two rates is narrowing. Without further efforts than already planned to reach the poorest and most remote, 565 million people are projected to remain without access in 2030, according to IEA estimates[15]. There are also marked differences between urban and rural areas. As of 2019, access rates to electricity were 81% in urban areas (and 76% in Sub-Saharan Africa), while 54% in rural areas (and only 34% in Sub-Saharan Africa). Rates can differ widely, per country, as indicated in Exhibit 3.

8 In Sub-Saharan Africa, 38% of population had to live on live on USD 1.9 a day in 2019

9 The top 1% had 36% of wealth (2021). The top 10% earned 54% of income. Source: www.wid.world. The figures have remained mor or less stable over the period 2090-2020

10 Data compiled from IEA (2022),

11 UN Population statistics

12 IEA (2019)

13 IEA (2022); IRENA-AfDB (2022)

14 Number of people without access in North Africa numbering about 5 million

15 Note by the author: Assuming population growth of 2.4%/yr, the need for new connections in Africa to achieve universal access will have grown to about 755 million (of which 742 in Sub-Saharan Africa); with the electrification pace of about 19 million annually of the past decade, only 190 million would get connected, leaving 565 million without access

Exhibit 3 Africa energy balance and definitions

The table below gives an overview of the energy balance for the whole continent of Africa for 2019 based on the latest available AFREC energy balance data. The available energy consists of production, imports and exports of energy commodities and changes in stock and bunkers. Energy commodities are electricity, fossil fuels (crude and natural gas liquids), petroleum products and natural gas, biomass (fuelwood, charcoal, biomass residues, bagasse, biofuels, other), renewable energy (RE: solar, hydropower, wind, geothermal and other sources (nuclear and energy from waste). Primary energy supply is the amount available for consumption (production plus imports and stock withdrawals minus exports and stock additions. Correcting for statistical differences the energy supply of an energy commodities equals consumption, which consists of final consumption or for transformation into other commodities.

Energy commodities can be transformed into other, such as the processing of crude oil into a range of petroleum products, e.g., gasoline, or diesel, the charcoal production from wood, or the transformation of a fuel in power plants into electricity or in cogeneration into combined useful heat and power (CHP). For the primary commodity net transformation is positive, while for the secondary commodities (like electricity or charcoal) net transformation is always negative. The difference between transformation input and output are losses. Own use is the consumption of energy by the energy production and transformation facilities (e.g., oil and gas extraction, refineries, coke ovens, blast furnaces, power plants). Distribution losses are losses in the transport and distribution of energy, including electricity transmission and distribution losses. Subtracting the distribution losses, own use and net transformation from the energy supply/consumption figures gives the final consumption, basically for energy uses in the various sectors (e.g., wood in household cooking stoves, gasoline in cars, diesel in trucks or productive machinery but also for some non-energy uses (e.g., bitumen or lubricants from oil, and natural gas for fertilizer).

(in petajoules, PJ)	Crude oil and NGL	Oil products	Coal	Natural gas	Trad biomass	Biomass	Hydro, solar wind, other	Electricity	Total
Production	10,147		235	10,252	10,886	3,629	579		35,728
Imports	693	4,118	1,895	630	0	655		55	8,046
Exports	-5,124	-3,074	-21	-4,570	0	0		-72	-12,861
Bunkers and stocks	17	-271	-42						-296
PRIMARY ENERGY SUPPLY	**5,734**	**773**	**2,068**	**6,312**	**10,886**	**4,284**	**579**	**-17**	**30,617**
Transfers & stat.differences	1,067	-1,107	-1	45	-433	192	48	-53	-241
Energy supply	**4,667**	**1,880**	**2,068**	**6,266**	**11,319**	**4,092**	**531**	**36**	**30,858**
TRANSFORMATION INPUTS	**-4,531**	**4,348**	**-1,639**	**-3,154**	**-2,571**	**-1,391**	**-517**	**2,092**	**-7,364**
Electricity production	-17	-183	-1,881	-3,148		-1,243	-503	1,974	-5,001
Refineries	-4,514	4,442							-72
Coke ovens & blast furnaces			248						248
CHP			-5	-6		-158	-14	117	-67
Charcoal					-2,571				-2,571
Other		88	0			10			98
Own use and distribution losses	**136**	**26**	**304**	**476**				**401**	**1,343**
FINAL ENERGY CONSUMPTION	**0**	**6,201**	**125**	**2,636**	**8,748**	**2,701**	**14**	**1,726**	**22,151**
Industry		695	111	776	358	1,271		631	3,842
Transport		4,249		80				23	4,352
Residential		718	0	1,204	8,102	900	12	667	11,603
Commercial and public		65	12	156	288	494	2	330	1,347
Agric, forestry and fishing		220	2			36		72	331
Non-energy and other		253		421				2	676

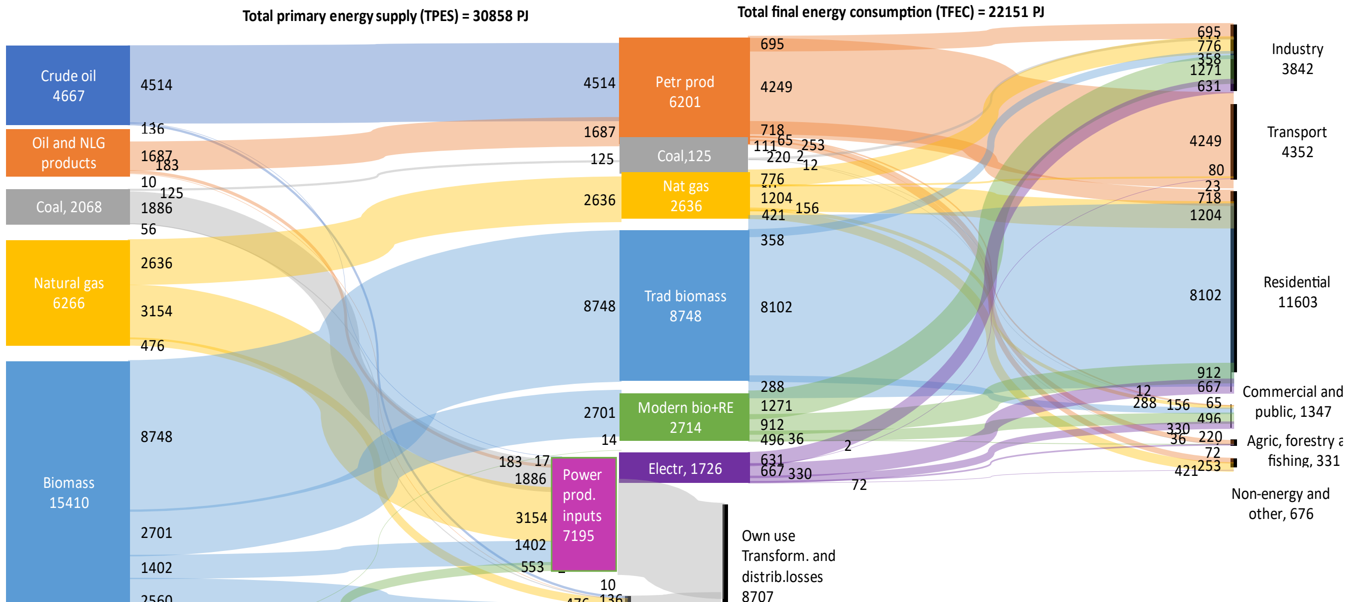

Table and Sankey diagram: own elaboration based on AFREC database (2019 data)

The global electricity access deficit remains concentrated in Africa and 99% of the non-connected are in Sub-Saharan Africa. Out of every four persons without electricity access, three lived in Sub-Saharan Africa in 2020; by 2030 the share will have increased to 3 out 4[16]. In 2019, the number of people in Sub-Saharan Africa without access to electricity was about 106 million in urban areas (99 million in 2020) and 466 million in rural areas (440 million in 2020 in Sub-Saharan Africa. The urban access rate rose from 68% in 2010 to 78% in 2020 and the rural access rate from 17% in 2020 to 28% in 2020[17].

Clean cooking

Globally, the number of people without access to clean cooking has dropped slightly from almost 3 billion (2010) to 2.4 billion (2020). The number of people gaining access is increasing but is barely sufficient to keep up with the population increase. Out of every 10 people with no access to clean cooking, four lived in Sub-Saharan Africa in 2020. There, the number of people not having access to clean cooking fuels actually increased from 770 million in 2010 to about 900 in 2019 and 940 billion in 2020. Urban areas have greater access to clean cooking than rural areas, but the gap is narrowing. In Sub-Saharan Africa, the access rate in rural areas was stagnant over the past 10 years, while access in urban areas decelerated[18].

If current trends continue, the small gains in the increase in people with clean cooking fail to keep pace with population growth., the number of people without access to clean cooking in Sub-Saharan Africa is set to see a net increase by almost 20 million every year this decade, rising from 940 million in 2020 to over 1.1 billion in 2030[19].

Biomass

Most of the solid biomass consumption (see Exhibit 4) is in the form of wood fuels (charcoal and fuelwood) and, in Sub-Saharan Africa, forms about three-quarters of final energy consumption. Around 1 billion people in Sub-Saharan Africa rely on the traditional use of biomass while another 70 million rely on kerosene or coal to meet their daily energy needs. Less than 240 million people in sub-Saharan Africa currently have access to cleaner options such as liquefied petroleum gas (LPG), natural gas, electricity or improved biomass stoves[20].

Traditional biomass use means firewood and charcoal utilized in inefficient stoves and other cooking devices. Poor combustion causes indoor pollution with serious health consequences, especially for women and children who are more exposed to smoke and particulate matter from cooking devices.

In rural areas, reliance on fuelwood, straw and waste is set to remain relatively high, although they are increasingly burned in more efficient and improved cookstoves. Continued reliance on bioenergy in rural areas is often compounded by a lack of infrastructure to supply clean cooking fuels like LPG. In many urban areas, charcoal continues to play a key role due to its light weight, low price and high energy content compared to fuelwood. Charcoal use across sub-Saharan Africa is thriving, with demand growing at an annual average rate of around 3.5% since the year 2000. The use of charcoal is rising most rapidly in urban areas where population growth and the, often, unsustainable use of forest resources limits the availability of fuelwood[21].

There is no one-size-fits-all option and each clean cooking solution comes with its disadvantages. Some countries may want to ban the use of charcoal to reduce stress on forests. However, as a source of income and employment creation along the value chain (for production, transportation, sales and distribution), charcoal manufacturing and trade have shaped the economy and employment patterns in many areas. Addressing the inefficiencies of charcoal stoves is a first step towards reducing demand for charcoal, while improved charcoal kilns and forest management may make charcoal production more energy-efficient and sustainable. Charcoal is currently

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[16] IEA Energy Access report (2017)

[17] Data from IEA (2022) and Exhibit 3

[18] IEA (2022)

[19] IEA (2022).

[20] Based on WB data.worldbank.org and IEA (2019)

[21] IEA (2019)

produced largely in traditional earth kilns with energy conversion efficiencies of between 10% and 20%, while improved metal, brick and retort kilns offer efficiencies between 25% and 40%[22].

In Sub-Saharan Africa, almost 75-80% of the population cooks on solid biomass[23]. The main pathway utilized to convince people away from the traditional use of biomass for cooking has been the promotion of improved biomass cookstoves (ICS). Decades of programs have left mixed results in terms of achieving a lasting, large-scale, impact[24]. Firewood in rural areas is often free (except for the time spent gathering, which may not be taken into account as an opportunity cost), while the supply chain of modern fuels does not reach remote areas, and if they do, at a high cost. Furthermore, the health benefits of using ICS have often been found in many cases to not live up to expectations (IEA, 2017). There have been some successes, such as Kenya's *jiko* improved charcoal stove. Given the vast number of people in sub-Saharan Africa living in remote rural areas without access to modern fuels in the foreseeable future, ICS such as *jiko*, may well be the only immediately practicable solution to enable reaching the SDG universal clean cooking access target. ICS programs may be combined with sustainably produced biomass pellets or briquettes.

Exhibit 4 Wood fuels production and consumption, Africa

	2010	2018
Woodfuel production (kton)	836,111	1,083,977
- Converted into charcoal	140,537	243,851
Charcoal produced (kton)	30,118	40,571
Final consumption, wood (kton)	671,424	775,558
- Households	625,944	692,226
Final consumption, charcoal (kton)	28,930	39,861
- Households	25,431	33,241

Source: data taken from *AU-Afrec database*

LPG and kerosene (also known as paraffin) are the primary cooking fuel for about 70 million and 60 million people, respectively, mostly living in urban Sub-Saharan Africa[25]. LPG is relatively safe compared to kerosene stoves and cooking with LPG on easy-to-connect burners offers clean indoor air as well as a more comfortable user experience than cooking on biomass or kerosene. However, LPG can raise problems of affordability, given the high upfront cost for the burners and hoses and the initial deposit for a cylinder. More widespread usage of LPG has often been hampered by swings in the price of the fuel; if LPG prices are high, users may not have enough money saved to be able to pay upfront to refill their cylinder.

Households seeking to switch to cleaner cooking solutions, such as LPG, ethanol, natural gas, electricity and improved cookstoves, will face barriers. The relatively high price of the technologies (and fluctuating fuel prices) forms an important impediment to the dissemination of clean cooking options. Cooking on LPG, natural gas or electricity will require the availability of infrastructure for fuel supply. Rather than switching from a traditional cooking method to a cleaner cooking solution, households may prefer to 'stack', that is, to use a mix of traditional and modern cooking options simultaneously depending on cooking need, fuel price and availability.

2.3 Energy supply and demand

With almost a fifth of the global population, the share in energy supply and demand of the continent is relatively small. Africa accounted for about 5.8% of the global primary energy supply in 2018 (and Sub-Saharan Africa 4.4%). The continent accounted for about 6.4% of global final energy consumption in 2018 (of which 4.9% in Sub-Saharan Africa) and 4.0% of electricity generation (of which 2.6% in Sub-Saharan Africa).

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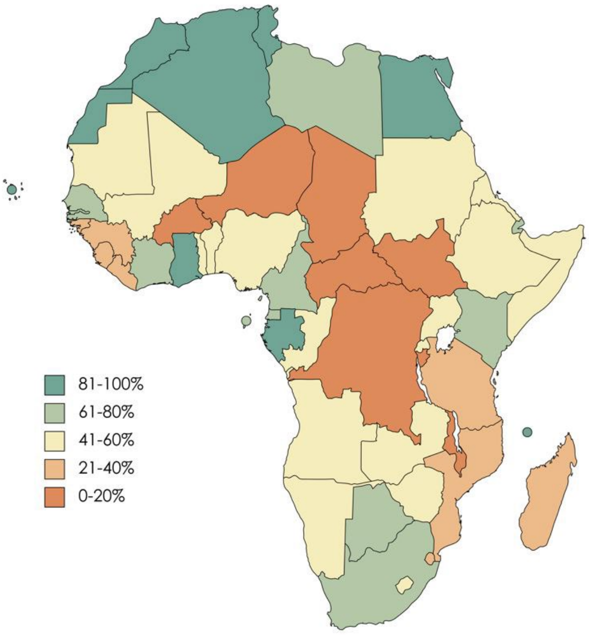
22 UN Habitat (1993)

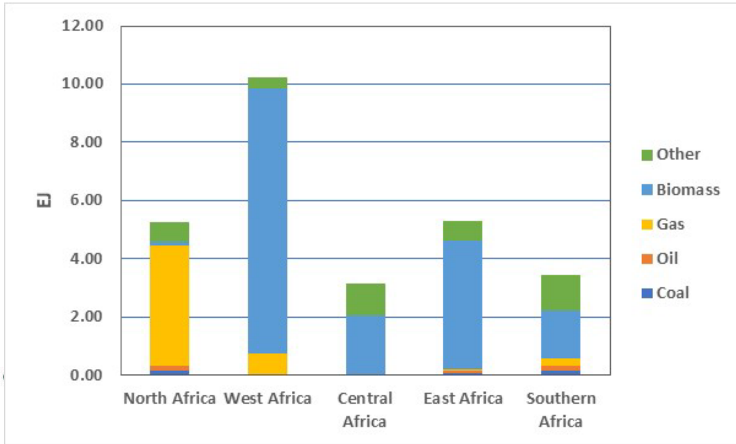
23 IEA (2017)

24 Ibid., Chapter 4

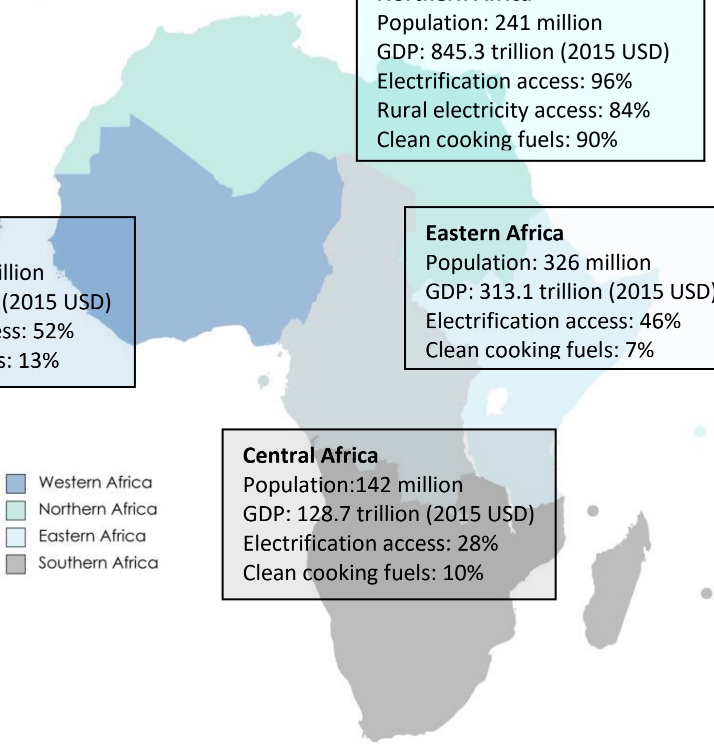
25 With about 40 million kerosene people using kerosene in Nigeria. IEA (2017)



Electricity access (%), 2019



Primary energy supply (in exajoules, 2019)



Northern Africa
Population: 241 million
GDP: 845.3 trillion (2015 USD)
Electrification access: 96%
Rural electricity access: 84%
Clean cooking fuels: 90%

West Africa
Population: 391 million
GDP: 740.1 trillion (2015 USD)
Electrification access: 52%
Clean cooking fuels: 13%

Eastern Africa
Population: 326 million
GDP: 313.1 trillion (2015 USD)
Electrification access: 46%
Clean cooking fuels: 7%

Central Africa
Population:142 million
GDP: 128.7 trillion (2015 USD)
Electrification access: 28%
Clean cooking fuels: 10%

Southern Africa
Population: 207 million
GDP: 554.4 trillion (2015 USD)
Electrification access: 50%
Clean cooking fuels: 39%

Clean cooking access (%), 2019

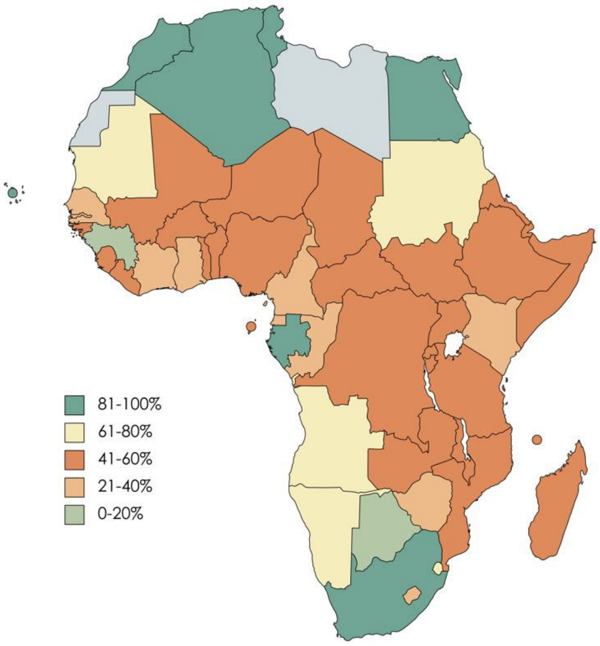


Exhibit 5 Energy access and population and GDP

Sources: own elaboration, using data compiled from AU-AFREC, SDG -7 Tracker 2022, WB World Indicators; IEA database (2018 data). Population and electricity access figures (2019) and clean cooking (2018)

Accordingly, the energy consumption per capita is low. Global final energy consumption was about 52.0 gigajoules (GJ) per capita in 2018 and 19.5 GJ in Africa (17.5 GJ in Sub-Saharan Africa)[26].

Such figures mask the big role biomass plays in energy supply, mostly traditional biomass, as well as the more prominent role of fossil fuels pattern in Northern Africa and South Africa. For Africa as a whole, energy consumption (without biomass) per capita was 10.81 EJ and for Sub-Saharan Africa 4.92 GJ per person. For Sub-Saharan Africa (excluding South Africa), energy consumption (without biomass) was 2.38 EJ or 2.33 GJ per capita[27].

The main drivers for energy demand are economic development, and demographic changes (population growth and urbanization), together with the realization of energy access targets and greening of energy supply (which is the subject of the next Chapter). The country's energy resources and energy conversion capacity (from primary energy supply to final consumption) determine how much can be made locally and how much energy needs to be imported, while exports are driven by outside factors. The relative importance of each driver varies from subregion to subregion and from country to country, depending on their respective starting points and economic prospects.

As developing economies expand, demand for electricity increases. Consumptive electricity demand grows because households earn more income and choose to spend some of it on electricity and appliances. Meanwhile, productive demand increases as new businesses and industrial activities are established and existing ones expand.[28] Growing urban populations imply rapid growth in material demand to build infrastructure, expansion of industrial and agricultural production, and increased mobility of people and goods. This will boost the demand for infrastructure, materials and energy services in Africa. This holds especially for industry, transport, and cooling in houses and commercial premises.

Africa's demand for industrial products is projected to rise by at least a third between 2020 and 2030 on the back of rising construction and increased industrial production[29] . Heavy and light industries, as well as agriculture, are all set to increase their energy demand in Africa. Increased industrialization means more transport of raw and finished goods, leading to higher demand for freight vehicles, rail, navigation and aviation. Continental free trade agreements will further stimulate the transportation of goods and materials from regions of production to major commercial centers and ports.

Sub-Saharan Africa (excluding South Africa) has the world's lowest per capita car ownership level. As the continent develops a large expansion of personal cars will take place, perhaps reaching 25-35 million by 2040, which will require oil demand to sour, even when the car fleet gets more efficient[30]. With respect to the latter, a concern is that the vehicles on the road will mostly be imported cars from Europe and Japan that no longer meet the emissions standards in those regions.

An expanding middle class with increased spending power will contribute to higher urban residential demand. The newly connected (mostly) rural (connected) dwellers will increase their energy demand as they move towards higher-level energy demand tiers (see Exhibit 51). LPG may make big inroads as well as natural gas (if resources are available or can be imported) but electricity demand will grow more than for any other resource to power lighting, and appliances in residential and office buildings. Electricity demand growth can be dampened by energy conservation and the increased energy efficiency of new appliances and equipment and more efficient industrial processes. The introduction of these is helped by smart energy management in buildings and industry, as well as implementing pro-efficiency deployment policies, including minimum energy performance standards for electrical appliances and energy building codes (see Exhibit 25).

26 Data compiled from WB-SDG (2020, 2021), IEA-WEO (2021), AU-Afrec

27 Ibid.

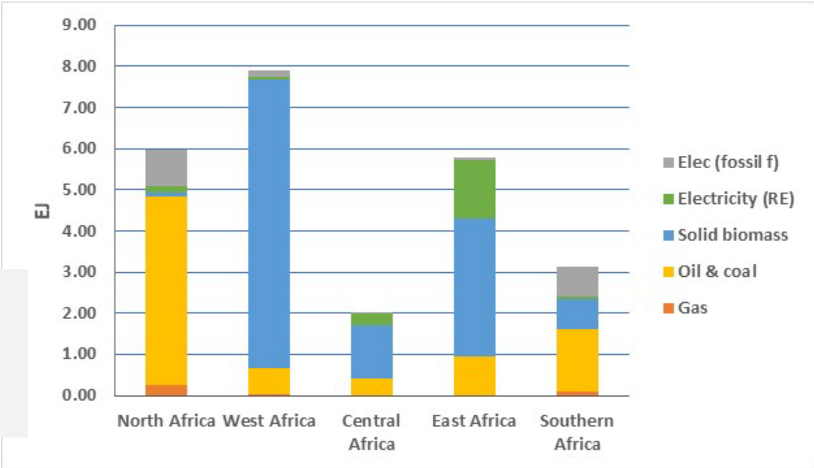
28 Having endured a recession brought on by the global COVID-19 pandemic, Africa's economy is now being hurt by the global effects of Russia's invasion of Ukraine. While these have affected negatively the economy on the short-term, the longer-term prospects for Africa's may follow the pre-Covid course. Growth in 2022-23 may reach 3.4-4.5% according to IMF. IEA (2022); IEA (2021a).

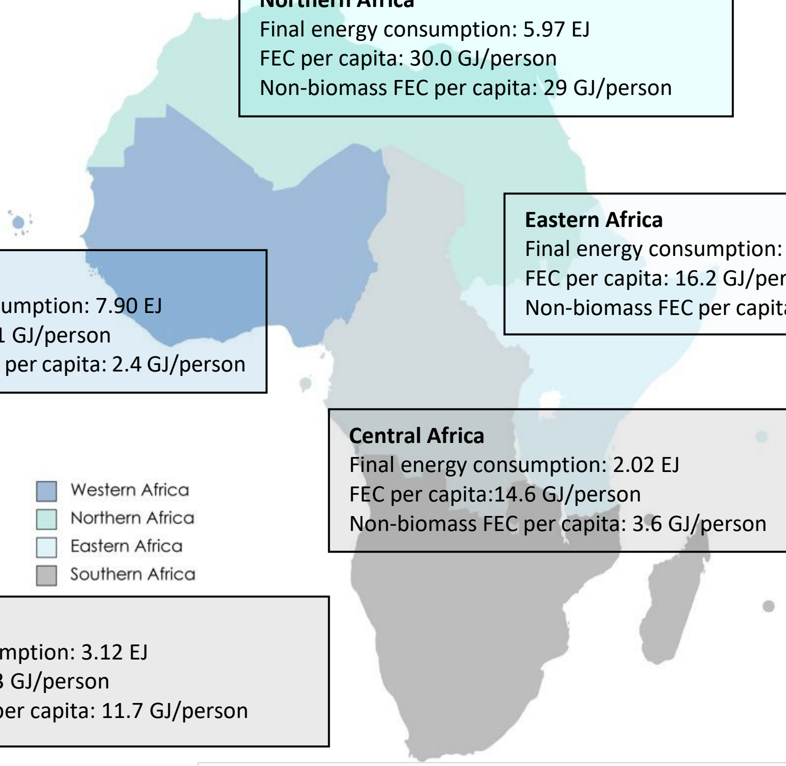
29 IEA (2022), p.63

30 IEA (2019)

Exhibit 6 Africa, final energy consumption (2018)

Final energy consumption (2018): Per type of fuel consumed
Electricity consumed allocated to sources of production, RE: renewable or fossil fuels.





Northern Africa
Final energy consumption: 5.97 EJ
FEC per capita: 30.0 GJ/person
Non-biomass FEC per capita: 29 GJ/person

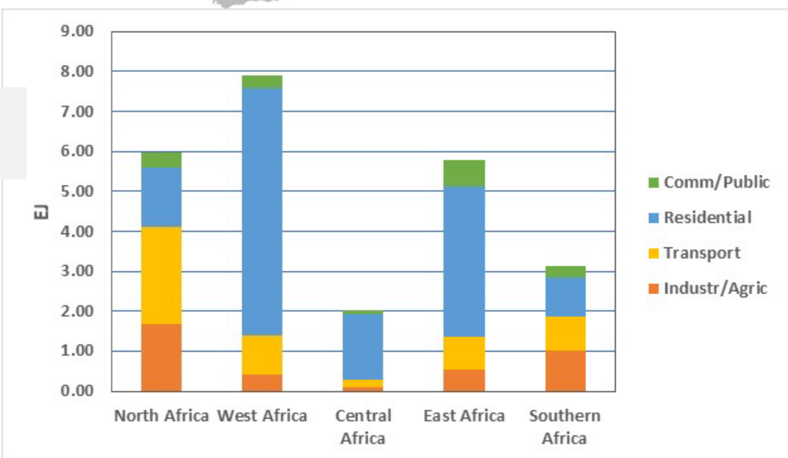
Eastern Africa
Final energy consumption: 5.78 EJ
FEC per capita: 16.2 GJ/person
Non-biomass FEC per capita: 3.2 GJ/person

West Africa
Final energy consumption: 7.90 EJ
FEC per capita: 21 GJ/person
Non-biomass FEC per capita: 2.4 GJ/person

Central Africa
Final energy consumption: 2.02 EJ
FEC per capita:14.6 GJ/person
Non-biomass FEC per capita: 3.6 GJ/person

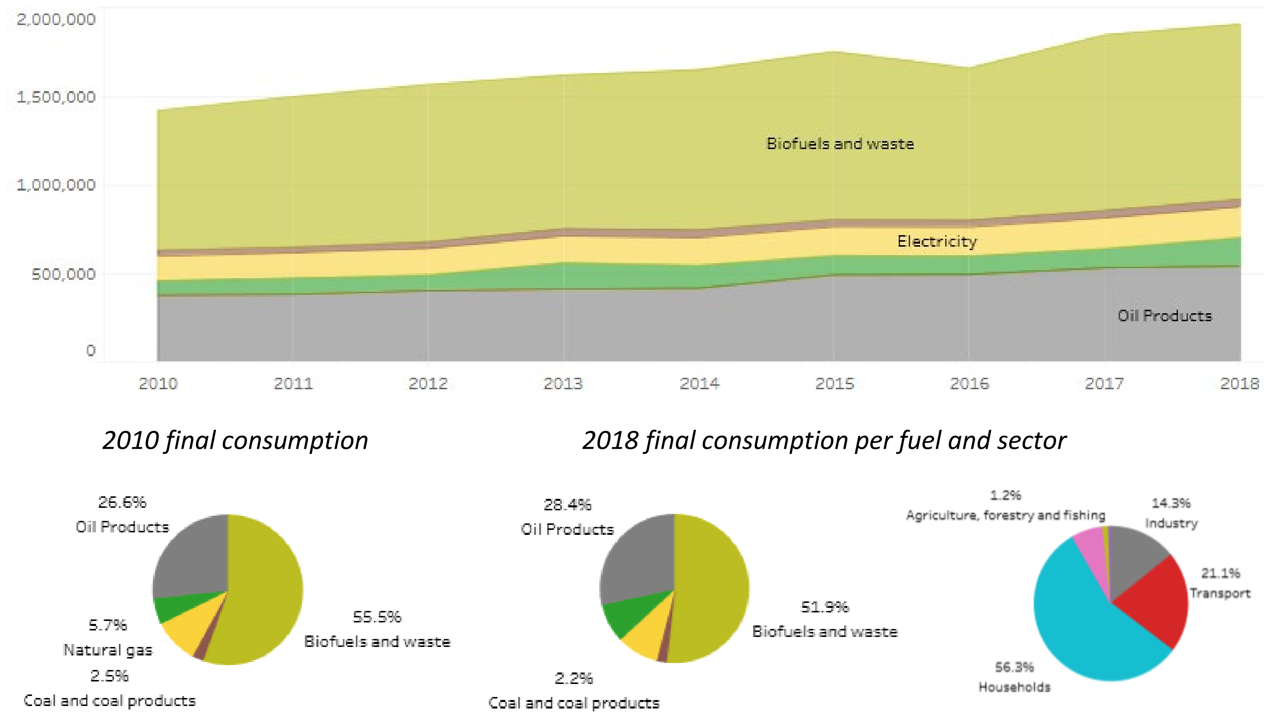
Southern Africa
Final energy consumption: 3.12 EJ
FEC per capita:15.3 GJ/person
Non-biomass FEC per capita: 11.7 GJ/person

Final energy consumption (2018): Per sector



Sources: own elaboration, using data compiled from AU-AFREC, SDG -7 Tracker 2022, WB World Indicators; IEA database (2018 data)

Exhibit 7 Evolution of final energy demand in Africa, 2010-2018



Source: AU-Afrec database (wbsite accessed 2022). Unit: kiloton oil equivalent (ktoe); 1 ktoe = $4.1868*10^{-5}$ EJ

Apart from population growth and urbanization, the higher temperatures due to climate change may significantly increase the need for cooling in Africa. About half of Africa's population lives in areas that may need cooling systems, by 2040 about 1 to 1.2 billion people (up from 700 million currently). This asks for more stringent policies for cooling equipment efficiency (through appropriate standards for cooling equipment and energy management), and passive cooling through better design of buildings. Without these, the IEA estimates that electricity demand for cooling will increase from 11 TWh in 2018 to 223 TWh in 2040[31].

Regarding the power sector, the African continent faces high rates of electricity transmission and distribution losses globally. Reducing transmission and distribution losses by modernizing and rehabilitating grid infrastructure will significantly reduce electricity supply requirements going forward. According to an IRENA estimate, decreasing losses by 1% across Africa would reduce electricity demand by approximately 10 TWh per year, equivalent to the annual production of 6,600 MW of solar capacity, more than the current installed solar capacity in Africa[32].

2.4 Africa's energy supply and resources

2.4.1 Fossil fuels

Africa relies today heavily on fossil fuels (oil, natural gas, coal) for energy consumption and its electricity generation. If not taking traditional biomass (fuelwood and charcoal) into account, the three fossil fuels (oil, coal, and gas, directly and indirectly through fossil-fuel-generated electricity) are responsible for providing 91% of

31 IEA (2019)

32 GIZ (2020); IRENA (2020). In general, T&D losses in are generally lower in Northern Africa than in Sub-Saharan Africa.

energy demand (71% for Sub-Saharan Africa; and 61% for Sub-Saharan Africa, excluding South Africa). Without solid biomass included, the share of fossil fuels (direct use and through electricity generated with fossil fuels) in Africa's final energy demand is 41% (24% for Sub-Saharan Africa; and 17% for Sub-Saharan Africa, excl. South Africa) [33].

One phenomenon is the striking concentration in energy production and use. Africa accounts for just 6.1% of the world's final energy consumption (and Sub-Saharan Africa 4.6%). Within the continent, five countries alone are responsible for about 60% of the continent's primary energy and a similar share in final energy consumption. This may not come as a surprise as these countries also have 40% of Africa's population[34]. If not considering solid biomass, the unevenness becomes more pronounced. Three countries (Algeria, South Africa, and Egypt) consume 56% of final energy consumption (without solid biomass), mostly provided by fossil fuels.

The production of oil, gas and coal is unevenly distributed in a similar way. Three countries (Nigeria, Algeria, and Egypt) produced almost half (48%) of Africa's crude oil in 2018. The same three countries plus South Africa produced 80% of the refined oil products in 2018. Algeria, Egypt and Nigeria produced 83% of the continent's natural gas. Coal production is virtually a South African monopoly (producing 93% of the continent's coal; see Exhibit 8).

This skewed distribution both in terms of production and consumption is linked to the geographical location of energy sources, but also reflects vastly different conditions of industrial and economic development. South Africa alone accounts for 96% of the continent's recoverable coal reserves. Basically, all fossil fuel production is concentrated in just 10 countries, the before-mentioned Algeria, Nigeria, Egypt, as well as Libya, Egypt, South Africa, as well as Angola, Congo and Gabon (oil and oil products) and Mozambique (gas)[35].

The prospects for oil, gas and coal will be determined by the available reserves and costs of exploitation and trade on one hand and by demand factors on the other hand. Demand consists of national, intraregional and

Exhibit 8 Fossil fuels demand, production, trade and reserves in Africa (2018)

Position of Africa in global production (2018) and reserves

	Oil (million tons)		Gas (billion m³)		Coal (million tons)	
	Production	*Reserves*	*Production*	*Reserves*	*Production*	*Reserves*
Global	4,489	221,000	3,974	196,000	7,866	1,139,000
Africa	395	17,000	248	17,700	276	16,400

Fossil fuels production and demand in Africa (2018)

Crude oil (Mtons)		Oil products (Mton)		Natural gas (billion m³)		Coal (million tons)	
Demand	*134*	*Demand*	*187*	*Demand*	*160*	*Demand*	*215*
Production	*395*	*Production*	*111*	*Production*	*248*	*Production*	*276*
- Nigeria	96	- Algeria	39	- Algeria	97	- South Africa	256
- Algeria	66	- Egypt	27	- Nigeria	47	- Mozambique	10
- Libya	53	- South Africa	19	- Egypt	62		
- Egypt	32	- Nigeria	3	- Mozambique/Tanzania	5		
Exports	*294*	*Exports*	*38*	*Net exports*	*88*	*Exports*	*75*
Imports	*33*	*Imports*	*114*	- LNG exports	51	*Imports*	*14*

Source of data: yearbook.enerdata.com ; statista.com; worldometer.com

33 See Exhibits 6 and 7 for sources of data

34 Nigeria, South Africa, Egypt, Algeria and Ethiopia had 40% of Africa's population, while having 59% of primary energy supply in 2018/19; source: statista.com

35 Data compiled from yearbook.enerdata.info; IEA (2019), and AU-AFREC database

international trade. Regarding international demand, the pressure on oil, coal and gas is growing. The recent Conference of the Parties (COP26) of UNFCCC explicitly referenced a shift away from coal and fossil fuels in general. Oil and gas investment in Africa mainly has been driven by large international oil companies and this weighs on the prospects for attracting capital. In this context, oil and gas majors are increasingly challenged to deliver higher returns more sustainably. African oil and gas assets are on average 15 to 20% more costly to develop and operate and 70 to 80% more carbon intensive than global oil and gas assets[36]. New oil and gas projects and infrastructure will take years to develop. This presents a risk for exporters, especially for new and emerging producers, as African oil and gas may become less competitive. If energy transitions (discussed in the next chapter) accelerate, newly approved projects may enter the market as demand and prices are falling and they could struggle to recover their upfront development costs. Thus, Africa may face an increased risk of stranded assets with its significant oil and gas reserves remaining untapped.

At the same time, energy demand on the continent threatens to outstrip supply. Over the next two decades, rapid population growth and industrialization are expected to drive strong energy demand growth across the continent, including for fossil fuels. For example, in one IEA scenario the demand in Africa for oil products, gasoline, diesel and LPG, will increase by 28% between 2018 and 2030 and 37% by 2040[37]. Similarly, in line with expected industrial energy demand growth (by 28% in 2040), a McKinsey analysis forecasts an increase from 4.1 million barrels per day today to approximately 5.3 million barrels per day by 2040, nearly half of which will need to be imported (based on current refinery capacity).[38]

The increased use of natural gas could help displace costly oil products, especially diesel and heavy fuel oil, and meet the needs of industry and the power sector as a flexible and dispatchable source of electricity generation (complementing hydropower and other renewables). Of the trillions of cubic meters of its proven conventional natural gas resources, Africa has only exploited approximately 2%. These resources could provide an additional 90 billion m^3 of gas a year by 2030[39], provided the right infrastructure is put in place (gas pipelines as well as processing and LNG infrastructure). Developing gas infrastructure (especially gas pipelines, processing infrastructure, and liquified petroleum gas (LPG), could enable African countries to overcome the challenge of relatively small national markets by promoting intraregional trade and boosting global exports of African energy products.

The share of gas in the energy mix in sub-Saharan Africa is one of the lowest in the world. At the global level, Africa's production of natural gas in 2018 accounted for only 6.2% of total production, of which one-third is exported outside the continent[40]. The remaining is mainly used for electricity production and to a lesser extent to meet cooking needs, particularly in North Africa.

The demand for gas can also be boosted internationally. Russia's invasion of Ukraine has prompted many European countries to seek to reduce their reliance on Russian resources, including energy. The European Union announced a plan to reduce Russian natural gas imports by two-thirds by end-2022 and deliveries from Russia may be halted well before 2030[41]. This could result in increased demand for oil and gas from the African countries that have the reserves and infrastructure in place to help meet the shifting European demand. First, countries in North Africa are well placed to benefit in the near term given their existing pipeline and LNG export infrastructure. The potential for additional exports to Europe could give renewed momentum to coastal LNG regasification plants to allow gas to be imported from other African countries with LNG export capabilities. On the other hand, if proceeding with its ambitious decarbonization targets, the EU's need for gas will gradually decline after 2030-40.

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36 McKinsey (2021)

37 IEA, Stated Policies scenarios, from 387 PJ in 2018 to 530 PJ in 2040; direct consumption and use for power generation. Esimates based on data from IEA (2019

38 McKinsey (2021)

39 IEA (2019); Exhibit 6

40 See Exhibt …; BP (2018)

41 REPowerEU: Joint European action for more affordable, secure and sustainable energy," European Commission, March 8, 2022. See also McKinsey

This prospect complicates investment decisions as it would oblige new projects to seek new export or regional markets if Europe's demand would decline in the next decade.

The African demand for petroleum products could be increasingly met by lower-carbon alternatives, such as biofuels (bioethanol and biodiesel). Expanding access to LPG, as an alternative to traditional biomass, in the distribution infrastructure could stimulate the uptake of cleaner cooking fuels for the millions of (urban) dwellers who rely on wood fuels for cooking. However, many attempts to increase the use of LPG have largely failed due to a lack of affordability for many potential users and various problems related to the inefficiency of the supply chain in more remote areas (see also In Focus 6). Even in fossil-fuel-rich countries such as Nigeria, Gabon or Angola, biomass still accounts for a significant share of the energy consumption (as shown in Exhibit 5).

2.4.2 Electricity generation and demand and the role of renewable energy

Power generation mix

Continent-wide, renewable energy forms 24% of installed power capacity (37% in Sub-Saharan Africa). Hydropower is the most important resource (providing two-thirds of renewable capacity), although the share of solar and wind in renewables has increased over the past decade (and in 2020 stood at 18% of renewable installed capacity; see Exhibit 9 for more details).

Fossil fuels make up the largest share of installed electricity generation capacities in Northern, West and Southern Africa. In 2020 natural gas capacity in Africa was 60% of the fossil fuel-powered capacity, followed by diesel and fuel oil, 27% and coal 13%[42]. The countries with natural gas reserves – such as Egypt, Nigeria, and Mozambique – are also expanding their natural gas generation capacity.

For countries with viable reserves, natural gas provides cost-competitive, flexible electricity that improves the security of supply and also provides balancing power for integrating variable intermittent energy sources. Here, natural gas can act as s a medium-term bridge technology until, as part of the global 'net zero' transition, more widespread adoption of renewable energy and complementary innovations (such as utilizing hydrogen as an energy carrier) takes place. In addition, natural gas is generally not subject, yet, to the same financing restrictions from international donors, export credit institutions and financing institutions as coal and oil do.

Power demand

Electricity demand was 719 TWh in 2020, while production was 870 TWh (the difference is formed by net exports), slightly up from 854 TWh in 2018. In Sub-Saharan Africa, production was 506 TWh in 2020 (and consumption 413 TWh). The dominant position of North Africa and South Africa together should be noted; together they are responsible for about 70% of Africa's electricity production and consumption (604 and 514 TWh respectively in 2020)[43].

Sub-Saharan Africa (without South Africa) is likely to see one of the fastest electricity demand growth in the world in the coming two decades. By 2040, electricity may have quadrupled almost from the current 208 TWh to 770 TWh (IEA, 2019) with electricity demand per capita (in Sub-Saharan Africa without South Africa) increasing from 190 kWh per capita in 2020 to 430 kWh. According to the same IEA analysis, the residential sector will be the largest contributor to electricity demand growth, accounting for some 50% of the growth to 2040 in sub-Saharan Africa (excluding South Africa), as a consequence of both population increase and economic development. By 2040, the urban population in sub-Saharan Africa (excluding South Africa) is projected to more than double to over 900 million, and average incomes in urban households increase by close to 40%. As income levels increase across Africa, households increasingly own appliances such as refrigerators, washing machines and phones, and fans and air-conditioning devices.

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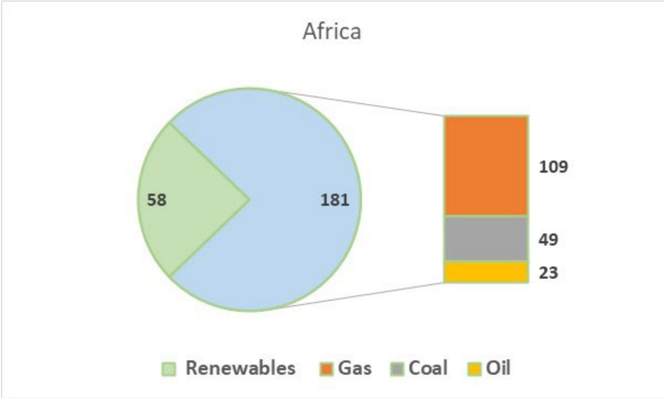
42 Source: www.statistia.com

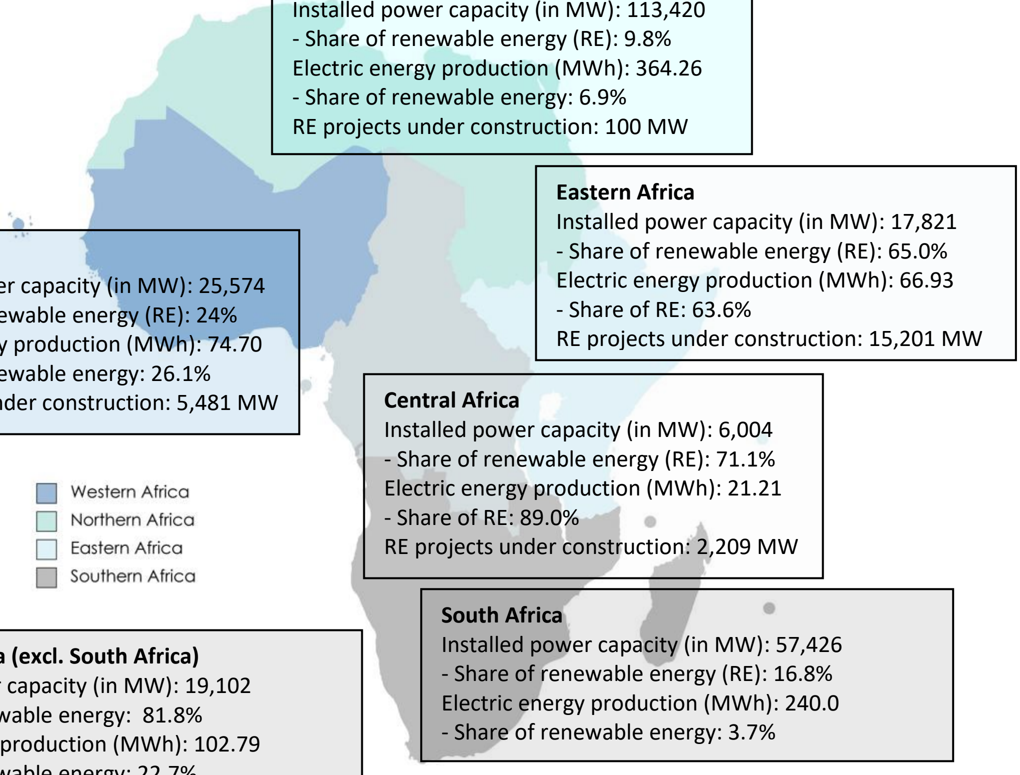
43 Yearbook.enerdata.com

Exhibit 9 Installed power generation capacity and annual electricity production (2020)



Installed power generation capacity (GW), 2020

Source: own elaboration, using data compiled from various sources (yearbook.enerdata; statista.com; IRENA; Africa-energy-portal.org; IRENA-AfdB (2022); ABiQ



Northern Africa
Installed power capacity (in MW): 113,420
- Share of renewable energy (RE): 9.8%
Electric energy production (MWh): 364.26
- Share of renewable energy: 6.9%
RE projects under construction: 100 MW

Eastern Africa
Installed power capacity (in MW): 17,821
- Share of renewable energy (RE): 65.0%
Electric energy production (MWh): 66.93
- Share of RE: 63.6%
RE projects under construction: 15,201 MW

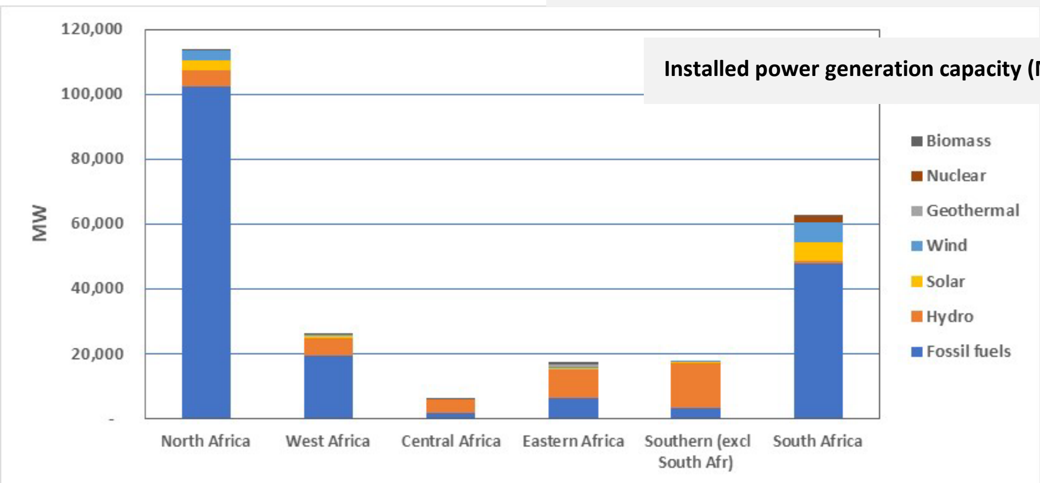
West Africa
Installed power capacity (in MW): 25,574
- Share of renewable energy (RE): 24%
Electric energy production (MWh): 74.70
- Share of renewable energy: 26.1%
RE projects under construction: 5,481 MW

Central Africa
Installed power capacity (in MW): 6,004
- Share of renewable energy (RE): 71.1%
Electric energy production (MWh): 21.21
- Share of RE: 89.0%
RE projects under construction: 2,209 MW

South Africa
Installed power capacity (in MW): 57,426
- Share of renewable energy (RE): 16.8%
Electric energy production (MWh): 240.0
- Share of renewable energy: 3.7%

Southern Africa (excl. South Africa)
Installed power capacity (in MW): 19,102
- Share of renewable energy: 81.8%
Electric energy production (MWh): 102.79
- Share of renewable energy: 22.7%

Southern Africa, RE projects under construction: 10,095 MW



Installed power generation capacity (MW), 2020

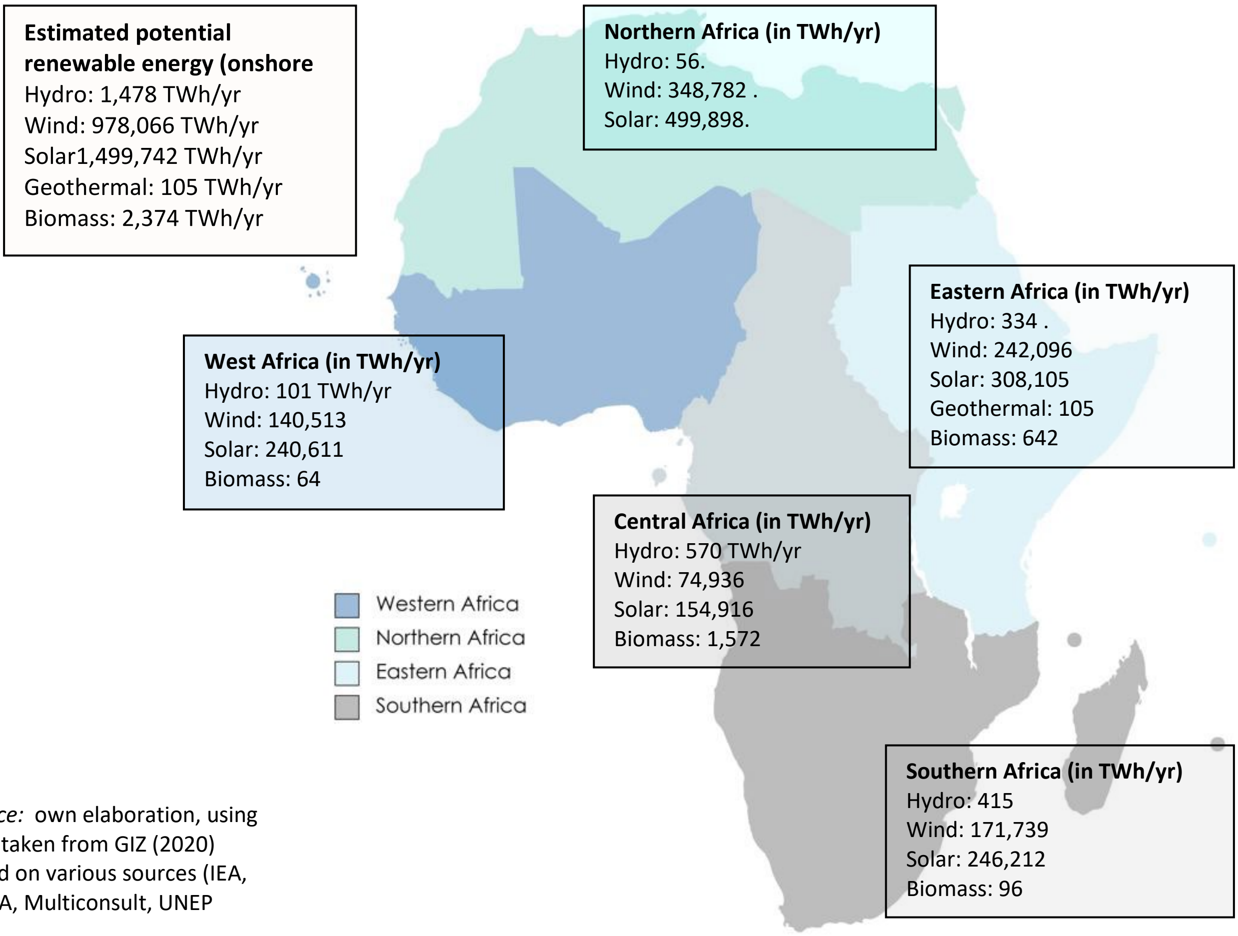
Universal access to electricity will add electricity demand (mostly in rural areas as well as increased access in urban areas) resulting in an additional 210 TWh of electricity demand by 2040 in sub-Saharan Africa (excluding South Africa). The service and the productive sector will have similar growth trends, according to IEA (2019).

Apart from these trends due to demographic and economic developments, demand will further increase due to the electrification of energy end-uses, such as electric cooking (replacing wood fuels or kerosene), and transport (increased penetration of electric vehicles)[44]. Low-heat and other processes in light industry is another energy end-use that can be electrified. For heavy industry and transport, green hydrogen can be a particularly attractive supplement to electricity as an energy carrier in the longer run, as will be discussed in the next chapter.

Resources for power generation

Africa arguably has the largest renewable energy resources of any continent, although each African country has a unique starting point in terms of electricity access, resource availability and demand. Africa's theoretical potential to generate onshore renewable energy from existing technologies is more than 1,000 times larger than its

Exhibit 10 Estimated potential for renewable energy generation



Source: own elaboration, using data taken from GIZ (2020) based on various sources (IEA, IRENA, Multiconsult, UNEP

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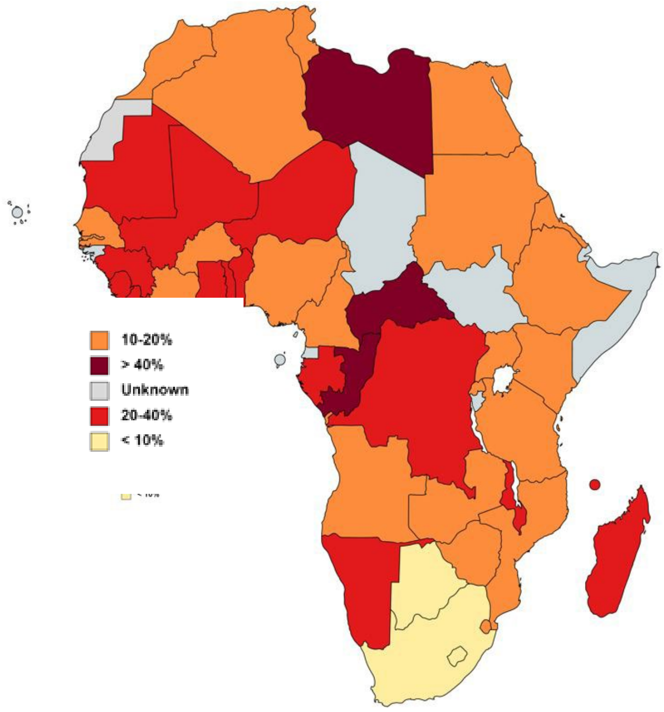
44 Increased demand resulting from transport electrification, with the required corresponding investments in generation and supply infrastructure, could become a burden to power system operators. However, if electric vehicle smart-charging technologies are widely adopted, then scaling up electric vehicle deployment could actually add much-needed flexibility to electricity systems and even support the integration of high shares of renewables, because car batteries can be charged during off-peak hours and then fed back into the grid during peak hours (IRENA, 2019c).

projected 2040 demand for electricity, which means that it has more than enough renewable energy resources to serve its own demand, even in the long run. The solar energy potential in Africa is virtually limitless, with high irradiation levels and 80% of land receiving more than 2 MWh/year per m^2 and distributed fairly uniformly. Wind energy has substantial potential but that is generally located in coastal areas. Hydro resources are also abundantly available, especially in Easter, Central and Southern Africa. Geothermal energy can play an important role in Eastern Africa in the Rift Valley zone. Biomass has big potential if produced sustainably, not only for power generation but as a source of process heat for industry. With the right investments and enabling frameworks, the continent will even emerge as a net exporter of renewable energy (as will be discussed in the next chapter).

