Clean Energy Transitions in the Sahel

International Energy Agency

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About this report

Africa's energy future matters to the world. That is why the International Energy Agency (IEA) is substantially expanding its engagement in African countries and with African regional partners. Since 2019, the IEA has initiated a programme of work in the form of enhanced institutional engagement, as well as an increase in technical activities in support of the energy strategies and objectives of African countries.

The IEA aims to support African countries with their transformative energy sector priorities and the implementation of clean energy transitions in the region by sharing expertise to enhance data, inform decision-making and guide policy implementation. This engagement takes place in coordination with local, regional and other international entities. The aim is to support a sustainable and an accelerated regional energy system transformation using a varied mix of technologies, in order to help achieve the UN's Sustainable Development Goal 7 (SDG 7), promote increased energy security and affordability, and accelerate the development of clean energy systems across Africa. As the Covid-19 crisis continues to affect economies and energy systems across the world, the IEA aims to support African countries in their efforts to stimulate economic recovery from the crisis in which the energy sector transformation plays a catalytic role.

Building on this framework, this report identifies pathways and makes recommendations to accelerate clean energy transitions in six Sahelian countries (Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal). Its aim is to take stock of current energy trends in the Sahel and illustrate policy-relevant best practices that can help speedily advance energy access, energy sector development and the transition of the region's energy systems towards the use of ever-cleaner sources. The report highlights key policy recommendations and opportunities to help policy makers build future energy systems based on clean, affordable and efficient energy sources and practices.

The IEA will present this report's findings during a virtual regional event on 30 September 2021. The event will convene regional policy makers and stakeholders for an exchange on pathways, best practices, success stories, lessons learned and recommendations to accelerate clean energy transitions in the Sahel. The event seeks to foster enhanced political will for ambitious clean energy transitions and to promote robust interregional stakeholder dialogues that will inform and guide national policy makers in their quest to implement high-impact policies in their respective countries.

This report is part of a wider IEA initiative that seeks to foster efforts towards advancing clean energy transitions in Africa by enhancing regional energy sector collaboration. The initiative covers three regions – North Africa, the Horn and the Sahel – with reports taking stock of energy sector conditions and proposing pathways for accelerated transformation, and with technical workshops.

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Executive summary

Advancing energy development in the Sahel is essential for building a prosperous future. The six Sahelian countries considered in this report *(Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal)* all face energy-related obstacles that challenge their objectives for regional stability and socio-economic development. These include very low electrification rates and high vulnerability to the impacts of climate change. This report sheds light on one of the least studied energy regions on the planet, bringing key energy data and analysis on possible energy futures for the region, which will be dictated by domestic energy policy decisions and national and international flows of capital. Our analysis is based on two scenarios:

- The **Stated Policies Scenario (STEPS)** reflects today's policy frameworks and plans, and their impact on energy development. It does not take government goals and pledges at face value, but rather assesses whether today's policies are on track to achieve these goals. It takes a granular, sector-by-sector look at existing policies and measures and estimates how energy systems could evolve to 2030 under the influence of today's concrete policies.
- **Africa Case 2021 Scenario (AC)** looks at what it would take to realise Africa's vision for more rapid economic development and the full achievement of universal access to electricity and clean cooking by 2030. Given the increasing global emphasis on and cost-effectiveness of low-carbon energy solutions, this scenario relies on achieving this additional economic growth while also managing CO_2 emissions growth so as to keep in line with STEPS levels.

Rapid growth and development require greater energy supply. In 2019, the Sahel was home to 100 million people, a population that had doubled in the previous two decades and now represents 9% of sub-Saharan Africa's population (excluding South Africa). Population growth in the Sahel has been faster than in other parts of the continent, with a fertility rate of 5.4 births per woman compared to a global average of 2.4. The region is mostly rural – over 60% of employment is in agriculture – with less than one-third of the population living in cities. However, urbanisation is accelerating, especially in the capitals where 30% to 55% of the national urban population is concentrated. The region generates 6% of sub-Saharan Africa's gross domestic product (GDP), but its economy has grown at a high pace with an average annual rate of 4.7% between 2010 and 2019, almost three times the South African rate of growth. Over the last two decades, primary energy demand in the six Sahelian countries has grown by more than 4%, and stands at 950 PJ – equivalent to the American State of Nebraska but with a population 50 times bigger. Energy consumption per capita in the region is still under 0.2 toe/capita, ten times below the world average and half of the average in sub-Saharan Africa.

A resource-rich but energy-poor region. Energy infrastructure is an essential building block for economic development and quality of life, but Africa and the Sahel notably lag behind other developing regions in most aspects of infrastructure quality. The level of power generation capacity in the Sahelian countries is 35 W per capita, which is only a third of the sub-Saharan Africa average and 4% of the global average. This is felt by the poorest in the region: two-thirds of the Sahel population does not have access to electricity and the disparities within the region are great. In Senegal, access levels reach up to 70% while in Chad only 8% of the population has access to electricity. Traditional use of biomass represents 60% of energy consumption, by far the most widely used energy source in the Sahel, with the exception of Senegal and Mauritania, where oil dominates. Still, the share of traditional biomass in the energy mix has decreased from 70% to 60% over the last decade. Fossil fuels represent the remaining 40% of the overall energy mix.

Electricity generation in the Sahel stood at 13 500 GWh in 2019. The power sector is dominated by oil-based power plants – accounting for 75% of total generation, and leading to high electricity prices. Renewables account for 20% of electricity generation. Hydropower remains the principal source of renewable power, accounting for 12% of the region's electricity and almost 40% in Mali. Solar PV and wind, almost absent from the power systems of the region a few years ago, now together contribute up to 5% of the electricity generated, and up to 15% in Mauritania. Generation from solar PV saw a doubling every year since 2015, following a number of solar plants coming online all across the region. But coal-fired power generation has also seen a sharp rise, quintupling from its 2010 levels and reaching almost 1 TWh in 2019 (or 7%).

Looking ahead, good energy policy and increased financial flows could boost economic growth and improve livelihoods. By 2030, the Sahelian population will grow to 140 million, 40% of which will be in urban areas. The economy is projected to be 90% larger than today. However, under current policies and development patterns, this leaves 80 million people without access to electricity and 120 million without clean cooking. This is how it is envisioned in the STEPS, where energy demand climbs 45% higher than today, with one-half of demand being met by fossil fuels and the other half by traditional biomass. However, in the Africa Case, a focus on the construction of critical infrastructure enables greater economic growth. By 2030, the Sahel's GDP grows 110% over today's level and the entire population is expected to have access to electricity and clean cooking. This brings socio-economic benefits and improves livelihoods, including for refugees and internally displaced people, a vulnerable group of the population, which grew from 1 to 3 million people in the last 3 years. Fuelling this economy will take 1200 PJ – 25% above today's levels – with almost 11% coming from modern renewable energy, compared to just 4% in the STEPS.

Energy access is fundamental for development, stability, improved health and environmental stability outcomes in the region, especially in rural areas. To reach universal electricity access by 2030, as in the Africa Case, the Sahel must connect 8.5 million people annually over the decade. We use geospatial analysis to identify whether grid connections or remote off-grid solutions are most effective in reaching Sahelian communities deprived of electricity. Grid extensions can reach almost half of households without access, especially in the more densely populated states of Senegal and Mauritania. Mini-grids can help connect one-third of the population cost-effectively and quickly, and stand-alone power systems are the best option for one in five people gaining access. To achieve universal clean cooking, more than 2 million modern cookstoves must be deployed every year. In remote communities, improved cookstoves that use biomass remain prominent, whereas in more densely populated areas, people gain access via LPG and electricity. Government action is needed to support the construction of the necessary infrastructure, develop programmes to roll out these technologies and ensure reliable, affordable fuel supply to those gaining access. Consistent support is particularly important in regions still experiencing conflict and uncertainty, where disruptions to fuel delivery can be detrimental to lasting developmental changes in the region.

The Sahelian countries are particularly vulnerable to climate change, and their energy investments must consider these risks. The Sahel is among the continent's most vulnerable regions to the impacts of climate change, despite contributing only 25 Mt of CO_2 emissions today or as much the Paris metro area. Climate change poses substantial drought and agricultural risks to the region. Food, water and energy security are strongly interrelated, with important implications for each sector and for the overall development plans of all the governments. Applying an integrated multi-sectoral approach to clean energy transitions in the Sahel would improve resource efficiency, productivity and security across all sectors. Ideally, this approach should factor in how to make these investments climate-resilient and regionally integrated.

The Sahel can achieve, with modest growth in emissions, universal electricity access and a doubling of the size of the economy by 2030. Both the Africa Case and the STEPS have emissions growing from 25 Mt in 2019 to around 50 Mt in 2030. However, this means that the Africa Case emphasises cost-effective energy efficiency and renewables in order to achieve universal access without translating into much higher CO_2 emissions. An increasing number of low-carbon access solutions, such as solar home systems and modern biomass cookstoves, receive increased support, although traditional grid connections and LPG cookstoves remain dominant. Governments also implement efficiency standards for imported cars and appliances and expand utility plans for solar and gas in the power sector. The resulting emissions growth still leaves the region's emissions per capita among the lowest in the world – the Sahel's 2030 emissions would represent only 0.15% of today's global emissions.

In the Africa Case, the demand for electricity outpaces every other type of energy and necessitates a major expansion of the power system. Over the past decades, electricity consumption in the Sahel has doubled every ten years. In the STEPS, the region's demand for electricity grows almost threefold by 2030. In the Africa Case, it grows over fivefold to above 65 TWh. The demand for electricity surges to meet 140 million connected users, and each household demands an increasing amount of electricity for fundamental services as incomes rise and commerce expands. In 2030, electricity meets a quarter of the total final consumption requirements in the Africa Case. Meeting this demand requires investments in new generation capacity; in the Africa Case this averages USD 3 billion per year, more than two times above the level in the STEPS. This is small compared to the power sector investment globally – comparable to the cost of building three coal plants.

The electricity mix moves rapidly away from oil towards gas and solar. This improves affordability, reliability and environmental performance. Today, heavy fuel oil dominates the electricity mix of the region, with renewables – largely hydro – accounting for only a fifth of the electricity mix. In the STEPS, solar and natural gas rapidly displace expensive fuel oil generation, while hydropower and wind also expand, bringing the renewable share to 45% by 2030. The Africa Case sees over half of the electricity generated by renewables sources in 2030, twice the levels of capacity when compared to the STEPS. Additional solar and natural gas capacity make up the vast majority of additions in the Africa Case over the STEPS. The high levels of renewables cut the CO_2 intensity of the grid by a third – the largest driver of decarbonisation over the next 10 years in the Africa Case.

Developing a robust, reliable electricity system is indispensable to realising electrification goals and helping develop and decarbonise the Sahel. Reliability levels in the Sahel are among the lowest globally. This hinders development, as businesses struggle to operate efficiently, health providers remain constrained in where they can safely treat patients, and citizens remain reluctant to become over reliant on electrical appliances, such as refrigerators and electric cookers. The lack of reliability also encourages the use of back-up diesel generators by those who can afford them, exacerbating air quality and inequity. Both scenarios see increased transmission and distribution investment with improved regional integration through power pools, and an expansion of domestic generation fleets to ensure power shortages elsewhere do not jeopardise the Sahelian countries' energy security. Decentralised microgrids play a significant role, and provide near-term, cost-effective access solutions in remote, rural areas. They enable higher shares of renewable generation and deeper electrification, providing the foundation for the adoption of electric mobility and all-electric buildings in the future.

Regional oil and gas demand expands, but fuel security risks are minimised through improved fuel infrastructure, efficiency and diversification. Regional oil demand grows by around 50% in both scenarios and gas demand grows from almost nothing today to 20% of the fuel mix in 2030 in the Africa Case. Improving transport efficiency and diversification of the energy sources helps keep more oil supply flowing to export markets, but requires substantial investment in regional fuel delivery infrastructure. Reliable fuel delivery enables switching to natural gas in the power sector, clean cooking with LPG, and greater car ownership in the Africa Case. Improved, diversified infrastructure, including remote microgrids, helps improve stability and minimise the ways in which conflict and climate can disrupt critical energy services.

Tapping into the Sahel's rich natural resources can diversify the economy and energy mix, at a time when other regions are emphasising decarbonisation. Currently, oil and gas are an important source of export revenue for Chad and Niger, while large offshore discoveries in Senegal and Mauritania could make them significant exporters. However, decarbonisation targets in other parts of the world are weakening the investment case for new oil and gas, and present the risk of declining demand and revenue for current producers. The countries of the Sahel also hold reserves of metals and minerals that are critical to clean energy technologies, such as copper, zinc, titanium and manganese. To date, Burkina Faso, Senegal, Mauritania, and Mali have begun to tap into these. If managed sustainably, and with new transportation and energy infrastructure supporting their development, these mineral resources could present significant opportunities for revenue and economic development.

Financing the Sahel's energy transition requires new approaches to finance and international collaboration. The inflow of investment for vital infrastructure across the Sahel today is well below what is needed. All of the countries in the region registered declines in economic growth in 2020, with Mali, Mauritania and Chad entering into recession. The global economic contraction had major impacts on the extractive industries across Africa, and it worsened the financial situation for governments and utilities, which had been providing relief to citizens and businesses. This could jeopardise their ability to finance critical infrastructure projects in the coming years. Scaling up energy investment cannot be achieved without strong political commitment and durable partnership strategies. International public finance institutions, donors and multilateral development banks must all play a role. So must local governments, who can improve regulatory systems and stability in the region in order to unlock international support and ensure that concessional financing is able to leverage the most from private investment.

The region's energy future is not predetermined. The Sahelian countries can decide the direction of their energy transition trajectories, and how best to align these with other developmental, environmental and climate-resiliency goals. The Africa Case lays out a plan for how the region can get there. But all pathways require enhanced regional and international collaboration to attract the energy transition financing that is needed to grow inclusive economies, improve livelihoods and achieve universal access to clean, affordable energy.

Introduction

This report aims to support the Sahelian countries' clean energy transitions and foster enhanced regional collaboration to accelerate transition pathways. The report examines six Sahelian countries, including Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal – hereafter referred as the "Sahel". The goal is to provide data and robust, evidence-based analysis to guide each country's energy decision makers in determining their energy transition pathways.

As overall objectives, the report seeks to take stock of the region's and country-specific energy sector landscapes, identify energy sector trends and propose pathways for future energy systems in the region based on two scenarios. It does so by highlighting best practices, providing policy recommendations and proposing pathways for the region towards clean energy transitions. The report therefore adopts an integrated perspective, considering opportunities and trade-offs within the context of the region's economic sectors, natural endowments and climate change.

This report outlines the current state of energy in the Sahel and suggests near-term actions that Sahelian countries can take to achieve its ambitious development and energy access goals. These actions would also keep the emission levels in 2030 similar to the levels the region would have reached under today's pace of development and energy policies. This pathway requires no revolution, but rather relies on low-cost, readily available technology and policy solutions, but it does necessitate a consistent strategy, supported by regional and international collaboration. In the IEA's recent *Net Zero by 2050: A Roadmap for the Global Energy Sector*, the Agency lays out a far more ambitious pathway at the global level where universal access is still achieved globally by 2030 via lower-emissions solutions. The IEA remains eager to work with African countries to design a roadmap for the region to help it reach a target consistent with this goal, and which would limit the worst of the effects of global warming.

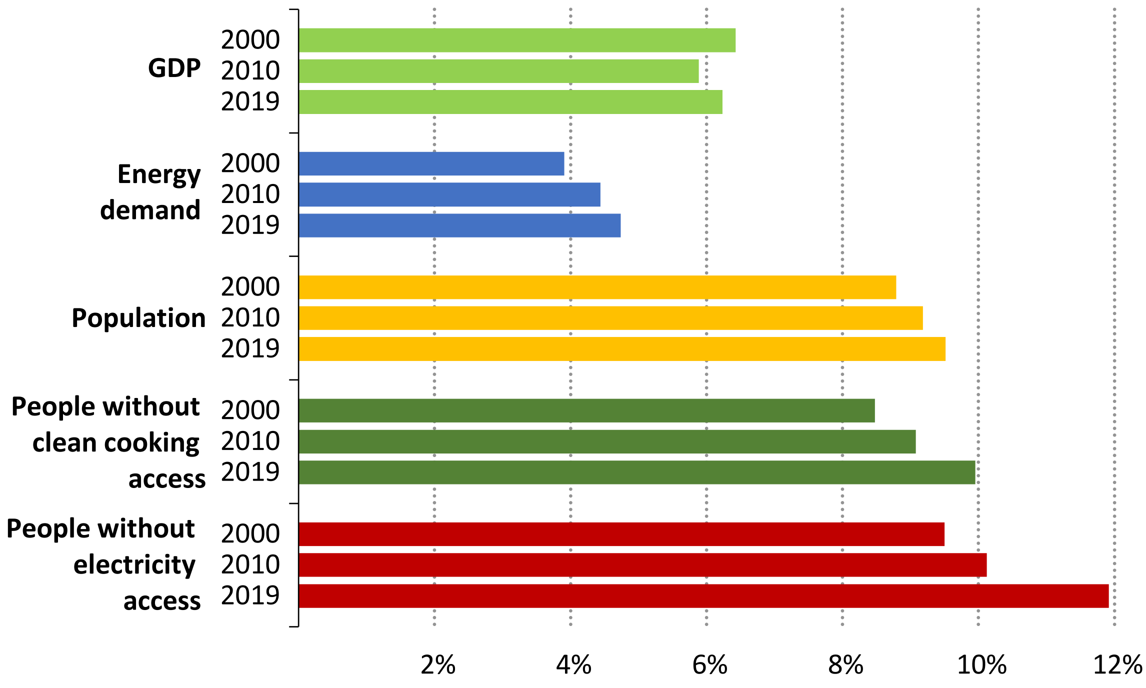
Context

Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal represent the West and Central part of the broader Sahelian region that comprises the mainly flat plains stretching between the Sahara desert in the north and the savannahs in the south, from the Atlantic Ocean to the Horn of Africa.

This French-speaking group includes six countries that belong to distinct regional organisations: four of them are part of ECOWAS, Chad is in the Central African grouping of the African Union, Mauritania belongs to the North Africa power pool COMELEC, and all countries except Senegal are part of the G5 Sahel institutional framework.

The Sahelian countries account for around 6% of sub-Saharan Africa (excluding South Africa) gross domestic product (GDP) and energy demand, and are home to more than 10% of the population lacking access to energy in sub-Saharan Africa (Figure I.1). The region's population growth rate is one of the highest in the world. Today, more than 65 million people in the region live without access to electricity and 90 million still rely on the traditional use of biomass for cooking.

Figure I.1 The Sahel's share of selected indicators of sub-Saharan Africa (excluding South Africa)



Source: IEA analyses (2021).

Structure

To provide a starting point for future analysis, **Chapter 1** presents a situational overview of the current energy sector in the six Sahelian focus countries. **Chapter 2** reflects further on the current status of SDG 7 and its subgoals in the Sahelian countries, detailing access to electricity and clean cooking, including for vulnerable displaced communities (SDG 7.1); renewable energy (SDG 7.2) and energy efficiency (SDG 7.3). This chapter also provides an outlook to 2030 under two scenarios, the Stated Policies Scenario (STEPS) and the Africa Case 2021 Scenario, shaping potential future evolutions of the energy systems of the region for the coming decade, and exploring their implications. **Chapter 3** looks at specific considerations relating to the role of the oil and gas sector in economic development in light of new and evolving developments in the Sahel. **Chapter 4** focuses on the challenges of integrating the water-food-energy nexus within the Sahelian energy sector and **Chapter 5** looks at the investment needs for future clean energy transitions in these countries in light of the simultaneous need for post-Covid-19 economic recovery.

The report also touches upon human development issues, such as energy and gender and energy and displaced communities, which reflect the relationship between energy and insecurity. It also looks at the climate resilience of energy infrastructure. Each chapter provides policy considerations based on lessons learned from other countries to inform decision makers' options for clean energy transition pathways.

Historical data

This first-time analysis reveals the latest available picture of these countries' energy systems. The energy data featured in this report results from an unprecedented effort to collect, review and validate the statistics of the focus countries' entire energy balances. The work was conducted through collaboration between governments and IEA Energy Data Centre teams, and benefitted from complementary sources and experts. The outcome is updated and detailed energy balances at both the country and regional level, in the form of figures, data and country profiles in the Annex.

This analysis covers energy data gaps in the region and in the focus countries, where statistics tend to be scarce, and provides data-based insights that can inform policymaking on clean energy transitions. Specific data was collected for the report across all energy sectors, supply and demand for each of the six Sahelian countries (see Annex C: Data References). In undertaking this major effort, the IEA seeks to deepen relationships and enhance continuous collaboration with the focus countries in order to develop energy data exchanges.

Understanding the scenarios

This report provides a framework for analysing the outlook for the Sahel's energy sector, particularly sub-Saharan Africa. It sets out what the future could look like based on two scenarios or pathways, with the aim of providing insights to inform decision-making by governments, companies and others concerned with energy:

The **Stated Policies Scenario (STEPS)** provides a measured assessment of where today's policy frameworks and announced national policies, together with the continued evolution of known technologies, might take the energy sector in the Sahel in the coming decades. Given that announced policies are by definition not yet fully reflected in legislation or regulation, the prospects for and timing of their full realisation are based upon our assessment of the relevant political, regulatory, market, infrastructural and financial constraints. This scenario does not focus on achieving any particular outcome: it simply looks forward on the basis of announced policies in various sectors.

The **Africa Case 2021 scenario (AC)**, which is built on the premise of Agenda 2063,[1] looks at what it takes to realise the African Union's vision for more rapid economic development and the full achievement of universal access to electricity and clean cooking by 2030, in particular for the Sahelian countries. Given the development and cost-effectiveness of low-carbon energy solutions over the next decade, this scenario relies on achieving this additional economic growth at minimal additional cost and in a decarbonised manner. CO_2 emissions growth is kept in line with STEPS levels, largely by accelerating the decarbonisation of the power sector and by enhanced electrification in end-use sectors. The current developments in international clean energy markets suggest that this low-carbon pathway is more readily attainable than that under the conditions previously detailed in the Africa Energy Outlook 2019, which strove to achieve faster economic expansion and access to energy by the end of the current decade (Table I.1, Table I.2).

Table I.1 Real gross domestic product growth assumptions by scenario (compound average annual growth rate)

Country / region	2000-2019	2019-2030	
		STEPS	Africa Case
Burkina Faso	5.8%	5.7%	6.6%
Chad	6.1%	5.8%	6.9%
Mali	5.1%	6.3%	7.3%
Mauritania	3.8%	3.6%	4.9%
Niger	5.4%	6.6%	8.0%
Senegal	4.6%	6.1%	7.2%
SAHEL	**5.1%**	**5.8%**	**7.0%**

Note: Gross domestic product in PPP terms, USD 2019 billion.

[1] Agenda 2063 was adopted in 2015 by the Heads of State and Governments of the African Union. It is the continent's strategic framework that aims to deliver inclusive and sustainable development.

Table I.2 Population assumptions

Country / region	Total population (millions)			2019-2030	
	2000	2019	2030	Delta (million)	CAAGR
Burkina Faso	12	20	27	7	2.8%
Chad	8	16	22	6	2.8%
Mali	11	20	27	7	2.9%
Mauritania	3	5	6	1	2.5%
Niger	11	23	35	12	3.7%
Senegal	10	16	22	5	2.6%
SAHEL	**55**	**100**	**138**	**38**	**3.0%**

Note: CAAGR is compound average annual growth rate.

Chapter 1: Regional overview of energy in the Sahel

1.1 Regional context

A significant exposure to climate change impacts

Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal together account for a vast area covering five million square kilometres, with deep geographical differences. The climate in the region is semi-arid to tropical, with average temperatures over 20°C in January and frequently exceeding 40°C during the summer. Economic activity and population densities tend to be highest in the coastal areas of Senegal and Mauritania, and in major river basins, such as the Senegal and the Niger.

Geographical disparity drives large differences in population distributions – Mauritania, Mali, Niger and Chad, which encompass large desertic areas, have population densities below 20 inhabitants per square kilometre. By contrast, Senegal and Burkina Faso have relatively smaller territories, with densities around four times higher.

A common challenge across the region is the increasing vulnerability to climate change, despite the fact that the Sahelian countries represent a minor share of global greenhouse gas emissions. The impact of climate change is already being felt sharply, and will be a future threat to the Sahelian communities' future socio-economic development and political stability in the coming decades.

Although there are still uncertainties in climate projections which have been transposed from global to regional scales, changes in rainfall patterns, seasonal variability and higher summer temperatures are expected to affect the water, energy and food systems of populations which survive largely on agriculture and animal husbandry. Temperatures are projected to continue to rise faster than the global mean temperature increase. Although changes in total precipitation may vary depending on the locations and exhibit uncertainties, the Intergovernmental Panel on Climate Change (IPCC) notes that 80% of models project that the Western Sahel will experience longer dry periods over the next half century (IPCC, 2018). Periods of extreme rainfall are set to increase. In deforested areas, this will accelerate soil erosion and the risk of landslides and flooding, as has already been witnessed in Northern Nigeria and along the Niger and Senegal River banks. Built-up areas with poor drainage will also be subject to increased flooding, as was witnessed in 2020 in Ouagadougou, Niamey and Dakar. In many countries, unplanned urban expansion, lack of land-use policies and regulations, lack of flood data, poor drainage, defective dams, deforestation and land reclamation along coastal areas, have led to the damaging flood events across West Africa and the Sahel (Okoye, 2020).

Some countries are more vulnerable to the projected impacts of climate change than others due to their low level of resilience, policy preparedness and socio-economic status. Incorporating an intersectoral policymaking approach within the clean energy transition pathways is key (Chapter 4).

Climate change is also expected to have an increasing influence on human security and has been found to interact negatively with conflict dynamics in the Sahel. Competition over resources has been a recurrent driver of conflict in the wider region. Climate change is adding additional pressures: For example, in the Lake Chad Basin which Niger and Chad share with Nigeria, high levels of rainfall and wide temperature variability have been found to undermine shelter, livelihoods, health and food security, contributing to grievances that led to the spread of armed groups (Vivekananda et al., 2019). These developments point towards the need to take into account climate change impacts in future energy planning across the region.

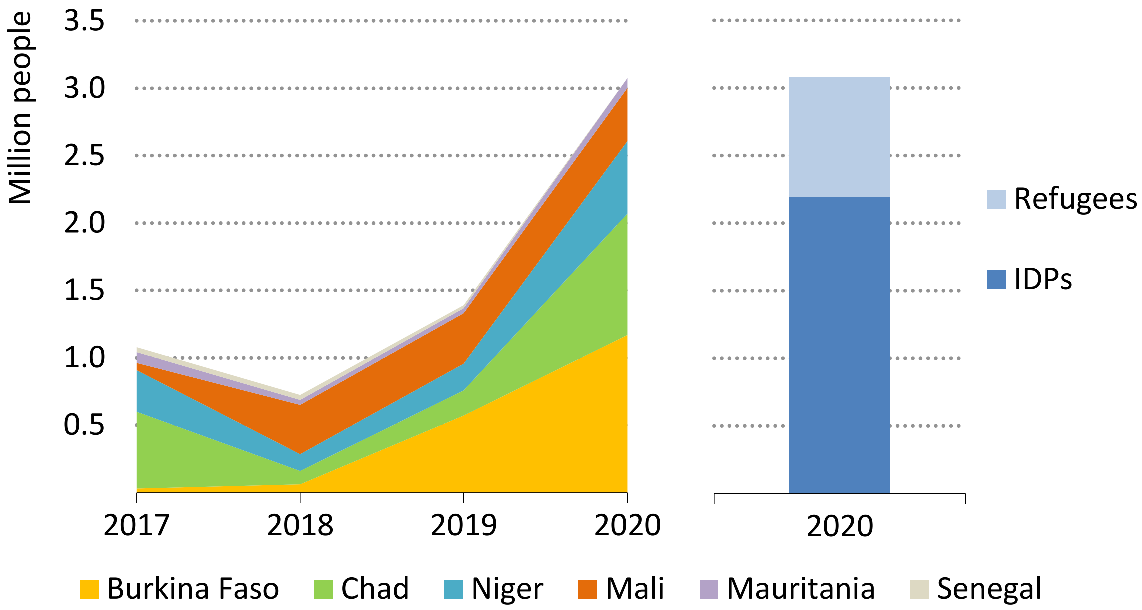
A tense political context, driving security and humanitarian crises

The Sahel has experienced considerable political instability and violent conflict over the last decade with several countries engaged in trying to quell ongoing conflicts in various regions of their territory, including spill-over from neighbouring areas. The intersection of human security and energy challenges is evident here as these conflicts have led to large-scale human displacement: over 3 million people have been internally displaced or moved to neighbouring countries, including half over the last year (Figure 1.1). In the G5 Sahel group, nearly 5% of the population, or above 4 million people, are registered by the UNHCR as "persons of concern"[1] (UNHCR, 2021).

[1] These figures represent the number of refugees, asylum-seekers, refugee returnees, internally displaced people (IDP) and IDP returnees, as reported either by national authorities or the UNHCR, in Burkina Faso, Mali, Niger, Chad and Mauritania. They does not necessarily imply individual identification, nor registration of each individual, and may include a degree of estimation, as per each government's statistical data processing methodology (UNHCR, 2021).

The security and humanitarian crises caused by conflict have been exacerbated by the Covid-19 pandemic, with containment measures aggravating food insecurity, notably in areas hosting refugees.

Figure 1.1 Internally displaced people and refugees in the Sahel

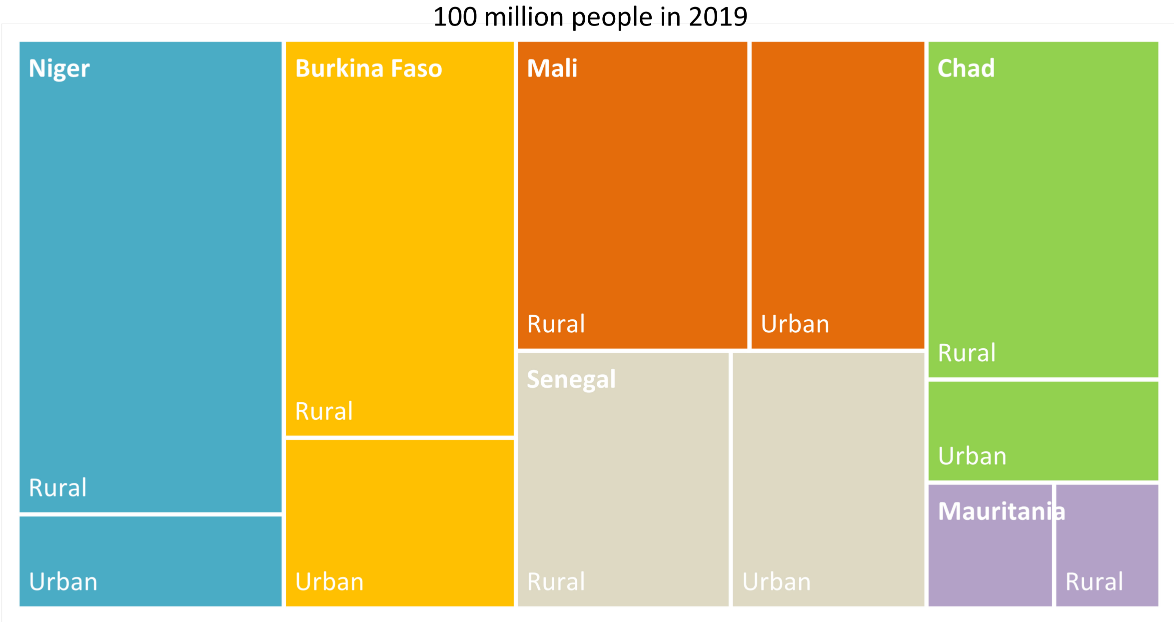


Source: Global Report on Internal Displacement, 2018- 2021; UNHCR (2021).
IDP data: Global Report on Internal Displacement (GRID), 2018-2021. Refugee data in 2020: West and Central Africa Update 1 December 2020 - 15 Jan 2021. All other refugee data: UNHCR Global Trends 2018-2020.

A growing and increasingly urban population

In 2019, the Sahel was home to 100 million people, a population that had doubled over the last two decades and now represents 9% of sub-Saharan Africa's population. Population growth has been faster than in other parts of the continent, with a fertility rate of 5.4 birth per woman, which is higher than the sub-Saharan African average of 4.6 birth per woman (World Bank, 2019). Niger hosts the largest population in the group at around 23 million people; the other countries, except Mauritania, have populations above 15 million people (Figure 1.2).

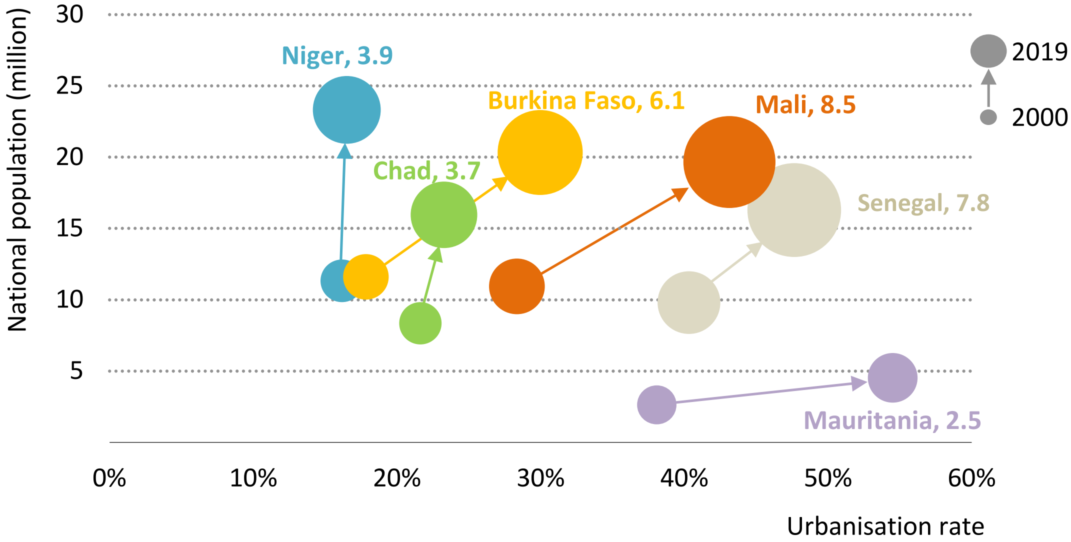
Figure 1.2 The Sahel population in 2019



Source: United Nations, Department of Economic and Social Affairs, Population Division.

The region is mostly rural, with less than one-third of the population living in cities, but urbanisation has increased over the last 20 years. However, the trends in rural-urban shares differ between countries. Chad and Niger have maintained a similar rural-urban ratio with less than one out of four inhabitants living in a city, while other countries such as Burkina Faso and Mali have rapidly increased the share of their urban population. Mauritania stands out with the majority of its population living in urban areas, closely followed by Senegal and Mali (Figure 1.3). The national capitals of the region have grown rapidly since 2000, doubling or even tripling in size in the case of Ouagadougou. Today they concentrate 30% to 55% of the national urban population. Dakar is the first city in the region with a population of almost four million people, while the populations of Ouagadougou and Bamako both exceed 2.5 million.

Figure 1.3 Evolution of urban population in the Sahel

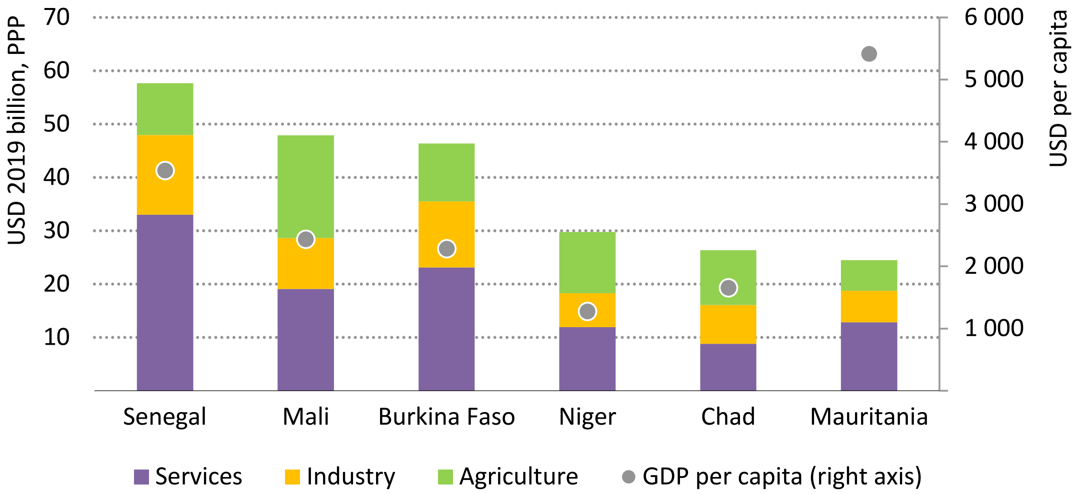


Note: Each bubble size represents the urban population of the country.
Source: United Nations, Department of Economic and Social Affairs, Population Division.

Dynamic, uneven economic growth

The region generates 6% of sub-Saharan Africa's gross domestic product (GDP) (excluding South Africa), but its economy has grown at a rapid pace at an average annual rate of 4.7% between 2010 and 2019. This was more than three times the growth rate of South Africa (World Bank, 2021e). The region's GDP almost doubled in the last 15 years, with notably sharp rises in Senegal, Burkina Faso and Mali. Senegal is the largest economy of the region, followed by Mali and Burkina Faso. However, GDP per capita varies across the countries (Figure 1.4).

Figure 1.4 Gross domestic product per sector and per capita in the Sahel

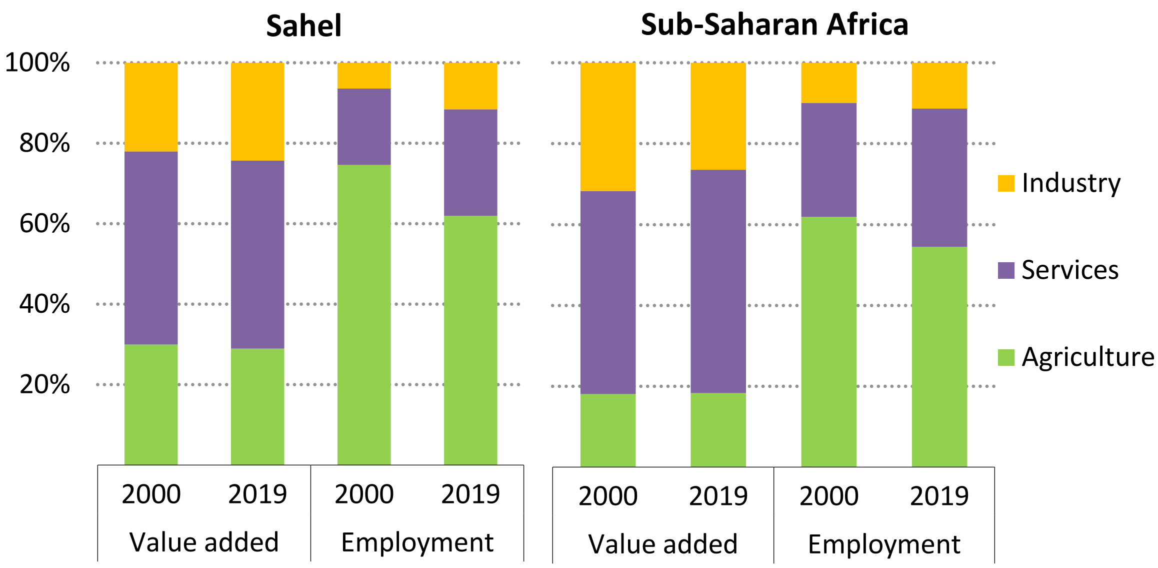


Source: IMF, 2021.

The region's economy is dominated by services, especially in Senegal, Mauritania and Burkina Faso: the services sector has tripled over the last two decades, driven by urbanisation. As in other parts of the continent, agriculture (mainly farming and pastoralism) employs the majority of the labour force but generates less than a third of the value added (Figure 1.5). In the coastal areas of Senegal and Mauritania, fishing and port activity are also important economic sectors. Raw or semi- processed products make up the bulk of exports. These include gold, seafood products, iron ore, crude oil from Chad and Niger, oily seeds as well as other agricultural products and minerals, such as phosphoric acid, zinc and uranium. Imports to the region are dominated by petroleum products and energy-using equipment such as vehicles.

In Burkina Faso and Senegal, relative stability and investment-friendly policies in recent decades have led to a slow rise in the contribution of industry to the national economies. Growth and productivity were affected by volatility in international markets for Chad's exports, by conflict in Mali, and by variations of investments and production of oil in Niger and Mauritania. However, looking at the contribution to GDP alone does not fully account for wider value addition across sectors. Industry is largely dominated by mining and oil where few nationals are employed relative to revenue generation (Quak, E. J., 2018).

Figure 1.5 Shares of value-added and employment by sector in the Sahel and in sub-Saharan Africa



Source: IEA, 2021a.

Several Human Development Indices, which give the bottom rankings for all countries and the region, indicate that the Sahel is home to some of the world's poorest people. While global poverty rates have been reduced by more than half since 2000, and good progress is being made in many African countries such as Nigeria, close to 35% of the population in the Sahelian countries, or 36 million people, continue to live below the poverty line on an income of less than USD 1.90 a day (World Bank, 2021c,g). In all countries except Mauritania, between one-third and a half of the population lives below this poverty line. Overall, the region's progress in poverty reduction has stagnated, and poverty has actually increased since 2018 in all countries except Mauritania.

Box 1.1 Effects of the Covid-19 Pandemic on the Sahelian economies

The Covid-19 pandemic and the related economic crisis have brought about the most serious recession in the Sahelian countries in recent years. Coupled with the impact of conflict and violence, the effects of climate change and other vulnerabilities faced by the region, the crisis is expected to have exacerbated existing food and humanitarian situations which had been caused by pre-existing conflicts. Although the decrease in remittance flows and FDI have been comparatively less than during the 2008 financial crisis, fiscal deficits and public debt increased in all of the countries due to blockages in economic and global trade flows, and the significant increase in the cost of borrowing (IEA, 2020). All of the countries in the region registered decreased economic output in 2020, with Chad, Mali and Mauritania entering into recession.

The global economic contraction had major impacts on the extractive industries in all of Africa. The global decline in oil demand affected the related revenues of the exporting countries In particular, Chad's oil sector, which represents 90% of exports and 40% of government revenues, has been severely impacted. At the same time, the lower global electricity demand slightly depressed uranium prices, affecting producers like Niger. Fortunes were mixed for oil importers who generally saw their current account balances improve due to lower fuel prices. The increases in gold and iron ore prices, induced by international market reaction to the crisis, translated into greater gains for exporters (Burkina Faso, Mali, Senegal, Mauritania and Niger). Contractions in the agricultural sector have generally proved less steep than in other sectors because it has lower dependence on international trade. Local food markets have continued to function, though many countries have had trouble in transporting inputs and products to market (World Bank, 2021b).

Regional and global organisations have provided emergency support to offset the impacts of the pandemic. The African Development Bank set up emergency funds such as a USD 3 billion *Fight Covid-19* Social Bond as well as a dedicated Covid-19 Response Facility worth USD 10 billion. Other regional institutions, such as the

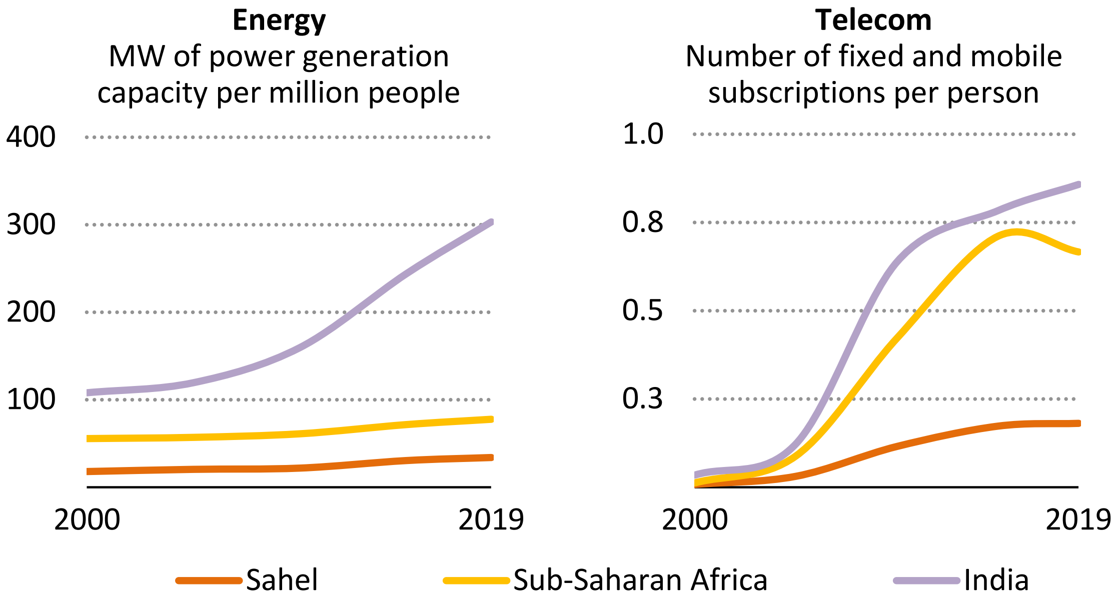
Central Bank of West African States, are providing liquidity and credit relief to banks and companies, while the West African Development Bank has channelled XOF 120 billion in concessional loans to each of its eight member states to finance urgent measures. The African finance ministers also issued a joint call for an emergency USD 100 billion economic stimulus, including a debt service payment suspension. Burkina Faso, Chad, Mali and Niger were among the 25 countries to receive debt service relief through the IMF's Catastrophe Containment and Relief Trust in April 2020, and Chad was the first country to request a restructuring of its debt in February 2021 (Rouaud, 2021).

As the informal economy plays a central role in the Sahel and the health and economic crises are still unfolding, the long-term economic impacts are difficult to assess. Investment and infrastructure plans slowed in 2020 throughout the region, including those related to energy (see Chapter 5: Enhancing energy investment in the Sahel), in line with the 75% drop in greenfield and project finance FDI announcements registered in the sub-Saharan region. The combination of national and international containment measures particularly affected poorer groups, for example by interrupting the ability of citizens to generate a daily income, limiting access to markets and restricting labour opportunities (Ali et al, 2020). All in all, urban areas were initially more impacted as service activities contracted, but the longer-term effect on rural areas may be disproportionate as declines in both formal and informal labour opportunities have major impacts on lower income rural families. For example, Senegal, the largest economy among the six countries, faced contractions in accommodation and food services, transportation and Information and Computer Technology, as well as in tourism. The country saw quarterly growth shrink for the first time since 2011 in the second quarter of 2020 (Trading Economics, 2020). Overall, the World Bank estimates that 1.3 million additional persons were thrown back into extreme poverty in the region.

Infrastructure and investment

Infrastructure is an essential building block for economic development and quality of life. However, Africa and the Sahel, in particular, lag behind other developing regions in most aspects of infrastructure quality. For example, per capita power generation capacity in the Sahelian countries is 35 W per capita, only a third of the sub-Saharan-Africa average (excluding South Africa). Although per capita power generation capacity has steadily increased over the past two decades in the Sahel, India, a country with 1.4 billion inhabitants, was able to almost quadruple its capacity, even though it had less generation capacity per capita than sub-Saharan Africa in 2000. As for telecommunications infrastructure, where sub-Saharan African countries have made good progress with levels comparable to India, the Sahel similarly still lags behind (Figure 1.6).

Figure 1.6 Infrastructure quality developments in the Sahel and selected regions



Note: Sub-Saharan Africa excludes South Africa.
Source: ITU, 2021.

Over the last two decades, the Sahelian countries have been able to attract investment in oil and gas, minerals and electricity infrastructure. At the same time, there has been a growing emphasis in recent years on renewable energy, as illustrated by the increasing size of the solar PV plants built. However, infrastructure construction has hardly kept pace with the rapid urban population growth. For instance, many cities and rural areas are in critical need of water and sanitation systems, waste treatment and flood protection, as they have not been developed sufficiently to ensure local health, food security and economic development. To meet these challenges, integrated multi-sectoral approaches will be required (see Chapter 4).

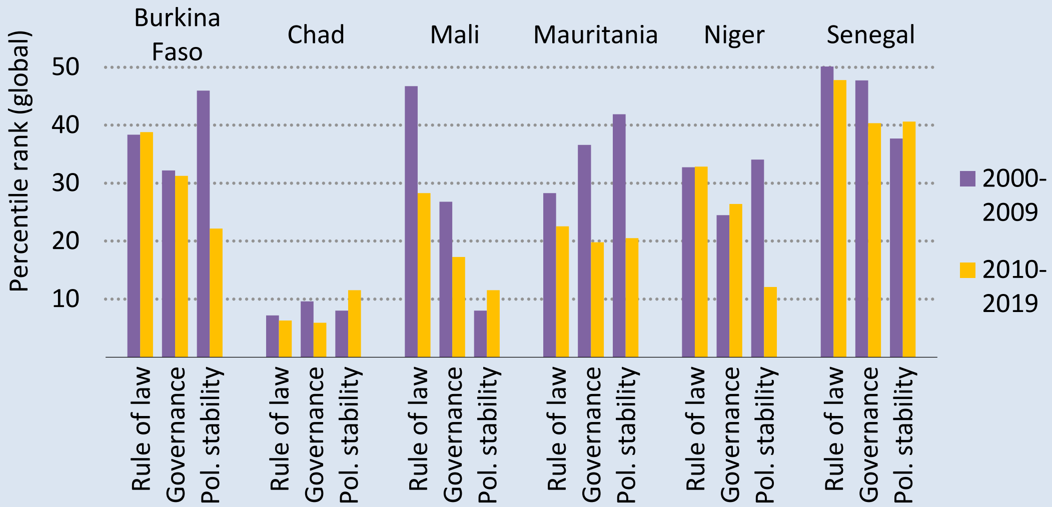
The countries of the Sahel remain highly dependent on aid and concessional finance: official aid amounted to 8% of the Gross National Incomes of the region or USD 7 billion in 2019 (World Bank, 2021a). To develop the required infrastructure, both large-and small-scale, future investment must come from a diverse range of public and private sector investors.

Box 1.2 Governance and policy frameworks

Good governance is correlated with faster growth, higher investment and faster poverty reduction. The World Bank Governance Indicators show that the Sahelian countries belong to the lower half of countries ranked in terms of rule of law, governance and political stability. Between 2000 and 2019, there was no progress in institutional quality and even sharp deterioration of political stability (World Bank, 2021f). However, progress has been seen in controlling corruption in some countries such as Niger, Senegal and Mauritania.

Stable and effective governance and regulatory frameworks are crucial for increasing competition and attracting investments in the energy sector; weak governance and regulatory frameworks at national and sub-national levels continue to impede performance in the energy sector. A key issue is the need for transparent and responsible management of hydrocarbon revenues (discussed more in detail in Chapter 3).

Evolution of governance indicators for the Sahel

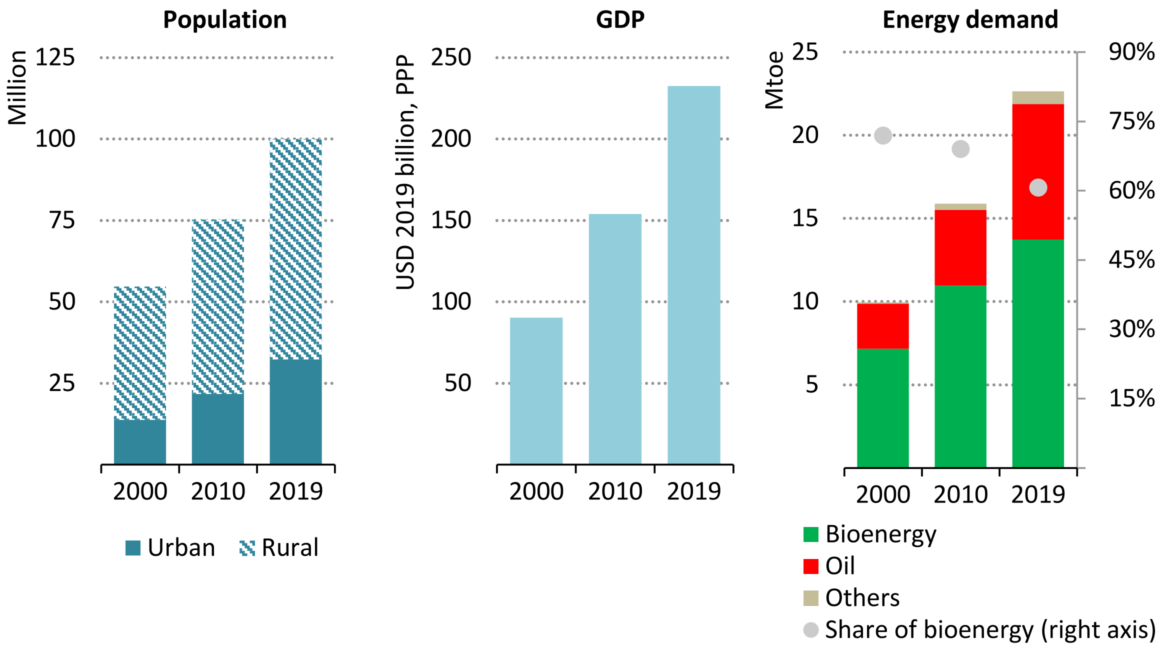


Source: World Bank, 2021f.

1.2 Energy trends in the Sahel today

Driven by strong population and GDP growth, energy demand in the Sahel has increased over the past two decades by more than 4% annually, driven mostly by the demand for oil products. With two-thirds of Sahelians living in rural areas, the demand for bioenergy still dominates the energy mix (Figure 1.7).

Figure 1.7 Selected demographic, economic and energy indicators for the Sahel

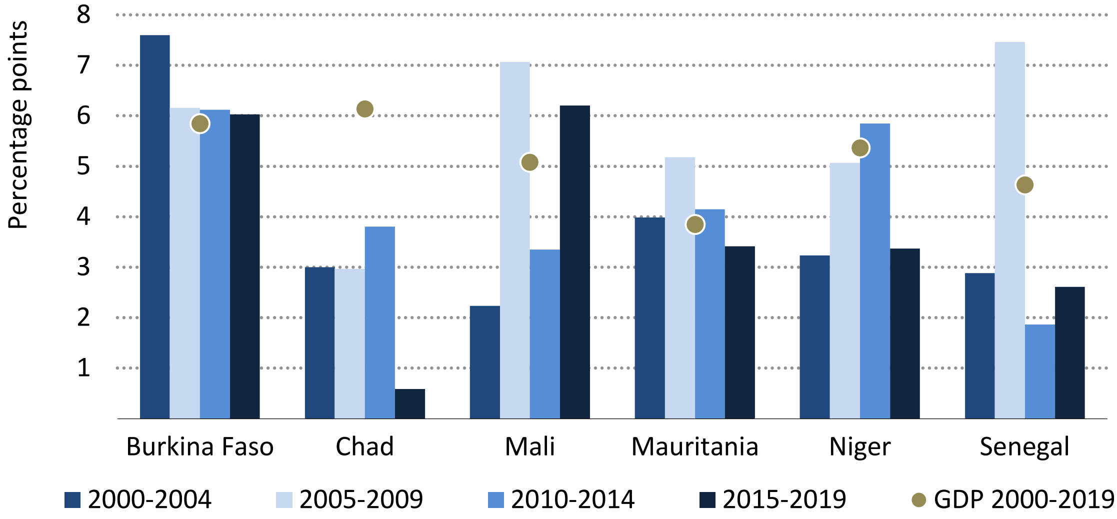


Note: Others include coal, hydro and other renewables.
Source: United Nations, Department of Economic and Social Affairs, Population Division.

Energy demand

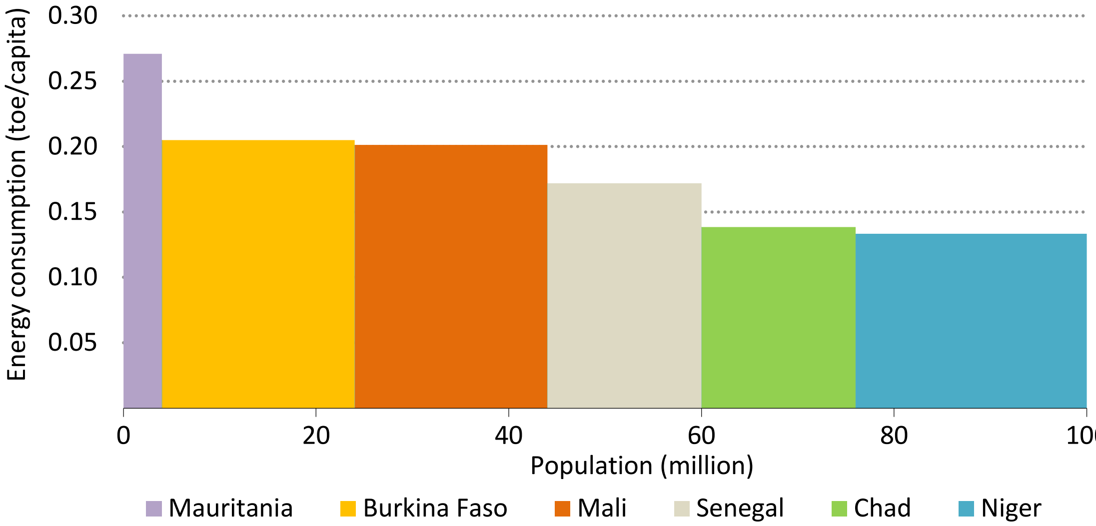
Over the past two decades, the six Sahelian countries' primary energy demand grew annually by more than 4% to 23 Mtoe, up from 10 Mtoe in 2000, while GDP increased even faster. Behind country discrepancies, the highest boom in energy demand occurred in the second half of the 2000s (Figure 1.8). However, energy consumption per capita in the region is still under 0.2 toe/capita, one tenth of the world average and half of the average in sub-Saharan Africa (excluding South Africa) (Figure 1.9).

Figure 1.8 Annual percentage change in total primary energy demand and Gross domestic product



Source: IEA, 2021a.

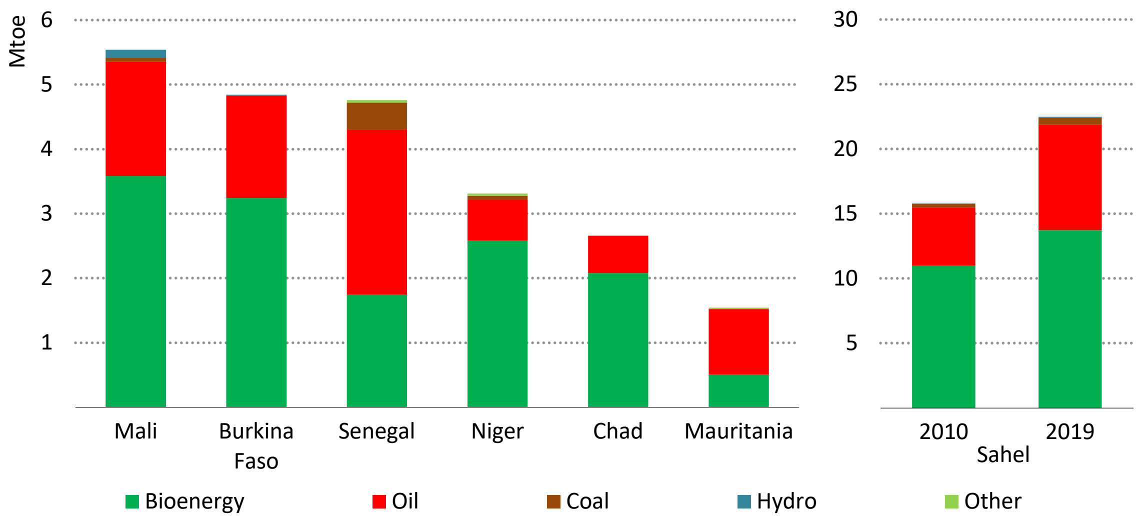
Figure 1.9 Population and final energy consumption per capita in 2019



Source: IEA, 2021a.

Of all the world's regions, Africa relies the most heavily on bioenergy, mostly for cooking, as well as industrial consumption. Bioenergy is the most widely used energy source in the Sahel, with the exception of Senegal and Mauritania, where oil dominates. Still, the share of traditional biomass in the energy mix has decreased from 70% to 60% over the last decade. Fossil fuels represent the remaining 40% of the overall energy mix, with oil meeting increasing energy needs and accounting for a third of total demand, or 160 thousand barrels of oil equivalent per day in 2019. The demand for both coal and natural gas is nascent but has doubled in less than 10 years (Figure 1.10)

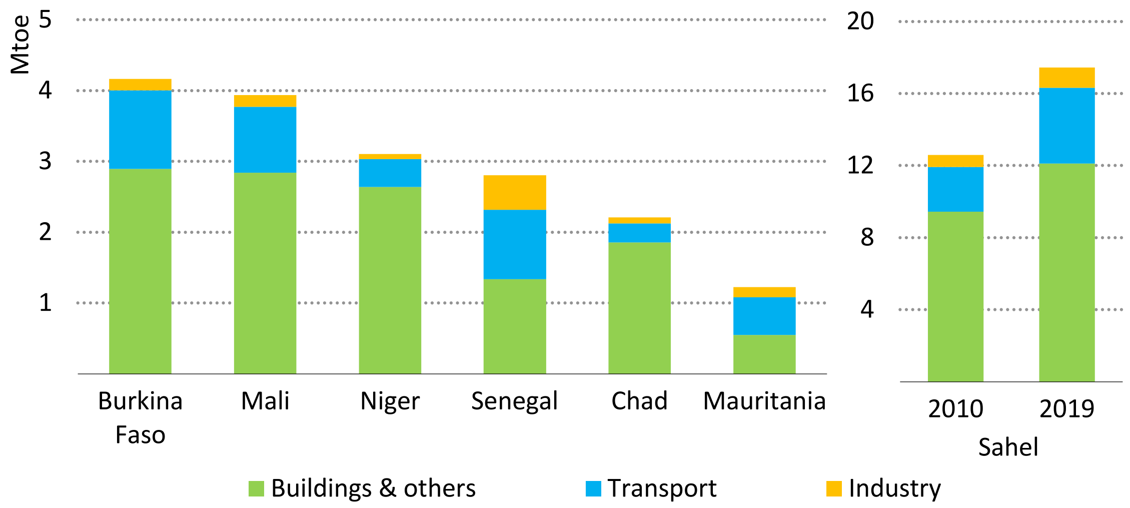
Figure 1.10 Total primary energy demand by country and in the region in 2019



Source: IEA, 2021a.

Starting from low levels, final energy demand has risen by 40% across the six countries since 2010, led by rapid growth in Burkina Faso, Mali and Niger. The building sector accounts for the largest share of final consumption with 12 Mtoe in 2019. While transport accounts for less than a quarter of the total, and industry for 5%, these two sectors have seen the fastest growth (Figure 1.11).

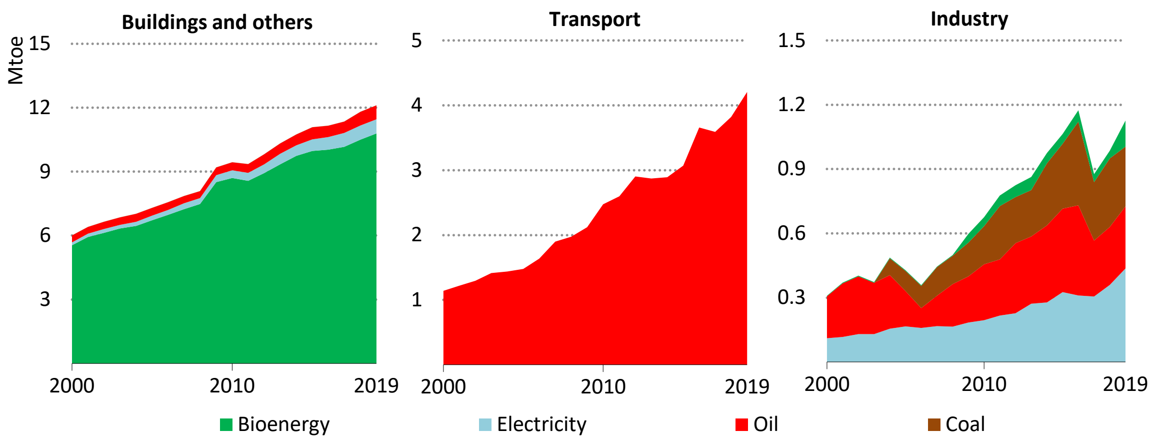
Figure 1.11 Total final consumption by end-use sector by country in 2019 and in the Sahel



Source: IEA, 2021a.

In the building sector, energy consumption has doubled in the region since 2000, following the near doubling of the population over the same period. Biomass remains by far the largest source of energy but electricity is gaining in importance, accounting for 5% of residential energy needs today. Transport is fully oil-based, whereas the industrial sector relies on a combination of fuels led by electricity at 40% of the total, followed by oil and coal (the latter mostly serving Senegal's industrial activities) (Figure 1.12). The mining sector is the main industrial consumer of energy in the Sahelian countries. Mining companies tend to have their own power facilities, primarily supplied by oil fuels, except for a dominance of coal in Senegal and Niger.

Figure 1.12 Total final consumption by sector and fuel in the Sahel



Source: IEA, 2021b.

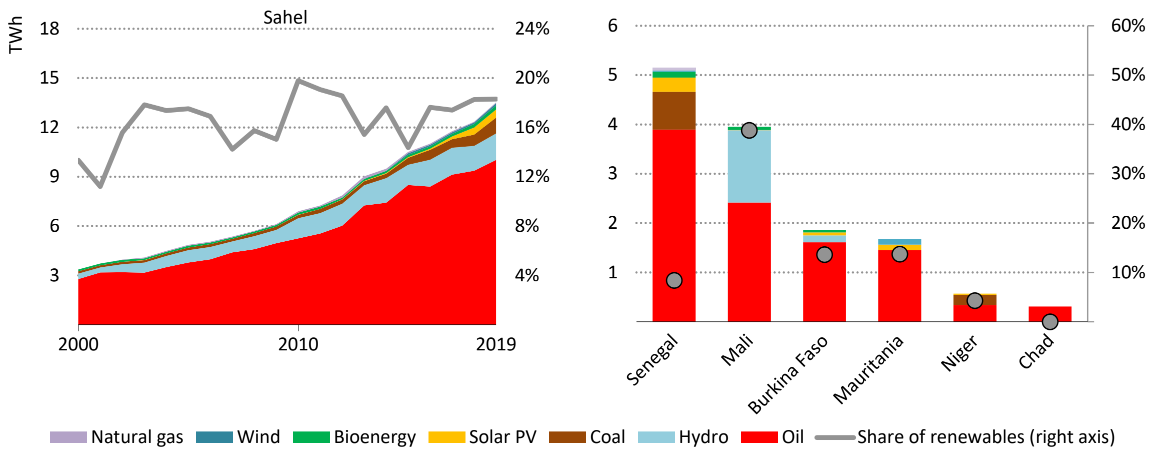
Power sector

Electricity generation in the Sahel has grown steadily since 2000, exceeding 13 500 GWh in 2019. The quadrupling of power generated has been mainly oil-fuelled but with a rising share of modern renewables. The Sahelian countries vary widely in their national power generation capacity. Senegal and Mali have the largest power systems among the six countries, followed by Burkina Faso and Mauritania. These four countries are individually generating on average ten times more than Chad, with only 300 GWh generated using domestic oil fuel (Figure 1.13).

Renewables account for almost 20% of all power generated in the Sahel today. This share dropped between 2010 and 2015 due to the increase in the output from oil-fired plants but it has steadily increased in recent years (Figure 1.13), including the recent projects coming online in 2020 and 2021 which are not captured in the

2000 – 2019 data. Hydropower remains the principal source of renewable power, accounting for 12% of the region's electricity and almost 40% in Mali. Plants in Mali include the 200 MW Manantali Dam that also generates power for Mauritania and Senegal, the 60 MW Felou run-of-river plant shared with Senegal, as well as the 50 MW Selingue plant. Solar PV and wind, almost absent from the power systems of the region a few years ago, now contribute together 5% of the electricity generated, and up to 15% in Mauritania. Generation from solar PV has almost doubled every year since 2015, following a number of solar plants coming on line all across the region. These include the 50 MW Senergy 1&2 in Senegal in 2017, the 33 MW Zagtouli Power Station in Burkina Faso and the 50 MW Kita plant west of Bamako, which is currently the largest solar plant in West Africa. Mauritania harnessed wind power with two plants bringing 34 MW of capacity. Starting in 2020, Senegal's 159 MW Taiba N'Diaye Wind Farm further diversified the country's renewable energy mix and represented West Africa's largest wind energy plant. In May 2021, two solar PV plants, Kael and Kahone, came online in Senegal through the Scaling Solar programme with a combined capacity of 60 MW (PEI, 2021). Coal-fired power generation has also seen a sharp rise, increasing fivefold from its 2010 levels and reaching almost 1 TWh in 2019.

Figure 1.13 Electricity generation by fuel and share of renewables in the Sahel, and by country 2019



Source: IEA, 2021a.

Despite this capacity expansion, electricity supply remains far below demand. National grids tend to serve cities and the costs of extending grids to rural areas with dispersed populations has proven financially prohibitive. Frequent power cuts plague Sahelian cities, with damaging effects for businesses. The growing power deficit has resulted in reliance on expensive and often inefficient back-up generators fuelled by diesel. Blackouts are frequent – as in the late 2000s in Dakar – causing governments to focus on increasing supply and reforming regulatory and legal frameworks to encourage the roll-out of solar PV capacity.

Regional trade of electricity is also on the rise. The four countries that are part of the Economic Community of West African States political grouping (ECOWAS) - Burkina Faso, Mali, Niger and Senegal – are connected to the West African Power Pool (WAPP) (Box 1.3). The WAPP enabled connections from Burkina Faso to Ghana (it was already importing from Côte d'Ivoire) and from Niger to Nigeria. Between 2011 and 2018, the project involving a transmission line between Bolgatanga in Ghana and Ouagadougou, Burkina Faso was able to reduce the weighted annual cost of electricity supply from USD 0.26 per kWh to USD 0.20 per kWh, reduce the duration of outages and connect 25 neighbourhoods on the outskirts of Ouagadougou (World Bank, 2021d). The Synchronized Western Network provides power from the Manantali Dam and Felou hydroelectric plant in Mali to neighbouring countries. These are joint projects with tripartite governance structures, in which the electricity produced is shared among the countries. Roughly half of the Manantali electricity is used in Mali, 30% in Senegal and 15% in Mauritania; while 25% and 45% of the Felou electricity also produced in Mali are respectively used in Mauritania and Senegal. While Mauritania left ECOWAS in 2000, it remains active in matters related to electricity trading. Chad is a member of the Economic Community of Central African States (ECCAS), which is working on similar initiatives, including the Cameroon and Chad Power Interconnection Project, scheduled for completion in 2022.

Box 1.3 The West African Power Pool

The Economic Community of West African States (ECOWAS) established the West African Power Pool (WAPP) in 1999 with the aim of building and harmonising a reliable power network for the region and a common, affordable electricity market (ECOWAPP, 2021). This made sense in the context of smaller, landlocked countries finding it difficult to secure investment for their own power production. To date, nine of the ECOWAS countries are connected, through three subgroups:

- *Synchronized Eastern Network (Part of Togo/Benin, Nigeria, and Niger)*: This subgroup comprises three power subsystems managed by three companies (CEB, TCN and NIGELEC).

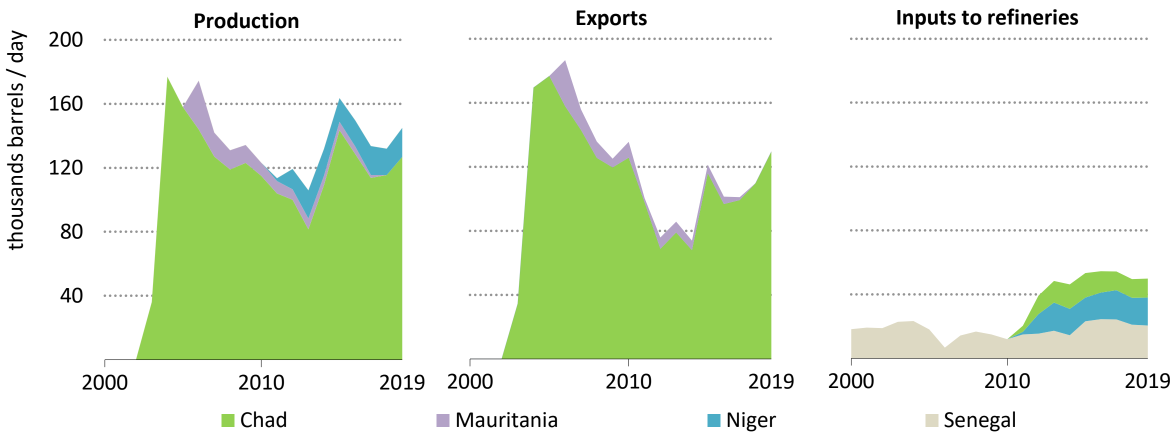
- *Synchronized Central Network (Burkina Faso, Côte d'Ivoire, Ghana, part of Togo/Benin and part of Mali)*: This subgroup comprises four power subsystems managed by five companies (SONABEL, CIE, GRIDCo, CEB and EDM-SA).
- *Synchronized Western Network Senegal River Development Organisation (OMVS)*: This operates a common power system, which links the second part of Mali, Senegal, and Mauritania, and distributes the output from the hydropower plant of Manantali and Felou.

In 2003, the countries adopted the ECOWAS Energy Protocol, a legal framework for co-operation that allowed for third party access to the grid and a right to the transit of energy. Within this framework, the ECOWAS Regional Electricity Regulatory Authority (ERERA) was formed in 2008 to support national electricity regulation and regulate the cross-border electricity trade. With these governance structures in place, the WAPP has facilitated generation and transmission projects, supported by a number of bilateral and multilateral development banks (MDB) partners. In December 2018, the ECOWAS heads of state adopted the ECOWAS Masterplan: the Development of Regional Power Generation and Transmission Infrastructure 2019-2033. This plans to extend regional coverage into Morocco and the Central African Power Pool (CAPP). Planned generation projects comprise a roughly 30-70% split between thermal and renewable energy projects. Together, the masterplan is estimated to require abovet USD 35 billion in investment (ECOWAS, 2018).

Fossil fuel resources and supply

Petroleum supply profiles differ markedly between the six Sahelian countries. Chad and Niger are net exporters, refining their own production for domestic use, while Mali and Burkina Faso are importers without reserves. Meanwhile, Mauritania and Senegal are embarking on natural gas and oil development following significant discoveries in recent years (see Chapter 3). Senegal also imports crude oil, which it refines for domestic use and export (Figure 1.14). Senegal and Niger also use coal in their power generation systems. Niger's demand is covered by domestic production, while Senegal's demand is met by imports.

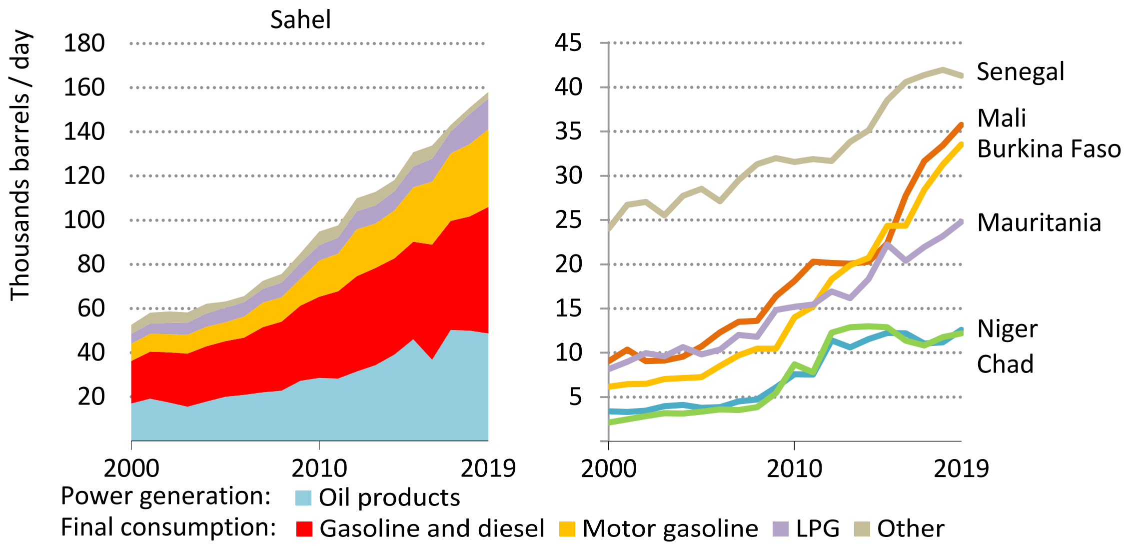
Figure 1.14 Crude oil production, exports and inputs to refineries in the Sahel



Source: IEA, 2021a.

Demand for fuel has changed rapidly, mirroring population growth and urban development. Between 2010 and 2019, the final consumption of oil products in the six focus countries rose by over 60%, with motor gasoline and liquefied petroleum gas (LPG) both doubling. Demand patterns vary from country to country, and Burkina Faso, Senegal and Mali each consume twice as much as the average level of Mauritania, Niger and Chad (Figure 1.15).

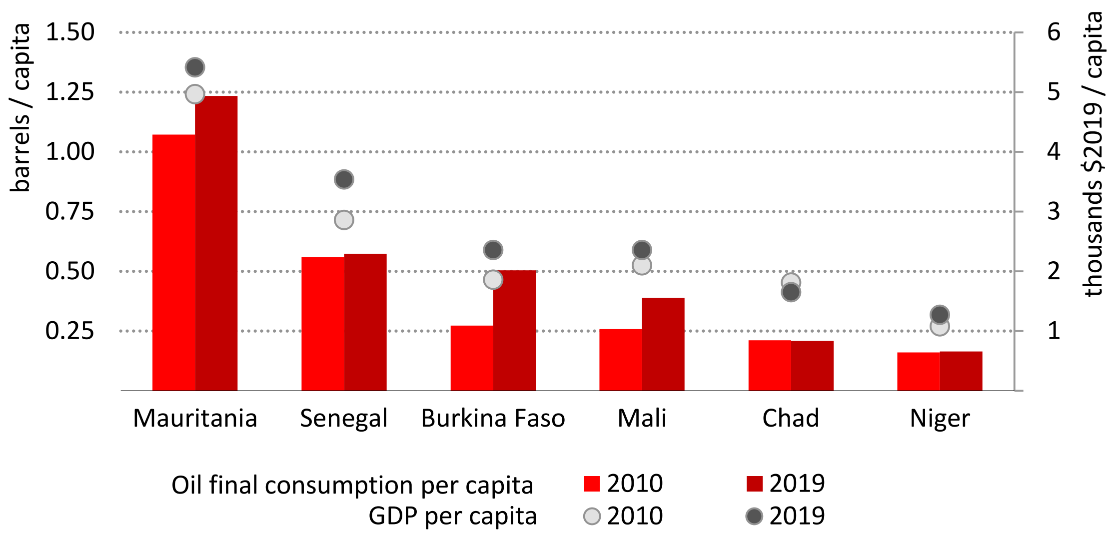
Figure 1.15 Oil use in power and in final consumption by products



Source: IEA, 2021a.

Although it is difficult to attribute product consumption to each sector precisely, national energy statistics indicate that the increase in oil demand across the region has been driven primarily by the growing use of oil in transport and power generation. In many developing economies, oil consumption is strongly linked to GDP per capita growth (Figure 1.16). The imports of fuel oil for example nearly doubled, chiefly for use in electricity generation with a small proportion in industry. Between 2010 and 2019, the use of oil products in transport rose by over 70%, reflecting growing vehicle ownership. This growth is above that on the continent more broadly, where the demand for road transport fuel increased by 45% over the same period.

Figure 1.16 Oil final consumption and gross domestic product per capita in the Sahel

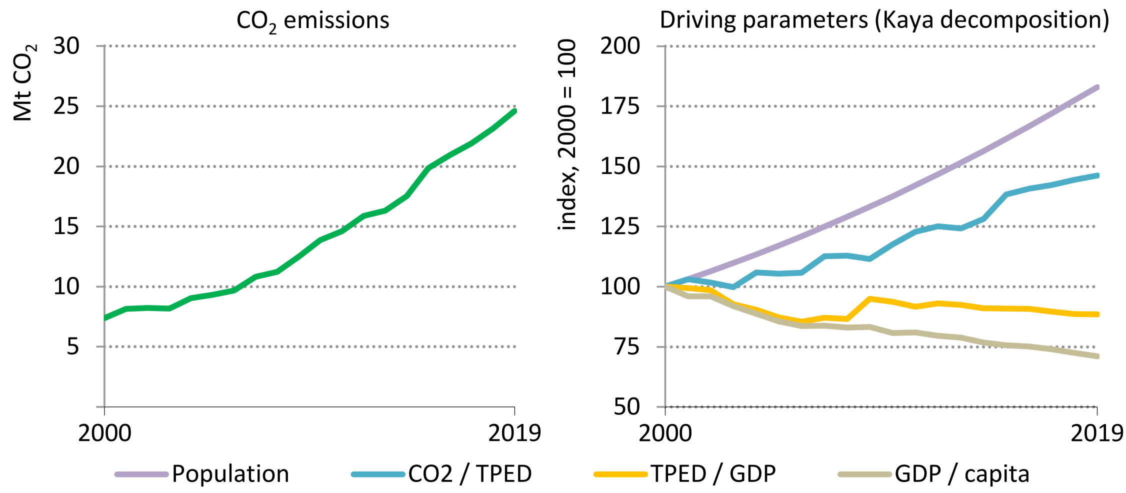


Note: This is only end-use sector oil consumption. It does not show the use of oil in power generation.
Source: IEA, 2021a.

CO_2 emissions, carbon intensities and air pollution

Today, the region accounts for 8% of all energy-related CO_2 emitted in sub-Saharan Africa (excluding South Africa), and less than 0.1% of global emissions. The six Sahelian countries have some of the lowest CO_2 emissions per capita in the world and all but Mauritania and Senegal come in lower than the sub-Saharan average (excluding South Africa), reflecting the lower levels of carbon-intensive energy access and industry. However, emissions have more than tripled between 2000 and 2019, growing at an annual rate of 7% since 2005. This correlates with strong population growth and increased use of fossil fuels in national energy systems (Figure 1.17). Regional CO_2 emissions intensity – calculated as the ratio between CO_2 emissions and primary energy demand – has also risen in all countries, increasing by 50% since 2000.