Efficiency in generation, transmission and distribution

The African continent faces rates of electricity transmission and distribution (T&D) losses that are higher than the average global values. A recent IEA study (2022) mentions that "Africa's power grids suffer from poor reliability and high technical and commercial losses due mainly to underinvestment and ageing infrastructure, though other factors such as overgrown vegetation (especially in remote areas), natural disasters, vandalism and theft contribute". The World Bank estimates that T&D losses in Sub-Saharan Africa are about 23%, excluding South Africa, and 15% including South Africa and can be as high as 48% in the Central African Republic, 46% in Congo, 40% in Comoros or even 30-60% in Togo and 20-70% in Benin[45]. The losses consist of technical and non-technical losses. In a well-run system, the technical losses could be 10% maximum and the non-technical losses almost zero. Only a handful of countries, South Africa (8-9%), Lesotho (9%), Mauritius (6-9%) and Botswana (7-11%) meet this criterion. In Northern Africa, the losses are generally lower than in Sub-Saharan Africa (with the exception of Libya). Reducing transmission and distribution losses by modernizing and rehabilitating grid infrastructure will significantly reduce electricity supply.

Exhibit 11 Power system transmission and distribution losses, Africa



Source : own elaboration, using data compiled from indexmundi.com, based on 2018 IEA data, and Trimbe et.al (2016)

Consequences of constraints in electricity supply

Consequently, there is also a significant deficit in electricity supply and reliability across the continent and particularly in sub-Saharan Africa. A recent survey found that nearly 25% of households in Africa with electricity access had electricity available half of the time or occasionally[46]. Even when electricity is available, the reliability of services is a major issue, particularly for the productive sectors. According to another survey, about 71% of

[45] Data based on Trimble (2016, World Bank) and IEA 2018 data (accessed through https://www.indexmundi.com/facts/indicators/EG.ELC.LOSS.ZS/map/africa. While the two soyurces generally correspond, widely different data are provided for Togo, 30-60% in Togo and 20-70% in Benin

[46] GIZ (2020), data taken from Afrobarometer (2019)

enterprises in Sub-Saharan Africa have no access at all or no access to reliable electricity[47]. About 41% of African firms identify having no or poor electricity supply as a major constraint on their operations[48]. This has resulted in substantial growth of inefficient and expensive onsite self-generation in industrial, commercial, and even residential sectors. Many enterprises often resort to backup facilities, mainly diesel generators, thus increasing both the overall cost of power generation and of greenhouse gas emissions.

Financial situation of utilities and cost-reflective tariffs

Public utilities will be responsible for much of the investment in upgrading the electricity systems across the African continent. This is not made easier given the perilous financial state of main utilities today. Poor payment collection rates, theft and non-payment of bills (non-technical T&D losses), cost increases (including the cost of capital), operational problems, political interference and supply chain constraints are reducing cash flows and driving up debt.

Only a few countries have fully cost-reflective electricity tariffs, while some countries employ tariffs that recover less than 50% of the total cost of supply. Reforms to make electricity tariffs cost reflective have been implemented or are under discussion in about half of the African countries, often at the behest of multilateral development banks[49]. The operating losses among all African utilities are thought to have exceeded USD 150 billion in 2020[50]. By a combination of higher electricity sales (1/3) and removing the subsidy element in the power tariffs (about 2/3), the operating losses of utilities could be brought down to USD 50 million in 2030[51]. The issue of cost-reflective tariffs and energy subvention is discussed in more detail in sections 4.4.2 and 5.2.3.

Regional electricity integration

Energy trade within Africa remains marginal, reflecting the low rate of Africa's economic integration and limited exchange of goods and services between African countries. However, there are signs of positive change such as the trend toward power pools in all five African regions. These play a vital role as they aggregate multiple sources of supply, including high levels of variable renewables, and loads over a larger area, pooling supplies and enhancing flexibility. This makes system balancing easier by taking advantage of various supply sources and can complement each other (as they have different production profiles or face varying weather conditions) to meet different demand patterns across the pooled supply.

National grid systems are gradually integrating into the regional power pools. Today there are five power pools at various stages of development in Africa (see Exhibit 12 for an overview of the regions covered by the pools)[52] but only the Southern African Power Pool has a fully functioning regional market[53]. Significant work is also being done on the continental level to strengthen the security of supply across Africa, notably through further interconnection of the regional power pools.

Security of supply is about more than strengthening and integrating electricity grids. At the national level, practical solutions need to combine several dimensions, including enabling technologies, market design and regulation, business models and system operation and sound financial management. These regulatory aspects are discussed in more detail in section 5.3.

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47 AU (2019); based on findings in AFD/World Bank *Electricity Access in Sub-Saharan Africa*

48 Energy for Growth. (2019). *Cost of unreliable electricity to African firms.*

49 IEA (2022), IEA (2019), see also Exhibits 55 and 56

50 IEA (2022), p.134

51 IEA (2022)

52 Often overlapping with a power pool, is a Regional Economic Community (REC). RECs are regional groupings of African states with a general purpose of facilitating regional economic integration between members of the individual regions and through the wider African Economic Community.

53 IRENA-AfDB (2022)

Exhibit 12 Electricity networks and regional power pools

Source: Update of similar figure in ECDPM (2019)

Transmission and distribution grid map made with geospatial data from World Bank GIS datasets

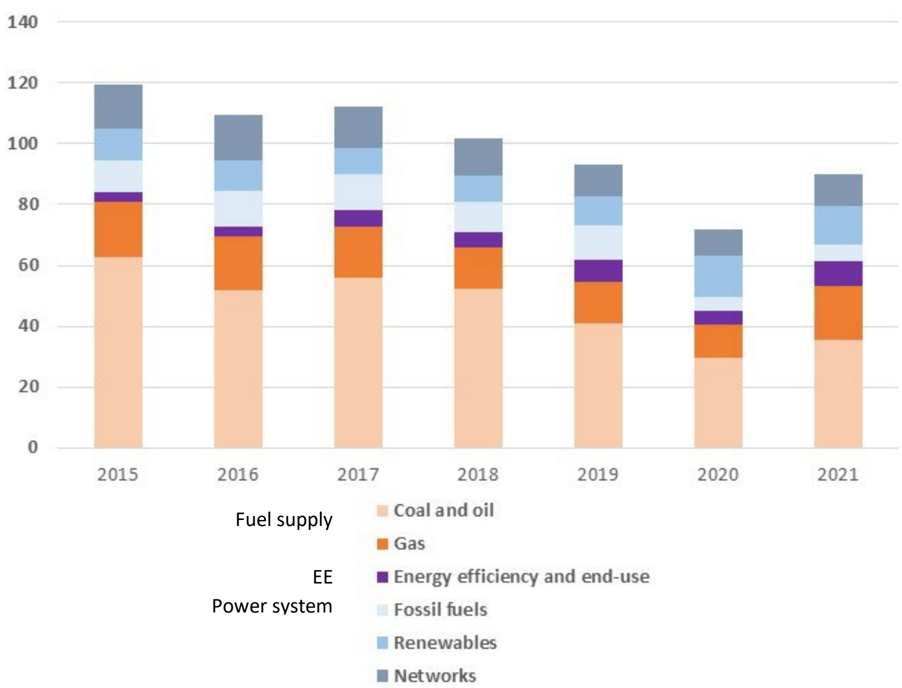
Correspondence of geographical area of RECs and of regional power pools

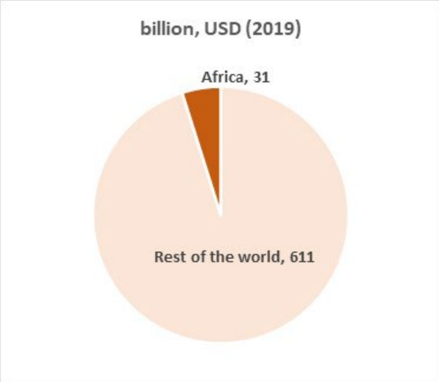
<table>
<tr><td rowspan="2">Regional Economic Community</td><td rowspan="2">Arab Maghreb Union (AMU)</td><td rowspan="2">Economic Community of West African States (ECOWAS)</td><td rowspan="2">Economic Community of Central African States (ECCAS)</td><td>East African Community (EAC)</td><td>Southern African Development Community</td></tr>
<tr><td colspan="2">Common Market for Eastern and Southern Africa (COMESA)</td></tr>
<tr><td>Regional power pool</td><td>Maghreb Electic Committee (COMELEC)</td><td>West African Power Pool (WAPP)</td><td>Central African Power Pool (CAPP)</td><td>East African Power Pool (EAPP)</td><td>Southern African Power Pool (SAPP)</td></tr>
<tr><td>Member-ship (2022)</td><td>Utilities from the five Maghreb countries are member</td><td>38 utilities from 14 of the 15 ECOWAS countries (except for Cabo Verde)</td><td>10 utilities from 10 ECCAS countries</td><td>16 utilities from Burundi, Djibouti, DRC, Rwanda, Egypt, Ethiopia, Kenya, Sudan, Tanzania, Uganda, and Libya. South Sudan and Somalia. Eritrea may join</td><td>17 utilities from 12 SADC countries (out of 1, except for Mauritius, Seychelles and Comores)</td></tr>
</table>

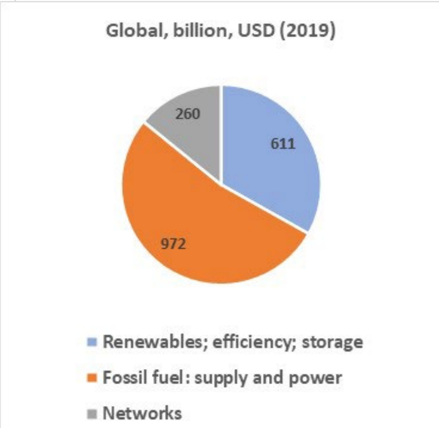
2.5 Energy infrastructure and investments

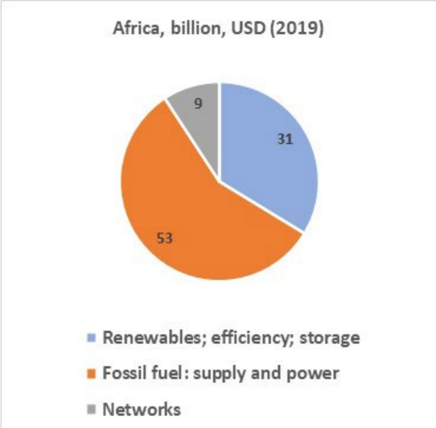
Infrastructure is an essential building block for economic development and quality of life, but Africa, especially Sub-Saharan Africa, lags behind other developing economies in virtually all aspects of infrastructure quality. The energy sector is no exception. While Africa accounts for almost one-fifth of the world's population, it attracts less than 5% of global energy investment[54]. This is spread unevenly across the continent. Ten countries accounted for 90% of private investment in energy and electricity infrastructure on the continent over the last ten years, South Africa alone accounting for nearly 40%. Total energy investment in Africa was already declining before the pandemic and fell even more quickly in 2020, by over 20%. The USD 73 billion invested in 2020 was equal to just 3% of Africa's GDP. I[55].

Exhibit 13 Energy investments in Africa (in billion USD), 2015-2021









Energy access investments

Mini-grid and off-grid investments form a small part of electricity sector finance:

(in billion USD)	2015	2016	2017	2018	2019	2020	2021
Power sector	38	40	40	36	38	21	35
- Minigrid and off-grid	0.20	0.23	0.24	0.25	0.29	0.28	0.38

Source: own elaboration, using data compiled from IEA World Investment data; minigrid finance data from IRENA-AfDB (2022)

54 Global investment in 2021 in electricity was USD 976 billion and 90.3 in natural gas of which Sub-Saharan Africa, USD 50.69 billion and USD 4.85 respectively. Source: https://ppi.worldbank.org/en/snapshots/sector/electricity and IEA (2022)

55 IEA (2022)

According to IEA, global investments need to achieve full energy access are estimated at USD 786 billion (or about USD 66 billion a year over the period 2018-2030), of which USD 734 for electricity access, divided over grid (37%), off-grid (29%) and minigrid solutions (34%), that is, about USD 62 billion annually. Investment needs of USD 52 billion are mentioned for clean cooking options (USD 22 billion for LPG and USD 24 billion for improved biomass and other options).

The figures mentioned in the IEA report (2019) for Sub-Saharan Africa are USD 454 billion for electricity access and USD 24 billion for clean cooking methods or about USD 22 billion annually for electricity access and USD 1.2 billion for clean cooking solutions (over the period 2010-2040). Thus, annual investments needed to achieve universal access in Sub-Saharan Africa are about USD 24 billion annually[56].

SE4All has done some research on finance flows for electricity investments in a number of 'high-impact countries' in Africa and South Asia (see Exhibit 14). Together, the group spent about USD 13 million on residential electricity. The 'high-impact countries' are home to 76% of the global population without access to electricity (580 million people). In other words, the USD 13 billion is substantially lower than their proportional need based on the above-mentioned investment needs of about USD 40-60 billion annually in the coming decade. The amounts currently invested are way off-track the annual financing needed to achieve universal energy access. Investment in power infrastructure in sub-Saharan Africa has mainly been financed by state budgets with substantial contributions from international donors. Public and international development finance collectively accounted for over 90% of the capital committed to power infrastructure in 2017[57]. While public sources of finance have an important role to play, they are unlikely to be sufficient to address the significant investment gaps that exist and need to be supplemented by private sector financing. However, Africa has so far had limited success in mobilizing private finance. Between 2013 and 2018, power sector investment based on private participation in infrastructure models in sub-Saharan Africa amounted to around USD 4.5 billion per year on average, less than 10% of the annual needs between today and 2040[58]. The electrification sector is failing to reach its potential due to a combination of state budget constraints, limited private investment and falling international finance commitments.

Investments in oil and gas in Sub-Saharan Africa have largely been driven by international oil companies. This contrasts with the prevailing trend in many other resource-rich countries where domestic companies, and in particular national oil companies, take the lead. In those cases where Sub-Saharan countries have established a national oil company, they have generally not been effective in accelerating resource developments in the country due to their limited financial capacity and lack of technical expertise in handling complex projects. The limited attractiveness of the domestic market also means that most spending on oil and gas has been directed at export-oriented projects (e.g., upstream and liquefied natural gas) rather than projects geared towards serving the domestic markets (e.g., gas pipelines and refineries)[59].

Ultimately whether projects can attract financing depends on whether developers and investors believe that they will deliver adequate returns and the timely repayment of debt to lenders. This requires a sound investment framework (e.g., tariff schemes, institutional and regulatory structures) as well as a robust contracting framework (e.g., sound off-take agreements and financing structures) to manage risks around future cash flows. The role of public and development finance is also important: these sources can not only provide necessary capital but also encourage private sector investment through targeted interventions such as risk sharing, liquidity support and take-out financing. Outside South Africa, public and development finance has not been very effective in catalyzing private capital, suggesting that much more needs to be done to plug the investment gaps in power and energy infrastructure. The role of public and private financing is discussed in more detail in section 5.4.

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[56] IEA (2019). Other sources give higher estimates, Race to Zero mentions a figure closer to USD 37 billion annually for off-grid (minigrid and stand-alone solutions only; see section 3.4 for a discussion in investment needs).

[57] IEA (2019), IEA (2017)

[58] IEA (2019)

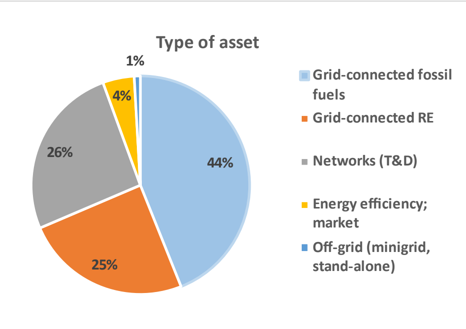
[59] Ibid.

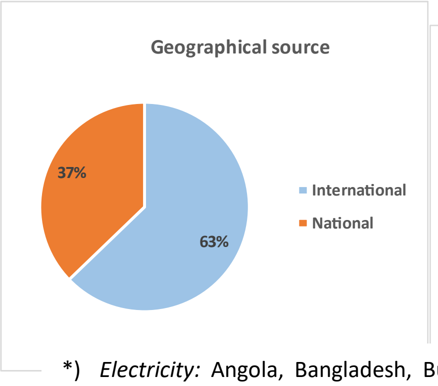
Exhibit 14 Tracking finance for investment in electricity and cooking

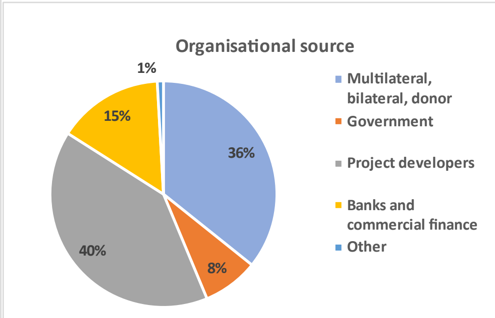
SE4All publshes annually a report on finance flows for electricity access and clean cooking. The reports are based on tracking the finance flows for investments in the electriicty sector (that is, all grid-connected plants, transmission and distribution infrastructure, and mini-grid and off-grid solutions) and for cooking (clean fuels and technologies for cooking, such as cookstoves, biogas, LPG, etc) by gathering data from several 'high-impact countries' in Sub-Saharan Africa and in South Asia*.

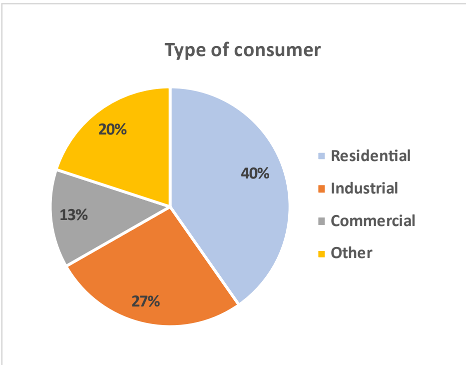
The figures below summarise the results for 2019. In terms of population, the countries chosen presented 76% of the global population without electricity access (580 out of 759 million) in the case of electricity and 81% of the global population without access to clean cooking (2,106 out of 2,651 million). For the 'high-impact countries' studied, a committed finance stream was tracked at a value of USD 31,988 million for electricity and USD 137 million for cooking

Electricity







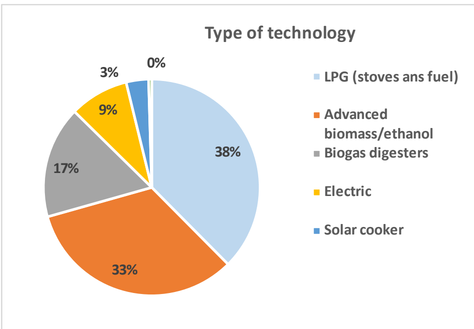


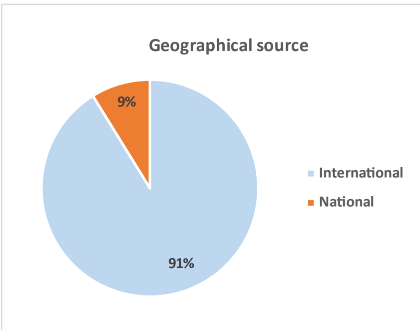
*) *Electricity:* Angola, Bangladesh, Burkina Faso, Chad, Congo (DR), Ethiopia, India, Kenya, Korea (DPR), Madagascar, Malawi, Mozambique, Myanmar, Niger, Nigeria, Pakistan, South Sudan, South Sudan, Sudan, Uganda, Tanzania
Cooking: Afghanistan, Bangladesh, China, Congo (DR), Ethiopia, Ghana, India, Indonesia, Kenya, Korea (DPR), Madagascar, Mozambique, Myanmar, Niger, Nigeria, Pakistan, Philippines, Uganda, Tanzania, Vietnam

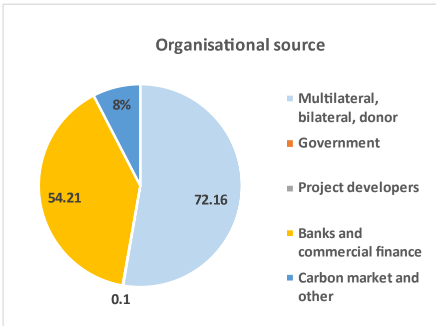
**) Committed means transactions that reached financial close or were backed by the necessary funds

Source: own elaboration, using data from *Energizing Finance, Understanding the Landscape 2021,* SE4All

Cooking







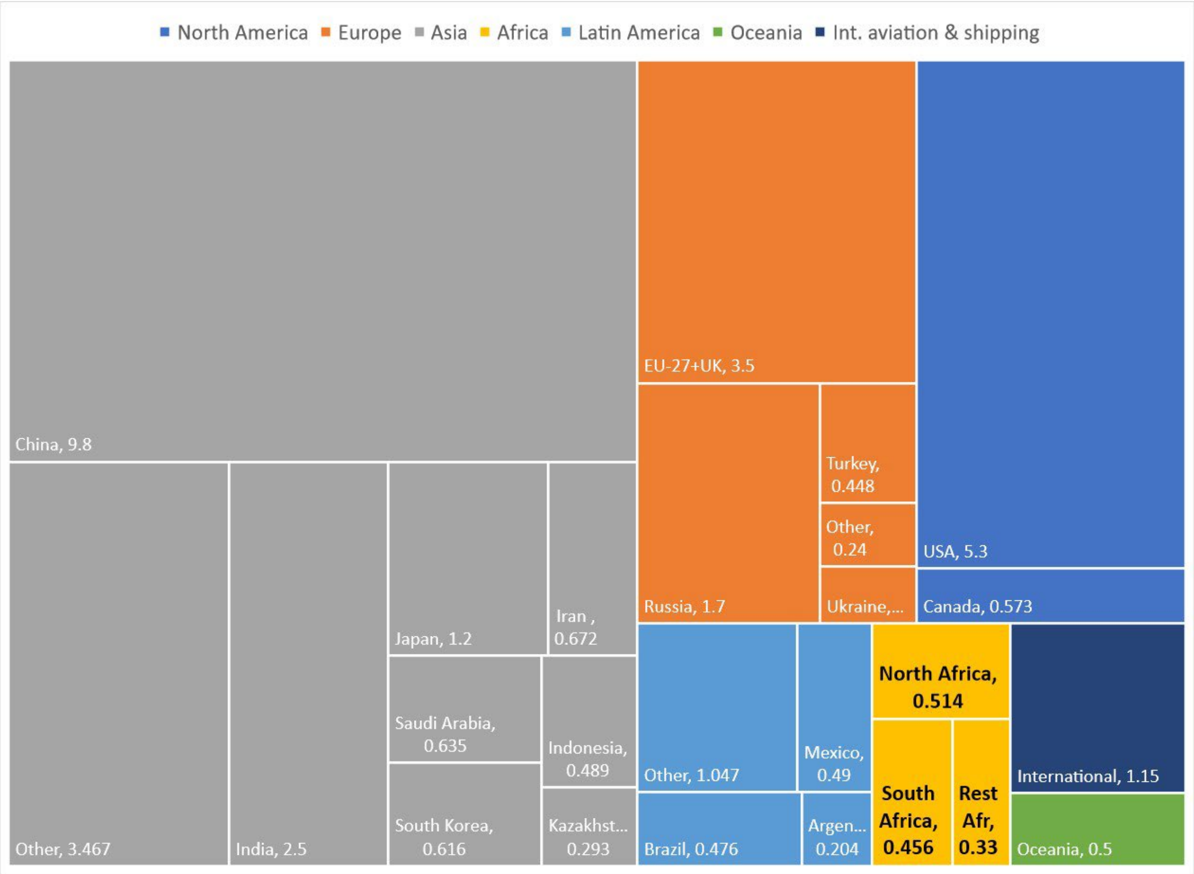
Most financing for clean cooking comes from international sources (91%)

2.6 Greenhouse gas emission

Africa is a minor contributor to global climate change. It accounts for less than 4% of global energy-related carbon dioxide (CO_2) emissions today and has the lowest emissions per capita in the world. Africa has not been a significant contributor to global greenhouse gas (GHG) emissions during the age of industrialization at all. Energy-related CO_2 emissions in Africa accounted for only 3% of global cumulative emissions from 1751 to today. Even when experiencing rapid economic growth, its contribution to global energy-related cumulative emissions will remain under 5% over the period to 2040 (IEA, 2019).[60]

Africa's regional contribution, relative to its population size, has been very small. Africa has 16% of the population but emits just 3.6% of the global CO_2 emissions annually. This is reflected in per capita emissions; the average North American's is more than 17 times higher than the average African's. Within the continent, there are marked differences in greenhouse gas emissions due to fossil fuels with South Africa and North Africa responsible for 36% and 35% of annual greenhouse gas emissions, respectively (see Exhibit 13). Thanks to technology improvements and energy and mineral resource endowments, Africa has the opportunity to pursue a much less carbon-intensive model of development than seen in many other parts of the world. Africa can follow a different pathway, with much stronger shares of renewables and natural gas in the energy mix than most industrialized countries or large emerging economies have done. Africa hence faces major challenges as well as opportunities to design and plan for a continuously changing energy mix that will be discussed in the next Chapters.

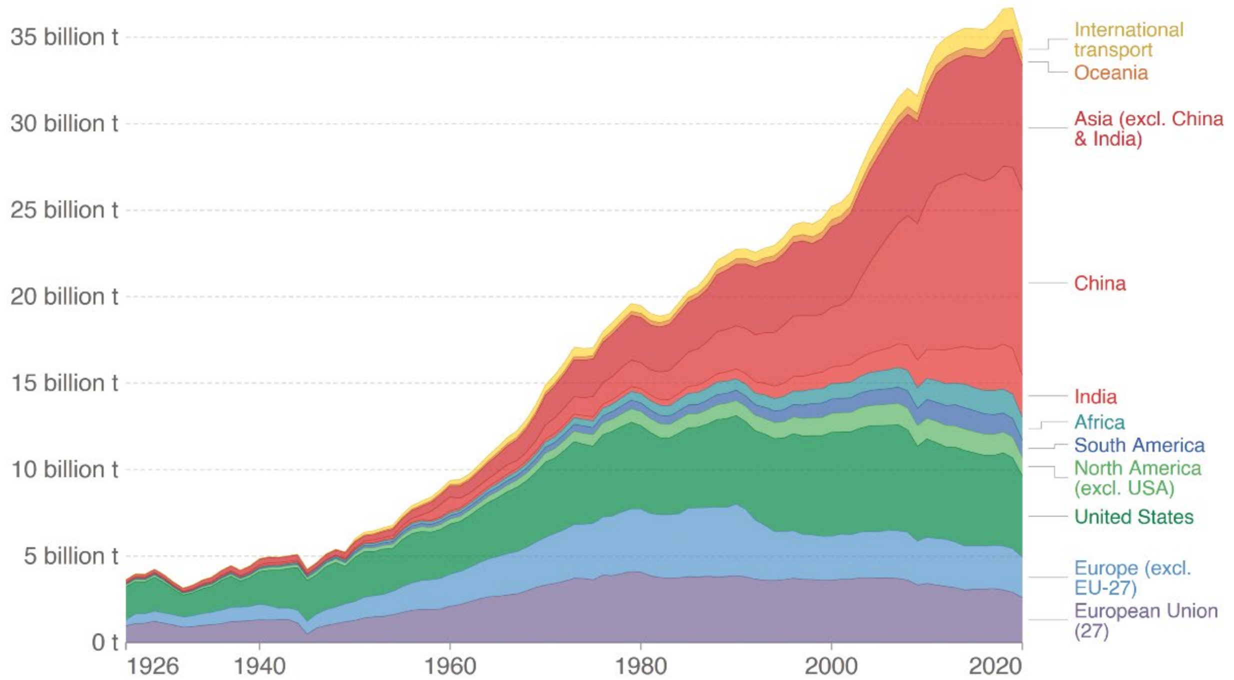
Exhibit 15 Cumulative CO_2 emissions 1751-2020 from fossil fuels



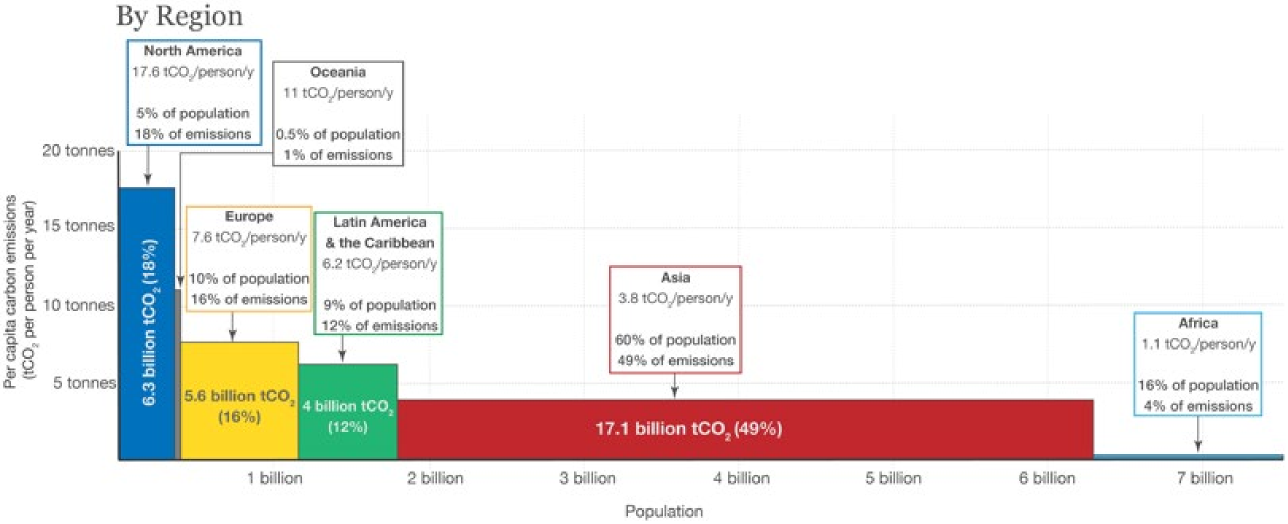
Compiled based on data from https://ourworldindata.org/co2-emissions. Global: 1,531 billion tons of CO_2.

[60] IEA (2019)

Exhibit 16 Africa's role in the annual CO_2 emissions (2020) from fossil fuels



Figures taken from the website https://ourworldindata.org/co2-emissions. In 2020, 36.14 billion tons of CO_2 were emitted due to fossil fuel combustion. .



While the sub-Saharan African energy sector makes a very small contribution to global CO_2 emissions, the region is among those most exposed to the effects of climate change. For sub-Saharan Africa, which has experienced more frequent and more intense climate extremes over the past decades, the consequences of the world's warming by more than 1.5 degrees Celsius (°C) would be severe. Temperature increases in the region are projected to be higher than the average global temperature increase. For example, regions in Africa within 15 degrees latitude of the equator are projected to experience an increase in warmer nights and longer and more frequent heat waves.

Climate change is also likely to affect the availability of hydro resources. The negative impacts of climate change on the availability and variability will affect hydropower outputs in several countries. While hydropower remains an essential element of Sub-Saharan Africa's electricity supply, diversifying the electricity mix will help to mitigate the risk of power disruptions during droughts and strengthen resilience to changing climate conditions, implying that the role of natural gas as baseload in the power supply cannot be discarded.

3. TOWARDS A GLOBAL ENERGY TRANSITION

The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015. At its heart are the 17 Sustainable Development Goals (SDGs). Apart from reaching the SDG-7 goals, the Global Roadmap for Accelerated SDG-7 Action in Support of the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change calls for deep energy decarbonization 1.5°C goal of the Paris Agreement, requiring net-zero emissions by 2050.

Energy transitions are shifts in the way people produce and consume energy using different technologies and sources. The energy access transition implies meeting the universal access by 2030 target of SDG-7. The low-carbon energy transition is a type of energy transition involving a shift from high-carbon energy sources such as oil, gas and coal to low-carbon and zero-carbon energy sources such as renewables and within fossil fuels from coal and oil to natural gas[61] or from unsustainably produced biomass to other sources.

The energy transition towards low-carbon fuels also offers opportunities. In North Africa, gas is a mainstream fuel. In much of sub-Saharan Africa, gas has been a niche fuel. Several major gas discoveries) have been made in recent years. Where resources are plentiful, it could provide the continent with additional electricity for baseload and flexibility needs, energy for industrial growth and a sizeable source of revenue from export through pipeline or LNG shipments. Africa has vast resource potential in wind, solar, hydro, and geothermal energy. Hydropower also remains a cornerstone of sub-Saharan Africa's power system, while falling costs will increasingly bring solar to the forefront of power generation.

In most African countries the bulk of the energy infrastructure is not yet built, allowing for rapid leapfrogging in the longer term, to using new energy carriers, such as hydrogen and biofuels, to be used domestically. As Europe and other parts of the world move from a low-carbon to a zero-carbon economy, in the longer run, the role of natural gas hydrogen and derivative fuels for export will become more pronounced. In the short run, meeting universal access to energy should receive priority. Here, decentralized systems, powered by solar energy (or other locally available renewable resources) will play an increasingly important role to supplement conventional transmission and distribution grid expansion. Taking a faster penetration of renewables in the mix of energy carriers to meet the rapidly growing energy demand, in line with the goal of 'net zero by 2050' and maintaining affordable energy for all by 2050, would require a tremendous investment of over USD 100-150 billion annually.

3.1 Guiding principles for the coming energy transition in Africa

AU Agenda 2063

Africa's energy vision is as follows: "By 2063, Africa's energy systems will largely be based on renewable energy resources coupled with a strong and to a considerable extent localized manufacturing sector, highly qualified human resources and integrated energy infrastructure for both centralized and decentralized energy systems". The ultimate objective is universal access to affordable modern and clean energy services. There will be energy convergence not only between and within countries and regions but also between urban and rural areas, particularly in Sub-Saharan Africa. Likewise, at a global level, there will be a convergence towards sufficiency and responsible well-being where Africa overall increases its energy use, while today's wealthy countries reduce theirs.[62]

[61] Definition adapted from IISD (2018)

[62] AU (2019)

Sustainable Development Goals

The United Nations 2030 Agenda for Sustainable Development, was adopted by the world's leaders, in 2015. All its 17 Sustainable Development Goals (SDGs) are closely linked to the 12 goals defined in AU's Agenda 2063. Energy is dealt with primarily by Sustainable Development Goal #7 (SDG7), whose overarching aim is to 'Ensure access to affordable, reliable, sustainable and modern energy for all', with three targets to be reached by 2030:

7.1: Ensure universal access to affordable, reliable and modern energy services
7.2: Increase substantially the share of renewable energy in the global energy mix
7.3: Double the global rate of improvement in energy efficiency

Paris Agreement on Climate Change

To tackle climate change and its negative impacts, world leaders at the UN Climate Change Conference (COP21) in Paris reached a breakthrough in December 2015; the Paris Agreement adds a new piece to the international framework of climate change agreements with its goal to maintain average global temperature rise to "well below 2° C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels", requiring reaching global carbon neutrality soon after 2050. This ambitious objective aims at limiting the impacts of climate change and preserving opportunities for development, notably in the most vulnerable regions and communities.

This is also true for African countries, despite their current very low collective contribution to climate change of less than 4% of global CO_2 emissions. Looking ahead, however, if they do not consider their climate impact (as their development accelerates and populations grow in coming decades), they could become major GHG emitters, threatening the achievement of the global climate objective and compromising their sustainable development aspirations. On the other hand, African countries have the legitimate right to satisfy their essential socio-economic development needs and, in particular, the eradication of poverty. The issue for these countries is to build long-term trajectories that reconcile the achievement of very low GHG emissions with the satisfaction of key objectives of development and the well-being of their populations.

Just energy transition

The transformative decarbonization of the energy transition can drive broad socio-economic development, while at the same time, the energy transition will be guided by long-term economic and social as well as environmental goals. The energy transition will be guided by, contribute to and deliver on the SDGs, to make it a just transition. This will be analyzed in more detail in the next Chapter Four.

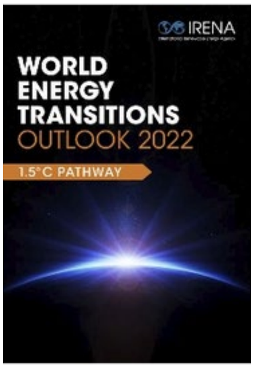
A just energy transition is a negotiated vision and process centered on dialogue, supported by a set of guiding principles, to shift practices in energy production and consumption. It aims to minimize negative impacts on workers, communities and regions with stakes in high-carbon sectors (that will wind down, such as coal and oil), and maximize positive opportunities. It strives to ensure that the costs and benefits of the transition are fairly and equitably shared, leaving no-one behind [63]. To support a just transition, the fair sharing of the costs and benefits of the energy transition, as well as labor, social, local environmental and other development aspects must be tailored to the specific needs of each country and region and integrated with energy policies and planning. Equity considerations, including gender aspects, must be integrated into policy and programs that are designed in a participatory way in order to tap societal potential fully and to ensure that "no one is left behind".

[63] Definition adapted from IISD (2018)

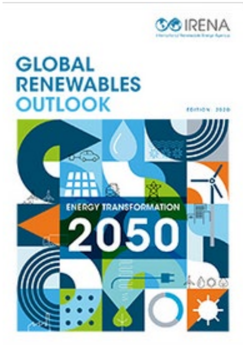
3.2 Global energy transition scenarios

Several scenarios have been developed by a number of international institutions that describe how the goals of universal energy access and global CO_2 reduction goals can be achieved. Understanding the essentials of the various scenarios with different names, discussed in an ever-expanding series of reports, can be a daunting task for the occasional reader. This Chapter, therefore, starts with a review and comparison of the various pathways leading to universal energy access by 2030 and near-zero emissions by 2050, with special attention to the role of and implications for Africa.

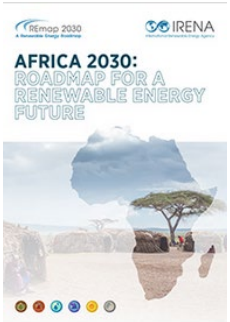
International Renewable Energy Agency (IRENA)

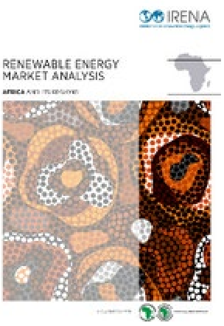


IRENA's REmap program determines the potential to scale up renewables. REmap assesses renewable energy potential assembled from the bottom up, starting with country analyses done in collaboration with country experts, and then aggregating these results to arrive at a global picture. The roadmap focuses not just on renewable power technologies, but also on energy end-use and technology options in heating, cooling and transport. REmap focuses on possible technology pathways and assesses various metrics therein, including technology, sector and system costs, investment needs, externalities relating to air pollution and climate, CO2 emissions, and economic indicators such as employment and economic growth. Energy access is part of the scenario analysis.



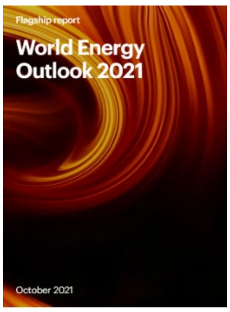
In the reports three scenarios figure, a) *Planned energy scenario (PES)*, b) *Transforming energy scenario (TES)*, and c) the *1.5ºC scenario*. The PES is based on current governments' energy plans and targets (as formulated, for example, in the National Determined Contributions). The Transforming Energy Scenario (TES) outlines a climate-friendly pathway with energy-related CO_2 emissions reductions of 70% by 2050 compared to current levels. The latest scenario addition, 1.5ºC pathway, goes furthest in terms of penetration of non-carbon energy and assumes drastic actions and policies as needed to achieve the 1.5ºC temperature increase by 2050 goal of the Paris Agreement. The Planning horizon is to 2030 and 2040-2050.





The REmap results appear in several reports and knowledge products. Although a bit outdated, the report *Africa 2030* is part of IRENA's global REmap analysis and focuses on the roadmap details and implications for Africa's energy transition. The recent publication *Renewable Energy Market Analysis* (2022) looks at the energy situation in the various African subregions and analysis the impacts of the new 1.5ºC pathway

International Energy Agency (IRENA)



IEA has been providing analysis and critical insights into global energy supply and demand in different scenarios and the implications for energy security, climate targets and economic development. The results of the analysis appear in various flagship reports, sectoral or thematic analyses and knowledge products. The World Energy Outlook (WEO) has been published every year since 1998, usually by November. The clean energy transition is discussed in the "Net Zero Emissions by 2050" report. Clean energy technologies are described in the Energy Technology Perspective and Tracking Clean Energy Progress series

Energy access has been part of the above-mentioned WEO analysis with a special report dedicated to the subject in “Energy Access Outlook 2017”. Special reports in the WEO series have focused on Africa, starting with the Africa Energy Outlook 2019. A new version, Africa Energy Outlook 2022, was recently released and explores pathways for Africa’s energy system to evolve toward achieving all African development goals, including universal access to modern and affordable energy services by 2030as well as achieving the global net zero emissions goals.

IEA uses its World Energy Model (WEM) to generate detailed sector-by-sector and region-by-region projections for the WEO scenarios, a) *Stated Policy Scenario (STEPS)*, b) *Assumed pledges scenario (APS)*, c) *Sustainable Development Scenario (SDS)* and d) *Net-Zero Emissions (NZE) scenario*. STEPS are projections based on current commitments, enough to steer away from historic business-of-usual trends, but leaving big gaps in achieving energy access or climate change mitigation goals, although not assuming that all commitments will be implemented. Unlike STEPS, the Announced Pledges Scenarios (APS) does assume that countries will implement all their 2030 and 2050 pledges. The Sustainable Development Scenario (SDS) represents a pathway according to Paris Agreement goals of ‘well below 2°C, while assuming universal energy access by 2030. The latest addition is the ‘Net-Zero Emissions’ which shows a pathway for the global energy sector to achieve net zero CO2 emissions by 2050. In this report, the results of STEPS, SDS and NZE scenarios will be used. For the Africa reports, two special ‘sustainable’ scenarios were developed, the *Africa case (AC)* scenario in the 2019 Africa Outlook report and the *Sustainable Africa Scenario (SAS*) in the 2022 Africa Energy Outlook. The planning horizon is to 2030 and 2040-2050.

<u>MultiConsult/AfDB – Low carbon case</u>

The African Development Bank (AfDB) has launched the New Deal on Energy for Africa with the goal of achieving universal energy access. A study carried out by MultiConsult maps the expansion of the electricity sector in a Reference and a Low Carbon scenario. The latter includes the ‘New Deal’ goal of universal access to electricity by 2025 (with 100% access in urban areas and 95% access in rural areas), regional optimization of investments, and substantial penetration of renewable energy. Unlike the IRENA and IEA modelling, the MultiConsult scenarios focus on the electricity sector and Africa only, while the planning horizon is up to 2030.

<u>Other Roadmaps</u>

The *Net-Zero Financing Roadmaps (NZFR)* project was commissioned by the UN High-Level Climate Action Champions with research from Vivid Economics for the COP26. The analysis breaks down the numbers behind the “where, who and how” of the trillions of investments required to meet the net zero goals.

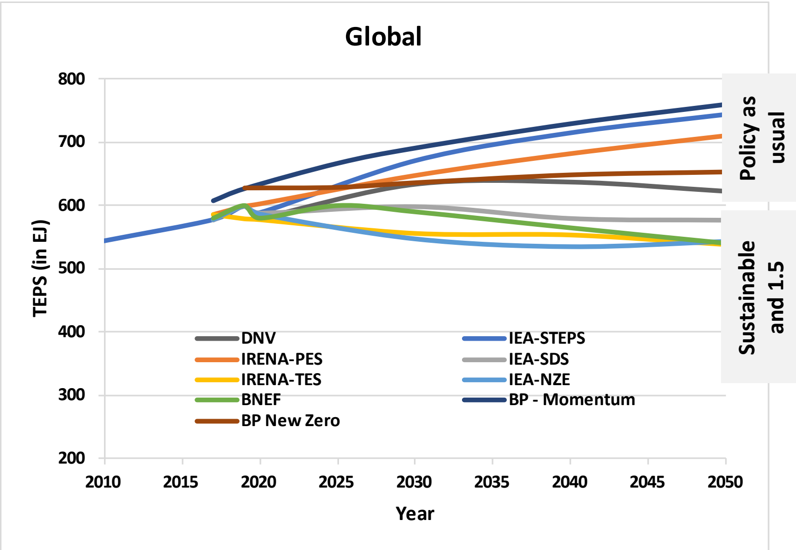
Bloomberg annually presents long-term scenario analysis in its New Energy Outlook series. The latest New Energy Outlook 2021 presents three ‘net-zero’ scenarios: the *Green scenario* (based on green hydrogen and renewables), a *Grey scenario* (allowing for some continued use of fossil fuels alongside the increasing use of electricity and renewables with significant carbon capture and storage) and, unique among the scenario builders, a *Red scenario* (with an important role of small, modular, nuclear plants).

BP Energy Outlook is also an annual series, to which Energy Outlook 2022 is the latest addition, presenting three pathways, we the *New Momentum, Accelerated* and *Net Zero* scenarios.

Recently published, *DNV’s Energy Transition Outlook 2022* describes a ‘policy-as-usual’ (e.g., a continuing role of traditional biomass and SDG-7 goals not achieved) with ‘sustainable’ elements (e.g., role of electrification and renewable sources). Detailed data can be downloaded. The outlook also gives hints for a net-zero future.

The different scenarios elaborated by the various organizations may be difficult to compare at first look, having different names and based on different assumptions regarding economic growth and energy supply and demand.

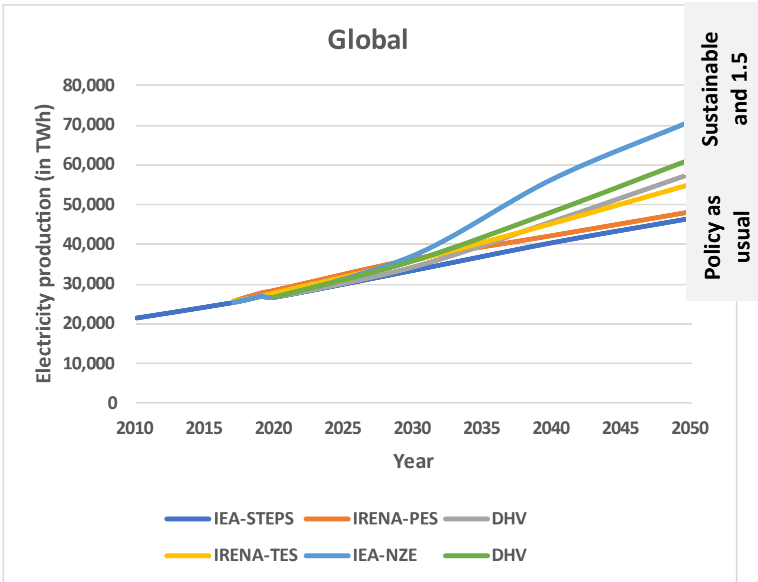
Exhibit 17 ‘Planning-as-usual’ scenarios vs. ‘green’ (sustainable and /net-zero’) scenario: global analysis

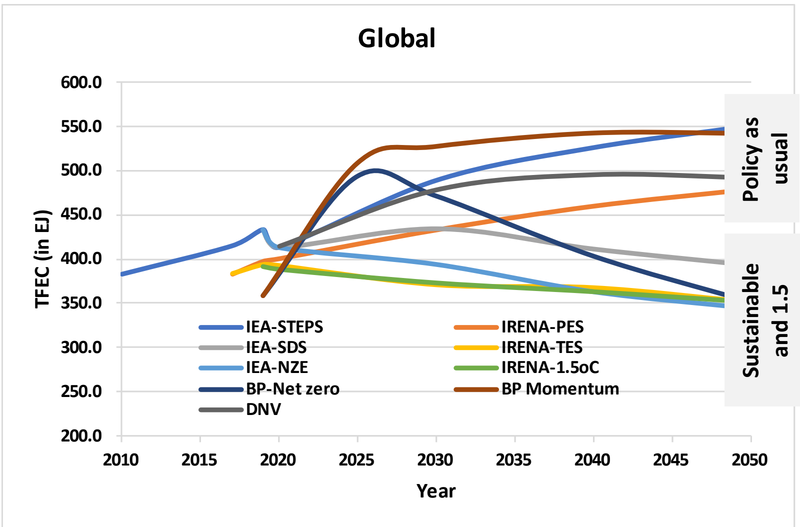


The IEA-STEPS (*Stated Policy Scenario*), BP *New Momentum, DNV* ETO (Energy Outlook) and IRENA-PES (*Planned energy scenario*) go beyond ‘business-as-usual’ trends but do not take for granted that governments will reach all announced goals, neither on universal energy access nor on climate objectives. There is limited energy efficiency improvement and limited penetration of renewables in the primary energy supply. In this report, these IEA and IRENA scenarios are referred to as ***“policy-as-usual’ pathways*** (the blue and red lines, in the figure on the left).

In the IRENA-PES, the TPES (total primary energy supply) increases from 586 exajoules (EJ) in 2017 to 710 EJ in 2050 with a modest increase in the share of renewables from 17% to 27% in 2050. Similarly, the IEA-STEPS, sees an increase from 589 EJ in 2020 to 744 EJ in 2050 with a renewables’ share of 26%.

Although in absolute terms, the renewable energy supply almost triples (from about 65-75 EJ in 2017-20 to 190 EJ in 2020) as does the contribution of natural gas (from 142 EJ in 2020 to 176 EJ in 2050), the share of oil remains high as does the role of coal (the modelling foresees a sharp decline in industrialized countries in the use of coal but continued importance in other parts of the world). Important is the role of traditional biomass that only slightly declines from 24 EJ in 2020 to 17.5 EJ in 2050. Progress is made in the expansion of energy access but not universal (90% in 2030) with differences between parts of the world (IEA-STEPS). In the BP New Momentum, energy supply increases to 760 EJ (with 39% share RE in 2050) from 627 EJ (and 18% RE in 2019). In comparison with other scebarios, BP attributes a low value to traditional biomass, resulting in lower overall energy demand.

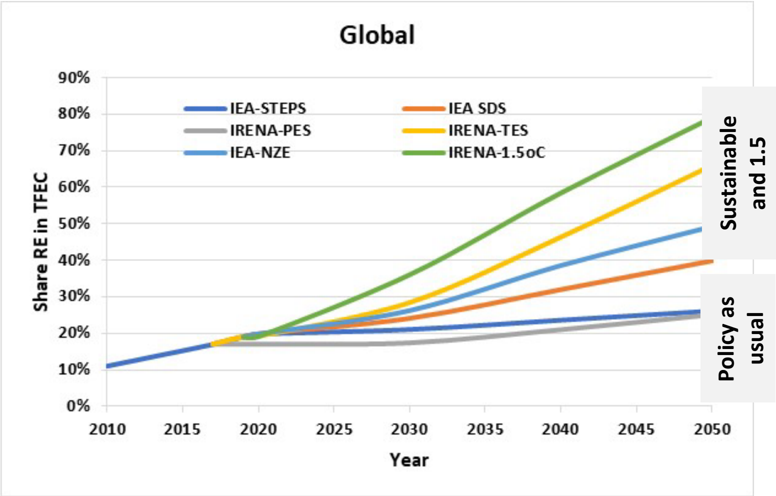




In absolute terms, there is a difference between IEA-STEPS and the lower figures of IRENA-PES and BNEF (IEA: 433 EJ in 2019, IRENA: 384 EJ in 2017 with IEA: 550 EJ in 2050 and IRENA: 488 EJ; BNEF: 415 EJ in 2019). Part of this difference can be attributed to the reliability of data on (traditional) biomass consumption and different assumptions on energy intensity in the scenarios. The base case sees a modest increase in the share of electricity in total **final energy consumption (TFEC)** from 19% in 2019 to 26% in 2050 (IEA-STEPS). The role of renewables in TFEC also modestly increases from 17% to 25% (IRENA-TES), which is largely the impact of the increased penetration of renewables in power generation from 32% in 2017 (IRENA; 36% in 2019, IEA) to about 66-59% of electricity generation in 2050. In BP analysis, energy demand increases and then stabilizes after 2030.

Exhibit (cont'd) 'Planning-as-usual' scenarios vs. 'sustainable/net-zero' scenario in IEA and IRENA work: global analysis

The ***'sustainable' pathways*** in the IEA and IRENA scenario work are in accordance with the Paris Agreement goals of limiting temperature increase to 2°C (or less). The sustainable development scenarios of IRENA *(Transforming energy scenario, TES)* and IEA *(SDS, Sustainable development scenario)* see energy access achieved by 2030, a substantial drop in use of traditional biomass, a higher share of renewables (in particular solar and wind) with substantial energy efficiency improvements. Despite population and economic growth, the TPES actually decreases to 577 EJ in IEA-SDS and 538 EJ in the IRENA-TES. Characteristics of the scenarios can be summarized as follows:



- Energy efficiency increases so that the energy intensity (energy use per GDP) declines. While the population grows, TFEC in 2050 is actually less than in the 'policy-as-usual' scenarios: 344 EJ in the IEA-SDS and 352 EJ in IRENA-TES. In the IRENA scenarios, TFEC declines by 8% in 2050 (while increasing by 24% (compared to 2017/18), in the PES)
- The share of electricity increases from 17% (2017-2020) to 40% in the IEA-SDS and 49% IRENA-TES, due to universal energy access (achieved by 2030), climbing up the energy ladder of the newly electrified, as well as increased electrification of transport (electric vehicles) and other sectors Incl. industry)
- The share of renewables in the electricity mix increases more aggressively to 78% in the IEA-SDS and 90% in the IRENA-TES.
- The combined effect of increased direct renewable use and penetration in the power mix makes the share of renewable increase from 16.5% in 2017/18 (of which, 5% RE in electricity, 5% modern biomass and other RE, and 7% traditional biomass) to 66% in 2050 in the IRENA-TES scenario (42% RE in electricity, 16% modern biofuels, 6% direct RE use).

More ambitious **'net zero'** scenarios have been formulated (IEA-*Net Zero; NZE*) and IRENA *1.5°C scenario* to reflect recent net-zero pledges done by an increasing number of governments at international climate fora. These go beyond the sustainable scenarios with an even more aggressive penetration of renewables in the energy mix (TPES) of 69-76% (IEA, IRENA respectively) together with energy efficiency improvements and even higher electrification of economic sectors with expanded hydrogen use (see section 3.3.4 on hydrogen) and/or more advanced use of carbon capture and storage (to offset emissions from fossil fuels). TFEC slightly decreases (IRENA, 1.5; 351 EJ in 2050 and. (344 EJ in 2050; IEA-NZE). In the BNEF scenarios final energy demand increases from 415 EJ in 2019 to 391-395 EJ in 2050 (Green and Grey scenarios respectively).

Bloomberg's (BNEF) two 'net-zero' scenarios most clearly distinguish between two pathways that both lead to 'net zero' emissions by 2050; the Grey scenario allows fossil fuels (natural gas and even coal) to continue to play a significant role but with substantial use of carbon capture and storage (CCS) in power generation and the end-use economy to compensate for the GHG emissions. BNEF's Green scenario comes with expanded use of electricity in transport (electric vehicles), heat pumps and lower-temperature industrial processes, combined with the expanded use of hydrogen and derivative fuels in industry (high-temperature processes) and transportation. In the case of *BP scenarios,* global energy supply decarbonizes mildly in the *New Momentum* and more profoundly in the *New Zero* scenarios. While the share of fossil fuel drops from 78% in 2019 to 19-58% in 2050 (depending on the scenario), the share of renewables increases from 14% in 2019 to 36-74% by 2050.

Whatever the assumptions behind the scenarios and estimated values by 2050, the scenarios show the **four pillars** of the coming global energy transitions:

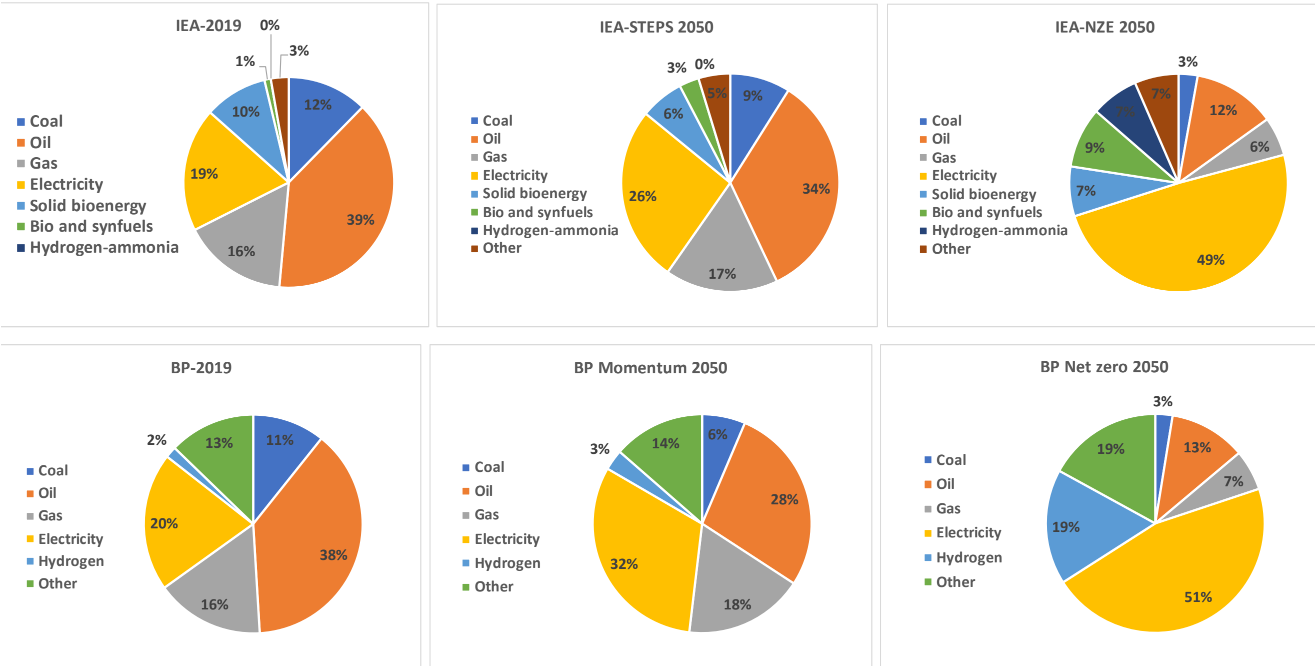
- *Energy demand:* energy intensity decreases and more sectors use electricity in their energy mix (thus, the relative share of electricity in energy supply increases)
- *Universal energy access:* SDG-7 goals on electricity access and clean cooking fuels (with a related drop in traditional wood fuels in the residential energy mix)
- *Increased use of renewable energy and fuel switching:* fossil fuels' share drops and, within fossil fuel, gas becomes the most important energy carrier).
- *Emerging role of new technologies* (hydrogen and derivative fuels) and modern biofuels and synthetic fuels increase

Figures: own elaboration data compiled from IEA, BP, BNEF and IRENA sources (websites, downloaded Excel sheets) and publication.
TPES: total primary energy supply; TFEC: total final energy consumption. EJ: exajoules

Regarding ‘Africa’, IRENA modelling and regional aggregation the focus is on Sub-Sahara Africa, while the geographical focus in the IEA reports is on the continent as a whole (i.e., including North Africa). Despite the differences, the IEA IRENA and BP scenarios based on existing or planned commitments (STEPS, PES, New Momentum) are quite similar (with limited penetration of renewables in the energy mix, and not fully achieving 2030 energy access and 2050 greenhouse gas emission reduction). These are referred to in this report as ‘**policy-as-usual scenarios**’. These are not ‘business-as-usual’, that is, they do move away from the baseline energy and greenhouse gas emissions trends, as increasingly policies and measures get implemented, but not enough to reach the universal energy access goals and not enough to achieve the Paris Agreements' target.