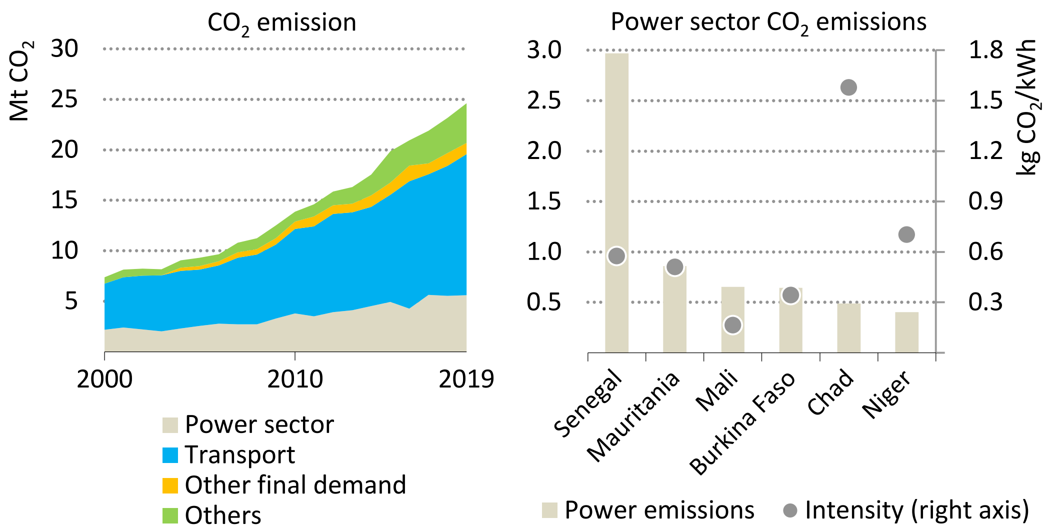
Figure 1.17 Energy-related CO_2 emissions and drivers in the Sahel



Source: IEA, 2021a.

The power sector is responsible for a quarter of CO_2 energy-related emissions in the region, reflecting the high shares of fossil fuels in the electricity mix. Senegal's power sector emissions are equivalent to those of the five other countries. In terms of intensity, defined as the power sector CO_2 emissions divided by the total electricity generated, one kilowatt-hour emits around 575 g of CO_2 in Mali and three-times more in Chad (Figure 1.18). The regional average stands today at 690 gCO_2/ kWh generated, down from 800 in 2000. This is 20% above the average in Africa and in non-OECD countries but favourably compares to above 900 gCO_2/ kWh in South Africa.

Figure 1.18 CO_2 emissions by sector in the Sahel, and in the power sector in 2019



Source: IEA, 2021b.

While the six Sahelian countries have low levels of industrial air pollution, indoor pollution caused by burning fuel for cooking is a long-standing challenge. Urban air pollution from a mix of traffic emissions, the burning of waste and biomass and dust have been growing issues. In Dakar, for example, air pollution is severe during the dry months (December to March) when the ‘harmattan’ dust combines with traffic, industrial and biomass pollution. Similar patterns are likely in several other growing urban centres in the Sahel zone (Lindén et. al. 2012) and are leading to increases in respiratory illnesses (Dewast, 2019).

CO_2 emissions from the transport sector account for between one-third (Senegal) and two-thirds (Burkina Faso) of national emissions from fossil fuels. Since 2000, they have been multiplied by between 1.5 and 5 across the region, with Senegal and Mali registering the largest emissions from this sector among the six countries. Vehicle use has rapidly increased with growing urban centres, as the number of passenger cars doubled since 2010. The bulk of the vehicle stock tends to be old and highly inefficient, and fuel consumption has barely decreased, especially for two- and three-wheelers. This, coupled with high sulphur fuels, has added to the problem of particulate matter in cities.

Legal standards on sulphur limits for fuel have been high, between 2 001 and 12 000 ppm for diesel across the region, except in Niger and Mauritania, where the limits are more stringent, between 501 and 2000 ppm (Stratas Advisors, 2020a, 2020b). There is little or no data available on on-the-ground sulphur emissions. A combination of a lack of enforcement and ageing vehicles may result in higher levels of pollutants. Importers of gasoline and diesel from Nigeria and Côte d’Ivoire would – at least until recently – have received fuels with sulphur levels of 2 000 to 3 000 ppm (Malins et. al., 2016). By way of reference, the EU phased out fuel regulations authorising the sulphur content of diesel and gasoline fuels above 10 ppm between 2005 and 2011.

Chapter 2: Clean energy transitions and SDG 7 in the Sahel

Achieving the UN's Sustainable Development Goal 7 (SDG 7), which aims to ensure affordable, reliable, sustainable and modern energy for all by 2030, is central to generate economic development and improve livelihoods in the Region. The Sahelian countries have among the lowest energy access rates in the world, and despite significant improvements in recent years, the region remains far from achieving each of the SDG 7 subgoals. Regarding SDG 7.1, electricity access and access to clean cooking remain below sub-Saharan Africa's average levels. Modern renewables (SDG 7.2) are expanding but they still represent small shares of the total energy mix, and energy efficiency (SDG 7.3) has improved but could accelerate across the region.

All countries have put energy access at the heart of their energy policies and aim to increase the share of renewables in their electricity mix to meet growing energy demand, reduce imports and take advantage of the Region's tremendous renewables potential. Accordingly, making progress on SDG 7 is the central objective for the Africa Case.

Overall, despite very low starting points, all focus countries have improved their **electricity access** rates over the past two decades with around one million people gaining access each year. Currently, each country sees electricity access as an energy policy priority and is aiming for universal access, albeit not all by the same date. The targets are also differentiated by zones, given the current urban-rural divide, where countries' vast territories show large discrepancies (80% electrification rate in cities vs. 10% in rural areas). Yet much progress is still needed in improving access rates and this remains the biggest challenge and barrier to accelerating clean energy transitions in the region. The same applies to access to clean cooking, where little or no progress has been achieved in recent decades, with the exception of Mauritania and Burkina Faso. Today 90 million people in the Sahelian focus countries do not have access to clean cooking and still rely on traditional use of biomass for their cooking needs. This means there are still high rates of premature deaths in many communities due to the indoor pollution resulting from a lack of access to clean cooking facilities. Moreover, Covid-19 is reversing the slow by steady progress made in providing energy access in sub-Saharan Africa. International partners must continue to make access to energy a top priority in Africa. Special consideration is needed for displaced and vulnerable communities, who face acute affordability challenges.

As for SDG 7.2 or **renewable energy,** progress is taking place with many projects coming online or being planned. Countries have started to act through regional or international initiatives to find synergies with their neighbouring countries and to tap potential in smaller- scale projects. All countries aim to bring their vast renewable energy potential into their energy access strategies by setting targets to increase the share of renewables in their electricity mix. Further deployment of renewables will be needed to meeting the growing energy demand, overcome energy access gaps and support transformative economic and industrial development in the countries.

Energy efficiency, or SDG 7.3, remains a large area for improvement. Energy intensity lags behind other regions in the world. Transport, industry and the built environment offer much potential for energy efficiency. Improvements in these areas will be essential to Sahelian countries' transitions with many opportunities for growth in each sector. Applying best practices in fuel efficiency standards is an important area for concerted action in the region.

Table 2.1 SDG 7 Indicators in the Sahel

				STEPS			Africa Case		
	2000	2010	2019	2025	2030	2019-2030 CAAGR	2025	2030	2019-2030 CAAGR
SDG 7.1: Access									
Percentage of access to electricity	14%	22%	32%	38%	41%	2.3%	68%	100%	11%
Percentage of access to clean cooking	9%	10%	9%	12%	15%	4.3%	56%	100%	24%
SDG 7.2: Renewables									
Total final consumption (Mtoe)	7.5	12.6	17.5	22.7	27.3	4.1%	19.0	22.7	2.4%
Share of all renewables in final consumption	72%	70%	64%	56%	50%	-2.1%	51%	38%	-4.5%
Share of modern renewables in final consumption	0.5%	1%	2%	5%	7%	13%	10%	15%	21%
SDG 7.3: Energy efficiency									
Total energy supply (Mtoe)	9.9	15.9	22.6	27.9	33.1	4%	23.4	28.7	2.2%
Energy intensity of GDP (toe/USD 1 000 [2019 PPP])	0.11	0.10	0.10	0.09	0.08	-2.2%	0.07	0.06	-4%

Note: "Modern renewables" refers to renewable energy excluding the traditional use of biomass.

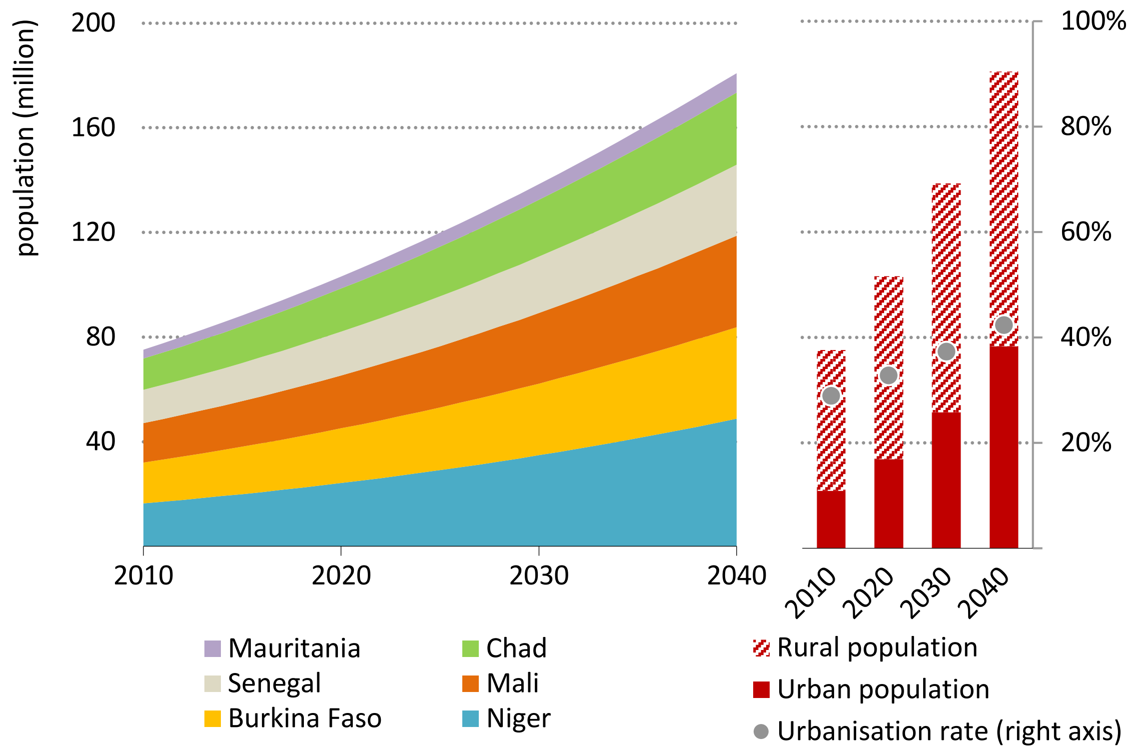
2.1. Overview of the outlook for the Sahel

Population growth and economic development will increase energy demand across all fuels by 2030

The region is projected to undergo important changes over the next two decades with rapid population growth, increased urbanisation and dynamic economic growth, though under uncertain patterns that are explored in our scenarios.

Steady population growth is bound to drive energy demand across the region. Increasing at an average annual rate of 3%, the population in the Sahel is to reach nearly 140 million people by 2030. The rural population will grow by 20 million people from today, reinforcing the need for basic electricity access. The number of people living in cities will double between 2015 and 2030 to account for almost 40% of the total (Figure 2.1): This acceleration in urbanisation will raise energy needs, notably in the transport sector. In Senegal, the rural to urban balance will shift around 2030. The cities will account for almost 55% of the population, or more than 11 million people, a 50% increase from today. Linked to an average 70% income growth, the population growth will drive the demand for cars and two-wheelers.

Figure 2.1 Demographic trends in the Sahel



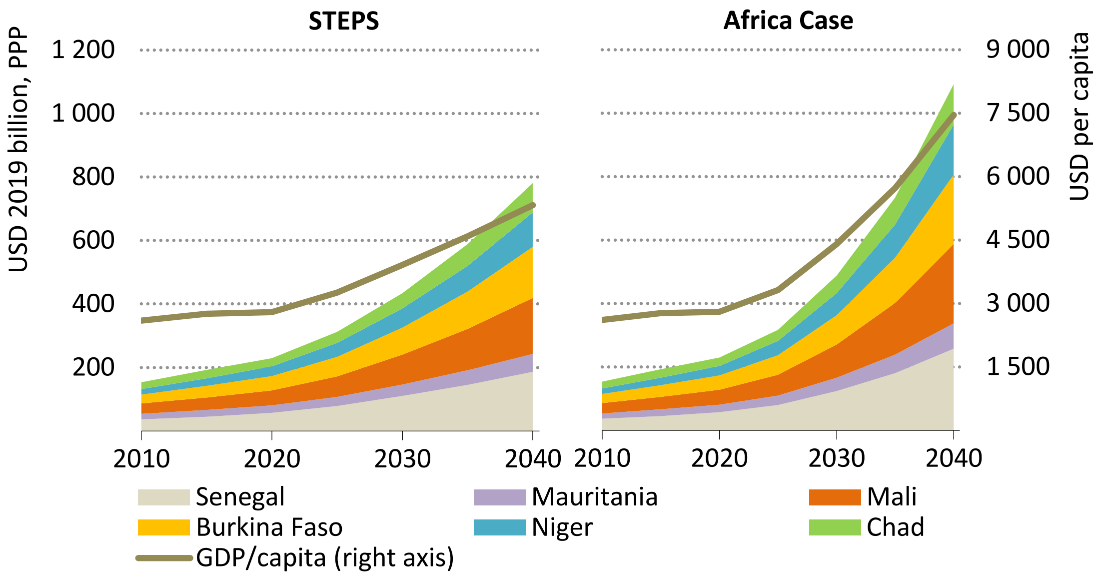
Source: IEA, 2021.

Although the recovery prospects from the Covid-19 pandemic and health crises remain uncertain, all of the Sahelian economies are showing signs of recovery at the time of writing. The evolution of local Covid-19 contamination rates – which have remained, up to now, relatively low in the region – and the lifting of the procurement and logistical constraints related to the vaccination roll-outs will determine the speed and resilience of the economic recovery. Given the uncertainty around both these factors and global market trends, it is still unclear how fast the Sahelian economies will recover over the long term and be restored to pre-crisis levels. Over the next decade, much will also depend on the bridging of the infrastructure gap, to enable services, especially renewable energy, water and transportation to serve communities and productive activities. This in turn depends on public and private stakeholders' capacity to invest. Public and private debt levels, as well as fiscal space and the general investing environment, will weigh heavily in the long-term growth prospects.

Our Stated Policies Scenario (STEPS) assumes that gross domestic product (GDP) will grow at an average annual rate of 5.8% by 2030, leading the regional GDP to reach USD 435 billion. Inclusive growth as well as social and economic development are at the heart of the IEA Africa Case, which sees the economy doubling, or rising at an average of 7.0% per annum. Per capita income will grow faster than over the past two decades, rising by more than 55% by 2030 (Figure 2.2). Services and industry grow faster than agriculture in both scenarios, but the stronger development of services in the Africa Case drives energy consumption, especially for power (Figure 2.3).

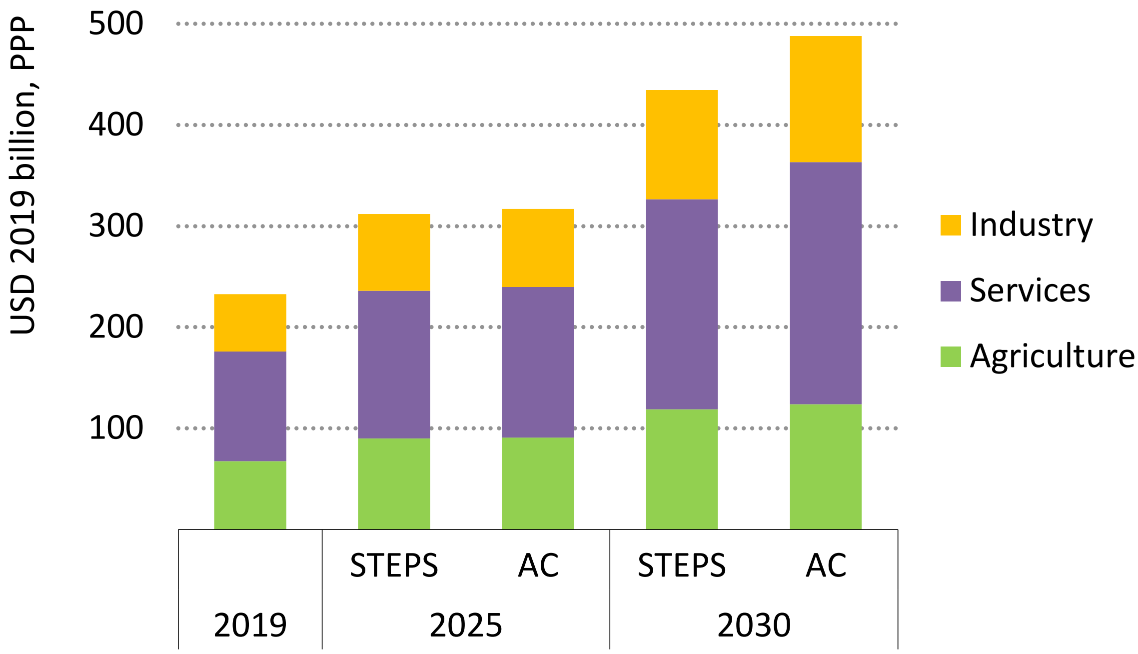
Country-level disparities are however likely to remain prevalent over the next decade in both our scenarios, as some countries (Senegal, Mali) are seeing strong per capita income growth, while other countries will experience less dynamic growth (Mauritania) or lower income (Niger's per capita GDP will remain half the regional average).

Figure 2.2 GDP evolution in the Sahel



Source: IEA, 2021.

Figure 2.3 Shares of value-added by sector in the Sahel



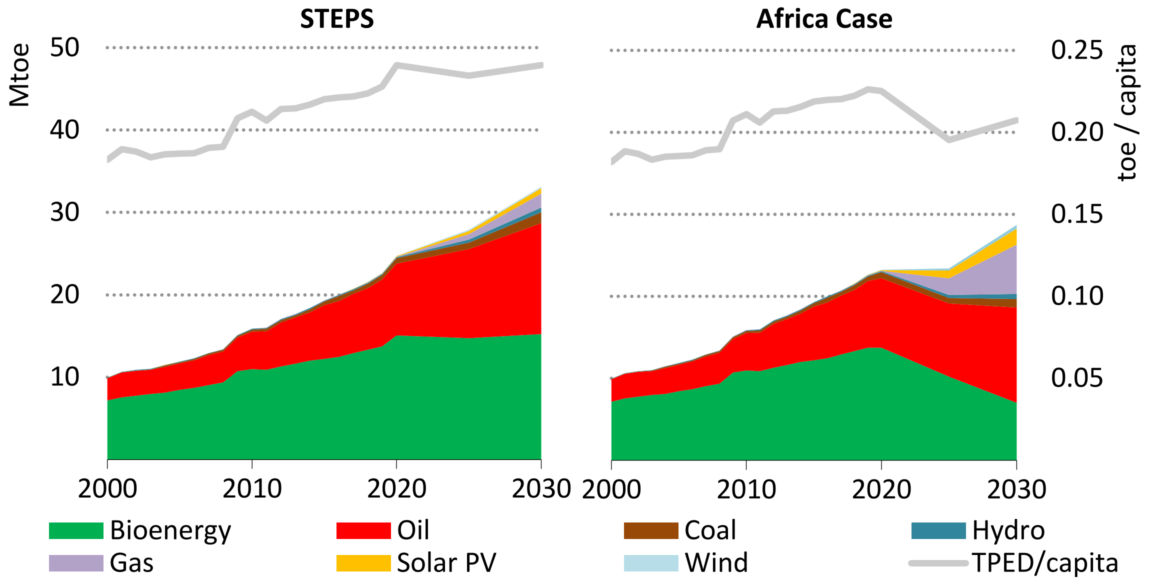
Note: "AC" is Africa Case.
Source: IEA, 2021.

Energy demand in the Africa Case grows more efficiently, and is met with cleaner burning fuels delivered by substantially improved energy infrastructure.

In the STEPS, total primary energy demand grows by 45% from today. Efficiency gains do little to prevent energy growth from moving in lock-step with economic and population growth. This demand growth is met largely with oil and the traditional use of biomass, as today's policies in the region do not meaningfully shift the supply structure. Modest policy pressure slows the growth of the traditional use of biomass, with more and more users switching to LPG, which contributes to the growth in oil demand. The power capacity expands in both scenarios, but investments in the Africa Case average USD 3 billion per year, more than two times above the STEPS levels. Renewable electricity, especially solar, begins to play a larger role in the energy mix and gas becomes an increasingly important fuel for power generation. However, without the investments in grids and natural gas infrastructure, the ramp up of these fuels will be limited. This will result in the continued use of expensive fuel oil generation, which is more readily deployed and operated in the absence of reliable infrastructure.

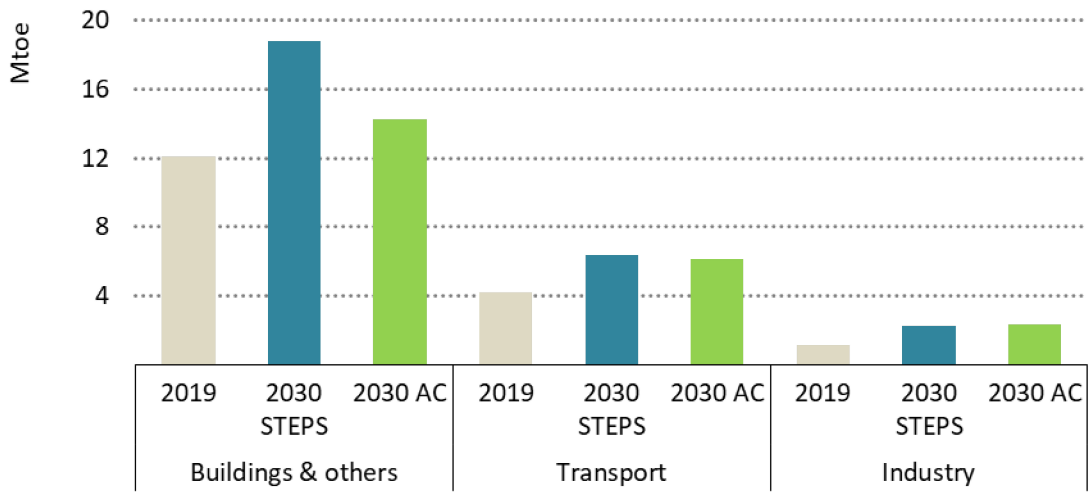
In the Africa Case, achieving universal access, especially through moving to clean cooking, creates huge efficiency gains, for both energy and labour. These efficiency gains are enough to offset the more rapid energy demand growth needed for a much larger economy, using 15% less energy per capita than in the STEPS. Demand is met by a more diverse fuel mix in the Africa Case, with gas and electricity making up 30% of total energy demand, up from 6% today (Figure 2.4). Most of this is in the power sector. However, rapid industrial growth in the Africa Case demands more gas, especially for the fertiliser and basic chemicals industries. This fuel diversification relies heavily on substantial infrastructure development: reliable regional electricity grids, a larger share of microgrids in remote areas and natural gas and LPG delivery infrastructure in densely populated regions.

Figure 2.4 Total primary energy demand by fuel and per capita in the Sahel



Source: IEA, 2021.

Figure 2.5 Total final consumption by sector in the Sahel

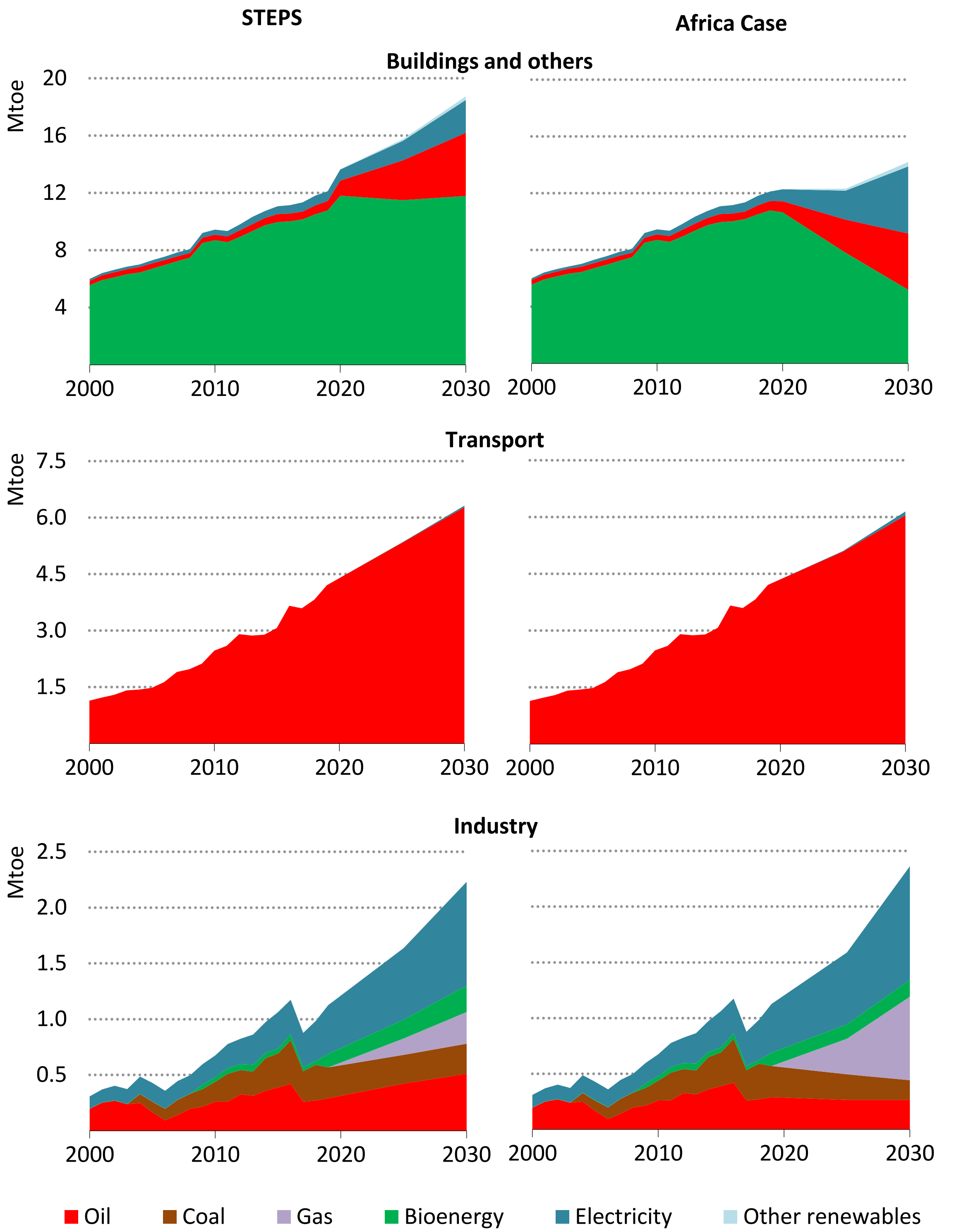


Source: IEA, 2021.

Rapid growth in industry and transportation demand features prominently in both scenarios, where the more notable divergence comes from the transformation of energy use in buildings, related to access to clean cooking and electricity (Figure 2.5). However, the demand for transportation services and added value from industry are much higher in the Africa Case, despite both sectors reaching similar demand levels in 2030. This underscores a consistent emphasis on efficiency in the Africa Case, notably in transport, where policies limit the import of the lowest-efficiency second-hand vehicles – a policy intervention shown to impact the affordability of vehicles negligibly. In industry, while efficiency remains important, the most notable is the shift from oil, bioenergy, and coal to gas and electricity. These fuel shifts improve efficiency and cost-effectiveness, reduce the emissions intensity of industry, and improve air quality.

The residential sector uses half the bioenergy used today in the Africa Case, with the remaining bioenergy largely used in modern efficient burning cookstoves (Figure 2.6). These enhancements make the use of bioenergy for cooking far more efficient, greatly reducing the time and labour associated with gathering cooking fuel. LPG demand grows to similar levels in the STEPS as in the Africa Case, with a high share of the urban population gaining access to LPG in the STEPS case as well. However, in the Africa Case, urban dwellers increasingly use electricity for their cooking needs, and those in smaller cities and towns are increasingly able to access reliable LPG fuel delivery. The major change is for rural populations in the Africa Case, where a substantial policy push delivers many clean burning cookstoves that rely on gathered biomass or modern bioenergy, like biocharcoal briquettes. Alternatively, the rural areas that gain access to electricity begin to use electric cooking appliances as a part of bundled solar home systems, driving electricity demand up substantially.

Figure 2.6 Total final consumption by fuel and by sector in the Sahel

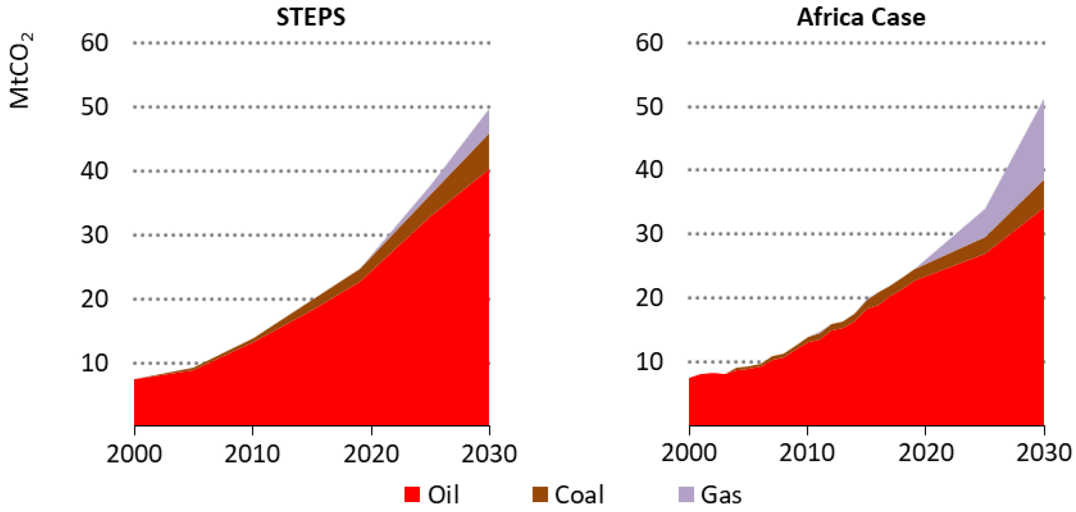


Source: IEA, 2021.

The Africa Case achieves a similar level of CO_2 emissions as the STEPS despite higher economic growth and reaching universal access.

Emissions climb from 25 Mt today to nearly 50 Gt in 2030 in the STEPS, almost the same as in the Africa Case. The Africa Case's emissions would have been much higher without the significant role of efficiency and a larger share of renewables in power generation (Figure 2.7). With the right policies, the efficiency gains and grid decarbonisation levels in the Africa Case are mutually reinforcing to universal access goals and maintaining affordability. Even as the demand for energy from vehicles, appliances and services expand, both the STEPS and Africa Case trajectories keep the Sahel's emissions per capita within the lowest 30 countries in the world. The Sahel's increased level of emissions by 2030 would be equivalent to less than 0.15% of today's global emissions.

Figure 2.7 Energy-related CO_2 emissions by fuel in the Sahel



Source: IEA, 2021.

The net impact on total GHG emissions in the Sahel may be even lower in the Africa Case than in the STEPS. Universal clean cooking access reduces the amount of black carbon emissions, and could improve the sustainability of biomass gathering by reducing the need for cooking fuels through efficiency. However, these are difficult to assess with certainty due to the very large gaps in data in the region and information about how people harvest biomass for their cooking.

A lower-emissions pathway is possible that still achieves the Sahel's goals. In the IEA's Net Zero by 2050 (NZE) scenario, renewable energy and sustainable access solutions take a more prominent role. However, speed remains essential to achieve universal access by 2030. So even in the NZE scenario, 45% of those without electricity access gain it from connecting to the grid, and 25% achieve clean cooking access via modern LPG cookstoves. While conventional pathways to electricity access marginally increase emissions in the near-term, they can provide a transition pathway to faster decarbonisation in the future.

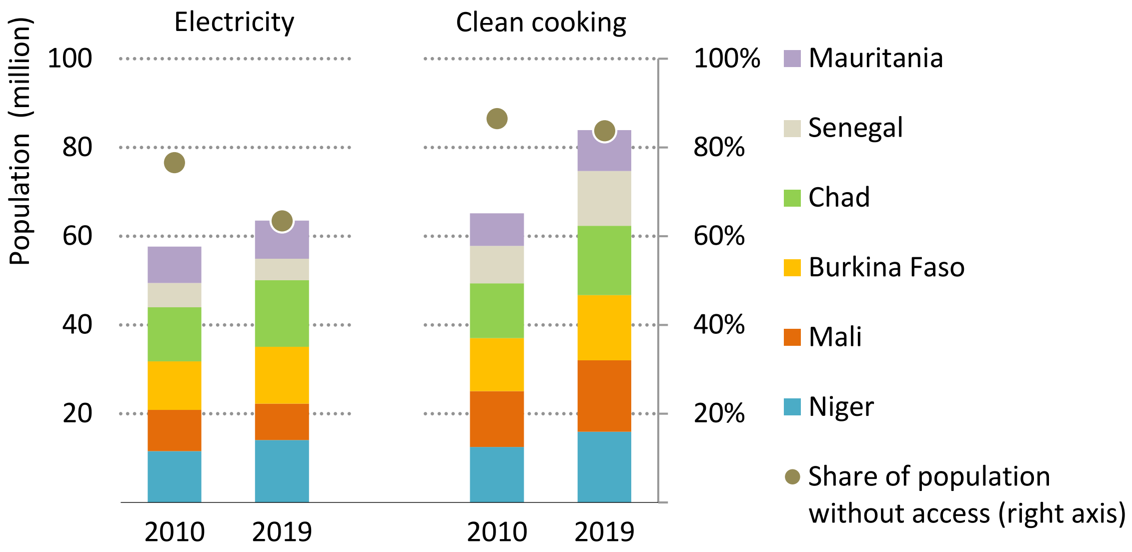
2.2. Expanding energy access (SDG 7.1)

Increasing access to affordable, reliable, sustainable and modern energy for all is fundamental to enhancing the resilience of communities and enabling development ambitions across the Sahel. The co-benefits of universal access to energy are vital for enabling countries in the Sahel to tackle socio-economic challenges and climatic threats. Although the access rates in the Sahel are among the lowest in the world, achieving universal access to both electricity and clean cooking by the end of the decade is still within reach. However, this would require unprecedented efforts and the piecing together of an integrated approach – building on and integrating renewable energy generation, improving grid extension, investing in off-grid and stand-alone solutions, developing clean cooking supply chains and focusing on efficient infrastructure and practices. There are sizeable opportunities as new technologies are scaling up, international markets and costs are shifting in favour of renewables and the potential for regional integration is increasing. To attract the investment needed to implement plans, enable market scale-up and secure long-term access gains, each country will require clear policies and strategies as well as strong regulation.

Status of access to energy and recent Covid-19 impacts

Today, more than 65 million people in the region live without access to electricity and 90 million still rely on the traditional use of biomass for cooking. Despite improvement in the share of population with access, population growth still outpaces the progress achieved over the last decade. As a result, there has been an increase in the number of people with no access to energy (Figure 2.8).

Figure 2.8 Population without access to electricity and to clean cooking in the Sahel



Source IEA, 2019a; World Health Organization (WHO) Household Energy Database.

The Covid-19 pandemic is putting additional constraints on energy access. Although the number of people without access to electricity in Africa has been constantly decreasing since 2013 – thanks to strong electricity access policies in countries such as Kenya and Ghana – the progress has recently been reversed. In 2020, the number of those lacking electricity in Africa rose to 600 million people, an increase of more than 10 million people from 2019, while 30 million people who previously had access can no longer afford basic energy services (IEA, 2020b,c).

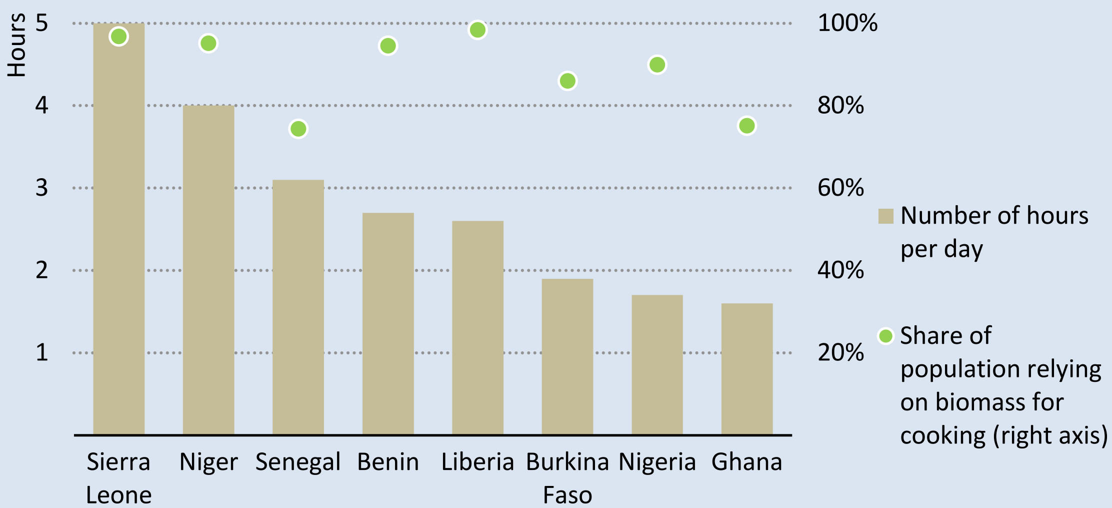
By cutting disposable income, restricting energy suppliers and affecting the investment outlook for companies, financiers and donors, the Covid-19 pandemic risks casting millions of people back into energy poverty, both within the Sahel and across the African continent. In response, most governments took measures in 2020 to increase the affordability of energy for households and businesses, including short-term provision of free or subsidised electricity and the suspension of bill payments (Akrofi and Antwi, 2020). A few countries even included specific Covid-19 measures for renewables, for instance Nigeria facilitated provisions from relief funds for renewable energy companies.

Access to energy can act as a catalyst for economic development and socio-economic well-being. Persistent lack of reliable and affordable access undermines countries' ability to tackle socio-economic challenges, inequalities and climatic threats. In addition, today's reliance on the traditional use of biomass comes with tragic consequences. Across sub-Saharan Africa, almost 500 000 premature deaths per year are related to household air pollution resulting from the lack of access to clean cooking facilities. Cooking with charcoal or wood also creates significant emissions of gases and black carbon, exacerbates forest degradation and jeopardises ecosystem stability and climate resilience (Chapter 4). Women and girls who are mainly responsible for collecting fuel and preparing food feel these impacts most acutely and bear the burden and loss of productive time (Box 2.1).

Box 2.1 Energy and gender in Africa, the case of traditional cooking

Women tend to bear the brunt of lacking access to electricity and/or clean cooking, often at the expense of their health, well-being and time. Women and children spend hours every day collecting firewood, a task that can take up to 10 hours per week (Clean Cooking Alliance, 2019). In many locations, women and children are walking ever-greater distances due to forest degradation and scarcity of wood fuel. In conflict settings, women face an increased vulnerability to physical attack when leaving their communities or refugee camps in search of fuels. UNHCR surveys in Chad have suggested that in almost two-thirds of refugee households, gender-based-violence problems have occurred when collecting firewood (Lahn and Grafham, 2015). Bringing attention to the gender aspect of energy access g is essential to reaching SDG 7. Women play a major role in enhancing electricity access and clean cooking solutions in their households and communities. They are central to the energy access and clean cooking value chain, from producing and distributing products to playing entrepreneurial and leadership roles in their households and communities. Ways must be found to accelerate the uptake of these solutions.

Average number of hours spent collecting fuel per day per household in selected West African countries

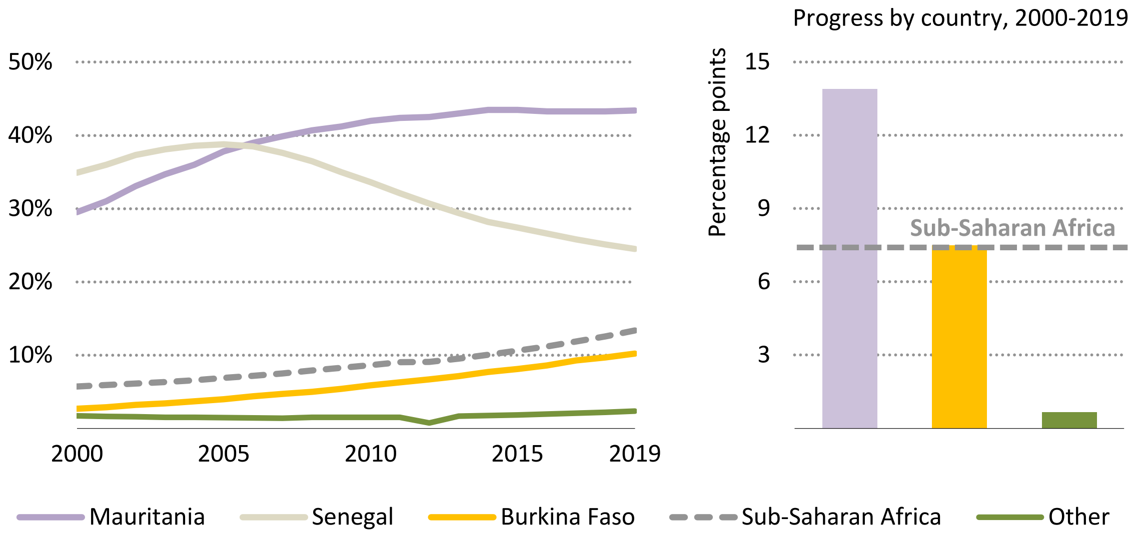


Source: IEA, 2019a.