Exhibit 18 Composition of global final energy consumption in 2050 in IEA and BP scenarios

The greener the pathway, the more pronounced the role of renewable energy as direct energy carrier and electricity in final energy demand, illustrated by comparing the IEA Sustainable Development (SDS) and Net Zero scenarios (NZE) with the BP New Momentum and Net Zero and the current situation (2019). As indicated in Exhibit 23, also electricity will become greener.



Source : own elaboration, using data compiled from IEA, BP and IRENA sources

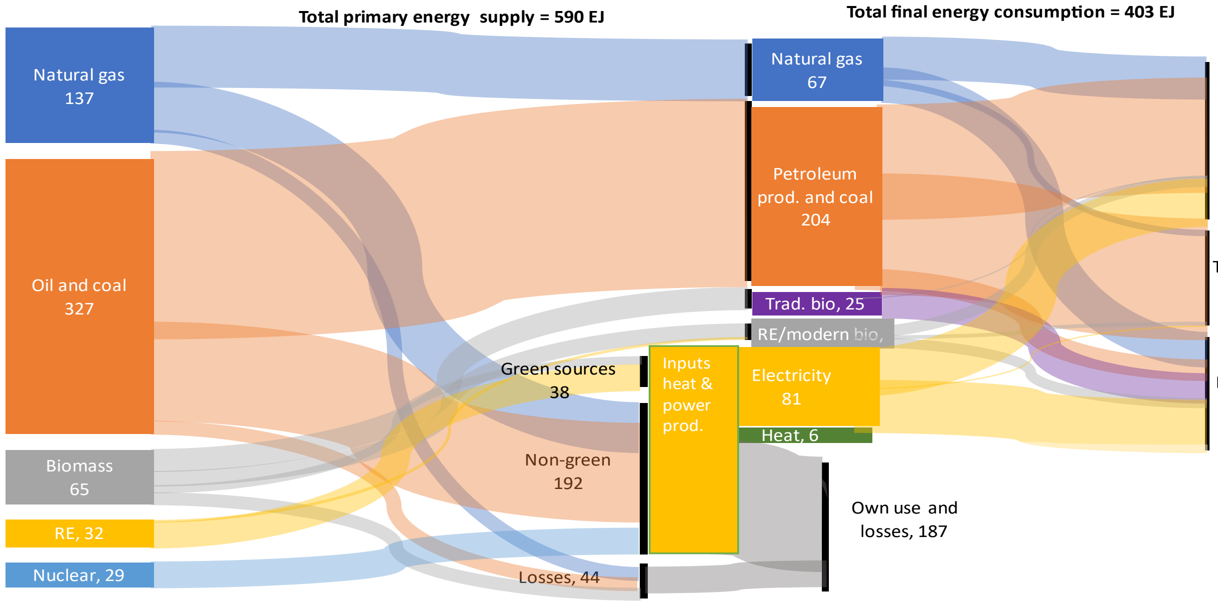
The **‘sustainable scenarios’** (such as IEA’s SDS and IRENA’s TES) have similarities in terms of achieving the universal access goals by 2030 and a mix of transformational elements (higher share of renewables in power generation and fuels; increased penetration of new energy technologies, such as electric vehicles and hydrogen as energy carriers, with a more energy efficiency and penetration of CCS) to achieve a low-carbon future (that is, in line with the Paris agreement target of less than 2ºC increase).

As a greener variant, most organizations now formulate **‘net-zero’ pathways** (meaning achieving ‘net’ zero emissions by 2050 in order to reach the maximum 1.5^{0}C temperature increase by 2050) that see a more pronounced penetration of one or more of these transformational elements in comparison with the low-carbon ‘sustainable scenarios’. An overview of the similarities and differences between the various scenarios and pathways designed by international organizations (IEA, IRENA) and private organizations (BNEF and BP) is presented in Exhibit 17 and Exhibit 18.

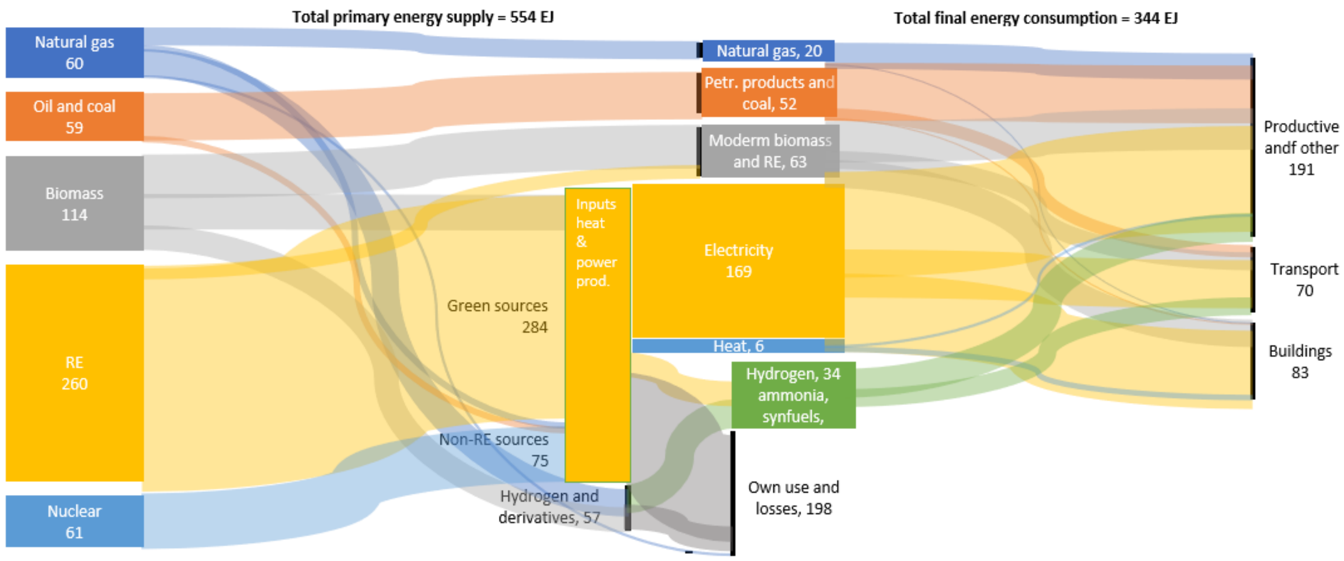
Exhibit 19 Visualisation of the energy flows in the global energy transition towards 'net-zero'

The Sankey diagrams below gives the energy flow from primary supply sources, fossil fuels, renewable energy (RE), biomass and nuclear, to energy consumption in the buildings sector (residrntial, commercial, public), productive sectors (industry, agriculture and non-energy uses) and transport

World energy supply and demand, 2020



World energy supply and demand in 2050 (IEA Net-Zero pathway)



Differences in the 'net zero' energy balance in 2050 as compared to the current world energy balance are:

- Despite the world having a higher GDP and population in 2050 than in 2020, final energy demand has not increased (due to higher efficiency in eneegy end-use, not shown in the diagram)
- Much higher share of electriicity in energy consumption (as compared to fuels)
- Predominant role of renewable sources (solar, wind, hydropower, geothermal, bioenergy) in electriicty generation
- Inefficient use of biomass in traditional cooking and other end-uses has stopped
- The use of fossil fuels has declined. Not shown in the diagram is the assumption in the IEA of production of natural gas with carbon caprture utilisation and storage (CCUS), 43 EJ. In 'oil and coal' the role of unabated coal is small (3 EJ) and coal with CCUS is 14 EJ.
- Hydrogen and derivates and synfuels are playing a notable role as energy carrier

Source: own elaboration, using data compiled from IEA Net zero

3.3 Main elements of energy transition in Africa

3.3.1 *Changing energy consumption and electrification*

Energy supply and demand in buildings, transport, industry and other sectors

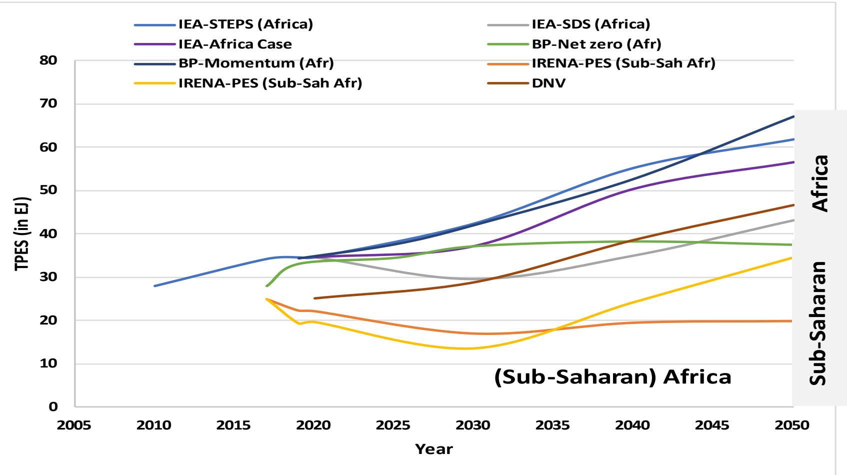
In the ‘policy-as-usual’ scenarios, total primary energy supply (TPES) will increase as the population grows and the economy expands. In the ‘sustainable’ scenarios, TPES will actually decrease in Sub-Saharan Africa, depending on the role of solid biomass in energy demand. In the ‘sustainable’ and ‘net zero’ scenarios, the traditional use of solid biomass (i.e., fuelwood, waste and charcoal burned in three-stone fires and basic inefficient stoves) is eradicated completely by 2030 with the achievement of full access by households to clean cooking. The net effect (see Exhibit 20) is that TFEC decreases with a similar effect on TPES, given the relatively large share of wood fuels in the energy mix.

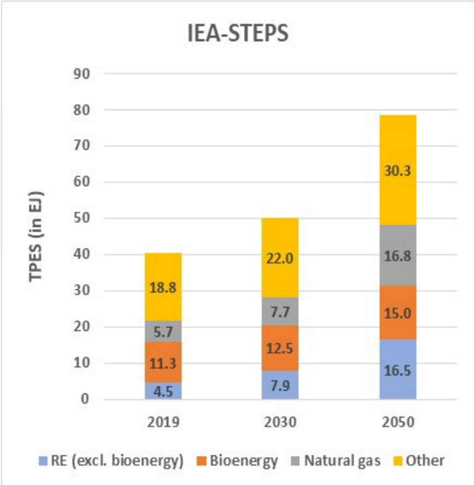
In contrast to this trend, the consumption of modern fuels will rapidly increase because the growing, more urbanized and overall wealthier population will consume more fuels (e.g., in the residential sector for cooking, and for transportation), for process heat in industry and electricity (in industry and residential sectors).

In Sub-Saharan Africa, there are thus two energy demand transitions. One is from traditional fuel-use methods to employing modern fuels. The second energy demand transition follows the global trend of decarbonization.

Exhibit 20 Primary energy supply pathways

Africa (IEA scenarios):

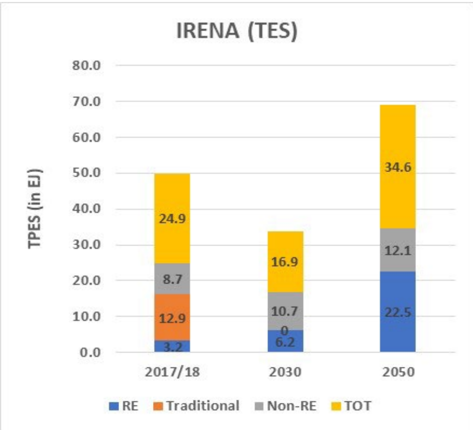


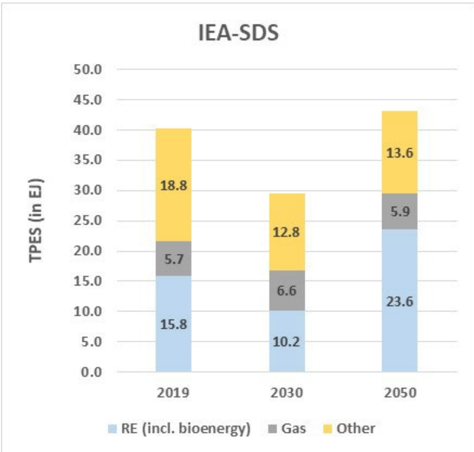


Sub-Saharan Africa (IRENA):

Note that the IRENA (TES) assumes different demand growth than the IEA-SDS and should not be regarded as a subset of the Africa-wide IEA scenarios. The purpose of the graphs is to show the increasing penetration of renewable energy and diminishing role of traditional fuels.

TPES: total primary energy supply. EJ: exajoule

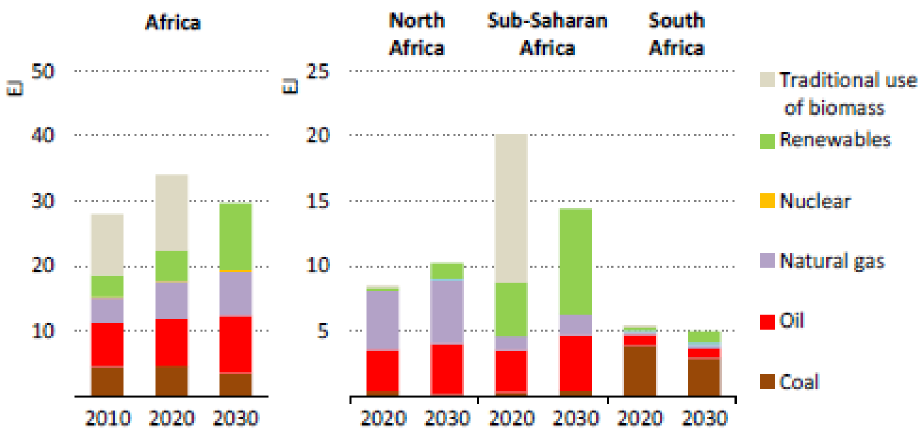




Source: own elaboration, using data compiled from IEA, DNV, BP and IRENA sources.

This transition will take place within the modern fuels with a 'green' transition with high energy efficiency, increased electrification sectors and penetration of renewable energy replacing fossil fuels in electricity, heat and transport applications. These trends may not necessarily be the same in all regions of Africa (see Exhibit 21).

Exhibit 21 Subregional differences in primary energy supply in 2030



Source: IEA (2022), figure 2.4.

Graphs present IEA's Sustainable Africa Scenarios, a variant of the Sustainable Development scenario. EJ: exajoules

In IEA's sustainable scenario SAS (a type of SDS, adapted to Africa), trends to 2030 are very different across the three main African regions in the SAS. Although modern renewables grow fastest everywhere, oil and gas continue to dominate energy use in North Africa and coal dominates in South Africa, due to the local availability of low-cost resources, while renewables become the dominant fuel category in sub-Saharan Africa. Overall primary energy use per capita declines in Sub-Saharan Africa, but modern energy use per capita increases to around 10 gigajoules (GJ) in 2030. In North Africa, per capita use of modern fuels increases to 44 GJ, but as in Sub-Saharan Africa, remains well below the current global average of 70 GJ, 100 GJ in China and 120 GJ in the European Union[64]. In North Africa, where car ownership rates are almost ten times higher than in sub-Saharan Africa, total final consumption will continue to be led by transport. In South Africa, industry remains the leading end-use sector, though transport demand will relatively grow faster than industry. In sub-Saharan Africa (excluding South Africa), households remain the biggest sector but the relative importance of industry and transport in overall energy demand increases.

High population growth and economic growth with higher living standards will inevitably increase demand for energy in a 'business-as-usual' development. Industrial expansion requires more infrastructure, materials and energy than is produced today. The population will not only increase but also become more urbanized and income levels will increase. Demand for lighting, electric appliances and cooling will imply a significant electricity consumption growth (in residential, commercial and public buildings). For example, ownership of air conditioners will jump by around 17 million to 40 million and electric fans by 110 million to around 340 million over 2020-30 in IEA's Sustainable Africa scenario (SAS)[65]. Thus, power demand for lighting and appliances will grow sixfold and demand for cooling more than tenfold by 2040.

Similarly, energy demand for transport will rise. The before-mentioned IEA Sustainable Africa scenario counts with a 40% energy demand rise over the coming decade. Most of the scenarios of IEA, IRENA and others consider a large expansion of the car fleet (currently Sub-Saharan Africa, excluding South Africa, has the lowest per capita

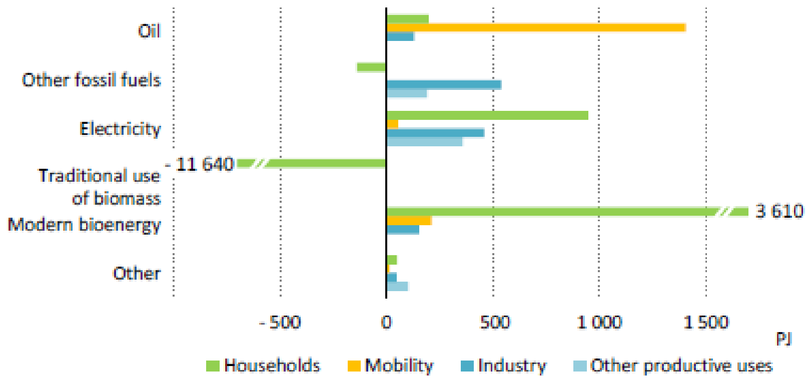
64 IEA (2022)

65 IEA (2022)

car ownership in the world). The increase in road transport will imply higher demand for oil products (gasoline and diesel account for 99% of road fuel consumption today[66]).

The demand is not only influenced by the number of cars, but also by the state of the cars. They account for over 50% of all new registrations across the continent today, despite an import ban in some countries. In some countries, over 80% of cars for personal transport are used cars imported from Japan and Europe which no longer meet emissions standards in those countries. Currently, more than half of African countries do not impose any restrictions on second-hand vehicle imports, while for those that have set restrictions, half of them apply age limits of between 8-15 years.[67]

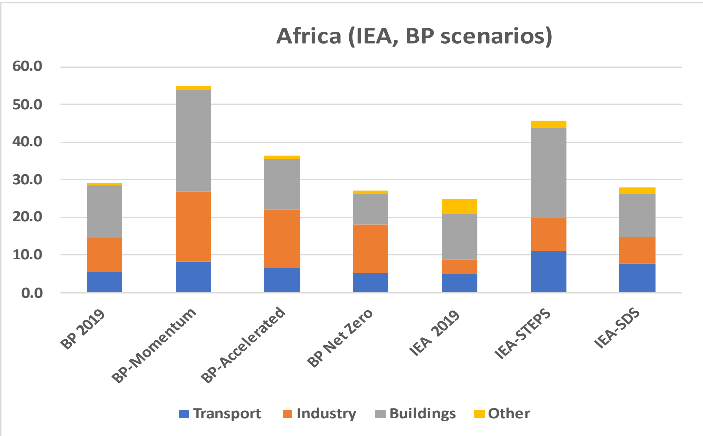
Exhibit 22 Changes in energy consumption per fuel and sector in 2030 in IEA SAS scenario



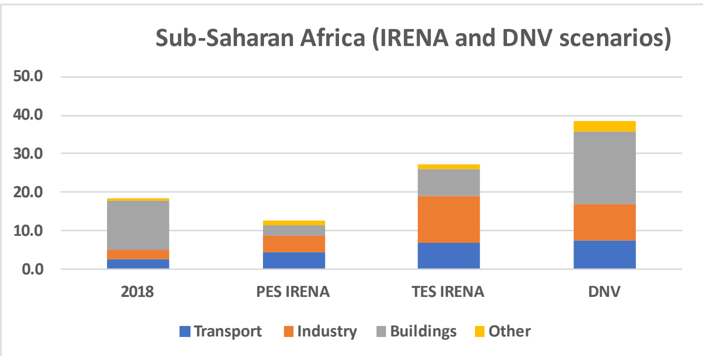
Source: IEA (2022), figure 2.7.

The data are from IEA's Sustainable Africa Scenarios, a variant of IEA's Sustainable Development scenario, and compares energy demand in 2030 with 2020

Exhibit 23 Final energy consumption (TFEC) in 2050 according to different scenarios



Source: Own elaboration, using IEA, IRENA and BP data



Increased industrialization means more transport of raw and finished goods, leading to higher demand for freight vehicles, rail, navigation and aviation. The new African Continental Free Trade Agreement will stimulate improved connectivity between countries to facilitate goods transport from regions of production to major commercial centers and ports.

The agriculture, industry and services sectors are all set to increase their energy demand, in particular in Sub-Saharan Africa. The light industries sub-sector is characterized by a strong degree of electrification often located near urban centers with electric grid access) and need for low-temperature heat. As agriculture will get mechanized demand for oil and electricity will increase.

Regarding heavy industry, Africa's per capita use of construction material currently is a small fraction of the global average, and most is imported. However, with Africa's rapid urbanization there is a significant opportunity to

[66] Ibid.

[67] IEA (2019), p. 93

produce cement and steel for the domestic market. Cement and steel are energy-intensive industries that require high-temperature heat and the share of natural gas is projected to significantly increase.

Energy efficiency

The impact on energy consumption is mitigated to some extent by energy efficiency measures. Actions to unlock energy savings in the building sector include renovating buildings, introducing stringent energy efficiency codes to reduce the use of fossil fuels in buildings; higher minimum energy performance standards (MEPS) for appliances and cooling systems with energy labelling to shift the sales of appliances to more efficient models and efficient lighting (e.g., 100% usage of light-emitting diodes, LEDs) and deploying building energy management systems.

Such measures will bring about some decoupling of electricity demand with growth in the buildings sector. Thus, in 'sustainable scenarios', average consumption per household will actually fall. Many measures mentioned are already being implemented; 40% of African countries have adopted mandatory MEPS for cooling equipment or are planning to do so, and around 20% for refrigeration[68] (see also Exhibit 57 in Chapter 5 for an overview of the status of appliance standards and building code regulation).

The fuel economy of cars can be improved by more stringent vehicle, efficiency policies and regulations, notably on the second-hand market. Africa relies heavily on imports of second-hand vehicles. For example, one practical solution is ensuring a uniform age limit on imported cars across all African countries and to ban the import of cars that do not meet minimum emissions standards. The IEA estimates that this would lead to an improvement in the average fuel economy of car registrations in Sub-Saharan Africa by nearly 15% compared to the current average[69]. The 'sustainable energy' scenarios include lower energy intensity (a measure of the energy efficiency) assumptions in transport then the 'policy-as-usual' pathways.

Biofuels account for less than 0.1% of transport energy use in Africa today, but there is strong potential for growth. The market grew 5% in 2018, mainly led by South Africa and Nigeria[70]. The potential for the production of advanced biofuels in many African countries is enormous, thanks to the size of the continent's agricultural sector. Many countries are considering mandates for boosting the use of biofuels in the transport sector, with the most popular mandates being ethanol blending rates of 5% or 10% (more on blending mandates in section 5.2; see Exhibit 57). IEA includes a modest increase in biofuels for transport by 2030 in its Sustainable Africa scenario[71]. IRENA's analysis for 2030 sees a production of biodiesel and ethanol increase to about 3 billion and 9.8 billion liters, respectively, by 2030, that is, an energy potential of 1.3 EJ of biodiesel and 2 EJ of ethanol (together 2% of transport energy demand in Africa). This will be part of a global trend that will see renewable transport liquid fuels increase from 130 billion liters (in 2019) to 370 billion in 2030 and 650 billion liters in 2050.[72]

Increased electrification of energy end-use

One important aspect of the energy transition, both globally as well as in Africa, will be the advancing electrification of the economic sectors, in the buildings, productive and transport sectors. The 'sustainable energy scenarios' of IEA, IRENA and others assume a limited application of electricity in transport in comparison with the average global pathways. With millions of Africans not having access to electricity at all, while the power systems are struggling to provide reliable power to those that are connected, it seems a long shot to expect a large-scale penetration of electric cars in the coming decades. However, electrification is likely to occur in the subsector of two/three-wheelers and some buses. In IEA's SAS scenario, the sales of electric two/three-wheelers in Africa will reach 1.2 million in 2030, accounting for around 35% of all such vehicle sales[73].

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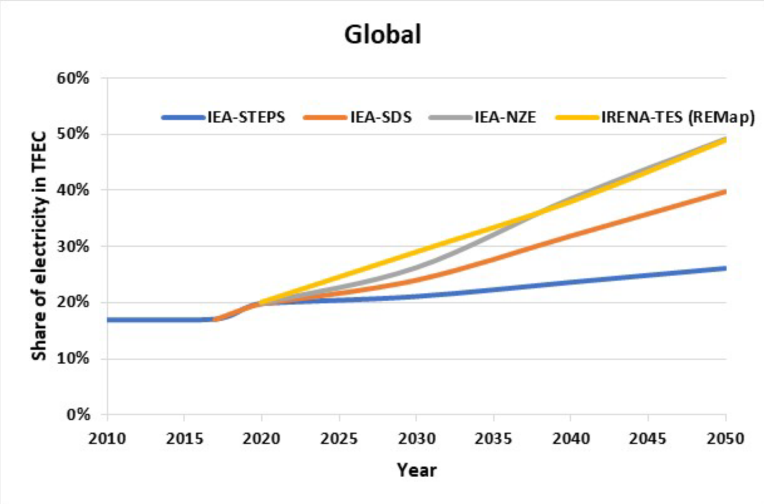
68 IEA (2022)
69 Ibid.
70 IEA (2019)
71 Ibid.
72 IRENA (2019)
73 IEA (2022)

Exhibit 24 Global electrification of energy demand

The share of electricity in global final energy consumption has been steadily proceeding from about 11% in 2010 to around 17-20% in 2017-2020 (IEA/IRENA data). In 2020, the share of electricity in the global energy demand of 22.9 terawatt-hours (TWh) was about 20%, of which was in the buildings sector, 9% in industry and 0.4% in transport. In the IEA STEPS ('policy-as-usual' scenario) electrification will proceed in the coming decades at the current pace.



In the 'sustainable' and 'net-zero' scenarios, replacing fossil fuels with electricity is one of the most important drivers of greenhouse gas emission reduction, because electricity generation gets more and more low-carbon. In the 'net zero 'scenarios of IRENA and IEA, the share of electricity in final energy consumption (TFEC) increases by 250% by 2050 in comparison with the current share.

Much of the increase will take place in transport and industry. In transport, the share of electricity in transport will dramatically increase from 2% in 2020 to about 45% in the IEA-NZE pathway (IEA, 2021b). While today there are about 6 million electric vehicles, in IRENA's sustainable pathway there will be 1166 million (IRENA, 2019).

By 2050, almost all vehicles will be electrical (including 25% of trucks, with most of the other vehicles hydrogen-powered). The growth of the electric vehicle park translates into increasing demand for critical minerals. For example, demand for lithium for use in batteries grows 30-fold to 2030 and is more than 100-times higher in 2050 than in 2020 (IEA, 2021b). In industry, there will be increasing use of electricity in scrap-based steel production and in low- and medium-temperature heat. Heat pump applications in productive uses and buildings increase from 20 million today to 334 million in 2050 in the IRENA clean pathway. In buildings, on one hand, electricity demand will be attenuated by a huge push to improve the efficiency of appliances, cooling, lighting and building envelopes in the 'sustainable' scenarios, but on the other hand, fuel switching away from fossil fuels and use of heat pumps imply steady electrification of the sector in the coming decades.

Apart from these direct uses of electricity, there will be a huge increase in the indirect use of electricity by means of electrically produced hydrogen (and derivative fuels, such as ammonia and methanol). In the IEA and IRENA scenarios, the share of direct electricity use will be around 50% in 2050. If the e-fuels (hydrogen-based carriers) are added, direct and indirect electricity use will make up about 58% of final energy demand in 2050 (IRENA, 2019)

In industry, electricity demand increases at an annual average of 6% in IEA's 2019 Africa case scenario, which is a third faster than the rate of growth of total industry sector energy demand. Much of the growth comes from the use of electric motors in processing, manufacturing and other light industries. Agriculture will get more mechanized with increased use of electric pumps in irrigation, cold storage and mechanization of other tasks in agricultural production and processing.

The increase in residential electricity demand stems partly from better access to electricity (the 'sustainable' scenarios assume universal access by 2030) and increased ownership of appliances due to wealth increase. As income levels increase across Africa, households increasingly own appliances such as refrigerators, washing machines and phones: the wealthier ones also own cooling devices anis even more appliances. The services and commercial buildings sector will follow suit with a growing demand for cooling and appliances.

Energy access

As discussed in the preceding section, the power demand will grow dramatically, in particular in the residential sector. In the 'sustainable scenarios', the increase in residential demand due to better access to electricity (100% access) and increased ownership of appliances is partially offset by efficiency gains, but demand will still almost

Exhibit 25 Residential power demand

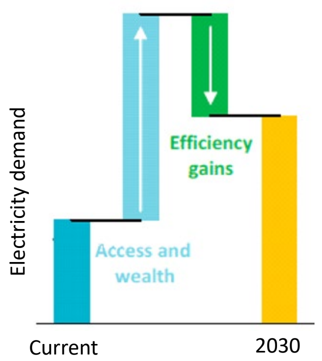


Figure adapted from IEA (2019)

double (see Exhibit 25). Apart from rising incomes, rising access will drive up electricity demand in Sub-Saharan Africa, not only for lighting but also for small appliances (refrigerators, TVs, high-efficiency cookers).

Bringing access to power will also benefit schools, health facilities, small businesses and public offices in the newly electrified areas. If realized, universal access to electricity in rural areas of sub-Saharan Africa (excluding South Africa) results in an additional 210 TWh of electricity demand by 2030, pushing household electricity demand to almost 500 TWh[74].

For Sub-Saharan Africa (most of North Africa is connected) reaching universal access by 2030 means that about 755 million new connections to the grid or through off-grid systems need to be provided[75]. Grid extension will not be sufficient to achieve the target, only providing 42% of connections in the IEA-Sustainable Africa pathway (IEA, 2022). In many areas, the least expensive way to achieve universal electricity access is with minigrids (31%) and stand-alone PV (27%), mostly powered by solar energy or other renewable sources. Including the part of main grid electricity generated by renewables, about 71% of the energy for the new connections by 2030 will be generated by renewable resources.

Looking beyond 2030, many of the households that gain first-time access through mini-grids and stand-alone systems are eventually connected to a grid, with off-grid systems, especially mini-grids, becoming integrated into it the main network[76]. Only the most remote settlements still lack a grid connection in 2050. In this process, households will increase their demand from a low level per capita (Tier 1 or 2) to higher levels (Tier 4 or 5; Exhibit 51). The relationship between electricity access and priorities such as local development is an important element of the SDGs. The vast majority of rural households in Africa rely on agriculture and integrating agricultural needs such as irrigation, agro-processing and storage into the design of electricity access business models and technologies can have a very positive development impact.

The number of people without access to clean cooking in Sub-Saharan Africa is set to see a net increase by this decade, rising from 940 million in 2020 to about 1.1 billion in 2030. This implies that to achieve universal access about 130 million people need to gain access to clean cooking (including 80 million from rural areas) each year between 2022-2030[77]. However, the successful switching to modern cooking techniques and fuels will actually reduce the total amount of energy needed for cooking substantially and the share in total household demand will drop from almost 90% to 60-70%.

The type of clean cooking method depends on the availability of biomass and liquefied petroleum gas (LPG) in different regions. Overall, LPG is the most cost-effective means to access clean cooking in more than half of all cases, with most of the rest moving to improved and more energy-efficient biomass cookstoves. This is generally the cheapest and most practical means of providing clean cooking as it avoids the need to switch fuels and build new supply infrastructure. In the IEA 'sustainable scenario', one-third of the people gain access via liquefied petroleum gas (LPG), 10% via electricity, 10% via biogas from biodigesters and 6% via ethanol[78]. It is worth mentioning that with the fossil fuel price hikes of the past years, the price of LPG cylinders has gone up forcing some households to revert to traditional biomass cooking. It can be expected that the use of LPG will grow rapidly

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74 IEA, Sustainable Africa secanrios (SAS) in IEA (2022)
75 IEA (2022)
76 Ppotentially improving the reliability of the electricity network, provided the quality has imporved in such a way it cann handle a large range of small producers (often with variable renewable energy sources)
77 IEA (2022)
78 For urban areas, LPG represents the easiest and quickest clean cooking solution, accounting for half of the people gaining access in urban areas by 2030, followed by electricity (20%). In rural areas, improved biomass cookstoves represent around 60% of the people gaining access, LPG around 20% and biogas from biodigesters around 10%. IEA (2022)

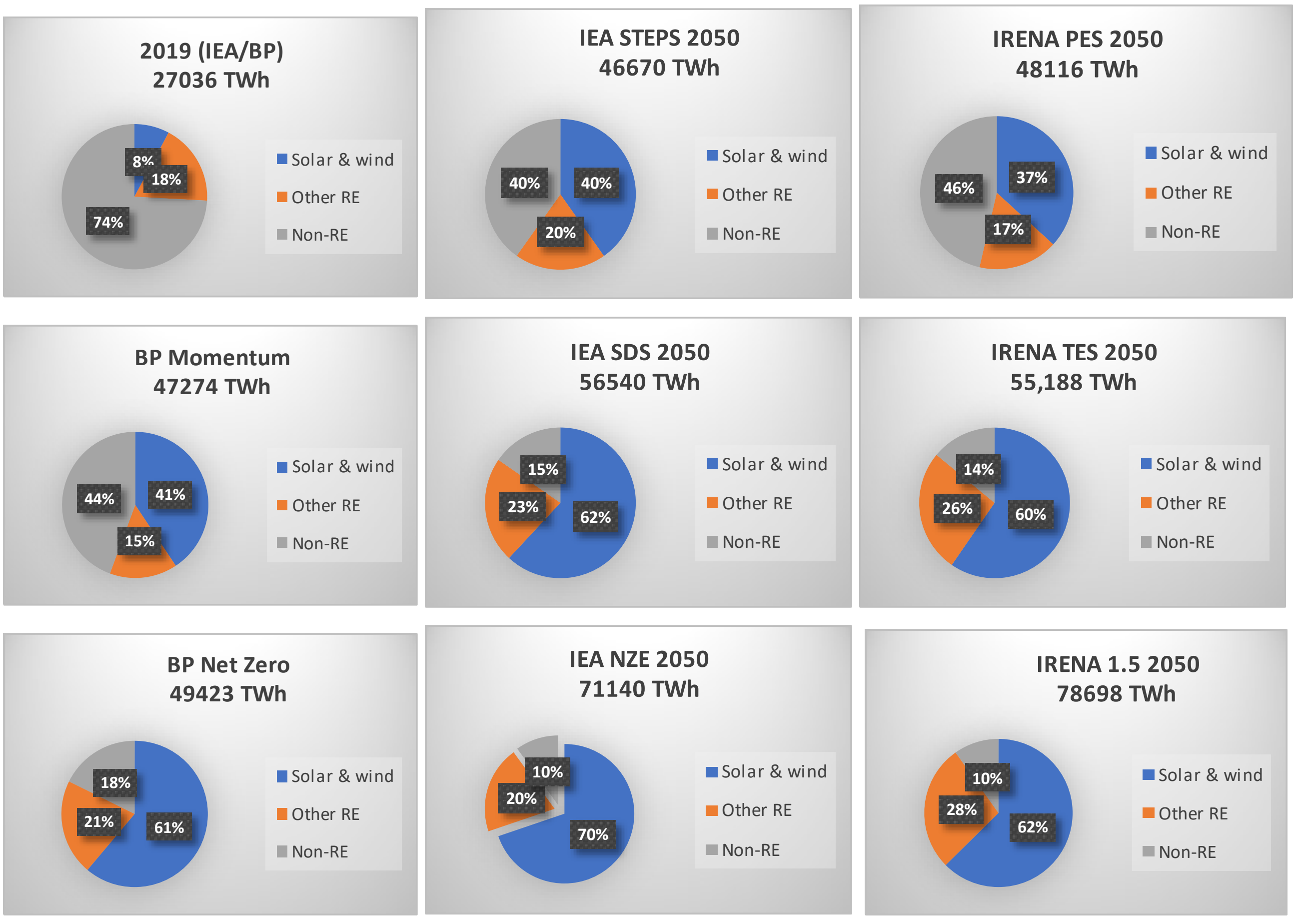
to 2030, and thereafter will slowly decline as households switch to electricity, a process starting with urban households initially). The role of LPG as cooking fuel in Ghana and Nigeria is the subject of the In Focus 6).

Exhibit 26 The increasing dominance of renewable electricity in global energy supply and demand

In the 'policies-as-usual' scenarios, installed power capacity will continue to grow modestly to about 10.0-11.1 TW in 2030 (IEA-STEPS; IRENA-PES) and 14.7-18.8 TW in 2050, with shares of RE of 54-52% (IEA-STEPS, IRENA-PES) in 2030 and 66-69% in 2050. In the 'sustainable' scenarios, the power generation expands more rapidly with a much larger level of decarbonization. In the IEA TES to 12.7 TW in 2030 and 26.0 TW in 2050; in IEA's NZE to 14.9 TW in 2030 and 33.4 TW in 2050 with renewable shares of 63% in 2030 and 78% in 2050 (TES) and of 69% in 2030 and 80% in 2050. Similar figures for the IRENA scenarios are for TES: 11.3 TW (with 69% RE share) in 2030 and 19.9 TW (with 91% RE share) in 2050; and for the 1.5ºC scenario: 14.2 TW (with 76% RE share) in 2030 and 30.2 TW (with 92% RE share) in 2050.

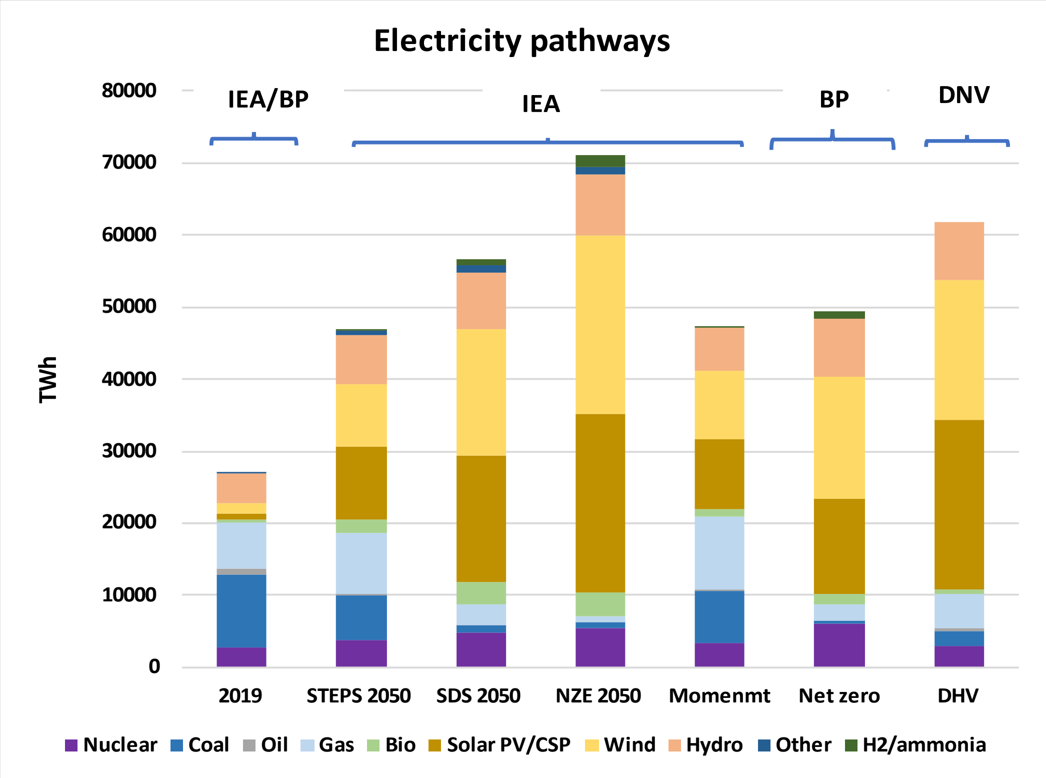
The capacity expansion allows electricity to become the main energy carrier in the total final energy consumption (TFEC). Standing at 19-20% share in 2019-2020, the share of electricity in TFEC increases to a 24-26% share in 2030 in the IRENA-PES and IEA-STEPS respectively and even 30% in the IRENA 1.5⁰C. The share of electricity in 2050 reaches and 40-49% in 2050 in the IEA scenarios (STEPS and SDS-NZE, respectively, and 50% in IRENA's 1.5ºC.

Renewables have already made impressive progress in the power sector. From generating 10% of the 2010 global power production of 21,421 TWh, their share was 25.5% in 2019 (out of total production of about 27,036 TWh (IEA/BP estimates). The total power production and share of renewable energy (solar, wind, biomass, hydro, and others) is expected to increase, depending on the pathway (policy-a-usual, sustainable or net-zero) and the assumptions taken by the scenario builders (IEA, IRENA, BP), as summarized in the figures below (for the year 2050):



Figures: own elaboration using BP, IRENA and IEA data

Exhibit (cont'd) The increasing dominance of renewable electricity in global energy supply and demand



Note: Own elaboration, using BP, DNV and IEA data. The IEA scenarios give details on fossil fuel power generation with and without carbon collection and storage (CCS) in 2050. In case of coal and gas, CCS is used with 45% and 83% of fossil fuels or power generation Iin (SDS and Net Zero scenarios) and in case of biomass, the shares of CCS used is 19% and 26% (in SDS and Net Zero pathways)

The **variable RE (VRE**), wind and solar PV will dominate the growth of renewables in the electricity sector. Even in the 'policies-as-usual' scenarios the share of solar and wind rapidly increases, reflecting the policy support in many countries and the success of solar PV and wind in becoming established as the cheapest and most competitive sources of new electricity. In the IEA STEPS, solar and wind will have grown ten-fold, for example, providing 40% of electricity production.

In the 'net zero' scenarios, such as IEA-NZE and BP-Net Zero, solar and wind electricity production will have grown 15-fold, providing 60-70% of electric energy by 2050. Hydropower, bioenergy, geothermal and concentrating solar power see smaller increases across the scenarios, as they require favourable site conditions, but, nonetheless, growth matching the pace of electricity demand. Power plants with carbon capture and storage technologies (CCS, to compensate for CO_2 emissions from biomass, gas or coal burning) are not in the STEPS or PES scenarios (being at the pre-commercial stage still) but start to make inroads in the sustainable scenarios; the same applies for co-firing power plants with ammonia and hydrogen.

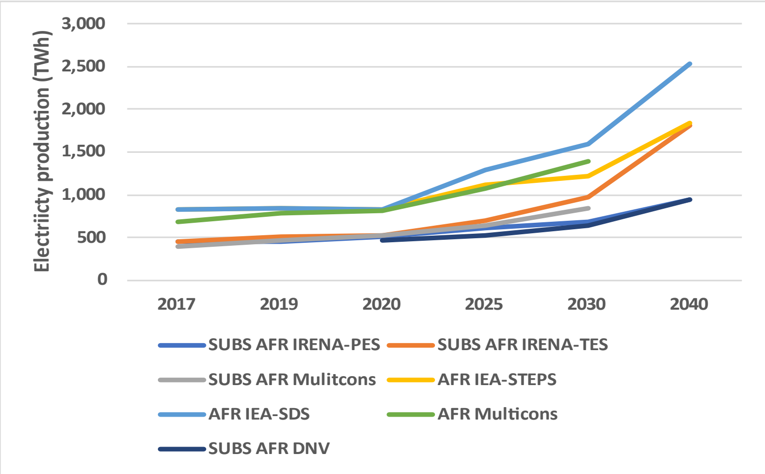
Today, thermal generators like coal and gas plants have been the main sources of electricity, providing stability and flexibility, but this is rapidly changing as their market share declines. In the coming decades, countries that are integrating variable renewable energy (VRE) at a share of over 30% will increase. Also, electrification (including road transport, heating in buildings and industrial processes) and expansion of electrolytic hydrogen production together reshape electricity demand, raising peaks and increasing variability throughout the day.

By shifting the hours when energy is consumed away from peak time, **demand-side response** helps to align demand with available supply, thereby lowering stress on the system. This has the potential to play a large role in system flexibility, but its ability to do so hinges critically on the regulations and digital infrastructure in place. On a technology level, both long-term and short-term storage will be important for adding flexibility. **Battery storage** systems have become an attractive option to address flexibility needs measured in seconds up to hours because they are capable of near-instantaneous charging or discharging to suit system needs. **Longer-term flexibility** needs can be addressed by pumped hydro, compressed air energy storage, gravity storage, hydrogen and ammonia. The amount of stationary storage (which excludes EVs) would need to expand from around 30 gigawatt-hours (GWh) today to over 9 000 GWh by 2050. Smart solutions, such as **smart charging of EV**s, can significantly facilitate the integration of VRE by leveraging storage capacity.

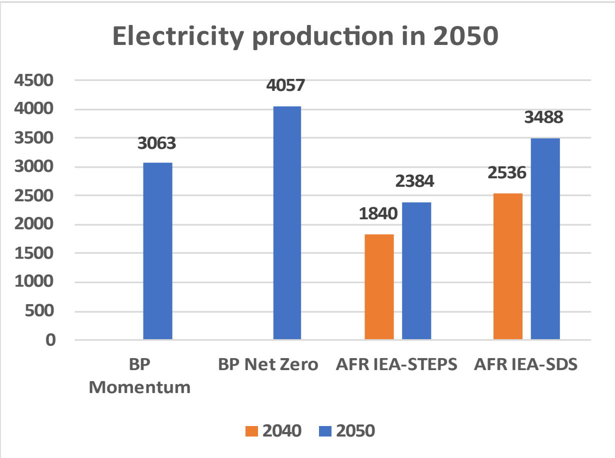
3.3.2 *Electricity*

Globally, the energy transition will be characterized by deep decarbonization of electricity production, driven by a rapid growth in solar and wind power (described in Exhibit 26) and increasing electrification of energy end-use processes (see section 3.3.1). Also, in Africa, efforts to meet rapidly growing electricity demand will lead to a significant expansion of the power system. while the structure of Africa's power sector will need to evolve rapidly to keep pace with global trends, exploiting its large renewable energy reserves, with natural gas as a bridging fuel in the electric power.

Exhibit 27 Electricity production in (Sub-Saharan) Africa



'Policy-as-usual' scenarios by IEA (STEPS: stated energy policies) for Africa and IRENA (PES: planned energy) and DNV for Sub-Saharan Africa.
'Sustainable energy' scenarios by IEA (SDS: sustainable development) and IRENA (TES: transforming energy) for Sub-Saharan Africa.
Multiconsult (AfDB New Energy Deal) scenario for 2030 for Africa and Sub-Saharan Africa with value in between the IEA/IRENA 'policy-as-usual' and 'sustainable' scenarios.
The figure below gives electricity production (in TWh) in 2050 comparison between IEA STEPS and SDS with BP New Momentum and Net Zero scenarios (for Africa). All figures own elaboration, using BP, IEA, IRENA and Multiconsult data.

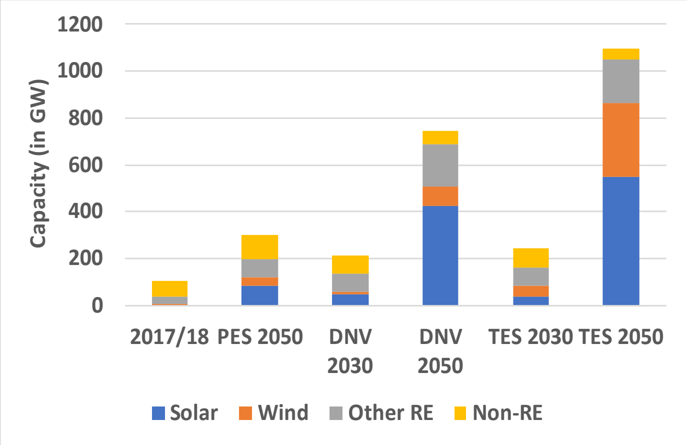


Efforts to meet rapidly growing electricity demand will lead to a significant expansion of the power system over the coming decades, in the 'policy-as-usual' and even more so in the 'sustainable' scenarios. Here, comparisons between various power sector scenarios of the various organizations are made difficult by the difference in focus areas, with IEA and BP on Africa as a whole and IRENA scenarios on Sub-Saharan Africa. Multiconsult's analysis provides details of its 2030 scenarios for each of the five subregions of Africa[79]. Exhibit 27 shows a summary view of the various pathways for Africa and Sub-Saharan Africa. Given the similarities between the institutions' 'policy-as-usual' and 'sustainable' scenarios, this report treats the scenarios as complementary, i.e., using IEA and BP scenario work to make statements about the continent as a whole and IRENA analysis when focusing on Sub-Saharan Africa.

IEA's STEPS sees power generation capacity in the whole of Africa almost triple by 2040 to reach 615 GW. In its Africa case (a variant in its Africa 2019 report with higher growth and more sustainability elements built in) capacity reach 924 GW. Electricity production will be 2,384 TWh in 2050 (STEPS), reaching 3,565TWh in the SDS (as the scenarios assumes a more the more aggressive electrification of the economy).

[79] The definition of 'North Africa' differs; in IRENA or IEA the region does include Mauretania but not Sudan, while in IRENA or AfDB definition the region doies not include Mauretania but does include Sudan.

Exhibit 28 Power sector expansion, Sub-Saharan Africa



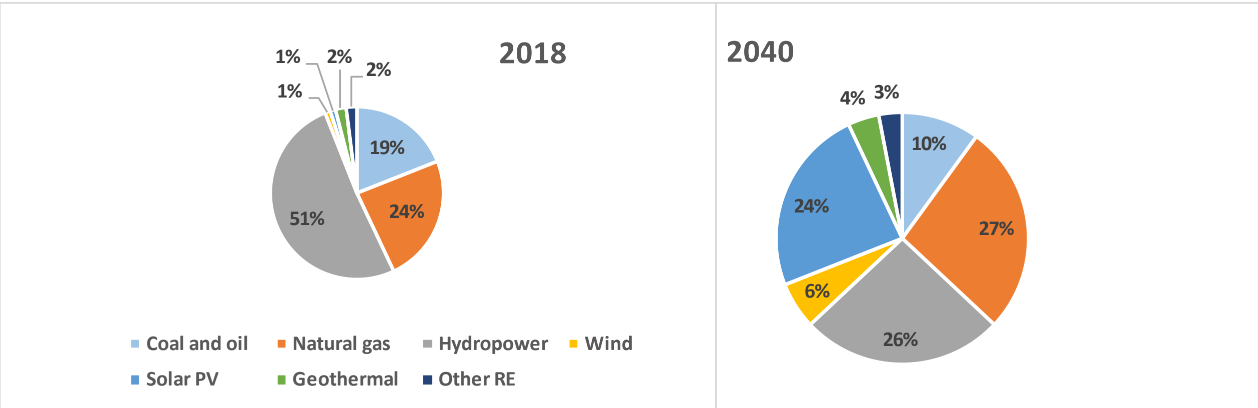
Own elaboration, based on IRENA (see irena.org/remap) and DNV Energy Transition Outlook 2022. In the 'policy-as-usual' situation, electricity sector will expand while fossil fuels and hydropower (non-RE) keep dominating, although solar and wind make important inroads. In the 'sustainable scenario', electricity has dramatically expanded, largely due to solar and wind

In the IRENA PES scenario, the installed capacity in power in Sub-Saharan Africa (103 GW in 2017) triples to 298 GW by 2050, but sees tremendous growth in the sustainable scenarios (TES), reaching 571 GW in 2040 and 1094 GW by 2050. In the TES, electricity production grows in tandem with the rapid expansion of solar and wind (see Exhibit 28), following the global trends (described in detail in Exhibit 26).

Developments will differ per region (and in regions between countries) depending on the availability of energy resources, population size as well as the level of industrial and economic development. Exhibit 30 provides a summary view of developments per subregions by 2030, based on the Multiconsult (2018) analysis. North Africa is dependent on natural gas, while in South Africa coal is predominant. In North Africa, natural gas will remain predominant and important in West Africa. Coal is dominating in South Africa but its share will decline in the coming decades.

It is interesting to look at the development in Sub-Saharan Africa (excluding the dominant position of coal-dependent South Africa). The first thing to note is that in Sub-Saharan Africa (excluding South Africa), the power sector is already relatively low-carbon. Electricity production in Sub-Saharan Africa (without South Africa) was about 225 in 2018 and 240 TWh in 2020, of which half was produced by hydropower. In the 'sustainable scenarios' of IEA (Africa case) and IRENA (TES), power production in Sub-Saharan Africa (excl. South Africa) will expand to about 1520-1760 TWh, respectively. In IEA's Africa Case, the role of natural gas remains, but within the renewable sources, solar and wind each produce as much electricity as hydropower (see Exhibit 26). The relative shares can be misleading. For example, although the natural gas's share remains roughly the same (about a quarter of total generation), the actual power production increases eightfold from 58 TWh in 2020 to about 475 TWh in 2040. The same applies to hydropower's share in the generation, which almost quadruples in size from 120 TWh to 426 TWh.

Exhibit 29 Power generation mix, Sub-Saharan Africa (excl. South Africa)

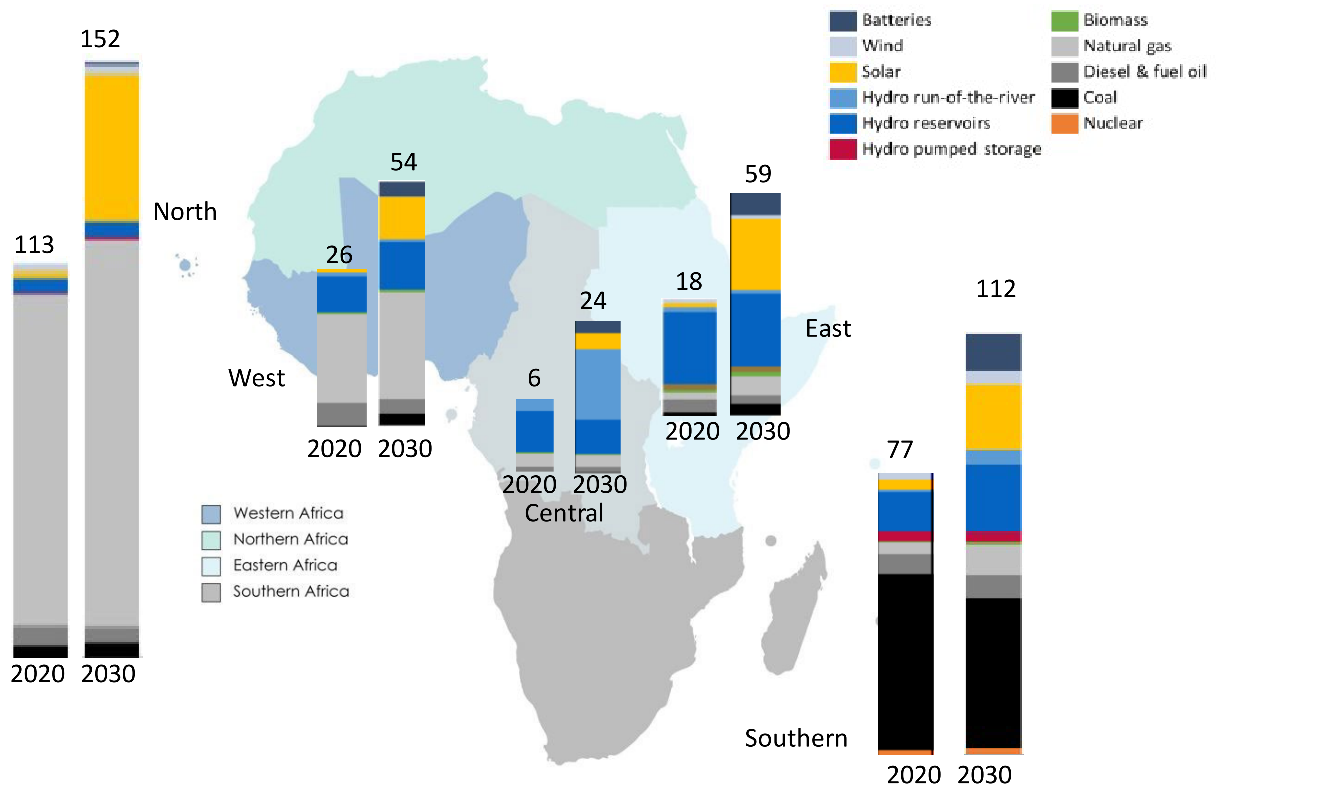


Own elaboration with data from IEA analysis (Africa case, in IEA, 2019)

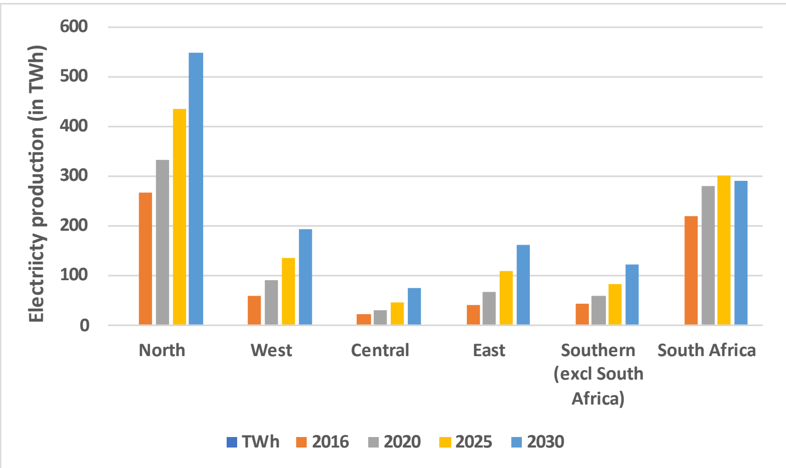
While the world shifts away from coal in the coming energy transition, the energy carrier will remain important in emerging and developing countries that often have invested in a large fleet of new coal plants. One such country is South Africa. Phasing down and ultimately replacing coal in these systems securely and affordably will be quite a challenge, apart from having a profound impact on employment and the local economy where coal is mined; see section 4.3; In Focus 3). As the role of coal and oil in power production will decrease that of natural gas will increase (in the case of South Africa imported from Mozambique), replacing coal as the provider of essential system flexibility and grid services while the share of solar and wind energy in the power mix will increase.