Trends in access to clean cooking

The situation for cooking is very concerning as all countries except Senegal and Mauritania fall below the sub-Saharan average clean cooking rate. In the Sahel, 90 million people rely on traditional biomass for their cooking needs, one-tenth of the 900 million without access in Africa. As is the case globally, clean cooking access in the Sahel lags behind electricity access. While all Sahelian countries have pursued national programmes to increase access to electricity and clean cooking, and to reduce the traditional use of biomass, the national objectives have been constrained by the population growth rate outpacing the provision of clean cooking to households with low and vulnerable incomes. To date, only Senegal and Mauritania track above the sub-Saharan average rate for clean cooking access. Progress has been uneven across the region. While there have been rapid improvements in Mauritania in the first decade of the century, the recent change in Burkina Faso has occurred at a pace comparable to sub-Saharan Africa's average. In Senegal, efforts to deploy improved biomass cookstoves have reduced the consumption of biofuel per capita over the past decade, but the access to clean cooking rate does not reflect these improvements – due to methodology – and shows a decline (Figure 2.9). Mauritania's clean cooking strategy has relied on a robust planning framework with a heavy focus on awareness raising, a last mile distribution plan and the LPG policy ("butanisation") launched in 1991 (ESMAP, 2021).

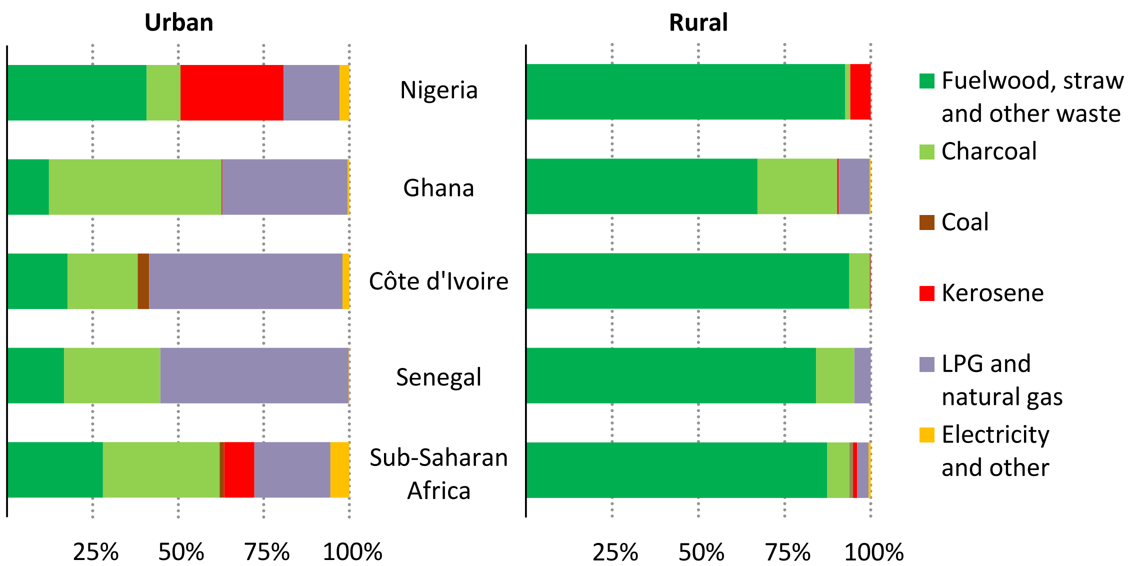
Figure 2.9 Access to clean cooking rates evolution and progress since 2000



Note: Sub-Saharan Africa excludes South Africa. "Other" regroups Mali, Niger and Chad where access rates are below 5%.
Source: IEA, 2021a.

A large range of cleaner cooking sources exists and is being adopted across the continent, depending upon policy choices and domestic circumstances (Figure 2.10). To reduce the prevalent reliance on the traditional use of biomass, several Sahelian countries promote the use of LPG. Over the past decade, the use of this fuel has almost doubled in the residential sector, although it remains low compared with wood fuel and charcoal consumption. Senegal pursued support for the production and sale of LPG by introducing subsidies in the late 1980s and then withdrawing them to allow a competitive market to develop. LPG is still exempt from taxes and duties in Senegal, while Chad and Niger, which produce their own supplies, both have policies to promote LPG. To date, success has been attained largely in urban areas, where there is distribution infrastructure. The penetration of LPG also depends on its price relative to the price of the other available fuels, taking into consideration both up-front investments and fuel refilling. Each country has different pricing mechanisms and canister sizes. The smallest size, at 3 kg in Senegal, was created to better enable affordability.

Figure 2.10 Primary fuels used for cooking by households in selected West African countries, 2018

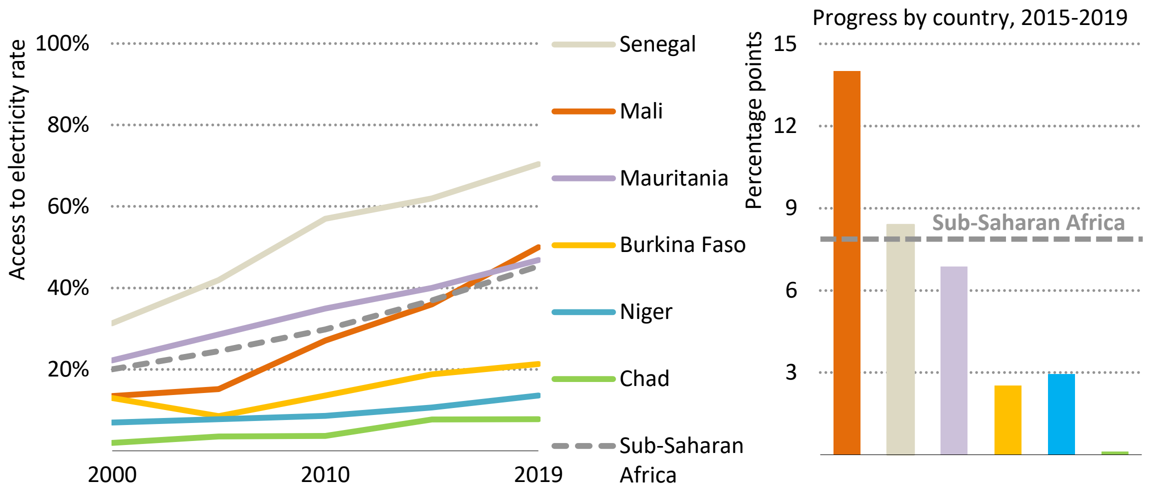


Note: Sub-Saharan Africa excludes South Africa.
Source: IEA, 2019a.

Trends in access to electricity

The region's access performance starts from a low baseline. In 2000 only one in seven people had access to electricity. Around one million people gained access every year, with a strong acceleration over the last decade, leading to an electricity access rate of 32% today. This is lower than the sub-Saharan African average electrification rate of 50%. Yet there are disparities: the recent progress in Mali has been stronger than the regional average, while more than two-thirds of the Senegalese population has access to electricity (Figure 2.11). As in other regions, access to electricity in urban areas is higher and has increased faster than the national average. The levels of access are very low in rural areas where two-thirds of the population lives. In Senegal or Mali, where a total of 15 million city-dwellers are connected to electricity, electricity is provided to almost all of the urban population.

Figure 2.11 Electricity access rates since 2000 and progress since 2015

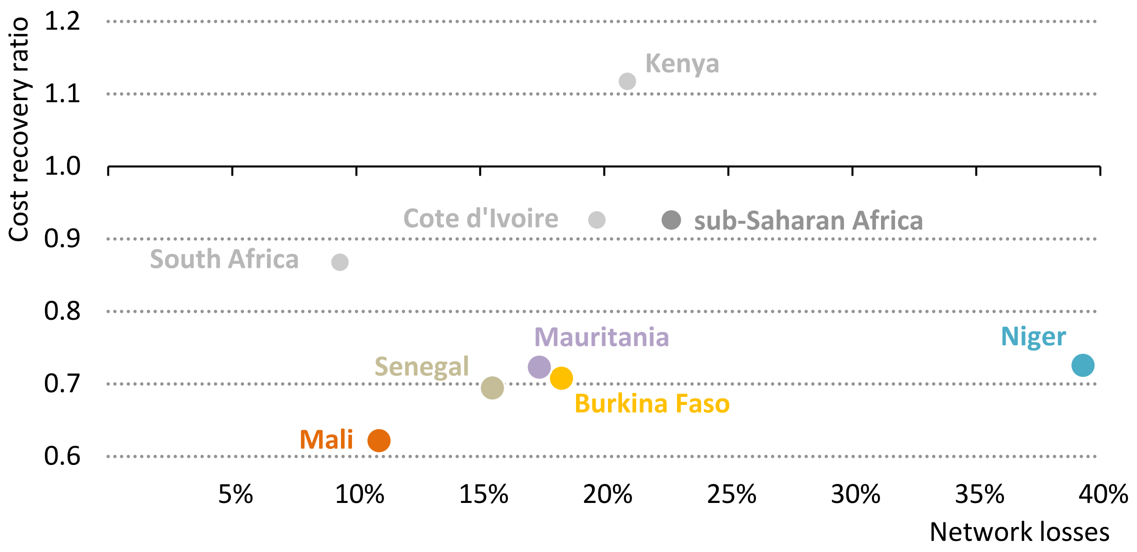


Note: Sub-Saharan Africa excludes South Africa
Source: IEA, 2020a.

The recent progress has been largely a function of the expansions of central power systems, although a number of initiatives have supported the deployment of mini-grids and solar home systems. Installed capacity in the region has more than tripled since 2000, and the per capita levels have almost doubled. Power systems are still heavily based on fossil fuels and to a far lesser extent on hydropower (in the case of Mali), but the integration of variable renewable sources of generation has steadily increased. Solar PV and wind together now contribute 5% of the electricity generated, and up to 15% in Mauritania, whereas they were absent in the power systems only a few years ago.

Central grids face significant challenges across the region, notably related to access to financing, creditworthiness of the utility and revenue collection, stability of grid networks and appropriate tariff structures. Such issues hinder progress in electricity access and power system developments. In Chad for example, the need to improve and expand the grid has slowed down the development of the new Djermaya solar plant (BNEF, 2020). As in many other developing countries, utilities present poor financial records and low-cost recovery, and the Covid-19 pandemic has exacerbated these pre-existing vulnerabilities further. State-owned utilities – which each of the six Sahelian countries have – have generally taken on greater debt in recent years, while facing more tenuous rates of collection. Covering costs is often very difficult for utilities with high network losses (Figure 2.12), a challenge shared by most emerging and developing markets. Tariff setting and good governance are critical, as poorly performing utilities are often subject to shortfalls from subsidised retail pricing and are not able to undertake effective system planning. In power systems where private participation is restricted, the difficulties in making a profit are often higher. Some measures which can boost the profitability of distribution companies over time include unbundling systems, developing private ownership in generation and injecting competition in wholesale markets (IEA, 2021b). Each Sahelian country is in the midst of planning and implementing reforms to address these weaknesses and foster investment. For example, Senegal and Mali have opened up the sector to allow independent power producers (IPPs), which sell electricity to the state utility. Burkina Faso, Mauritania and Chad are facilitating public-private partnerships (PPPs) in this area.

Figure 2.12 Utility cost recovery and network losses in selected African countries



Note: Cost recovery is the ratio of revenues to costs, including operating costs, depreciation and financing. A number of factors influence this ratio, including system costs; sales revenues; operational efficiency; the connecting, metering, billing and collecting from customers; and debt levels and financing costs. Losses include technical and non-technical losses in electricity transmission and distribution.

Source: IEA, 2021c.

Off-grid solutions have gained traction in recent years. Solar home systems and other stand-alone devices make an increasing contribution to the provision of reliable clean electricity. Even with the effects of the Covid-19 pandemic, sales of off-grid products in West Africa totalled close to half a million units between July and December 2020, one-fifth more than in the same period in 2019. Although lower than the volumes seen in other regions, West Africa was one of the few regions to show growth during this period, and some individual Sahelian countries like Mali and Burkina Faso reported a sales rise of around 50%, suggesting a "boom" in the off-grid industry (GOGLA, 2021). Companies advancing the off-grid agenda across West Africa are well informed of the needs and priorities of their customers. They are becoming increasingly sophisticated at meeting these needs through a variety of mechanisms. Notable examples include Pay-As-You-Go mobile banking-based pricing mechanisms that meet the needs of low-income populations and smart systems that allow for remote monitoring of product performance.

Compared to East Africa, the mini-grid industry is at an earlier stage of development in most countries of the Sahel. However, Senegal is reportedly one of the top countries in terms of the number of installed mini-grids, and recent changes to the governance of the Senegalese energy sector will aim to drive this progress further. In early 2021, the Rural Electrification Agency launched a tender for above 130 off-grid PV plants, aiming to boost the off-grid clean power supply.

Outlook: reaching universal access to electricity and clean cooking is challenging but possible with ambitious measures

More efforts are urgently needed to ensure progress on SDG 7 in the Sahel. In the STEPS, more than 80 million people will still lack access to electricity and close to 120 million to clean cooking in 2030. Only Senegal and Mauritania have set targets for universal access to electricity by the end of the current decade (Table 2.2), and in the STEPS, only these two countries will be successful in reaching universal access. Solid biomass remains a mainstay of the energy mix as a primary fuel for cooking because clean cooking policies lag population growth, resulting premature deaths and other negative impacts in the region.

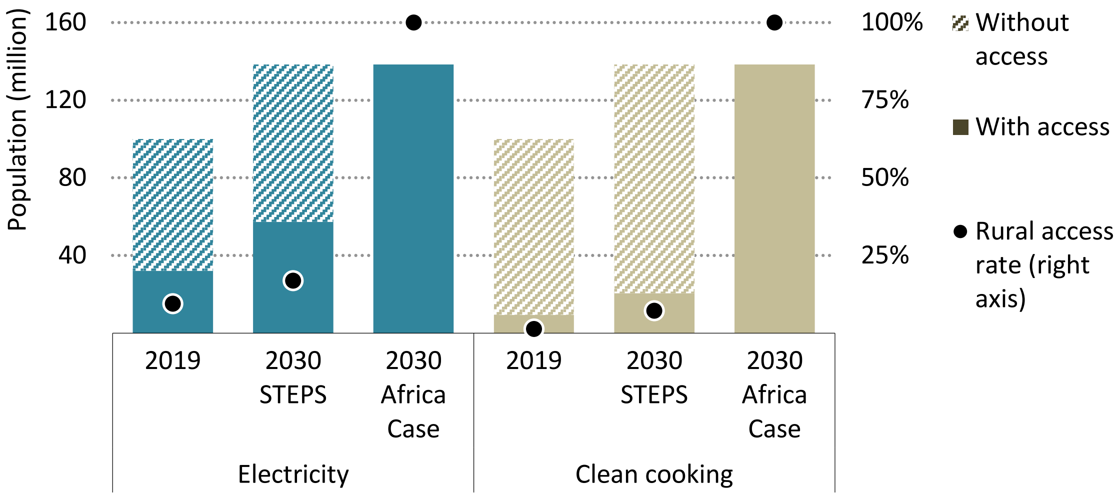
Table 2.2 Energy access targets for the six Sahelian countries

Country	Electricity access targets	Clean cooking targets
Burkina Faso	95% access for urban areas and 50% for rural areas by 2030.	Universal access in urban areas and 65% in rural areas, by 2030. LPG urban penetration of 68% by 2030[1]
Chad	30% access by 2023 and up to 53% by 2030. 20% rural access by 2030.	N/A
Mali	70% access by 2025, 80% by 2030 and 90% by 2036. 100% urban access by 2025. 31% rural access by 2025, 50% by 2030 and 55% by 2036.	Universal access by 2030.[2]
Mauritania	Universal access in urban areas and doubling of the current rate in rural areas by 2024. Universal access by 2030	100% access to LPG in urban areas and 50% access to LPG in rural areas by 2030.
Niger	Universal electricity coverage by 2035. Expansion based on the NIGELEC network (85%), mini-grids (5%) and distributed solutions (10%).	100% urban penetration of improved cookstoves (ICS) and 30% rural by 2030. Support to biogas and biofuels.[3]
Senegal	Universal access by 2025	Dissemination of 8.4 million ICS sold (cumul 2010-2030) Support to ICS efficiency, sustainable production of firewood, and diversification of domestic fuels.[4]

The Africa Case points the way to a brighter future, starting with the achievement of universal access to both electricity and clean cooking by the end of the decade (Figure 2.13). This will require a strategy that employs both grid extensions and off-grid solutions, as well as the substantial roll-out of modern cookstoves and support to clean cooking fuel supply chains.

[1] The Global LPG Partnership (2017). https://static1.squarespace.com/static/5633c4c2e4b05a5c7831fbb5/t/5acbc7d6562fa79982af9a6a/1523304406277/National+and+Regional+Targets+for+Clean+Cooking+Energy+Access+in+Africa+by+2030.pdf.
[2] SEforALL Africa Hub (2021), Mali Country Overview, https://www.se4all-africa.org/seforall-in-africa/country-data/mali/.
[3] SEforALL Network (2015), Niger Country Overview, http://www.se4all.ecreee.org/content/niger.
[4] GCF, 2019a,c, Accélération de l'adoption de solutions énergétiques de cuisson plus respectueuses du climat au Sénégal et au Kenya.

Figure 2.13 Access to electricity and clean cooking



Source: IEA, 2021c.

At present, a number of obstacles inhibit the rollout of clean cooking. Improved cooking solutions are unaffordable to many households, particularly in rural areas where available biomass does not incentivise the purchasing of fuel-efficient equipment. Moreover, customers have shown some reluctance to adopt new solutions – partly stemming from low awareness of the risks associated with traditional cooking practices (Hooper et. al., 2018), but also for many cultural reasons associated with taste, habit and trust in new products and vendors. In the STEPS, the Sahel is still home to 120 million people without access in 2030.

However, the cooking sector in the Sahel could be ready for transformation. Our Africa Case shapes a pathway to universal access that would enable almost 12 million people to gain access to clean cooking solutions every year. This vision would require unprecedented efforts in expanding LPG and electricity in urban areas, and equipment for modern biomass and biogas solutions in rural ones where the majority of the Sahel's population live.

Demand for more efficient solutions does exist, driven by the increasing scarcity of biomass in rural areas and higher prices in urban areas. Artisanal sellers dominate the cooking solutions markets across the Sahel. The potential for better manufacturing processes and more efficient cookstoves is immense, with improved supply chains and enhanced technical knowledge, access to finance and business skills. Several international manufacturers who are promoting aspirational goods under market-based innovative business models are now looking for distributors in the region. Recent progress in the standards for clean cooking devices now helps facilitate implementation, formalises the sector, drives product innovation and helps track progress towards policy objectives and outcomes.

The approaches to expanding clean cooking differ between urban and rural settings. Access to LPG and electricity for cooking can serve urban populations with higher income levels and a willingness to adopt transition fuels. Savings or credit schemes and subsidies are worth considering (Berkouwer and Dean, 2019), and the expansion of mobile money and digitally enabled solutions can also help make these options more accessible and affordable. In rural areas, transportation, storage and affordability will remain key constraints to LPG expansion. Enabling the safe, reliable delivery and refilling of smaller gas canisters has been a factor in most successful rural schemes as customers turn back to traditional fuels if there are supply chain bottlenecks or unaffordable prices (Cross et. al., 2019). Innovative methods can be considered to bring down transaction costs for traders and businesses. The UNHCR's partnership with Niger's regional government directorates illustrates how novel approaches can stimulate demand for LPG, provide an "anchor client" and also reduce costs for households and businesses. Opportunities to deploy electric cooking via efficient appliances are emerging with studies showing that electric pressure cookers powered by solar PV systems could cost-effectively improve access to clean cooking without putting additional pressure on the grid (MECS, 2020). Biogas or bioethanol could also have a part to play in many regions, depending on the availability of suitable waste products and pricing. Increasingly, individual equipment like bio- digesters and bioethanol cook stoves are deployed under private sector-led innovative business models or under government programmes. Other technologies are also becoming more affordable, especially for larger-scale batch cooking and water boiling for institutions like schools, clinics and for communal cooking (Aramesh et. al., 2019).

Lessons from clean cooking success stories in other parts of the world suggest that high-level policy support is critical to unlock finance, improve affordability and enable a sustainable business ecosystem. Scale-up of LPG adoption for example, has tended to occur in countries with a petroleum industry, where the national oil company has a mandate to assist with energy access and there is investment in supply chains. Enhancing demand can be done through awareness campaigns for increasingly urbanised populations. SPARK+ Africa Fund, an investment vehicle targeted at scaling up clean cooking solutions in Africa, supported by the African Development Bank and the European Commission is committed to developing clean cooking business ecosystems.

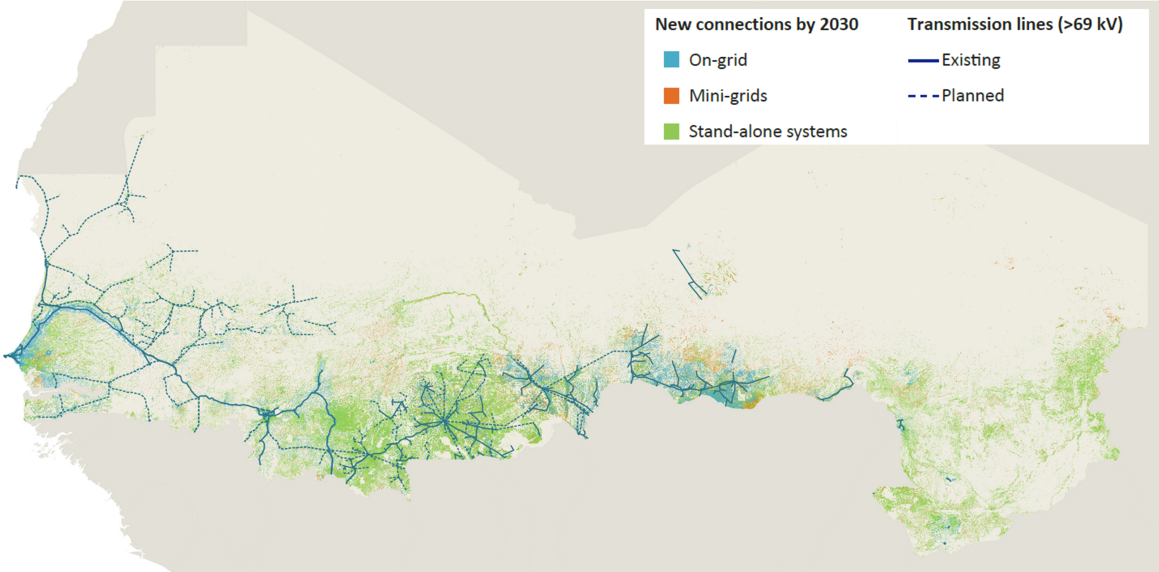
The outlook for access to electricity is more variable across countries, compared to clean cooking. Whereas our STEPS still projects 80 million people without electricity in 2030, 85% of whom are concentrated in Niger, Burkina Faso and Chad, the Africa Case envisions universal access.

Based on current plans, the region will need to scale up its generation capacity significantly. With the prices of renewable energy sources continuously falling, governments and utilities across the Sahel are adjusting their generation plans and a new wave of projects and partnerships promise increasing investments. In the STEPS, the power system grows from around 3.5 to 11 GW of installed capacity. Grid extension and densification, complemented by the deployment of mini-grids and solar home systems would extend the number of people with access to electricity from one-third today to 42% in 2030.

Nonetheless, reaching universal access by the end of the decade, as per the ambition of SDG7, is still possible. The Africa Case sees the entire 140 million population with access in 2030. This would require that the number of people gaining access every year rise from around one million today to 8.5 million on average between now and 2030. Electricity demand from the residential sector would then be multiplied by seven between 2019 and 2030, more than twice as much as in the STEPS. Growing electricity consumption demand is driven by the households' rising needs for appliances and services such as cooling, and by a more developed services sector.

As in other regions of the continent, deploying a combination of on- and off-grid new connections is crucial to reaching universal electricity access. In the Africa Case based on IEA geospatial analyses, expanding and densifying the grid would be the least-cost pathway for less than half of the 95 million people gaining access across the Sahel by 2030, especially in Senegal, Mauritania and Niger. However, national grids are not always the most cost effective and efficient solution for every community, especially in fast-growing and significantly rural populations. Given the geographical distances that separate many rural communities, and the financial constraints on-grid expansion plans, the expanded use of off-grid technologies and services is essential to the future of energy access in the Sahel. Mini-grids could account for one-third of new connections, mostly in Chad and Mali, where they would provide electricity to 75% and 50% of the population respectively. Stand-alone systems would be the most economical solution for 18 million people across the region, providing for example almost one in every three new connections in Burkina Faso (Figure 2.14).

Figure 2.14 Electricity access solutions by type in the Africa Case, in the Sahel



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.
Source: IEA, 2021a.

In all our scenarios, it is crucial that investment in developing and constructing new generation capacity is accompanied by investment in transmission and distribution infrastructure. To reach full electricity access in the continent, the expansion, reinforcement and maintenance of grids along with other power infrastructure will require half of total investments in the power sector by 2040 (IEA, 2019a). More system flexibility will be required to allow a new generation of renewable energy projects and higher shares of solar and wind to feed into the grid systems of the future. The principal components providing flexibility include a diverse mix of variable renewable sources, regional interconnections and battery storage, whose costs have fallen rapidly over the last decade. However, other forms of flexibility, such as pumped hydro storage and demand- side management, may also be appropriate depending on the region.

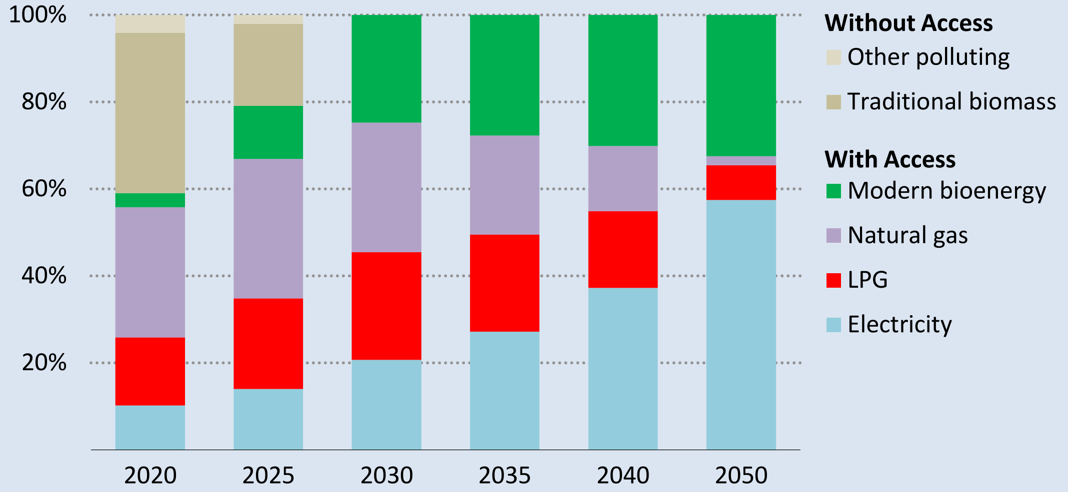
Equally pressing is the issue of grid densification – finding ways to ensure that all those living close to existing grids are able to connect and obtain access to electricity. Densification will help utilities throughout the region to secure the reliable revenue streams they need in order to reinvest in the system. The Sahelian utilities are keenly aware of this challenge. Many are exploring a range of methods to promote increased connections. Burkina Faso, Mali and Niger deploy a "lifeline tariff" that allows for large consumer savings when use falls below a certain kWh threshold per month. Mobile banking and smart metering technologies, as well as prepaid and Pay-As-You-Go systems, are enabling utilities in neighbouring countries such as Nigeria to collect payments more accurately and fairly. Across the continent in Rwanda, discounts are offered to rural households that organise themselves in a group, thereby offering a level of consumption that will justify connection. Other countries support inclusive rural economic development plans to foster electricity demand from small and medium enterprises.

Box 2.2 Access to clean low-carbon energy

For countries with part of their population living without electricity and relying on unclean cooking, efforts to expand energy access need not come at a cost to the climate. Energy access and climate goals can be aligned. A recent report by the IEAshapes a pathway for the world to reach universal access to both electricity and clean cooking by 2030 and net zero CO_2 emissions globally in 2050. The report proposes aNet Zero Emissions (NZE) scenario, in which almost one billion people gain access to electricity by the end of the decade, the vast majority via renewable sources. In sub-Saharan Africa, close to 60% of those gaining access benefit from off-grid solutions, and these mini-grids and stand-alone systems are almost exclusively running on solar PV. For those relying on grids, the emission intensity of their electricity depends on the power mix of the region. Sub-Saharan Africa would still generate around 55% of its electricity from fossil fuels in 2025 in the NZE scenario, but grids have the potential to gradually decarbonise to 2050. This requires that the right investments be deployed on time and that additional fossil capacity be avoided.

Clean cooking is more context-specific and full access requires a different set of solutions. In the NZE scenario, the use of improved cooking stoves and bio-digesters is the preferred solution in rural areas, while LPG is deployed in urban zones gradually until 2030. In the following decades, the mix of fuels for clean cooking continuously evolves and decarbonises. Electric cooking gains ground especially as new super-efficient devices such as pressure electric cooking make it possible to e-cook off-grid, with clean solar PV and storage systems. In the longer term, LPG infrastructures can also be used by renewable fuels, such as bio-LPG from municipal waste, and then CO_2 emissions related to cooking can be reduced with modern fuels (GLPGP, 2020). Moreover, replacing the traditional use of biomass with clean cooking solutions, including fossil LPG, carries net positive benefits in relation to climate change. The avoided emissions of CH_4, N_2O and black carbon related to traditional biomass cooking more than offset the emissions due to LPG cooking in most cases. Limiting the non-sustainable use of wood and charcoal also reduces the stress on forests and ecosystems.

Primary cooking fuel by share of population in emerging markets and developing economies in the NZE



Notes: Modern bioenergy includes improved cook stoves, biogas and ethanol. Liquefied petroleum gas (LPG).includes fossil and renewable fuel.
Source (IEA, 2021c).

Providing energy to displaced communities in the Sahel

Escalating violence and insecurity have triggered a crisis of displacement across the Sahel. In terms of energy, the displaced groups of people are among the most at risk of being left behind in the push for universal energy access by 2030 (Grafham, 2020). Internally displaced communities and cross-border refugees often face conditions of extreme energy poverty. Refugees use only the most rudimentary sources of energy for cooking and lighting and a significant percentage reported exchanging food items or skipping meals due to a lack of fuel (Corbyn and Vianello, 2018). Displaced people also report high frequency of gender-based violence when gathering or collecting firewood, and Covid-19 has clearly underlined the necessity of energy for health and sanitation in overcrowded camps (OECD, 2020).

The insecure and frequently remote conditions of displaced people, especially those who have crossed national borders, mean that they are usually not included in national energy transition plans. Yet, internal displacement and refugee status is rarely short-term as the average age of a refugee camp is eighteen years (Grafham and Lahn, 2018) and this offers opportunities for changing the status quo. In addition, displacement is driving urbanisation across the Sahel, as most of the Internally Displaced Persons (IDPs) in Mali live in urban and peri-urban areas.

This movement is particularly affecting "second cities" and puts pressure on services, but it also provides opportunities for concentrating and driving up energy consumption levels. It is critical to consider energy and environmental solutions in displacement settings that deliver long-term benefits to their residents, as well as the communities and cities that host them.

Humanitarian agencies are ramping up efforts to implement sustainable energy provision in their operations as a response to these conditions,[5] paving the way for collaboration with local and national governments. Refugee settings are normally perceived as the responsibilities of organisations like the UNHCR or the International Organization for Migration (IOM), dominated by free distribution and ruled by a complex set of interactions and permissions. However, host country policy measures and donor interventions can create favourable conditions for energy projects, for example by providing clarity about whether camps can or will be connected to a national grid.

When displaced people fall outside of national plans for energy access, opportunities to combine humanitarian aid and investment towards sustainable development targets are missed. The Sahelian countries are taking steps to avoid this and show their engagement in the Comprehensive Refugee Response Framework (CRRF). The government of Niger has afforded refugees the legal rights to work, study, access healthcare and finance, and raised the idea of providing housing for 40 000 refugees during the first-ever Global Refugee Forum held by the UNHCR in Geneva in December 2019 (UNHCR, 2020).

For refugee camps linked to or embedded within a wider community of villages or cities, sustainable energy projects for refugees can address the energy needs of locals. Large-scale solar projects built beside Azraq and Zaatari refugee camps in Jordan are examples of legacy assets that serve both displaced people and local communities. A solar hybrid mini-grid in the Kalobeyei refugee settlement in Kenya has also led to steadily rising power consumption for refugee households, businesses and host communities around the camp, and enabled the connection of two health facilities during the Covid-19 pandemic

A number of humanitarian agencies are moving beyond simple supply-led additions to basic services and moving towards the integration of energy access as part of a package of infrastructure and vital services that can better serve

[5] In its "Clean Energy Challenge" the UNHCR committed to "bringing affordable, reliable, and sustainable energy to all settlements of forcibly displaced people and nearby host communities by 2030 (source: https://www.unhcr.org/uk/clean-energy-challenge.html). The International Organization on Migration (IOM), World Food Programme (WFP) and Food and Agriculture Organisation (FAO) have also made significant policy changes to incentivise a greater focus on energy management and provision.

humanitarian objectives. In terms of clean cooking, the provision of LPG as a fuel has been tested in a collaboration between the UNHCR, the Government of Niger and SONIHY (a private Nigerien company) in the Diffa region of Niger. It was found to reduce air pollution impacts, reduce deforestation caused by a reliance on wood, and draw upon supply chains and local businesses that are already well established in the region (Patel and Gross, 2019). Of the 25 000 UNHCR-supported households, 70% continued to purchase LPG with no subsidy or other support after the programme formally closed. In the first 15 months alone, the full amount of EU funding for Soutien Energétique et Environnemental dans la région de Diffa (SEED) (around EUR 2 million) was recovered in savings from fuel purchases by people living in the region (Patel and Gross, 2019).

Cleaner cooking solutions and solar power can be more affordable and improve safety for displaced people. Although Solar Home Systems providers and clean cooking operations have not usually been able to run a business at market rates in displacement settings (Practical Action, 2021), their experience with supplying low-income communities could add significant value in humanitarian settings. The population density can be an advantage over dispersed rural markets that pose a challenge for nascent energy access businesses. Moreover, although not all displaced communities in the Sahel will be well placed to adopt market-based mechanisms for energy provision (for example those in active conflict zones), previous work in the Sahelian countries has shown that displaced people both want to and can pay for better energy provision. For example, in the Goudoubo refugee camp in North Eastern Burkina Faso, "two-thirds of residents surveyed expressed a willingness to pay for cooking solutions, indicating a potential customer base of 2 000 families and a market worth up to USD 270 000 per year" (Corbyn and Vianello, 2018). For larger investments such as solar mini-grids, the humanitarian system's single year funding windows make up-front investments or long-term contracts with the private sector difficult (Lahn and Grafham, 2015). However, new models are emerging, especially where there is government encouragement and financing linked to national SDGs and climate resilience (GPA, 2020). Recent analysis suggests that every dollar spent on better energy access for displaced people generates between USD1.40 and USD 1.70 in the form of employment, environmental benefits, productivity and time-savings (Shell, Dalberg and Vivid Economics, 2020).

Considerations for energy access in the Sahel going forward

Reaching universal energy access in the Sahelian countries will involve piecing together a mosaic of intersecting parts – building and integrating renewable power, grid extension, off-grid and stand-alone solutions, clean cooking supply chains and efficient infrastructure and practices. To attract the necessary investment to implement plans, enable market scale-up and secure long-term access gains, each country will require clear policies and strategies and strong regulation. Policy considerations for achieving SDG 7 during the Sahelian countries' clean energy transition include:

- **Pursue a holistic approach to electrification planning:** To meet their ambitious energy access targets, countries across the Sahel will have to expand and densify their electricity grids at the same time as harnessing the potential of mini-grids and off-grid technologies and services. Doing so will require countries in the region to:
  - Develop and continuously improve on a national electrification strategy which addresses the institutional, technical and financial aspects;
  - Continually build the data on national consumption and costs;
  - Focus on densification to ensure that those within reach of existing grids are able to access power;
  - Improve revenue collection and affordability, learning from a range of innovative models and technologies being deployed by others;
  - Provide clarity on-grid extension plans and incentives to allow greater certainty for investors, developers and businesses.
- **Re-energise the "clean-cooking" situation**: This can be done by understanding local community practices, existing fuel sources and costs and the necessary supply chains that will be needed to supplant the status quo. For example, Botswana offers experience in rolling out LPG to rural populations, while ongoing experimentation with electric cooking in South Africa, Tanzania and Ethiopia is worth observing.
- **Encourage productive uses**: Experience from around sub-Saharan Africa suggests that populations across the Sahel will benefit most from newfound access to power when they are able to use it to enhance their existing economic activities and start new ones. This will both improve their ability to pay and enable long-term, reliable demand.
- **Focus on optimising and enabling increased on-grid renewable energy**: This can be achieved by investments in national grids that encompass transmission, distribution and regional interconnection; as well as setting up progressive incentives.

- **Ensure that off-grid industries are well supported and well regulated**: This will be crucial, particularly as the sector emerges from the impacts of the pandemic. It will be possible to learn from the ongoing experiences of mini-grid development in Kenya, Tanzania and Senegal (particularly on regulation, tariffs and sizing to anticipate growth over time). Stand-alone devices will need the right incentive structures, standards and – crucially distribution networks to ensure that quality products reach the people who need them most.
- **Consider policies for enhancing energy access within displaced communities:** Energy access in displacement settings should be thought of in terms of long-term needs and solutions given the average length of displacement conditions. A country's broader plan and regulations for energy access or a sustainable energy transition are key. Countries and donors can encourage energy access organisations and businesses to work on clear energy needs in humanitarian settings by making data and information available and by providing incentives to move into these locations.
  - **Make information and data available:** Countries and international partners can engage in enhanced data exchange on key energy access indicators to improve monitoring progress and understanding developments.
  - **Apply innovative, co-ordinated approaches in humanitarian settings to meet needs:** Humanitarian agencies and actors can involve energy access solution providers in humanitarian settings by providing energy as part of a package of infrastructure solutions. Where sustainable solution providers are not able to run a business at market rates in displacement settings, humanitarian organisations can leverage future energy interventions through co-ordinated approaches (e.g. non-conditional cash transfers and energy subsidies).
  - **Utilise SDG and climate financing:** Larger investments such as solar mini-grids for communities can be enabled by allowing models based on SDG and climate resilience financing, which can provide legacy assets for hosting communities, thus supporting humanitarian objectives and realising longer-term energy ambitions for the hosting country.

2.3. Accelerating deployment of renewables (SDG 7.2)

Renewable forms of energy (notably wind and solar) have tremendous potential in the Sahel and governments in the region are increasingly integrating them as a central part of their energy transition strategies. With the right mix of policy measures and financial support, the renewable energy sector can bring about transformational change, but a new scale of progress is needed on SDG 7.2. The value of renewables to meet energy access targets require the piecing together of an in integrated approach – building on and integrating renewable energy generation, improving grid extension and interconnections, and investing in on-grid, off-grid and stand-alone solutions. A vast future for renewable energy in the Sahel.

Renewables will play a central role in the Sahel's future energy systems and are critical for achieving SDG 7. All countries in the region have abundant renewable energy resources. They receive some of the highest solar irradiation in the world and show excellent potential for practical solar PV power. There is also a huge potential to develop wind, hydro and sustainable biomass in the region. While hydropower remains the principal source of renewable power, accounting for 12% of the region's electricity and almost 40% in Mali, all countries aim to harness sources and increase share of these in their energy mix. New technologies are scaling up, international markets and costs are shifting in favour of renewables, and the potential for regional integration is increasing. To attract the necessary investment to implement plans, to enable market scale-up and secure long-term access gains, each country will require clear policies and strategies as well as strong regulations. All six countries are looking for renewable energy solutions to both diversify their energy mix away from reliance on fossil fuels, and achieve their energy access targets (Table 2.3).

Table 2.3 National renewable energy targets

Country	National renewable energy targets
Burkina Faso	To increase the share of renewable energy in total electricity production to 50% by 2030.
Chad	To reach a 20% share of renewable energy in national electricity production by 2030.
Mali	To increase the share of renewable energy in the energy mix to 59% by 2025, 64% by 2030 and 70% by 2036.
Mauritania	To increase the share of modern renewables in the energy mix to 60% by 2030.
Niger	To reach at least 30% of the energy balance from renewable energies by 2030.
Senegal	To achieve 30% of electricity production from renewable energy sources by 2020.

Renewable energy provides the Sahelian countries with the opportunity to find development models that avoid the high-carbon choices pursued by other economies in the past. With SDG 7 in mind, many new renewable energy projects have been started in recent years, several of which have materialised in recent years (Chapter 1). Most recently Senegal brought online two solar PV plants through the IFC Scaling Solar program in May 2021 and the following month, Niger joined the same programme to accelerate uptake of solar PV projects in the country.

The implementation of renewable energy projects is also pushed at the regional level through important initiatives on regional system planning and coordination for project development at scale. The G5 Sahelian countries (*Burkina Faso, Chad, Mali, Mauritania and Niger)* endorsed the Desert to Power initiative to harness the solar potential of the region alongside five key priorities: increasing on-grid solar generation capacity; strengthening transmission and distribution; rolling out decentralised solutions at scale; reforming national utilities; and strengthening the policy, legal and regulatory framework. Building on the initiative, all five countries adopted national roadmaps in 2020, collectively envisaging 10 GW of additional capacity. Some 85 priority projects were identified, including over 2 GW of solar PV, with associated investment of USD 3 billion. A few projects have also been approved for financing by the African Development Bank (AfDB), though realising the scope of the initiative will require much greater mobilisation of resources and a high degree of coordination between public and private entities.

Interconnections are pivotal in maximising productivity in the energy sector

Regional interconnections will also be vital to optimising generation capacity, increasing reliability and facilitating the full potential of renewable energy. Good regional coordination and integration across the G5 (Burkina Faso, Chad, Mali, Mauritania and Niger) are not always perfectly reflected in regional energy regulations or energy markets. This becomes a challenge as questions arise as to whether investment would be more effective in regional programmes or through a country-by-country approach. Nonetheless, regional power sharing is crucial for the region, with all countries emphasising the desire and need to improve current interconnections. Mali, Mauritania and Niger, for example, are all keen to strengthen their energy-import capacity, especially to the main consumption hubs. For Senegal, the long-term objective is to develop the country’s natural gas resources and renewable energy capacity to become an energy hub for both electricity and natural gas. All countries in the region, except Chad and Mauritania, are members of the WAPP, which has enabled connections from Burkina Faso to Ghana and from Niger to Nigeria as well as joint projects around the Manantali Dam in Mali.

Building a reputation for strong regulatory frameworks

Enabling grid, off-grid and mini-grid connections means addressing affordability, subsidy and regulatory frameworks. The Sahelian countries are pursuing a raft of regulatory changes as they attempt to transform their power sectors and create the right business models and regulatory frameworks that will accommodate the energy systems of the future. Building a reputation for strong, stable regulatory frameworks will be essential for Sahelian countries to attract the investment they need across generation, transmission infrastructure and distribution. Doing so is also essential for providing the requisite enabling environment essential to promote the burgeoning off-grid technologies and services across the Sahel. Over the past decade, the countries in the Sahel received less than 2% of global renewable energy finance flows from development financial institutions (IRENA, 2021). The off-grid industry however is showing signs of progress. Utility-scale solar PV projects are emerging across the region, and a range of large finance initiatives has since emerged targeting energy or energy- related infrastructure.

Experience from around the world suggests that a national electrification strategy, which addresses the institutional, technical and financial aspects involved in electrification, usually underpins success (IEA, 2019). In the Sahel, both Mauritania and Chad still lack such a central planning document, although Chad has recently announced an “Emergency Plan for Access to Electricity 2020-2023”. Senegal also has a similar overarching strategy and its action plan has been adopted, demonstrating its role at the forefront of policy innovation.

To implement such strategies, countries need a certain level of institutional capacity and the right regulatory framework (Box 2.3). Several Sahelian countries – such as Mali and Mauritania – have appropriate legal frameworks in place but are still developing the financial and regulatory incentives to encourage renewable energy deployment at scale. Others are also taking steps to improve the overall policy environment. In 2018, Chad established an action plan and target for renewable energy, one that included measures to integrate renewable energy into electricity generation and transmission planning, as well as a legal framework for private sector ownership of generation. Despite its low rates of access and early stage of regulatory development, Chad was the “fastest climber” globally in the World Bank’s 2020 report on regulatory indicators for renewable energy policy (ESMAP, 2020).

Box 2.3 Senegal's electricity sector journey

In Senegal, major electricity sector reforms at the turn of the century saw regulation and renewable energy responsibilities removed from the portfolio of the national utility, SENELEC, and assigned to two new institutions: the Electricity Sector Regulatory Commission (Commission de Régulation du Secteur de l'Électricité) and the Senegalese Rural Electrification Agency (Agence Sénégalaise d'Électrification Rurale, ASER). Established through law nr. 98-29, ASER was given sole responsibility for promoting renewable energy, providing financial and technical assistance; coordinating tenders and proposals from private operators; and supervising contracted installations.

ASER administered the Senegalese Rural Electrification Action Plan (Plan d'Action Sénégalais d'Électrification Rurale, PASER) which was established in 2002. This 20-year strategy sought to mobilise private sector investment in RE through both a top-down approach for relatively large microgrids and a bottom-up approach for entrepreneurs to build small microgrids in rural areas (Mawhood and Gross, 2014). Senegal's government divided the country into ten electricity concessions (6 of which were subsequently awarded), which are bid-for and run by private sector firms. To make each project commercially viable, ASER provided a fixed, predetermined subsidy to help finance the high, up-front connection and installation costs associated with rural electrification projects. This was complementary to the law on renewable energy of 2010.

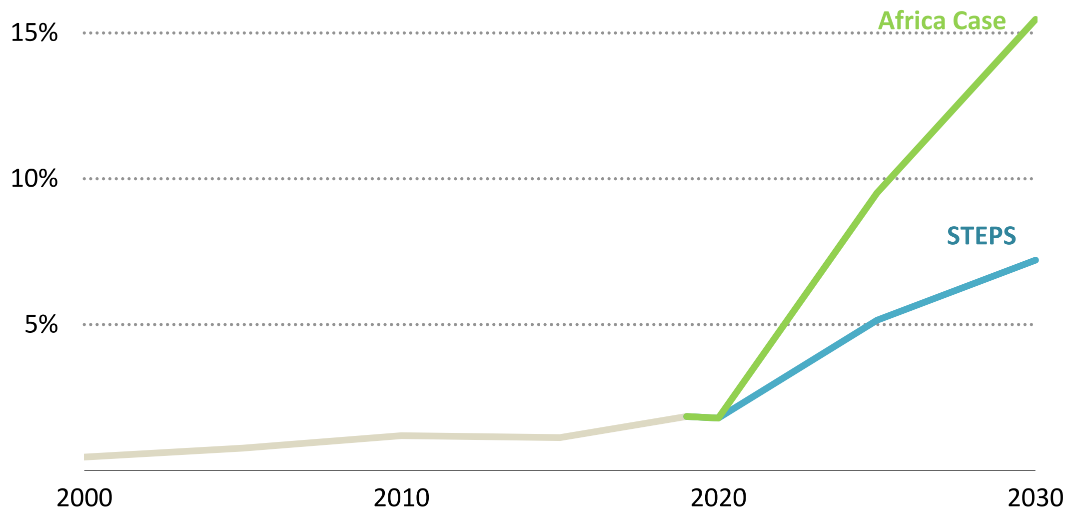
Since the establishment of PASER, Senegal has largely kept track with energy access targets set for itself in 2002. The plan has been lauded for the scale of finance mobilised and the number of development organisations who were keen to collaborate (Mawhood, 2012). However, progress from directly initiated projects has been slower than expected: in ten years, 2002-2012 PASER realised more than 6 000 electricity connections (Mawhood and Gross, 2014) and rural electrification rates remained lower than hoped. The slow progress of the main projects – and the persistent inability to reduce the inequalities between rural and urban areas – disappointed stakeholders and meant that political support was often minimal or mixed. PASER's overlapping areas of authority also reportedly created political tensions with SENELEC. Yet, it is acknowledged that PASER had opened doors by mobilising interest in a sector previously neglected by investors.

In the period since 2015, PASER has been replaced by The National Rural Electrification Program (PNER), which was approved in 2015 and subsequently replaced by an Operational Programme for Universal Electricity Access (POAUE), which came into effect in 2020. The financing of the POAUE was estimated at CFAF 660 billion, and the programme has been designed to electrify the remaining villages and areas, including the most remote ones. PASER's initial target was for universal access by 2023. However, in the Plan Sénégal Emergent (PSE), which was launched in 2020, the government pushed this target date back by two years to 2025. The overall objective of the POAUE is to ensure electricity coverage for 100% of Senegal's villages by 2023 and – through a densification strategy - universal access by 2025. The plan aims to create an ambitious backbone for the national grid with network extension reaching 8 444 localities and 225 600 households, alongside a mini-grid programme that will reach 1 019 localities and 4 730 households.

Outlook: modern renewables are pushed further in the Africa Case, driven by solar in the power sector and by modern cooking fuels and stoves

Modern renewables grow in both the STEPS and the Africa Case, as more and more renewable solutions are cost-effective and widely deployable. However, focused policy interventions in the Africa Case drive modern renewables much further by 2030. Most of renewable energy growth in the Africa Case comes from displacing traditional use of biomass in rural areas and the increased share of renewables in the electricity mix . Renewables' share of modern energy in the Africa Case increases together with growth in the power sector, solar in particular, and exceeds 15% in the coming decade (Figure 2.15).

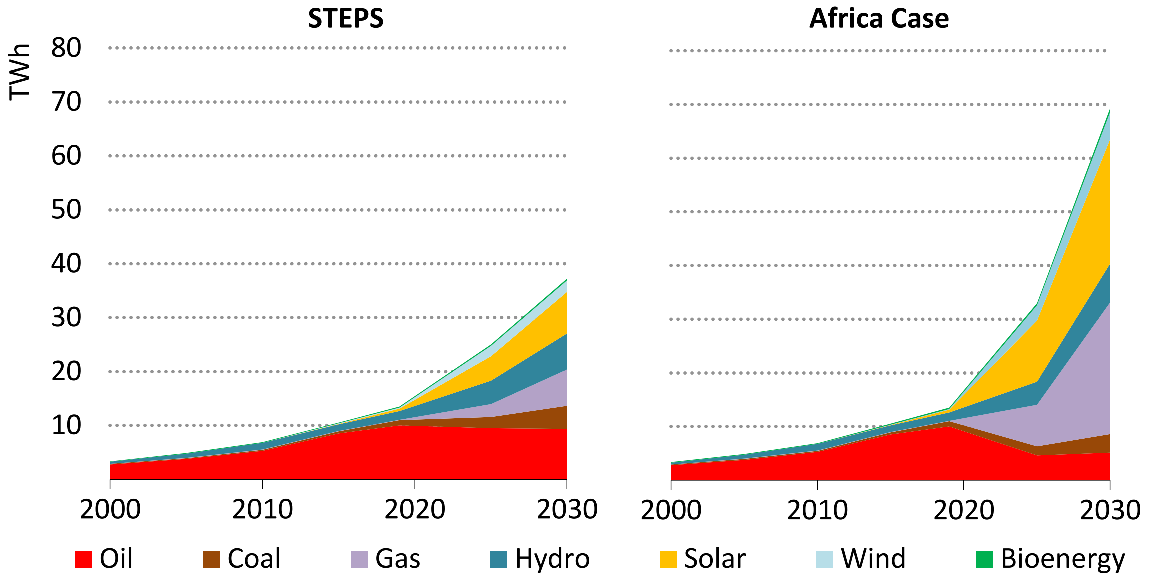
Figure 2.15 Share of modern renewables in total final energy consumption



Note: "Modern renewables" refers to renewable energy excluding the traditional use of biomass.
Source: IEA, 2021.

The growth in renewable electricity goes towards displacing oil generation, reducing total costs for customers and being the major source of decarbonisation in the Africa Case over the STEPS (Figure 2.16)Oil, mostly in the form of heavy fuel oil, represents three-quarters of the electricity generation today. It is expensive to run, and often relies on subsidies in regions where it is the primary source of power, even in producer economies. However, oil-based electricity generation is common in areas with less developed electricity networks and can ensure a more continuous supply of electricity. Accordingly, in the STEPS, fuel oil maintains its role, despite its high cost and pollution, because the supporting fuel delivery infrastructure for gas and electrical grid investments are insufficient to allow for cheap solar and gas to displace fuel oil. In the Africa Case, a large outgrowth in robust, interconnected infrastructure allows for this transition, driving fuel oil to 7% of the electricity mix.

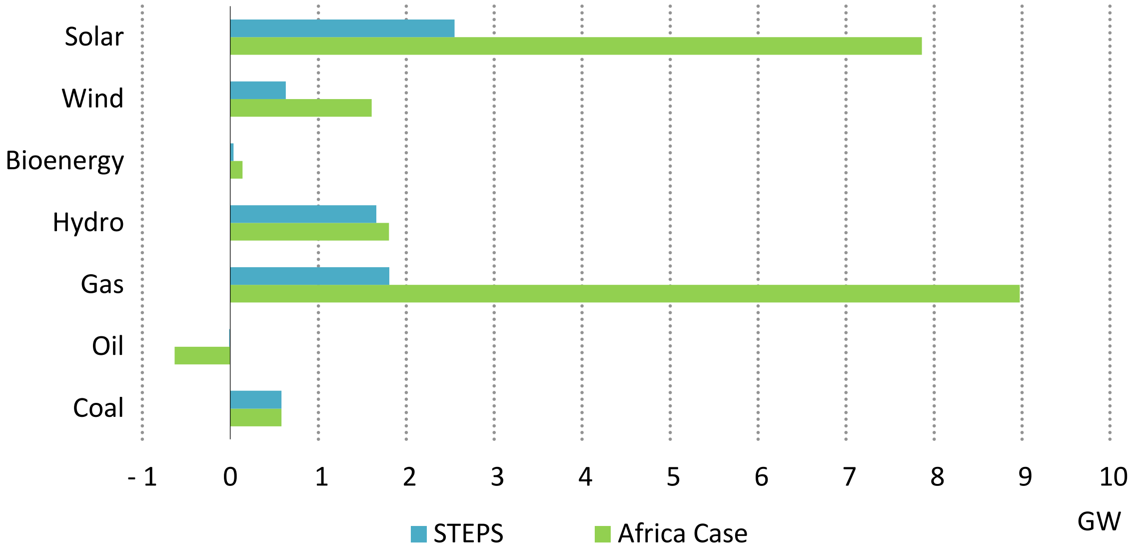
Figure 2.16 Power generation by fuel in the Sahel



Source: IEA, 2021.

Renewables exceed 50% of the total electricity mix by 2030 in the Africa Case, up seven percentage points or 20 TWh over the STEPS. However, this actually equates to more than twice as much renewable capacity given the substantial electricity demand growth in the Africa Case. Renewable capacity grows more than fossil capacity in this decade in the Africa Case, with solar growing the most of all renewable capacity (Figure 2.17).The Sahel reaches 8 GW of solar PV by 2030 in the Africa Case, up from only 0.25 GW today. Gas generation capacity grows rapidly to help support variable renewable integration, but also plays an important role in displacing fuel oil generators and ensuring reliability in the region, which was previously subject to power cuts when neighbouring grids faced system security issues. The total investments required to develop power generation capacity average USD 3 billion per year in the Africa Case and more than USD 1 billion per year in the STEPS.

Figure 2.17 Evolution of installed power capacity by fuel between 2019 and 2030



Source: IEA, 2021.

Considerations for renewable energy in the Sahel going forward

In order to tap the full potential benefits from renewable energy for the Sahelian countries, decision makers should combine a roll-out of regulatory, information and incentive measures. As experience grows, there is scope for more ambitious efforts to achieve each country's renewable energy objectives in the region. Continuing development of the policies, coupled with an increasing level of ambition, can make the region a global centre of faster renewable energy growth if certain challenges are addressed.

- **Address key bottlenecks for large-scale deployment of renewables:** Overcome barriers by introducing regulatory and policy frameworks that can lead to bankable projects for subsequent investments. Improved regulatory frameworks and effective policy design can facilitate faster growth.
- **Enhance access to affordable financing for renewable energy projects**: access to affordable financing and risk reduction measures at scale is needed for both large-and small-scale deployment. There will be increasing learning from a

number of multi-stakeholder initiatives address the capital investment gap and the participation of international public institutions and development banks remains crucial to developing the market and crowding in private sector financing.

- **Invest in grids and networks:** The Sahelian countries should focus on improving the ability of national grids to absorb larger amounts of variable renewable energy. They should also improve regional coordination through interconnections and trade.

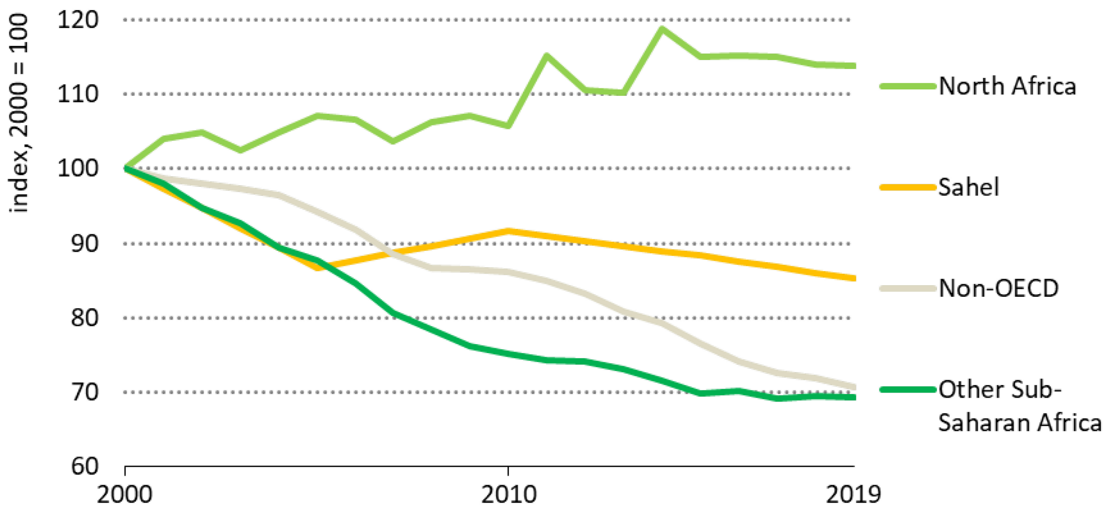
2.4. Making progress with energy efficiency (SDG 7.3)

Energy efficiency will be central to achieve transition pathways in the Sahel. Addressed in SDG 7.3, energy efficiency remains the largest area in which improvement is required with respect to SDG 7 in the Sahel. Making progress on energy efficiency is essential for the Sahelian countries to achieve their energy transition and development goals without reverting to a high-carbon pathway. Despite countries' high ambitions on energy access and renewables, progress with energy efficiency has been slow across the Sahel, necessitating further dedicated efforts to implement sectoral energy efficiency policies. Improvements will be central to achieve transition pathways. Clear opportunities and "low-hanging fruit" exist in the power, transport and buildings sectors and subsectors to help countries efficiently meet energy demand growth, lower energy expenditures for households, create jobs and improved competitiveness. Countries should develop a tailored approach to efficiency by combining a roll-out of regulatory, information and incentive measures as well as adapting best-practice policy recommendations that have proven effective in other countries.

Recent energy efficiency progress

Despite ambitions set for energy access (SDG 7.1) and renewables (SDG 7.2) by the Sahelian countries, the progress with energy efficiency (SDG 7.3) needs greater attention. Energy intensity in the Sahel is relatively low, compared to the average in other sub-Saharan regions and non-OECD countries. Over the past two decades, energy intensity in Sahel has been decreasing but progress in recent years has slowed down. It also compares unfavourably with other regions, as energy intensity dropped by an average 1.9% per year in other parts of sub-Saharan Africa and in non-OECD countries, a rate three times above the one in the Sahel (Figure 2.18).

Figure 2.18 Energy intensity evolution in the Sahel



Note: Other sub-Saharan Africa includes other countries in sub-Saharan Africa excluding the Sahel.
Source: IEA, 2021.

Opportunities for energy efficiency improvement in the Sahel

Energy efficiency is central to all energy development and transition pathways. Known as the "very first fuel", energy efficiency represents the fuel that has not yet been used and brings about a range of benefits. Increased energy efficiency of products and services provides economies, communities and businesses with less energy-intensive and more cost-effective options. Enhanced energy efficiency can help reduce the pressures on national energy supplies that accompany growing energy demand while decreasing pressure on public budgets. In turn, demand-side management frees up production capacity, ensuring a more stable energy supply. The drive for efficiency is known to create good quality jobs, while also improving the resilience of national climate change targets and strategies.

Regulating and enforcing efficiency standards and increasing them in a practical way over time are needed, and setting targets can reduce any transmission losses. "Product dumping" is a problem for many developing countries – including in the Sahel – whereby sub-standard or used energy consuming goods such as lighting, air conditioners, white goods and vehicles are brought onto the market because they cannot be sold in other places.

The ECOWAS region, which covers four of the focus countries, has a Regional Energy Efficiency Policy which targets reducing energy intensity by 4% each year and offers support for country policy and capacity building (ECREEE, nd). The initiatives focus on replacing inefficient lighting, cooling, reducing losses in electricity distribution systems, aiming at access to clean efficient stoves for all, implementing standards and labelling for equipment and developing region-wide efficiency standards for buildings. ECOWAS is also coordinating the first-ever African regional fuel efficiency roadmap – a significant step for the 15 member countries. Many opportunities appear for the Sahel when looking at sectors where energy demand will grow. This will translate into higher energy use that could be offset if energy efficiency is enhanced. A few practices and low-hanging fruit opportunities can be observed in the region, notably in the area of product efficiency, cooling and transport.

Opportunities for energy efficiency in buildings

Most of the anticipated increase in energy demand in the Sahelian countries is related to households and buildings. This is why it will be vital that energy strategies consider building codes appropriate to the region. Energy efficiency can help save in the typically carbon-intensive building sector, in a region where urbanisation and demographic growth will put strong pressure on buildings and composites like steel and cement. There is ample scope for innovation in applying both modern and traditional techniques and materials to increase safety and comfort-levels, while reducing the need to consume energy. With the length of annual and diurnal hot spells likely to increase, the demand for cooling and refrigeration will rise with living standards, and this must be a focus for integrated energy planning in the region (Box 2.4).

Box 2.4 Cooling, a fundamental element of clean energy transitions in the Sahelian countries

Without efficiency improvements, the IEA estimated in its Africa Case that a combination of climate change and urbanisation would increase energy demand for cooling appliances in Africa tenfold between 2018 and 2040 (IEA, 2019). The Sahel is warming faster than the global average. Longer periods of extreme heat are forecast, with temperatures already reaching 50°C in some parts of the Sahel. At the same time, meeting the SDGs and achieving country development targets means building many more homes as well as warehousing, office and factory buildings – for which cooling will be needed. Cooling plays an indispensable role within the energy transition, as it ensures food security, productivity and human well-being.

Dense urban build-up can create a “heat island effect” which further increases temperatures (IEA, 2018). In the Middle East, a region that faces similarly high temperatures, cooling accounts for around two-thirds of a building’s electricity demand. This has led to surges in oil and gas consumption over the last few decades as population and urbanisation grew rapidly (Lahn et. al., 2013). Building codes around cooling for example will play an important role in lowering this demand. Several countries including Saudi Arabia and the United Arab Emirates are working to retrofit houses, hotels and office blocks that were designed inefficiently and inappropriately to the climate. In turn, the Sahelian countries have a greater chance to build differently, avoiding expensive retrofitting. Sustainable “cooling services” as part of energy service company approaches also offer the opportunity for job creation.

Science and practice in green urban planning, architecture and materials is evolving rapidly with demonstration projects in arid climates, combining the use of modern and traditional techniques and materials to create liveable temperatures. Incentives can be put in place for appropriate building regulations and standards, and subsequently be enforced. Governments can foster the demonstration and application of passive techniques and materials - see for example, the Habitat Centre for Research and Development in Katutura, Namibia (BMU, 2009). Heat-insulating local materials and techniques such as bamboo, typha concrete and super adobe offer the potential to grow national industries; painting roofs white reflects heat; in large buildings, sensors can increase comfort and efficiency, while trees provide an important natural cooling effect in the cities. Spreading awareness about efficient air-conditioning use and the need for maintenance of the equipment can be helpful, as simply regular cleaning can save over a third of the energy consumption.

Appliance standards and compliance are also critical to implement. In 2013, all ECOWAS countries agreed to develop regional standards for appliances, including air conditioners and refrigerators (Kappiah, 2019). The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), the NGO (non-governmental organisation) CLASP (Collaborative Labelling and Appliance Standards Program), and the Kigali Cooling Efficiency Program (K-CEP) across the continent in East Africa are mandated to help countries implement national energy efficiency policies. Meanwhile, incorporating cooling into the NDCs can help attract the necessary finance. For example, Burkina Faso received a K-CEP grant in 2020 to improve the efficiency of cooling solutions as part of its long-term climate plans. Such initiatives are also key for regional learning and exchange. CLASP has developed a Regional Product Registration System (PRS) and information-sharing platform that initially covers air conditioners and refrigerators but can be expanded to other products (CLASP, 2020).

Opportunities for energy efficiency in transport

The setting of road and fuel efficiency standards for vehicles is an effective way to improve fuel consumption efficiencies. Examples include regulating for progressive efficiency in the vehicle fleet as ECOWAS countries are currently doing, and by introducing mass urban transport services as well as facilitating the switch to compressed natural gas (CNG) or electric mobility. In East Africa, for example, Rwanda's government is working with car and electric services companies to put in place electric charging infrastructure in Kigali.

Vehicle use in the Sahel is increasingly driving the growth in oil demand. Vehicle and fuel efficiency standards are critical to slowing this growth and should be implemented in coordination with both regional industry and urban planning regulation. Such measures will help curb not only the growth in CO_2 emissions, but also the growth in other pollutants such as nitrous oxide (N_2O), sulphur dioxide (SO_2) and carbon monoxide (CO), which are emitted by internal combustion engine (ICE) vehicles. These pollutants are known to contribute to respiratory and heart illnesses and can increase susceptibility to infection (WHO, 2020).

In February 2020, all the countries of the ECOWAS region, which includes Burkina Faso, Niger, Mali and Senegal, adopted the continent's first regional fuel efficiency roadmap. The plan aims to shift the average fuel economy of all newly imported light vehicles to 5 litres of gasoline equivalent per 100km by 2025 and 4.2 by 2030. This represents an improvement by 35% over the 2015 regional averages and will involve restricting imports for all vehicles coming into the region from January 2021. The presence of sulphur in fuel impairs the effectiveness of emission control elements and also causes pollution. Hence, governments have also adopted new standards for imported fuel of 50 ppm sulphur for both petrol and diesel fuels from 1 January 2021. Refineries, including the one in Niger, were given until 1 January 2025 to upgrade their facilities to produce 50 ppm S fuels (GFEI, 2020). Standards for gasoline and diesel for vehicules are low, and a combination of lack of enforcement and ageing vehicles may result in high levels of pollutants.

The new standards, if enforced in the coastal countries, will also have a positive impact on neighbours who import from them. Most diesel vehicles and diesel fuel supplies in Burkina Faso for example, are imported from Côte d'Ivoire and Senegal. Without strengthening customs regulations for imported vehicles and fuels and developing regional vehicle industries, the Sahel will continue to be a market for old, ICE vehicles from Europe, Asia and parts of North Africa and for low-grade fuel from the Middle East as refineries seek markets for their lower quality products.

In 2017, the first regionally manufactured cars were exported from Nigeria to Mali, which suggests the opportunity to develop a regional vehicle industry and trade. However, this should be coupled with urban and transport planning to ensure that rising individual vehicle ownership does not result in heavy traffic, polluted air and higher business transaction costs in cities. The existing dependence on walking, bicycles, motorcycles and shared taxis and microbuses could form the basis for a different vision with urban centres and roads designed around people's needs rather than increasing traffic (Mwaura and Kost, 2017). Dakar and Ouagadougou both plan bus rapid transport (BRT) systems and lessons can be drawn from the Abidjan, Dar Es Salaam and Lagos BRT and transport reforms. In Lagos, travel times were reduced by up to one-third since 2008, while saving an estimated USD 240 M each year (Otunola, 2019).

There is potential for future fleets to be based on electricity and/or compressed natural gas (CNG). Given the current costs of new electric vehicles, the fast-growing market in two and three wheelers offers a priority area for electrification. While these produce significantly less CO_2 per km travelled, they produce more smog-causing particulates – particularly nitrogen oxides and carbon monoxide – than cars. In West Africa and the Sahel, there is potential to develop an accredited industry for electric motorcycle assembly and affordable vehicle conversion, services which are beginning to emerge in Europe (Autocar, 2020). The United Nations Environment Programme (UNEP) promotes the transition of low-income countries to zero emission vehicles and offers an e-mobility calculator to help with country assessments of fuel use and the pollution impacts of switching (UNEP, 2021). With the right regulation and smart technology, vehicle electrification could increase system resilience through use of batteries during power cuts (Gaventa, 2021).

Opportunities for product efficiency through performance standards and labels

Increasing product efficiency has great potential in the Sahelian countries and many countries are already showing initiative in this field. Moreover, a number of Sahelian countries are actively developing minimum energy performance standards (MEPS) and labels to incentivise the uptake of efficient products, saving both energy and the money of consumers. Senegal is currently developing MEPS and labels for refrigerators, air conditioners and domestic lighting. Mali, Niger and Burkina Faso are also in the planning phase of similar initiatives. ECREEE is developing a regional Product Registration System, a database tool that will enable regional compliance collaboration within the Economic Community of West

African states (ECOWAS) and help accelerate the implementation of regionally harmonised policies for cooling products (CLASP, 2020). Additional international programming is supporting the advancement of this agenda, for example through the Super-Efficient Equipment Appliance Deployment [SEAD] Initiative[6].

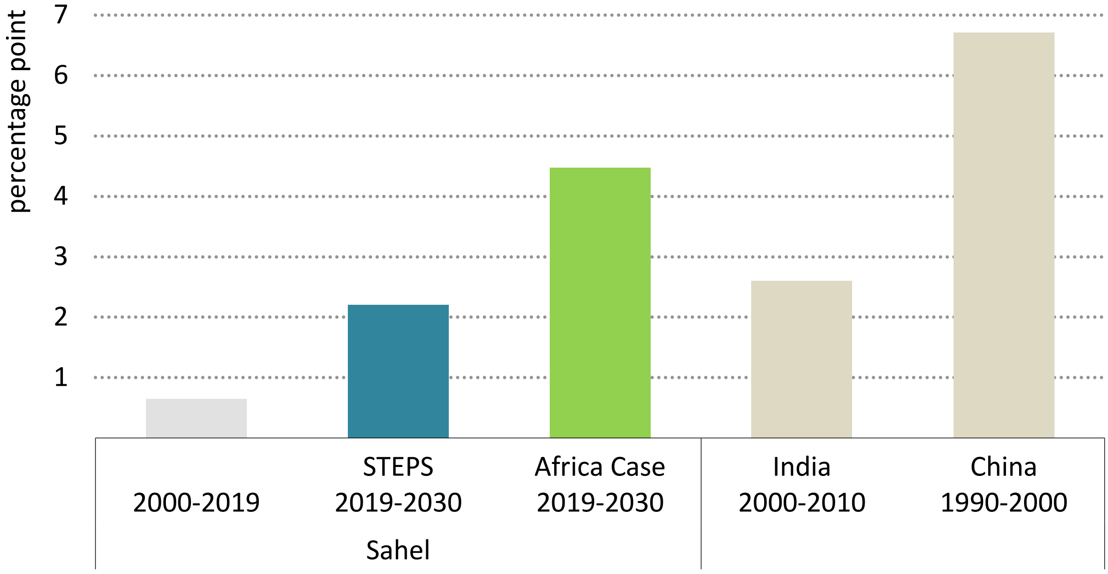
In 2013, all ECOWAS countries, including Burkina Faso, Mali, Niger and Senegal, agreed to develop regional standards for appliances. ECOWAS supports a co-ordinated regional approach for energy efficiency, which is especially important considering the trade between these countries and their dependence on imports coming through coastal states such as Nigeria, Côte D'Ivoire and Senegal. ECOWAS' Centre for Renewable Energy and Energy Efficiency (ECREEE) has been helping countries implement national energy efficiency policies.

Outlook: energy efficiency in the Africa Case allows the Sahel to use 15% less energy to supply a 15% larger economy than in the STEPS

The Africa Case scenario elevates policy action on energy efficiency in the Sahelian countries to meet energy access and development objectives. The Africa Case shows that the Sahel could be using 15% less energy by 2030 than in the STEPS, while supporting 15% more economic activity. Energy efficiency is an essential lever to realising this, as well as managing affordability for end-customers and minimising fuel security risks associated with more energy-intensive growth. The Sahel is projected to improve its energy intensity – primary energy demand per unit of GDP – by 4.5% annually within this decade. Though much higher than the 2.2% improvements in STEPS, it is consistent with the transformations of a rapidly modernising economy, such as China from 1990 – 2000 which saw annual energy intensity improvement of almost 7% (Figure 2.19).

[6] SEAD was founded in 2009 under the Clean Energy Ministerial. It is coordinated by the IEA and it aims to support appliance energy efficiency policies in its member countries and wider. Ahead of COP26, the United Kingdom and the IEA have launched a call to action to strengthen the Initiative to support countries in achieving raised ambition more quickly, easily and at a lower cost. IEA work under the SEAD initiative: www.superefficient.org

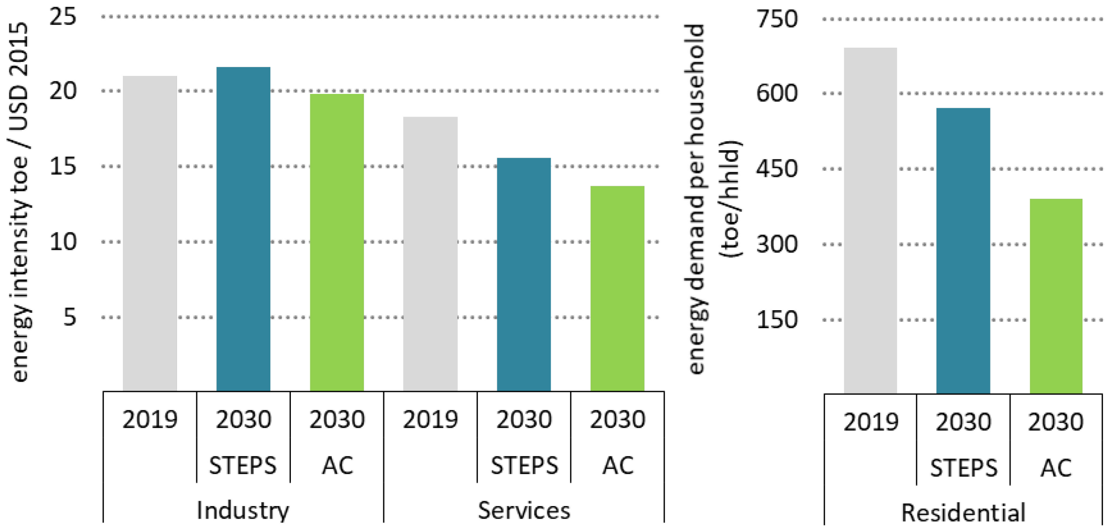
Figure 2.19 Energy intensity annual improvement in the Sahel and in selected regions



Note: Energy intensity improvement is defined as the compound annual average decrease rate of energy intensity.
Source: IEA, 2021.

The main savings in the Africa Case are in the buildings sector, followed by the transport and then industry sectors (Figure 2.20). The efficiency gains from the switch to modern cookstoves are perhaps the most notable, with efficiency gains of between 10% (improved cookstoves using biomass) and 30% (modern fuels). With universal access in the Africa Case, this represents the largest single energy efficiency intervention in the Africa Case. The electricity demand of buildings is much higher in the Africa Case than in the STEPS, largely due to increased adoption of appliances and higher use of these appliances. In the Africa Case, the Sahelian countries adopt minimum energy performance standards that help prune the most inefficient appliances from the second-hand market, with the support of international programmes. This keeps electricity demand growth in buildings much lower than it might have otherwise been.

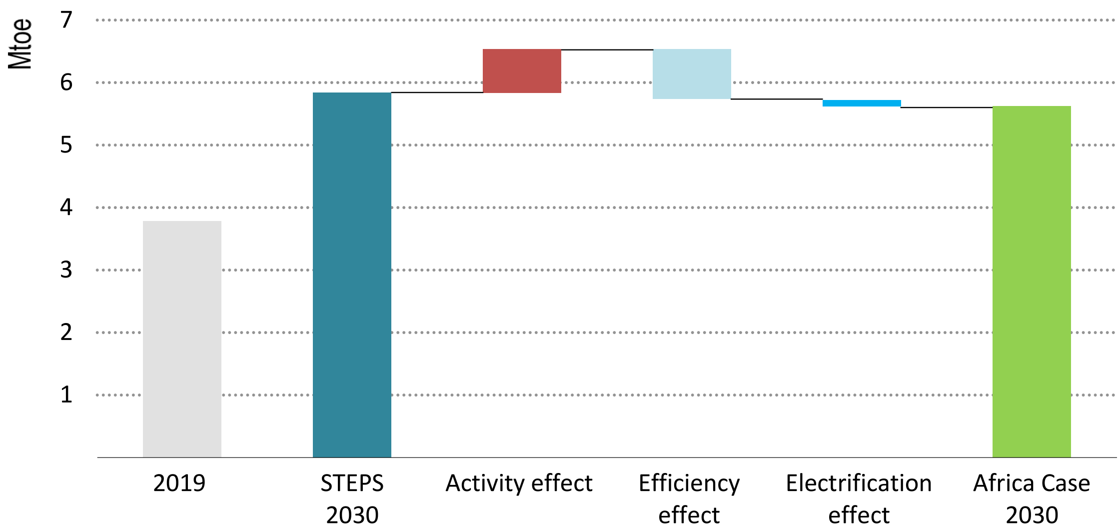
Figure 2.20 Energy intensity indicators per sector in the Sahel per scenario



Source: IEA, 2021.

In the Africa Case, transport efficiency gains help reduce energy demand by almost 1 Mtoe more than it would have been in the absence of efficiency and electrification. Despite increased vehicle adoption and higher use of vehicles, the Africa Case has slightly less oil demand from transport than in the STEPS (Figure 2.21). This is driven mainly by efficiency standards being applied to vehicle imports, preventing the most inefficient second-hand vehicles from being sold and resold in the region. A small degree of road transport electrification begins to happen in the later years of the scenario, largely for electrifying 2-3 wheelers in urban areas, and produces a substantial efficiency gain. Vehicle electrification is predicated on much more reliable and widespread electrical connections that can support more substantial end-user loads. Even by the end of the decade, the electrical infrastructure in most places is insufficient to support widespread electric passenger car adoption, especially outside urban areas where the road and charging infrastructure are likely still insufficient to use electric cars reliably.

Figure 2.21 Evolution of energy consumption in road transport in the Sahel



Source: IEA, 2021c.

Industrial energy-use increases substantially more in the Africa Case than in the STEPS, alongside a 12% higher economic activity. Efficiency plays a substantial role in keeping electricity demand growth lower than it would have otherwise have been in this sector. Industrial energy efficiency largely takes the form of electric motors and low-grade heat. Fuel switching in heat away from coal, oil and biomass helps improve efficiency, along with minimum energy performance standards for industrial motors, particularly in irrigation for agriculture, which is likely to grow alongside modernisation and growth in the value added of agriculture. Many of these interventions have been the focus of successful policy interventions in developing regions in the past (for example, agricultural pump programmes in India), and have been supported by international finance institutions.

Considerations for energy efficiency in the Sahel going forward

In order to bring into play the benefits of energy efficiency, decision makers should combine a roll-out of regulatory, information and incentive measures. Policy packages based on measures and best-practice policy recommendations that have proven effective in other countries can bring about rapid and long-term positive results which unlock energy efficiency opportunities in the Sahel. Tried and tested measures and opportunities exist across multiple sectors including appliances, buildings and transport. On a national level, improving energy efficiency can mean a number of things including:

- **Further progress on product efficiency:** The combination of MEPS, energy efficiency ratings, standards and labelling (S&L) programmes and incentives have proven effective policy measures in many countries in many countries worldwide. The Sahelian countries can expand performance indicators and labels for energy-intensive products that will increasingly be in demand such as air conditioners, refrigerators, etc. Countries can also promote good maintenance of equipment, such as motors, generators, and air-conditioning systems in buildings, so that they work at optimal efficiency, while setting efficiency standards for and promoting appliances and industrial equipment that can do the same job with less energy.
- **Fuel efficiency standards:** Appropriate policies can ensure that the Sahel's growing personal transport sector does not stay limited to energy-intensive modes. This can be done by setting standards and regulations to encourage a vehicle fleet that can travel the same distance with less fuel. Mandatory fuel economy standards have been essential in boosting the efficiency of road vehicles in other regions and can be likewise for the Sahelian countries as well. Key measures to promote energy efficiency in the transport sector should therefore focus on the establishing of mandatory fuel economy standards and on encouraging a more rapid turnover of vehicle fleet with a mix of regulatory and incentive measures.
- **Energy efficiency in buildings:** A co-ordinated approach can deliver the next generation of efficient buildings while improving the efficiency of existing buildings through developing and promoting building codes, incentives for retrofitting and user awareness. The Sahelian countries can learn from other regions and aim to build with better building material resources, focusing on innovative solutions and policies that support local industries and employment. One example is building energy performance codes: these effectively improve the minimum performance of new and existing buildings and set long-term signals to developers and builders to meet or exceed minimum energy efficiency standards. They also deliver better energy services with less energy consumed and reduced energy bills over time. Another approach is to encourage energy services to strive for energy efficiency – including performance contracting for large urban buildings such as hotels, offices and light industry.
- **Co-ordinated approaches:** Coordinating regional approaches and sharing of lessons learned among countries and across regions can help to achieve more momentum to enhance energy efficiency. Regional organisations which focus on renewable energy and energy efficiency already exist and are actively enhancing interregional collaboration that can further help in the scale-up and impact of a wide range of energy efficiency measures.