Exhibit 30 Power capacity and electricity production in Africa in 2030

Installed capacity (in GW)



Electricity production (in TWh) in the period 2016-2030



The figures have been drawn using 2020 data from Exhibit 7 and 2030 from Multiconsult (2018) analysis in accordance with AfDB New Deal for Africa goals

	Production (TWh)		Capacity (GW)	
	2020	2030	2020	2030
Africa	861	1392	238	401
Sub-Saharan Africa	528	843	133	249
Sub-Saharan (excl. South Africa)	247	553	72	182

Hydropower will remain an important basis for electricity generation in Sub-Saharan Africa. Diversifying the electricity mix helps to reduce the risk of power disruptions during droughts and in the long term to strengthen resilience to changing climate conditions. While solar and wind capacity is small at present (providing 2% about 10 TWh in 2018), these will produce seven times more power in 2050 in Sub-Saharan Africa (8% of the total) in IRENA's 'policy-as-usual' scenario). Production will increase to about 490 TWh in 2040 (in IEA's Africa case and provide a whopping 60% in the IRENA 'sustainable' TES scenario (2,100 TWh) in 2050. Thus, solar PV will become at least as important as hydropower and natural gas in the generation mix and, depending on the pathway followed, even become the largest source for power generation.

Hydropower occupies an uncertain position in the energy transition. Although there can be significant methane emissions from rotting reservoir vegetation, hydroelectricity produced by turbines using vast water power behind dams is considered a low carbon source of power. Some hydro schemes actually produce substantial methane – a potent greenhouse gas – from rotting vegetable matter in the reservoir. But the amount is likely to vary project to project, and the technology is regarded as being, on balance, a means of tackling climate change, rather than causing. Hydro also offers baseload power production to help balance out intermittent solar and wind power output... However, the impact of climate change on rainfall patterns is forecast to affect water availability, in particular in southern and eastern Africa. Thus, banking on drought-prone large-scale hydropower to solve power problems across the continent may be risky.

3.3.3 The future of fossil fuels and nuclear energy

The continent's only commercial **nuclear** power plant, South Africa's 1,900 MW Koeberg facility, began operations in the 1980s and generates 5% of the country's electricity. In September, Pretoria announced plans for a new 2,500 MW project, for which it hopes to end the procurement process by 2024, but this is the latest in a long line of similar announcements, many of which involved far bigger generating capacities. Nuclear power remains on South Africa's radar because of the country's ongoing lack of power production and fears that overreliance on intermittent forms of generation, such as solar and wind, will create supply imbalances. In most of the scenarios, nuclear plays a minor role.

Many governments give thought to developing in nuclear programme as a last resort when other options will not be sufficient. Opinion is deeply divided on whether Africa is ready for, and should invest in, nuclear energy. The main concerns on nuclear power revolve around safety, massive capital costs and environmental impacts. Moreover, the technological challenges and costs of building reactors and managing nuclear waste must compete with the plummeting prices of renewables such as solar and wind.

Globally**, coal production** is projected to decline gradually in most 'policy-as-usual' scenarios until 2030 as a net result of a somewhat increasing demand in large emerging economies (India, China) but a large reduction in industrialized countries. After 2030, gas and renewables provide an increasing share of electricity generation, coal use will drop sharply, but consumption in certain industries (iron and steel, cement) will remain steady. In BP's New Momentum, coal demand will fall to about 80% of the 2020 level in 2030 and about 60% in 2050. The 'sustainable scenarios' see an even more rapid phase-out. For example, in IEA's NZE and BP's Net Zero, in comparison with 2020 levels, coal demand will fall to 45% and 48% respectively in 2030 and to 10% (in both scenarios) in 2020 levels in 2050). Most of the remaining coal use is in facilities equipped with carbon capture and storage (CCS).

Globally, rising concerns over the compatibility of **oil production** and use with environmental objectives and compliance with the Paris Agreement will have a growing impact on the long-term prospects for oil supply. In IEA's STEP (policy-as-usual) oil demand flattens, slightly increasing from 189 EJ in 2019 to about 198 EJ in the period 2030-2050. In the 'sustainable scenarios', oil demand decreases after 2030 to about 89 EJ in the IEA-SDS and 42-44 EJ in the two Net Zero scenarios. Regarding **natural gas,** the IEA-STEPS and BP-Momentum scenarios see a 15% global increase by 2030 (mainly due to demand from emerging and developing countries) from the 2019 level of 140 EJ and will continue to rise, albeit at a slower pace, at a level about 26-30% higher in 2050 than today. In the

BP and IEA 'sustainable scenarios', natural gas demand falls in nearly all regions, in particular, due to the decarbonization in the power sector, except those that are currently heavily reliant on coal, where it largely displaces coal. In the BP New Zero analysis, natural gas demand has dropped to 60.5 EJ by 2050, while in the IEA analysis demand has lowered to 75.2 EJ in SDS and 57.7 EJ in the NZE scenario[80].

Exhibit 31 Global and African fossil fuel production scenarios

(in EJ) Global		BP New Moment.	BP Net Zero	BP New Moment.	BP Net Zero
Production	**2019**	**2030**	**2030**	**2050**	**2050**
Coal	167.9	135	80	98.8	16.3
Oil	190.4	193	171	142.6	42.8
Gas	143.1	160	134	180.7	60.5
Africa					
Demand	*18.4*	*21.6*	*19.8*	*35.3*	*8.1*
Coal	4.3	4.9	3.5	8.0	0.6
Oil	8.5	9.9	9.2	13.7	4.1
Natural gas	4.3	6.7	9.2	13.7	3.3
Production	*33.3*	*31.0*	*28.9*	*28.8*	*7.2*
Coal	6.8	6.8	4.8	3.3	0.2
Oil	17.7	14.3	13.7	7.8	2.6
Gas	8.8	9.9	10.3	17.8	4.4
Net trade	14.9	9.4	9.1	-6.5	-0.9

Data taken from BP Energy Outlook (2022)

In Africa, production continues to be dominated by South Africa. But while South Africa's output will decline, Botswana, Mozambique and Zimbabwe aim to boost output, resulting in a modest net increase in coal production in IEA's STEPS by 2040. In the longer term, the prospects for coal production in Africa are weak, due largely to declining export demand and the increased competitiveness of alternative low-carbon domestic energy sources. In BP's New Momentum, coal production in Africa by 2050 will be half of the 2020 level and almost zero in the Net Zero pathway. Once plants currently under construction are completed, Africa builds no other coal-fired power station with China's announcement in 2021 to end support for coal projects abroad. More than 70% of proposed coal plants, including almost all in Africa, relied on Chinese financing, so their construction now seems more unlikely than ever.

The prospects for oil and gas production in Africa hinge not only on exports in the global market but also on domestic demand trends. Regarding the domestic demand in Africa, this market will increase by about 20-30% by 2030 in the IEA and BP 'policy-as-usual' pathways and by 130% in 2050 (BP New Momentum). Oil demand is set to double by 2040 and production will approach 5 million barrels of crude a day. As current refining capacity is limited in size (currently standing at 1.3 million barrels a day), this means that increasingly it has to rely on imports of oil products. This would justify investing in new refineries in the region, but mobilizing the huge investment required to build new capacity is a daunting task given the difficult business environment for investors and ample refining capacity elsewhere in the world[81].

Historically, there has been low penetration of natural gas in Sub-Saharan Africa. The region continues to be the most untapped and underexplored continent when it comes to natural gas. In the recent past, when oil majors hit gas, they would stop drilling and did not develop the resource, and they continue to flare off associated natural gas when tapping into oil reserves.

In many cases, there is a considerable distance between production (in a few countries) and the main consumption centers (the supply of which would need large-scale, capital-intensive infrastructure). Natural gas will become more important in the near future, as the fuel will replace polluting coal and more expensive oil products in industry and power generation. The finds in East Africa (Mozambique and Tanzania) of large gas fields in recent years have been followed by further discoveries in Egypt and off the coast of West Africa on the maritime border

80 Of which 43.3 EJ used in facilities equipped with CCS (carbon capture and storage) in NZE and 25.8 EJ in SDFS

81 IEA (2019), IEA (2022). In general, there may be a need to tailor investment to the dynamics of the transition, focussing less on large-scale, complex greenfield projects and more on smaller, essential upgrades given refiners' limited cash flow and working capital

of Mauritania and Senegal with a combined value of maybe more than 5,000 billion m^3. These resources could provide an additional 90 billion m^3 of gas a year by 2030[82].

The Russian invasion of Ukraine, which is having deep human, social, and economic impacts across countries and sectors, adds another layer of consideration. The European Commission has announced a plan to make Europe independent of Russian fossil fuels before 2030 through a combination of acceleration of renewable energy and diversification of natural gas supplies. This could result in increased demand for oil and gas from the African countries that have the reserves and infrastructure in place to help meet that demand. Europe's efforts to reduce imports from Russia could increase the prospect of an import of African gas by 30 billion m^3 in 2030 (in addition to the 'normal' exports of around 90 million m^3)[83].

Probably the biggest barrier to the expansion of gas use across Africa is the lack of infrastructure on the continent. North Africa is quite well connected from a main hub in Algeria with pipelines connecting Algeria to Morocco and Tunisia as well as through to Europe. Libya also has a gas pipeline to Europe and Egypt one to Jordan. However, in the other African regions, the only operational cross-border gas pipelines are the 678 km West African Gas Pipeline from Nigeria to Benin, Togo and Ghana and the 865 km pipeline from Mozambique to South Africa. For comparison, this kilometrage is 3% of the length of Italy's gas network[84].

In addition to major long-distance pipelines to supply large-scale power plants, companies are increasingly looking at reaching markets via liquefied natural gas (LNG) delivery. Several LNG import projects had been promoted in Sub-Saharan Africa (including Benin, Côte d'Ivoire, Kenya, Mauritius and Namibia) in the past but progress on them has been slow with constant deferral. The potential for additional exports to Europe could give renewed momentum to numerous LNG projects that have been delayed or stalled for many years. The longer-term potential for Africa to meet additional natural gas needs from Europe would gradually decline after 2030. Depending on how the European Union progresses in achieving its ambitious decarbonization targets, investments in new gas projects would need to consider non-European export markets after 2030.

Thus, such longer-term ambiguity in the global energy transition pathway complicates investment decisions in oil and gas in Africa. Global oil demand could peak by 2030, while global gas demand could peak by 2040, implying new markets for African export in 'policy-as-usual' pathways. If leading countries achieve their net-zero commitments effectively (following a 'sustainable' or 'net -zero' pathways, these peaks could shift to 2025 and 2030 respectively[85].

Currently, a large part of Africa's oil and gas production is exported, which means that future oil revenues will be determined by complex dynamics in export markets and prices, influenced by the competitiveness of exploiting and developing new oil and gas infrastructure in the framework of the above-sketched global demand trajectories. Regarding oil production, the outlook is driven by a handful of major producers, mainly Algeria, Angola, Libya and Nigeria, and in the case of gas, also Egypt, Mozambique and Tanzania. Each country has its own characteristics in terms of market prospects, costs of exploitation, and financial-economic environment. While production figures differ per country, in the IEA STEPS scenario production in Africa is more or less maintained until 2040 at 8 million barrels a day[86] (5 billion bpd in Sub-Saharan Africa), and will decline to about 4 million barrels per day by 2050 (BP New Momentum). In contrast, natural gas production will double by 2040 to 400 billion m^3 and 500 billion m^3 in 2050 in the IEA STEPS and BP New Momentum pathways. In the 'net-zero pathways' the situation is quite different; in BP Net Zero the production of natural gas in Africa will be half of the production in 2020.

To summarize, in the 'policy-as-usual' scenarios, fossil fuel production will slightly decline (from 33 to 29 EJ in 2050 in BP New Momentum) with gas taking over oil's lead position. In the green scenarios, fossil fuel production will

82 IEA (2022)

83 Ibid.

84 AU-AFREC (2021)

85 McKinsey (2021)

86 Data in this paragraph are mostky taken from Excel spreadsheet "BP Energy Outlook Summary Tables" and the IEA "WEO2021 Free Data" that can be downloaded from the BP and IEA websites

drop, driven by declining demand for fossil fuels globally with leading international oil and gas companies already refocusing their portfolios to include higher renewables exposure and/or investing in regions where the cost of exploitation is lower. In BP's Net Zero, combined fossil fuel production (coal, oil, gas) will drop by 80% (with coal dropping by 96% and oil by 85%).

This wide-ranging set of scenarios illustrates that investing in oil and gas will require careful balancing of domestic needs and expected export prospects helped by tailored infrastructure expansion plans. In a greyer, 'policy-as-usual', approach, gas will play an important role by helping to displace costly oil products, especially diesel and heavy fuel oil, and meet the needs of industry and the power sector as a flexible and dispatchable source of electricity generation to complement renewables, though the economics of switching to gas vary by their sources and costs of transport. At the other end of the set of scenarios, the 'net-zero' pathways, Africa will be leapfrogging into a decarbonized energy system, developing its renewable energy sources as fast as possible. However, the 'million-dollar' question will be how such a green transition can be achieved cost-effectively in the coming decades while also meeting the continent's stated goals for universal electricity access, employment, industrialization and economic development.

Exhibit 32 Global production scenarios of hydrogen and derived fuels

Global	2019	2050	
	EJ	EJ	Mton
BP Net Zero	11.9	70.0	446
- Share RE	0%	84%	
IRENA 1.5ºC	0	74.0	614
- Share RE	0%	66%	
IEA Net Zero	11.5	69.7	528
- Share RE	5%	62%	

Data taken from BP (2022), IEA (2021c), IRENA (2022a)

Projects that are now under construction or planned in the natural gas industry are not consistent with the "net-zero" emission pathways. This raises questions about the future use of gas infrastructure and the risks associated with investments in natural gas. These could become stranded assets with high costs to decommission fossil fuel infrastructure. However, the reuse of the gas infrastructure for green gas, such as carbon-free hydrogen and biomethane, thus offers a strategy for helping to avoid stranding assets while also accelerating greenhouse gas mitigation; options that will be discussed in the next section. Investing in one option may not exclude the other.

3.3.4 Hydrogen and derivative fuels

As global economies aim to become carbon neutral, competitive hydrogen and synthetic fuels derived from hydrogen (such as ammonia, methanol and synthetic kerosene) will offer an emission mitigation solution for industry and transport processes that are hard to decarbonise through direct electrification. Hydrogen could play an important role in a sustainable energy future, including clean energy trade and displacing fossil fuel use in industry. Technologies for the production and use of low-carbon hydrogen are being developed and projects around the world are scaling up.

The 'policy-as-usual' pathways do not attribute an important role to hydrogen. The 'net-zero' scenarios include a substantial of hydrogen in final energy demand by 2030, around 20% in the IRENA, BP and IEA 'net zero' scenarios (see Exhibit 29). In 2040, virtually most of the hydrogen in these scenarios will be 'blue' (produced from natural gas with carbon capture and storage, CCS) or 'green' (from renewable energy). In the IEA Net Zero scenario, of the 528 million tons of hydrogen and hydrogen-derived fuels, 39% is used in transport, 19% for power generation, 21% in (heavy) industry and 14% for non-energy purposes.

Today, hydrogen is produced and used at an industrial scale in Africa to make ammonia-based fertilisers and to refine oil. Among the larger suppliers, Algeria, Egypt and Nigeria use natural gas to produce the vast majority of Africa's hydrogen for ammonia, while South Africa produces ammonia from coal at a smaller scale (all resulting in greenhouse gas emissions). African countries also import considerable amounts of ammonia and ammonia-based fertilisers produced from fossil fuels without carbon capture, utilisation and storage. As technology for ammonia production from water electrolysis gets cheaper and smaller, hydrogen from solar power could help to avoid greenhouse gas emissions while meeting latent fertiliser demand.

In Focus 1 Gas in Africa and Mozambique

The most significant driver in recent years of the energy sector in Africa has been the discovery of sizeable natural gas resources across Africa, notably in Mauritania, Senegal, Tanzania and Mozambique, alongside the traditional producers (such as Algeria, Nigeria and Egypt) and to a lesser extent Equatorial Guinea, Angola. Gas demand has also grown rapidly in nearly every region of the world as a cleaner alternative to oil and coal. LNG is natural gas that has been converted to a liquid through cooling for more efficient, safe, and simple transportation, and accounts for about 35% of global gas trade. In recent years, Sub-Saharan Africa has emerged as an important region for the development of small-scale LNG projects.

Since natural gas was first discovered off the coast of northern Mozambique a decade ago, it has become central to the country's development strategy. Mozambique has smaller scale gas project already in operation, Pande-Temane (providing 147 GJ of gas to South Africa) and three major LNG projects in development, Mozambique LNG (operated by Total, expected at least 12.9 Mton per year), Rovuma LNG (by Exxon-Eni, 15.2 Mton/year) and Coral South (Eni, 3.4 Mton/yr). The projects involve building infrastructure to extract gas from a field offshore northern Mozambique, pump it onshore and liquefy it, ready for further export by LNG tankers, while Coral South will have a floating liquifaction plant offshore. The government has determined that a portion of natural gas production should be used locally to address the needs of the domestic market. Projects include Gas-to- Liquids (GTL) plant, a fertilizer plant and gas-to-Power projects.

The potential production level as estimated by IMF and Mozambique's national gas plan as between 20 and 50 Mton per year by 2026, yielding 25% of all revenue, 30% of GDP and 50% of exports, allowing Mozambique to follow Angola's footsteps in the fossil fuels field. Production was about 4.1 Mton LNG in 2019 and suggests that LNG expansion in Mozambique is likely to be less than suggested in these optimistic projections (which were based on LPG prices remaining high). In the longer run the international energy transition may be limiting the space for new gas projects to come fully on stream. In IEA's Net Zero pathway gas prices in Mozambique's main markets of Europe and Asia in the range of USD 3.8-5.2/million Btu, while the breakeven for the Mozambique LNG project is estimated at USD 5.5/million Btu and for Rovuma LNG at $5.9/million Btu. Mozambique has issued large sovereign guarantees to enable the participation of its national oil company ENH in the gas projects. If LNG prices achieved by Mozambique's gas projects are persistently lower than expected, there is a significant risk that the gas investments will add to rather than reduce Mozambique's debt burden. In such a pathway, a large part of the LNG expansion may be stranded. Much will depend on international developments. The LNG projects have been criticized by their lack of local employment creation, while leaving yje communities with negatiuve impacts, such as forced removals from land and their environmental impacts on the coastal magrove and coral reefs in Mozambique's north.

Regional demand creation will be important for gas exporters, such as Mozambique, network across Africa. Actually, development of Africa's natural gas resources will be needed to meet the energy demand of growing populations and developing economies. Gas-fired generation could supplement hydropower, replacing coal and oil products, specifically in Southern Africa, as a key source of electricity in sub-Saharan Africa as a baseload for variable solar and wind. While there is substantial hydro-power generation in Africa, it has limitations such as those stemming from hydrological and drought uncertainties. This applies to Mozambique as well, where about 82% of power is generated by hydro resources (and 17% gas).

About 60% of LPG is produced during the processing of natural gas where it is separated from the gas mixture and pressurized into liquid form for storage in steel cylinders or tanks. LPG is also found with crude oil and recovered through oil refining. A major market opportunity for LPG in Africa involves fuel-switching from biomass to LPG to increase access to clean cooking fuels. Some countries have already started to encourage LPG adoption through subsidies or other government programs, with mixed success, as infrastructure issues and investment costs are not inconsequential (see In Focus 7).

Other commodity byproducts of natural gas processing, such as ethane and ethylene, can be used for a variety of purposes such as a feedstock for petrochemical production. Natural gas is the base of many fertilizers (ammonia) and a few countries in Sub-Saharan Africa produce it domestically. Low-cost gas produced in Africa could reduce fertilizer import costs. Production for both fertilizer and gas byproducts is best situated close to the production site for natural gas, since they can be produced at a large scale and then easily shipped overland as finished products. Building out a large gas distribution infrastructure, similar to what exists in the U.S. and Europe, would not be economically feasible for most African countries, especially for reaching rural areas. Plans or proposals exist to expand the gas. Other solutions include "virtual pipeline," which involves LNG or compressed natural gas (CNG) that is transported on existing transportation infrastructure: rail cars, barges, trucks, and "by wire" (gas-fired power generation)..

Mozambique has very high renewable energy potential, estimated at over 23 GW of deployable potential. Falling costs for solar and wind technologies increase the possibility to use renewables to increase energy access, power Mozambique's economy and export excess electricity to neighbouring countries. Mozambique is also endowed with extensive deposits of critical minerals that will play a key role in the global energy transition, such as lithium and copper. No single resource is likely to reach the scale of revenues that Mozambique had expected from the gas projects; however a mix of resources (minerals, gas, hydropower) may be able to manage volatility better than over-dependence on one resource.

Source: Africa50 (2018), Oxford (2014), Oxford (2019), AFREC (2021), Gaventa (2021)

The EU is keen to achieve its 2050 decarbonization goals with an estimated 24% of hydrogen (about 8 EJ) in its total energy demand[87]. Africa has a high potential for producing hydrogen and ammonia from low-cost renewable electricity. According to an IRENA estimate, the region could produce about 2.4 EJ of hydrogen and 1.6 EJ of ammonia to Europe in 2050[88].

Europe has a well-developed gas grid that can be converted to accommodate hydrogen at minimal cost, as the existing gas transmission and distribution infrastructure is suitable for hydrogen with minimal or no modifications[89]. There is a gas transport infrastructure available between North Africa and Europe, transporting gas from Algeria and Libya to Europe via Italy and Spain. Production costs of green hydrogen in North Africa from solar power are expected to be two-to-three times lower than in most of Europe.

For longer distances or places without existing natural gas infrastructure, ammonia ships become the most attractive option[90]. Transport by ship represents a relatively small component of the ammonia supply cost, so longer distances can be covered without significantly increasing the total delivered cost. The most cost- and energy-intensive step is the reconversion back to hydrogen, which can be avoided by using the ammonia directly rather than as a hydrogen carrier.

Exhibit 33 Connecting Africa and Europe with hydrogen

Source: van Wijk & Wouters (2021)

African hydrogen routes

Source: V.Oldenbroek, African Hydrogen Partnership (2019)

Thus, hydrogen also presents a potential export opportunity, whether as hydrogen itself or in the form of ammonia or other synthetic fuels. African countries endowed with natural gas resources could also export low-carbon

87 Bhagwat & Olczak (2020)

88 IRENA (2022)

89 Van Wijk & Wouters (2021)

90 A distances larger than 4,000 km, shipping is cheaper expensive than pipeline transportation (Lanphen, 2019).

hydrogen produced (using CCS). A similar logic could apply to goods produced with low-carbon hydrogen, such as low CO_2 intensity steel. The first commercial plants using hydrogen as an alternative to fossil fuels for steel production are planned for the 2030s, a period when Africa's steel capacity is expected to grow. As a leapfrogging strategy, African countries could be good places to test this new technology in the steel industry, if governments and financers are supportive[91].

In a futuristic vision, a local hydrogen economy can be built alongside the existing infrastructure routes of roads, railways and seaports for use within and across regions. In this setup, hydrogen routes will connect major mining and industrial centers. Hydrogen-powered heavy-duty transport would connect with harbors, trade centers, metropolitan areas overland and near-shore islands, while in the metropolitan areas light-weight hydrogen fuel cell buses vehicles could provide public transport services (see Exhibit 30).

3.3.5 Modern biofuels

Around half of the current biomass use for energy is traditional, for cooking and heating in developing countries, where biomass is used in simple and inefficient stoves. The IEA, IRENA and BP 'net zero' scenarios implicitly incorporate compliance with the SDG-7 universal goal of clean cooking access by 2030.

Modern bioenergy plays an essential role given its potential to replace fossil fuel in electricity production, in end uses in industry, buildings and transport and as a chemical feedstock. Modern bioenergy includes bioliquids, such as biodiesel and ethanol, and biogas and biomethane. Biomethane is biogas upgraded to a near-pure source of methane to replace natural gas in engines.

At present, the role of modern bioenergy is small. Biofuels (liquids and gas), globally provided about 3.5-4 EJ (about 9-10%. In the 'net zero' scenarios of IEA and IRENA, the role increases substantially. Biofuels increase to about 21-31 EJ by 2050 in the IEA and IRENA 'net zero' scenarios respectively. Solid biomass for energy increases to 28-69 EJ in the IRENA 1.5ºC and IEA Net Zero. Adding the role of biomass as chemical feedstock (12-19 EJ), the total use of bioenergy is between 78 and 102 EJ in the IRENA-IEA scenarios, in other words providing about 22-29% of global energy demand.

The feedstock used for the production of liquid biofuels includes starch and sugar crops in the case of ethanol and oil crops in the case of biodiesel. The most common crops used for the production of liquid biofuels in Africa are sugarcane and molasses for ethanol, as well as oil palm, jatropha and, to some degree, soybean and sunflower for the production of straight vegetable oil and biodiesel. Advanced technologies also allow for the production of ethanol and biodiesel from woody (lignocellulosic) biomass, albeit at a higher cost.

In many African countries, there is a significant gap between the current and potentially attainable crop yields. Through sustainably improved productivity of agricultural production, sufficient crops would be produced to ensure food security while providing feedstock for the production of liquid biofuels. IRENA estimates global biofuel demand in its 1.5ºC scenario at 16.6 EJ in 2030, of which about a minimum amount in Africa. The potential production in Sub-Saharan Africa is estimated by IRENA at about 4.8 EJ in Africa. Of this amount, 3.6 EJ corresponds to crop-for-ethanol (of which 65% of ethanol potential in Southern Africa, and 20% in East Africa). Oil palm, the fruits of which are important feedstock for biodiesel, is produced widely in plantations in West and Central Africa. For the biodiesel of 1.2 EJ, 41% of the potential is found in Southern Africa and 22% each in Central and Eastern Africa, while West Africa accounts for 15% of the potential and 20% is in East Africa[92]. Apart from cooking fuel in some countries, ethanol has been used as a blending agent in gasoline at levels of between 5% and 15% in several countries (see biofuel blending mandates, Exhibit 53), while biodiesel is a potential replacement for diesel and, in the future, an important option for decarbonizing the aviation fuel sector. In shipping, it could play a role alongside hydrogen-derived methanol and ammonia as fuel.

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91 IEA (2019)

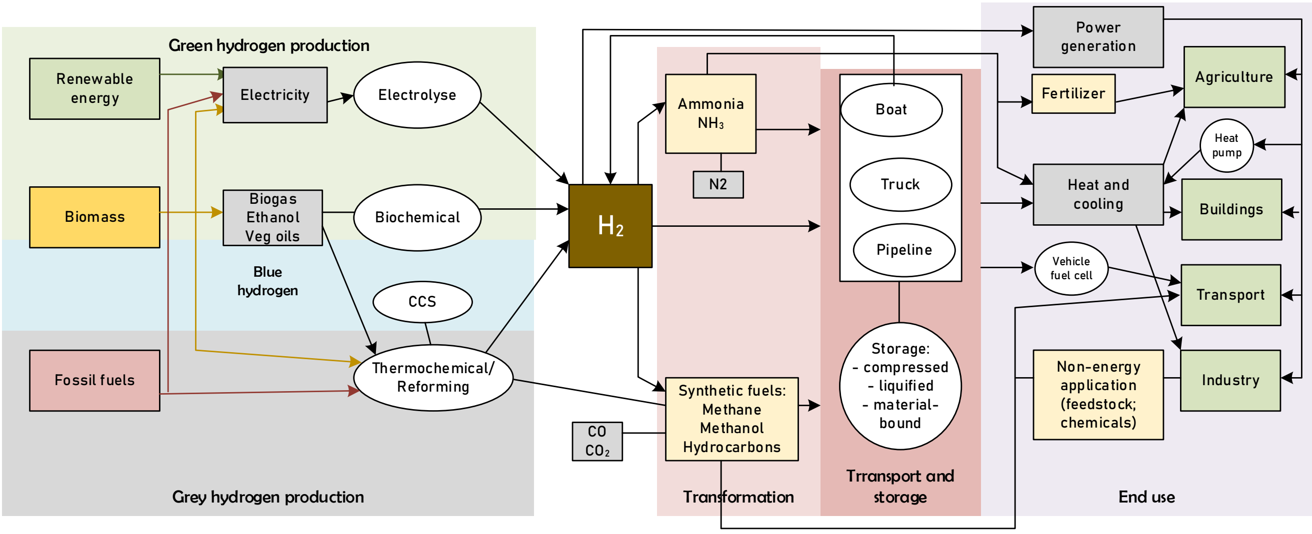
92 Data compiled from IRENA (2015) and IRENA (2022a)

Exhibit 34 The role of hydrogen and derivative fuels in future global energy demand and supply

Hydrogen is a versatile energy carrier that can be produced by water electrolysis (i.e. splitting water into oxygen and hydrogen, fuelled by electricity). Hydrogen can be used to replace fossil fuels in high-temperature applications in furnaces and boilers. In the buildings sector, the gas can be used for heating and cooling, in particular where an existing gas infrastructure can be retrofitted. Hydrogen can be used in the transport sector. While personal and light truck vehicles can be powered by batteries, fuel cells have an advantage in heavier vehicles (trucks, buses) over batteries. In the energy field, most hydrogen is used through fuel cells. In the device electrolysis in reverse takes place, i.e., hydrogen and oxygen are combined to generate water and electricity. Also, hydrogen can be used in an adapted gas turbine to generate electricity.

Hydrogen is used in several industrial processes, as raw material in the chemical industry, and as a reductor agent in the chemical and metallurgic industries. Hydrogen is a fundamental building block for the manufacture of ammonia (and hence fertilizers) and of methanol (used in the manufacture of many polymers). Annually about 120 million tons of the gas are produced globally. Hydrogen application for energy purposes is at present limited to about 10%, while 55% is used the ammonia synthesis, 25% is used for crude oil refining and 10% in methanol production.

A limiting factor of hydrogen is that the volumetric energy density of hydrogen is comparatively low. Therefore, for practical handling purposes, the density of hydrogen must be increased significantly. Hydrogen can be stored and transported in compressed gaseous or liquid hydrogen by lorry and of compressed gaseous hydrogen by pipeline to selected locations. The most common storage is compression or cooling or a combination of the two, but comes at additional energy and economic cost. As an energy carrier, hydrogen has a higher energy density than gaseous hydrogen, but it requires liquefaction at –253 °C, which involves a complex technical plant and an extra economic cost. Other new hydrogen storage technologies are being pursued or investigated, referred to as materials-based storage, using solids and liquids and on material surfaces.



Ammonia can be produced, for example, from hydrogen and atmospheric nitrogen (under high pressure and temperature). Ammonia can be used as fuel directly, similar to hydrogen (by reaction with oxygen, releasing water, nitrogen and energy), as stationary fuel in power generation (co-fired with natural gas in gas turbines). Ammonia is also being proposed as fuel in the maritime sector. Third, ammonia can be used as hydrogen carrier to overcome storage challenges of hydrogen and for transport (in boats). Hydrogen-derived synthetic fuels are a variety of gaseous and liquid fuels based on hydrogen and carbon, referred to as syngas or synfuel. Synthetic fuels include, for instance, synthetic kerosene in aviation and synthetic diesel for vehicles. For synthetic fuels to be considered renewable, the hydrogen part of the syngas should be renewable.

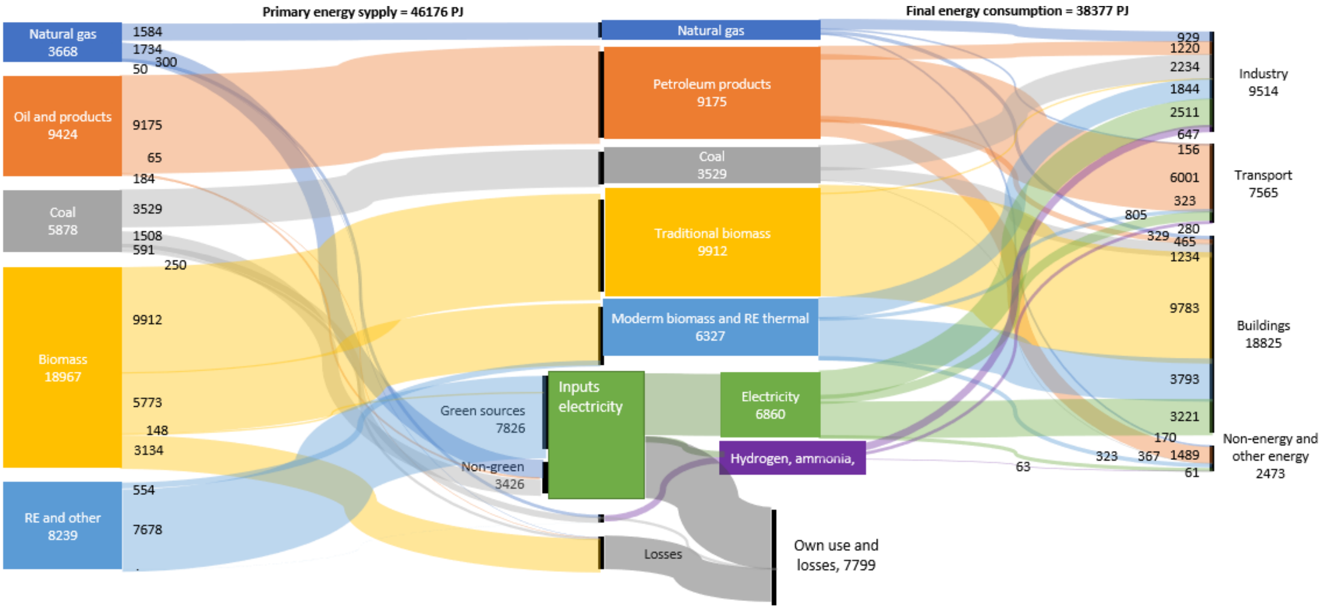
'Grey hydrogen' is produced with fossil fuels. Currently, about 75% of the hydrogen is produced from natural gas as using steam methane reforming) and 20% from coal using gasification). Thus, the use of grey hydrogen entails substantial CO_2 emissions. Retrofitting with carbon capture and storage (CCS) helps reduce greenhouse gas emissions and the H_2 produced is often referred to as 'blue hydrogen'. Hydrogen produced from renewable sources is referred to as 'green'. The price of electricity procured from solar PV and onshore wind plants has decreased substantially in the last decade and this is making green hydrogen production more economically attractive. Furthermore, green hydrogen can be stored for long periods and can be used in periods when the variable sources (solar and wind) are not available for power generation.

More information in IRENA (2022a), IEA (2019), IEA (2022), BP (2020), BP (2022). Figure designed by the author.

Exhibit 35 Sub-Saharan Africa in a policy-as-usual pathway

If no actions are taken as described in Chapter 5, various barriers to universal energy access, healthy power sector governance and greening of energy supply will remain. Sub-Saharan Africa is far from being on track to reach the SDG-7 energy access goals. In a policy-as-usual pathway, the inefficient traditional biomass use will decline but still provide the bulk of residential (buildings sector) energy by mid-century. In DNV's Energy Transition Outlook 2022, access to clean cooking methods will be 32% in 2030 and 63% in 2050. Electrification of the unconnected proceeds and in terms of energy generated the contribution of off-grid may be about 15% of electricity demand in 2050 in the DHV Outlook. However, achieving the SDG-7 access goal by 2030 remains elusive and access to electricity will be 65% in 2030 and only near-universal, 96% in 2050;

Africa will see a rapid rise in demand for fuels and electricity due to rapid economic and population growth. Energy demand may double, despite energy efficiency gains, due to the Increased demand in residential (appliances, cooling) as society gets more urbanized and wealthier, industries (manufacturing of products as well as the energy-intensive production of steel, cement and fertilizer. All this development needs expanded transport of people and products; the number of vehicles may triple by mid-century. If current trends continue, African demand for liquid fuels will rise more than production capacity can provide and the Sub-Saharan region may become an oil importer, somewhere in the 2030s. Gas production will increase exports will increase on medium term and determined by exports prospects to Europe, local demand and infrastructure constraints. The use of coal will slowly decline. The prospects for coal production in Africa are weak, but remain important for countries, such as South Africa. Power demand may triple (with larger share of RE, in particular solar and wind, alongside hydro and gas). Unlike the low penetration of biofuels and renewable energy for direct use in 'policy-as-usual' pathways, the share of variable renewable energy will increase. By 2050, some 50-80% may be generated by renewable energy (of which about 30-50% hydro and wind 20-30% solar and wind). Most of newly added capacity will be variable renewable (solar, wind) with hydro, biomass, and natural gas and storage



Electricity access by 2050: 96% (65% in 2030); Off-grid PV: 1020 EJ. Access to clean cooking: 63% (32% in 2030).

Source: Based on DNV Energy Transition Outlook 2022

Biogas plays a role as a traditional cooking method replacement in the transitions towards universal clean cooking access in rural areas, as well as in the agricultural sector. The biogas is generated from organic waste, agricultural residues and animal manure feedstock. In urban areas, methane can be captured and used for energy in wastewater treatment and municipal solid waste facilities. In the IRENA-IEA 'net zero' scenarios, globally biogas and biomethane increase their share from almost minimal (0.2-0.5 EJ) to 7.6-8 EJ by 2050. In the IRENA sustainable scenario, biogas is 6 EJ in global energy consumption, of which a modest 0.1 EJ in 2030 in Sub-Saharan Africa, implying a large underutilized potential. The role of modern solid biomass does not increase as impressively as the biofuels, increasing to 28-69 EJ in the IRENA-IEA 'net zero' scenarios respectively. By 2030, the global use of solid biomass for energy is 23 EJ, of which 4.8 EJ in Sub-Saharan Africa[93].

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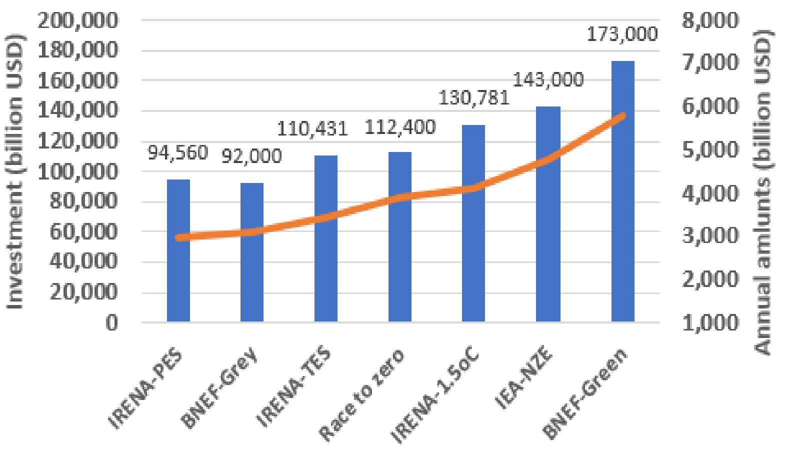
93 Ibid. Data from IEA (2021a)

3.4 Investment and financing needs

3.4.1 Investment needs for accessible and sustainable energy

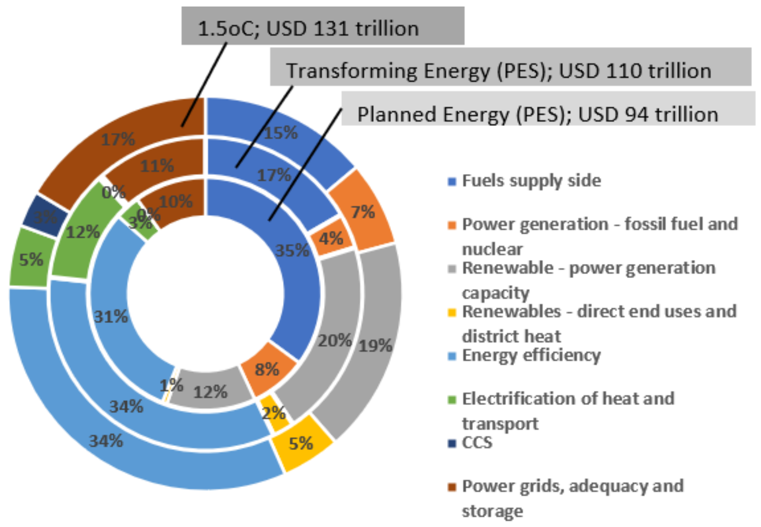
Exhibit 37 Global total and annual energy investments 2017/20-2050



Own elaboration, using data from IRENA website, IRENA (2022a), IEA (2021b), Race to zero (2021) and BNEF (2021)

A big question is how much investments will be needed to achieve lofty goals of the energy transition according to the various low-carbon and no-carbon pathways in addition to the investment already part of the 'policy-as-usual' scenarios. In the preceding section, these pathways have been described and analyzed, showing the differences and similarities between the various scenarios built by IEA, IRENA and BP for the world as a whole and Africa in particular over the period 2018/2019-2050 (and by Multiconsult, describing, in particular, the power sector development according to AfDB's New Deal for Africa, for the period 2018-2030). The scenarios all have different assumptions but in terms of energy supply and demand and penetration of renewable energy, these can be broadly grouped into 'policy-as-usual' versus green scenarios. The latter can be subdivided into 'sustainable' scenarios with low-carbon goals and the more ambitious 'net zero' scenarios that seek net carbon emissions by 2050 through a faster penetration of renewable energy and new technologies (such as hydrogen, synfuels and biofuels) together with carbon capture and storage (CCS) to compensate for the use, although smaller, of fossil fuels.

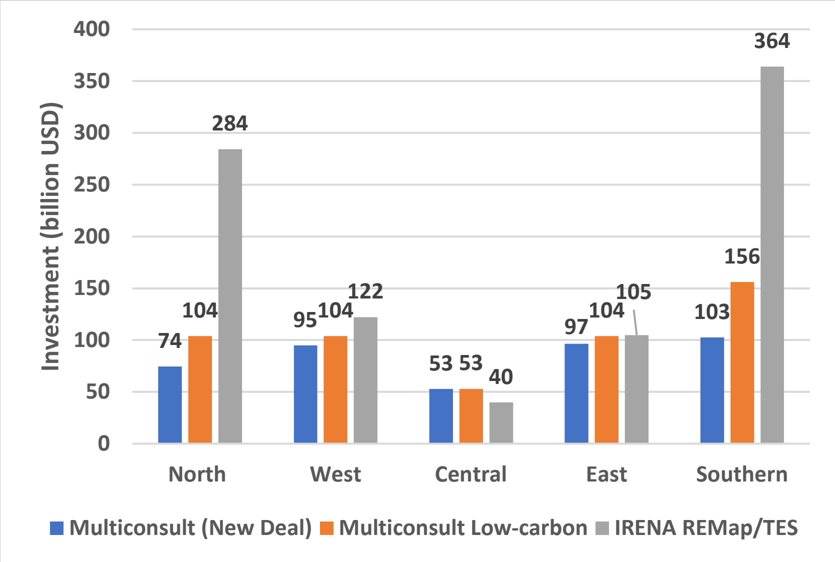
Exhibit 36 Global investments in IRENA scenarios per technology and measure (2018-2050)



Own elaboration with data from IRENA website, IRENA (2022a), IEA (2021b), Race to zero (2021) and BNEF (2021)

It may not be surprising that the more ambitious the pathway in terms of reducing carbon emissions, the higher the investment needs. The 'sustainable' scenarios will require an investment of between USD 110 and 170 trillion in the coming three decades (or between USD 3,450 and USD 5,800 annually), depending on the scenario. This implies that annual investments in the energy sector need to more than double in comparison with the average annual investment of about USD 1.88 trillion during the period 2016-2020. Not only are larger investments in energy infrastructure needed, but the capital is also flowing away from fossil fuels and toward sustainable energy and low-carbon solutions.

Exhibit 38 Investments in the power sector IRENA scenarios per technology and measure in 2017/18-2030



Own elaboration with data from IRENA website, IRENA (2022a), IEA (2021b), Race to zero (2021) and BNEF (2021)

Investments per region:

	North	West	Central	East	Southern	TOTAL
Total investments over 2017-2030 (**Multiconsult/AfDB**)						
Generation	66	48	35	51	81	281
Interconnection	1	2	2	4	1	11
Grid	7	40	12	33	17	108
Minigrid/Off-grid	0	4	5	9	4	21
TOTAL	74	95	53	97	103	**421**
Total investments over 2018-2030 (**IRENA-TES/REMap**)						
Generation	210	77	28	62	213	590
- share of renewable	91%	75%	94%	79%	46%	72%
Grid	75	45	12	42	151	325
TOTAL	**284**	**122**	**40**	**105**	**364**	**915**

Data compiled from Multiconsult (2021), IRENA (2022a) and IRENA website

In the power sector, investments will be increasingly directed toward renewable energy capacity, grid extension and flexibility measures (including storage), electrification of sectors (such as charging infrastructure for electric vehicles), improved energy end-use efficiency, increased biofuels supply, and infrastructure for the supply of hydrogen and derived fuels, as well as carbon capture and storage (CSS) associated with remaining fossil fuel use.

While Africa accounts for almost one-fifth of the world's population, it at present attracts less than 5% of global energy investment; about USD 97.8 billion annually in the period 2016-2020, or 5% of the region's GDP. Of this, about USD 31.8 billion[94] was invested annually on average in this period in the electricity sector.

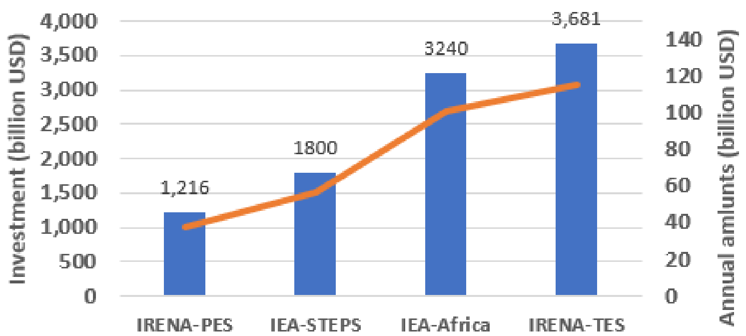
Similarly, the clean energy transition in Africa (as described in the previous sections of this Chapter) requires a substantial increase in investment (almost a doubling of the total capital needed compared to the current level of investment over 2020-2050, ranging from USD 50 billion annually in AfDB's New Deal[95] to about USD 136 billion annually in the IEA Sustainable Africa (a variant of its Sustainable Development, SDS scenario), thus, a cumulative investment of about USD 4.3 trillion over 2018-2050. According to Race to Zero a full 'net zero' pathway would need an even larger investment of USD 6 trillion over 2021—2050 (at an average annual cost of USD 228 billion annually, starting with investments of USD 150 billion a year during the period 2021-2030).

In Sub-Saharan Africa, about a third of investment in the power sector needs to go expand electricity access, foremost in the first decade of 2020-2030 to achieve universal energy access and thereafter for maintaining the universal access and increasing the energy service level, see Exhibit 51). The 'policy-a-usual' pathways give annual

94 IEA (2019), IEA (2022)

95 The New Deal concerns the period up to 2030 only and estimates that to meet the universal access goals by 2030 and the forecasted energy demand in general, will need about USD 40 billion in the power sector and an additional USD 10 billion in low-carbon development (of which USD 80 billion in LNG projects, USD 20 billion in gas pipelines and USD 8 billion in gas-to-power projecys

Exhibit 39 Total and annual energy investments 2017/20-2050 in Sub-Saharan Africa

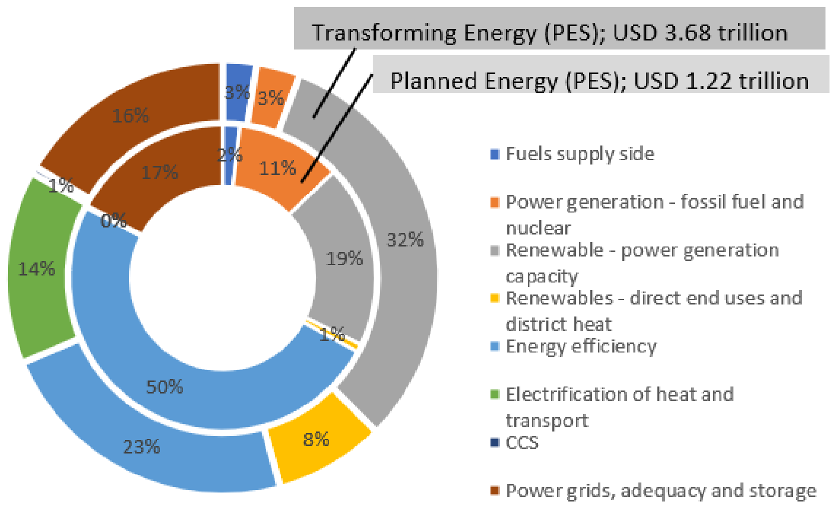


Own elaboration with data from IRENA website, IRENA (2022a), IEA (2021b),

expenditures in the period 20172020 of about USD 32-40 billion (AfDB/Multiconsult[96]) for Africa and for Sub-Saharan Africa between USD 27-32 (AfdB/Multiconsult) and USD 25 (IEA-STEPS). IRENA's TES presents an improvement over these scenarios with investments of USD 42 billion in Sub-Saharan Africa and USD 76 billion for Africa as a whole, reflecting the penetration of more low-carbon (renewable generation) in the electricity mix. Exhibit 38 provides an overview of the total investment figures in the period 2017/2018-2020 with a breakdown per subregion.

Such investment will not be enough even to achieve universal electricity access, let alone achieve the Paris Agreement low-carbon objectives, by 2030. The IEA reports (2019, 2022) give estimates for Sub-Saharan Africa's investment needs of about USD 22 billion annually for electricity access and USD 1.7 billion[97] for clean cooking solutions (a total of about USD 800 billion over 2020-2040). The current investment in energy access has been about USD 8-12 billion annually in recent years, implying that these need to be expanded fivefold over the period in the coming decade.

Exhibit 40 Energy investments in IRENA scenarios per technology and measure (2018-2050), Sub-Saharan Africa



Own elaboration with data from IRENA website, IRENA (2022a), IRENA (2015)

IEA's Africa case (presented in its report IEA, 2019), and IRENA's TES/REMap come with more ambitious investment estimates to reach the universal access goal and expand power generation in Sub-Saharan Africa and work on greening power generation in North Africa and in South Africa. Thus,

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96 Multiconsult 'reference scenario' (in accordance with AfDB New Deal on Energy) and 'low-carbon' scenario respectively

97 The report does provide details on how the amount of USD 1.7 billion is calculated. Assuming 1,100 million people need to be provided over 2021-2030 with clean cooking methods (at 5 people per household), this means 220 million households. If 41% are provided with two ICSs (improved wood or charcoal stove) at USD 30 per stove, the cost is USD 5.41 billion, 33% with LPG at USD 100 per equipment (incl. one 14 kg cylinder and stove), cost is USD 7.26 billion, household-size biogas plant (at USD 300) for 10% of households means USD 0.32 billion, electric stive (at USD 35 per stove for the 10% that have access to new electricity and can afford the tariff), USD 0.77 billion and ethanol stoves (6% of households at USD 50/stove) gives a total cost of USD 0.66 billion. Adding the clean cooking options up, gives a total of USD 14.5 billion, or 1.45 billion annually over 2021-2030. The cost does not include cost of setting up infrastructure (such as replacing traditional charcoal production with more efficient methods), LPG infrastructure (production/import facility, bottling plants), while cost of electrification is part of the electrification cost estimate. The cost of LPG infrastructure may add another USD 100 per household (own estimate). Thus the cost of clean cooking may approach USD 2 or 3 billion annually.

investments in the power sector in Africa in the coming decade may be in the order of USD 102 billion annually. Of this amount, USD 34 billion/yr is invested in generation capacity, USD 50 million/yr in grid expansion, maintenance and reinforcement, and a substantial USD 18 billion for minigrid and stand-alone off-grid solutions. Of the investment needed for electricity access, about USD 8 billion/yr will be for grid extension, about USD 13 billion/yr for minigrids and USD 1.6 billion/yr for off-grid[98].

Other sources give even higher figures. For example, Race to Zero provides a figure of USD 38 billion/yr for mini-grid and off-grid alone for the period 2021-2030; to keep up with population growth and accommodate households ascending the energy ladder, the investments required may reach USD 61 billion annually over the period 2031-2040.

Exhibit 41 Energy investments in energy and power for different scenarios per transition measure (2018-2050), Africa

	2017/18-2050		2017/18 - 2030	
'(USD billion)	**Total**	**Annual**	**Total**	**annual**
Africa (energy)				
Race to Zero	6,600	228	1,500	150
Africa (power sector)				
Multiconsult			421	32
IEA-SDS (Africa case)			792	66
IRENA-TES			915	76
CCSI	4,442	136		
Sub-Saharan Africa (energy)				
IRENA-PES	1,216	38		
IEA-STEPS	1,800	56		
IEA-SDS (Africa case)	3,240	101		
IRENA-TES	3,681	115		
Sub-Saharan Africa (power sector)				
IEA-STEPS	558	17	304	25
Multiconsult			346	27
IRENA-TES	1,893	59	551	46
IEA-SDS (Africa case)	1,787	56	670	56

Own elaboration with data from IRENA website, IRENA (2022a), IRENA (2015), IEA (2019), IEA (2022) and IEA website. Multiconsul only covers power sector up to 2030. The CCSI (2021) Roadmap covers the power sector

3.5 Impact on CO_2 emissions

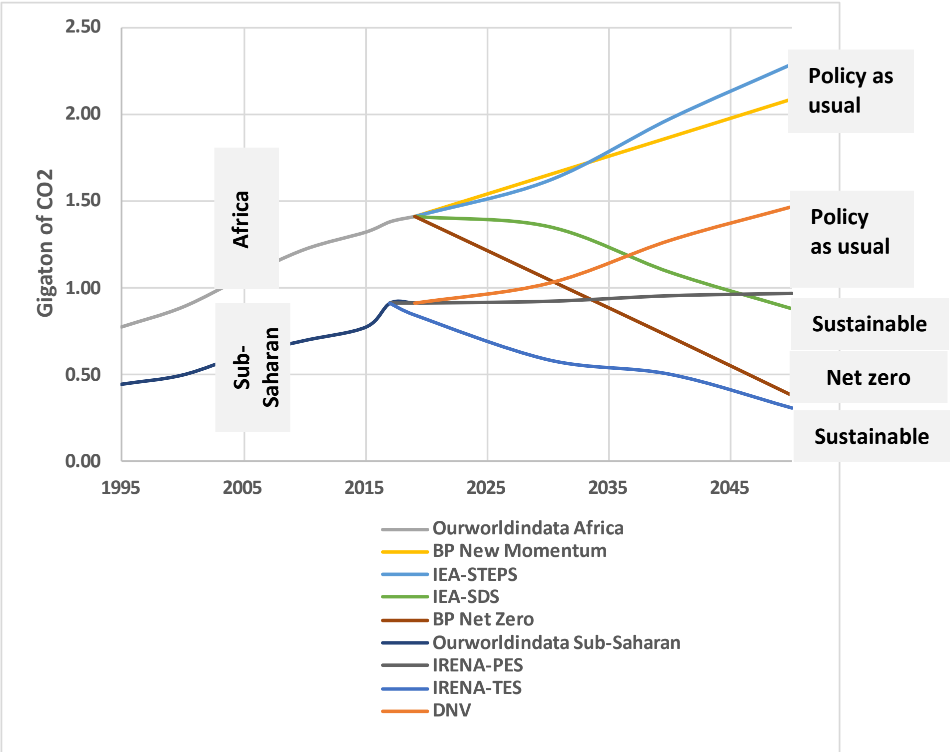
The scenarios presented in the previous sections 3.1 to 3.3 explore the range of possible pathways over the next three decades. Such scenarios do not inform on the future and what is likely to happen or not. They inform on what technologies should be used and measures to be taken in accordance with the SDG universal access goals and to achieve a substantial reduction in carbon emissions in line with the Paris Agreement. The previous section 3.4 informs about the price tag of these ambitious goals and a summary is provided in Exhibit 41.

If no action would be taken the carbon emissions might increase from the 34.8 gigatons of CO_2 ($GtCO_2$) emitted in 2020 to about 43 $GtCO_2$ by 2050[99]. Such a baseline development could lead to a temperature rise of 3ºC or more by the end of this century. Most governments have already put carbon mitigation policies in place or have announced pledges to reduce greenhouse gas emissions and incorporated these into their national policies. Based on these policies and their status of implementation, organizations such as IEA or IRENA formulate 'policies-as-usual' scenarios (e.g., IEA STEPS and IRENA PES). In these scenarios, global emissions would rise to about 35 $GtCO_2$ by 2030 and remain about this level or slightly decrease. While this would break the trend of carbon emissions annually increasing, this development would still see global temperature rise by 2.4-2.8ºC by the end of the century.