Chapter 3: An evolving role for hydrocarbons in the Sahel

The Sahelian countries are expecting new developments in both oil and gas production and consumption patterns. Senegal, Mauritania and Niger are planning to expand oil and gas producing capacity in the near future and are beginning or increasing exports, while countries such as Chad remain highly dependent on oil exports. Thus, the countries should take into account a number of considerations related to economic development models, evolving market dynamics, lessons learned and the overall benefits and risks related to oil and gas development plans. In deciding their pathways, it is important for the countries to make clear assessments of the potential benefits and trade-offs involved in developing the oil and gas sector vis-à-vis other sectors of the economy. The decision making relating to extraction and the associated infrastructure and governance models will have long-term implications for each country's clean energy transition pathways. There are a number of ways in which these economies can prepare the sector for transitions.

3.1 New oil and gas expectations in the Sahelian countries

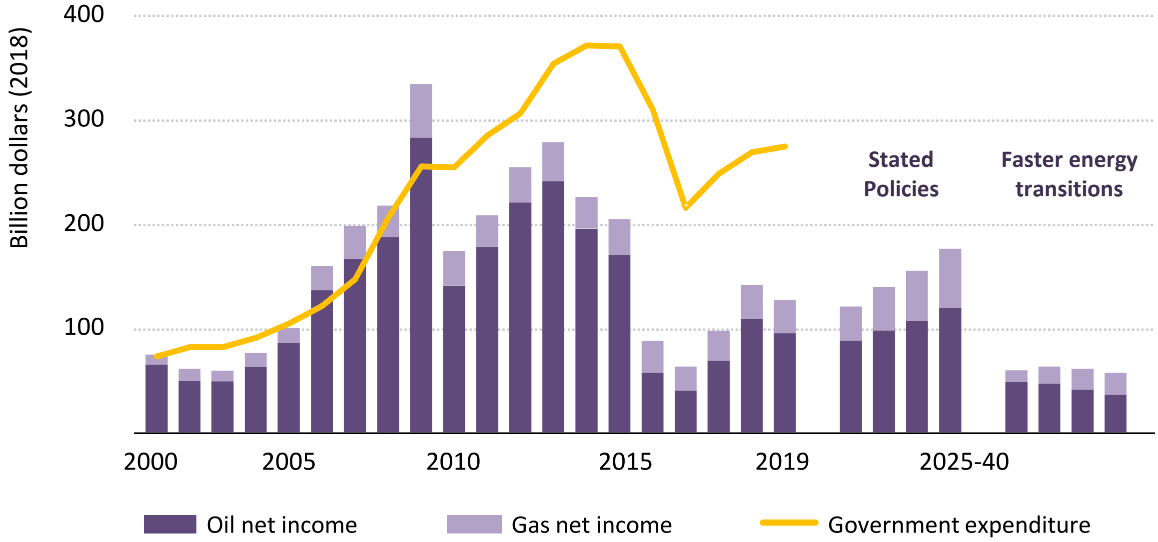
Senegal, Niger and Mauritania all expect oil and gas to play a significant role in their economies over the coming years. A succession of offshore oil and gas discoveries since 2014 off the Senegalese coast near the maritime border with Mauritania has attracted interest from international oil and gas companies (IOC's), causing these countries to consider their potential oil and gas trajectories. The principal offshore gas field, Grand Tortue Ahmeyim (GTA), overlapping the waters of Mauritania and Senegal, is planned to have its first development phase in 2023, and is set to produce 2.5 million tonnes of LNG annually. Two other major fields were found in Senegal – Yakaar Teranga hub, that is aimed to mainly produce gas for domestic consumption and Sangomar, set to be Senegal's first offshore oil development field, – also to come online in 2023. Niger, where operators are expanding oil and gas production in the Agadem Rift Basin, expects to export crude oil by 2024 through a pipeline to the coast of Benin which the China

National Petroleum Corporation (CNPC) began building in 2019. The government expects the share of oil in the country's gross domestic product (GDP) to rise from around 4% in 2020 to 24% by 2022 (Mutethya, 2020).

These governments are leading the ongoing and planned oil and gas developments around these discoveries. The government of Senegal plans to develop gas-to-power plants and a gas-based industry around its recent gas resource discoveries over the next five-year horizon, as well as exporting LNG. This is seen as a strategy to divert the heavy fuel oil (HFO)-rich energy mix away from fossil fuels and towards gas and renewables. Following Senegal's national consultation on the management of revenues from oil and gas exploitation in 2018, a draft law has been prepared and introduced into the approval process, while a digital oil register of property ("Cadastre pétrolier") was introduced in May 2021 to increase the transparency of oil and gas sector related activities. Senegal and Mauritania also plan to use levels of domestic production to contribute to national energy access plans and long-term objectives. Mauritania aims to use some of its natural gas production in national power generation and is working with the World Bank to develop its institutional and governance frameworks for the sector (World Bank, 2018).

The potential behind these discoveries can reveal significant opportunities for economic development, domestic energy needs and possible export revenues. The Sahelian countries seeking to develop new oil and gas supply should consider the accompanying development benefits and vulnerabilities, usually shaped by future market dynamics and past lessons learned. In deciding their pathways, the Sahelian governments should be aware of the potential strengths and pitfalls of oil and gas development. Aspiring producers in Africa face a world where markets for their hydrocarbon reserves are not guaranteed. Government overall expenditure has far outpaced the income from oil and gas among the top-ten producers in the region since 2010 and this gap widened considerably following the price crash of 2014 (Figure 3.1). In a world facing energy transitions, there may be lower demand for oil and high competition from other producers. This may affect revenue expectations for new producers. In turn, this implies an important need for diversifying and managing revenues and production.

Figure 3.1 Net income from oil and gas production in the top-ten producers of Africa



Source: IEA, 2019a.

Interactions between hydrocarbons and economic development

Over the last century, oil and gas have played a significant role in the development of many countries. This includes the fiscal contributions from royalties of production and export, tax revenues to government, as well as related energy services in industry and mobility. Together these have contributed to increased standards of living, especially with respect to access to electricity and clean cooking. Auxiliary services and industrial clusters supporting domestic oil and gas production can represent an important employer. Following recent discoveries, several new producers in sub-Saharan Africa, including Senegal, are interested in developing gas-based industries such as urea to increase productivity in the national agriculture sector, for example. Senegal and Mauritania regard the expansion of their nascent domestic production as key to their national energy access objectives as well.

How these linkages, between the oil and gas sector and the rest of the national economy, contribute to country development depend heavily on governance, societal expectations and international market trends (Box 3.1) discusses the well-understood economic risks of oil and gas-led development and the measures to address them. Understanding the costs of production, the likely time-frame for reserve depletion (given plans for both export and domestic use) and revenue potential under a range of market scenarios are necessary in order to make sensible choices about the sector.

Box 3.1 Traditional risks associated with oil and gas in economic development

Uncertainty of demand: oil prices are determined primarily through international benchmarks and are influenced largely by prevailing supply and demand dynamics. Growing global efforts to respond to climate change, including through pursuing net zero ambitions, pose major questions over the strength of long-term hydrocarbon demand. In the IEA's Net Zero 2050 roadmap, the demand for oil decreases to just 24 mb/d by 2050. Countries that rely on oil exports could therefore suffer the double impacts of lower volumes and lower prices, affecting potential gains from planned production projects. In turn, this can present a vulnerability for countries looking to develop hydrocarbon export potential.

Overdependence on hydrocarbons and the impact on other sectors: aspiring producers should consider the impact on other economic sectors of developing oil and gas reserves and associated infrastructure. Rising inflows of oil or gas revenues in the form of foreign exchange to a central authority (usually governmental) risk crowding out other forms of an economy's productive enterprise. This is not only in the form of so-called "Dutch disease" whereby currency appreciation and labour-movement impacts render other export sectors, such as agriculture uncompetitive, but also in terms of encouraging allocative forms of governance. Economies that develop on the basis of extractives revenue face the risk of amplifying political-economy structures around rent seeking rather than for example, increasing efficiency or investing in innovation (Lahn and Stevens 2018, Stevens et. al. 2015). Governments may consider a slower, more integrated pace of development that enables the knowledge and institutions governing the sector to mature.

Volatility and pro-cyclical policies: Benefits to an economy's overall development will depend on the relationship between hydrocarbon revenues and national budgets (IEA, 2018). The rollercoaster ride in oil prices seen since 2014 and during the 2020 Covid-19 crisis has exerted severe fiscal and economic strains on African oil and gas producers, making a compelling case for economic diversification and reform. Relying on oil and gas revenues for government budgeting can lead to pro-cyclical policies, meaning that government expenditure rises while prices are high, and falls when they fall, with implications for the entire economy. The resulting macro-economic instability will make it difficult to plan long-term investments that underpin sustained economic growth. One way to mitigate the negative impacts of commodity price volatility is to develop effective, transparent and prudent revenue management. Another is to plan public spending that allocates funds over multi-year cycles towards agreed objectives, to iron out the effect of boom years. A third measure is proactive management of revenue streams via hedging and via "stabilisation" funds that can be built up in good times and drawn down when the prices collapse. An example of mitigating the effects of price volatility is Senegal's sovereign wealth fund, which has played an important role in scaling-up solar PV installations using its oil revenues. Nascent producers that see an influx of revenue could allocate some of it towards programmes that provide training and policy support to grow other parts of the economy.

In a few cases, countries have managed to circumvent some of the negative effects through a mix of policies and revenue management arrangements, for example, Botswana's management of its diamond revenues. It was based on a consensus-based political system, monetary and fiscal prudence and careful domestic infrastructure investments (IEA, 2014). However, such cases exhibit specific governance characteristics and capacities which would be difficult for many developing countries to acquire within a short time-frame. Ultimately, diversifying government budget dependence by enlarging its tax base over time will reduce these risks as well as some of the other challenges associated with rentier economies (Andilile et al., 2019).

In countries with high levels of poverty, considerable potential for social instability and low financial cushion and bureaucratic capacities, the cyclical nature of the oil and gas market could have detrimental effects on the economy if expectations and national economic dependence upon it are too high. This could also lead to an increasing wealth gap and related socio-economic tensions. One illustration is the experience of Chad with its growing inequalities since its oil boom began in 2003 (Gadom et. al, 2018). Existing producers clearly offer both shared and contrasting experiences that can inform the planning of new production in the region (Box 3.2).

Box 3.2 Contrasting experiences of oil and gas production: Chad and Niger

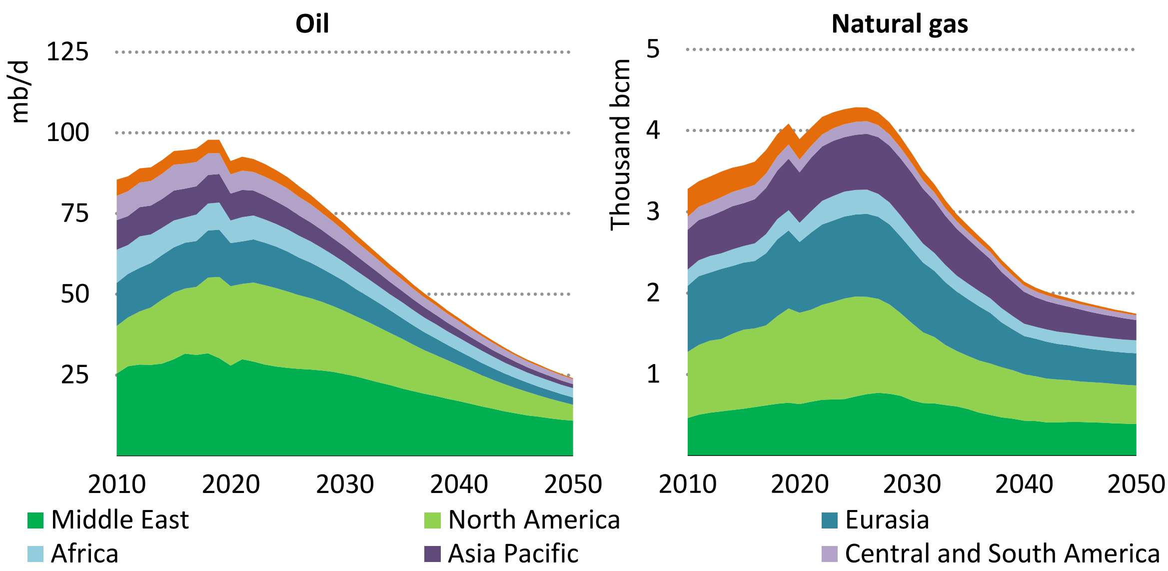
Chad represents an example of how development expectations from oil and gas production can be complex. Due to instability and high costs, Chadian oil discoveries in the 1970s did not reach commercial production until 2003. In a world of rising oil prices, assistance from the World Bank and European Investment Bank aimed to enable foreign investment while avoiding the so-called "resource curse" issues by focusing on conditions of good governance. Specifically, their agreement for financing the Chad-Cameroon pipeline was conditional on channelling a percentage of revenues for development.

However by 2013, in the context of conflict – which escalated in 2006 – USD 4 bn out of a total of USD 10 billion in oil revenues were estimated to have been spent on the military (instead of the envisaged 80% for development) to shore up government control (Hicks, 2015). At the time of writing, Chad remains highly indebted with oil production essential to service its debt. Its public spending had to be curtailed following the 2014/15 oil price crash due to the fall in export revenue and continued high levels of debt servicing. This situation was compounded by conflict and a mounting humanitarian crisis (IMF, 2018). Its high level of dependence on oil – around 40% of government revenue pre-Covid – means its balance of payments has been severely affected by the current global downturn (IMF, 2020).

Oil development in **Niger** has so far benefitted from relative stability and a welcoming environment for business in recent years. Exploration concessions, which began in the 1970s, changed hands several times before finally producing after a period of rising oil prices in 2011. A long-term commitment from the China National Petroleum Corporation (CNPC) and investment in essential infrastructure prioritising domestic needs appear to have been key. Although landlocked, the country now plans a 2000 km pipeline to the coast of neighbouring Benin to enable exports by 2024. Plans for an export pipeline have been long delayed, meaning that production and revenues fell far below initial government and IMF projections (Mihalyi and Scurfield, 2020). With larger public expectations given the increase in estimated reserves, the government will need to prepare for managing wealth for economic development before export revenues begin to flow. In view of Niger's challenging historical experience in the extractive sector with uranium mining (World Bank, 2014), (Oxfam, 2013), issues of transparency, fair distribution of benefits and strong health, safety and environment regulation are paramount.

It will be important for countries to take into account the factors that affect the choices around hydrocarbons extraction and expansion. The energy transitions taking place at the global level mean that the old thinking about the role of hydrocarbons in development can be overlaid with new ones, which could be termed "carbon risks". The carbon risks for oil and gas exporting countries relate to a changing international energy market in which growing global efforts aimed at responding to climate change pose major questions over the strength of long-term hydrocarbon demand. Products entailing greenhouse gas emissions may lose value through a mix of technological substitution, carbon taxation, carbon intensity grading for oil products and carbon border adjustment tariffs (Bradley et. al. 2018; Perkins 2020). Moreover, under the IEA Net Zero emissions by 2050 scenario, Africa's share of global oil supply remains at levels similar to the early 2010s, while the continent's relative contribution to global natural gas output slightly increases (Figure 3.2).

Figure 3.2 Oil and natural gas production per region in the NZE scenario



Note: NZE means Net Zero Emissions or net-zero emissions by 2050.
Source: IEA, 2021a.

Global demand and price trends

Other elements that Sahelian countries should take into account when planning the future development of oil and gas resources are demand and price considerations. Globally, there may be a post-Covid-19 oil and gas demand surge and oil supply tensions. Yet higher prices as well as related policy and investment responses could set in motion a structural easing of demand trends. While Mauritania and Senegal reached the FID before the pandemic, Sangomar and Grand Tortue Ahmeyim projects could require a long-term USD 60 price to break-even (Olan'g, 2020), (IMF, 2019). The breakeven price for the LNG produced from the natural gas fields shared between Senegal and Mauritania is estimated, in one analysis, at USD 5 to USD 8 per Metric Million British Thermal Unit (Global Data Energy, 2020). These prices are in the same ballpark as for LNG from Russia, Mozambique and the US.

A number of demand and supply fundamentals will affect future Asian-bound LNG. Plans to phase out coal and increase gas power in Asia suggest that gas market growth will continue until at least the mid-2030s. After a dip in 2020, Asian gas demand is bouncing back and expected to exceed pre-pandemic levels by 2021. In the event of slower recovery, a combination of planned increases in Qatar, US and Russian Arctic LNG exports over the next decade, coupled with the continued falling costs of renewables and battery storage, could exert downward pressure on prices (Jaganathan, 2021). The expectation of higher prices appears to offer an impetus to speed up development, and increase energy access. However, this theory deserves caution, given the challenges of locking in both dependence on revenues and on fuel consumption.

Uncertainty over pandemic recovery and investment appetite

As the world tries to recover from the Covid-19 pandemic, uncertainty over future energy demand and raising capital may affect the outlook for these new projects as well. The government of Senegal and investors had made final investment decisions on the initial phases of development for two projects – GTA and Sangomar by 2018 and 2020, respectively. However, as with many prospective producers (e.g. Guyana, Lebanon and Uganda), the Covid-19 pandemic has stalled development plans by holding back project planning and moving the planning timelines into later this decade (FT, 2020). Due to Covid-19, the commissioning of the GTA was delayed from 2022 to 2023. At the time of writing, Chad’s Badila and Mangara fields producing 10 000-14 000 b/d had been shut down for one year, with the asset owner citing "continued pandemic-related challenges in international mobility" (Perkins, 2020). Mauritanian government also indicated that Covid-19 had impacted the time horizons for ongoing plans, slowing down projects and temporarily reducing the appetite for investment.

At the same time, the Covid-19 crisis has brought forward some major adjustments, affecting companies’ willingness to invest in decarbonisation. (Marcel, 2020) In 2020, the Covid-19 pandemic hit investment in Africa particularly hard. It dropped by one-third in 2020, compared with a decline of around 18% globally (IEA, 2021c), affecting strongly oil and gas upstream. In turn, lower oil and gas prices have led IOCs to revise long-term price assumptions. IOC shareholders are pressuring company management to prove the corporate resilience to "carbon risks'" and to demonstrate that investments are in line with climate change commitments (Blondeel, 2021). While it looks likely that investing companies will continue to invest in the infrastructure needed to produce and export GTA gas, for example, they have made efforts to cut costs.

Considerations for domestic use of natural gas

For both Senegal and Mauritania, natural gas discoveries are encouraging the phase-out of HFO and coal-fired power plants which dominate their electricity mix. In Senegal, Mauritania and Burkina Faso, between 75% and 85% of the electricity is generated from oil, at 90% under the form of heavy fuel oil. In the Africa Case scenario developed by the IEA in 2019 for the entire continent (IEA, 2019a), plans to phase out HFO hinge on successful implementation of new gas-to-power plans. Since 2018, the government of Senegal has been implementing a gas-to-power strategy which aims to phase out oil and coal plants or convert them to natural gas – One example is the 125-MW coal facility in Sendou that is being turned into a natural gas plant (Agence Ecofin, 2019). The government of Senegal is also building new thermal power plants. In April 2021, construction started on a 300-MW gas-fired combined-cycle power plant (CCGT) at Cap des Biches near Saint Louis, Senegal, which is expected to cover 25% of the national power requirements and would become the country's largest generating plant. Scheduled to start operations in 2022, it is hoped that the plant will help meet the national objective of universal access to electricity in 2025 (vs. 54% in 2019). Senegal's share of GTA phase 1 natural gas (35 Mcf/d) will feed the new Cap des Biches CCGT.

The experience of using gas for domestic energy needs in sub-Saharan Africa is, however, modest (Box 3.3). Investment will be key.

Box 3.3 Deploying gas for power in Tanzania, Ghana and Nigeria

Certain African countries have benefitted from natural gas power deployment. Tanzania has had success with developing Songo-Songo natural gas for domestic use, and Ghana has developed its processing and transmission facilities of offshore gas for use in domestic power. Both Ghana and Tanzania feature an acknowledged higher level of bureaucratic and technical capacity than several other countries in their sub-region, and have benefitted from sustained interest from foreign donors and financiers. Even so, Ghana continues to flare far more gas than anticipated and has faced large take-or-pay penalties as a result of over-optimistic demand projections.

Nigeria, the largest producer of natural gas in sub-Saharan Africa, has been building gas power plants since the 1980s, but has struggled to utilise this resource for domestic energy needs. While infrastructure was built, sabotage, wastage and under-utilisation meant that much of the generating capacity went unused in a situation where overall power supply has frequently been less than half of consumer demand (Ekpu and Obadina, 2020). Security threats, corruption and the vandalisation of infrastructure continue to plague many gas-to-power projects. The problem is compounded by a combination of the costs of infrastructure to bring gas onshore and process it, as well as the insecurity in the Niger Delta region, where most of the onshore fossil fuel resources and related facilities are located.

In the last few years, Nigeria has made significant progress in bringing online more gas-fired power generation. The country has been working with the Global Gas Flaring Reduction Partnership (GGFR) and has reduced flaring from around 17 bcm in 2011 to 7 in 2020 (World Bank/GGFR, 2021).

More specifically, countries that do not yet have gas infrastructure in place will require large capital investments to build the necessary processing plants and pipelines bringing the gas-to-power plants and industry. Attracting foreign capital and commitments to build domestic infrastructure will depend to a large degree on the prospects for exports, particularly in view of non-convertible currencies.

At the same time, it should be noted that the prospects for exports could jeopardise plans for a scale- up of domestic energy infrastructure. Gas-fired power may also be increasingly difficult for most multilateral development banks (MDBs) and other international financing institutions (IFIs) aligning with the Paris Agreement, to finance, given that the lifespan of most new gas infrastructure may not be compatible with the global 1.5 degree scenarios (Tong et. al., 2019). Defining energy projects within a clear national transition pathway that is consistent with a country’s long-term strategies under the Paris Agreement will help in attracting this required new kind of finance (Fekete, 2020).

The export revenues tabled to support repayment of domestic power investment also matter. In Mauritania, for example, the drop in global oil and gas prices in 2014 rendered development of the Banda oil and gas field uncommercial. When investors pulled out, the gas-to-power project tabled for international development financing became unviable, and the plant’s operation depends on increasing volumes of HFO.

3.2 Preparing the oil and gas sector for transition

The African Union (AU)'s Agenda 2063 vision for the economic structural transformation of the continent and the priority programmes of multiple multilateral agencies are envisioning a move away from Africa's heavy dependence on the export of raw materials, towards the flourishing of local innovation, circular economies and sustainable agriculture. This is all expected to take place within the context of much greater interregional as well as intra-regional trade (African Union, 2015, Rademaekers, 2021, UNECA, 2016). The African Continental Free Trade Area (AfCFTA), which came into effect in January 2021, is intended to play a fundamental role in driving this transformation. There is now a chance to put in place measures to reduce the economic dependence of new producers on export revenues from trading their extractive assets outside of the continent and to increase the use of African hydrocarbon revenues to support domestic and regional energy transitions.

Countries such as Malaysia, the Arabian Gulf countries and Trinidad and Tobago, all began with comparative advantages and larger per capita reserves than the countries in the Sahel. However, they also became locked into carbon-intensive pathways, which they are now trying to turn back. While they have some of the highest CO_2 emissions per capita, leaders from some of these countries are trying to diversify and provide jobs against the clock. Given oil and gas market and investment uncertainties and fast-growing populations, the needs for strategic thinking on future investments and transparent resource revenue management, the efforts to reform and diversify the economies are greater than ever (IEA, 2020b). The countries of the Sahel have the opportunity to integrate low-emission pathways into their plans to monetise their indigenous raw materials.

While the use of stabilisation and other kinds of revenue management funds are important for countries pursuing export-led development strategies for commodities with volatile markets, there are two more important factors: i) assessing the optimal role for the sector in the economy over time given the costs, trade-offs and risks for a country with undeveloped reserves, in bringing production to market, and ii) setting the indicators and incentives for the sector in order to guide its role over time.

For producers, good decision-making for optimal national benefit requires access to information about changing fuel markets and how competitive their production is vis-a-vis other producers in terms of carbon intensity. It means making use of and improving on scenarios for production, domestic consumption and robust price scenarios that include the impact of future carbon price trends in consuming markets' pricing, ensuring that policies are flexible for the worst case scenarios, as well as the best case ones (Bradley et. al. 2018).

Potential for upstream efficiencies

The oil and gas industry is facing increasing demands to step up its contributions to emissions reduction. Whatever the transition pathway, the oil and gas industry must look at ways to reduce the environmental footprint of its own operations and mitigate carbon emissions in production (IEA, 2020b). This can be done by removing elements of methane emissions, and introducing good practices with respect to the lowest possible carbon intensity of production. There are ample, cost-effective opportunities to bring down the emissions intensity of core oil and gas operations by minimising the flaring of associated gas and venting of CO_2, tackling methane emissions and integrating renewables and low-carbon electricity into new upstream and LNG developments (IEA, 2020b). As of today, 15% of the global energy-related GHG emissions come from the process of extracting oil and gas out of the ground and transporting it to consumers. Reducing methane leaks to the atmosphere is the single most important and cost-effective way for the industry to bring down these emissions.

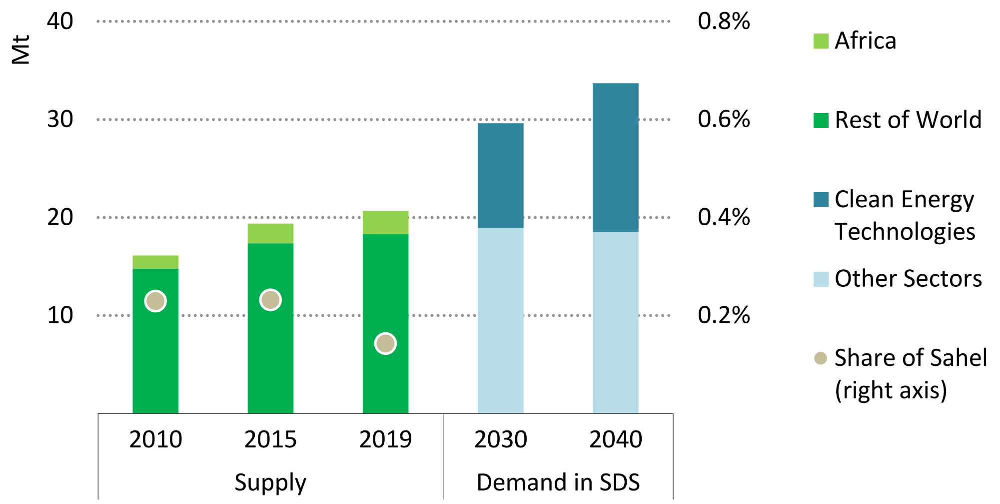
Role of critical minerals in energy transitions

Several countries also hold reserves of metals and minerals that are used in the technologies which are critical to global energy transitions (Box 3.4). As the world embarks on global energy transitions, there are some important lessons that countries should take into account as they design their oil and gas trajectories.

Minerals are essential components in many of today's rapidly growing clean energy technologies – from wind turbines and electricity networks to electric vehicles. In light of the net zero objectives set by many countries around the world, global clean energy transitions are gaining momentum. The rapid deployment of clean energy technologies as part of energy transitions implies a significant increase in the demand for minerals such as rare earth elements for wind turbines, silicon and silver for solar panels and copper and aluminium for power grids. According to a recent IEA report (IEA, 2021b), achieving the current global climate goals will require at least four times more mineral resources in 2040 than today. In general, there is no shortage of resources, but there is a question whether supplies will be available at the right time at affordable prices. There are challenges around the long lead times necessary to develop new projects, compounded by declining resource quality, growing scrutiny of environmental and social performance and the lack of geographical diversity in extraction and processing operations. There is therefore a looming mismatch between the production capacity and political ambitions of the energy transitions.

As several Africa states have significant reserves of the needed mineral and metal ores, they are uniquely positioned to ensure reliable supplies. For example, South Africa is responsible for 70% of the global production of platinum and one-fifth of the manganese, and the Democratic Republic of the Congo provides 70% of global cobalt production. West Africa and the Sahelian countries are also endowed with considerable mineral resources, and the extractive sector is already a significant source of national revenues. Between 10% and 15% of global gold production comes from West Africa, with Ghana ranking first and Mali and Burkina Faso belonging to the top five African producers. Guinea accounts for one-fifth of global bauxite production, and Niger accounts for 6% of global uranium production. While the Sahelian countries are not today major producers of the minerals that are vital to clean energy technologies, some countries have the potential to become major players. Burkina Faso has increased its production of zinc, a resource critical for renewable technologies such as wind turbines, reaching 1% of global production and ranking among the top three African producers. Senegal began extracting titanium in 2014 and today accounts for 7% of global output. Titanium is used in technologies that are employed in high temperature and high corrosive environments. Mali plans to develop its lithium spodumene resources. Copper is imperative for all electricity-related technologies due to its unmatched thermal and electrical conductivity. The demand for copper is expected to rise significantly, which could offer opportunities for Mauritania which has been annually producing around 35 thousand tonnes of copper since 2010 (Figure 3.3).

Figure 3.3 Historical supply and projected demand of copper



Note: SDS =Sustainable Development Scenario. Supply is for mined production, which serves to meet demand together with secondary supply sources (e.g. scrap). Copper production in Sahel is concentrated in Mauritania.

Source: IEA, 2021b.

Although the presence of mineral resources represents opportunities for economic development, large investments in exploration, development and associated supply chains will be necessary. Moreover, it is crucial to manage the environmental and social impacts of mineral development carefully, including the emissions associated with mining and processing, the risks arising from inadequate waste and water management, and the impacts from inadequate worker safety, human rights abuses and corruption. Ensuring that mineral wealth brings real gains to local communities is a broad and multi-faceted challenge, particularly in countries where artisanal and small-scale mines are common. Supply chain due diligence, with effective regulatory enforcement, can be a critical tool to identify, assess and mitigate risks, and to increase traceability and transparency. There is also a major role for innovation in production technologies, including those that help reduce water use and energy consumption. These will not only bring operational benefits, but also contribute to improving the global competitiveness of the region’s resources.Opportunities for pricing mechanisms and standards

In order to meet the SDGs and allow clean technologies and practices to grow, it is important to set the pricing, taxes and regulations correctly at the domestic level. While consumption subsidies can promote energy access (as Chapter 2.2 notes in the case of LPG) and economic growth, long-term, untargeted subsidies tend to increase inequalities and encourage inefficiency over time, while adding an increasing burden to state budgets (IEA, 2020a). The Sahelian countries have been providing some type of energy consumption or supply subsidies, either for electricity, or for oil products such as LPG for cooking and other fuels. For importing countries, this results in increased government spending when international prices rise, For exporting countries, it can mean that they carry an “opportunity cost”, namely the difference between the export and domestic price.

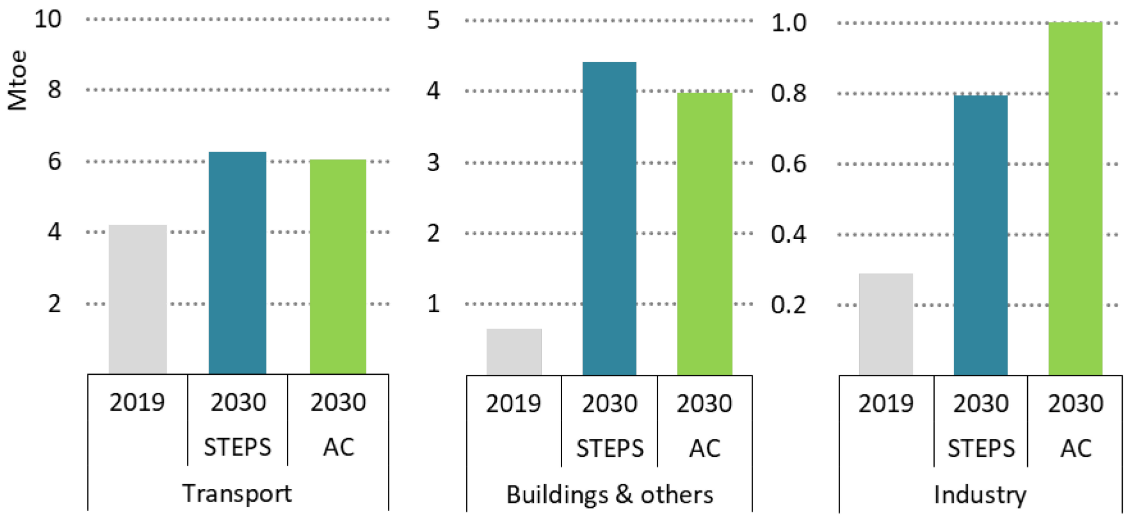
As low-income households and smaller businesses are extremely vulnerable to fuel price rises when there are no affordable alternatives, price reform must be paced carefully. A first step to improving price efficiencies is to spread awareness about the costs to the public purse. Where oil products and natural gas are imported, it is relatively easy to know the level of subsidy. However, the situation for domestically produced gas can be more complicated (Lahn and Stevens, 2014). Understanding the full costs can enable a country to set a pathway towards subsidy reform in an equitable way and towards taxing negative externalities such as local air pollution and CO_2. It will also provide an incentive for investment in both efficiency and alternative energy sources (Parry et. al., 2014).

Infrastructure choices will also be critical in avoiding high future operating costs and emissions lock-in (Seto et al. 2016, Lahn & Bradley 2016). Tenders for large civil engineering projects can specify higher efficiency materials and design by ensuring that '"lowest cost" rules assess not only capital costs but also the lifetime operational costs of infrastructure. Similarly, the strategic location and design of industrial hubs with a clear focus on efficient energy use can leverage co-generation benefits such as the use of excess heat (usually from the combustion of fossil fuels or bioenergy) from one production centre in another. A growing range of industrial opportunities are opening up that can produce useful materials, such as those for construction, without fuel or with significantly less fuel burning. For example, a factory in Côte d'Ivoire is manufacturing limestone calcined clay cement (LC3) which needs lower temperatures and releases 40% less CO_2 (Rocks and Dezem, 2020), and a company dealing with bioclimatic solutions in Senegal is expanding the production of sun-baked earth bricks (Peyton and Van der Perre, 2021).

Outlook: opportunities to shape the national fuel consumption trajectory

Domestic oil and gas consumption is expected to roughly double in both the Stated Policies Scenario (STEPS) and the Africa Case in the coming decade (Figure 3.4) . Even with higher economic growth and consumer spending in the Africa Case, efficiency and fuel switching keep regional consumption lower. Demand increases come primarily from power (heavy fuel oil) and transport (diesel and gasoline). However, the STEPS has far greater emphasis on oil products, with fuel oil remaining the largest source of electric generation and considerably less efficiency in road transport. In the Africa Case, domestic natural gas infrastructure is developed substantially, going well-beyond the current plans in the STEPS for Senegal and Mauritania to expand their domestic gas markets. This Sahel-wide infrastructure greatly increases the potential for affordable gas generation to displace fuel oil use in power generation and the industry sector.

Figure 3.4 Oil and gas final consumption per sector in the Sahel



Source: IEA, 2021d.

Vehicle ownership is expected to increase across the Sahel, twofold in the STEPS and 2.5-fold in the Africa Case. Vehicle efficiency standards in the Africa Case keep the higher car usage from driving up demand substantially, with both scenarios having roughly 6 Mtoe of demand for transport fuels. LPG use in cooking expands and drives oil products demand in the building sector to roughly 4 Mtoe in both scenarios as well. Additionally, further mechanisation of farming – the majority of which is currently unmechanised – increases oil use in agriculture from tractors, stand-alone diesel generators and water pumps. Growth in inefficient diesel generators features in the STEPS as urban expansion takes place in the absence of reliable electricity from either national grids or local renewable sources – a fate avoided in the Africa Case.

Country trajectories are not fixed and the Sahelian governments can shape their consumption profiles going forward, which will be influenced to a large degree by the policies they enact today. For producer countries, this demand growth could affect the availability of products to export and/or the country's foreign exchange and subsidy bill. Governments can use a number of policies, measures and approaches to shape their consumption profiles going forward (Box 3.4).

Box 3.4 Factors Impacting future of oil and gas demand in the Sahelian countries

The demand for oil and gas in countries is influenced by a number of internal and external factors. These shape governments' decisions in determining policies geared to shaping their consumption profiles. Some of these factors include:

Regulation: Government regulations, pricing and taxation applied to fuels and their potential substitutes can impact the evolution of energy demand.

Producers' planning: How regional oil and gas producers expand or phase out their production, and to what extent they receive financing for the sector affect domestic fuel costs and thus demand over time.

Growth pathways: Countries face some choices on their growth-paths in terms of greater self-sufficiency or greater import dependence. Growth pathways can be adopted that follow either western or recent Asian models of urban and industrial growth, or that capitalise on competitive rural and biodiversity advantages with greater levels of regional trade (UNECA, 2016). The incentives offered by the African Continental Free Trade Area that came into effect in January 2021 will play a role in this.

Planned infrastructure: Future energy consumption will be linked to planned infrastructure as well. Firstly, infrastructure may affect national and regional economic growth, which in turn will influence energy consumption as well as potentially facilitating the consumption of certain fuels (e.g. planned roads, rail, airports, urban expansion projects, etc). Some infrastructure will directly influence the demand for specific energy and fuels for years to come such as refineries, pipelines, gas processing and distribution systems, power plants and LNG storage facilities. Regional infrastructure could also change the distribution patterns, e.g. the Trans-Saharan Gas Pipeline and the Niger-Benin oil pipeline. Secondly, how infrastructure is designed and built will affect the demand for energy consumption more directly. It could potentially encourage or avoid fuel consumption through for example, the use of high efficiency materials and design, passive buildings and green urban and industrial expansion, water storage to complement solar power, electric vehicle charging, etc., and avoid locking in fuel demand. Lastly, the particular equipment and vehicle stock that is purchased also plays a role, such as mechanisation of farming, types of water pumping technology, second hand or new vehicles with higher fuel efficiency standards (See Chapter 2.4), EV's and air conditioners.

The mix of government policy, regulation and foreign finance available can help countries leapfrog the carbon-intensive industrialisation experienced in other regions of the world when building new infrastructure.

Considerations for hydrocarbons in the Sahel going forward

Whichever pathway the Sahelian countries pursue in terms of their ongoing and planned oil and gas development, it is important to consider the associated benefits and risks under different scenarios. For the Sahelian countries planning to export oil and gas products, strategic scenario planning and policy- making for the sector will benefit from regular assessments of the markets for their products, including potential downside scenarios. Governments will need to do this in full sight of their project production costs, volumes of product used to cover companies' original capital investment and operational costs or potential deductions in taxation relating to profit losses.

When a country is in the early stages of production or expansion, it needs to keep expectations within limits. This is not easy if politicians, industry and the media raise expectations for the development potential. The record of regional oil and gas discoveries over the last decade reveals that few targets are met (Mihalyi and Scurfield 2020). Clarifying the range of revenue projections, alongside clear plans for managing them can benefit public and sectoral expectations. It can also prevent the expected revenue from becoming challenged by uncertainty. As extracting oil and gas at scale, including building the associated infrastructure, will entail environmental risks and trade-offs, it will be important to recalibrate environmental assessments in view of the changing value and potential for these assets.

Policy considerations for managing the role of oil and gas in line with climate policy, and for mitigating carbon risks include:

- **Governance, cost and externality transparency**: Increasing the transparency of the costs and externalities of oil and gas plans in both the upstream and domestic energy system can help inform planning that serves the public interest and can underpin long-term price reform plans. This would include the costs of any public subsidies and debt servicing as well as emissions and other resource costs such as water inputs. Putting in place mechanisms to ensure effective and transparent hydrocarbon revenue management is essential. Best practices in transparency can help. Senegal's recent adoption of an oil register of property ("cadastre pétrolier") to keep track of oil and gas related activities benefits governance and transparency with respect to extractive industries.
- **Diversification of resources and resource management as part of a transitional vision**: Given the uncertainties related to future income generation based on hydrocarbons, producers will need to carefully assess how much is reinvested in the sector over time, particularly National Oil Company (NOC) borrowing, and diversify and manage revenues for sustainable diversification.

- **Infrastructure choices avoiding lock in:** Domestic plans for oil and gas in the power and industry sectors can be best made within broader industrialisation plans, which take into account evolving economic opportunities that capitalise on sustainable local production and regional trade. Standards, regulations and price mechanisms can work in tandem, helping to shape infrastructure, equipment and consumption choices.
- **Nationally Determined Contributions (NDC) alignment:** For existing producers, commitments for the oil and gas sector in the country's NDC should be included, as is the case for Nigeria, stating the timeline (Bradley, 2020). For prospective producers: how oil and gas projects will conflict or align with the NDC should be considered. Investors seeking alignment with the 2015 Paris Agreement goals will increasingly look at how new power infrastructure fits within a country's NDC and increased ambition.
- **Value assessment:** The value of damage or impairment of environmental and biodiversity assets that will take place should be assessed in view of the growing value of these resources vis-à-vis the potentially shrinking value of hydrocarbon exports. Ecosystem service accounting can help in planning transitions and setting goals for the national oil company and/or regulator.
- **Regulation for mitigating emissions in oil and gas sector:** Adopting Strong regulation and provisions for preventing and eliminating flaring and methane leakage should be adopted.
- **Developing carbon taxation**: South Africa began rolling out carbon taxation in June 2019 (IEA, 2019b). Although initially low, the tax allows for increasing quality of accounting for emissions which is useful for future access to climate and green finance. A clear timetable for its increase allows industries to plan and invest for transition.

Chapter 4: Addressing the water-energy-food nexus in the Sahel

The water-energy-food nexus is vital to economic and social development in the Sahel. These sectoral interdependencies reveal how food, water and energy security are strongly interrelated, with important implications for each sector and for overall development and livelihoods. Adopting a nexus approach to energy services will help governments maximise precious resources in the Sahelian countries, revealing opportunities for sustainable agriculture, climate resilience, gender empowerment, productive energy uses, green urban planning and local community development. To offer optimal development outcomes, policies and strategies for energy must take this nexus into account. Applying an integrated multi-sector approach to clean energy transitions in the Sahel can illuminate opportunities to improve resource efficiency, productivity and security, which may change the scale and type of the energy technologies deployed in the region.