98 Own estimates, using IEA (2017), IAE (2019) and IEA (2022). Assuming 740 million people need to be connected over 2021-2030 this means (at 5 people per household), about 148 million new connections. If 46% of new connections are through grid extension at USD 1200 per connection, the cost is USD 82 billion (or USD 8.2 billion annually). Assuming 34% of new connections are through minigrids (at USD 2500 per connection), costs are USD 126 billion (or USD 12.6 billion annually). The remaining 18% are stand-alone solar (at USD 550/system) implying a cost of USD 16.3 billion (or USD 1.6 billion annually), giving a total of USD 22.4 billion annually. This corresponds with the IEA figure of about USD 22.2 billion annually in the 10-year period 2021-2030.

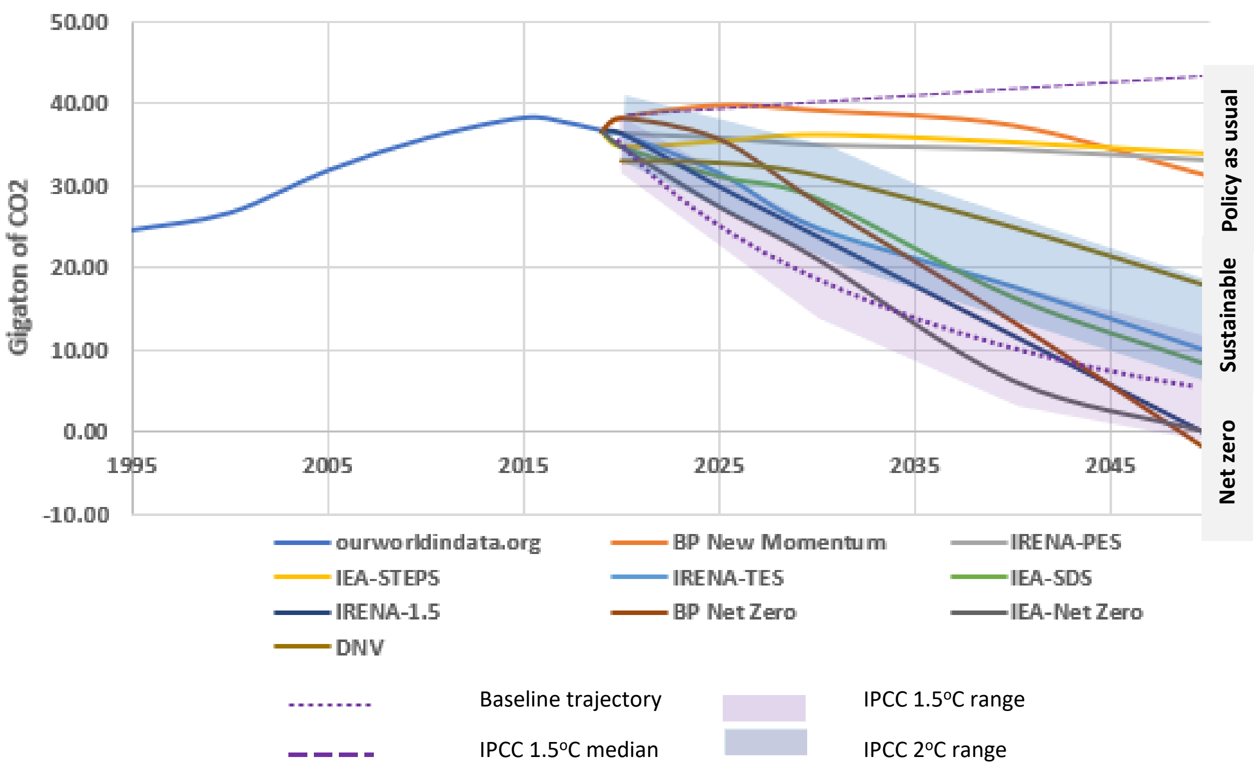
99 IRENA

Exhibit 42 Carbon emission reductions in various scenarios for Africa and Sub-Saharan Africa



Own elaboration with data from IRENA and IEA website and downloadable spreadsheet of IRENA (2020), IEA (2021a), IEA

Exhibit 43 Carbon emission reductions in various scenarios compared with 'Paris-consistent' IPCC scenarios



Own elaboration with data from IRENA and IEA website and downloadable spreadsheets and data, IRENA (2020), IEA (2021a), IEA (2021b) and BP (2022)

The pace and extent of the 'sustainable' pathways (e.g., the IRENA-TES, IEA SDS scenarios) are broadly aligned with a range of scenarios in the IPCC reports that are consistent with maintaining a global average temperature rise of 1.4-1.7°C by 2100 below 2°C[100]. The 'sustainable' scenarios are in line with the Paris Agreement objective of "holding the increase in the global average temperature to well below 2°C.

The pace and extent of the 'net zero' pathways (as in the IRENA-1.5°C, IEA-Net Zero and BP Net Zero scenarios) are broadly consistent with the range of scenarios in the IPCC report corresponding to a rise of 1.3°C-1.5°C; thus, in line with the Paris Agreement objective of "pursuing efforts to limit the temperature increase to 1.5 °C". In general, the pace of the 'net zero' scenarios is lower than the median of the IPCC 1.5°C scenarios until after 2035-2040 when the pathways are faster than the IPCC 1.5°C median.

The difference in temperature rise between the scenarios has stark consequences for global ecosystems and human well-being. The higher the temperature rise, the greater the risks of severe weather events such as extreme heat, drought, river and coastal flooding and crop failures. Even during the last decade, with an average temperature rise of 1.1 °C above pre-industrial levels, extreme heat events occurred almost three times more frequently than in pre-industrial times. For example, the IEA (2021) World Energy Outlook mentions that in its STEPS scenario, there would be a 100% increase in the frequency of extreme heat events around 2050, compared to today, and these would be around 120% more intense; there would also be a 40% increase in ecological droughts that would be around 100% more intense.

Africa is a minor contributor to global climate change. It accounts for less than 4% of global energy-related carbon dioxide (CO_2) emissions today and has the lowest emissions per capita in the world. Exhibit 39 attempts to make a summary of IEA and BP scenarios (for Africa) and IRENA (Sub-Saharan Africa). Emissions trajectories in these scenarios diverge significantly. In the 'policy-as-usual' emissions continue to rise, driven by the fossil fuel consumption in Northern and South Africa. The 'sustainable' emission scenario sees emissions drop; energy efficiency advances and a larger share of renewable energy offset emissions increase due to industrial growth, infrastructure development and urbanization.

The scenarios presented here give the CO_2 emissions due to fossil fuel combustion (including the impact of fossil-fuel-related carbon capture and storage). Emissions can be further reduced by employing other carbon capturing and subsequent removal that is outside the scope of the energy sector. These include "natural carbon storage" referring refers to actions that conserve, restore or manage forests, wetlands, grasslands and agricultural lands in such a way as to increase carbon storage or avoid greenhouse gas emissions. In doing so, these actions either reduce carbon emissions or remove CO_2 already in the atmosphere. There is considerable uncertainty about the potential scale of such removals. The IEA SDS-Net Zero scenario gives a figure of about 1.1-1.9 $GtCO_2$ per year by 2050 (up from nil currently and 0.1-0.3 $GtCO_2$ respectively in 2030). The BP New Momentum and Net Zero scenarios give 1 $GtCO_2$ and 6 $GtCO_2$ annually by 2050 (up from nil in 2030/2035).

The numbers should be compared with the current emissions from agriculture, forestry and land-use change (AFOLU) which have been hovering around 3.2-5.2 $GtCO_2$ annually during the period 1975-2020[101]. Achieving the climate goals assumed in the 'net zero' pathways can only happen if the clean energy transition is accompanied by commensurate actions to reduce AFOLU emissions. In this respect, stopping deforestation is important. Africa contains around 16% of the world's forested land area, the maintenance of which is key to achieving biodiversity and climate goals. However, deforestation has accelerated in recent years in Africa, with 4 million hectares lost every year between 2016 and 2020 on average; an annual rate of about 0.6% (larger than South America's 0.3% p.a. and the global 0.1%)[102].

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[100] With 33-67% confidence levels. Data taken from IEA (2021a) and IRENA (2020)

[101] https://ourworldindata.org/co2-emissions

[102] FAO (2020); IEA (2022)

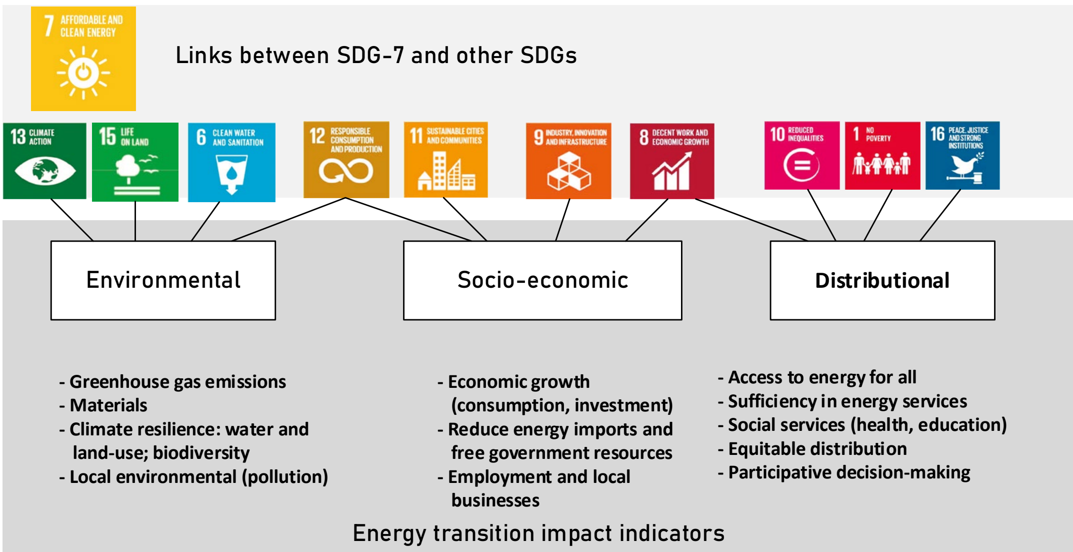
4. ELEMENTS OF A JUST ENERGY TRANSITION

The 21st century's energy transition is predominantly understood in terms of changing from high-carbon energy sources and high quantities of energy use to low-carbon energy sources and reduced energy consumption. However, this is only one part of the energy transitions; its transformative decarbonization will have a two-way interaction with local environmental and socio-economic aspects. In particular, the energy transition will be guided by, contribute to and deliver on the Sustainable Development Goals. The energy transition will have various environmental, economic and social impacts, whose net effects can be positive or negative, and vary from region to region, country to country, community to community and from person to person. In other words, there may be winners and losers. The winners are those that will benefit from cleaner sources of energy, reduced emissions from the removal of fossil fuels, and the employment and innovation opportunities that accompany this transition. The losers are those that will bear the burden or lack access to the opportunities. Failing to address potential injustices that will arise will leave the sustainable development goals unfulfilled, generate widespread suffering, and even risk derailing the transition through widespread resistance. Energy justice is centered around the notion that all individuals should have access to energy that is affordable, safe, equitable sustainable and able to sustain a decent lifestyle, as well as the opportunity to participate in and lead energy decision-making processes throughout the life-cycle of energy resources from extraction to production to consumption to waste[103].

4.1 Energy and sustainable development

The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015. At its heart are 17 Sustainable Development Goals (SDGs). The SDG cover everything from energy and climate; to water, food and ecosystems; to health and poverty; to jobs and growth; among several other objectives. Energy is dealt with primarily by Sustainable Development Goal #7 (SDG-7), whose overarching aim is to 'Ensure access to affordable, reliable, sustainable and modern energy for all'. Underpinning this grand objective are three distinct, yet related, targets to be reached by 2030, namely "ensure universal access to affordable, reliable and modern energy services" (target 7.1), "increase substantially the share of renewable energy in the global energy mix" (7.2), and "double the global rate of improvement in energy efficiency" (7.3).

Exhibit 44 Impacts of the energy transition and links with SDGs



103 Adapted from texts in Carley & Konisky (2020)

Exhibit 45 Interaction between SDG-7 and the non-energy SDGS

		Access	Renewable energy and energy efficiency
13	Climate action (global warming)*	Achieving access, even with fossil fuels, will have a minor effect on global CO_2 emission.	Meeting the renewable energy and energy efficiency targets of SDG7 is a necessary, but not a sufficient, conditioon for long-term temperature stabilization below 2° C (Paris Agreement). For the latter to be achieved with high probability, an upscaling of efforts beyond 2030 will be needed.
12	Responsible production & consumption		Sustainable practices adopted by public bodies, consumers and producersin their operations go in tandem with RE and EE.. Waste-to-energy technologies can generate useful energy (electricity, heating/cooling) from disposables that are not suitable for recycling. Renewable energy and energy efficiency slow the depletion of several types of natural resources, namely coal, oil, natural gas, and uranium. Increasing recycling rates offers a means to improve the energy efficiency of materials production
			Advanced technologies and infrastructure will, however, require vast amounts of minerals, including both common commodites and even more critical minerals and are earth elements.
15	Life on land - Health terrestrial ecosystems	Access to modern energy services (reducing firewood and charcoal) reinforce the goal of stopping deforestation	Protecting terrestrial and inland freshwater ecoystems, stopping deforestation and biodiversity loss can potentially clash with RE expansion, in particular with biofuel production and large hydropower. On the other hand, soil degradation must be avoided in biofuel production to be successful.
6	Clean water & sanitation	Upscaling access will enable access to cl\ean water through pumping or purification (energy-for-water)	An up-scaling of renewables and energy efficiency will, in most instances, reinforce targets related to water access, scarcity and management, for example by lowering water demands for thermal cooling at energy production facilities and lower levels of pollution) compared to less-efficient fossil energy technologies.
			Bioenergy and hydropower technologies could, if not managed properly, have counteractng effects that compound existing water-related problems in a given locale. Third- and fourth-generation biofuels (e.g., algae) may have lower water impacts, since they can utilize land and water that is otherwise unsuitable for food production.
11	Sustainable cities & communities	Ensuring households have access and sufficiency in modern energy form is a part of basic housing services	Efficient transportation technologies powered by renewably-based energy carriers will be a key building block of any sustainable transport system (higher-efficiency fossil-fuelled vehicles, electric vehicles, public transport, densification). Modernized telecommunication networks and 'green buildings' are interlinked with a successful expansion of renewable energy and energy efficiency
8, 9	Decent work & economic growth; Industry, innovation & infrastructure - Employment	Provision of energy access can play a critical enabling role for new (local) productive activities, livelihoods and employment	Deploying renewables and energy-efficient technologies, when combined with other targeted monetary and fiscal policies, can help spur innovation and reinforce local, regional, and national industrial and employment objectives.
			While scenarios indicate a positive gross employment effect of sustainable energy transition, the net effect can differ markedly per sector and region. The distributional effects experienced by individual actors may vary significantly. Strategic measures may need to be taken to ensure that a large-scale switch to renewable energy minimizes negative impacts
	- Economic growth; Inclusive and sustainable industrialization	Reliable access to modern energy services can have an important influence on (local) productivity and earnings.	Decarbonization of the energy system through an up-scaling of renewables is consistent withs sustained economic growth and resource decoupling. Upgrading energy infrastructure and making the energy industry more sustainable (e.g. reduce losses in power T&D; upgrade fossil fuel industries to reduce leaks and fugitive emissions).
			A rapid up-scaling of renewable energies could necessitate the early retirement of fossil energy infrastructure (e.g., power plants, refineries, pipelines) on a large scale. The socio-economic implications of this could in some cases be negative where the industries are locally important
1 10 3 4	No poverty Reduced equalities Good health Good quality education	Access to modern energy forms is (electricity, clean cook-stoves, high-quality lighting) is fundamental to human development and necessary for access to basic services (health clinics, schools) and have a positive gender impacts (clean cooking and health; gender and productive uses)	The distributional costs of new energy policies (e.g., supporting renewables and energy efficiency) are dependent on instrument design, but can be cost distribution can be addressed with the right policy instruments
		However, if costs are above ability to pay, this could impair progress toward universal energy access	The impacts of energy efficiency measures and policies on inequality can be both positive (if they reduce energy costs) or negative (if mandatory standards increase the need for purchasing more expensive equipment and appliances; taxation on non-renewable energy carriers) f costs do fall disproportionately on lower-income groups, then this could impair acceptability and impair progress towards RE and EE goals
16	Peace, justice and strong institutions	Effective institutions (at local, national and international level) will be needed to for providing energy access, RE and EE, together with a strengthened role of international organizations (UN, development banks, bilateral partners, etc.) To support clean energy and energy access efforts, strengthened financial institutions in developing country communities are necessary for providing capital, credit, and insurance to local entrepreneurs attempting to enact change.	

Source: adapted from McCollum (2018) and UN (2021b)

Energy is intrinsically linked with many other SDGs. Exhibit 45 presents an overview of the interactions between SDG-7, indicating a reinforcing link (green), or a counteracting link (orange), with neutral links that can go either way (in blue). Being aware of these linkages may help policymakers to or action along individual SDG dimensions as part of integrated, holistic thinking on development policy. For example, realizing that by that rural electricity access also positively impact rural universal water access (SDG 6) and positively impacts access to essential social services (health center, school) may incentivize policy-makers to put more emphasis on the universal energy access goal.

4.2 The environmental dimension of the energy transition

4.2.1 Water and energy

Today, more than 2.1 billion people lack access to safe drinking water. More than half the global population, about 4.5 billion people, lack access to proper sanitation services, according to UN Water. More than a third of the global population is affected by water scarcity. Roughly 80% of wastewater is discharged untreated, adding to already problematic levels of water pollution[104]. By 2050, water demand is set to increase by over 50%. The provision of freshwater from surface water, groundwater or desalination, its transport and distribution, and the collection and treatment of water and wastewater all depend on energy. In 2016, the water sector consumed globally about 1400 terawatt-hours (TWh) of energy, for supply (pumping and treatment), 42%, desalinization (26%), and wastewater treatment (14%). Most were in the form of electricity (850 TWh in 2016), which would rise to 1,470 TWh in 2040[105]. In terms of energy use, meeting the SDG-6 goal would add only 1% to the total energy demand for the water section[106].

For Sub-Saharan Africa, 30% of the population has no access to safely managed drinking water, only 21% uses a safely managed sanitation service, and only 28% of wastewater is safely treated[107]. As many of those without access to drinking water in rural areas also lack electricity, there is an opportunity to use plans for the provision of electricity in pursuit of SDG-7 to provide access to safely managed drinking water. The report IEA (2018) further states that almost two-thirds of those who gain access in rural areas to safely managed drinking water do so through electrified solutions. For areas where it is too expensive for the main grid to reach, community solar-powered water pumps are one option to replace labor-intensive hand pumps or more expensive diesel pumps.

The energy sector consumes a lot of water. Globally in 2016, the energy sector withdrew about 340 billion m^3 and consumed about 50 billion m^3, in particular for cooling towers in power generation. About 90% of power generation is water-intensive and three-quarters of all industrial water withdrawals are used for power production. In Africa, power plants consumed 502 million m^3 and withdrew 518 million m^3. Fuelwood production consumed an estimated 4.5 billion m^3 of ground water in 2016. The major water user was hydropower with an estimated 42 billion m^3 loss due to evaporation at the hydro reservoirs[108].

The role of increased penetration of renewables may work both ways. Wind and solar PV are less water-intensive whilst providing the power needed. Other energy carriers, biofuels, concentrated solar power (CSP) and even nuclear power, if not managed properly, may increase water stress. The use of non-hydro renewable energies instead of fossil fuels can contribute significantly to reducing water use while covering the growing energy needs in Africa. The hydropower potential remains largely untapped in several regions of the continent. Nevertheless,

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104 IEA (2018); UN (2021b)

105 Ibid.

106 IEA (2018)

107 https://sdg6data.org/region/Sub-Saharan_Africa

108 Gonzales et.al. (2020)

new hydropower developments need to be carefully considered especially in regions characterized by severe water scarcity.

The demand for bioenergy can result in a substantial increase in water demand for irrigation, thereby potentially contributing to water scarcity in water-stressed regions, unless risk-mitigation measures such as rain-fed production of bioenergy, are put in place.

4.2.2 Modern biofuels, land use and biodiversity

Bioenergy makes up a large share of renewable energy use today and will remain a significant source of fuel for power and heat generation in industry and as a fuel used in transport. While the traditional use of bioenergy (fuelwood and residues burning in inefficient methods) will decline, the share of primary energy that is met with modern bioenergy worldwide will increase from 5% today to 10% in the IRENA Planned Energy (PES) and 23% in its Transforming Energy (TES) scenarios.

Biofuels are a type of fuel derived from solid biomass through different chemical and biological processes. Currently, liquid biofuels (e.g., bioethanol and biodiesel) produced from edible plants or animal fats are by far the most popular biofuel types for transport purposes in the United States, Brazil, European Union, China and India. The USA are the largest producer of bioethanol, while the EU is the largest producer of biodiesel. In 2019, worldwide biofuel production provided 3% of the world's fuels for road transport and a very small amount of aviation biofuel. In the IEA and IRENA sustainable scenarios, biofuels will meet more than a quarter of the world's demand for transportation fuels by 2050, in order to reduce dependency on petroleum. In the IRENA pathways, the production of liquid biofuel will increase from the current 136 billion liters to 285 and 393 billion in 2030 and 2050 (PES) and even 378 billion in 2030 and 662 billion liters in 2050 the TES[109].

Across Africa, Jatropha (for biodiesel), sugarcane (for ethanol) and molasses (for ethanol) have been the biofuel feedstocks that have attracted the most interest, dominating proposed biofuel investments in the continent. Other feedstocks such as cassava, palm oil, sweet sorghum, tropical sugar beets, canola oil and sunflower oil have been identified as promising but, to date, their contribution has been much low.

IRENA estimates that the energy content of that potentially available for conversion into liquid biofuel by 2030 at about 4.8 EJ/yr. Of this potential, 3.6 EJ corresponds to ethanol production; 65% of ethanol potential is found in Southern Africa and 20% is in East Africa, followed by Central Africa. West and North Africa contribute a negligible amount. Oil palm, the fruits of which are important feedstock for biodiesel, is produced widely in plantations in West and Central Africa and particularly in Nigeria, Ghana and Benin. For biodiesel, 41% of the potential is found in Southern Africa and 22% each in Central and Eastern Africa, while West Africa accounts for 15% of the potential[110].

Ethanol and ethanol gels are emerging as cooking fuel options in Africa. While bottled LPG and electricity serve the wealthier market segment, ethanol can position itself as a (cheaper) alternative to dirtier wood fuels and kerosene that are used by a majority of households. In the IRENA TES, ethanol for cooking increases from 13 PJ to 82 PJ by 2030. Regarding transport, ethanol is blended with gasoline in Malawi, and more countries plan to blend biofuels (see Exhibit 54). Currently, the use of biofuels is a modest 13 PJ a year (0.3 billion liter) which in the PES will grow to 7.5 billion liters by 2030[111] and 13 billion liters in PES, increasing to 12 and 21 billion liters in 2050 in PES and TES respectively.

Biofuel production and use in Africa have been linked to numerous environmental and socio-economic impacts such as greenhouse gas and pollutant emissions, water use, water pollution, soil erosion, deforestation,

[109] IRENA (2020).

[110] IRENA (2014b)

[111] Of which 2.8 billion liter (93 PJ) for ethanol, and 7.5 billion liter (205 PJ) biodiesel. In the IRENA scenario, ethanol use increases to 82 PJ in the residential sector, while use of biofuels in transport will be 93 PJ (biodiesel) and 123 PJ ethanol in 2030. Sources: IRENA (2015), IRENA (2020)

biodiversity loss, income and employment generation, energy security, food security, human health and social conflicts. Whether these impacts are positive or negative depends on a multitude of factors such as the feedstock, the environmental and socio-economic context of biofuel production, as well as the policy instruments in place during biofuel production, use and trade.

The scale-up of bioenergy use has meanwhile triggered debate over the risk of converting forest and high carbon stock areas to monocultural agriculture or timber plantations for bioenergy production. The plantations generally have much lower carbon stock than natural forests. Carbon stock loss resulting from land conversion may exceed the emission savings achieved from fossil fuel substitution, defeating the purpose of bioenergy development. Expansion of commercial agriculture and forestry, including bioenergy production, can also have negative biodiversity impacts, as the conversion of natural habitats to croplands can threaten native species. Large-scale monoculture plantations and other biomass production practices, such as changing forest management to strategies favoring faster growing species, greater residue extraction and shorter rotations may also have a negative impact on biodiversity[112]

Competition with land for food production is often cited as a drawback. Increasing biofuel production from the transformation of agricultural waste can be sustainable if based on the intensification of crop production and livestock grazing on existing agricultural lands, rather than the extension of crop and grazing lands. The potential for production of advanced biofuels in many African countries is enormous, thanks to the size of the continent's important role of the agricultural sector in the economy. As food production expands to meet the nutritional needs of growing populations, there is also increased output of agricultural residues. Part of these residues would be available for energy production if collected in a sustainable way (allowing for residues to use as natural fertilizer or soil improver, or fed to animals for meat and dairy production). By improving yields through modern agricultural practices, it should also be possible to grow the same amount of food on less land. By managing the food chain more efficiently and by modifying food consumption habits, food losses and waste can be reduced (about one-third of food in Sub-Saharan Africa is lost or wasted)[113]. If food products would be handled and consumed more efficiently, more land could be made available for bioenergy and biofuel production.

Bioenergy generated from waste streams may have extra benefits in emissions reduction, especially biogas produced from methane released from landfills, animal manure, and other organic residues. This can be an important way to reduce methane emissions in some regions, while producing biogas and biofuels (from waste, animal manure and residues) supports better waste management practices and promotes the circular economy.

Food systems are energy-intensive, currently consuming as much as 30% of the world's available energy; they are also heavily dependent on fossil fuels. Spanning from land-use change activities and agricultural production (71%) to packaging, fuel and fertilizer production and waste management, food system emissions were estimated at 18 gigatons of CO_2eq in 2015, equivalent to 34% of the global total Water, energy, and food are essential for human well-being, poverty reduction, and sustainable development. Demand for freshwater, energy, and food is expected to increase significantly over the next decades. By 2050, it is estimated that global demand for energy would nearly double, and water demand is set to increase by over 50%. Agriculture accounts for 70% of total global freshwater withdrawals, making it the largest user of water[114].. Similarly, water needs for agriculture, industrial, and domestic purposes will increasingly rely on resources that are harder to reach and more energy-intensive to exploit. Energy is needed in all aspects of the food chain, in production, harvesting, transport and storage and subsequent retail, preparation, cooking and consumption. Given such significant interlinkages between energy, water and food, an inclusive and just energy transition must address these issues in an integrated approach food, energy and water, and climate policy approach.

[112] IRENA (2022)
[113] IRENA (2017)
[114] Data based on Crippa et.al. (2021) and UN (2021b)

4.2.3 Air pollution

Particulate matter ($PM_{2.5}$)[115] is emitted from vehicles, coal-burning power plants, industrial activities, fuelwood and waste burning, and many other human and natural sources. Household air pollution results from the burning of various fuels (coal, charcoal, wood, agricultural residue, animal dung, and kerosene, among others) for heating or cooking, using open fires or cookstoves indoors with limited ventilation. Burning these fuels produces an array of pollutants that may harm human health, including $PM_{2.5}$, black carbon, and carbon monoxide. Exposure to household air pollution is widespread in Sub-Saharan Africa. The 10 countries with the highest proportion of households cooking with solid fuels in the world are all in Sub-Saharan Africa[116].

Outdoor air pollution ($PM_{2.5}$ and ozone) is linked to 4.4 million premature deaths globally in 2019, of which household air pollution (mostly from the traditional use of biomass as cooking fuel) to more than 2.2 million premature deaths. In \Sub-Saharan Africa, household air pollution-related death rates are close to 200 out of 100,000 in several countries, according to HEI (2020). The trends of deaths attributable to $PM_{2.5}$ are modestly increasing, while those to household air pollution somewhat decreasing.

In the IEA sustainable scenarios, the emissions of the three major air pollutants, sulfur dioxide (SO_2), nitrogen oxides (NO_X) and fine particulate matter ($PM_{2.5}$) will decline sharply from current levels. The result is a major reduction in health impacts; premature deaths linked to outdoor air pollution fall by half a million and premature deaths from household air pollution by 1.9 million in 2040[117]. Universal access to clean cooking is instrumental in almost eliminating residential $PM_{2.5}$ emissions and sharply reducing household air pollution.

4.2.4 Minerals

The energy transition involves energy efficiency and the mass electrification of end-use sectors as well as renewable energy generation and penetration of new energy carriers, such as hydrogen. Key technologies such as solar panels, wind turbines and batteries require critical materials such as nickel, copper, lithium, and rare earth elements. As demand will soar, ensuring sufficient quantities of these materials will be increasingly challenging, for several reasons; extracting them is difficult, only a handful of countries have deposits (of which some in Africa), while the quality and quantity of the natural resources have been declining. There are no direct substitutes and recycling is difficult (they are hard to recover, as only small amounts of materials are used in end-use applications).

The most important critical materials are copper, cobalt, nickel, lithium and rare earth elements (REEs, particularly neodymium and dysprosium). Copper is a crucial component of power lines connecting generators with end-users. Lithium and nickel are used to produce rechargeable batteries for electric vehicles (EV) and stationary systems. Cobalt is often used in electric vehicles (EV). Neodymium and dysprosium play key roles in the permanent magnets found in wind turbines and EVs. None of these elements can easily be replaced by alternatives.

Current reserves of copper are an estimated 2,100 million tons (Mt), spread widely geographically (including Africa's Copperbelt in DR Congo and Zambia), although currently half of the copper is produced in three countries (Chile, Peru, and China). Reserves of lithium are an estimated 80 Mt and are currently produced in 12 mines around the globe (Australia, China, Argentina, Brazil)[118], while half of the processing takes place in China. Supply will increase while new entrants will enter the market (in Africa, Zimbabwe and Namibia). Nickel reserves are 89 Mt and currently over half of the production is in three countries (Indonesia, Philippines, and Russia). Reserves of neodymium are 8 Mt, but demand surpasses projected supply by a factor of up to 3.5 times for dysprosium and up to 2 for neodymium by 2030[119].

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115 Meaning 2.5 micrometer in diameter

116 Central African Republic, South Sudan, Rwanda, Burundi, Niger, Mali, Madagascar, Tanzania, Uganda, and Guinea-Bissau. HEI (2020)

117 IEA (2018), SD scenario

118 Half of Li production in 2019 was in Australia (1.6 Mt)

119 IRENA (2022a), based on various sources of info

A small number of countries dominate the production of clean energy metals. The concentration of processing and refining is even greater. China accounts for a dominant share of the processing of rare earth minerals (88%), cobalt (65%), lithium (58%), copper (40%), and nickel (35%)[120]. In the current energy order, the production of fossil fuels in a limited number of countries has often meant that geopolitical issues have already disrupted the supply chain, as happened in the two oil crises in 1973 (Arab oil embargo) and 1979-1981 (Iran revolution and start of the Iran-Iraq war) and more recently, the disruption of natural gas supply from Russia to Europe after its invasion of Ukraine in 2022. There is a danger that the dependency on oil and gas is replaced by a dependency on critical materials that are even more prone to be used as a geopolitical weapon. Certain materials, such as neodymium and cobalt, are more sensitive to supply chain disruptions than others because of their limited geographical distribution.

Technology development and economies of scale have pushed down the cost of many technologies that will play a crucial role in the energy transition, such as lithium batteries and PV panels. A longer-term continuation of rising supply chain cost material prices would slow down or even reverse the downward trajectory of overall technology cost. On a global scale, this could add billions to the already high amounts of investment needed to achieve sustainable energy pathways.

Mining activities have various adverse environmental impacts. They can reduce biodiversity, produce greenhouse gas emissions, and contaminate water and soil (see also In Focus 2). For example, in the mining of rare earth minerals, one ton results in 2,000 tons of toxic waste, including 75 cubic meters of wastewater and 1 ton of radioactive waste. Concern over environmental externalities creates local opposition to new activities, which can delay the opening of mines and result in supply bottlenecks. It is important for mining activities to work with local governments and civil society to find ways to provide socio-economic benefits to the people living in areas of operation. Mitigating environmental risks and supply shortages will be essential in future mineral production expansion. Mineral resources have to be conserved more by re-using products and recycling products and recovery of the rare minerals therein.

Africa holds huge amounts of mineral resources, many of which are critical to various clean energy technologies. For some mineral resources such as cobalt, platinum-group metals (PGMs) and manganese, the region is already a major supplier to the global market (manganese, 45%). South Africa dominates global supplies of PGMs and is also a leading producer of chromium (48% of world production) and manganese (30%). DR Congo accounts for about 45% of global cobalt production (Africa as a whole for 54%). The continent also holds a sizeable share in the production of other mineral resources such as bauxite, graphite and copper. There are also substantial untapped resources of other minerals such as lithium and nickel of which mining is currently under development (e.g., Ghana, DR Congo, Namibia, Zimbabwe). Production of mineral resources is already a vital source of income for Africa, representing around 8% of government revenues in resource-rich African countries[121].

The potential economic contribution of mineral production is much greater as demand for many critical minerals is set to grow quickly as a result of global energy transitions. In the IEA policy-as-usual (STEPS) demand for minerals will increase twofold in 2050. If the global energy transition follows the greenest of the IEA (NZE) and IRENA (1.5°C) pathways, total demand for materials will increase:

- Copper from 24-30 million tons a year (Mt/yr) in 2021 to 34 Mt/yr in 2040 and 50-70 Mt/yr in 2050 (of which about half for energy-related products),
- Nickel from 2.2-2.8 Mt/yr to 6.2 in 2040 and up to 8 Mt/yr in 2050 (of which 70% for energy purposes),
- lithium from 0.3-0.41 Mt/yr to 1.2 Mt/yr in 2040 and 2-4 Mt/yr in 2050 (most for batteries),

[120] IRENA (2022a)

[121] IEA (2022); NAI (2018)

In Focus 2 Minerals, energy and poverty in DR Congo

The Democratic Republic of Congo (DR Congo) is also the world's largest producer of cobalt and the hird largest producer of copper. Both minerals are critical for clean energy technologies, and demand for these resources are projected to increase in response to the global energy transition. DR Congo's share in global cobalt production was 70% in 2021, producing about 78,000 tons of cobalt. Cobalt is mined industrially, as a by-product of copper mining. Currently, the Swiss company Glencore and the company China Molybdenum account for almost half of all cobalt production in DR Congo. However, it is estimated that about 15 to 20% of the cobalt mined in DR Congo stems from artisanal mining and that about 110,000-150,000 artisanal miners (more than 90% of cobalt's mining employment) are active in cobalt mining. The copper-cobalt mining has sparked conflicts. Most of the artisanal cobalt mining activities in DR Congo are done informally and without permits, creating conflicts when the industrial companies attempt to remove artisanal miners from their concessions. A second conflict is between the local communities that host the mines and industrial mines, caused by expectations regarding employment and social infrastructure (schools, clinics). NGOs often jump in to argue for a fairer distribution of benefits the mining. A third issue concerns the artisanal mines, which are in general low-tech, posing severe health risks to the miners, while causing local soil and water pollution. An area of concern is the vulnerability of women and children. Although discouraged by national legislation, women and children constitute a growing proportion of miners and workers but, due to their low status, were generally forced to undertake the most strenuous or poorly paid activities, sometimes pressured by their families in mining communities in the Katanga region that have become dependent on informal cobalt mining. Paradoxically, as the global society embarks on the decarbonization transition, other players, in this case, vulnerable mining communities, get negatively affected. This does not mean we should slow down the low-carbon transition but a just transition will require addressing the social issues. Forced formalization of arsenal workers will not solve the issue and drive them into unemployment or deeper illegality. Instead, improving arsenal mine and supporting community health, and broader and more robust community benefit sharing agreements are another, more just, solution.

.DR Congo has the largest hydropower potential in Africa and one of the largest worldwide, with a technically feasible potential of some 100,000 MW. Only about 2.5% of this potential has been developed so far. The potential enabling DR Congo to export power to other parts of Africa via long distance transmission lines, made possible as the country already enjoys the privilege of belonging to three of the five power pools of the African continent, namely CEAPP, SAPP and EAPP (see Exhibit 12). Currently, DR Congo actually imports electricity, but will turn into an exporter if the 5,000 MW of planned hydropower plants (HPP), such as HPP Inga 3 (4,230 MW), HPP Luapula (900 MW) get in production. With its enormous hydroelectric potential, the DR Congo aims to produce green hydrogen by reserving a portion of the electrical energy to be produced.

Meanwhile, less than 10% of the population has access to electricity today, making DR Congo the third largest population in the world without electricity access. Centralized grid expansion has failed to increase access to electricity in the DRC, hindered by weak governance, conflict and security issues, poor transport infrastructure, lack of public financial capacity, and remoteness of some areas. While the huge hydropower potential will provide important export revenues, main grid transmission and distribution in the vast country may not be the least-cost solution for expanding access to electricity in the country. Better solutions will be small and mid-sized hydro, solar and hybrid plants with local grids near or within population centers, and a significant penetration of off-grid systems. A World Bank study has estimated that providing all households of the 26 provincial capitals of DR Congo in this way would cost approximately USD 10.5 billion in investment. It proposes that the USD 3.4 billion (5% of the annual government budget) would be taken up by the government, while generation would be commercially implemented and financed. For this to happen, the government needs to government needs to offer favorable investment conditions and create a transparent and stable regulatory environment. This would still leave 2/3 of population without access that could be provided at tier 2 level with solar energy at a total cost of USD 3.3 billion

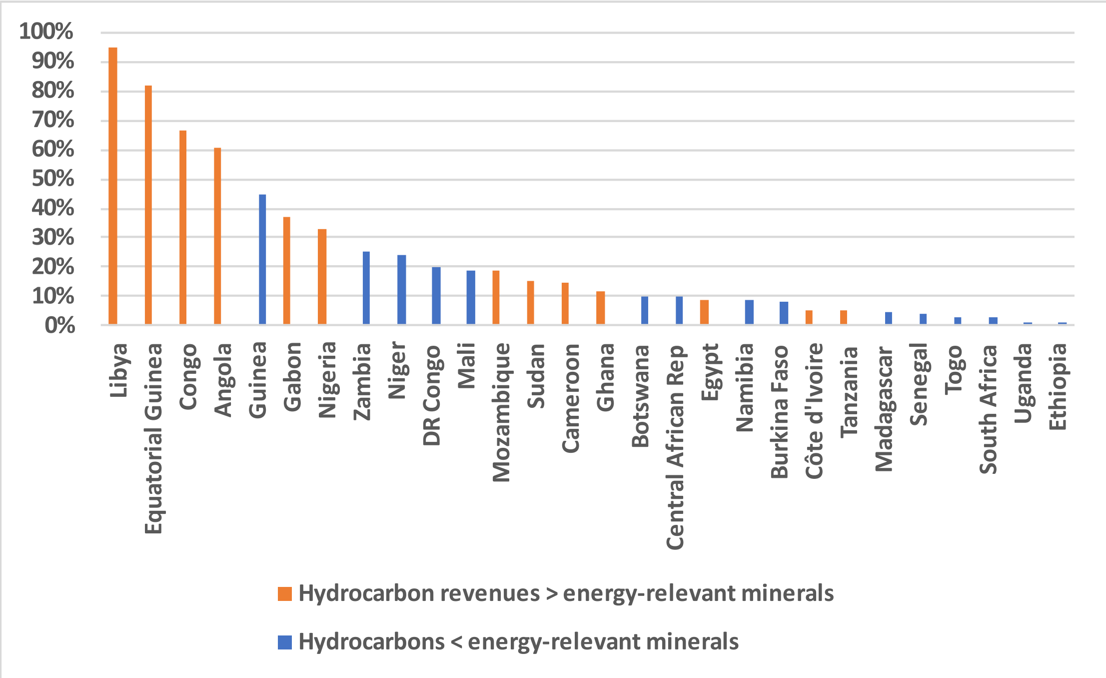
Given the availability of fuelwood in rural areas and the affordability of charcoal in urban areas, almost all people are still likely to cook with wood fuels in 2030. In terms of universal energy access to clean fuels, improved cookstoves seem the most likely option to provide clean cooking access in both urban and rural areas. In parallel, kilns for making charcoal need to be improved to increase their energy conversion efficiency.

Source: https://www.andritz.com/hydro-en/hydronews; World Bank (2020c), Prause (2020), Sovacool, et.al. (2019), IEA (2019)

- Cobalt from 0.18 Mt/yr to 0.7 Mt/yr in 2040 (of which about 70% energy-related)
- Rare earth element minerals (incl. neodymium) from 0.025 Mt/yr to 0.1-Mt/yr in 2040 and 0.2-0.5 Mt/yr in 2050 (of which about 40% energy-related)[122].

[122] Data compiled from IRENA

Exhibit 46 Natural resources exports as % share in government revenue in selected countries



Data compiled from Natural Resource Revenue Dataset (March 2022 version) of the Natural Resource Governance Institute (NRGI)

Currently, of the 24 Mt of copper, 6 Mt per year is used energy-related, which will increase to 14 Mt by 2040. Thus, in 2040, the use of minerals for energy-relevant purposes will increase from about 10 Mt in 2020 almost four-fold in the 'net zero' scenarios and twofold in the IEA STEPS.

Exploiting those minerals can bring multiple benefits to African countries such as export revenues, job creation, local economic and social development, and improved infrastructure. For example, revenues from copper and key battery metals production in Africa are estimated to have totaled over USD 20 billion in 2020 (about 13% of the global market). For comparison, revenues from fossil fuel production were about USD 100 billion[123]. In the energy transition, the revenues from fossil fuels production would drop to below USD 60 billion annually, but revenues from minerals would increase to USD 60-100 billion annually[124].

Several hurdles need to be overcome for Africa to capitalize on its mineral resources and for its revenues to be distributed equitably. A first step is expanding the range of supporting infrastructure such as roads, railways and power supply, which will increasingly call for better cooperation between host governments and mining firms and, regionally, between governments. For Africa to profit more, investments should go beyond just mining and exporting into local value-added activities (refining, processing). As with minerals and fossil fuel production, the risk of overdependence on one revenue source remains with adverse effects such as underinvestment in other productive sectors. Volatile price developments can cause wasteful spending, often exacerbated by corruption, in boom times and strain in times of downturns.

4.3 Socio-economic dimension

The energy transition is often viewed from the angle of technology, in particular the pros and cons of more widespread utilization of renewable and new energy technologies. However, the energy transition will influence

[123] Ibid. IEA Sustainable Africa scenario.

[124] Ibid.

and be shaped by the economy and society as part of one holistic system. The scenario assessments of IRENA and IEA come with assessments of the impacts of changes in the energy sector. This section focusses on the impacts on employment (formal and informal) and the economy (GDP), while the subsequent section 4.4 will discuss the distributional welfare effects.

Economy (GDP)

Gross Domestic Product (GDP) is the most commonly used indicator for income and growth. IRENA uses an integrated macroeconomic model[125] to evaluate the likely socio-economic footprint created by different combinations of energy policies and driven by socio-economic factors, such as trade, consumer spending (influenced by taxes and prices) and investment. In the IRENA modelling, GDP changes by 2.0% by 2030 and 2.4% in 2050 in the TES comparison with the reference case (PES), mainly due to the consumers' responses to taxes and prices. The 1.5°C scenarios see slightly higher GDP growth (2.2-2.3% higher than in comparison with PES).

Exhibit 47 Global jobs in the energy sector in IRENA scenarios in 2050

'(million)	TES	PES	Difference
Total	99.8	86.5	13.3
- Renewable energy	41.9	25.6	16.3
- Energy efficiency	35.0	31.2	3.8
- Fossil fuels	22.9	29.7	-6.8

Source: IRENA (2020)

It is often stated that climate-related investments will adversely affect economic growth. In the IRENA analysis, the net effect is positive. In terms of per capita annualized GDP value[126], the GDP gain is 367 USD per person-year, outstripping the clean energy investment cost of USD 122 USD per person-year[127]. For Africa, the positive effects are even more pronounced. On average, GDP is 7.5% higher in the first decade and 6.4% higher over the nearly three decades until 2050.

This GDP benefit (above growth in the 'policies-as-usual' scenario comes from the combined effects of a) differences in net trade (gains by hydrocarbon import reduction minus export revenues); b) additional public investment in clean energy (RE and EE) and net effects of subsidies and financing, and additional private investment; c) social policies (with payments for lower-income groups); and d) prices of energy (with effects of carbon taxes, reduced fossil fuel subsidies)

Employment

The same model is used by IRENA to estimate employment impacts on the economy as a whole and in the energy sector in particular. Overall employment effects depend on similar socio-economic factors and labor-related effects (wages). Across the world economy, overall employment increases between 2018 and 2050, but at a slower pace than GDP.[128]

Employment in the energy sector is made up of jobs in the three transition-related technologies (renewable energy, energy efficiency, and the power sector) plus jobs in the conventional sectors (fossil fuel and nuclear industry). Job losses in conventional energy (i.e., fossil fuels and nuclear) are more than offset by gains in renewables and other energy-transition-related technologies (i.e., energy efficiency, power grids, hydrogen). Energy sector jobs will increase from about 58 million in 2017 and 65 million in 2019 to about 100 million in 2030

125 E3ME is Cambridge Econometrics' macro-econometric model. IRENA's socio-economic footprint analysis uses the E3ME model to evaluate the systemic implications of transition roadmaps.

126 Using average world population for the period 2019-2050

127 Clean energy investment through 2050 in Sub-Saharan Africa will be 49 USD per person-year

128 With relative differences of only 0.16% by 2050 between PES and TES (an additional 6.5 million jobs). The additional wage volume available can be translated either as wage increases for all workers, or as an increase in the number of jobs, or a mix of both. Historical trends show that wage effects tend to dominate, leading to smaller increases in employment than GDP.

and 140 million in the 1.5ºC scenario. Renewable energy jobs will increase to 17.4 million in PES by 2030 and 45.8 million in the 1.5ºC scenario (IRENA, 2022)

With around 420 million people ages 15 to 35, Africa is a demographically young continent (IRENA-AfDB, 2022). There is an urgent need in Africa not only to create jobs but to create jobs that are productive and well paid to underpin that employment can be a strong path out of poverty. Most African countries are characterized by underemployment, widespread informal employment and limited social system protection. The official unemployment rate across sub-Saharan Africa was 7% in 2020, slightly above the global average. Over 80% of employed Africans work in the informal sector, where wages are low and jobs less secure. About 45% of the employed work in agriculture, earning on average just a dollar per day, while 13% work in manufacturing and 38% in services[129].

According to official data, around 2.1 million Africans were formally employed in the energy and minerals sector in 2019, accounting for about 0.5% of the total labour force[130]. In reality, there are many more informal energy-related workers, particularly in the sectors requiring low-skilled labor such as the commercial collection and sale of biomass, firewood harvesting and charcoal production. Thus, the total of energy-related jobs in Africa may be as high as 11 million. The figures differ per region. The oil and gas sector and thermal power generation are important employers in North Africa, while coal mining jobs make up a relatively high share in South Africa.

The clean energy sector itself has the potential to create 9 million additional jobs by 2030 (as compared to the current 2 million)[131], reaching 12 million by 2050, according to its latest 1.5ºC scenario (employing 5.5 billion people more than in the PES). IEA has a more moderate assessment of a total of 4.1 million additional jobs in the clean energy sector in its IEA's Sustainable Africa scenario (SAS, in IEA, 2022) and about 1.3-1.5 million new jobs by 2030 in the areas of power grids and energy efficiency and fuel switching.

Large part of the new jobs will be in energy access; about 2.8 million jobs are projected to be created (grid extension, minigrids, stand-alone PV, improved biomass stoves, LPG and biogas). The SAS scenarios assume universal access by 2030 so jobs in energy access will decline thereafter, but still about half will be needed for maintenance and upgrading of the energy systems.

Most affected in the energy sector from job losses will be the fuel industry and related value chains (mining, extraction, refining, distribution/logistics and power generation), employing 4.2 million less people in IRENA's 1.5ºC scenario in 2050 than in the 'policy-as-usual' PES[132] and 2.1 million people less in 2030. On the other hand, jobs are created in renewable energy (8 million by 2050), energy efficiency (5.2 million) as well as grid and storage and hydrogen[133]. In fact, fossil fuel employment has been showing a declining trend in Africa from 3.7 million in 2010 to around 2.1 million currently. The renewable energy industry currently employs about 0.32 million people, but this may increase to about 5 million in 2030. In fact, the green energy sector has been shown globally to have a far greater employment multiplier than that of fossil fuels.

Exhibit 48 Socio-economic outlook in IRENA energy scenarios 2019-2050 for Africa

	2019	2030		2050	
		PES	1.5ºC	PES	1.5ºC
Population (thousand)	1.065	1,352		1,947	
GDP (in 2019 USD trillion)	2.56	3.9	4.1	9.7	10.4
GDP difference PES-1.5ºC		5.9%		7.1%	
Overall net employment (million)	280	548	569	722	747
Employment difference PES-1.5ºC		3.8%		3.6%	
Energy sector jobs (million) - Renewables	4.5 0.36	14.3 0.9	20 4.3	17.5 2.3	23 8.1

Source: IRENA-AfDB (2022) and IRENA (2020)

129 IEA (2022)

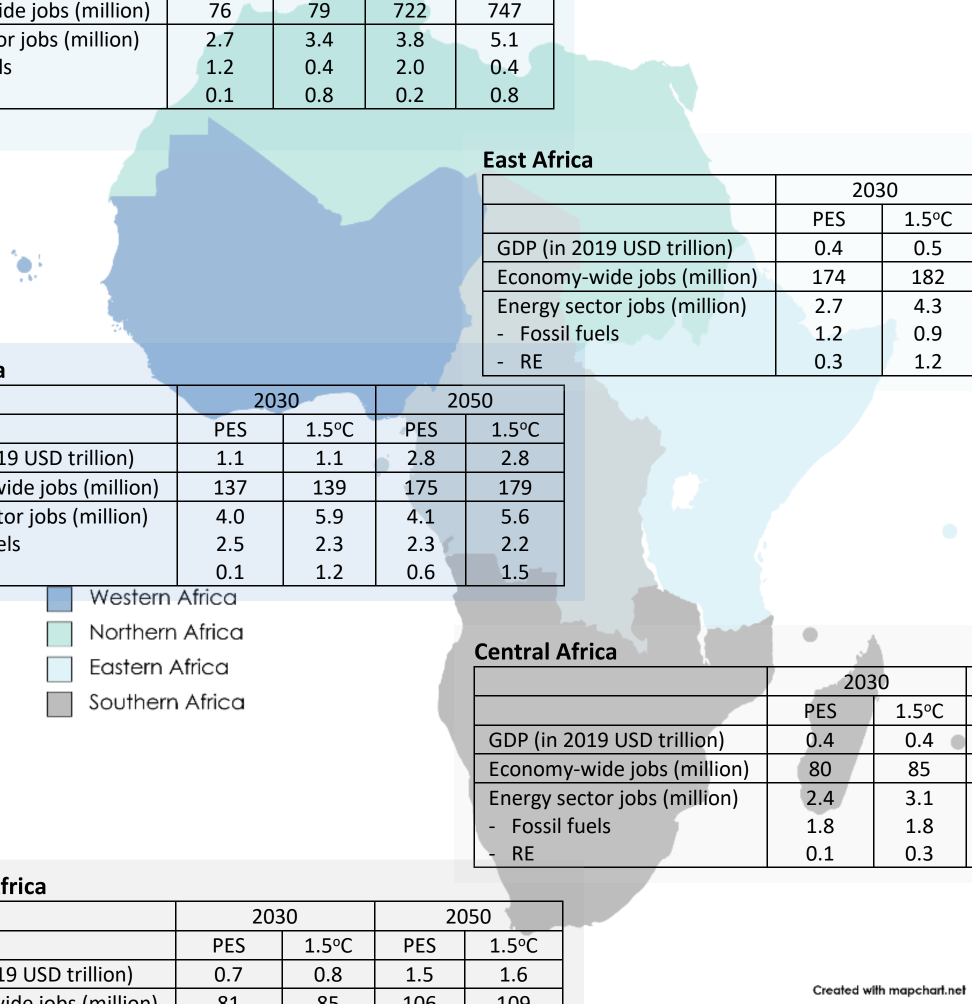
130 Ibid.

131 Of which about 1.3 million in Sub-Saharan Africa and 0.7 million in North Africa. IRENA (2022)

132 IRENA-AfDB (2022)

133 IRENA-AfDB (2022). Employment of 23 million in energy in 2050 in 1.5ºC up from 11 million in 2011.

Exhibit 49 Socio-economic impact of IRENA energy transition scenarios 2019-2050 in Africa



Northern Africa

	2030		2050	
	PES	1.5°C	PES	1.5°C
GDP (in 2019 USD trillion)	1.3	1.3	9.7	10.4
Economy-wide jobs (million)	76	79	722	747
Energy sector jobs (million)	2.7	3.4	3.8	5.1
- Fossil fuels	1.2	0.4	2.0	0.4
- RE	0.1	0.8	0.2	0.8

East Africa

	2030		2050	
	PES	1.5°C	PES	1.5°C
GDP (in 2019 USD trillion)	0.4	0.5	1.2	1.3
Economy-wide jobs (million)	174	182	242	252
Energy sector jobs (million)	2.7	4.3	3.8	5.7
- Fossil fuels	1.2	0.9	2.0	1.3
- RE	0.3	1.2	0.6	2.1

West Africa

	2030		2050	
	PES	1.5°C	PES	1.5°C
GDP (in 2019 USD trillion)	1.1	1.1	2.8	2.8
Economy-wide jobs (million)	137	139	175	179
Energy sector jobs (million)	4.0	5.9	4.1	5.6
- Fossil fuels	2.5	2.3	2.3	2.2
- RE	0.1	1.2	0.6	1.5

Central Africa

	2030		2050	
	PES	1.5°C	PES	1.5°C
GDP (in 2019 USD trillion)	0.4	0.4	0.8	1.0
Economy-wide jobs (million)	80	85	107	115
Energy sector jobs (million)	2.4	3.1	2.5	3.0
- Fossil fuels	1.8	1.8	1.8	1.6
- RE	0.1	0.3	0.2	0.6

Southern Africa

	2030		2050	
	PES	1.5°C	PES	1.5°C
GDP (in 2019 USD trillion)	0.7	0.8	1.5	1.6
Economy-wide jobs (million)	81	85	106	109
Energy sector jobs (million)	2.5	3.2	3.2	3.5
- Fossil fuels	1.5	0.7	2.2	0.7
- RE	0.2	0.9	0.3	1.2

Source: Data taken from IRENA-AfDB (2022)

The fossil fuel industry creates 2.7 jobs per USD 1 m invested, whereas the clean energy sector (renewable energy and energy efficiency) creates between 7.5 and 15 jobs per USD 1m invested[134].

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 wage. IRENA estimates economy-wide employment difference in 2050 in Africa (incl. North Africa) of 3.5%, due to the energy transition.

[134] International Finance Corporation. "A Green Reboot for Emerging Markets". Accessed 19 October 2021.

In Focus 3 Jobs and the just energy transition in South Africa

South Africa is forging ahead with policy development to plan its coal transition. The 2019 Integrated Resource Plan (IRP) schedules the decommissioning of Eskom's fleet of coal-fired power stations of 1,000 MW by 2030, and 35,000 MW by 2050. This trajectory will fundamentally alter the energy mix in South Africa with broad socio-economic implications. There will be significant consequences for employment associated with upstream and downstream activities in the coal sector, as well as the towns and local economies that depend on these activities.

Currently, direct employment across the coal value chain stands at around 150 000 workers. Mining accounts for the lion's share, about two-thirds of total direct jobs (about 92,000 workers in 2020) with about 15,000 in transport. The impact on employment is larger; for every direct job, there may be two indirect jobs, in the form of jobs and restaurants serving coal workers. Outside of these formal categories of employment, there is a sizable number of people who scavenge coal for either self-use or to sell in the market. These workers are often referred to locally as *zama zama*s or people who "try and try." These jobs are fundamentally at risk with the demise of coal-based activities. Some direct coal sector jobs (about 40,000) are related to power generation (Eskom) petrochemical production (Sasol) and steelmaking. Here, jobs may be preserved as the industries will introduce alternative feedstocks or technologies.

The coal sector is also regionally concentrated. About 90% of coal production and 70% of coal power plants in South Africa are in Mpumalanga. In terms of the structure of the coal industry, coal mining is completely in the hands of the private sector, while coal power plants are exclusively run by state-owned power company Eskom. Overall, the mining sector contributes 25% of Mpumalanga's GDP, more than any other sector. The unemployment rate in the region is already high at 34%. Of those employed today, 5% work directly in coal mining,

In Mpumalanga, agriculture and tourism, among others, have a potential for expansion and thus for creating employment. However, bringing these sectors into the coal-dependent municipalities involves unique challenges. The tourism areas (Kruger Park) are in the east, while the mines are in the western part. About 47% of South Africa's arable land is in Mpumalanga, but the areas around the mines have been degraded making agricultural expansion there difficult. In any case, wages in the agriculture sector are low in comparison to those in coal-related sectors, and will not attract many ex-coal mine workers.

According to the IRP, the aggregated net jobs (direct and indirect) in construction and operations and maintenance for all the renewable energy indicate a net increase of 226,000 jobs that could be created by 2030, while job losses in the coal sector by that time would at least be 52,000 by 2030. The IRP acknowledges that lost coal jobs will only partly be replaced with other energy sector jobs. First, solar and wind employment would be in various places other of South Africa. Most renewable energy facilities have been in development zones outside Mpumalanga. Second, it should not be assumed that replacement in renewable energy, which require different skills sets, can absorb the unemployment coming out of the shrinking coal value chain. Competences in green jobs like wind and solar PV sector are generally low in areas that have been coal dominated.