Energy is essential to other sectors in the Sahel

Energy is the golden thread enabling the improvement of human well-being, security, sustainable economic growth, resilience and climate action in the Sahel. The provision of renewable energy will play a vital role in empowering and growing other sectors of the Sahelian economies, and in the use of innovative technologies and solutions. The production of energy and its use in these sectors are interlinked with the availability and quality of other vital resources, such as water, food, soil, forests and air. Energy planning can therefore not be done in a silo. To offer optimal development outcomes, policies and strategies for energy must take into account this nexus.

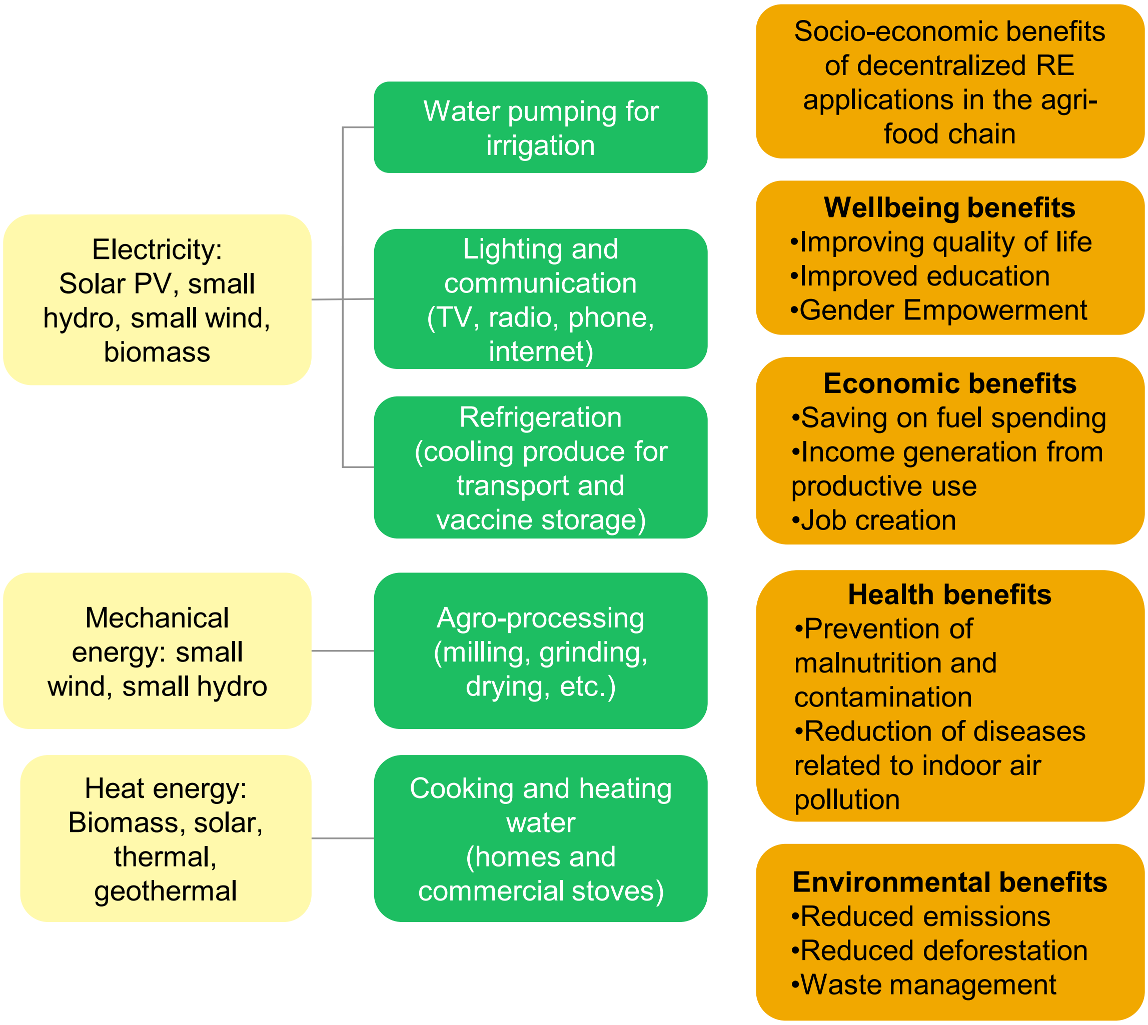
The sectoral interdependencies among water, energy and food underpin economic and social development and are therefore precious resources in all parts of the world. Water is essential for all phases of energy production, from fossil fuels to biofuels and power plants. Energy use is vital for a range of water processes, including water distribution, wastewater treatment and desalination, as well as for agricultural and supply chain processes. Food requires vast amounts of water and energy for production, processing, distribution, storage and disposal of products.

Consideration of this nexus is particularly important for climate resilience and human security in the Sahelian countries. The societies in this region have suffered from repeated periods of drought and food insecurity that are set to continue. Reduced water availability and competition over fertile land exacerbate conflicts and displacement conditions. Ongoing environmental degradation and urban expansion, coupled with climate change are putting pressure on water and land resources. However, this trend is not inevitable. There is widespread recognition that addressing security and development requires an integrated approach (UNISS, 2019; Helly et. al., 2015). Increased awareness of these interrelations in policymaking is essential. The role that renewable energy solutions can play, for example, in sustainably powering agri-food value chains and agricultural production represents such an integrated approach. In turn, this can help with linking renewable energy to a range of SDG goals. For example, switching from traditional biomass to modern renewable energy sources can contribute to good health and well-being (SDG 3), women's empowerment (SDG 5), and the restoration of forests (SDG 15).

Opportunities for renewable energy and agriculture

Agriculture in the Sahel stands to gain in particular from innovative renewable energy uses. Agriculture provides 60% of employment in the Sahel and 30% of gross domestic product (GDP). It plays a vital role in social welfare, with many people living in rural areas working small subsistence plots. Agriculture – including the production of cereals, vegetables, seeds, fruits and fibres – presents a rich seam for economic development in the region. At present, agriculture remains largely un-mechanised, reducing potential productivity. It also lacks tools for improved crop management, from irrigation to soil enrichment. Deploying off-grid renewable and sustainable biomass technologies presents many opportunities to enhance productivity and social well-being. The Sahel's agricultural sector undoubtedly stands to gain from efficiency and productivity enhancement of renewable and sustainable solutions in for example, agri-food value chains (Figure 4.1). Renewable energy can help transform productivity and quality in agriculture in a number of ways.

Figure 4.1 Enhancing agricultural productivity and well-being through renewable energy



Source: Adaptation from IRENA, 2016.

Solar powered food production

Many farms in the Sahel do not have either mechanised pumps or diesel generators to pump water from the ground. Fuel is expensive and prevents communities from saving to invest in communal facilities. Renewable energy-powered solutions can provide sustainable and cost-efficient alternatives to enhance agricultural productivity. The cost of a solar water pump over its life cycle is 25 to 55% that of a diesel pump, enabling a payback period of two years (GOGLA, 2019). Off-grid or microgrid renewable energy applications can help food production businesses grow. They can enable processing, which can reduce wasted produce and increase food availability and revenue (USAID, 2018). They can also make the milling and mass cooking of produce possible –

for example, pre-cooked beans can be sold to improve both nutrition and reduce firewood demand (IDRC, 2019). Shea nut processing represents promising opportunities for women farmers (Box 4.1) As the Sahel is particularly poor in water resources, it is particularly important that the renewable irrigation practices are designed to prevent the inefficient usage of water resources.

Cold supply chains for produce are important as well. Cold storage and cold-chain management for producers, wholesalers and retailers is imperative because fresh fruit, vegetables and milk, for example, frequently go to waste before reaching urban markets. One study in Mali estimates that approximately one-third of the produce never reaches the final consumers and is lost during transit, partly due to a lack of adequate storage and transportation, including temperature and humidity control (USAID, 2018). Cooling technologies can improve hygiene and have a beneficial impact on nutrition, enabling more foods to be kept longer. Refrigeration and freezing can also assist in the development of small businesses, for example, for the sale of cooled water, drinks and ice. In addition to the use of solar PV for power cooling, technology in using solar to directly refrigerate in both stationary and mobile applications is advancing as well.

Box 4.1 Economic opportunities for women through sustainable energy productive uses

When agricultural income declines in rural areas, it is often the men who migrate to the cities for work. This has become a trend across the Sahel, leaving many villages reliant on a larger proportion of female labour and putting greater burdens on women to combine childcare with hard physical labour. It also means that many children are taken out of school (Boyer and Deubel, 2016). Several initiatives exist that aim to reinvigorate village economies through the use of energy in ways that can alleviate these problems. A mix of local agroforestry and improved energy-using equipment can free women from hours of firewood collection. Shea nut processing is a female-led industry, for example, with benefits for local economies and ecosystems while also being energy intensive (Chen, 2017). A number of initiatives in Burkina Faso seek to deploy sustainable energy to assist in the production of the butter, which requires boiling, crushing, roasting and milling. Using the waste products (shells) as fuel can reduce energy demand (Noumi et. al., 2013) and solar cookers have been trialled successfully for the boiling and roasting stages (WISIONS, 2011). One village uses a solar milling hub to allow the local women’s cooperative to produce their butter without the arduous collection of firewood or expense of diesel generation (Solar Milling, 2019). In Matam, Senegal, solar drip irrigation is assisting women to reduce diesel costs and improve harvests in five villages. This is leading to reported water-savings of around 70%, and incentivising some men to return to work on the land (Al Jazeera, 2020).

Sustainable biomass

There are a number of applications for the use of agricultural waste including rice husk, cotton, millet, sorghum and corn stalks. – Invasive species also present opportunities for sustainable biomass in the Sahelian countries. Though the aquatic plant, Typha australis, which has proliferated in rivers and lakes in the Sahel (partly as a result of damming and subsequent river flow regulation) inhibits irrigated agriculture and fosters waterborne diseases, it can be harvested and turned into briquettes for fuel and used in climate-resilient construction materials (UNDP, 2012; Dione, 2019). Some restorative, income-generating projects in Senegal and Mauritania point to the potential for scale-up with multiple benefits (Reuters, 2019).

Wastewater treatment

Wastewater treatment and reuse can be vastly improved through the deployment of closed-loop systems which can treat wastewater using solar and biogas (created through sewerage) systems which send backwater to irrigation networks and create fertiliser from the sludge. This is successful at scale in Jordan where the As-Samra plant treats 100 million m^3 annually, and meets 80% of its energy demand through its own biogas digester and hydraulic turbines. It reportedly covers almost 10% of Jordan's farming requirements, equivalent to 10 000 hectares irrigated (Millennium Challenge Corporation, 2018). Smaller systems, such as those pioneered by the social enterprise, Sanivation, are turning human waste into fuel using solar power, and are providing multiple benefits in Kenya (County Government of Nakuru/Sanbitation, 2019) illustrating the potential opportunities for wastewater treatment applications in the Sahelian countries.

Mobile-enabled communications and payment schemes

The use of off-grid solar is competitive in many rural areas, but the capital costs are prohibitive. Scaling up requires a commercially affordable and reliable service for farmers, of which examples are already appearing across the continent and region. In Kenya for example, solar pumping and irrigation are spreading through "pay as you grow'" schemes in which mobile phone payments are used to enable repayment and receive after-sales support, and farmers are able to pay at harvest time (REEEP, 2018, Shieber 2020). Similarly, the AfDB-financed Desert to Power solar initiative in the Sahel envisages the spread of solar pumping with mobile payment. As many people in rural Sahelian communities are unwilling or unable to take loans, saving in advance with scratch cards and phones is another option. Operating in Mali, Senegal and Tanzania, one company offers a way for farmers to save ahead of the planting season, and then delivers their chosen input package of fertiliser, drought-resistant seed and technical training (Ratnayake, 2020). Weather-indexed insurance accessed through phones is another option that is becoming available to farmers (UNDP, 2018).

The urban nexus in the Sahel

Increased urbanisation in the Sahel affects resource needs as well. With one-third of the Sahelian population living in cities, there is great need for services such as expanded electricity coverage, fresh water delivery systems, sewerage, wastewater treatment and domestic refuse systems. A green urban planning approach that focuses on liveable, healthy cities where resources are maximised and waste and pollution are minimised could be developed. Building regulations, urban infrastructure and the upgrading of informal housing all play a role in helping meet citizens' energy and water needs and reducing air pollution. Senegal has made significant progress in providing fresh water to its capital, Dakar, with a number of water treatment plants and is in the process of expanding these. Treated wastewater, brackish water – and in the case of Senegal and Mauritania, desalination – are likely to play a greater role in water provision. Providing clean water and treating waste will all require increasing infrastructure and energy. Water conserved therefore also saves energy, reducing the pressure on treatment and production facilities, while effective sewerage systems reduce the need for trucks to remove dangerous waste, thereby reducing health risks as well as road pollution.

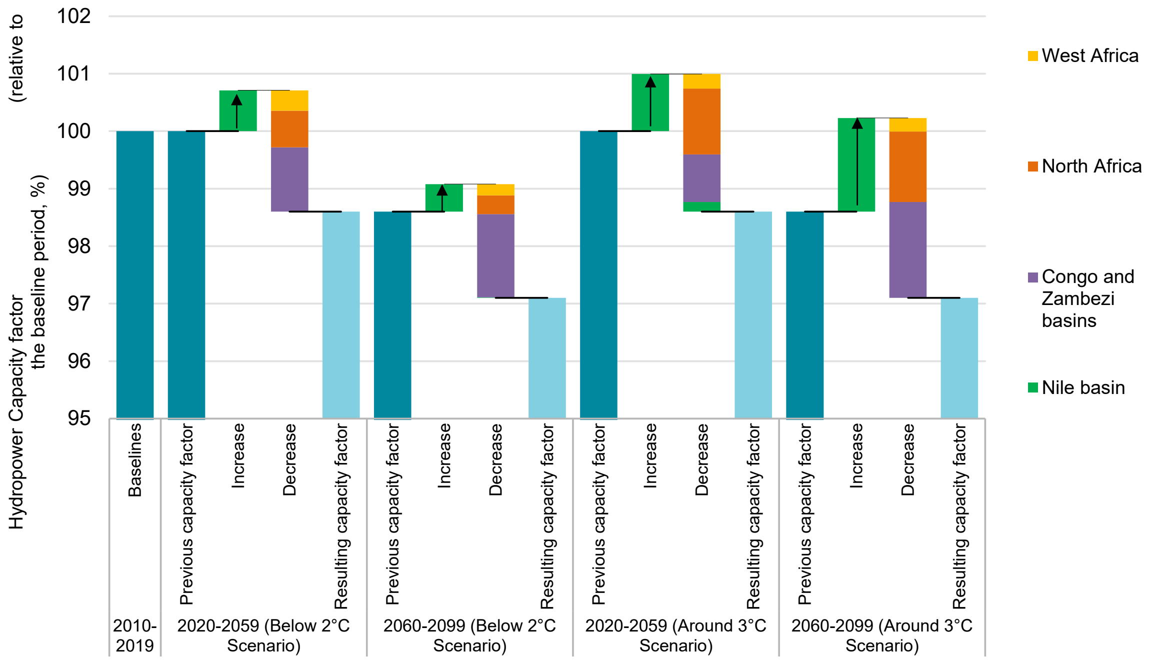
Sewerage remains a challenge to rapidly growing cities in the region. In 2015, for example, only 27% of the sewage was treated before being discharged in the Dakar region of Senegal, and only 5% in Nouakchott, Mauritania. Moreover, with flooding set to increase due to climate change, the lack of sewerage heightens the risks of disease. It is also vital that adequate drainage be built. In the summer of 2020 for example, floods claimed the lives of over 100 people and left hundreds of thousands homeless in the region. In Ouagadougou, Burkina Faso, more than 24 000 homes were destroyed and 150 000 properties were damaged (EIB, 2021).

There are useful lessons to be learned about urban water systems that can also assist with climate resilience. In 2016, Mauritania set several targets in its 2030 National Strategy for Sustainable Access to Water and Sanitation (NSWAS), including Sanitation Master Plans that aim at a 50% sewage collection rate target by 2030 for Nouakchott and Nouadhibou with 50% of the treated wastewater to be reused by 2030. Chinese bilateral aid funded a drainage system in Nouakchott in 2018, which aims to divert floodwaters for water treatment and use in the city (Takuleu, 2018). New investment backed by the European Investment Bank (EIB) and Agence française de développement (AFD) will construct a 5-km water evacuation channel and improve flood protection in the Tanghin district of Ouagadougou. In Dakar, a small aid-funded pilot plant is transforming faecal sludge into electricity, water for industrial purposes and ashes that can be used in agriculture and civil engineering". This is now owned by a private Senegalese company as part of a public-private partnership (PPP) with the National Office of Sanitation of Senegal (ONAS), which looks to scale up this model (Cashman, 2020).

Climate resilience of hydropower

Hydropower demonstrates how energy, water and climate are closely linked. Changes in water availability due to the impacts of climate change (e.g., growing variability in streamflow, shifting seasonal flows, and augmenting evaporation losses from reservoirs) are expected to affect hydropower potential and output directly (Figure 4.2). On the other hand, hydropower can be used as an important tool for water management, specifically, against adverse climate impacts. Indeed, hydropower dams can be used for multiple purposes such as irrigation, flood control and water supply for domestic and industrial use, while addressing the adverse climate impacts of more frequent extreme precipitation events (IEA, 2020).

Figure 4.2 Hydropower capacity factor evolution in selected African regions, 2020-2099



Note : The Below 2°C scenario and Around 3°C scenario are based on different trajectories of GHG emissions concentration evolution, associated to climate change by 2100 of respectively less than 2°C and around 3°C.
Source: IEA, 2020.

The Sahel region has several important rivers and lakes, including the Senegal River Basin and Lake Chad, which function as vital sources of hydropower capacity. The hydropower plants relying on these rivers and lakes have played a significant role in enabling affordable electricity access in the region. For instance, Mali, Senegal, Mauritania and Burkina Faso together have 350 MW of hydropower installed capacity with Mali, Senegal and Mauritania highly dependent on the 200 MW Manantali hydroelectric plant, based in Mali.

However, climate change may pose a challenge to hydropower in the region. A projected extension of dry periods in the Western Sahel (IPCC, 2018) and an increase in precipitation variability may reduce hydropower generation output or add difficulties in operation and maintenance. For instance, over the last decade, Mali has experienced reduced hydropower generation due to rainfall and hydrological changes. The adverse impacts of climate change on hydropower could bring further unfavourable outcomes. The reduced hydropower generation in Mali, due to rainfall and hydrological changes, has led the government to resort to more oil-powered stations which have in turn raised the cost of tariffs and subsidies (IRENA, 2019).

The Sahelian countries have 700 MW of hydropower projects of various sizes in different stages of development. However, approximately half of this capacity still needs to be financed and approved. Realising all these projects will require a comprehensive assessment of the interlinkage between energy, water and climate (e.g., climate risk and impact assessment) (IEA, 2020), in addition to affordable financing, supportive infrastructure (e.g., transmission lines and interconnection with neighbouring countries) and an analysis of environmental and social impacts (Box 4.2).

Box 4.2 Measures for improving the climate resilience of hydropower

Climate change directly affects every segment of the electricity system. It alters generation potential and efficiency, tests the physical resilience of transmission and distribution networks and changes demand patterns (IEA, 2021). Climate change poses a number of threats to existing and planned energy infrastructure and the reliable delivery of electricity in the Sahel. For example, projections show that the Gambia River, for example, could lose over a quarter of its flow by 2050 compared with the 1971- 2000 period, though there remain many variables that could affect this (Bodian et al., 2018). Regardless of potential flow reduction, hydropower generation for example will be challenged by flow variability and mechanical damage due to extreme weather events. Flow variability can result in different sediment loads which can cause turbine erosion. Further damage to turbines may be caused by algae blockages and corrosion which reduce the efficiency of electromechanical equipment (International Hydropower Association, 2019).

Governments need to play a central role in overcoming the existing barriers to implementing resilience measures. Without support from governments, private actors may have limited incentive to implement resilience measures. However, if hydropower systems remain vulnerable to climate impacts, their costs to society will rise while electricity service providers would bear only a fraction of the entire socio-economic costs. Thus, governments need to send strong signals to the private sector to encourage their investment in building climate resilience.

Effective policy measures and co-ordinated action among key actors play a central role in building climate resilience for hydropower in Africa. IEA analysis proposes the following recommendations (IEA, 2020):

- **Mainstream climate resilience as a core element of energy and climate plans and regulations:** Integrating climate resilience into national strategies and plans sends a strong signal to utilities and investors to build climate-resilient electricity systems. The focus should be on integrating concrete plans to handle the climate resilience of countries' entire electricity systems in national adaptation strategies.

- **Ensure that a systematic and comprehensive assessment of climate risk and impacts is available to all relevant stakeholders:** Such an assessment is the first step towards climate resilience and should be organised systematically using scientific methodologies and established guidelines. Some governments, international organisations and academia have already introduced a few comprehensive methodologies to identify and assess climate risks and enhance the resilience of hydropower. The assessments should be as comprehensive as possible.
- **Create the right incentives for electricity providers to align their interests with investments that are beneficial to the public:** Adequate levels of rewards and penalties based on the assessment of social and economic costs will encourage service providers to go beyond the minimum mandatory standards, seek cost-effective solutions and invest in climate resilience measures (World Bank, 2019). Governments with limited financial resources could consider working with multilateral development banks or other support programmes of international organisations.
- **Integrate climate resilience into national energy plans and regulations:** Governments can send strong signals to service providers and developers by mainstreaming climate resilience in clean energy transition policymaking. Incorporating the assessed climate impacts into national policies for clean energy transitions helps countries develop climate-resilient roadmaps. Governments can include resilience standards into construction codes, ask for regular climate risk assessment in the operation and maintenance rules, facilitate further deployment of resilience measures by removing or adjusting conflicting regulations and streamline environmental permitting processes for certain resilience projects. This will encourage project developers to incorporate climate risk and impact analysis as a regular part of energy projects, promoting technology development and investment in resilient energy systems.
- **Build capacity of both public and private sector stakeholders:** Governments can accelerate the implementation of resilience measures by supporting capacity building for risk and impact assessments, forecasting and early-warning, emergency response and recovery in public and private sectors. This will provide African hydropower plants with more accurate information about anticipated climate hazards and how to quickly restore their functions after damages.

Good transboundary management of water and ecosystems will be vital in optimising energy potential alongside other water uses. The Senegal River Basin

Development Authority (OMVS) (Box 4.3) provides an example of basin-wide co-operation in river management and development of water resources with a significant role to play in future hydrological and hydroelectric power management.

Box 4.3 The Senegal River Basin Development Authority

Founded in March 1972 by the presidents of Mali, Mauritania and Senegal and later joined by Guinea, the Organisation pour La Mise en Valeur du fleuve Sénégal (OMVS) has provided a forum and well-established governance mechanism for defining the distribution of river water between states, regulating navigation, investigating projects on the river and aiming to harmonise development policies in the basin.

OMVS also plays a significant role in energy. It oversees the distribution from the 200 MW Manantali hydroelectric plant, which is connected to Mali, Mauritania and Senegal by 1 500 km of transmission lines, and has led projects to increase rural electrification (DEVEX, nd). It is financed equally by the countries themselves and a number of other donors including the French government.

Another low-carbon energy solution includes small hydropower plants, which have the potential to contribute to decarbonisation and electricity access in the region, but will critically depend on the information from climate impact assessments. According to the United Nations Industrial Development Organization (UNIDO), West African countries have developed less than 15% of their potential for small-scale, run-of-river hydro. The potential is highest in southwest Burkina Faso and southern Mali where topographic conditions are amenable (UNIDO, 2020). Good hydrological data, financial incentives such as tax-free zones and guarantees for investors during site acquisitions as well as regulation for selling electricity from renewable energy sources into the grid could help bring private investors into this space (UNIDO, 2020). Off-grid applications for under 1 MW (mini, micro and pico-hydro) could be suitable for community or rural industry in remote areas away from the grid.

Considerations for taking a nexus approach to energy in the Sahel

When looking at pathways for clean energy transitions, it has become ever more important to understand the linkages among these sectors, to anticipate future stress points and to implement policies, technologies and practices that soundly address the associated risks. Adopting a nexus approach to energy services will help governments maximise precious resources in the Sahelian countries, especially as climate change and population increase the pressure on these.

Below are some opportunities for further action – both overarching and sector-specific – that can help mitigate choke points, capitalise on synergies and ensure the region remains on track for a sustainable future. Considerations and factors for the success of nexus approaches include:

- **Increasing governmental coordination:** including increasing communication, engagement of relevant ministries (for example authorities responsible for national planning, water, energy, agriculture and forests) at strategic planning and project assessment stages.
- **Building the data and understanding of resource interactions nationally:** This will assist in valuing vital resources by periodically reviewing resource pricing and natural asset evaluation so that pricing, regulation and financial incentives can better align with development goals in order to create the right conditions for long-term investments.
- **Using integrated modelling and cost-benefit assessments** that will help understand trade-offs between different options based on a range of measures (e.g. influences on long-term water and energy demand, job creation and climate resilience outcomes). Taking an ecosystem services approach can help. Useful studies are available from a collaborative project on this by researchers in Burkina Faso, Niger and Sweden (Stockholm Resilience Centre, 2021).
- **Addressing land and legal issues** that may hinder the scale-up of plans. For example in Mali and Niger, laws introduced under French colonial rule meant that trees were the property of the government, giving no incentive for people to plant or nurture them. The governments of both countries changed these laws in the early 2000s, empowering farmers to manage their trees (Carey, 2020). Changes to individual from collective land tenure and restrictions on traditional seasonal movement have sometimes been factors driving conflict between pastoralists and herders and land degradation. Careful socio-economic understanding should underpin interventions (Chomba et al., 2020).
- **Encouraging responsible urban planning that conserves ecosystems and builds resilience to climate change**. This will involve training for public agencies to make informed decisions that balance the trade-offs between conservation of natural assets and other land-uses, take a whole-systems approach to energy (e.g. considering passive, circular and nature-based solutions as well conventional supply systems), and are able to enforce regulation to avoid harmful practices such as building on flood plains and industrial water pollution.
- Raising awareness of climate impacts, increasing capacity for climate risk assessments and requiring these for energy infrastructure feasibility studies.

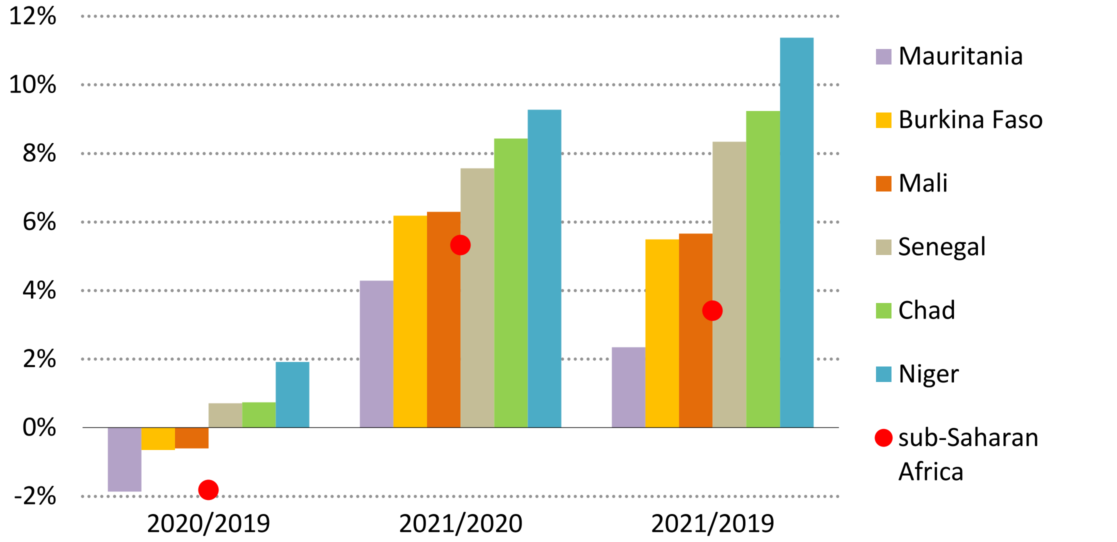
Chapter 5: Enhancing energy investment in the Sahel

Financing and investment are fundamental to accelerating clean energy transition pathways in the Sahel. 2020 was a difficult year for energy investments globally and especially in Africa. The pandemic is reversing progress in Africa - a trend that needs to be urgently corrected if SDG 7 is to be achieved by 2030. As the region looks towards recovery, energy investment needs to stay a priority for the continued development of countries' energy infrastructure and sector growth. A strong mandate for international public finance, partnerships, climate financing and innovative approaches will be vital. This is particularly pertinent for Africa and the Sahel since the future of energy is intimately tied to the ability of Sahelian states to meet SDG 7 ambitions. Moreover, massive financing will be needed across Africa and the Sahel in clean energy transitions for global efforts to address climate goals and to reach sustainable development goals.

Impact of Covid-19 on the Sahelian countries' economic outlook and energy projects

The pandemic has had an important human and economic impact across Africa. All the countries in the Sahel have grappled with the substantial negative impacts that the Covid-19 pandemic and crisis have wrought on their state finances (Figure 5.1).

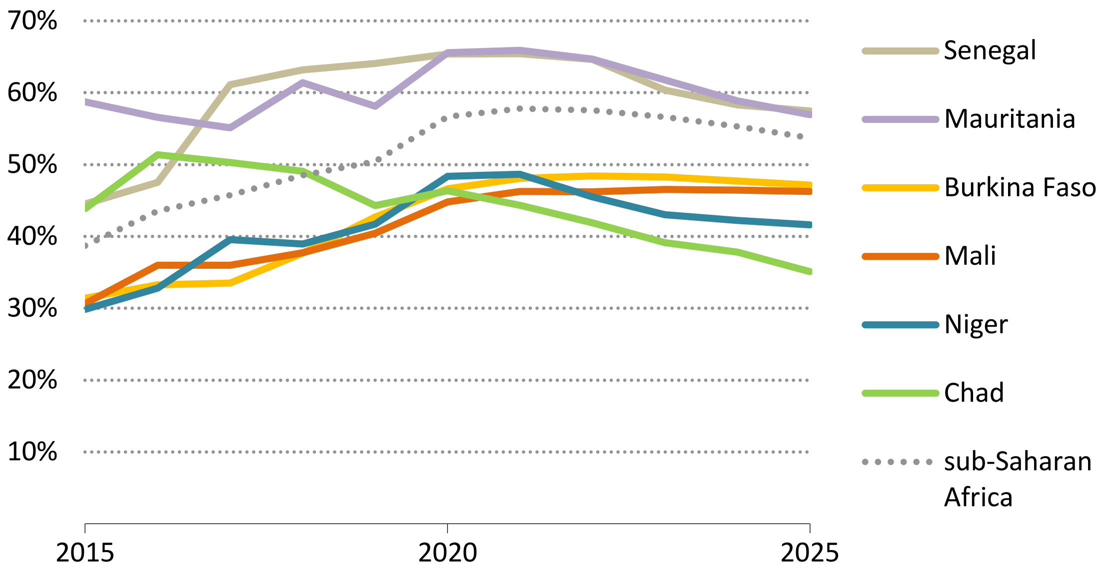
Figure 5.1. Change in gross domestic product in the Sahel and in sub-Saharan Africa



Source: IMF, 2020.

Across Africa as a whole, foreign direct investment flows decreased by an estimated 30 to 40% last year (OECD, 2020), while remittance inflows – a vital source of household income and foreign currency receipts – have also plummeted (OECD, 2020). 2020 also saw a sharp rise in government indebtedness, as economic activity and government revenues plummeted while pandemic-related spending increased (Figure 5.2). Chad for example, requested that the global commodity trading house, Glencore, suspend payments on its large oil-for-cash loan. Senegal and Mauritania's central government debt burden reached over 65% of gross domestic product (GDP) in 2020 and is likely to increase further in 2021. This large increase in the debt ratio reflects pandemic-related spending and weaker revenues, in addition to the significant growth slowdown.

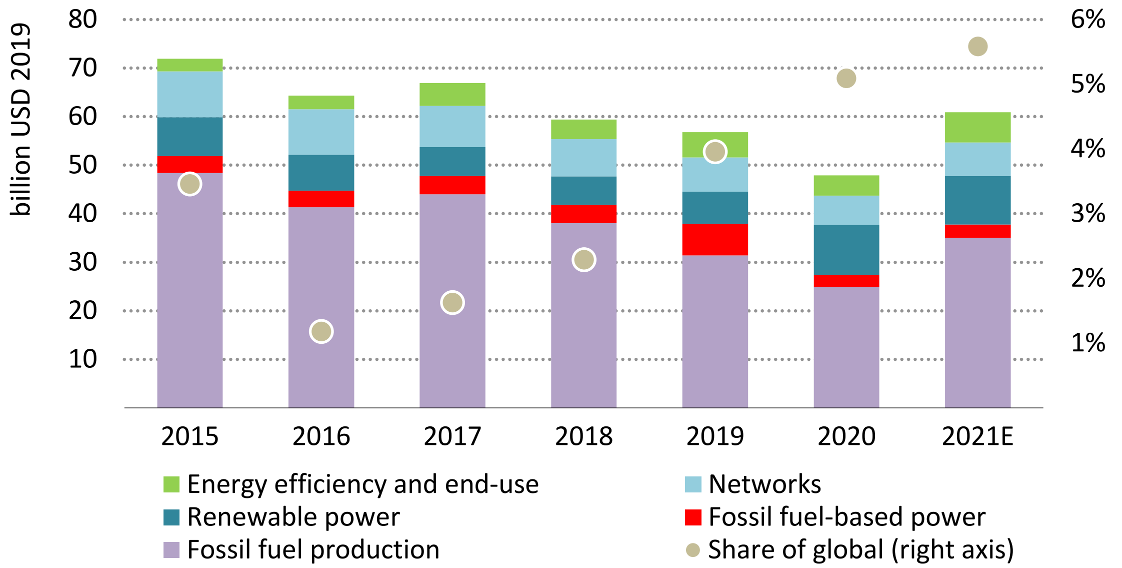
Figure 5.2. General government gross debt as a share of GDP in the Sahel and in sub-Saharan Africa



Source: IMF, 2021.

In turn, 2020 saw important changes in energy sector investment. The Covid-19 pandemic hit investment in sub-Saharan Africa particularly hard, with energy investment dropping by over 15% in 2020, above the global average (IEA, 2021a). In pre-pandemic years, fossil fuels have dominated energy sector investments in sub-Saharan Africa, outpacing electricity network investments. Yet there is partial recovery in energy sector investments (Figure 5.3) with renewables and electricity networks taking up a larger share than before. While there is recovery, investment levels are still at one-third below the 2015 levels, pointing towards a long road ahead to reach pre-pandemic levels. These are important trends to keep in mind as energy investment will be key to building a resilient and reliable energy sector that can respond to energy demand growth, underpin clean energy transition pathways and support economic recovery. As shown by a recent IEA report, increasing financing and investment across Africa is now more relevant than ever to reach climate and development goals (Box 5.1) (IEA, 2021b).

Figure 5.3. Energy sector investments in sub-Saharan Africa



Note: 2021 estimates.
Source: IEA, 2021a.

Box 5.1 Financing clean energy transitions in emerging and developing economies in Africa

There is a need for a massive increase in financing and investment across Africa. This is increasingly important for the world to meet its climate and development goals. According to a recent IEA report (IEA, 2021b), energy investment in Africa needs to at least double over the next decade from the most recent five-year average, in a climate-driven scenario.

So far, energy investments in Africa (especially sub-Saharan Africa) have relied heavily on public sources of finance including from international financial institutions and state-owned enterprises. This is particularly true in the power sector, but also characterises fuel supply investments in producer economies. In addition, financial systems and capital markets are generally underdeveloped, and capital is significantly more expensive than in other parts of the world. For example, the indicative, economy-wide cost of capital in Nigeria and South Africa are four to eight times higher than in the United States or Germany.

Clean energy transitions involve a major shift towards private sources of capital – globally over 70% of clean energy investment would come from private sources over the 2016-2030 period in IEA climate-driven scenarios. Governments need to implement consistent, targeted policies and work with the private sector to ensure investment. Across the continent, policies and financial measures would need to be strengthened to reduce risks and improve the availability of lower-cost private finance. In the countries of the Sahel which are conflict-ridden, this will require additional support and attention. Innovative partnerships will be needed between climate finance, public-private partnerships and development financing. The Sahel governments will therefore need to step up efforts to channel lower-cost capital from international sources and will need capacity- building to facilitate better local management of risks, all underpinned by partnerships and collaboration.

Recognising the catalytic role of international public finance, especially in helping to de-risk renewables projects and in opening up investment in new development opportunities in markets such as Senegal and in East Africa, international financial institutions should be given a renewed mandate to provide clean energy investment funds to support Africa. In Africa, addressing the following issues is critical in mobilising finance for clean energy:

- Putting in place long-term strategies and robust competitive frameworks for procuring renewable power with bankable long-term contracts.
- Improving the financial and operational performance of utilities which is a major factor in the region's elevated counterparty risk and underinvestment in the grid.
- Improving project facilitation, to reduce project development timelines.
- Creating more supportive enabling environments for rural electricity access.
- Putting in place performance standards and direct financing measures to support efficiency investment.
- Improving the overall availability of long-term, local currency finance.

Covid-19 is also affecting energy projections in the region. The Sahelian countries have seen significant progress in recent years with respect to sustainable energy projects, with the commissioning of several utility-scale solar PV plants and wind farms. In June 2021, Niger joined the IFC Scaling Solar scheme in order to develop a 50-MW solar plant that would represent around 20% of the country's installed capacity (IFC, 2021). All of these developments are emblematic of a new era of renewable energy investment that is emerging in the region, reflected by forthcoming projects throughout the region (Table 5.1). In addition to this, ranges of projects are also at an earlier stage. Niger – for example – has ten significant renewable energy projects in advanced stages of planning, in addition to two projects that have secured financing and one that has been commissioned, totalling a combined 284 MW (BNEF, 2021). The project pipeline highlights the significant regional renewable energy potential of the region but also demonstrates that such projects tend to take a long time to get to market.

Table 5.1 Selected renewable energy projects under development in the Sahelian countries

Name	Status	Sector	Country	Announcement /permitting data	Financing Date	Capacity Total (MWe)	Current Ownership >> Owner >> Name
Africa REN Kodeni PV Plant	Financing secured / under construction	Solar PV	Burkina Faso	21/11/2018	22/12/2020	38.00	Société de développement des énergies renouvelables SASU
Merlin Solar Gaoui PV Plant I & II	Financing secured / under construction	Solar PV	Chad	n/a	21/11/2020	100.00	Merlin Solar Technologies Inc.
Akuo Kita PV Plant	Commissioned	Solar PV	Mali	24/07/2013	10/11/2018	50.00	Akuo Energy SAS, Pash Global Ltd
Somelec Boulenouar Wind Farm	Financing secured / under construction	Onshore Wind	Mauritania	06/06/2016	03/07/2018	102.57	Société Mauritanienne d' électricité
NIGELEC Agadez Hybrid PV Plant	Financing secured / under construction	Solar PV	Niger	n/a	15/10/2020	18.90	Nigerien Electricity Society

Source: BNEF, 2021.

Across Africa, oil and gas projects have been affected by Covid-19, with delays in final investment decisions. Only two of the 28 upstream project sanctions expected pre-pandemic were approved in 2020 (IHS Markit, 2021). Senegal's efforts to harness investment in its hydrocarbon potential have been stymied through repeated delays to its first bid round, which has been extended three times and is now due to close at the end of May 2021 (IHS Markit, 2021). Similarly, the Niger-Benin pipeline – originally expected to be operational at the end of 2021 – has also been delayed and now has an expected completion date of 2024. Emerging producers all across Africa have also noted, with concern, a reduced interest in petroleum licences, and also that many companies are seeking to change the agreement terms (Marcel, 2021).

In parallel with stalling financial commitments from external partners, governments in the Sahel have struggled to find the capacity to implement ambitious energy access and expansion plans as the pandemic has triggered restrictions in the scope and scale of activities that can be taken by rural electrification agencies across the region. For example, Burkinabe officials reported delays in projects due to difficulties obtaining the necessary energy infrastructure equipment and the Chadian government highlighted difficulties in effectively implementing programmes and activities, particularly when reliant on external partners. Moreover, the pandemic affected populations that were already connected, preventing them from being able to afford modern energy services. At the height of the pandemic, Chad, Niger and Burkina Faso were seeing more than 10% of their connected populations unable to pay for existing connections (IEA, 2020a).

Progress in the off-grid sector and investments in power systems must remain a priority

Currently more than 65 million people across the Sahelian countries are still in need of access to affordable, reliable and sustainable electricity. Bridging this energy access gap will require a diverse mix of grid-based strategies and off-grid technologies and solutions such as solar lanterns, solar home systems and stand-alone mini-grids. Globally, off-grid solutions have benefitted nearly 350 million people since 2010. It is estimated that five million people are undertaking more economic activity as a direct result of owning an off-grid solar system and these same systems are also estimated to have opened up USD 6.3 billion in income over the same period. Combined with the savings generated from smaller off-grid products - such as lanterns - the sector's benefit to the finances of millions of low-income households is estimated to be over USD 18 billion. However, the market disruptions caused by COVID-19 through 2020-2021 have led to an estimated 10-15 million people missing out on improved energy access (GOGLA, 2021).