However, Mpumalanga has a well-connected infrastructure network such as road connectivity, broadband connection, and electricity transmission lines built for expansion of the coal mining and power sectors. While the potential for wind is small in the province, solar energy can take advantage because the coal phase-out will leave sufficient grid infrastructure that solar PV power plants can easily utilize to transmit power

The reskilling of coal sector workers towards the renewable energy sector will be necessary to achieve a just energy transition that absorbs former coal sector workers and at the same time ensure that a highly skilled and technically competent workforce base is available for a successful energy transition. Partnerships in the local skills development ecosystem include institutions and firms as well as vocational training centers and universities. Apart from formal training, skills could be acquired through several instruments including workshops, short courses, online learning, self-learning and learning-by-doing.

The national government will have a crucial role in allocating funds to help diversify the province and coal-dependent regions within the province as part of an integrated industrial policy to promote these investments throughout the province and in local coal-dependent municipalities. It will also require a better alignment between national, provincial, and local-level planning, to encourage private sector companies to invest in sectors such as renewable energy in Mpumalanga.

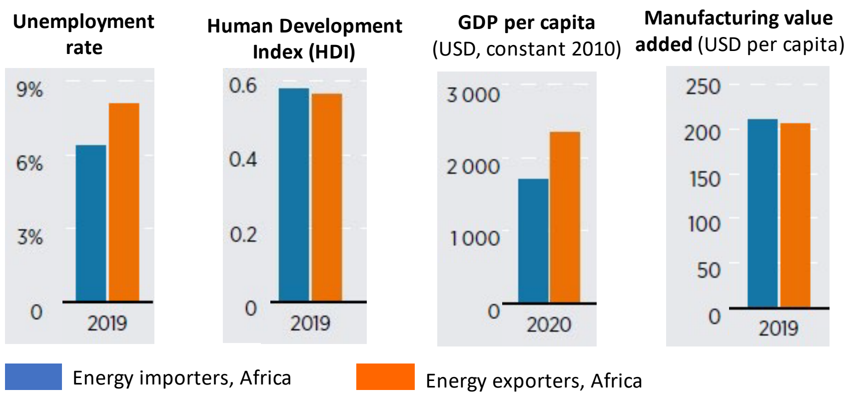
In response to the prospect of a radical change in job requirements in the energy sector, the government has established a Presidential Climate Change Co-ordinating Commission (P4C) to develop a transition framework for economic diversification, labour market intervention and social support to be finalised in 2022. It has prepared a "just transition framework" setting out goals for distributive, procedural and restorative justice for all stakeholders. In the coming five years, donors may make available up to USD 8.5 billion over the next three to five years to fund the transition away from coal. This will include funding for worker transition and community support.

Source: JTI (2021, TIPS (2021), RES4Africa (2018), IEA (2022)

4.4 Distributional dimension

Already today, there are huge inequalities in energy production and consumption between countries and regions in Africa, as was discussed in Chapter 2. The skewed distribution both in terms of production and consumption is partly linked to the geographical location of energy sources, but also reflects vastly different conditions of industrial and economic development. In a continent with very limited infrastructure connections, countries with low access to modern forms of energy are further isolated. Equally important is Africa, and particularly sub-Saharan Africa, is also characterized by a high level of inequality difference within countries, and above all, between urban and rural areas, with huge disparities in access to modern forms of energy.

Exhibit 50 Socio-economic indicators of energy exporters and importers



Source: adapted from IRENA-AfDB (2022)

4.4.1 Sectoral and regional distribution

<u>Differences between fossil fuel exporters and importers</u>

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 countries. However higher GDP per capita is not necessarily associated with higher income equalities. In other words, greater wealth does not by itself imply better living standards for all. For example, there is no difference between oil importers and exporters in performance on UNDP's Human Development Index (HDI), as shown in Exhibit 50. Also, energy exports have seldom promoted value-added manufacturing activities. Only in the composition of employment, a difference is visible; industry (associated with fossil fuels) employs 29% compared to 6% in oil-importing countries.

In addition, the energy resource mix, based heavily on fossil fuels has failed to provide populations throughout Africa with complete and reliable energy access. Sub-Saharan oil exporters do not have electrification rates that are markedly different from their neighbors, as can be seen from Exhibit 5 in section 2.2.

Endowed with significant energy resources, many of them renewable, African countries could push ahead with the sustainable energy transition. However, for this transition to be a just transition it must avoid past mistakes and take into account the wider socio-economic perspective, maximizing the benefits (access for all, more equitable income distribution, value-added industrial development) while minimizing potential harm in terms of the environment (such as large hydropower schemes impacting biospheres) and local communities (e.g., job losses in the coal and oil sectors).

<u>Regional differences</u>

Exhibit 49 summarizes differences in expected GDP and employment development according to IRENA's 1.5°C in comparison with 'policies-as-usual'. All African regions benefit from a green energy transition in terms of GDP growth. It should be noted that these averages at the regional level mask the differences between individual countries in a region, such as differences between oil and gas exporters and importers, and between large and small economies.

The energy transition will contribute to diversifying economies, by boosting demand for new product ranges and services, and promoting innovation in new technologies and knowledge-based products in some sectors. Thus, manufacturing and engineering-related economic activities gain from the energy transition, and this effect increases over time. Supplying inputs and services for these sectors, retail and transport will also see net gains. Electricity utilities will gain as will decentralized energy service providers.

This net positive effect of the transition can be observed across all five African regions in general, but the effect of the energy transition will also differ across Africa, based on existing economic structure and infrastructure; type of domestic energy and mineral resources; the availability of enabling economic and institutional factors; the presence of financing resources for investment, as well as the potential for providing transition-related skills. The most difficult, and hence politically challenging, transitions occur in countries and regions that are highly dependent on fossil fuels, notably Northern Africa and South Africa, where coal and oil industries stand to lose as do their respective utilities. The impact on the natural gas sector will depend on its position in the energy transition.

Energy-relevant minerals (23%), together with hydrocarbons (48%), made up more than 70% of the value of Sub-Saharan's exports to the rest of the world between 1995 and 2018. Exports of crude oil, natural gas, and metals accounted, on average, for 2% of government revenues in the region in 2014. While hydrocarbon products remain the largest source of Sub-Saharan Africa's exports to other regions, their value has fallen sharply in recent years. By contrast, the value of energy-relevant minerals exports has risen steadily, growing seven-fold since 1995[135].

Africa's proven fossil fuel reserves are estimated at more than USD 15 trillion, based on current market value. In Sub-Saharan Africa alone, nearly 50% of export value is derived from fossil fuels with an estimated annual contribution to GDP from Africa's current oil, coal and gas production of approximately USD 156 billion[136]. The global energy transition is, however, putting this crucial income source for the continent at risk. While demand for coal will decline the quickest, there will be a slower global decline in demand for oil while gas is expected to see continued growth until the mid-2030s before peak demand is reached. This will specifically impact Africa's fossil-fuel exporting economies. On the other hand, oil and gas importers will benefit if their economies become less dependent on imported fossil fuels and can use domestically available (renewable) resources.

On the other hand, the global energy transition will be metal- and mineral-intensive, as clean energy technologies (for example, battery storage and electric vehicle manufacturing) and other technologies (computers, smart phones) require these materials. African countries already producing and exporting minerals and metals needed in electric vehicles and renewable energy technologies could benefit from increased demand. DR Congo, Zambia and Madagascar, for example, are important cobalt producers, while Zimbabwe and Namibia have significant lithium reserves.

Although a nascent market, the rapid development of green hydrogen could also provide attractive energy export revenues, in particular in North Africa. Africa has an abundance of solar and wind energy potential as well as the largest reserves of platinum group metals, including platinum and iridium, which are critical in the manufacture of electrolysers and fuel cells. Green hydrogen opens the door to downstream exports as a zero-carbon fuel, including, green ammonia and green methanol, and countries such as South Africa may benefit (see section 3.3.4)

Negative effects on jobs in fossil fuel-related industries are acute in the two regions where oil and coal producers have concentrated: North Africa and Southern Africa. Substantial public investment in transition-related technologies and education can help create substantial new employment, while greater social spending, can counteract negative income impacts (see section 4.3).

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135 WB (2020b)

136 PwC (2021), WB (2020b)

4.4.2 Energy access and sufficiency

Energy access

A large part of the population in Sub-Saharan Africa still depends on older/traditional forms of more polluting and hazardous energy sources like kerosene for lighting and wood or charcoal for cooking. Efforts to achieve universal access to affordable, reliable, and sustainable electricity by 2030 should be at the forefront of any energy transition strategy in line with the SDG 7 ambition. Furthermore, lack of access to modern energy can make it difficult or impossible for the African region to confront the myriad challenges that it faces to realize other SDGs, such as poverty (SDG 1), air pollution, low levels of life expectancy and lack of access to essential healthcare services (SDG 3), delivering quality education (SDG 4), adaptation and mitigation of climate change (SDG 11), food production and security (SDG 2), economic growth and employment (SDG 8), sustainable industrialization (SDG 9) and gender inequality (SDG 5). A summary of indirect links of energy with the non-energy SDGs is provided in Exhibit 45.

Over the last several years a new way of thinking about energy and development has been developing. New business models are starting up that take advantage of improvements in technologies, including the declining cost of renewables, and improvements in energy efficiency. Thus, a wide array of system designs is now available (off-grid (such as stand-alone solar home systems) and mini-grid (powered by solar, hydro or hybrid, with the use of high-efficiency appliances) complementing efforts to provide electricity access from the grid expansion.

Access to electricity is not 'all or nothing' but takes place on an ascending scale, in which pico PV are the first rung on the energy ladder, followed by solar home systems (SHS), pico-hydro or small wind or small gasoline or diesel generators. Another rung is added by mini-grid systems in hybrid (with diesel) or renewables-only[137]. For large parts of the rural population (distant from power grids), mini-grid or off-grid systems may provide the most viable means of access to electricity[138].

Generally, mini-grids provide electricity at a higher levelized cost which is higher than the tariff at which the main power system provides. However, is offset by the cost of constructing the transmission line that connects the area with the main grid. In the past, many minigrids were powered by diesel (with reliability depending on the diesel supply to the, often, remote areas), or by hydropower (depending on the availability of this site-specific resource. The past decade has seen the levelized cost of minigrids powered by solar energy come down (as global prices of solar panels and batteries have dropped considerably). For the same reason, stand-alone solutions (pico-PV and solar home systems) have become an affordable option for off-grid, usually poor, households.

Apart from providing access to households, rural electrification also implies new connections for non-household uses, including public services such as schools or health facilities and commercial businesses, thus contributing to the realization of other sustainable development objectives. Local agro-processing or mining companies as well as telecommunications, often serve as important anchor customers for grid extensions and mini-grid projects. An anchor customer can lower costs and tariffs, boost household incomes and, in turn, improve repayment rates to facilitate the financing of electricity access projects. Thus, integrating energy and rural business development planning is one strategy to accelerate the pace of electrification.

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

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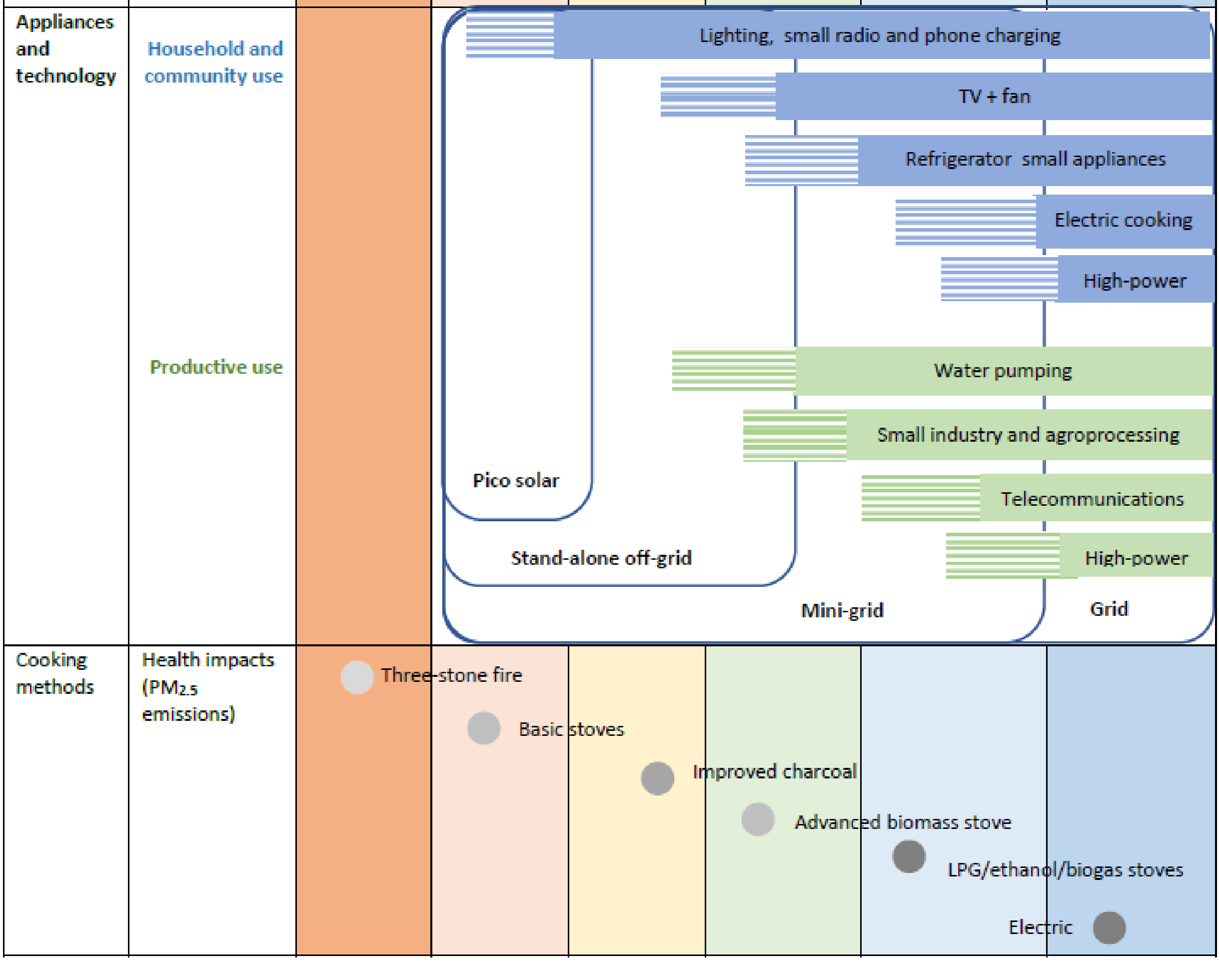
[137] Size-wise, minigrids are defined as between 11 kW and 10 MW but renewable enery minigrids may often be smaller than 1 MW

[138] Where rural communities of more than 200 inhabitants are near a road, but more than 10-20 kilometres (km) from a main grid, mini-grids prevail in most situations in terms of investment cost.

Exhibit 51 Energy ladder with energy demand tiers

		Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Electricity	Power	< 3 W	≥ 3 W	≥ 50 W	≥ 200 W	≥ 200 W	≥ 2000 W
	Energy/ day	< 12 Wh	≥ 12 Wh	≥ 200 Wh	≥ 1 kWh	≥ 3.4 kWh	8.2 kWh
	Minimum availability		≥ 2 hrs	≥ 4 hrs	50% of working hrs	75% of working hrs	95% of working hrs
	Minimum availability		Day: 4 hrs Night: 1 hr	Day: 4 h Night: 2 hr	Day: 8 hrs Night: 3 hr	Day: 16 hr Night: 4 hr	Day: 23 hr Night: 4 hr



About 740 million people in Sub-Saharan Africa will still be without access to electricity and around by 2030[139], if access growth and population growth continue. Based on current policies and electrification plans in the IEA STEPS scenario, about 230 million people in Sub-Saharan Africa will connected by 2030, of which 70% by grid extension and densification and 30% with decentralized solutions. These figures fall short of what is needed. To fully achieve universal access, by 2030 will require about 148 million new connection (740 million people) by grid extension and densification (about 52 million) but the role of decentralized systems will increase, having to provide about 96 million new connections (65%), of which 234 million through minigrids (26%) and 58 million (39%) by stand-alone, mostly, solar PV options[140].

[139] Based on current number of people without access in Sub-Saharan Africa (570 million; IEA (2022), the need for new connections in Sub-Saharan Africa over 2020-2030 will be 742 million. Assuming 5 people per households, this is about 150 million new connections.

[140] Based on IEA (2022), but using adapted assumptions on share of grid (35% of new connections), minigrid (26%) and stand-alone options (39%). Cost

In Focus 4 Rural electrification in Zambia and Nigeria

Zambia has an estimated population of approximately 19.3 million people (in 2022), the majority of whom (54.7%) live in rural areas. Electricity consumption was 12.53 TWh in 2019 and 11.48 in 2020, with the mining sector consuming about half, almost twice that of the residential sector. Zambia's installed capacity stood at about 3,011 megawatts (MW) in 2020. About 11% comes from coal, 7% from diesel/fuel oil, 3% from solar and 80% based on large hydropower.

Zambia's installed capacity stood at about 3,011 megawatts (MW) in 2020. About 11% comes from coal, 7% from diesel/fuel oil, 3% from solar and 80% is based on large hydropower. Zambia's economic activity is concentrated in the corridor running from Lusaka to the Copperbelt and this reflects the power transmission and distribution infrastructure. The electrification rate was 42% in 2019 for the overall population, of which 36% are connected to the main grid and 6% off-grid access (mostly solar lanterns, rechargeable batteries, and solar home systems). The rural electrification rate recently increased from just 5% in 2015 to close to 12% in 2019 (of which 4% were grid-connected and 8% off-grid).

(ZESCO) is the state-owned vertically integrated utility company, established in 1970, that operates the national grid, and is responsible for the generation of much of the electricity supply in Zambia. The country officially regulated and liberalised the power sector so that it is open for generation by IPPs. There are a few Independent Power Producers (IPPs) that feed electricity into the grid. Prior to 2008, Zambia enjoyed the lowest electricity tariff in Southern Africa, with an average tariff of USD 0.027 per kWh). The heavily subsidised tariffs led to challenging commercial environments for both private developers and ZESCO, resulting in very little investment in power infrastructure and new generation capacity. Also, the low tariffs have discouraged minigrid development, as the low ZESCO retail tariffs provided customers with the expectation of electricity services at a price that is often untenable. Tariffs have been increasing since 2008 and the average tariff in June 2020 was about USD 0.074/kWh.

REA is tasked with developing and implementing a plan to electrify rural areas. Aided by the World Bank, a new National Electrification Strategy is being developed. Least-cost geospatial planning (supported by USAID and World Bank to estimate the magnitude in terms of size and cost. To achieve universal access in 2030, about 25.3 million people will need to be provided with electricity, including the 36% already electrified with 13-20% to be provided by grid extension and densification, 8-19% through minigrids, and 25-40% with stand-alone (solar PV and other) options. The cost of grid extension and extension would be about USD 3.57 billion in the coming decade, of which about USD 0.80 billion for grid expansion and extension (about USD 350 per connection for densification and USD 1200 for extension), USD 2.12 billion for minigrid (at about USD 2200 per connection) and USD 0.64 billion for off-grid solutions (at USD 400 per household). This means a whopping USD 350 million a year, in the same order as ZESCO's revenues in 2017 (USD 409 million). The amount currently invested in minigrids, of a couple of million of USD a year for non-grid options is far short of the amount needed.

Several companies sell small PV systems (< 10-30 W with LED light, radio and phone charging, costing about USD 70-200) as an alternative between solar lanterns and more expensive larger solar home system (30-200 W or larger, costing about USD 300-500). PAYGO schemes are on the increase, allowing mobile phone payments. Supported by donor funding, such as the Swedish-initiated Beyond the Grid for Africa, World Bank, and European Union, a number of private developers are developing minigrids, operated and financed by these developers, or in a public-private partnership with REA.

According to Nigeria's National Renewable Energy Action Plan (NREAP 2015-2030), there will be about 120.5 million people living in rural areas in 2030. Of these, 95% should be served by electricity in 2030, of which 80% connected to the grid, 10% by renewable energy minigrids and by 5% by stand-alone systems. In other words, about 3.6 million rural households would be served by solar and pico-hydro systems (60 MW in total), and 10,000 minigrids (about 5400 MW). The rural electrification rate currently stands at 34% out of a rural population of 99 million (and 85% of the 115 million urban people). This means that Nigeria will have to connect about 1.5 million households annually to achieve universal energy access in 2030 (15 million households in total). A rough estimate can be made of what such an electrification endeavor would cost; a total of USD 13.9 billion, assuming 76% of new connection is grid, 16% minigrid and 8% solar PV systems*. In addition, to rural electrification, an estimated 5 million urban households will have to be connected in the coming decade. Assuming USD 300 per household, urban grid densification would add USD 1.5 billion to the electrification bill. Other studies indicate an even higher amount; for example, Ohiare (2015) estimates that USD 34.5 billion would be needed to electrify 28 million households

Source: Project document Z*ambia Minigrids project* (UNDP/GEF); *Preparation of a Least-Cost Geospatial Electrification Plan for Grid and Off-Grid Rollout in Zambia,* World Bank-Engie Impact; *Geospatial model for Zambia* (April 2018), USAID. Zambia electrification cost estimates elaborated by the author, based on data provided in these studies. Nigeria estimates based on NREAP electrification target, with current electrification rates (from World Bank data) and Ohiare (2015)

*) Based on the NREAP targets, 11.3 million rural clients would have to be grid-connected (at USD 920 per connection) would cost USD 10.4 billion. About 2.4 billion rural customers would be connected to a minigrid (at USD 1200 per connection) would require investment of USD 2.9 billion, while stand-alone systems would provide energy to 1.2 million households (at USD 500 per system) at a cost of USD 0.6 billion. Other assumptions on the electrification mix give other result. For example, electrifying the 15 million new connections with grid (46%), minigrid (16%) and stand-alone (38%) would be a smaller (USD 12 billion) but still be substantial amount.

Energy sufficiency

When discussing "energy access" the discussions focus usually on "achieving energy access" in terms of the number of people or households that have access to reliable energy access and clean cooking. Another dimension is formed by "sufficiency", that is progression along the energy ladder. This helps focus the discussion on what will help if universal access would be achieved by 2030.

The size of off-grid systems varies. A pico-lighting systems comprise a solar panel, battery, one or more LED lamps and in many cases a mobile phone charging port and can be regarded as a first step onto the energy ladder. Those households that can afford, will aspire to acquire a solar home system, which provides power for TV and radio. A larger SHS, larger SHS of more than 100 W can power more than this essential bundle of appliances but would struggle to produce enough power for additional services, such as refrigeration, unless high-efficiency appliances are integrated with the system. Solar home systems cover tiers 1-3 of the UN Sustainable Energy for All (UN SE4All) classification, as explained in Exhibit 51, standalone home systems are not adequate for higher-consuming households, and particularly businesses will need more power.

Mini-grids provide a more feasible full electrification option, covering the mid-range in the diagram covering up to tiers 3-4. Historically, most mini-grids have been in the lower tiers, with a resultant high level of capital and overhead costs relative to power output. Mini-grids on this scale are unlikely to be as cost-effective for 'entry level' power compared to standalone home systems (that do not have the additional cost of the local grid distribution system). Instead, the logical role of mini-grids is to provide fuller tier four (or even reaching tier five electricity access). Thus, mini-grids have an important role to play in accelerating access to electricity for communities which cannot be reached by larger centralized grids.

The deployment of decentralized (off-grid and minigrid) renewable energy technologies opens the way for more massive electrification as we have seen in the past decade. But in terms of energy provision, these have drawbacks. Minigrid and stand-alone only provide electricity in the lower tiers of the energy ladder. In terms of energy sufficiency, universal access with the lowest-tier technologies still leaves a huge gap in terms of energy equality as half of the newly connected will be in the 1-3 tier range of energy access.

As demand increases there is the inevitable need to upgrade connections. Some households are already "stacking" stand-alone solar systems, by buying additional PV panels to power more appliances. Where investment funding is available, rural communities of a certain size gradually shift to mini-grids or grid connections after gaining initial access via stand-alone systems. In principle, mini-grids built to provide first access can be expanded and more generation capacity and storage added as demand rises. Mini-grids are often designed with specific local circumstances in mind, depending on rural population density, affordability and willingness to pay, and the presence of anchor loads affordability. Oversizing mini-grids in anticipation of demand growth will negatively impact project economics. At a certain point, substantial redesigns may be required, at additional cost. Some mini-grids can be interconnected to a broader grid, especially if built near planned grid expansions. For that to occur, interoperability standards for mini-grid systems and specific regulations to guarantee future integration must be present.

4.4.3 Affordability

One of the biggest challenges of achieving universal access to electricity relates to the cost of providing power, which increases dramatically to supply sparsely populated and remote areas compared with households close to an existing grid. Minigrid- and off-grid solutions are often claimed as 'least cost' in comparison with grid extension for remote or scarcely populated. While true in many cases, 'least cost' should not be translated as 'low-cost', as the cost in terms of investment per energy end-user or power kW installed is usually high. The cost of providing access to a remote household by the least-cost option (whether grid extension, minigrid or off-grid) may be a factor of four higher, compared to connecting a household in an already electrified area.

Even in electrified areas, households have difficulties with affording basic energy services unaffordable for a large share of the population connected. These often live in urban slums and other informal settlements. A least 110 million of Africa's about 580 million people without electricity, access live in informal urban settlements close to the electricity grid[141]. In Sub-Saharan Africa, the average percentage of the population in urban areas in 2020 that were not connected was 22%[142]. In those cases, off-grid solutions may even become a financially viable alternative, when the electricity supply is not reliable or not sufficient, or where electricity tariffs are (too) high. As the poorest households may not be able to afford high electricity tariffs, many governments have introduced 'lifeline' tariffs or subsidized tiered rates, whereby those who use the least energy pay the lowest price. These measures are meant to make electricity more affordable to newly connected households in the short term.

However, such electricity consumption subsidies require a constant stream of revenue from national governments but often utilities are not compensated sufficiently to be able to recoup their costs of supply. The risk is that this locks the power sector into a cycle of low revenue, high debt, inadequate maintenance, under-investment and poor quality of service (as will be discussed further on in this section). Low tariffs encourage consumers to use more power than they would if the price were not subsidized. In countries where the price of electricity is subsidized, but access to the grid is low, rich households, which are more likely to be connected to the grid, are the main beneficiaries of the price subsidies and the unconnected, often poor, households. Balancing the burden of subsidies with affordability is discussed in the next section.

The main barrier in terms of electricity cost for consumers is often not the tariff, but the connection fee, that is the charge consumers must pay to connect to the electricity network. Many African households that could afford the monthly electricity bill, are not able to pay the initial charge to obtain an electricity connection (to which the cost of the internal wiring of the house must be added). The connection charges in Sub-Saharan Africa can be among the highest in the world, depending on the utility or country. At one extreme, subsidies are provided to cover entire connection charges; at the other, the new customer is required to bear, in advance, the full costs of providing a connection. Although a bit dated, a WB (2013) study found connection fees ranging from 5% to 150% of the monthly income in the country. The cost of connection can range from a mere USD 2 to USD 400, depending on the country or utility. High connection charges mean that the social and economic benefits of electricity are available only to wealthier households. Making connection charges affordable is a necessary and important first step in addressing the electricity access and poverty gap between rich and poor households.

4.4.4 Subsidies and government expenditures

Despite the prevalence of subsidies in the energy system, there is no standardized definition of what an energy sector subsidy is. Pre-tax subsidies allow consumers to pay prices below the supply costs, basically a direct financial transfer, and producer subsidies (tax breaks, preferential credit, import/export instruments). Post-tax subsidies occur when prices are below the total supply costs, plus the cost of fossil fuels' contribution to global warming, local air pollution and other externalities. Estimates can vary widely, not only because of the definition but also in the methodology used to measure them[143].

Pre-tax subsidies amounted to USD 330 billion in 2015[144] and USD 357 billion in 2017 and down to USD 312 billion in 2019. An IRENA estimate is USD 447 billion for direct fossil fuel subsidies (of which USD 220 billion on oil products, USD 82 billion for gas, USD 17 billion for coal and USD 128 billion for fossil-fueled electricity). IISD's GSI estimates that USD 425 billion was spent in 2015 on directly subsidizing fossil fuels. Renewables did receive a

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[141] IEA (2019), based on data provided in GTM (2017)

[142] Data.worldbank.org (accessed 2022)

[143] For example, IMF uses a price-gap approach, by multiplying current fuel consumption by the difference between supply and consumer prices, covering 191 countries. IEA uses also a price-gap approach but its database is limited to about 40 countries. The OECD uses an inventory approach that includes consumer subsidies and direct budgetary support well as tax expenditures that provide a benefit or preference for fossil-fuel production in 43 countries (but not covering electricity)

[144] IMF (2015), IEA fossil fuel database

subsidy (USD 166 billion in 2017), about 27% of direct subsidies but only 5% of the global total of post-tax subsidies[145]. Post-tax subsidies are much higher. The 2015 IMF study gives an estimate of USD 5.3 trillion or 6.5% of global GDP and of 5% of GDP for Sub-Saharan Africa. The 2020 IRENA report gives a figure of USD 3.1 trillion for fossil fuels.

As mentioned in section 3.4, an additional investment of USD 25 billion per year is required to achieve universal energy access globally. While this sounds like a lot of money, the above-mentioned estimates for subsidies on fossil fuels are about 5-6 larger than the investment required to achieve global universal access to electricity and clean cooking[146].

Energy subsidies are widespread in Africa today. In 2020, African consumers, households, businesses and other end-users, spent USD 190 billion on energy for final use. But they only paid around 80% of the real cost of the energy consumed, which totaled USD 230 billion, with government subsidies of USD 40 billion filling the gap (comparable with the USD 25-35 billion a year needed in the coming decade to achieve universal energy access by 2030 in Sub-Saharan Africa). Around 60% of the energy subsidies in Africa in 2020 benefited households (electricity, cooking and transport fuels). Energy subsidies do play an important role. Around half of consumer energy spending (net of subsidies) in 2020 was for oil products, mainly transportation fuels (gasoline, diesel and jet kerosene), LPG and kerosene for cooking, and diesel for small generators and industrial use[147].

Subsidies, in the form of prices set below the true cost of supply, appear to present a direct, simple means of providing support to poor households in a continent, where over *40% of sub-Saharan Africans* live below the poverty line[148]. On the other hand, energy subsidies are a substantial drain on the government budget which needs to be financed by some combination of higher public debt, higher tax burdens, and crowding out of potentially productive public spending. Overall government debt rose by 16.3% of GDP in low-income and developing countries between 2012 and 2020 and by 23% among the subset of oil-producing nations[149] over the same period. The COVID-19 crisis and policy responses to it only deepened the fiscal crisis in many countries. Given the recent significant deterioration in public finances, the resources now spent on energy subsidies are now needed more than ever.

In addition to the direct subsidies, the cost of fossil fuel production and consumption in many countries (including those in Africa) frequently fails to fully incorporate externalities such as local pollution and, impacts on climate change, which IMF estimated at about USD 50 billion in 2015. Energy subsidies provide the wrong price signals, discouraging investments in energy efficiency and renewable energy. In the era of the green energy transition, fossil fuel subsidies stand in the way of persuading the consumer to switch the clean energy alternatives and can be seen as a form of a negative carbon tax.

Moreover, direct energy subsidies are notoriously difficult to target, as they will also benefit richer households and businesses that do not need them. Many subsidies are actually regressive in nature. A study by IMF found that globally the wealthiest 20% of the population gets a disproportionate 43% of the benefit from fossil fuel subsidies, while the poorest 20% got only 7%. In fact, the poorest 6% of the population still does not get as much benefit as the wealthiest quintile[150]. For liquefied petroleum gas (LPG), the study found that 13% of the benefits were allocated to the poorest 40% and 74% to the richest 40%. This makes fuel subsidies highly inefficient as they achieve small energy access benefits at exorbitant costs. Often, keeping fossil fuel prices artificially low may also

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145 Figures based on IRENA (2020b)

146 IEA (2017), based on estimate bi IISD's Global Subsidy Initiative (GSI)

147 IEA (2022), section 4.5

148 Living below the US$1.90-a-day poverty line in 2018 and Sub-Saharan Africa accounting for two-thirds of the global extreme poor population. While the poverty rate has decreased from 56% in 1990 to 40% in 2018 the number of poor continues to rise. In other words, the poverty rate in Sub-Saharan Africa has not fallen fast enough to keep up with population growth in the region and 433 million Africans are estimated to live in extreme poverty in 2018, rising from 284 in 1990. Poverty reduction has been much slower at the higher lines: between 1990 and 2018 the poverty rate fell 15 percentage points. Source: World Indicators, Word Bank https://blogs.worldbank.org/opendata/number-poor-people-continues-rise-sub-saharan-africa-despite-slow-decline-poverty-rate

149 IMF. 2020. Fiscal Monitor: April, https://www.imf.org/en/Publications/FM/Issues/2020/04/06/fiscal-monitor-april-2020

150 IMF (2010)

encourage smuggling and fuel adulteration, thus further reducing government revenue. Worse, shortages can create a black or parallel market where the poor have to purchase fuel at higher rates than the official rate, thus, defeating the purpose of the fuel subsidy. Subsidies are usually focused on modern commercial fuels (LPG, kerosene, electricity), while the forms of energy most commonly used by the poor, urban and rural, are traditional fuels.

The substantial leakage of subsidy benefits to the top and middle-income groups means that universal fuel subsidies are an extremely costly approach to protecting the welfare of poor households. For example, if we take the lowest quintile of households as the “poor” group, the cost to the budget of transferring one dollar to this group via gasoline subsidies is around 33 dollars (i.e., 1:/0.03 ratio)[151]. By one estimate, the cost of transferring USD 1 to the poorest 20% of the population via gasoline subsidies is USD 33. If countries instead shifted that funding to targeted support for the poor, the funding would help the people who need it most, rather than those who need it least.

In IRENA’s sustainable scenario, the level of fossil-fuel subsidies in the energy sector will decline, driven by the reduction in the rate of subsidy to fossil fuels and the reduction in fossil fuel consumption over time, as the energy sector transitions to a sustainable future. However, new fossil fuel subsidies will emerge, depending on the role of concentrated where carbon capture and storage (CCS) that some energy-intensive industrial sectors will need to address process emissions in the framework of net-zero by 2050 pathways. Regarding, renewables the IRENA case assumes that subsidies for renewables in the power sector will fall as solar and wind become more competitive. Energy efficiency is typically a cost-effective solution to reduce energy consumption. However, a subsidy is likely to go to more expensive energy efficiency options that may need some investment support as well as for the deployment of renewable solutions in the hard-to-decarbonize industry and transport sectors. The net effect is that in IRENA’s sustainable scenario[152], total energy subsidies decline from USD 634 billion in 2017[153] to USD 465 billion in 2030[154] and USD 475 billion in 2050[155], noting that in the reference case (policies-as-usual) total energy subsidies might increase to USD 865 billion by 2050.

Clean energy subvention might be criticized for the same reason as fossil fuels for distorting the market and stifling innovation as well as forming a drain on the government budget. On the other hand, these should be compared with the net economic effects that accrue to the economy as a whole, as discussed in section 4.3. Also, these should be compared with the avoided externalities of fossil fuel costs (global warming and pollution) in the order of USD 0.62-2.16 trillion by 2030 and USD 2.5-6.3 trillion by 2050. A balance may have to be found, in which renewable energy is focused (smart) and time-bound to overcome initial market development barriers, but decreasing over time not to stand in the way of innovation and competition.

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[151] This reflects the fact that over 97 out of every 100 dollars of gasoline subsidy “leaks” to the top four quintiles. For kerosene, this cost-benefit ratio is around 5 dollars (i.e., $1/0.19). Source: IMF (2010)

[152] REMap

[153] Of which, USD 447 billion for fossil fuels, USD 22 billion, nuclear and USD 166 billion, renewables

[154] Fossil fuels: USD 165 billion, nuclear USD 21 billion, EV: USD 34 billion, EE: USD 47 billion, renewables USD 192 billion

[155] Fossil fuels: USD 139 billion, nuclear USD 21 billion, EE: USD 106 billion, renewables: USD 475 billion

5. ENABLING THE JUST ENERGY TRANSITION

To develop, Africa will need to industrialize. Historically, as countries have industrialized, their energy consumption has increased and this has meant a high fossil fuel consumption. With Africa's industrialization still in the early stages, this offers an opportunity for a new different development pathway, decoupled from carbon emissions. Many African countries are endowed with abundant renewable energy potential, mainly biomass, solar, wind, hydro and geothermal and in most African countries the bulk of the energy infrastructure is not yet built.

With abundant indigenous renewable energy resources, Africa is well placed to leverage this potential. Technology developments, falling costs for renewable energies, power and gas network extension, development of new energy carriers (such as hydrogen) with innovative approaches (digitalization in the energy networks) will open new opportunities and allow for rapid leapfrogging to new energy low-carbon energy systems. However, the potential and availability of cost-effective technologies is one important condition but not a sufficient one; a just energy transition encompasses maximizing the socio-economic and environmental benefits of the energy transition, while minimizing the negative impacts, with net benefits distributed in an equitable manner.

Doing so will require development-conscious energy sector growth and socially responsible investments. Partnership with the private sector is essential to meet the required investments. This will require reforming, or improving, energy market regulation and creating a conducive market environment. It will also require organizing energy markets towards greater efficiency and participation of diverse market players. Integrated planning is crucial to leverage benefits within and across sectors. Regional opportunities are also key, particularly within efforts towards continental harmonization of electricity regulations are expanding the scope of regional energy integration. Addressing these and other gaps will improve the sustained flow of infrastructure investment in Africa.

As with the current global energy system, the distribution of benefits of the 'net zero' transition will not be uniform, indicating that the energy transition alone cannot resolve income and wealth inequalities. A just energy transition leaves no one behind. This Chapter describes measures required as part of an inclusive approach to the energy transition, such as ensuring affordable and reliable energy access, improving institutional capacity, aligning infrastructure development and socio-economic development goals, enhancing partnerships, reinforcing investment in social infrastructure, promoting value chain opportunities, and reinforcing technical and vocational training programs to build required skills for the successful just energy transition.

In the global context of Africa's just energy transition, the negative impacts of climate change in Africa are disproportionately large when set against the negligible contribution that Africa has made to climate change mitigation in terms of CO_2 emission reduction (see Exhibits 15 and 16). Industrialized countries pulling funding for hydrocarbon projects in Africa is a move that can be regarded as very hypocritical given their overwhelming contribution to the anthropogenic greenhouse gas emissions in the past and many of their own fossil fuel projects continue to be developed unabatedly. Given the scale of the electrification and energy required there is more than enough room for renewables and "cleaner" fossil fuels, in which natural gas will take over from oil (and coal) in conjunction with renewables. Rather than moralize and take finance off the table for 'grey' energy projects, industrialized countries should instead find a balance and seek to partner with African countries by offering financial and other incentives to develop the low-carbon energy transition

With that in mind, energy transition measures will have to include foreign transfers to ensure that all African countries can make the transition, at the international level. At the national level, cross-sectoral policies need to redirect government revenues to the lowest income quintiles. Only when the energy transition will improve both inter-and intra-inequality will the coming energy transition be a just energy transition.

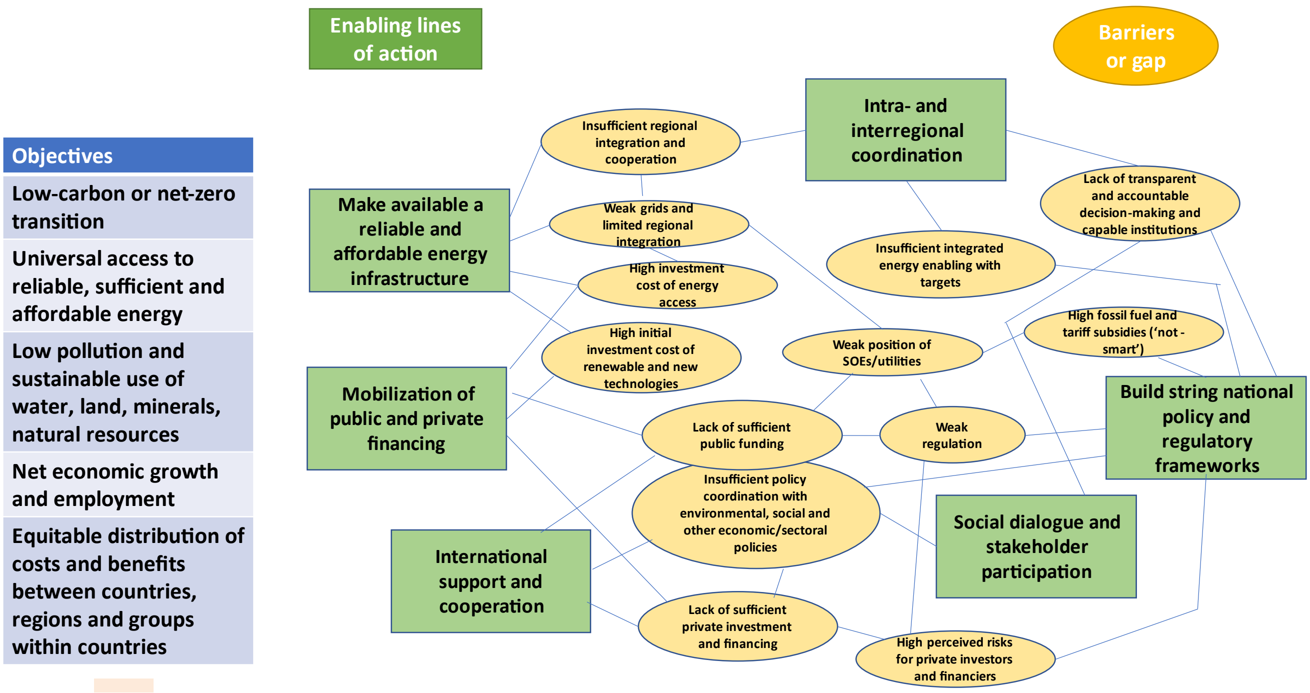
5.1 Barriers to just energy transition

Chapter 3 presented several pathways as part of the low-carbon or net-zero energy transition in line with the goals of the Paris Agreement. A just energy transition is one that not only has a low-carbon objective but that minimizes adverse environmental impacts and maximizes socio-economic development of which the gains are distributed equitably, as described in Chapter 4. These chapters also describe many barriers that are common to most African countries to achieving the main objectives of the energy transition.

These include the weak policy and planning and regulatory frameworks; lack of capacity in decision-making institutions and financially weak utilities and energy service providers; insufficient private financing and investment to complement the scarce public funding; lack of cost-reflective electricity tariffs and financially unsustainable fossil fuel subsidies; high cost of electrification and lack of business models for off-grid electrification. Exhibit 52 gives a summary of these barriers and how these inhibit in an interrelated way the realization of the just energy transition goals.

There is a need for concerted action on the part of African countries and collective action at a regional level pan-African institutions, supported by their international development partners, to address these structural barriers and make decarbonization, universal access and just socio-economic development goals a reality. .Exhibit 52 presents a summary of the main groups of enabling actions that should be taken to tackle the barriers. These actions include least-cost investment plans for universal energy access, market reforms to make a financially viable electricity sector with scaled-up private investment and partnership, conducive energy regulations, regional infrastructure connection and trade, integrated development-energy-environment planning with targeted social, health and education spending, with sustained investment supported by international transfer and cooperation.

Exhibit 52 Barriers to achieving just energy transition objectives in Africa



Own elaboration

5.2 Policy, regulatory and institutional enabling environment

5.2.1 Strong policy and regulatory frameworks with competent institutions

Clean energy and energy access policy and planning

At the country level, achieving universal energy access and decarbonization goals requires long-term strategic policy. The core of the policy is formed by the formulation of clear targets for energy access, renewable energy and energy efficiency and have these integrated with their national energy and electricity plans. These plans should indicate the role of natural gas in the transition process in the medium term and the role of renewable and new technologies (such as hydrogen and derivative fuels) in the longer term.

Currently, such commitments exist in many countries in Africa, as laid down in national energy or electrification plans and strategies and Nationally Determined Contributions (NDCs). Almost all countries have renewable energy targets either in national plans or NDC. However, the commitments vary widely in scope, target dates and ambition[156]. Some pledges cover the energy sector as a whole or focus on the power sector only.

About 28 countries had renewable energy targets in their electrification plans and about half had energy efficiency targets, according to a 2021 IRENA analysis[157]. Most targets are numerical but often non-binding, aspirational goals embedded in energy planning or at a broad policy level. Several countries in Africa are formulating Energy Compacts with targets for the SDG-7 pillars of renewable energy, energy efficiency and energy access. In Africa, Ethiopia, Kenya, Malawi, Mauritius, Nigeria, Rwanda, Sierra Leone and Zambia have submitted such Energy Compacts to UN-Energy[158]. At the COP26 in Glasgow (2021), twelve African countries have announced long-term net zero emissions pledges, aiming to reach carbon neutrality between 2050 and 2070[159].

Policy instruments for energy access and clean energy deployment

Renewable energy and storage technologies are already cost-competitive, but high upfront capital expenditures combined with adverse regulatory and legal frameworks may make fossil fuel alternatives easier and cheaper to finance in many cases, which risks unnecessarily locking systems into a higher share of fossil fuels. Mobilizing the necessary investments for the penetration of renewable energy and expanding energy infrastructure to provide access for all will require governments and other stakeholders to work towards an environment formed by a conducive policy and regulatory framework. However, many countries still need to build stable, predictable enabling frameworks, as indicated by the World Bank's RISE indicators on energy policies and regulation (see Exhibit 54) and AfDB's electricity regulatory index (ERI, see Exhibit 56)[160].

156 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 target. 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

157 IRENA-AfDB (2022) and UNDP (2022b). For example, only 14% of the NDCs submitted by African countries refer to 'just transition'; three-quarters had renewable energy targets (most focusing on the power sector; only one out of three with non-power RE targets; and about half with energy efficiency targets.

158 https://www.un.org/en/energycompacts

159 Cabo Verde (by 2050), Côte d'Ivoire (by 2030), Liberia (by 2050), Malawi (2050), Mauritania (2050), Namibia (2050), Nigeria (2050), Rwanda (2050), Seychelles (2050), and South Africa (2050). Climate neutrality means the net effect between emissions and sinks. In this sense, São Tomé and Príncipe claim already having received climate neutrality

160 Apart from RISE, an overview of the status of deployment policies in various countries can be found in the annual REN21 Renewables, Global Status reports and through the website https://climatepolicydatabase.org

Exhibit 53 Examples of actions and milestones for just energy transition 2022-2050

Sector	Action / goals	Up to 2030	By 2030	2050
Available, reliable and affordable (low-carbon) energy infrastructure				
Clean cooking	% using a clean cooking method	About 130 million people get access annually 2019-2030	100%	
	% using electricity in cooking		10-15% cook on electricity	More households adopt electric cooking
Off-grid solutions	% reached at Tier 1	Make least-cost investment plan for electrification. About 62 million new on-grid and off-grid connections annually over 2019-2030	100%	
	% reached at Tier 2		50%	100%
	% reached at Tier 3 or higher		25%	75%
	Electrification of health centers and schools		100%	
T&D	Grid densification and extension		50% of electrification target	75%
	Cost-reflectiveness tariffs	Affordability and LCOE analysis for tariffs	80%	100%
	Collection rate		80%	100%
	Reduction in losses	Plan to reduce losses	15%	12%
Generation	National plans for utility-scale expansion	Investment and caoacity expansion plans formulated	50% implemented	100% implemented
	Installed capacity		Capacity expanded	Doubled - tripled
	% share of RE		60%	90%
Regional cooperation and integration				
	Fully functional power pools	Analysis and plans at AU and regional level	25% of planned links	100%
	Integration of gas and other networks	Regional planning for role of role of gas, LNG and hydrogen	Plans reviewed and updated	
Strong policy and institutional-regulatory frameworks				
Fuels and demand	Renewables as share of energy mix	Update RE and fossil fuel targets in energy planning and optimize country's needs	30% in Africa (40% Sub-Sah Africa)	60% in Africa (90% Sub-Sah Africa)
	Phasing out coal and oil		Completion strategy on stranded assets	10-17% of primary energy consumption
	Role of natural gas			7-16%
	Remove fossil fuel subsidies		100%	
	Electrification (% of final energy consumption	Plans for end-use electrification	25%	50%
Transportation	Electric private vehicles (% of light-duty vehicles)	Stringent fuel standards; Plan for % of EV, and biofuels in transport	5%	35-50%
	Public transport		15%	30-50%
	Cargo transport on hydrogen or biofuels		10%	25-45%
	Charging stations	Prepare plan and policy-regulations		100% deployment
Social, environmental impacts and distribution	Socio-economic impacts (employment, income, distribution)	Analysis and plans on social externalities	Review and update	
	Environmental impacts (land use, water use, forest land, pollution)	Analysis and plans of environmental externalities	Review and update	
	Education and vocational training	Analysis and plans with targets for skills development	Review and update	
Industry	Industrial target achievement (% of value added)	Targets for solar panel, wind turbine, battery and green hydrogen production	25%	60%
Public and private financing of the energy transition; international cooperation				
Investment and support	Annual investment needed	Finance mobilization according to investment plans	USD 150-200 billion annually, of which USD 65-135 for power sector (Africa) with 30-40% public and 60-70% private sources and 25-40% from international sources	
	Common approach development partners	Formulate Green Deal for Africa	Review and update	

In Focus 5 Ambitious goals: Cabo Verde becoming 100% renewable energy

Cape Verde, has set itself a very bold renewable energy target. As part of its "sustainable energy for all" agenda, it has pledged to obtain 100% of its electricity from renewable resources by 2050. Cape Verde is made up of 10 islands, nine of which are inhabited. About 93% of the 550,000 residents currently having access to electricity and Cape Verde's per capita electricity consumption of 727 kWh per person per year is substantially higher than the Sub-Saharan Africa average of 488 kWh per person per year.

Almost all of the islands' 550,000 residents have access to electricity, but about one-third still rely on firewood and charcoal for cooking. Cape Verde's per capita electricity consumption of 727 kWh per person per year is substantially higher than the sub-Saharan Africa average of 488 kWh per person per year. But electricity prices are high, ranging from USD 0.26 to USD 0.32 in recent years. Most is produced by generators, which run on imported petroleum products, and 17% by renewable sources (83 GWh out of 490 GWh). The government aims to achieve a penetration rate for renewable energy of 50 percent by 2030, with a phased implementation schedule. Making the transition to renewable energy has become an even more pressing priority given the recent increase in energy prices. To meet the 2030 energy demand (estimated at 843 GWh) will require installed capacity of 251MW (up from the current 176 MW) with a penetration rate for renewable energy of 54% by 2030 (160 MW) to be provided by wind (23%), solar (14%) and 615 MWh of storage devices. . To achieve its ambitious goal, the government anticipates that Cabo Verde will need more than 150 MW of new solar projects and more than 60 MW of new wind farms.

The regulatory framework on promotion and incentives for the use of renewable energy is provided by Decree-Law No. 1/2011, which establishes the rules concerning the promotion, incentives, access to licenses, and independent production of electricity using renewable energy sources, with the aim of promoting and incentivizing the use of renewable energy in Cape Verde. The renewable energy goals are accompanied by an energy efficiency strategy that aims to reduce transmission and distribution losses from 23% to 8% and reduce final energy consumption by 15% (e.g., by the mandatory use of solar water heaters in buildings, and introduction of building codes and appliance standards and labeling.

Cape Verde can achieve its 100% renewable energy goal in a way that is cost-effective and equitable by building an energy system that is based on solar, wind and energy storage (such as batteries and pumped hydropower). Cape Verde's northeasterly trade winds with average annual wind speeds that exceed 9.0 m/s considered excellent for wind farms.

Another technology that could be integrated into the electricity generation offering is the country's desalination systems. Many of Cape Verde's communities depend partially, or entirely, on these for drinking water. Desalination systems require electricity and can be run at times when the wind turbines are operating, but electricity demand is low, such as at night. Additionally, the desalinated freshwater can be pumped into a high-elevation reservoir and used for energy. When demand peaks the water flows back down, spinning hydro turbines and generating electricity in the process. Integrating desalination and energy systems like this could be highly beneficial. For example, on the island of São Vicente it could enable wind turbines to meet up to 84% of the island's electricity demand

The solar PV capacity potential is more than double the currently installed electrical generating capacity. Most of the potential development is on the densely populated island of Santiago. The challenge, as with wind, is integrating variable irregular flows into the grid by have adequate storage or integrate with renewable base load energy, such as geothermal energy. As a volcanic archipelago Cape Verde has potential for geothermal energy that has the advantage of running all the time.

Source: Coelho (2018), https://peds.gov.cv/caboverdef4dev/wp-content/uploads/2018/12/Ennergy-Sector-web.pdf; https://qz.com/africa/1122149/a-tiny-african-island-nation-will-run-on-100-renewable-energy-in-less-than-a-decade/#:~:text=Cape%20Verde%2C%20the%20small%20island,from%20renewable%20resources%20by%202025; Pina & Mendes (2015),

Strengthening regulatory environments and institutions and making electricity tariffs cost reflective enables power suppliers, energy service providers and grid operators to meet their financial commitments to producers while maintaining and expanding their grids as demand increases. Countries have adopted a wide variety of policy instruments to promote renewable energy deployment. Prevailing policies in Africa are fiscal incentives, including tax reductions, public investments, loans and grants. Tax reductions are the most widespread incentive, as these do not require any additional budget allocation, fewer administrative procedures and minimal regulatory supervision compared to other support policies. Regulatory-fiscal measures are most mature in power sectors; the topic is discussed further in more detail in section 5.2.

Integrated policies for structural change and just transition

The energy transition in Africa promises benefits related to economic growth, employment, welfare, and climate resilience, as described in Chapter 4. The energy transition will impact how Africans will consume, produce, and commute, while their energy demand patterns will influence the energy transition.

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 in the residential, public, productive and transport sectors; macro-economic conditions; export and import situation, availability of resources; the infrastructure already in place; and the level of development, accessibility, and cost of technologies. Thus, policy and planning for the energy transition should therefore be closely linked with other sectoral and regional development policies.

Local value added in industry and minerals

The expected huge increase in renewable energy deployment in the coming decades will provide opportunities for the development of domestic, African, industries for manufacturing and assembly of renewable energy technologies. Developing strategies for increasingly locating the renewable energy technology value chain in African countries will foster wealth creation and a thriving manufacturing sector across African countries.

One measure to promote productive capacity development and employment creation consists of local content requirements (LCRs) and incentives. One issue is the exact definition of LCRs; quotas set too high can scare off investors, while those that are too broad allow investors to exploit ambiguities. One example is formed by the LCRs that are part of South Africa's Renewable Energy Independent Power Producer Procurement Program (REI4P; see In Focus 4). Other measures include supplier development and business incubation programs, supported by targeted fiscal incentives for firms that supply or manufacture clean energy goods or provide related services. To boost development away from the main population centers, some African countries could consider relocating industrial facilities to areas with abundant low-cost renewable electricity. Such innovative business models would not only support the electricity sector but also create new economic opportunities for disadvantaged regions within a country.

Central and Southern Africa have abundant mineral resources essential to the production of electric batteries, wind turbines and other low-carbon technologies, in particular copper, cobalt, and lithium. Producers of these minerals might leverage the energy transition to move into higher value-added segments of the renewable energy supply chains, leapfrogging into processing and exporting at a higher price than the raw materials (and also reducing hereby the dependency on widely varying global raw material price cycles).

Industry and new energy technologies

Another example of leapfrogging is formed by electric mobility. The mass penetration of electric vehicles (EV) will likely remain a far-away objective for Africa over considerable time given the lack of infrastructure and the currently high initial investment costs in EVs. Globally, industrialized countries are likely to ban to restrict or even ban light vehicles running on fossil fuels within the next couple of decades, which will likely revolutionize the system and rapidly lower the costs of EVs and the needed charging infrastructure. It may be crucial for African countries to have the foresight to set ambitious targets for EV deployment despite currently high costs, as part of a long-term leapfrogging strategy. It may also be wise to develop industrial strategies for increasing the manufacturing of components for the EV value chain within Africa. Other developing countries, for example, Indonesia which has large lithium deposits, are already formulating ambitious electric vehicle plans for the production of batteries and local manufacturing of EVs. Regarding transport, other opportunities are in the sustainable development of the biofuel industry (see section 3.3.5).

For development planners, it may be 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. On the other hand, in the long run, green hydrogen (and derivative fuels) could be part of another leapfrogging strategy for green industry and sustainable, long-distance exports (see section 3.3.4).

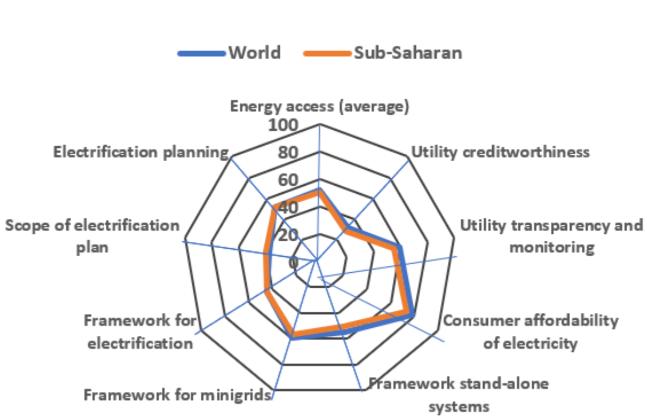
Agriculture and rural development

Energy infrastructure expansion is urgently needed to drive economic growth and social development across sectors. An important example is the agriculture sector, which is a major contributor to GDP, employment and exports, and the basis for livelihood and well-being among the many small-scale farmers on the continent.

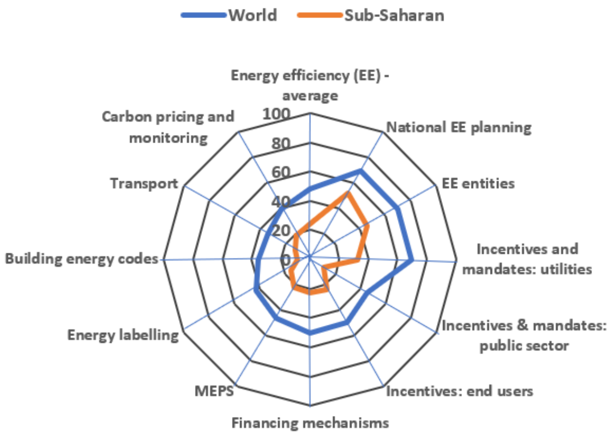
Exhibit 54 Planning and regulatory indicators for sustainable energy

A useful set of indicators for the advances in policy and regulatory frameworks that countries have put in place to support the achievement of the SDG-7 goals are the *Regulatory Indicators for Sustainable Energy (RISE)* of the World Bank-ESMAP. RISE analysis consists of 31 indicators that are grouped into four pillars (access to electricity, clean cooking, renewable energy, and energy efficiency. The indicators are given scores between 0 and 100 and are distributed into three levels (red, 0-33: policy adoption remains at an early stage; yellow, 33-66: some serious efforts are made in the policy-regulatory framework; green, 66-100: relatively mature environment). Details per country and information on the methodology can be found at http://rise.esmap.org. A summary of the RISE scores for Sub-Saharan Africa is given in the figures below. The RISE 2020 report mentions that Sub-Saharan Africa's average score is the lowest of all world regions: 17 out of 35 Sub-Saharan African countries covered under RISE are in the red zone, although noting that, in general, the region has moved up in comparison with 2010 in particular with respect to energy access (more on grid expansion than on minigrid or off-grid). In general, the continent while lagging behind energy efficiency and to a lesser extent with renewable energy regulations in comparison with the global average

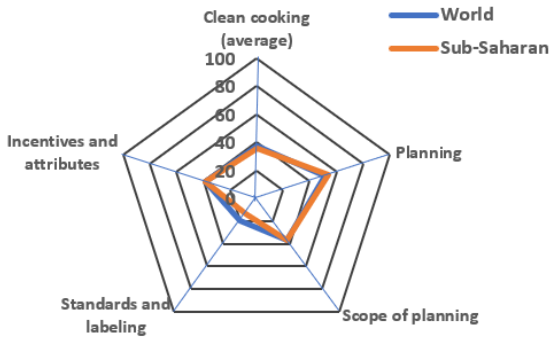
Energy access



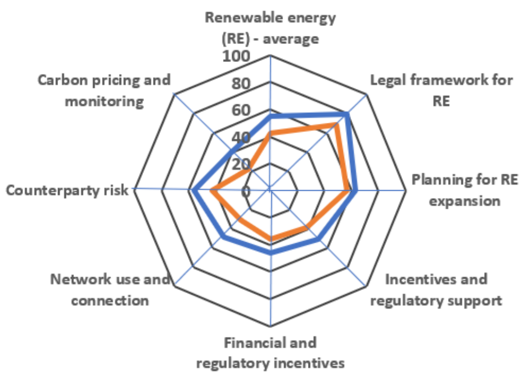
Energy efficiency

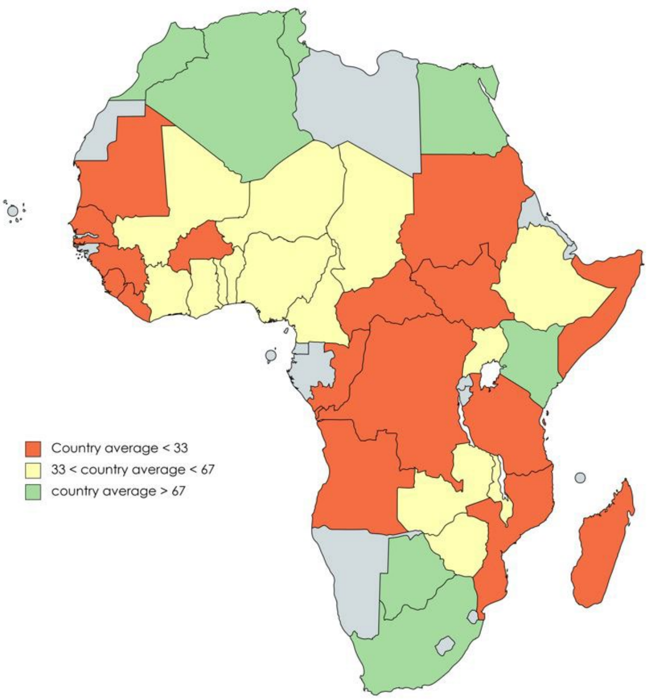


Clean cooking



Renewable energy





Along with agriculture, micro- and small enterprises (MSEs) in manufacturing and service sectors are also critically important for increasing rural incomes and providing greater opportunities. Higher quality of life in rural areas also relieves pressure on urbanization and associated challenges. Through access to modern energy, MSEs across different sectors can increase output and improve the quality of products and services.

Energy and resource efficiency; circular economy

Energy efficiency forms an important cross-cutting area that brings significant economic and social and climate benefits. Yet, African countries have barely tackled energy efficiency, although in many cases energy efficiency programs and projects offer a significant return on investment in addition to mitigating greenhouse gas emissions. The potential for energy savings and GHG mitigation is significant in all sectors and particularly buildings, transport and industry as energy demand will rise with population growth. Energy efficiency and conservation have been embraced by fiscal and non-fiscal and regulatory measures, incentive schemes and voluntary initiatives.

Many countries in Sub-Saharan Africa (e.g., Botswana, Cameroon, Chad, Ethiopia, Lesotho, Malawi, Mauritius, Sierra Leone, South Africa, Sudan, and Zambia), as well as North African countries, have enshrined energy efficiency policies (see Exhibit 57 for an overview per country). Appliance standards and labelling have been introduced for appliances such as cooking stoves, air conditioners, refrigerators-freezers, on a voluntary, later followed on a mandatory basis.

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) and help to lower electricity demand (in electric geysers). Typically, these policies offer subsidies to support SWHs.

Building energy codes have a positive effect on the energy demand of buildings because they typically require energy efficiency improvements, while these can also stipulate the use of renewable energy systems. South Africa, Rwanda and Ghana have mandatory building codes with voluntary codes in Nigeria. REN21 (2022) reports building codes in development in Senegal, Côte d'Ivoire, Cameroon, Kenya, Uganda and Tanzania. While introduced in many countries, it should be noted that the application of standards, labeling and codes will not be effective, if no appropriate monitoring, verification, compliance and enforcement scheme is implemented.

Renewable energy use in Africa's transportation has been minimal. Currently, 7 out of 54 countries have some form of biofuel blending mandate[161]. Provided, biofuels get environmentally sustainably produced, blending can be an important measure to make transport greener.

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. So far, investment in EV infrastructure has focused on a few cities in Africa, such as Cape Town in South Africa. Depending on the electricity mix, electric mobility counts as a decarbonization solution that is set to take an ever-larger part globally. This will require forward-looking transport-energy planning and governments attracting the amounts of public and private investment needed for charging stations are required for EVs.

Africa is rapidly urbanizing, which will have an important environmental footprint in terms of materials and energy use as well as producing waste, unless existing resources are better used and processed. Africa's megacities should foster circular economic activity, creating jobs in collecting, separating and recycling. With worker safety measures in place, such jobs could lead to formal employment creation in an expanding circular economy. In Africa, organic material makes up to 60% of municipal waste flows. Treated organic waste (in landfills or wastewater) can be used energetically, in the form of biogas, and can also produce fertilizer and animal feed for agriculture.

[161] IRENA-AfDB (2022) and REN21 (2022) mention Angola, Ethiopia, Kenya, Malawi, South Africa, Sudan and Zimbabwe as countries with a biofuel blending mandate

In Focus 6 Renewable Energy Independent Power Producer Procurement Program, South Africa

Rather than going for feed-in tariffs, the South African government favored a competitive tender approach to reach the renewable energy goals set in the Integrated Resource Plan 2010. For this purpose, the Renewable Energy Independent Power Producer Procurement Program (REI4P) was established in 2011 by the Development Bank of Southern Africa (DBSA), Department of Energy (DoE) and the National Treasury; the first Sub-Saharan country to implement an auction program. The REIPPPP's main objective is to secure private sector investment for the development of new electricity generation from renewable energy sources. The REIPPPP has provided a clearer framework upon which Eskom could enter into power purchase agreements with producers. The auctions have been 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 concentrated solar power (CSP).

From August 2011 to 2015 seven procurement rounds known as Bidding Windows (BWs, in which 6,422 MW of electricity was procured from 112 RE Independent Power Producers (IPPs). 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, as well as a hiatus in the procurement program. By June 2021, 91 of the 92 projects reached financial closure.

Renewable energy capacity was 9,638 MW (out of a total of 57,436 MW in 2020). The RE4P is in line with the new IRP 2019 which proposes the energy mix to be expanded to 82,893 MW (36,230 MW) will be generated by renewable energy. Preparation for future bid windows is underway. During 2021/22, the IPPPP plans to roll out five bid windows (11,813 MW). To alleviate the medium-term electricity supply constraints and reduce the extensive utilization of diesel-based peaking electrical generators, the 2 GW "technology-neutral" Risk Mitigation IPP Procurement Program for dispatchable capacity was launched in late 2020, which was awarded to projects that combined solar PV, wind, storage and gas-fired generation.

By June 2021, 5,250 MW of electricity generation capacity from 81 IPP projects connected to the national grid, contributing to South Africa's climate change objective with the cumulative reduction of 63.9 million tons of carbon dioxide and generating 62,949 GWh of energy (since the first project became operational in 2013). The annual expected generation is 12,690 GWh.

The multi-phase bidding process has been characterized by progressive reductions in the prices offered by RE independent power producers (IPPs). Prices fell with each bidding window, averaging ZAR 0.71 per kWh in the last and fourth bidding round, a decline of 100% compared with the first bidding round with ZAR 1.42 per kWh. Likewise, solar PV bid prices decreased from ZAR 3.29 /kWh to ZAR 0.82/kWh in Round 4. For onshore wind, average tariffs went down with 50% from ZAR 1.67/kWh to ZAR 0.84 per kWh.

The REIPPPP has attracted significant investment into the country. The total investment (total project costs, including interest during construction), of projects under construction and projects under (financial) negotiation, is ZAR 209.7 billion (this includes total debt and equity of ZAR 209.2 billion, as well as early revenue and VAT facility of ZAR 0.5 billion). The REIPPPP has attracted ZAR 41.8 billion in foreign investment and financing in the five BWs and small-scale windows. Investment costs have been ZAR 22/MW on average for wind (ZAR 31/MW for solar, and ZAR 89/MW for CSP)

The employment for South African citizens in the construction and operation of RE IPPs has continued to grow from about 2,500 in 2013/14 (DoE, 2017) to 68,517 job years by mid-2021, which is almost 90% higher than the originally planned target of 32,000 jobs. This has been encouraged by evaluation criteria for the REIPPPP that demand that 70% should be related to price and the remaining 30% to economic, job creation, local content, ownership management, and preferential procurement consideration.

Local content minimum thresholds and targets were set higher for each subsequent bid window. Currently, about ZAR 61 billion is spent on local content in line with what was planned. Minimum ownership by local communities in an IPP of 5% is required as a procurement condition, with the actual achievement being about 9%. For projects that have reached financial closure, South Africans on average own 52% equity in all IPPs. Black South Africans own, on average, 34% of project equity, while local communities hold 9% equity in the IPPs. Black South Africans hold 34% of the shares across the complete supply chain. Local communities hold 8% equity in the IPPs.

*) The bidding rounds are called 1, 2, 3, 3.5 and 4 with small-scale bidding rounds (99 MW) for small developers (launched in 2014)

Source: *IPPPP, An Overview (June 2021).*

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Integrated energy resources planning

In the energy sector, reducing the losses in electricity generation and transportation and distribution losses (see sections 2.4.2 and 5.3.3) will help contribute to increased profitability of the utilities by reducing fossil fuel inputs per unit of electricity generation as well as having positive impacts on GHG emission. In government planning, there is usually a focus on the power sector, not in the least because utilities are often state-controlled or regulated by governments, unlike the petroleum products sector.

Sometimes, electricity and fuels are covered by different ministries. However, as renewable energy and electricity will get more integrated with the productive sectors and transport, effective cross-sectoral planning will become more important that integrates electricity production, renewable energy and supply with each other and the demand for electricity and fuels for cooling and heating in the sectors, residential, and productive sectors and motive energy demand in transport.

Labor, social and education policies to make the energy transition just

While industrial and infrastructural policies will be needed to support the creation of sustainable and competitive local supply chains, active social and labor market policies will be key to supporting human capital development and to be sure the energy transition is a just one. For example, in the energy transition, there may be net employment, both in the energy sector and the economy as a whole (as discussed in section 4.3). But in certain sectors and regions there will be winners and losers. Jobs will be lost in the formal sector activities (in fossil fuel production and distribution) as well as informal (firewood and charcoal production and distribution). Employment policies can support formal employment in newer sectors, shifting labor shift from less productive, obsolete sectors. It can also encourage the formalization of small enterprises in these areas and enable access to information, banking and small loans.

Stepping up social security systems is particularly relevant in countries largely dependent on fossil fuels, such as Algeria and Nigeria (oil) and South Africa (coal), which could invest more systematically in transition-related funds that can re-channel fossil fuel revenues into social protection and labor training. Given the dependence of many countries and regions on fossil fuels, the closure or repurposing of coal mines and power plants could have significant economic and social consequences. Especially in coal-producing regions, the local identity is closely tied to the coal value chain. Managing closures appropriately and successfully depends on planning for the impacts on affected workers and communities, and on the repurposing and reclamation of affected land (see In Focus 2).

Reskilling energy sector workers will be an important part of leaving-no-one-behind in the energy transition. Technical and vocational education (TVET) needs to be strengthened to provide skilled staff in the changing energy sector as well as for employment outside the fossil fuel or wood fuels sector they had been working. The new and renewable technologies sector needs trained technicians who can install, operate and maintain the systems. 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, labor associations and governments. Private and business-led educational initiatives could complement national education programs. Collaboration between public and private institutions in this regard should receive encouragement and support.

Social infrastructures such as healthcare facilities and effective education infrastructure (from primary schools to graduate institutions) are also instrumental in building human capital in Africa. Building the necessary human capacity and skills within African countries would enable them to undertake energy transitions on their own terms while also boosting economic growth and job creation on the continent. Programs that target skill-building across population segments should ensure that women, youth and older workers, minorities, low-income persons and those with disabilities are included to ensure that energy transitions will be just.

5.2.2 Affordable access and electrification models; integration with rural development

Current access expansion efforts are insufficient to achieve universal electricity access by 2030. A clear, coordinated break with 'policies-as-usual' will be required to achieve that objective. Expanding the electricity grid into all rural areas in Africa will be costly, and in the end perhaps not the most economically viable option. To bridge this gap, countries rely on three main electrification strategies: the extension of the main power grid (usually by a national utility) or the development of decentralized systems; delivery of solar home systems (often delivered by the private sector or NGOs); and minigrids (delivered by private sector or in private-public partnership (PPP) with government agencies). Mini-grids and SHS are the most relevant for areas that are located far from the main grid (or are sparsely populated) and have lower levels of consumption and the ability to pay.

Financing electricity access expansion is an important aspect of achieving universal access goals. Thus, it is important to attract private investment, in particular for mini-grid and off-grid solutions, in a range of business models (such as public-private partnerships with split assets; private-owned and financed). Whatever model, investment subsidies (grants from government entities or development partners) will be needed to lower investment costs so that power remains affordable (most of the unconnected households are also the poorest) and or acceptable (not deviating too much from the main grid tariffs). For grid extension, financing may take the form of direct subsidies for infrastructure investments (by governments and development partners) and tariff cross-subsidization from other consumers.

The best way to determine the optimal mix of solutions to provide access for all is to prepare integrated electrification plans based on geospatial mapping. Such plans allow governments to develop a precise strategy, assess the investment needed, design adapted policies to reach all populations, and clarify the roles of different actors (government stakeholders, donors, private sector and non-governmental organizations). Geospatial analysis helps government agencies to determine how least-cost universal access can be achieved with grid extension and densification as well as minigrid and off-grid solutions. Regulation and planning must ensure fair competition for example by securing similar levels of subsidy to grid extension as to minigrids (that can provide to private developers in regulation and planning to ensure fair competition with other means of access). Turning such plans into actual investment flows and concrete progress on the ground raises some challenges but they remain a good basis to mobilize private sector participation (see In Focus 4).

Many companies involved in minigrid electrification are currently struggling with profitability, resulting in frequent requests to increase subsidies. One reason is that minigrids are often implemented on a project-by-project basis with high overhead costs and varying capital subsidy support levels. This shows the need to reduce the cost per kWh (kilowatt hour), by distributing fixed costs across bigger programs and optimized risk management in minigrid operation and maintenance (by applying digital solutions, such as mobile payment and remote monitoring), supported by investment subvention based on clear guidelines based on a solid rural electrification plan. Given the increase in mobile financial services, having a robust and sustainable digitalization strategy that recognizes the needs of the energy sector will be essential to scaling up energy programs. Africa is the world leader in mobile money, and this has been leveraged by some countries in the provision of energy services through "pay-as-you-go" schemes for off-grid solar projects. Some 85% of the world's solar systems with pay-as-you-go mechanisms are in East Africa[162] with many providers utilizing mobile money for the large-scale deployment of various energy technologies through a variety of micro-financing mechanisms.

It is crucial to put in place a regulatory framework that can unlock private investment in the off-grid and mini-grid sectors. For solar home system, this should include consistent and market-enabling fiscal incentives with a minimum technical quality framework. For mini-grids, this encompasses clear licensing processes, appropriate tariff methodologies, clarification around operations and connection in the instance of grid arrival, and a quality-assurance framework.

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162 www.lightingglobal.org (World Bank, 2018)

In Focus 7 Use of LPG for cooking in Nigeria and Ghana

LPG is an unavoidable by-product of oil and natural gas production and oil refining (and some of the surplus goes to waste through venting or flaring at oil and gas production sites). On a domestic level, however, it is a scarce resource: many countries need to import LPG, which is a drain on already strained foreign capital reserves. Oil-rich countries such as Ghana and Nigeria have the resource available, Ghana produced about 222,000 tons in 2018 (and imported 175,000 tons in addition from Nigeria) and Nigeria 3.0 million tons (of 2.22 million tons were exported). Domestic consumption in Nigeria was in the residential sector only; in Ghana, 187 tons were consumed in the residential sector and 206,000 tons in transport and industry.

Despite these resources, biomass remains by far the dominant fuel used for cooking, usually in inefficient ways. In Nigeria, only 18% had access to clean fuels or technologies (and 15% use LPG primarily to cook) and 5% of rural population (of which 4% primarily uses LPG) in 2020. Wood and charcoal were used by 62% of population as primary cooking fuel (and 83% of rural population. In urban areas, 25% use LPG, 26% kerosene and 43% wood fuels. If using LPG about 2,790 Naira (about USD 10) a month. Wood fuel users that purchase charcoal or wood spend about 1,100-1,200 Naira.

In Ghana, only 22% has access to clean fuels or technologies (and almost all use LPG) and 6% of rural population (5% use LPG). Wood and charcoal were used by 76% of the population as primary cooking fuel (and 93% of rural population). In urban areas, 35% uses LPG and 67% wood fuels (of which 53% charcoal). On average, households spend about 40-50 cedi (USD 5-6) a month on wood or charcoal purchase. Nigeria is the most populated country in Africa with 206 million people or about 49 million households (2020), distributed equally across urban and rural areas, and may increase to 263 million by 2030. Ghana had 31 million people o (2020), of which 56% were urban, and this may increase to 38 million by 2030.

Nigeria's SE4All Agenda and National Renewable Action Plan (NREAP, 2016) mention 34-80% of households using modern cooking fuels by 2030 respectively and 59-20% efficient improved woodstoves. The UN Energy Compact refers to the National LPG Implementation Plan which, among others, has the target of increasing household LPG consumption from the current 780,000 tons to 5 million tons by 2027 through an incentivization scheme and awareness and sensitization campaign in partnership with state governments as well as by the establishment of at least six cylinder-manufacturing plants for gas stoves and accessories and establish about 7,400 filling stations, increasing the number of cylinders in circulation from 2,5 to 20 million in 2025.

It may not be easy therefore to persuade households. Ghana launched the LPG Promotion Program in 1990 with the primary aim of eliminating the flaring of LPG at Tema Oil Refinery and encouraging the citizenry to switch to LPG usage due to its advantages over wood fuel. There is a gradual switch from wood fuel to LPG mostly in the urban areas. In rural areas, lack of LPG accessibility has reduced the ability of most prospecting customers to easily get access to the product since they must travel long distances to the supply point. This challenge has made many prospecting buyers stay with wood fuel which is readily available and easily accessible. Also, LPG gained popularity as an alternative fuel for commercial vehicles. However, there is a gradual drop in the converting gasoline and diesel cars to LPG due to subsidy removal. Ghana's new National LPG Policy (NLPGP), approved in 2017, aims ambitiously at a 50% household target uptake by 2030. A recent study (KfW, Global LPG; 2018) argues that, although ambitious, the target could be reached. Getting the necessary infrastructure in place (bottling plants, storage, pallets, cylinders) would require an investment of about USD 350 million. The health impact could be in the order of 12,000-19,400 death avoided in the period 2020-2030. The global greenhouse gas mitigation impact is calculated by looking at averted deforestation (assuming that 65% of wood is taken from forests in a non-renewable manner, which can be applied to both charcoal and wood). Thus, while LPG consumption would increase GHG emissions, those due to wood and charcoal would decrease, given a net effect of about 630 kilotons of CO_2eq.

From a consumer's point of view, cooking meals costs less on wood (55 cedi a month = USD 10 than on LPG (88 cedi, USD 16) but less than on charcoal (68 cedi, USD 12 a month. The cost of the required cooking equipment, amortized over its useful life, does not materially change the costs to the consumer of cooking a meal, although it must be noted that the up-front cost to acquire the equipment requires adequate consumer savings, or, instead of savings, a mechanism to spread out the cost of the equipment over time. In both countries, 90% of households that use clean cooking fuel have high-quality housing, and have access to electricity and a bank account, indicating a relatively high purchase power. In Ghana, LPG equipment (double burner stove, 14.5kg cylinder and required accessories) costs about 360 cedi in total (USD 65). A LPG microfinance program has been proposed with an LPG operational and a financial partner, in which the client would pay the amount of 360 cedi over time in six instalments and a deposit of 72 cedi.

Given the importance of electricity to making progress on other SDGs (such as those related to gender, health and education; see Exhibit 45), the sequencing, timing and scale of rural electrification projects should follow broader government plans for rural development, in particular agricultural and other productive uses and public services, such as health clinics and local primary and secondary schools. Targeted measures to link electricity access programs 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.

Cross-sector synergies, especially with health and agricultural productive use, can also contribute to easing financial constraints and making projects more commercially attractive. Scaling up can be achieved by making mini-grid and off-grid solutions an integral part of local development plans for which government and private funding can be mobilized (see section 5.4 on scaling up financing).

5.2.3 Energy subsidy reform

Fossil fuel subsidies

Governments need to step up the proportion of spending on green investments in their economic plans, provide energy access and reduce the substantial losses that power utilities make. At the same time, a significant proportion of many countries' budgets are dedicated to subsidising fossil fuels (as discussed in detail in section 4.4.2). These form a drain on public finances, which can be better used for other purposes. For example, the amount of fossil fuel subsidy spent is in the same order as the annual investments needed to achieve universal energy access by 2030 in Sub-Saharan Africa, about USD 40 million annually. Often, subsidies benefit the rich more in absolute terms than the poor. In many cases, fossil fuel subsidies persist even when their original rationale or justification has ceased to exist and the original policy objectives have been achieved. Subsidies that were intended to be temporary can eventually become permanent.

Fossil fuel reforms have three approaches: a) remove subsidies that do not support energy access and hinder decarbonization, such as producer subsidies; b) target fossil fuel subsidies that are currently deemed necessary to reaching SDG 7 towards access and those people that need them, and c) swap existing fossil fuel subsidies by investing in renewable energy technologies and energy efficiency.

Governments face several barriers to implementing subsidy reform. Foremost is garnering public support in the face of often fierce opposition from those who stand to lose the subsidy. Cheap energy is critically important for household welfare, particularly among poorer families, among whom these costs account for a higher overall share of total household expenditure. Special interest (e.g., transport unions) and lobby groups (from fossil-fuel-related industries) resist the removal of subsidies. Subsidies make good politics but bad policy. Gradual removal is better than shock therapy. The sudden withdrawal of subsidies often can provoke widespread protests that are often intensified by underlying long-standing discontent with the distribution of wealth and income and the power structure, accompanied by declining trust in public institutions. Such protests often take place in the capital or other large cities. With its rapidly growing urban populations, the risk of instability can be a real concern for politicians in Africa and create a barrier to reform, even if it might be economically possible to mitigate.

Any reforms to phase out subsidies for fossil fuels should therefore include measures to mitigate the likely negative impacts on the poorest, which can lower the overall cost of living more efficiently than maintaining fossil fuel subsidies. Thus, fossil fuel subsidy reforms need to include compensatory measures that target the poorest and most affected households, such as reinforcing existing social welfare benefits, including cash transfer mechanisms and temporary basic incomes (see, for example, In Focus 7). However, in Africa, such social welfare nets are rudimentary developed and do not cover the millions that work in the informal sector.

Electricity

The consumption subsidies for electricity can be replaced by connection subsidies. These are better targeted, since the poor account for the majority of those without access to basic services, and are one-time (for the connection to be realized). The grid connection charges in Sub-Saharan Africa are among the highest in the world, which has been a contributing factor to having low rates of electrification in many countries (see section 4.4.2). Even when the infrastructure has been put in place, an issue for many poor households is often not the cost of the energy consumption but getting connected to the new service in the first place. Lowering the grid connection fees or upfront costs may be financially smarter than subsidizing consumption for an indefinite period.

Energy efficient appliances can enable consumers to access higher levels of energy services at lower costs, and so reduce the size (and the cost) of the system needed to support these services. Particularly in minigrid and off-grid solutions, broadening the scope of electricity access plans to include the provision of energy for productive uses, such as agriculture or industry, can support the ability of end-users to pay while at the same time bringing down the cost of supply by increasing the load factor. Here, private companies including providers of mini-grid and solar home systems are starting to consider how best to support the development of commercial activities among electrified communities to ensure the sustainability of their projects.

In Focus 8 Subsidy reform in Morocco and Egypt

Record-high oil prices between 2010 and 2014 prompted several energy importers in North Africa to raise domestic energy prices. In 2012, Morocco still spent up to 6% of GDP on fossil fuel subsidies, higher than its combined spending on health and education. The subsidies reached just 15% of the households in the poorest quintile of the population and actually 20% in the richest. In 2014, a process was started to end subsidies on fuel oil and gasoline and later cut subsidies on diesel, and prices were fully liberalized by 2015. By 2018, fossil fuels were about 1% of GDP in 2018 (for comparison, fuel and electricity excise revenues were about 2.2% of GDP. However, the electricity sector's tariffs are underpriced, costing about 0.5% of GDP, bringing total energy subsidies to about 1.5% of GDP). However, Morocco has continued with LPG, used in households and for irrigation tasks.

Conditional cash transfer mechanisms, for example, have proved attractive for compensating former recipients of energy subsidies. In Morocco, the *Tayssir* (meaning 'facilitation') program targeting poor rural households expanded from 80,000 families in 2009 to 466,000 families in 2014 (around 5% of the population). The total program cost grew to USD 70 million per year, equivalent to around 0.1% of GDP (energy subsidies previously cost around 1.7% of GDP). The households included in the program received approximately USD 153 per year – a similar amount to pre-reform (net) household fossil fuel subsidies in the case of a family of four. A second program, the *Regime d'Assistance Médicale pour les Économiquement Démuni*s (RAMED (Medical Assistance Scheme for the Economically Deprived) grants free medical treatment to its members. Membership is free for households living below the national poverty line and highly subsidised for households living barely above the poverty line, covering 11.5 million people in 2017. Both programs have faced severe difficulties in targeting and the government has been working on a new population registration system.

When Morocco started its reform in 2012, Egypt's share of fossil fuel subvention of GDP was even higher, 8.5% (forming 22% of government spending in 2012, about USD 21 billion). The subsidies disproportionately favored wealthier people, who consumed more petroleum products: the wealthiest 20% of households enjoyed 46% of the benefits in absolute terms, and the poorest 20% received just 9% of total subsidy spending. In July 2014, the Egyptian government implemented wide-ranging subsidy reform for the first time in decades, cutting subsidies back to USD 14 billion. By 2019, fossil fuel subvention was about 2.7% of GDP (noting that in comparison with Morocco, excise revenues from electricity and fossil fuels were low). Over 2019-2020, subsidies were slashed further by 65%. As in Morocco, Egypt's energy subsidy reforms have addressed transport fuels. The country remains one of the largest electricity subsidizers (costing about USD 2.6 billion in 2020), while fossil fuel subsidies remain relatively high (USD 5 billion, 2020).

Employing some of the revenues generated by subsidy reform to alleviate the impacts of increased household energy costs on vulnerable groups can help ensure progressive outcomes while protecting the fiscal base. Egypt focused on food subsidies (including bread, rice, sugar, tea, flour and oil) to limit the impact of rising energy prices on the cost of food. An increase in the public-sector minimum wage was financed by a USD 12 billion support package from Gulf countries. Stronger social safety nets, for example via cash transfer mechanisms like in Morocco, are needed to protect livelihoods while simultaneously continuing efforts to rationalize consumption. Measures such as direct cash transfer to poor households or a targeted subsidized fuel ration towards income-eligible households would have been more cost-effective than an economy-wide food subsidy program but cannot be implemented in the absence of a unified registry of households and the lack of administrative foundations for an electronic smart card system

Source: Vidican, G & Löwe, M. (2021), UNDP (2021); /www.oecd.org/tax/tax-policy/taxing-energy-use-egypt.pdf; www.oecd.org/tax/tax-policy/taxing-energy-use-morocco.pdf; https://www.wri.org/update/egypt-transitioning-away-subsidizing-fossil-fuels; https://www.wri.org/update/morocco-fuel-subsidy-reform-designed-support-just-transition-renewable-energy; https://www.chathamhouse.org/2022/02/five-takeaways-decade-energy-subsidy-reforms-mena

5.2.4 *Strong institutions and conducive environment*

Electricity tariffs

Electricity tariffs in most African countries are below cost-reflective levels, that is, they are lower than the actual cost of generating, transporting and distributing electricity to consumers. Operating losses among all African utilities are thought to have exceeded USD 150 billion in 2020.[163] Service providers (most often utilities) are seldom fully compensated for these losses, which leads to several adverse effects;

- Lack of incentives and financing for connecting new consumers. While aimed to help the poor, the adverse effect of subsidies is that it often leaves the utility without sufficient revenues to fund grid expansion (thus harming the unconnected poor).
- Underinvestment in generation and the grid. Underfunded service providers do not have the revenue required to invest in strengthening and maintaining their network. Over time, this leads to poor, unreliable electricity supply at high cost and frequent supply interruptions.
- High investment risk. When independent power producers (IPPs) fear that the utility will not be able to pay for the electricity, it becomes difficult and expensive for them to raise the necessary debt and equity. In many cases, such risk will even prevent otherwise viable investments.

The recent AfDB Electricity Regulatory Index (see Exhibit 56) reports that out of 43 countries in Africa studied, 15 had cost-reflective tariffs[164] (see Exhibit 57). Thus, many African utilities still are not able to charge cost-reflective tariffs. This is often accompanied 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 liabilities" for the government's budget.

Institutional setup of the power sector

To a varying degree and with varying results, African countries are trying to address the structural issues that threaten their security of supply via reforms aimed at improving efficiency and attracting 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 in the power sector, such as commercializing 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; and allowing private sector participation.

The above-mentioned sectoral reforms have for the most part been implemented only partially and many African utilities remain vertically integrated monopolies (see Exhibit 55). There are currently only a few examples of competition in transmission, distribution and retail, but in many countries sector reform has allowed private investment into the generation side of the power system, especially through Independent Power Producers (IPPs).

IPPs are privately owned companies that develop, operate and own power plants on the basis of long-term PPAs with utilities or other off-takers. In addition, new types of electricity service providers are emerging, such as community-owned companies and private mini-grid operators. Now present in about 30 countries, the IPPs represent more than 20 gigawatts (GW) installed capacity and USD 45.5 billion in total investment[165].

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[166]

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[163] IEA (2022)

[164] Benin, Burundi, Cameroon, Congo, Egypt, Eswatini, Ghana, Kenya, Liberia, Namibia, Niger, Rwanda, Seychelles, Tanzania, Togo, Uganda

[165] GIZ (2020); AfDB

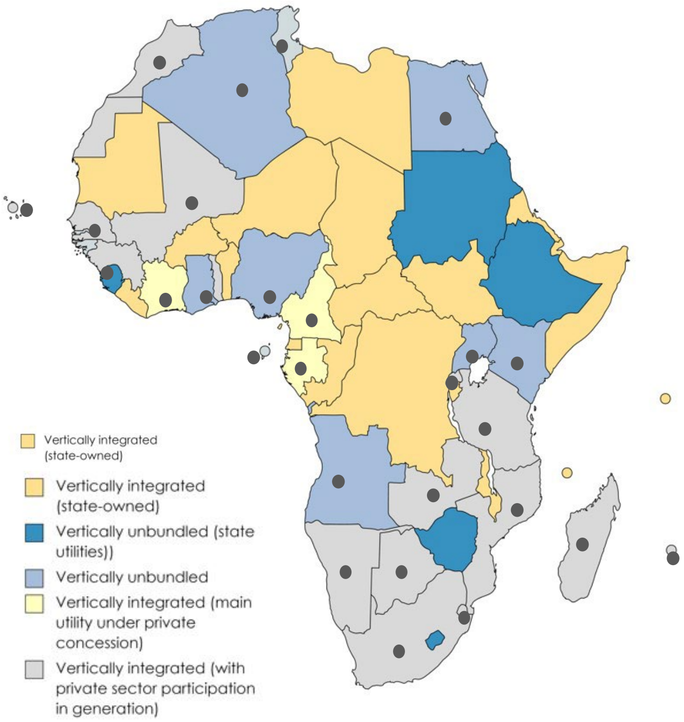
[166] IRENA-AfDB (2022), based on 2021 Power Futures Lab data

According to Grids4Africa (2021), these private operators, with their profit motivation, tend to outperform in general their public counterparts across a range of technical and commercial indicators. Private companies can contribute much-needed capital and expertise to strengthen the security of supply in Africa, but many African countries still do not allow private investments in their power sectors.

Unbundling and liberalization are indispensable for unlocking the full benefits of private involvement, although private participation can also take place in a vertically integrated structure. As for the structure of the power system, there has been a rethinking regarding the prescriptions of the 1990s reform model of market liberalization that may not be uniformly applicable, especially less so in small and less-developed economies (see the Uganda case In Focus 5)

Whether unbundled or not, for a private investor to sign a PPA (and a bank to provide debt financing), these assume a certain level of financial stability of the project off-taker. However, by 2016, only three electricity utilities in Sub-Saharan Africa had an investment-grade credit rating: Namibia, Uganda and Seychelles[167]. As discussed, the financial status of utilities of often precarious, due to the inability to charge cost-reflective tariffs, low tariff collection and high technical T&D losses. Because in most countries, IPPs can only sell power to the state-owned main utility as off-taker, such projects often need sovereign guarantees. As many host states often find themselves in difficult fiscal positions (having low sovereign ratings), the private sector windows of multilateral development banks play an important role in providing guarantees to backstop private lending.

Exhibit 55 Power sector structures, Africa



Vertically integrated	Vertically integrated with PSP	Vertically unbundled
One utility manages G-T-D, usually state-owned (C.A.R, Chad, D.R. Congo, Guinea-B., Liberia, Libya, Mauretania)	One main state utility managing G-T-D. Private sector participates in G (Botswana, Burkina Faso, Burundi, Egypt, Gabon, Gambia, Madagascar, Malawi, Rwanda, Tanzania, Tunisia)	State-owned G and state-owned T&D Lesotho)
One main utility managing G-T-D with smaller state-owned G-T-D companies (Congo, Niger)	One main state utility with PSP in G, T and D (Benin, Guinea, Mali, Morocco, Mozambique, namibia, Senegal, South Africa, Togo, Zambia)	Separate public and private G, T and D (Algeria, Angola, Ethiopia, Ghana, Kenya, Nigeria, Sudan, Uganda, Zimbabwe)
	One main private utility with IPP in G (Cameroon, Cote d'Ivoire)	

Regarding power structure, African countries largely be divided into three groups, as illustrated in the figure below: i) vertically integrated with no private sector participation, ii) vertically integrated with private sector participation, and iii) vertically unbundled (in state-owned, private or state/private utilities). ● private generation, G: generation, T: distribution, D: distribution

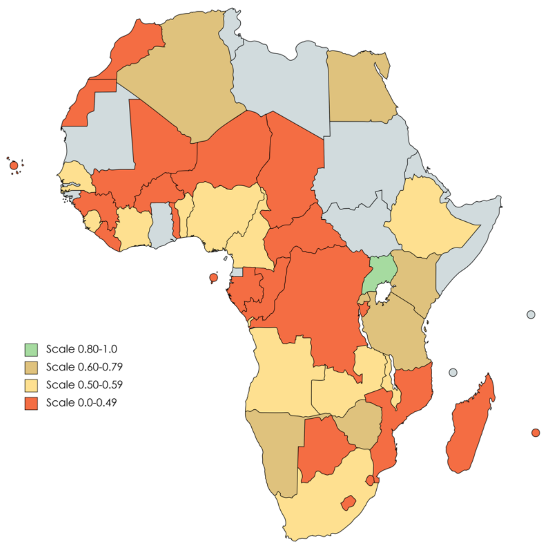
[167] IRENA-AfDB (2022)

Exhibit 56 Governance and electricity regulation

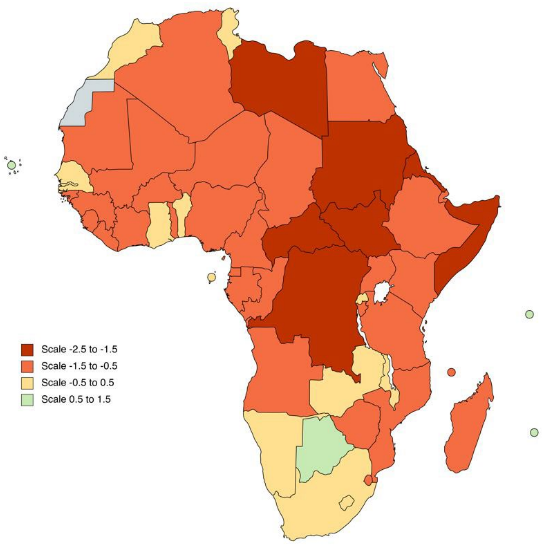
AfDB's electricity regulation index (ERI) measures It measures the level of development of electricity sector regulatory frameworks in African countries and the capacity of regulatory authorities to effectively carry out their relevant functions and duties. The ERI is made up of three pillars or sub-indices: the Regulatory Governance Index (RGI), the Regulatory Substance Index (RSI); and the Regulatory Outcome Index (ROI) which are assessed on a scale from 0 (zero) to 1 (one). The first two can by aggregated into the RGSI index that gives an indication of effectiveness of a country's regulatory environment to support electricity sector reforms, carry out electrification, promote efficiency and fulfill national objectives.

The RGI is determined by looking at legal mandates, clarity of roles and objectives, independence (from government, stakeholders and financially), accountability, transparency, participation in decision-making, predictability and open access to information. The RSI looks at economic regulation (tariff setting), technical regulations (frequency and duration of outages, requirements for connection, grid code; licensing framework; institutional capacity; IPP regulations; framework for minigrid systems; energy efficiency promotion). The third indicator, ROI, looks at how financial performance, quality of service (commercial and technical) and facilitation of energy access. In general, countries score in the range 0.33-0.66 (yellow band) on RGI, indicating that a necessary legal framework for electricity sector regulation has been put in place. On average, the RSI scores are lower, indicating that many countries need to improve the implementation of the regulatory framework. On the ROI, countries do not score well, indicating, in particular, poor financial health of utilities and sector indebtedness due to insufficient revenue generation (as in many cases tariffs are not cost-reflective).

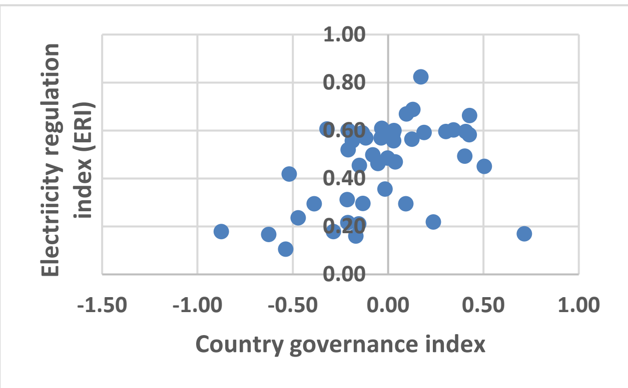
AfDB's ERI ratings in 2021

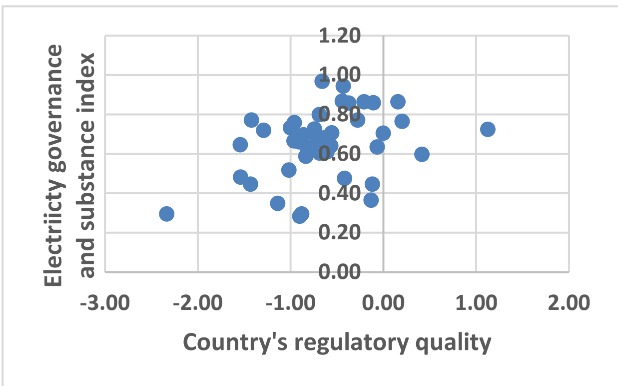


General governance index



World Bank's Worldwide Governance reports aggregate governance indicators for over 200 countries looking at six dimensions of governance, namely 1) voice and accountability, 2) political stability and absence of violence, 3) government effectiveness, 4) regulatory quality, 5) rule of law, and 6) corruption control. For the purpose of this report, the six indicators have been aggregated into one composite 'governance index' for the various African countries (see also Exhibit 60). It is tempting to relate the electricity governance and regulation indices with general governance indicators. The scatter diagrams below seem to suggest some but not very clear relation between a country's ERI rating and scale on the general governance index, while some relation exists between the electricity governance and regulation substance index (part of ERI) and the regulatory quality index (part of the general governance index).





In Focus 9 Power sector reform and public-private partnerships in Uganda

In 2005, Uganda descended into a power crisis with a sharp decline in hydropower generation output that dropped to half the electricity demand, leading to a period of long power outages and load shedding. This development took place in the framework of a new global paradigm for power sector reform was put forward that emphasized the restructuring of utilities, the creation of regulators, the participation of the private sector, and the establishment of competitive power markets. Uganda completed vertical unbundling of the national utility and split it into three utilities for generation, transmission and distribution with the establishment of an independent sector regulator. To have a viable power sector, the government has strived for having cost-reflective tariffs since 2012. Private sector participation has been encouraged in both the electricity distribution and generation segments through private-public partnerships (PPP). Hydropower played an important role in this transition. This started with the construction of the 250 MW Bujagali hydropower plant (HPP) during 2007-2012, The facility was the first independent power project (IPP) in Uganda and is a good example of public and private sector sponsors can work together to address their financing and risk mitigation concerns, and meet the country's development objectives Bujagali HPP was later followed by smaller (private HPP)s) facilitating Uganda's transition from a supply deficit to a surplus with generation capacity tripling to about 1,270 megawatts (MW) in 2020.

The PPP has proved to be a unique opportunity for the two diverse sectors to learn how to work together. For the private sector, sharing risks and securing guarantees are important benefits. For the government, private sector investments supplement the limited resources available for the government in technology, finance and management. Nonetheless, the experience with Bujagali and other PPPs has also illustrated some governance challenges associated with the IPP model. One is that costs can still be significant even when the procurement process is carefully structured and transaction costs are high. Private investors will require significant compensation for the associated risks.

In the past decade, the transmission and distribution network did expand, but in terms of power transport capacity lagging the total grid generation capacity. Available grid supply has surpassed the grid peak demand by 523 MW, i.e., generation capacity is 172% greater than the peak demand. The power surplus capacity has grown so big that it threatens the power sector viability. As a result of failure to have adequate demand growth or export to meet supply capacity, the Government is forced to pay for deemed energy and it partly responsible for driving up the end-user tariffs. These are already relatively high, as the private sector investments and financial risks need to be covered.

To keep tariffs ow, the Government has resorted again to public funding of large generation projects (with Chinese loans), such as the two large hydro projects at Karuma (600 MW) and Isimba (183 MW). The true costs are unclear and the viability of these projects is also yet to be proven. The two projects are expected to shift Uganda into a position of even more excess supply. The question remains open in how far investments and operations are paid for by the customer (through higher tariffs) or by the taxpayer (through increased taxes). But hiding the real costs may lead the sector into a vicious circle of underfunding and debt the Government will be obligated to pay a high price for the electricity that it is not able to dispatch in the current situation of power oversupply.

One challenge is that over 70% of Uganda's population lives in rural areas in predominantly dispersed settlements. The distance between households creates logistical difficulties and high costs for both distribution lines. While energy access has improved very much, compared to a decade ago, at 28% it is still quite low compared to the Sub-Saharan Africa average of 42%. Another challenge is that the unbundling also brought a distribution in the responsibility of coordination and resource planning over various entities, which hampers coordinated least-cost power and T&D network planning. Advancing electricity access was not given sufficient attention in the early years of reform. Once the reforms were implemented the expectation that small-scale private rural concessionaires would invest in rural electrification proved to be overoptimistic. Planning and procurement capabilities are essential to the functioning of the sector. With the unbundling, responsibility for power generation, transmission and distribution of the former state monopoly was scattered over multiple public agencies and private companies. There has been a lack of coordination among various entities in the quite complex institutional framework for the electricity sector, particularly on the distribution side.

Uganda's experience illustrates the complexity of power sector reform and the need for all the different parts of the sector, from generation to distribution, from planning to regulation, to function effectively in tandem. The private sector has financed a substantial expansion of generation capacity. Yet, its contribution to power distribution has been much more limited, struggling with cost recovery issues. Private utilities are often praised for better performance on efficiency, but some countries that did retain a dominant (but competent state-owned utility and guided by strong policy objectives) have also achieved admirable results. In general, reforms seem to have worked best in larger middle-income countries with a relatively large power system at a high level of electrification. This makes a case for greater pluralism of approaches going forward and that reform efforts need to be shaped by both the political and economic context of the host country.

Source: Van den Akker (2021); World Bank (2020)

Exhibit 57 Overview of sustainable energy national commitments and deployment policies in Africa

	Enabling policies								Deployment policies						
	Renewable		Energy eff.		Access		Grid		Regulations					Incentives	
	NDC - RE target	National energy policy - RE target	NDC - EE target	National energy policy - EE target	Offgrid or RE electrification target	Clean cooking target	Cost-reflective power tariffs	Off-grid or RE network connection policy	Biofuel mandate	RE quota/mandates/ obligations	RE net-metering policies	RE feed-in tariff	RE auctions or tenders	Tax incentives	Financial support, subsidies, rebates
North Africa															
Algeria	P	P HC	No	P B I	No	No	No	Yes				★	★		★
Egypt	P T	P HC	P	P L S B	No	No	Yes	Yes			★	★	★	★	★
Libya	No	P HC	No	No	No	No	-	-						★	★
Morocco	P HC	P HC	P L S B I	P L S B I	No	No	No	Yes			★		★		★
Sudan	P	P HC	P	No	No	Yes	-	-	★						★
Tunisia	P HC	P HC	P B I	P S B	No	No	-	-					★		
East Africa															
Burundi	P	No	P	No	No	No	Yes	No							
Comoros	P	No	No	No	No	No	-	-							★
Djibouti	P	P	P B HC	No	No	Yes									★
Eritrea	P	P	P	No	No	Yes	-	-							
Ethiopia	P	No	P	P	Yes	Yes	No	Yes	★				★		
Kenya	P	P HC	P	P L B I	Yes	Yes	Yes	Yes	★		★		★	★	★
Rwanda	P	No	P L I	No	Yes	Yes	Yes	Yes			★		★	★	★
Seychelles	P T	P	P L S B	P B I	No	No	Yes	Yes			★		★	★	★
Somalia	P	Access	No	No	No	No	-	-							
South Sudan	P	No	P	No	Yes	No	-	-							
Tanzania	Yes	P	No	P L S B I	Yes	Yes	Yes	Yes			★		★	★	★
Uganda	P	P HC	No	No	Yes	Yes	Yes	Yes							
Central Africa															
Cameroon	P	No	P	P B I	No	No	Yes	No							★
Central African Rep.	P	No	No	No	No	No	No	No							
Chad	P	No	No	No	No	No	-	-						★	
Congo	P	No	No	No	No	No	Yes	No							
D.R. of Congo	P HC T	No	P B HC	No	Yes	Yes	No	Yes						★	
Equatorial Guinea	P	No	No	No	No	No	-	-							
Gabon	P	P	No	No	No	No	No	No							★
São Tomé e Príncipe	P	No	P B HC	No	No	No	No	No							

	Enabling policies								Deployment policies						
	Renewable		Energy eff.		Access		Grid		Regulations					Incentives	
	NDC - RE target	National energy policy - RE target	NDC - EE target	National energy policy - EE target	Offgrid or RE electrification target	Clean cooking target	Cost-reflective power tariffs	Off-grid or RE network connection policy	Biofuel mandate	RE quota/mandates/ obligations	RE net-metering policies	RE feed-in tariff	RE auctions or tenders	Tax incentives	Financial support, subsidies, rebates
West Africa															
Benin	P	P	P L S B I	P L S B I	Yes	Yes	Yes	Yes					★	★	
Burkina Faso	P	P	P.	P L S B I	Yes	Yes	No	No					★	★	★
Cabo Verde	P	P HC	P S B	P L S B I	No	No	No	Yes			★		★	★	★
Côte d'Ivoire	P	P	P B S	P B S	Yes	No	No	No					★	★	
Gambia	P HC	P	P	P L S I B	Yes	No	No	No					★	★	★
Ghana	P	P	P	P L S B I	Yes	No	Yes	Yes	★	★	★	★	★	★	★
Guinea	P	P	No	P	No	Yes	No	Yes						★	
Guinea-Bissau	P	P HC	P	P L S B I	Yes	No	-	-					★		
Liberia	P T	P HC T	P HC	P S B I T	Yes	Yes	Yes	Yes						★	
Mali	P	P	No	P L S B I	Yes	Yes	No	Yes					★	★	★
Mauritania	P HC	No	NO	No	No	No	-	-							
Niger	P	P HC	P	P L S B I	Yes	No	Yes	Yes					★	★	
Nigeria	P	P HC T	P	P L S B I	Yes	Yes	No	Yes		★		★	★	★	★
Senegal	P HC	P HC	P	P L S B I	Yes	No	No	Yes					★	★	★
Sierra Leone	P HC	P	P	P L S B I	Yes	No	No	No						★	
Togo	P	P	No	P L S B I	Yes	No	Yes	No						★	
Southern Africa															
Angola	P	P	P B	P B	Yes	Yes	No	No	★		★				★
Botswana	P	No	No	P L B	No	No	No	No					★	★	
Eswatini	P T	No	No	No	No	No	Yes	Yes					★		★
Lesotho	P HC	No	P	No	No	Yes	No	No			★		★	★	★
Madagascar	P	P	No	No	Yes	Yes	No	Yes					★	★	
Malawi	P HC T	No	No	No	Yes	Yes	No	No	★	★			★	★	★
Mauritius	P	P	No	No	No	No	No	No					★	★	★
Mozambique	NO	P T	No	No	Yes	No	No	Yes	★				★	★	★
Namibia	P HC T	P	No	No	Yes	No	Yes	Yes		★					★
South Africa	P	P	No	P L S B I	No	No	No	Yes	★	★		★	★	★	★
Zambia	P T	No	No	No	No	No	No	Yes				★	★	★	★
Zimbabwe	P HC	P HC T	No	P	No	No	No	Yes	★				★	★	★

P: power, HC: heating and/or cooling, T: transport
L: lighting, S: standards and labeling, B; building, I: industry
Source: information taken from IRENA-AfDB (2022), REN21 (2021)

Regulations and other deployment policies

An enabling regulatory environment with appropriate procurement and contracting frameworks, a supportive, and committed government, together with the financial stability of the sector, are indispensable to the success of any form of private involvement. Even if allowed *de jure,* regulatory challenges prevent direct private sector participation in practice. Renewable energy and storage technologies are already cost-competitive on a levelized cost basis, but high upfront capital expenditures combined with adverse regulatory and legal frameworks may make fossil fuel alternatives easier and cheaper to finance in many cases, which unnecessarily locks the energy systems into a higher share of fossil fuels. A number of strategies have been designed to create a more level playing field for renewable energy.

Contracting frameworks

To attract more extensive private investment and financing, regulation must also guarantee the financial viability of utility business models by providing for adequate remuneration of benchmark costs and reasonable returns on investment. Several countries have developed model power purchase agreements (PPAs) for independent power producers, thus helping to reduce the time and cost associated with the contracting process.

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 from solar PV, onshore wind, biomass and small hydropower. Tariffs offered have varied between from about USD 0.075 to 0.20/kWh, depending on the country and type of RE technology (solar, wind, hydro, biomass, geothermal)[168]. One reason that FiTs have failed to deliver much investment in Africa is that these are often not accompanied by the necessary regulatory environment or backed by an appropriate contractual framework, or hindered by the financial situation of the utility off-taker. Worldwide, there is a trend away from administratively set feed-in pricing policies to the use of competitive tenders or auctions for large-scale power generation[169].

Auctions and tenders

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. However, the awarded capacity has concentrated in two countries, South Africa (almost 9 GW) and Morocco (about 2.4 GW). Also, in the bidding and awarding stage, many auctions have experienced delays or cancellations, equivalent to almost 8.5 G, out of which a total of 1.25 GW has been cancelled. Nonetheless, auctions are now prevalent in many African countries, as summarized in Exhibit 57)

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. The competition in auctions has brought down prices. Solar auctions have realised prices that have repeatedly broken previous continents' solar PV price records. For example, Tunisia's Tatouine solar PV farm and Ethiopia's Gad and Dicheto solar farm broke the 2018 weighted average of solar PV auctions of USD 56/MWh with USD 25.34 and USD 25.26/MWh respectively[170]. Wind power auctions have yet to gain as much attention as solar PV; only South Africa, Morocco, Egypt and Tunisia have contracted onshore wind IPPs following an auction, but also in wind power, auctions have achieved a cost reduction.

Another interesting feature of auction programs is their ability to incorporate socio-economic objectives as has been the case in South Africa (see In Focus 4). It also offers the opportunity to combine generation by variable

[168] Ibid.

[169] REN21 (2021)

[170] IRENA-AfDB (2022)

sources (solar wind) with grid stability (such as linking variable sources with other renewables energy, such as solar PV and concentrated solar power or with battery storage)

Net-metering

Net metering policies compensate the owners of renewable power systems for surplus electricity fed into the grid. This can apply to smaller and larger energy systems, although in some countries there is a focus on small-scale or distributed renewable energy, such as rooftop solar PV systems. Several African countries are incentivising self-generation through net-metering regulations applied at the national level, including Botswana, Egypt, Mauritius, Morocco, Namibia, Rwanda, Senegal, Tanzania and Tunisia[171].

In 2020, Botswana launched a new net metering programme for both large and small rooftop solar PV systems. Tunisia issued a decree allowing private companies that generate renewable power for their use to sell any excess generation to the national utility under net metering rules. Zimbabwe also launched a net metering programme for rooftop solar PV[172].

Fiscal and financial incentives

Fiscal policies that render renewable (and energy efficiency) energy more affordable include tax incentives (such as value-added tax), customs and import-duty exemptions, and capital depreciation/capital allowances. These have been adopted in Africa, in particular in East and West Africa (see Exhibit 57). For example, many countries have adopted import tax exemptions for solar products. Financial incentives include soft loan schemes for renewable energy technologies, such as solar water heaters, solar pumps, solar home systems and other sustainable energy technologies.

Policies to promote solar water heaters (SWH) 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. For example, in Tunisia's PROSOL programme 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. In Kenya, a 2012 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[173].

5.2.5 Policy definition, stakeholder engagement and public awareness

While governments will play a crucial role in promoting energy transition, they cannot achieve this outcome alone. A right balance between the public and private sectors will need to be struck in policy formulation, while the involvement of local communities and civil-led initiatives should be encouraged to increase the uptake and support by communities.

Successful transitions can only be just if these are inclusive. Towards this end, planning should be consultative, at both national and sub-national levels, offering some degree of influence to the various stakeholder concerned. Collaborative approaches can be strengthened, first by getting inputs from stakeholders, including businesses and civil society, on national policies and plans. Some countries have set up multi-stakeholder working groups or task forces as a regular and institutionalised way of discussing with and involving stakeholders. These can serve not only to discuss new initiatives but to have a feedback channel on how existing or newly implemented policies affect businesses and local communities.

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[171] Ibid.

[172] REN21 (2021)

[173] REN21 (2019)

One aspect of just transitions is the empowerment of stakeholders to influence and potentially own decision-making processes that affect their economic and social well-being, based on the transparent sharing of information about the risks and the structural changes needed. This will require more inclusive governance structures and institutions at the national level than presently is the case in many countries (see Exhibit 56 and Exhibit 60 on governance). Related to this empowerment is the overall vision for transition planning; is the preference to achieve change through incremental steps through existing social and economic systems, or is there the ambition to overhaul existing political and economic systems that are incompatible with the energy transition, sustainable development and social equity?

5.3 Strengthening energy infrastructure and regional integration

5.3.1 Fossil fuels: investment for the future or stranded assets?

Countries must avoid locking themselves into new, costly fossil fuel-based infrastructure as the world rapidly moves to zero-carbon futures. Even for countries with their own supplies of oil, coal and natural gas, it makes more sense to focus on export (during the transition period) for foreign exchange earnings while creating a modern and increasingly renewables-based system.

Least-cost scenarios in the power sector only point to a rapid shift to renewables for both new generation capacity and as replacements for old coal and fuel oil power plants. Today, solar PV and wind are 40% cheaper than new-built coal and nuclear power in South Africa, and it has already started to make economic sense to decommission existing coal power plants in favor of new wind and solar facilities[174]. Solar, wind and hydro will provide a growing share in power generation in the coming decades replacing oil and coal.

Exhibit 58 Local communities, indigenous people and gender equality

To be just and inclusive, the energy transitions must fully identify and address potential trade-offs and take care to advance the rights of local communities and indigenous people rather than compromise them. Activities in the extractive industry (in particular mining, oil, and gas, as well as logging projects), have led to land loss, marginalization, loss of livelihoods and cultural identity to local communities and indigenous groups. Thus, special attention must be given to minimizing potential conflicts of use, such as those between energy production (e.g., ground–mounted solar parks, large-scale bioenergy, mining, big hydro power plants) and arable land for agriculture. Ensuring sustainable energy production will mean avoiding conflicts with food production and food security, as well as ensuring the safe management of agricultural land, water and natural resources. Ultimately such actions, paired with a participatory planning process that ensures the voice of the affected populations in decision-making, will help protect the health, livelihoods, and environment of local populations and vulnerable communities.

Women living in poor communities will be greatly impacted by the energy transition. Currently, female-headed households are less likely than male-headed ones to have access to electricity, whether portable solar, mini-grid, or grid electricity. Women, who are typically the main procurers of energy in the home, are often excluded from taking part in selection of the stoves and fuels used for cooking or of modern energy technology. Moreover, women, in Africa and globally, women are under-represented in, or even absent from, decision-making processes and formulation of national energy policies and programs. With challenges ranging from insufficient training opportunities, bias in career choices, as well as cultural norms and perceptions, the barriers for women's active participation in the energy value chain are often insurmountable, particularly for those rural women working in the informal sector. A just and inclusive transition should enable and even encourage stronger engagement of women in the energy workforce by promoting and supporting women's roles as engineers, policymakers, and entrepreneurs.

Source: based on text in UN (2021b)

[174] Bischof-Niemtz and Creamer (2019)

A 2021 analysis of around 2,500 power plants to be built across the continent found[175] that, that coal and gas will account for up to two-thirds of Africa's electricity generation by 2030. Within the fossil fuels sector, shifting from coal to gas may reduce greenhouse gas emissions in the near term. A detailed assessment of lifecycle greenhouse gas emissions of gas and coal supply by the International Energy Agency (2018) found that gas on average resulted in 33% fewer emissions than coal per unit of heat used in industry and buildings, and 50% fewer emissions than coal per unit of electricity generated.[176] Fuel switching to cleaner fossil fuels, primarily natural gas, in energy-intensive industries and power production, contributes to greenhouse gas emissions reduction. Natural gas is cost-effective as a source of high-temperature heat in industry.

Africa is home to some 20 trillion m^3 of known natural gas reserves which can be utilized to initiate and expedite Africa's just energy transition, about 7% of the natural gas reserves in the world[177]. Much of the natural gas is currently exported either through gas pipelines linking North Africa to Europe or as LNG. The combination of increasing income and growing urbanization suggests a growing market for cleaner cooking solutions. Attainable supply-side interventions, like reducing the distance to LPG retail points and improving access to affordable multi-burner stoves, could expand usage by up to 58% of households by 2030[178]. The transition away from biomass cooking fuels will enable the continent to invest in the technology and infrastructure that would facilitate the adoption of even cleaner fuel sources in the future.

In transport modernizing urban and intercity public transport through the deployment of transport systems based on cleaner fuels (LPG, biogas, natural gas and, increasingly, electricity) offer major prospects to reduce GHG emissions and urban pollution, and increase the overall performance of African economies.

Natural gas will rather, during the transition, increasingly play a role to fill the gap when solar and wind cannot meet peak demand. It is technically possible and feasible from least-cost modelling scenarios to design a system that over time, to a large extent relies on solar PV, wind and hydro as baseload, to which natural gas, stored energy and demand-side management are added during the peak demand, corresponding to the remaining load.

On the other hand, investment in natural gas would commit individual countries to long-term fossil fuel infrastructure with an economic lifetime beyond 2050 that would have to be paid back over an extended period. As renewable-based power becomes increasingly competitive and governments formulate renewable energy targets in planning, fossil fuel power plants now risk becoming *stranded assets*, that is, over time fossil plants would be dispatched less, rendering them obsolete.

In the 'sustainable development' scenarios discussed in Chapter 3, there is an increase in the relative share of natural gas in the primary energy supply mix, particularly as the use of other fossil fuels such as oil and goal decreases. The 'net zero' scenarios outline future trajectories where natural gas does not increase its share, that is, it remains a relatively cost-effective fossil fuel with less dramatic climate change impact and in industry and power generation will be used primarily to balance peak demand rather than as the main source of energy. Whether natural gas production and consumption will increase in the longer term will depend on risk assessments and strategic choices in the overall energy planning that balances short and longer-term investment prospects with cost development of other energy sources (such as renewables) and climate concerns.

5.3.2 New energy technologies; hydrogen

Africa has abundant renewable resources and demonstrated potential for (green) hydrogen production at globally competitive costs. Several European countries are looking into investing in Africa's green hydrogen production and transport infrastructure (see section 3.3.4). Hydrogen could be part of a long-term strategy of long-distance

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175 Alova et.al (2021)

176 IEA (2018)

177 Energy Capital and Power (2021)

178 Shupler, et.al. (2021)

exports and the development of a green, local, industry. Several hydrogen initiatives have been undertaken. The *African Hydrogen Partnership* is a continent-wide trade association dedicated to the deployment of green hydrogen and fuel-cell technology. *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).

Some countries have introduced hydrogen and derivative fuels in their longer-term energy planning, such as South Africa, Nigeria and Namibia. Projects to set hydrogen-based ammonia production are mooted in Egypt (50-100 MW) and Mauritania (100 MW)[179]. South Africa has high potential because it is already familiar with the production of around 8 billion liters annually of synthetic fuels. Hence, the present infrastructure might be repurposed for green hydrogen production.

5.3.3 Strengthening of energy networks

Building a robust power network

The poor technical state of many African electricity grids, often coupled with design issues, long low-voltage lines and the lack of preventive maintenance, results in high technical transmission and distribution (T&D) losses, which together with the non-technical losses (non-payment or illegal connections) will negatively impact the security of supply. The ageing and poorly maintained grid and generation infrastructure in many African countries is also a barrier to the integration of more renewable energy in the electricity mix.

Therefore, investments in transmission and distribution, including interconnectors for regional electricity trade, are indispensable enablers in achieving universal access and realizing renewable energy's potential. These investments need to be coupled with capacity building for the planning, operation and maintenance of generation and grid infrastructure. Selected measures include:

- Improve grid maintenance by better outage management and installing computerized maintenance management and control tools;
- Enable real-time data exchange, by automation of substations and adding fiber optic cable along transmission lines (for providing communication between generation and control centers, and for internet connectivity in general);
- Reduce non-technical losses through increased payment collection (using smart meters at distribution and consumers' sites)

The integration of (variable) renewable energy sources can be encouraged by enabling the operation and/or connection of minigrids (often powered by solar or hydro) with the main grid, digitally managed battery storage helps to better dispatch renewable-based generation.

Decentralized vs centralized

Renewables will need to be at the core of the energy-system expansion, as explained in the previous sections, and will play an important role in providing minigrid and off-grid solutions to meet the goal of providing universal energy access needs. Through their distributed nature, renewables present opportunities to build smaller-scale, modular and rapidly constructed energy infrastructure across all communities. This can much easier to cater to the needs of both local productive sectors, farming, households and public services than the old centralized model. In other words, minigrid and stand-alone options may provide the least-cost solutions as compared to grid extension, especially in more remote or sparsely populated areas,

New, decentralized energy systems also allow for a much more diversified landscape of actors involved in energy generation, with numerous entities – communities, cooperatives, small and big companies, utilities and public entities – becoming both producers and consumers of energy. Over time this modern, bottom-up approach allows

[179] IRENA-AfDB (2022)

for increasing interconnection of local micro and medium-sized grids into larger systems that expand in capacity, enhanced load sharing and balancing. Thus, new 'virtual power plants can draw on numerous, dispersed energy generation points to effectively constitute the equivalent of a large power plant, catering to the needs in the geographical area covered (see also Exhibit 59).

Research, development and innovation

Developing such new technological approaches requires research and innovation. It is indicative of the status of research and development (R&D) that Africa's share of global funding for R&D is less than one percent of the global total. The Coalition for African Research and Innovation has identified two major barriers that need to be addressed, namely, inadequate allocation of resources to innovation, and the fragmented nature of available resources. Resource fragmentation severely limits any opportunities for collaboration. In fact, many African 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%)[180].

Leveraging new technologies and spurring innovation is a key success factor for the energy transition in Africa. Several instruments are available to support such innovation. Governments can channel financial support, in terms of fiscal incentives and subsidies, towards emerging industrial sectors where they could secure competitive advantages (i.e., LNG, hydrogen, batteries, etc.). Development partners can provide project financing or portfolios of innovative projects with scaling potential. Access to cheap capital can be provided via local currency lending as well as lending in international currencies.

Grants and technical support for innovative pilot projects can also be provided, for example, through challenge funds. Challenge funds can help to develop markets and leverage private sector expertise to address high-risk market barriers. These funds can be provided in the form of grants to help de-risk private sector engagement in projects that are perceived as too risky for prospective developers. They can also help to build a project pipeline by providing capital for feasibility studies and fundamental analyses.

One example of such a challenge fund is the Geothermal Risk Mitigation Facility (GRMF), launched in 2012. The GRMF awards grants to cover part of the investment costs associated with early-stage geothermal power projects in East Africa. At an early stage (survey, exploration, first drilling) the uncertainty about the geothermal reservoir potential at a site is usually very high, while the cost of reservoir development already has to be made). Up to June 2022, seven rounds have been organized with about USD 131 million for 14 surface studies and 16 drilling programs in 6 different countries.[181]

One way is to pool resources by working together in a network of joint research and innovation centers. UNIDO in partnership with sub-regional economic communities (RECs) and their Members States, has set up the Global Network of Regional Sustainable Energy Centers (GN-SEC). For Africa, these centers are:

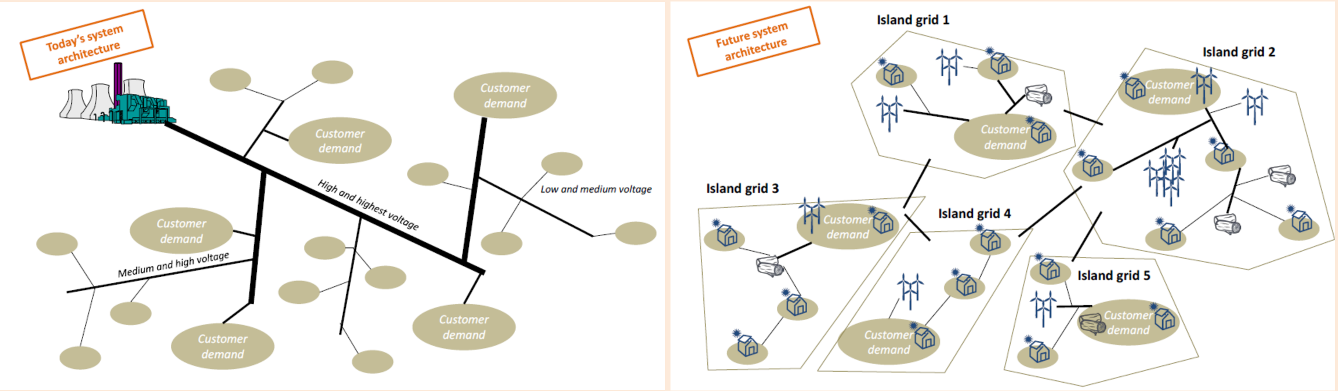
- CEREEAC (Centre for Renewable Energy and Energy Efficiency for Central Africa), in cooperation with ECCAS,
- EACREEE (East African Centre for Renewable Energy and Energy Efficiency), in cooperation with EAC, headquartered in Uganda
- ECREEE (ECOWAS Regional Centre for Renewable Energy and Energy Efficiency), with ECOWAS, based in Cabo Verde
- SACREEE (SADC Centre for Renewable Energy and Energy Efficiency), with SADC, based in Namibia
- RECREEE (Regional Center for Renewable Energy and Energy Efficiency), with the Arab League and Arab Ministerial Council for Electricity (AMCE), based in Egypt.

[180] AU (2019)

[181] grmf-eastafrica.org/about-grmf/

Exhibit 59 Regional sustainable energy plans and strategies

The **Africa Renewable Energy Initiative (AREI)** The is an Africa-owned and Africa-led effort to accelerate and scale up the harnessing of the continent's huge renewable energy potential. Under the mandate of the African Union and endorsed by the Committee of African Heads of State and Government on Climate Change (CAHOSCC), the initiative was launched in December 2015 at COP21 with the goal to achieve new and additional power generation capacity over the period 2017-2030 by at least 10 GW of by 2020 (Phase I), and at least 300 GW by 2030 (Phase II)* in conjunction with achieving universal energy access, as well as allowing for a higher electricity use per capita (from 50-1500 kWh to 8000 kWh per capita). AREI comes with an action plan that has the following elements: a) Mapping of renewable energy policies, regulations, experiences and programmes, b) Strengthening of policy, regulatory and support frameworks, c) Capacity mobilization and building, d) Mobilization of finance for incentives and investment, e) Project development and support, f) Socio-economic and environmental assessments of renewable energy technologies, g) Multi-stakeholder engagement, h) Wider context monitoring and assessment, i) Communications and outreach. The AREI envisions smart, distributed energy systems that can handle a mix of renewable energy generation as indicated below



The **African Union Green Recovery Plan** is in response to the economic and other challenges faced after the COVID-19 pandemic and aims to tackle the combined challenges of the COVID-19 recovery and climate change, by focusing on critical areas of joint priority, including climate finance, renewable energy, resilient agriculture, resilient cities, land use and biodiversity. Investing in sustainable energy will require enhancing existing initiatives such as the Africa Renewable Energy Initiative (AREI) and the SDG7 Initiative for Africa*** in order to reach the goal to mobilize African potential to generate the before-mentioned 300 GW by 2030. Energy efficiency is also a key area of focus in supporting countries to reduce emissions while also improving cost effectiveness of energy generation, transmission and distribution. Work is needed o secure investment (public and private) and technology transfer in grid expansion, transmission, distribution and efficiency improvements, to widen access to electricity, while increasing the roll-out of mini-grids and off-grid products to those that cannot reach. The Plan calls for a transition from investing in fossil fuels, and in particular coal to renewables is becoming increasingly economically viable with renewable energy envisaged to be now cheaper than new coal and creating more jobs per dollar invested. However, for African countries, particularly those reliant on fossil fuels as a primary source of energy and foreign exchange earnings, it is acknowledged that the "Just Transition" is a complex and long-term process, which will be dependent on national circumstances, capabilities and the provision of adequate support. Furthermore, the Plan calls for supporting Support countries' development and implementation of new and updated Nationally Determined Contributions (NDCs) and Long-Term Low-Emissions development Strategies (LT-LEDs).

At the subregional level, the various economic communities have adopted sustainable energy plans. For example, **ECOWAS Renewable Energy Policy** (2013) mentions that the ECOWAS region's target for the share of renewable energy in the region's overall electricity mix to 10% in 2020 and 19% in 2030. Including large hydro, the share would be 35% in 2020 and 48% in 2030. Around 25% of the rural ECOWAS population is mentioned to be served by mini-grids and stand-alone systems by 2030. The **SADC Renewable Energy and Energy Efficiency Plan** (2016-2030) formulates the target to be achieved by 2030 for the region as a whole: 85.% energy access, 39% renewable energy mix in the grid, 7.5% off-grid share in overall electricity capacity, 15% efficient cooking device penetration, 20% blending of ethanol with gasoline, 10% blending of biodiesel with diesel, 5% efficient charcoal production in the charcoal market and 15% energy efficiency savings obtained.

* *Note:* Installed renewable energy (RE) power capacity was about, 45 GW in 2016, 52 GW in 2019 and 58 GW in 2020. The Multiconsult scenario (see Exhibit 27 expects about 170 GW of RE capacity (out of total installed capacity of 400 GW by 2030), of which about 120 GW RE in Sub-Saharan Africa (our of total of 250 GW). The IRENA scenarios (for Sub-Saharan Africa) see 203 GW (with 124 GW of RE) and 242 GW (with 163 GW of RE) installed capacity by 2030 in the PES and TES scenarios respectively. In the IRENA scenario capacity increases to 281-571 GW in 2040 (in PES and TES scenarios respectively. See also Exhibit 30

** The UNECA-initiated **SDG7 Initiative for Africa**, based on three pillars of sustainability, governance and finance, aims to fast-track private sector investments for clean energy for enhanced access and climate action for the realization of over 10 GW by 2025.

Source: AREI (2016), AU (2021b), ECOWAS (2013), SADC (2016)

Governance, conflict and fragile states

In conflict-affected and fragile states, the decentralized access to energy afforded by renewables is a lifeline which makes all other support possible, including clean water, light, warmth, and sustenance, as well as basic and emergency services. Choosing renewables and clean technologies in reconstruction efforts strengthens resilience and avoids costlier efforts to retrofit at a later stage.

Successful transitions can only be just if they are inclusive. Towards this end, planning should be consultative, at both national and sub-national levels, offering some degree of influence to the various stakeholder concerned. One aspect of just transitions is the empowerment of stakeholders to influence and potentially own decision-making processes that affect their economic and social well-being, based on the transparent sharing of information about the risks and the structural changes needed. This will require governments to require adherence to civil liberties, rights of association and organization, respect for individual rights as well as political pluralism. This will also require more inclusive governance structures and institutions and rule of law at the national level than presently is the case in many countries (see Exhibit 60)

5.3.4 Regional energy networks and coordination

Grid integration and power pools

African countries will benefit from the development of enhanced webs of electricity integration. Cross-border electricity trade coupled with market development has the potential dramatically reduce average electricity prices for all African countries and increase the share of renewables and energy security for the whole continent.

Integrating African electricity markets by building on existing regional power pools will help to balance load curves and stabilize neighboring countries' grids, especially when it comes to the future introduction of large-scale variable renewable energy capacity. For example, as discussed above, hydropower supplies are flexible (baseload) in one country and can help balance the inherent variability of other renewable energy supplies in other countries through interconnection and energy trade. An increase in interconnector capacities in the region enhances cost-efficient production by enabling an increased flow of lower-cost electricity supplies and will enable the pooling (and mutual balancing) of supplies from variable resources.

Power pools go in tandem with liberalizing national energy markets. However, this may not be in the interest of monopoly utilities and the decision-makers they are connected to. A regional market is also difficult to achieve in the context of continuing energy subsidies, which many African countries maintain with the argument of guaranteeing an affordable price for consumers. There may be also strong resistance from powerful and privileged consumers who stand to lose from a liberalization of the sector and phase-put of subsidies.

Ultimately, power pools depend on a critical mass of surplus capacity, which on the African continent has long been in short supply. This leads to a tricky situation, where the immediate interest in regional electricity trade is often limited due to insufficient current surplus capacity. Structural deficits in many of the regions do not make a strong case for expensive interconnection investments that may want to invest in local grid upgrading first. On the other hand, electricity imports from the regional power pool can help ease those shortages, rather than making expensive investments. With no export options due to lack of interconnection, power-exporting countries also run the risk of ending up with capacity they cannot use (see In Focus 5 on the overcapacity issues in Uganda). This may be the case when major infrastructure comes online (such as the recent large hydropower developments in Ethiopia). African regions and countries therefore may have an interest in ensuring that grids and interconnections are in place and up to standard sufficiently ahead of time.

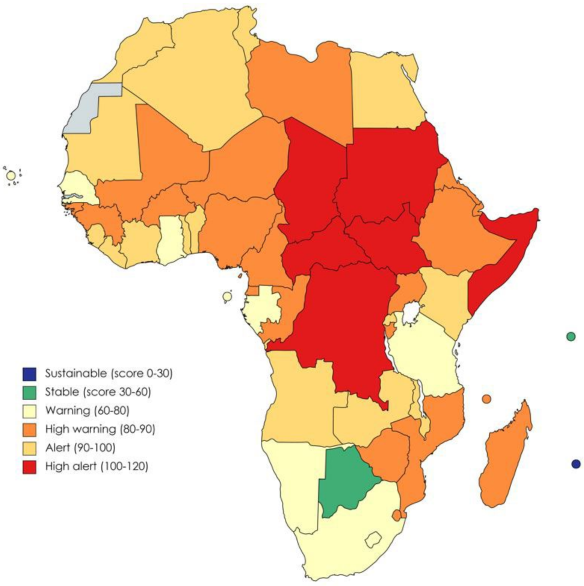
Exhibit 60 Governance, natural resources, social dialogue and conflicts

Promoting good governance is recognized by the African Union (AU) as an essential component in the efforts to achieve continental development goals, including natural and energy resources development. Natural resource extraction shapes social, economic and political relations in Africa in multiple and complex ways. One of its sadder visible impacts is the tendency to generate or worsen a spectrum of violent conflicts. Conflicts can be about resources with low market but high livelihood value, such as cropland and water, or with high market value (oil, gas, minerals). Examples in the recent past have been in Mozambique (gas), Sudan (water, oil), Sierra Leone (diamonds), West-Sahara (phosphates), Liberia (various), DR Congo gold, diamonds, cobalt, other), Congo (oil) and Angola (oil, diamonds).

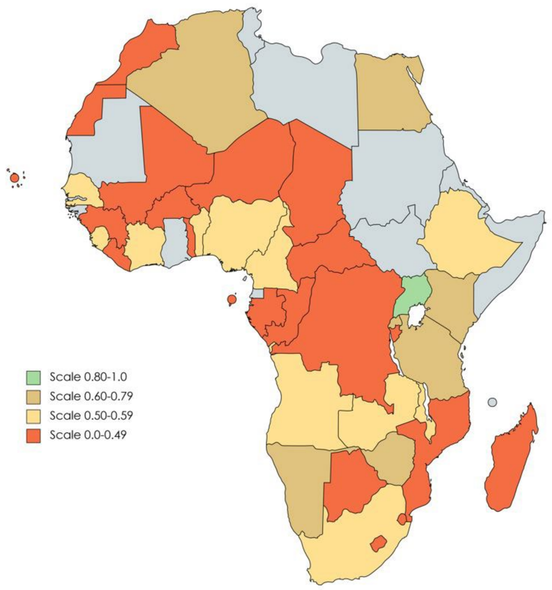
There is a connection between social relations in states (or sites) with natural resources and the subsisting nature of governance. Where governance processes, institutions and actors are strong and equitable, the chances of natural resources generating violent conflict diminish significantly. Effective governance is critical in achieving natural resources will be used for the betterment of the population in an equitable way. Collaborative governance, involving state governments, the private sector, and local community representatives is vital to promoting sustainable land-use and the while defusing conflict. Despite having vast energy and mineral resource, many African countries have failed to transform this potential into tangible benefits in terms of inclusive socio-economic development as well as human security and peace.

* See fort example the AU APRM Governance Report 2021

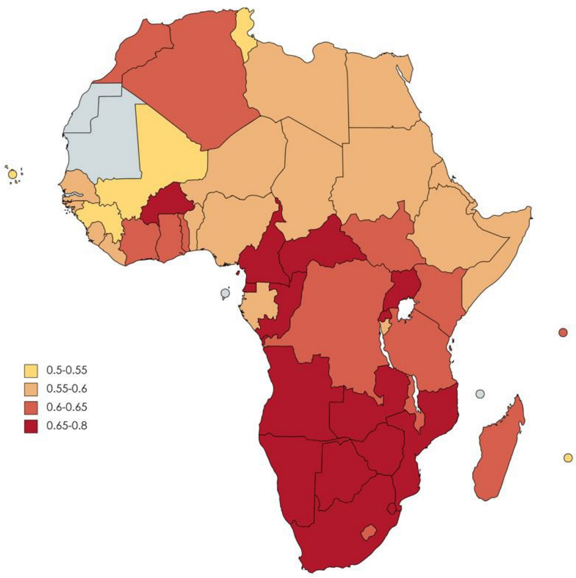
Fragile State Index*(below)*
based on twelve indicators of state vulnerability, grouped by category: Cohesion, Economic, Political, Social. The index highlight not only the pressures (including conflict and violence) a country faces but also its capacity to manage those pressures. Source: www.fragilestatesindex.org



Composite governance index *(below)*
World Bank's Worldwide Governance reports aggregate governance indicators for over 200 countries looking at six dimensions of governance, namely 1) voice and accountability, 2) political stability and absence of violence, 3) government effectiveness, 4) regulatory quality, 5) rule of law, and 6) corruption control. For the purpose of this report, the six indicators have been aggregated into one composite 'governance index' for the various African countries



GINI index of national income *(below)*
is a measure of statistical dispersion intended to represent the income inequality. A Gini coefficient of 0 expresses perfect equality, where all values are the same, while a Gini coefficient of 1 (or 100%) expresses maximal inequality among values. For example, Norway has one of lowest: 0.39; South Africa one of the highest: 0.75 (2020 data). Source: World Inequality Database (www.wid.org)



Gas and oil networks

Through the establishment of integrated, regional power markets, proven gas reserves can be mobilized on a regional basis, in which gas-producing countries can meet the rising demand for power of gas-deficient countries, interconnecting electricity grids and utilizing excess capacity. One example, is the Trans-Mediterranean (Transmed) pipeline (2,475 km), carrying gas from Algeria to Italy via Tunisia and Sicily. The West African Gas Pipeline Project (WAGP) is a 678 km natural gas pipeline linking Nigeria's Escravos region of the Niger Delta with Benin, Togo and Ghana.

East African Crude Oil Pipeline (1443 km), agreed upon in February 2022, will link Uganda oil fields with the Tanzanian port of Tanga. The African Renaissance Pipeline Project (ARP) is a proposed 2,600 km natural gas pipeline that aims to link Mozambique's gas-rich Rovuma basin to Springs in Gauteng, South Africa. The new Trans Sahara Gas Pipeline[182] is set to link sub-Saharan Africa with North Africa and would offer opportunities to access supplies of natural gas for transit countries and as a way of exporting gas to European markets.

Regional energy planning

Some regions have advanced with regional energy planning coordination. One example, is ECOWAS's Renewable Energy Policy (adopted in 2013), aiming 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 MW of power generation capacity through efficiency gains and ultimately double the rate of improvements in energy efficiency[183]. In the Central African region, 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[184]. SADC adopted the Renewable Energy and Energy Efficiency Strategy and Action Plan in 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.

Regjonal trade

Regional trade coordination 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 small-sized national markets that hinder productivity gains in many African countries. Larger market access, regional clustering, free movement of people and workers across Africa 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 renewable and new energy technologies 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 a local value-added renewable energy and hydrogen industry.

5.4 Scaling up financing

Getting the world on track for net-zero emissions by 2050 requires clean energy investment to accelerate from current levels of about USD 1.9 trillion annually to around USD 4 trillion annually by 2030, a doubling in investment needs. Similarly, investments in Africa will need to increase from about USD 60-90 billion to about USD 135-150 billion annually on average over 2020-2030 (depending on the scenario followed; see section 3.4). Total

[182] A Memorandum of Understanding was signed between Nigeria, Niger and Algeria in July 2022

[183] IRENA-AfDB (2022)

[184] Ibid.

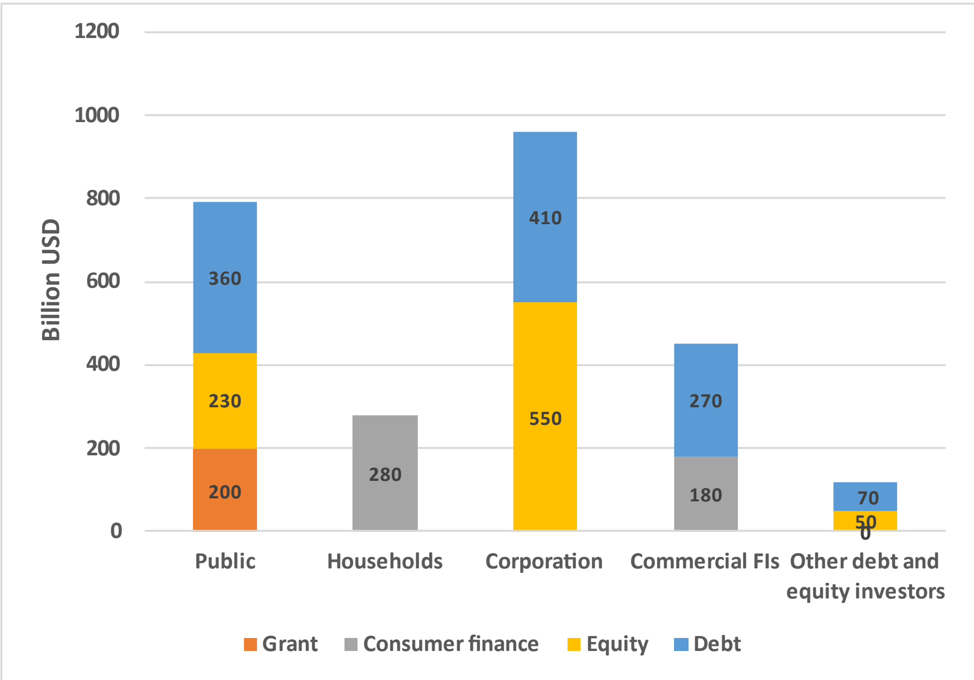
cumulative investments required are estimated at USD 1,500-1,600 billion over the period 2020-2030 and about USD 4,300-6,600 billion over the period 2020-2050[185].

Whichever way the energy system will evolve, green or grey, a lot more capital will be required in the energy sector to ensure that the energy supply is both reliable and adequate to meet demand. In the period until 2030, investments for energy access need to be scaled up to about USD 40 million annually.

Who will supply the capital needed to enable this investment? While investments will inevitably be funded from a variety of sources and types of funds (international and local; private and public; equity and debt) the choice of capital provider and financing vehicle may make a big difference to the pace and affordability of Africa's shift

Exhibit 61 Global energy transition investment and financing

Section 3.4 discusses the annual investment need for the various 'net zero' sceanrios over the period 2021-2025 as USD 2600 billion annually and of USD 4,500 billion annually over the period 2026-2050, giving a total cumulative investment requirement of USD 112 trillion over 2021-2050. Thus, investments need to triple beyond 2025 s as compared to average annual investment of USD 1,880 over the period 2016-2020 (IEA data). All actors in the energy systems have key roles to play supporting these amounts that are in accordance with the 'net zero' pathways described in Chapter 2. The figure below gives a summary view of annual financing from public and private sector over the period 2021-2025. Total annual financing amounts to USD 2,600 billion, of which 30% from public (USD 460 billion from government and public finance institutions and USD 360 billion from SOEs) and 70% from private sources with corporations being the largest direct investor. In the calculation, USD 200 billion is grant financing, USD 460 billion consumer investment and financing, USD 830 billion is equity (project and balance-sheet) and USD 1,110 billion is debt financing (project and balance sheet). Of the commercial finance (equity and debt), USD 880 billion is project financing (of which about USD 550 billion private financing) and USD 1,050 billion is balance-sheet financing (of which USD 790 billion by corporations)



Of the commercial finance of about USD 900 billion, USD 390 billion is financed by commercial finance institutions (FIs) and other private debt and equity investors. Commercial FIs also facilitate about USD 180 billion in consumer finance.

Apart from commercial FIs, private debt and equity investors include private equity and venture capital, institutional investors and infrastructure funds.

[185] Data derived from Race to Zero and IEA publications. In the Race to Zero, the annual energy investments needed in 2030 are 202 billion annually (see section 3.4 for more details)

towards more reliable, sustainable and affordable power. The financing must be able to support a doubling in investment by 2030, with a shift in electricity access from centralized grid extension to decentralized options, and in fuel supply and power generation from fossil fuels to low-carbon fuels.

Currently, public sources provide 40-45% of investments in the energy sector in Africa (see Exhibit 62), notably through national oil and gas companies and utilities and of which large part through development finance institutions (DFIs). The majority of the power sector investment in sub-Saharan Africa, about two-thirds, is from public funding. In particular, state-owned enterprises (SOEs) play an important financing role, which is often hampered by the high debt they face, one factor in the relatively slow electrification process (see section 5.2). In the electricity sector, most private investments have focused on generation with renewable energy sources, including off-grid and minigrids.

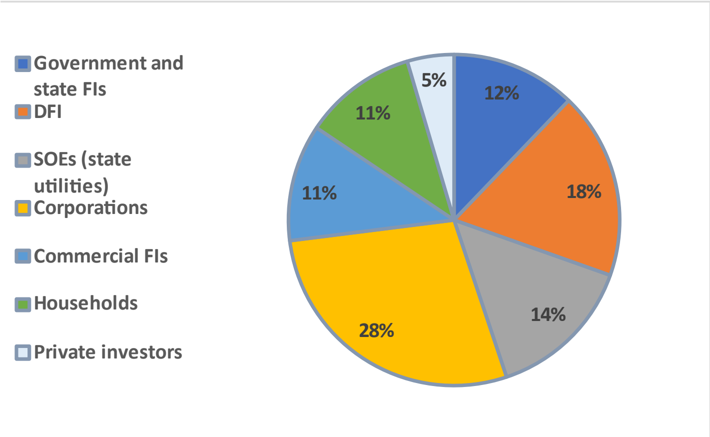
The majority of the continent's infrastructure is funded through government budget allocation and state-owned enterprises. However, limited governmental capacity translates to a substantial financing gap remaining. Private sector investment and lending, as well as private-public partnerships, are needed as the means to bridge the current and future infrastructure financing gap.

Debt financing makes up less than 40% of energy investment in Africa today, reflecting the prevalence of equity-based financing in the fossil fuel sector. The reliance on reliance on debt financing will rises. Given the concerns about the sustainability of public debt, this will require increasing the availability of privately sourced debt, which is generally constrained in Africa due to perceived currency and other risks, and due to lack of expertise in assessing (off-grid) energy infrastructure projects in Africa. Development finance support has been substantial across sub-Saharan Africa and, to various degrees, has helped to catalyze private funds.

Exhibit 61 provides a summary of global financing needs in 2025, based on the investment estimates of the Race to Zero scenario, and Exhibit 62 shows the sources of financing for the investment needs in Africa in 2030. While government policies and regulations, along with public finance, are critical to the clean energy transitions, most of the actual investment will need to come from the private sector. The investments needed to meet Africa´s growing energy demand, providing energy for all with low-carbon energy, will be far greater than the funds available from public sources, such as African governments and development partners.

Several investment funds have been supporting sustainable energy and energy access, often supported by DFIs. Examples are AfDB's Africa Renewable Energy Fund (USD 200 million), the Beyond the Grid Fund for Africa (set up by Sweden, later joined by other donors; about USD 110 million), Clean Technology Fund (established by the multi-donor Climate Investment Fund, about USD 5.5 million), Green Climate Fund (GCF; had approved about USD 5.2 billion in energy climate mitigation projects, of which about

Exhibit 62 Financing of the energy sector investments in energy sector in Africa per source (2030)



Own elaboration based on data from Race to Zero www.gfanzero.com/netzerofinancing.

Total annual investment needs in 2030 in the energy sector in Africa in the 'net zero' scenario is USD 202.3 billion. It is instructive to compare this amount with the amount of aid released by US, EU and other to Ukraine in the six-month period after the start of the Russian invasion, EUR 43 billion, EUR 28 billion and EUR 11 billion, respectively. A total of USD 80 billion was committed, more than the investment needs to achieve universal access in Africa. Financial aid includes loans and grants, humanitarian aid (including food and medical items), and military aid includes arms, equipment, and utilities provided to the Ukrainian military. https://www.nationalworld.com/news/world/ukraine-war-amount-military-humanitarian-aid-revealed-3763553

USD 2.8 billion in Africa), UNDCF's Renewable Energy Challenge Fund, and AfDB's Sustainable Energy Fund for Africa (SEFA, USD 95 million)[186].

Corporate actors can play an important role in renewable electricity systems. Despite the dramatic drop in costs, renewable energy developers in Africa still face structural barriers stemming from the cash-flow profile of such projects, including significant upfront capital requirements, with long payback periods. The real and perceived risks will differ from country to country, but they are generally related to political instability, macroeconomic uncertainty, weak policy and regulatory frameworks, financially weak utilities, and lack of transparency and institutional capacity. If investors can accommodate higher investment costs and longer return periods, many renewable or low-carbon options actually offer higher net present value than many fossil fuel alternatives.

Commercial finance institutions (FIs) will play an important role in transport decarbonization and buildings decarbonization investment through direct investment and making available consumer finance. Investments by corporations (project equity or balance sheet) will require additional funding from commercial FIs and other private debt and equity investors. Instructure funds will play an important role in facilitating investments in the less mature African markets, while institutional investors could contribute substantially through project finance.

Alongside commercial FIs, local pension funds and institutional investors more broadly can also become actors of financing for energy infrastructure. Thus, the channeling of savings towards domestic investment and local market opportunities can be increased. The challenge with local commercial FI financing for infrastructure projects is that local banks prefer high-yielding, short-term investments as lower-risk alternatives to the longer-term loans necessary for infrastructure investment. Institutional investors lack the expertise to run credit risk evaluation of energy infrastructure, so they prefer to invest in established real-estate holdings, short-term bank deposits, and risk-free government securities.

Development finance institutions (FIs) can incentivize local banks and institutional investors to engage in riskier and longer-term operations by providing guarantees, refinancing or on-lending mechanisms. They have the institutional experience and understanding of the risks involved in energy projects. They also have developed a set of risk mitigation instruments such as guarantees and insurances against expropriation and payment defaults.

Risk mitigation instruments can be an effective tool to lower perceived and real investment risks and, therefore, mobilize capital from private investors. A wide array of risk-mitigation instruments is available on the market today, made available by host governments; DFIs (national and multilateral), export credit agencies and insurance companies to address a host of risks (see Exhibit 63).

Governments can also assist in the mobilization of private capital by enacting regulatory instruments, fiscal incentives, and other policies and initiatives aimed at reducing risk and promoting market development (as discussed in section5.2; see Exhibit 57). Through public finance, governments can take steps to de-risk projects and mobilize private capital via blended finance. Blended finance transactions have averaged approximately USD 9 billion per year worldwide. Africa makes up the largest share of these, accounting for 60% of transactions in 2020, according to (IEA, 2022). However, the same report notes that it does not always attract much private capital and blended finance is most often used by DFIs and multilateral development banks to de-risk their own capital.

Often coupled with risk-mitigation instruments, blended finance encourages the sharing of risks and solutions can include: 1) co-financing of projects among multiple parties; 2) on-lending transactions (whereby a DFI on-lends its low-cost capital to local institutions), 3) the use of subordinated debt and convertible loans or grants provided by other public sources.

Blended finance has a great potential to attract private financiers to invest in energy access or renewable energy projects which on their own might have difficulty obtaining commercial financing without the backup participation of the public financier. Many projects that used to rely exclusively on grant financing, such as electricity access projects in remote villages, have begun to use models that rely on a mix of concessional and commercial financing.

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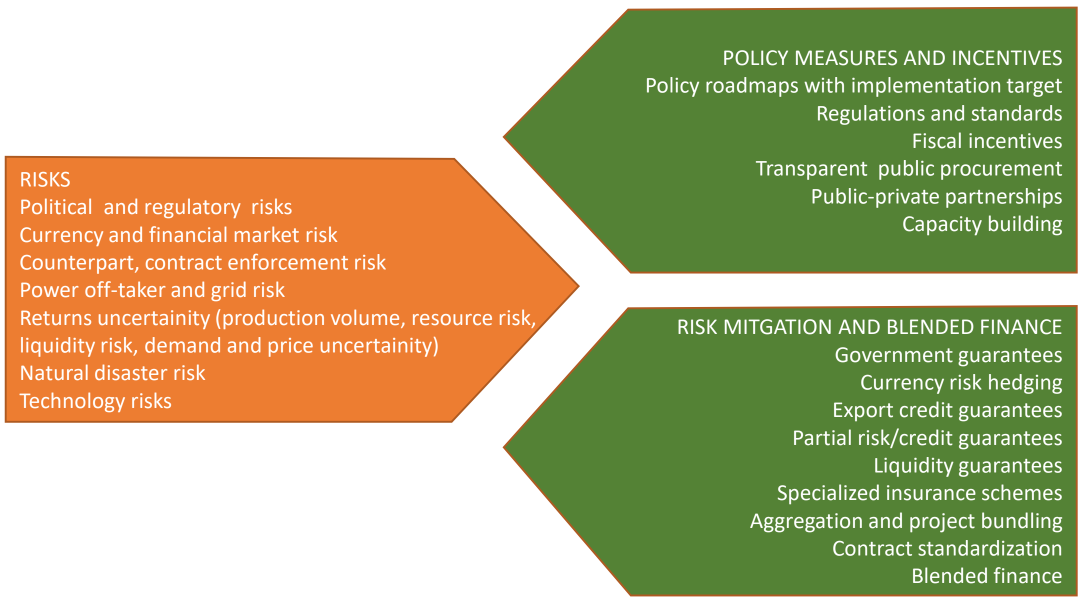
186 IRENA-AfDB (2022), GCF, BGFA websites

These models, which are forms of blended finance mechanisms, use limited concessional public capital to lower financing costs and attract private finance.

Innovative instruments, such as green bonds, sustainable bonds, and other sustainability-linked corporate financing products, are surging in financial markets and are increasingly accessible by investors. So far, these schemes have been used mainly to finance projects in wealthier nations but are starting to make inroads in the African markets. Green bonds[187] are a particularly effective tool for mobilizing capital from institutional investors who prefer to invest large amounts indirectly via bonds or funds rather than directly into specific projects. Total global issues reached USD 270 billion in 2020. From the first issuance in 2007, global cumulative issues topped USD 1 trillion in December 2020. 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[188].

Sub-Saharan Africa (except South Africa) has significantly higher needs for electricity infrastructure, both in generation and networks. Off-grid and mini-grid solutions can offer a relevant pathway that provides clean electricity at accessible costs to populations while attracting private investment. Solutions include solar, wind, and mini-hydro, in stand-alone renewables generation or combined with local distribution networks into mini-grids (see section 5.2.2). One estimate is that to achieve universal access in Sub-Saharan Africa, about USD 28-38 billion may be needed annually, in the coming decade for off-grid and mini-grid solutions[189]. According to Race to Zero, funding is to see a large projection from corporations (about 20%), commercial finance institutions (12%) and infrastructure funds (5%), with households (7%) and the public sector 54% (government and state financial, 12%; state-owned utilities 20%, supported by DFIs, 24%).

Exhibit 63 Key financing issues and mitigation measures



Compiled from IRENA-AfDB (2022) and Race to Zero (2021)

187 A bond is a type of security under which the issuer (debtor) owes the holder (creditor) a debt, and is obliged, depending on the terms, to repay the principal (i.e., amount borrowed) of the bond at the maturity date as well as interest) over a specified amount of time. Interest is usually payable at fixed intervals. Bonds and stocks are both securities, but the major difference between the two is that (capital) stockholders have an equity stake in a company (i.e. they are owners), whereas bondholders have a creditor stake in the company (i.e. they are lenders). Like normal bonds, green bonds can be issued by governments, multi-national banks or corporations. Climate bonds are a special case of green bonds, as the purpose is to raise finance for climate change mitigation or adaptation.

188 See Climate Bond Initiative website, www.climatenbonds.net

189 Depending on estimates given in IEA (2019, 2022) and Race to Zero (2021). See also section 3.4

Funding amounts are projected to see a large contribution from corporations. These may have to finance their investments through their balance sheets mainly, as long as collateral requirements will continue posing issues for (local) solar equipment companies and minigrid developers that are often small without substantial balance sheets. They are often not considered creditworthy by many commercial banks (that commercial banks are often not familiar with the riskier and longer lending periods of off-grid investments). Revenue and demand uncertainty from low and variable incomes reduces the attractiveness of lending to companies working in the minigrid and off-grid sectors.

Blended finance is likely to take an important role in managing risks and scaling up emerging decentralized power technologies, in particular mini-grids. This could involve guarantees to developers and off-grid solar providers or commercial lenders to manage repayment uncertainty. Many minigrids will need some grant support to keep tariffs affordable within the ability (or willingness) to pay range of rural low-income (and often irregular) income households in the order of 45-50%.

The high upfront investment, together with seemingly cheap fossil fuels and biomass, discourages households from investing in stand-alone solutions, such as solar home systems. Most common distribution models involve distribution through conventional dealer networks (distributor, retailer). The dealership model is often used for extending end-user financing (by providing credit to dealers and/or franchises to allow them to sell to clients on an instalment basis. Another model is 'one-stop-shop' in which companies provide products move through a proprietary distribution channel, in which finance can be offered by the company manufacturer. Other models include institutional partnership (in which a company teams up with an NGO or rural bank to market its products to its customer base/members).

5.5 Just transition: the role of international cooperation

The global energy transition is being led by developed economies. Through this acceleration towards net zero, an increasingly widening 'fault line' threatens to develop between developed and developing countries. Developed and developing economies do not have equal ability to finance and resource a journey to decarbonize and achieve net-zero goals. Developed economies are more fiscally robust, with greater access to financial backing to support their economies through these disruptions.

Many African countries are already taking important steps to put in place the energy transition actions described above. Many countries on the continent are making or enabling large investments in solar PV and wind generation. An increasing number of African countries are also improving their enabling frameworks and attracting increased private sector participation. A small number of countries are even venturing into hydrogen.

The reality is that many nations in Africa are fiscally constrained, with less defined regulatory frameworks in support of the energy transition, debt-stricken utilities, large government debt burdens and struggling economies. There has been increasing support from international support by a large number of bilateral, regional and multilateral initiatives and programs (see Exhibit 64). While this multipronged approach allows testing and has supported many initiatives, it also has the danger of creating inefficiencies. Different initiatives often have the same end objective, leading to duplicating each other's efforts, while leaving gaps in other areas.

Current efforts should be streamlined and more resources (e.g., financial support and capacity building) should be made available to realize the energy transition in Africa. Programs should be driven by the countries' demand and each country's particular situation rather than a 'one-size-fits-all' approach. Reducing fragmentation, increasing coherence and leveraging synergies between existing initiatives to support national policies and strategies will maximize the impact of existing allocations and help mobilize more resources for the energy transition.

There is a need for a more coordinated, global just transition, to ensure that African countries are not left behind. A successful energy transition will be different for every African country, but will generally involve achieving universal access to affordable, reliable, sustainable and modern energy across the continent by 2030 and fully harnessing the potential of renewable energy by 2050. These are highly ambitious yet achievable goals, One key to success will be mobilizing sufficient investment within the established timeframe. Current investment levels are insufficient for Africa to keep pace with the global net-zero journey and required emissions reductions, let alone to achieve the 2030 universal access goals. The African Union's Agenda 2063 sets out the goals of mitigating climate change, broadening the policy space for sustainable development, eradicating poverty within a generation and building shared prosperity through social and economic transformation. The comprehensive energy transition in Africa will require a broad, more joint initiative by Africa's development partners in line with each country's needs.

In the 1930s, U.S. President Franklin D. Roosevelt's New Deal entailed fiscal, monetary and banking reforms, public works and other programs, and new regulatory measures in response to the devastating global financial crisis known as the Great Depression. This has inspired the European Union's members to respond to the crises formed by the 2007-2008 Great Recession, the 2020-2021 COVID-19 pandemic and the longer-term threat posed by global

Exhibit 64 Selected global, Africa-wide and regional electricity-sector institutions and initiatives supported by development partners

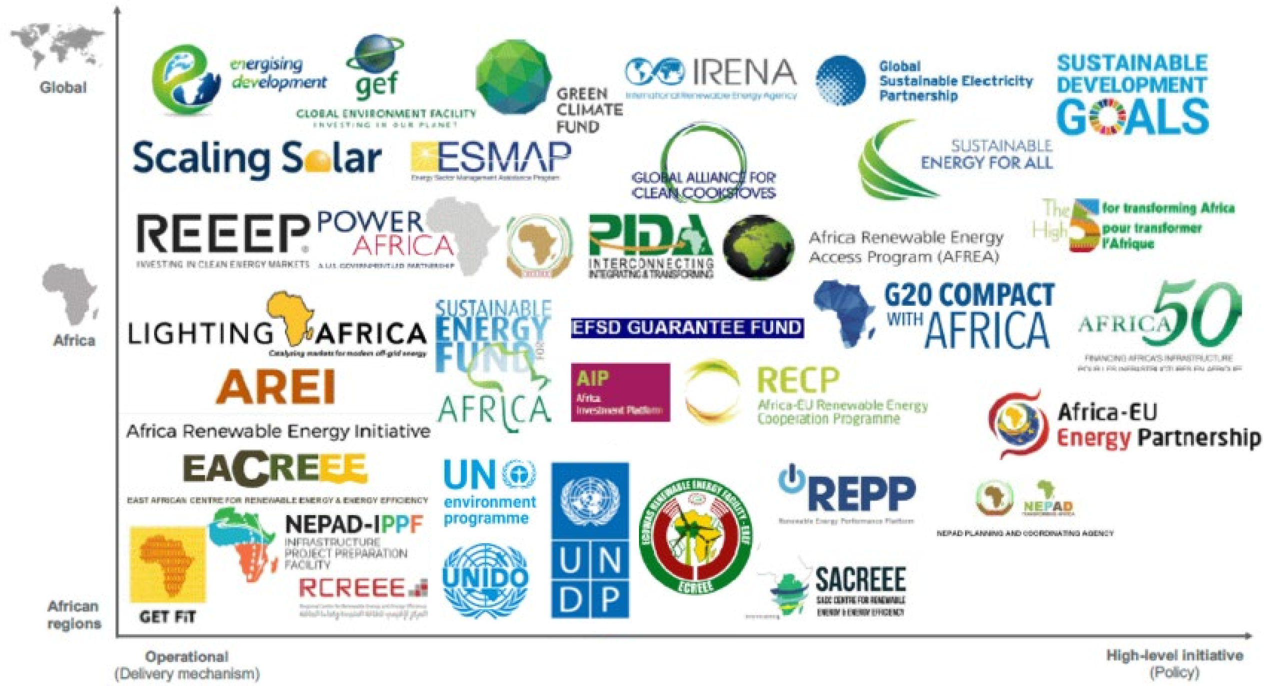


Figure adapted from GIZ (2020)

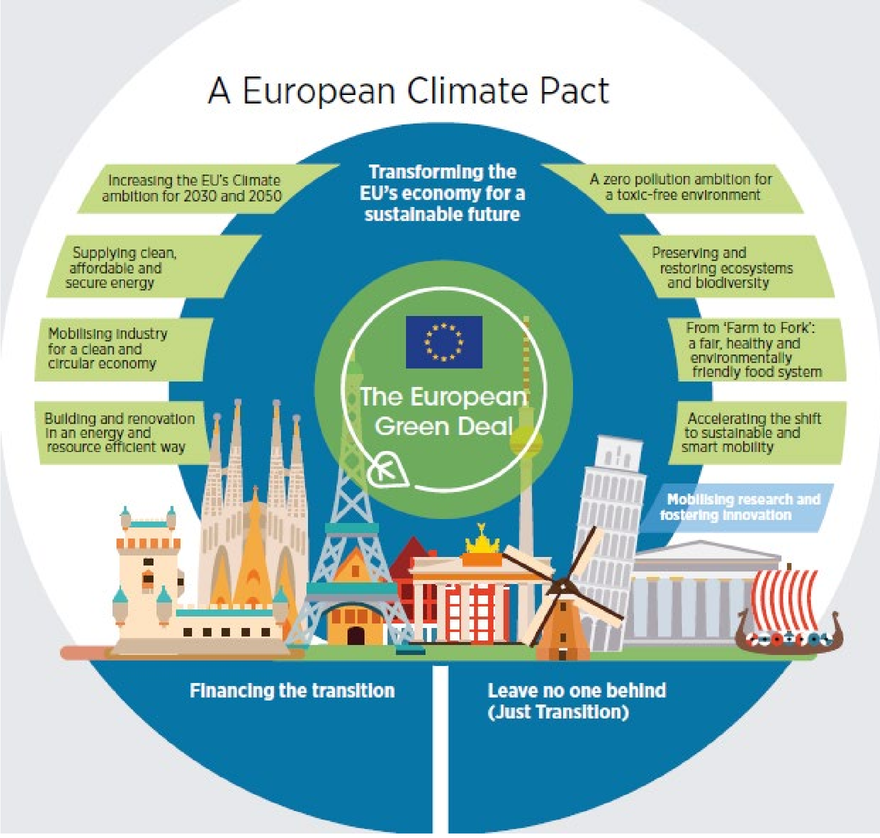
warming and climate change impacts to agree on a European Green Deal (see Exhibit 65). The European Green Deal aims to collectively decrease emissions by 55% from 1990 levels by 2030, and become a net-zero (climate-neutral) economic zone by 2050. While, Europe is financing its own Green Deal, Africa will need external support. Again, an event in history can be referred to; the Marshal Plan helped Europe in the postwar transition by making over USD 13 billion available (about USD 115 billion in today's money).

An African Green Deal Plan should be specifically around the continent's own needs and circumstances but could build on similar concepts and ideas:

- Recognizing the need for action and call for mobilization of resources on a scale corresponding to the global scale of climate change;

Exhibit 65 European Green Deal

The European Green Deal, approved 2020, is a set of policy initiatives by the European Commission with the overarching aim of making the European Union (EU) “climate neutral” in 2050. One goal is to decarbonise their energy system by aiming to achieve “net-zero greenhouse gas emissions by 2050, alongside circular economy, sustainable buildings, zero pollution, sustainable agriculture, biodiversity and sustainable and smart mobility objectives (as indicated in the figure below). In July 2021, the Commission presented the "Fit for 55" package, which entailed a series of legislative proposals to achieve the EU Green Deal. Where possible existing legislation is made more ambitious and where needed new proposals are put on the table, across a range policy areas and economic sectors: climate, energy and fuels, transport, buildings, land use and forestry.



To support this, the EC has made available a massive total budget of approximately. Over half of the budget, €528 billion, will come directly from the EU budget and the EU Emissions Trading System. The remainder will be sourced through the InvestEU programme, which combines €279 billion from the public and private sectors to 2030 and €114 billion from national co-financing.

The Just Transition Mechanism (JTM) is a key tool to ensure that the transition towards a climate neutral economy happens in a fair way, leaving no one behind. The Mechanism provides targeted support to help mobilise at least EUR 100 billion over the period 2021-2027 in the most affected regions, to alleviate the socio-economic impact of the transition. The JTM will is expected to generate about EUR 100 billion of funding, consisting of three main sources of financing, a EUR 17.5

Sources: EC (202010; https://www.nortonrosefulbright.com/de-de/wissen/publications/c50c4cd9/the-eu-green-deal-explained; Figure taken from GIZ (2020)-European Union (2019)

- Explicitly endorse or imply the need for stronger public policy tools within comprehensive longer-term policy frameworks, implemented by financially sound, strong, institutions,
- Encourage and support market-driven approaches to promote a just energy transition (including innovative business models in off-grid electrification and transparent procurement methods for renewable energy in power production; and blended finance and other de-risking investments);
- Regional coordination on energy planning and integration of energy networks;
- Promotion of economic diversification and value chain development;
- Emphasize the opportunities to simultaneously resolve other pressing societal problems (in public health, biodiversity protection, environmental resilience, and social justice);
- A just transition for workers and regions affected by the needed economic restructuring as an essential component and an equitable distribution of the net benefits of the energy transition
- Financing and least-cost planning of universal access to affordable, reliable, sustainable and modern energy.

An African Green Deal Plan should be designed specifically around the continent's own needs and circumstances and could provide the institutional and programmatic framework needed to mobilize resources and policy action at the appropriate scale. The Plan would combine the objectives of achieving climate goals, fostering economic development and job creation, and guaranteeing social equity, environmental safeguard and welfare for society as a whole. It would 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.

Development finance institutions (DFIs) can help by acting as a catalyst, for example by providing guarantees, refinancing or on-lending. DFIs can strengthen the role of local banks and help enterprises access cheaper and longer-term finance. Their involvement in blending commercial lending with grants, technical assistance, concessional loans, and guarantees is vital to the deployment of new energy technologies, for ramping up implementation of high-quality clean-energy projects and energy-efficiency programs, and for expanding energy access in rural areas and high-risk countries. DFIs are also well-positioned to initiate and support inclusive cross-sectoral dialogues at the local, national, and international levels and to provide technical assistance to build country-level capacity and develop transition plans. Donor governments and multilateral institutions need to mobilize resources, provide technical assistance, engage in knowledge- and capacity-building, share best implementation practices, and make direct financial investments, not in isolated small interventions but as part of the overall Green Deal Plan.

Exhibit 66 Climate, energy and sustainable energy: UNDP's approach

UNDP's Nature, Climate and Energy practice supports Governments to focus on enabling an inclusive, resilient, green recovery by: building competency to accelerate access to sustainable energy and climate and nature-positive policies and finance; scaling capacity to ensure No One is Left Behind; catalyzing SDG and Paris-aligned investments (public and private); delivering client focused solutions that respond to countries' immediate, mid and long-term recovery and socio-economic development priorities, and; leveraging our on-the-ground presence and networks to unlock bottom-up solutions that deliver lasting impacts at country level..

UNDP's Climate Promise, which is supporting over 120 countries to enhance and implement their NDCs, acts as an integrator to connect the dots between UNDP's vast portfolio of work on climate action, social inclusion and gender equality, and sustainable development. UNDP works with countries to revise their NDCs and support NDC implementation through it extensive technical and financial assistances and its support on mitigation and adaptation actions around the world.

UNDP's Sustainable Energy Hub is supporting countries in their energy transition to ensure that decarbonization pathways are inclusive and aligned with development priorities. The energy transition is critical to achieving NDP is supporting over 100 countries with their energy transition. The UNDP Global Environmental Finance Unit focuses on securing climate and environmental financial resources from global trust funds to catalyze and unlock other types of public and private financing for sustainable development.

Sources: UNDP website and *Issue Brief: Just Transition* (UNDP, 2022)

ANNEX A. LIST OF DOCUMENTS

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