This is particularly pertinent for Africa and the Sahel since the future of the off-grid industry is intimately tied to the ability of Sahelian states to meet SDG 7 ambitions. Currently, more than 4 000 mini-grids are being planned for development in Africa, representing more than half of the total planned mini-grids globally. In addition, more than a quarter of the planned mini-grids in Africa are expected to be developed in Senegal (ESMAP, 2019). For the first time, West Africa has also attracted more investment deals in the off-grid industry than East Africa (USD 142 million in West Africa compared to USD 70 million in East Africa) (Corbyn, 2021) which provides strong evidence that off-grid solar companies are now expanding and pivoting towards the region. Over 40,000 off-grid solar products were sold in Burkina Faso in the second half of 2020, 40% above sales levels in the first half of the year. Mali recorded a 60% increase, with almost 20,000 units sold in the same time period (GOGLA, 2021).

However, companies advancing this agenda are facing huge short-term survival challenges, with sales dropping, staff being laid off and a lack of support available to their businesses (Endev, 2020). Many off-grid companies lost huge proportions of their revenues during the pandemic, and a great many have limited Operational Expenses (OPEX) available (SEforAll, 2020). Supply chain disruptions have meant that many businesses have struggled to supply spare parts, and border closures have made transportation almost impossible and very expensive. For larger projects (such as mini-grids), overseeing operations has also been challenging due to lockdowns. Although investment in the off-grid solar sector has remained stable, debt financing has increased by 20% and equity financing has dropped by 45% in the same year, causing worries about the continued growth of key players (Corbyn, 2021).

Crowding-in off-grid private sector investment will be key to overcoming the Covid-19 related difficulties and maintaining progress on energy access by growing off-grid opportunities and markets across West Africa. Success stories in other African regions like East Africa can provide examples of growing markets based on more cost-efficient technologies.

Globally, more than half of the cumulative investment to 2030 is expected to support mini-grids and stand-alone systems. In sub-Saharan Africa, these solutions can be the least-cost electricity option for two-thirds of the population without access (IEA, 2019) and require USD 135 billion cumulatively invested by 2030.

Investing in the Sahel's power sector is essential for overcoming constraints. Beyond decentralised solutions, a significant increase in investment is required to bring more power online, to extend and maintain national grids, and to connect more households across the Sahel and Africa overall. Achieving universal access to electricity globally by 2030 requires investments of more than USD 35 billion per year, in new on-grid generation, electricity grids and decentralised solutions.

It is estimated that only 19 out of 39 utilities in sub-Saharan Africa earned enough revenues to cover operational expenses, and less than five of these covered at least half of their capital expenses (Kojima & Trimble, 2016). Partly because of this, blackouts and brownouts are common in many cities across the region. Insolvency also hobbles attempts to encourage IPPs, including those who could bring more renewable power online. This is because investors and lenders worry that they will not receive payment for the kilowatt-hours that they produce.

Discussion on the financial viability of African utilities revolves around the self-reinforcing combination of high connection costs, unaffordable tariffs and poor collection rates, low consumption rates, weak regulatory frameworks, and unreliability (see for example Trimble et al., 2016). These challenges resonate for many of the utilities across the Sahel. For example, in Niger, households typically pay a fee of USD 500 to the utility for connection to the grid (with no pole), which amounts to roughly a 140% of average annual GDP per capita (Blimpo and Cosgrove Davies, 2019). Moreover, Covid-19 added pressure on already financially stressed utilities due to outstanding payments. Burkina Faso for example cancelled certain penalties to its national utility Sonabel to provide relief (ECREEE, 2020).

However, utilities across the Sahel may be better placed than others in Africa to break this cycle. Despite wide-ranging problems, Sahelian utilities score relatively well in terms of reliability when compared to many other regional neighbours (Chingwete, Felton and Logan, 2019).[1] This means that potential customers are more likely to trust the service that they will receive. Continuing to focus on "reliability" will also equip Sahelian utilities to take advantage of opportunities for business, manufacturing and industry as these sectors grow and develop over time. Around 80% of sub-Saharan African businesses recently suffered from electricity disruptions, leading to average annual losses of around 8% of sales (IEA, 2019), demonstrating just how crucial reliable energy access is to powering economic development.

Energy efficiency as key to future investment trends

Appropriately designed, highly energy-efficient, cost-effective products and services are essential to delivering energy services at the lowest cost, and to scaling and accelerating global energy access efforts. At a global level, the IEA's

[1] Senegal and Mali are placed near the "best reliability" category in Africa while Burkina Faso and Niger sit around the average. Mauritania and Chad are not included in the surveys.

Sustainable Recovery Plan highlights that one-third of the USD 1 trillion financing required would go into efficiency (IEA, 2020b). Efficient appliances can make delivering electricity access with off-grid renewable solutions more affordable to households, with the cost of efficient appliances being more than offset by energy savings. There are examples of how international investment in energy efficiency can promote best practice and an enhanced role for the private sector across the Sahel (Box 5.2).

Box 5.2 An international partnership supporting the distribution of solar water pumps in Senegal

Senegal's participation in the Global LEAP Awards has helped to ensure that Senegalese consumers have access to best-in-class products by providing clear and actionable data to the global off-grid market about appliance quality and performance.

A small off-grid energy system and the appliances and equipment it powers can be one of the biggest purchases that poor households and businesses will ever make. Farmers in Senegal – like most across the Sahel - often rely solely on unpredictable seasonal rainfall to meet water needs. Solar water pumps can play an important role in delivering a sustainable water supply in an increasingly climate-vulnerable world with many farmers able to increase yields and reduce expenditure on irrigation. However, such systems also present significant technical challenges, for example withstanding variance in water quality, being transported across rough terrain, and having components that are easy to maintain and repair. It is therefore crucial to have adequate data on the performance of different pumps across size and form factor categories.

Through results-based financing, the coalition behind the Global LEAP Awards[2] are catalysing the uptake of high quality super-efficient appliances by: 1) lowering the cost to procure large volumes of best-in-class off-grid appliances for early mover off-grid solar companies, and 2) facilitating new business partnerships for appliance suppliers that have invested in the production of high-quality off-grid appliances.

[2] The Global LEAP awards are implemented through the Efficiency for Access Coalition and managed by CLASP, with support from Power Africa, UK aid, Energising Development, Powering Agriculture and USAID.

International partnerships continue, new opportunities for green recovery

The IMF expects several countries in the Sahel to grow after the difficulties of 2020 pass. With renewed shutdowns seen as unlikely, and a range of key projects restarting, a rebound in growth is seen across many countries in the Sahel, particularly Niger (IMF, 2021). Nonetheless, 11 African countries had their credit ratings downgraded in the first half of 2020, and a further 12 (including Senegal) had a negative change in their sovereign rating outlook, meaning that they are at risk of being downgraded in the short or medium term (AU, 2020). All of this affects the ability of Sahelian countries to raise funds from international markets with significant increases in the cost of borrowing.

In this context, mobilising development finance institutions and donors is critical to enabling energy access to start expanding again. Table 5.2 shows the major finance initiatives targeting energy or energy-related infrastructure in the region.

Table 5.2 Current projects outlining finance and investment opportunities

Project name	Region/countries covered	Focus areas	Amount and type of finance/investment
AfDB (Desert to Power Initiative)	11 countries from Senegal to Djibouti, but focus on Burkina Faso, Mali, Mauritania, Niger and Chad for phase 1	Solar (on and off-grid electrification) 2019-2025	USD 1 250 million (Green Climate Fund, AfDB and others)
Alliance Sahel Energy and Climate Projects	Burkina Faso, Mali, Mauritania, Niger and Chad	Energy and Climate Change (various)	USD 2 400 million (various funders)
Climate Finance Facility to Scale Up Solar Energy Investments in Francophone West Africa LDCs	Benin, Burkina Faso, Guinea-Bissau, Mali, Niger and Togo	Energy Access and Power Generation	EUR 122 million (BOAD) and (GCF))
DESFERS (Economic and Social Development of Women through Renewable Energy in the Sahel) Under the Women and Sustainable Energy initiative in developing countries of the EU	Senegal, Mali and Niger	Women's economic empowerment through sustainable energy	EUR 7,6 million (EU)
ECOWAS Regional Electrification Access Project	Gambia, Guinea-Bissau, Mali, Niger, Togo	Grid extension (2019-2025)	USD 225 million (World Bank)

Project name	Region/countries covered	Focus areas	Amount and type of finance/investment
ECREEE Regional Off-Grid Electrification Project (ROGEP)	Benin, Burkina Faso, Cabo Verde, Côte D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo	Solar market development (2019-2024)	USD 150 million (World Bank)
Niger Solar Electricity Access Project (NESAP)	Niger	Electrification in rural and peri- urban areas (2017-2024)	USD 42,7 million (World Bank)
Niger Electricity Access Expansion Project (NELACEP)	Niger	Electrification (2016-2023)	USD 65 million (World Bank)
PERZI (Programme d'Electrification Rurale en Zone Isolée)	Mauritania	Hybrid mini-grids (2016)	USD 1,67 million (UNDP, GEF)
Promotion of Climate-Friendly Cooking	Senegal (and Kenya)	Clean cooking	EUR 57,17 Million (GCF, BMZ)
Solar Rural Electrification	Mali	Off-grid electrification (2019-2025)	USD 41,5 million (GCF)

Source: Various (see bibliography for further details on individual projects).

Although the table above is non-exhaustive, taken together, the schemes listed therein equate to only a fraction of the investment required to stay on track with SDG 7 ambitions. However, in the current landscape of the Sahel, where grant finance is essential for de-risking future private sector enterprise, the value of such projects is not in meeting the total energy requirements of future generations, but in showing the way for future private capital.

Many countries in sub-Saharan Africa have seen their first large-scale renewables projects allocated through competitive auctions at internationally competitive prices. When well-run and attractive to bidders, auctions can spur competition and drive down subsidy costs. Mali launched a solar-plus-storage auction in August 2019, putting 1.3 MW of PV and a 1.5 to 2 MWh of storage out to tender. Senegal has also been at the forefront of auction processes. Auction schemes (especially those involving development finance) often involve a range of de-risking measures such as pre-securing project sites, standardising contracts and protecting against political risk. Yet such programmes are not without transaction costs: the level of support accorded to developers should not be overlooked and the price expectations of governments can be raised to unrealistic levels (particularly where the risk exposure remains high) (Climatescope, 2020).

Using climate finance to help attract and maintain investment

In order to attract the required levels of investment, governments across the Sahel will need to take advantage of new financial opportunities with climate finance, like blended finance solutions – and especially new flows to adaptation and resilience. To attract and effectively deploy some of this finance to help realise energy objectives, it is important for governments and donors to make sure sustainable access remains a priority across the Sahel and to include it in recovery plans wherever appropriate. In a world where finance is constrained, access projects will need to be smart (e.g. linked with agriculture to unlock related benefits), effective and capable of being implemented quickly (Box 5.3) (IEA, 2020a).

The largest climate funds sit with the multilateral development banks, the United Nations Framework Convention on Climate Change (UNFCCC) and a number of key donor countries, yet only a small proportion is disbursed each year. Challenges include the current structure of funds, the lack of country climate policy and regulation and compliance criteria that can be difficult for lower capacity countries to meet (Dia, 2019). However, climate finance has been ramping up in Africa since 2018 since the Green Climate Fund (GCF) accreditation of several agencies that serve the Sahel region including AfDB, West African Development Bank (BOAD) and L'Observatoire du Sahara et du Sahel (OSS). In partnership with Dutch bank FMO, the GCF has created a USD 820 million blended finance facility called Climate Investor One (CIO). Established in 2018, this aims to run for 20 years and reduce the costs of development, construction and commissioning of renewable energy projects. Senegal is one of nine African countries included (Green Climate Fund, 2021). Senegal has secured the most funding so far from the GCF where four out of 11 projects and facilities target energy specifically (CIO is one). Other GCF-funded energy-specific projects include the Yeleen Project in Burkina Faso and the Mali Solar Rural Electrification project (referenced in Chapter 2.2).

With renewed international attention on the Sahel and greater acceptance of the urgency of acting to build resilience to climate change, there will be opportunities to build on climate-financed projects. There are a number of new finance initiatives in this space, which could benefit Sahelian countries. Opportunities for financing adaptation and resilience through green bonds are a small but growing area. Issuance of green bonds reached its highest to date in 2020 at USD 269.5 (Institutional Asset Manager, 2021). Out of the near USD 1 trillion issued to date, only a fraction – around USD 2.78billion - is from African countries (mainly South Africa, Morocco and Nigeria) and around USD 2.6bn from the AfDB (Climate Bonds Initiative, 2020). Almost half of African green bonds have financed renewable energy and energy efficiency projects (Marbuah, 2020). However, experience is growing, with a useful toolkit available to countries such as the Climate Bond Initiative or FSD Africa Investments (FSD Africa, 2020).

Box 5.3 Investment risks and remedies in the Africa renewable energy space

Risks such as political instability, non-payment, delays in or inadequate grid connection, currency fluctuation, land disputes and curtailment have all presented obstacles to profitable investment in the African renewable energy space. Some countries have been willing to provide sovereign guarantees, while most would prefer a sound power purchase agreement (PPA) backed with a kind of buy back guarantee called a Put or Call Option Agreement (PCOA) that would allow them to effectively sell back the asset to the host government if payments for power were not made, yet unlike a letter of guarantee, can avoid being recorded as a liability on the balance sheet of that government.

A few years ago, a raft of initiatives to unlock private finance in the solar sector began focusing on reducing transaction costs and on de-risking private investment through insurance and re-insurance packages. These are gaining experience and could enable rapid up-scaling of investment in African solar.

African Trade Insurance (ATI) has a Regional Liquidity Support Facility (RLSF), which enables liquidity guarantees to investors in a number of projects in its almost 20 member countries, through an initiative funded by the German state bank, KfW. This mechanism can remove the risk of cash flow problems for developers if state off-takers (the entities that buy the electricity – often highly indebted with low customer knowledge) fail to pay. The facility entails a letter of credit from a commercial bank, enabling cash within 15 days of a failure to pay and for up to six months. To date, seven countries have signed on – including Benin and Côte d'Ivoire. IPPs in Burundi and Malawi have accessed the facility to support investment in two major solar projects (ATI, 2020).

At the same time, the Africa Energy Guarantee Facility (AEGF) supported by Munich Re and the European Investment Bank (EIB) gives ATI virtually unlimited capacity to re-insure projects that meet EU Sustainable Energy for All criteria (ATI,

2021) – significant for larger projects such as hydro in Zambia and Ethiopia and some geothermal projects.

Several other initiatives by AfDB, World Bank and USAID also try to cover this space in de-risking and reducing transaction costs for investors. IRENA works with countries to do this through increasing the provision of information and has worked with Power Africa to match lenders and financiers with projects.

There are also emerging finance mechanisms enabling countries to better prepare for and respond to climate risk. African Risk Capacity, which was created by the 34 African Union Member states that signed the ARC Establishment Treaty, is a specialised Agency and company that helps African governments improve their disaster risk management capacities and offers insurance packages that fund pre-approved contingency plans in the event of disasters. Mauritania, Niger and Senegal have already accessed payouts to assist farmers during drought crises (African Risk Capacity, 2021). More specifically related to energy is the ATI's Regional Liquidity Support Facility and a number of other emerging mechanisms (Box 5.3).

Emerging policy responses

Governments across the Sahel have deployed a range of policy measures to protect and stimulate energy industries during the pandemic and many of these will remain relevant in the coming years. For the off-grid industry, Senegal gave essential service status to off-grid companies to ensure operational continuity and maintained tax exemptions on solar products. Mali also introduced VAT exemption on those bills for consumers from April to June 2020. Such measures – in addition to removing diesel subsidies, facilitating access to public or direct foreign investment, direct funding to electrify health centres, and low-cost loans for large customers – could be useful measures to support the off-grid industry as the sector emerges from the pandemic (IEA, 2020a). More broadly, in the electricity sector, during the first months of the pandemic, many Sahelian countries implemented energy policy measures that focused on relieving the energy end users' financial burden by waiving or reducing electricity bills for vulnerable communities. For example, Burkina Faso provided a 50% reduction in electricity bills and for the cost of Solar Home Systems for poor communities, while both Senegal and Mali provided support for the electricity and water bills of the poorest communities. In Niger the state announced it would provide electricity and water for the months of April and May 2020, while Senegal covered power and water utility bills (ECREEE, 2020). Finding ways to ensure that access remains affordable, while continuing to focus on the efficiency and operational performance of state utilities will be crucial to longer-term success.

All these measures, however, must be considered in the overall economic context, and choosing which support to keep and which to phase out will be a key decision for policymakers in the region. A focus on expanding and accelerating the modernisation of existing grids and scaling-up investment in new transmission and distribution infrastructure will support utilities across the Sahel (and jobs within them). As Table 1.3 showed, a large pipeline of PV projects is now emerging, but many of the countries region have little experience of integrating grid-scale solar. Drawing on interconnections (see Chapter 1 and Chapter 2.1) will be important for Sahelian countries struggling to integrate these large volumes. In the longer term, countries in the Sahel can also look towards net metering and carbon pricing to support renewable energy integration and encourage further deployment of renewables (Climatescope, 2020).

For oil and gas developments, Covid-19 has brought forward changes at the investor and insurer level for adjusting to carbon risks and there is now renewed emphasis on phasing out carbon and methane. The slowdown offers an opportunity to think about building flexibility and resilience into nascent institutional development, strengthening preparation for health, safety and environmental regulation and considering how revenues might be deployed on a transition pathway. Furthermore, a renewed emphasis on reducing emissions in the oil and gas sector (OECD, UNEP, World Bank) also offers capacity-building opportunities for many countries in the Sahel.

For international lenders, as of 1 May 2021, the G20 economies are allowing the world's poorest countries (including all of those in the Sahel) to suspend repayment of official bilateral credit. The G7 and the Bretton Woods Institutions have also indicated support for further measures to suspend debt obligations. Current approaches suggest that "positive net flows" of low-cost financing along with strong technical assistance on debt management are central to the packages being deployed (World Bank, 2021b).

Considerations for future energy investment in the Sahel going forward

There are multiple considerations for energy decision makers as well as other stakeholders to guide thinking on energy investments in the Sahel. A few stand out:

- **Ensure that access to both electricity and cooking remains a priority:** Policymakers across the Sahel must ensure that energy investments – both grid and off-grid – continue to match the levels required to fulfil regional and national ambitions. One way of doing so is to develop policies that are supportive of and conducive to investment for renewable energy, including for rural electricity access. Given the upcoming importance of off-grid solutions, policymakers across the region should ensure that off-grid solution providers are regulated and incentivised appropriately. Policy options such as clean energy targets and tax breaks are essential to this, but net metering and carbon pricing will also be useful as the sector matures.
- **Seize on a new wave of finance mechanisms to better unlock private finance:** Governments across the region can draw on a major wave of finance initiatives targeting energy or energy-related infrastructure. Initiatives such as "Desert to Power", "Alliance Sahel" and the Regional Off-Grid Electricity Access Project, "ROGEP" offer opportunities for generating transformative change in energy ecosystems across the Sahel. Novel partnerships with humanitarian and other non-traditional actors are also possible, while development finance can be channelled towards SDG-labelled projects with dedicated monitoring and evaluation systems. International public financing and institutions should take a more central and invigorated role to intervene. Donor-backed de-risking mechanisms are crucial to overcoming perceived project risk and a lack of local finance. It is key to put in place robust competitive frameworks for procuring renewable power with bankable long-term contracts. Current recovery package and stimulus initiatives can be directed to support de-risking instruments for projects and sectors that have already demonstrated their viability. The overall availability of long-term, local currency finance should be a priority.
- **Invest and prepare grids for a large pipeline of renewable energy projects:** Much work will be required to ensure that grid systems are able to accommodate this new capacity. Investment in distribution and transmission remains crucial, as does investment in the capacity and governance of state utilities, notably to reduce off-take risk for IPPs and increase bankability for new projects.

Annex A: Region & Country Profiles

Regional profile

SAHEL	Historical			STEPS			Africa Case		
Energy demand (Mtoe)	2000	2010	2019	2025	2030	2019-2030 CAAGR	2025	2030	2019-2030 CAAGR
Total primary energy demand	9.9	15.9	22.6	27.9	33.1	3.5%	23.4	28.7	2.2%
Coal	0.0	0.3	0.5	0.8	1.3	8.6%	0.7	1.0	6.1%
Oil	2.7	4.5	8.1	10.8	13.4	4.7%	8.9	11.6	3.3%
Natural gas	0.0	0.0	0.0	0.7	1.7	39.4%	2.0	6.0	56.4%
Hydro	0.0	0.1	0.1	0.4	0.6	13.9%	0.4	0.6	14.7%
Bioenergy	7.2	11.0	13.7	14.7	15.2	0.9%	10.2	7.0	-5.9%
Total final consumption	7.5	12.6	17.5	22.7	27.3	4.1%	19.0	22.7	2.4%
Coal	0.0	0.2	0.3	0.3	0.3	-0.3%	0.2	0.2	-4.0%
Oil	1.7	3.2	5.2	8.5	11.2	7.3%	7.7	10.3	6.4%
Electricity	0.2	0.5	1.1	2.0	3.3	10.3%	2.7	5.8	16.3%
Bioenergy	5.6	8.7	10.9	11.7	12.0	0.9%	7.9	5.3	-6.3%
Industry	0.3	0.7	1.1	1.6	2.2	6.4%	1.6	2.4	7.0%
Coal	0.0	0.2	0.3	0.3	0.3	-0.3%	0.2	0.2	-4.0%
Oil	0.2	0.3	0.3	0.4	0.5	5.3%	0.3	0.3	-0.8%
Electricity	0.1	0.2	0.4	0.6	0.9	7.1%	0.6	1.0	8.0%
Bioenergy	0.0	0.0	0.1	0.2	0.2	6.4%	0.1	0.2	2.1%
Transport	1.1	2.5	4.2	5.3	6.3	3.8%	5.1	6.1	3.5%
Oil	1.1	2.5	4.2	5.3	6.3	3.7%	5.1	6.0	3.3%
Buildings and others	6.0	9.4	12.1	15.7	18.8	4.1%	12.3	14.2	1.5%
Oil	0.3	0.4	0.7	2.8	4.4	19.0%	2.3	4.0	17.8%
Electricity	0.1	0.4	0.7	1.4	2.3	11.8%	2.0	4.7	19.4%
Bioenergy	5.6	8.7	10.8	11.5	11.8	0.8%	7.8	5.2	-6.4%

SAHEL	Historical			STEPS			Africa Case		
Electricity generation (TWh)	2000	2010	2019	2025	2030	2019-2030 CAAGR	2025	2030	2019-2030 CAAGR
Total generation	3.4	6.9	13.5	25.0	37.2	9.6%	33.0	69.3	16.0%
Coal	0.1	0.2	1.0	2.1	4.3	14.4%	1.7	3.5	12.3%
Oil	2.8	5.3	10.0	9.5	9.4	-0.6%	4.6	5.1	-5.9%
Natural gas	0.0	0.1	0.1	2.4	6.7	54.1%	7.8	24.5	73.3%
Renewables	0.4	1.4	2.5	11.1	16.9	19.1%	18.9	36.2	27.6%
Hydro	0.3	1.2	1.6	4.4	6.7	13.9%	4.3	7.3	14.7%
Bioenergy	0.1	0.1	0.2	0.2	0.4	3.9%	0.4	0.7	10.4%
Wind	0.0	0.0	0.1	1.9	2.1	28.1%	2.9	5.0	38.7%
Solar PV	0.0	0.0	0.5	4.5	7.7	28.3%	11.4	23.2	41.9%

SAHEL	Historical			STEPS			Africa Case		
CO_2 emissions (Mt)	2000	2010	2019	2025	2030	2019-2030 CAAGR	2025	2030	2019-2030 CAAGR
Total CO_2	8	15	27	38	50	5.8%	34	51	6.1%
Coal	0	1	2	3	6	9.2%	3	4	6.8%
Oil	8	14	24	33	40	4.7%	27	34	3.1%
Natural gas	0	0	0	1	4	38.5%	4	13	55.0%
Power sector	2	4	6	10	15	8.4%	9	18	10.5%
Final consumption	5	10	17	26	34	6.8%	24	32	6.3%

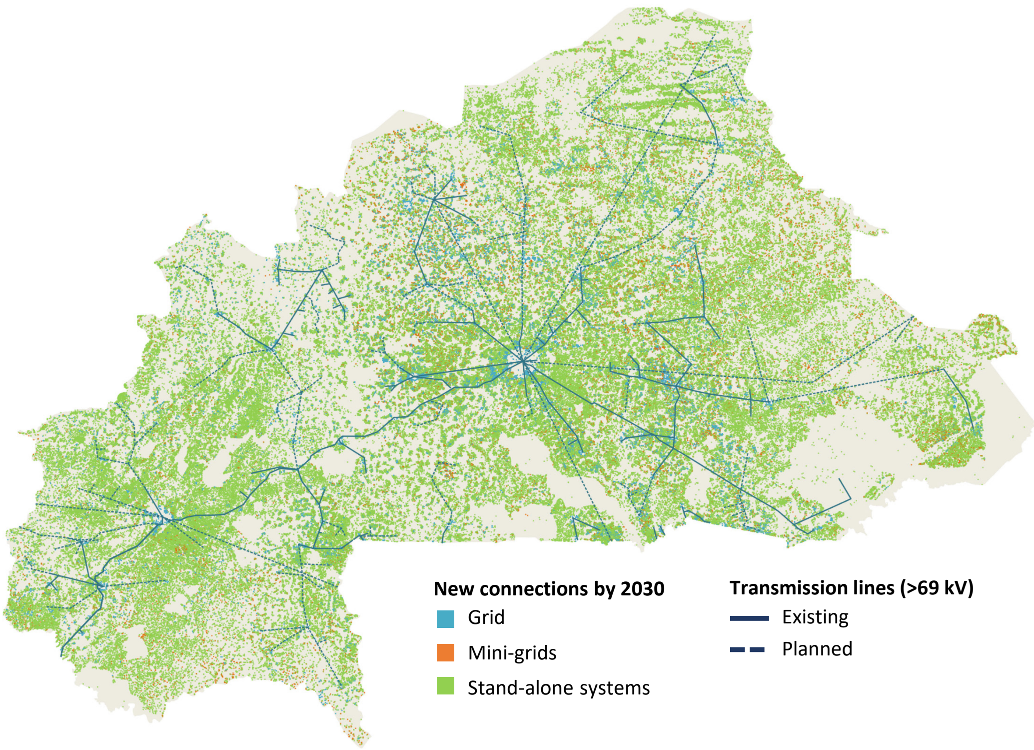
Country profile: Burkina Faso

	Burkina Faso Energy demand (ktoe)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total primary energy demand	**1,465**	**2,113**	**2,849**	**3,834**	**4,646**	**4,845**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	329	373	589	1,076	1,474	1,583	33%
Natural gas	-	-	-	-	-	-	0%
Hydro	8	9	10	8	11	12	0%
Bioenergy	1,128	1,732	2,250	2,749	3,156	3,244	67%
Total final consumption	**-**	**-**	**0**	**0**	**5**	**5**	**0%**
Coal	987	1,604	2,375	3,077	3,982	4,166	100%
Oil	-	-	-	-	-	-	0%
Electricity	232	254	538	792	1,186	1,275	31%
Bioenergy	35	55	81	149	191	201	5%
Other renewables	720	1,294	1,756	2,136	2,605	2,689	65%
Industry	**35**	**24**	**116**	**114**	**155**	**163**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	18	-	62	21	33	36	22%
Electricity	15	21	35	71	98	103	63%
Bioenergy	2	3	19	22	24	24	15%
Transport	**174**	**217**	**396**	**609**	**1,029**	**1,107**	**100%**
Oil	174	217	396	609	1,029	1,107	100%
Buildings	**778**	**1,362**	**1,862**	**2,352**	**2,797**	**2,894**	**100%**
Oil	40	37	79	161	123	130	5%
Electricity	20	34	46	77	94	99	3%
Bioenergy	718	1,291	1,737	2,114	2,581	2,665	92%

	Burkina Faso Electricity generation (GWh)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total generation	**390**	**517**	**672**	**1,526**	**1,746**	**1,862**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	292	416	545	1,419	1,510	1,609	86%
Natural gas	-	-	-	-	-	-	0%
Renewables	98	101	127	107	237	253	14%
Hydro	98	101	118	93	129	141	8%
Bioenergy	-	-	8	12	52	52	3%
Wind	-	-	-	-	-	-	0%
Solar PV	-	-	1	2	56	60	3%

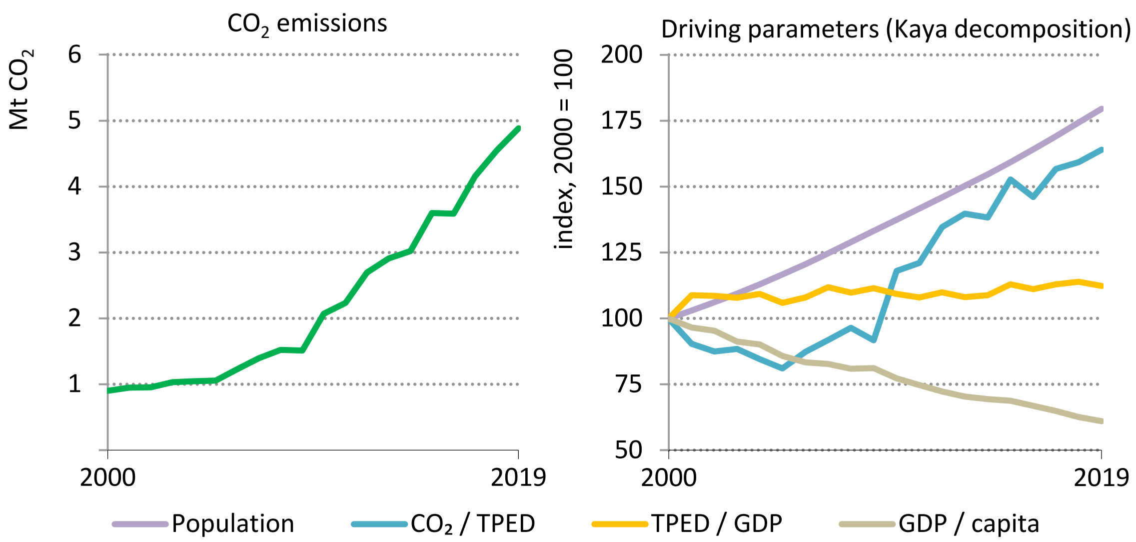
	Burkina Faso CO_2 emissions (kt)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total CO_2	**901**	**1,053**	**2,067**	**3,598**	**4,550**	**4,884**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	901	1,053	2,067	3,598	4,550	4,884	100%
Natural gas	-	-	-	-	-	-	0%
Power sector	**208**	**297**	**335**	**792**	**604**	**643**	**13%**
Final consumption	**693**	**756**	**1,617**	**2,364**	**3,537**	**3,805**	**78%**

Figure A.1. Electricity access solutions by type in the Africa Case, Burkina Faso



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.
Source: IEA, 2021c.

Figure A.2. Energy-related CO_2 emissions and driving parameters, Burkina Faso



Source: IEA, 2021c.

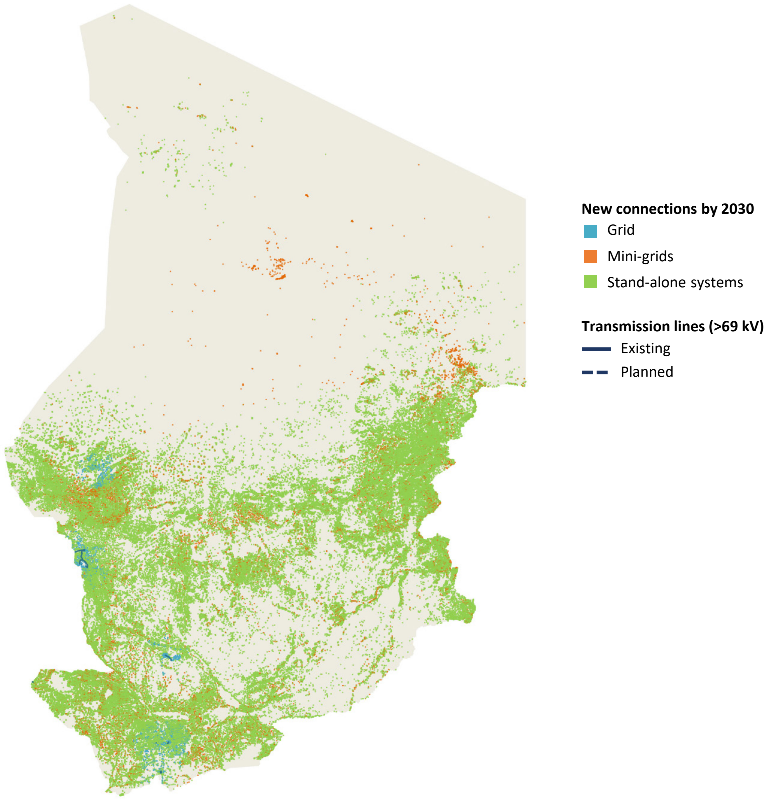
Country profile: Chad

	Chad Energy demand (ktoe)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total primary energy demand	**1,604**	**1,860**	**2,153**	**2,595**	**2,647**	**2,657**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	97	159	271	592	559	579	22%
Natural gas	-	-	-	-	-	-	0%
Hydro	-	-	-	-	-	-	0%
Bioenergy	1,507	1,701	1,882	2,003	2,087	2,078	78%
Total final consumption	**-**	**-**	**-**	**-**	**-**	**-**	**0%**
Coal	1,506	1,754	2,196	2,479	2,188	2,210	100%
Oil	-	-	-	-	-	-	0%
Electricity	73	102	322	450	404	422	19%
Bioenergy	7	5	5	15	17	18	1%
Other renewables	1,426	1,647	1,869	2,014	1,767	1,770	80%
Industry	**8**	**14**	**20**	**81**	**83**	**87**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	5	11	18	75	75	79	91%
Electricity	3	2	2	7	8	8	9%
Bioenergy	-	-	-	-	-	-	0%
Transport	**43**	**68**	**280**	**335**	**255**	**266**	**100%**
Oil	43	68	280	335	255	266	100%
Buildings	**1,454**	**1,672**	**1,897**	**2,063**	**1,849**	**1,856**	**100%**
Oil	24	23	25	41	73	77	4%
Electricity	4	3	3	8	9	10	1%
Bioenergy	1,426	1,647	1,869	2,014	1,767	1,770	95%

	Chad Electricity generation (GWh)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total generation	**66**	**100**	**100**	**290**	**306**	**309**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	66	100	100	290	306	309	100%
Natural gas	-	-	-	-	-	-	0%
Renewables	-	-	-	-	-	-	0%
Hydro	-	-	-	-	-	-	0%
Bioenergy	-	-	-	-	-	-	0%
Wind	-	-	-	-	-	-	0%
Solar PV	-	-	-	-	-	-	0%

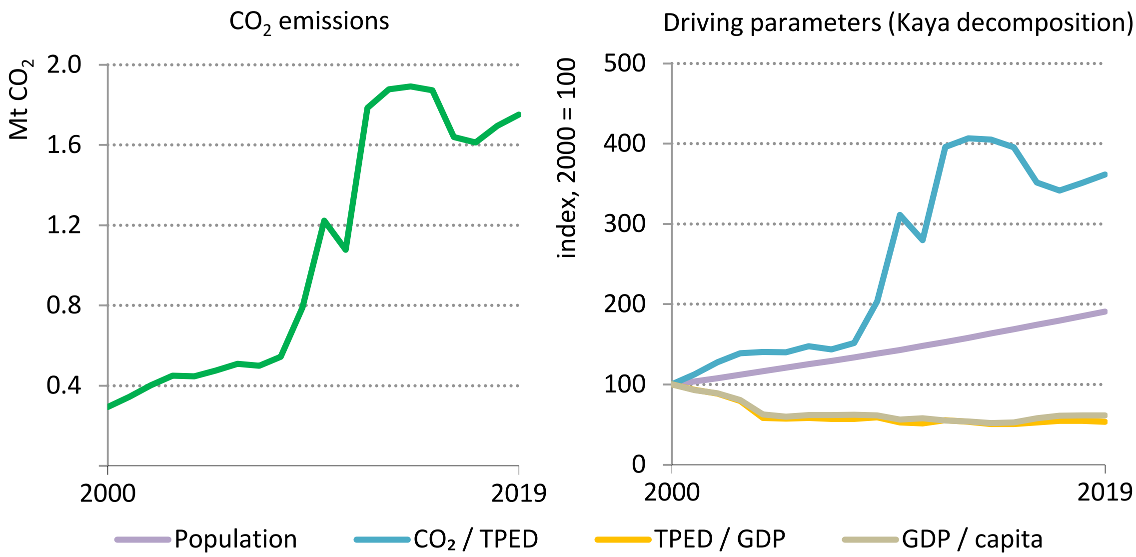
	Chad CO_2 emissions (kt)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total CO_2	**293**	**475**	**1,223**	**1,873**	**1,695**	**1,752**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	293	475	1,223	1,873	1,695	1,752	100%
Natural gas	-	-	-	-	-	-	0%
Power sector	**80**	**173**	**273**	**516**	**483**	**488**	**28%**
Final consumption	**212**	**302**	**950**	**1,335**	**1,196**	**1,248**	**71%**

Figure A.3. Electricity access solutions by type in the Africa Case – Chad



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.
Source: IEA, 2021c.

Figure A.4. Energy-related CO_2 emissions and driving parameters, Chad



Source: IEA, 2021c.

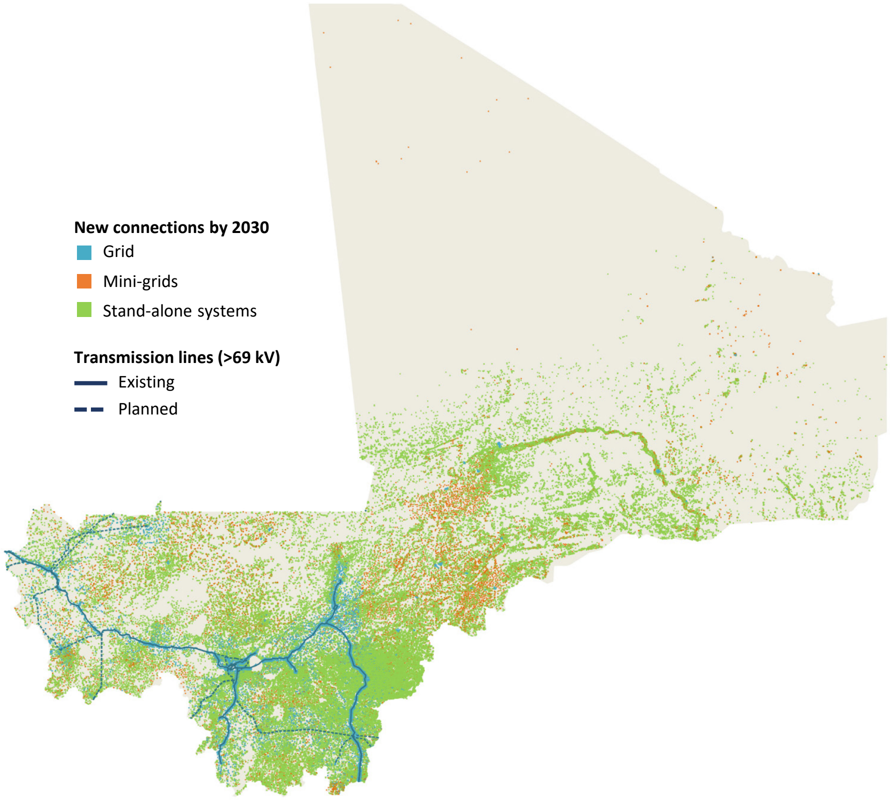
Country profile: Mali

Mali	Energy demand (ktoe)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total primary energy demand	**2,350**	**2,624**	**3,692**	**4,352**	**5,300**	**5,536**	**100%**
Coal	-	-	-	-	51	53	1%
Oil	546	599	921	1,109	1,640	1,771	32%
Natural gas	-	-	-	-	-	-	0%
Hydro	21	55	95	98	118	126	2%
Bioenergy	1,783	1,970	2,676	3,146	3,491	3,586	65%
Total final consumption	**-**	**-**	**-**	**0**	**0**	**0**	**0%**
Coal	1,602	1,862	2,592	2,956	3,806	3,959	100%
Oil	-	-	-	-	51	53	1%
Electricity	260	349	540	486	989	1,047	26%
Bioenergy	60	97	122	209	252	271	7%
Other renewables	1,282	1,416	1,929	2,261	2,514	2,588	65%
Industry	**36**	**55**	**56**	**122**	**157**	**167**	**100%**
Coal	-	-	-	-	51	53	32%
Oil	1	2	1	27	13	14	8%
Electricity	35	53	55	95	93	100	60%
Bioenergy	-	-	-	-	-	-	0%
Transport	**249**	**325**	**509**	**395**	**880**	**933**	**100%**
Oil	249	325	509	395	880	933	100%
Buildings	**1,317**	**1,482**	**2,027**	**2,439**	**2,749**	**2,838**	**100%**
Oil	11	22	30	64	76	79	3%
Electricity	25	44	67	114	159	171	6%
Bioenergy	1,282	1,416	1,929	2,261	2,514	2,588	91%

Mali	Electricity generation (GWh)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total generation	**814**	**1,270**	**2,104**	**2,541**	**3,660**	**3,952**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	517	575	944	1,350	2,216	2,417	61%
Natural gas	-	-	-	-	-	-	0%
Renewables	297	695	1,160	1,191	1,445	1,534	39%
Hydro	245	643	1,108	1,135	1,377	1,463	37%
Bioenergy	52	52	52	55	64	67	2%
Wind	-	-	-	-	-	-	0%
Solar PV	-	-	-	1	4	4	0%

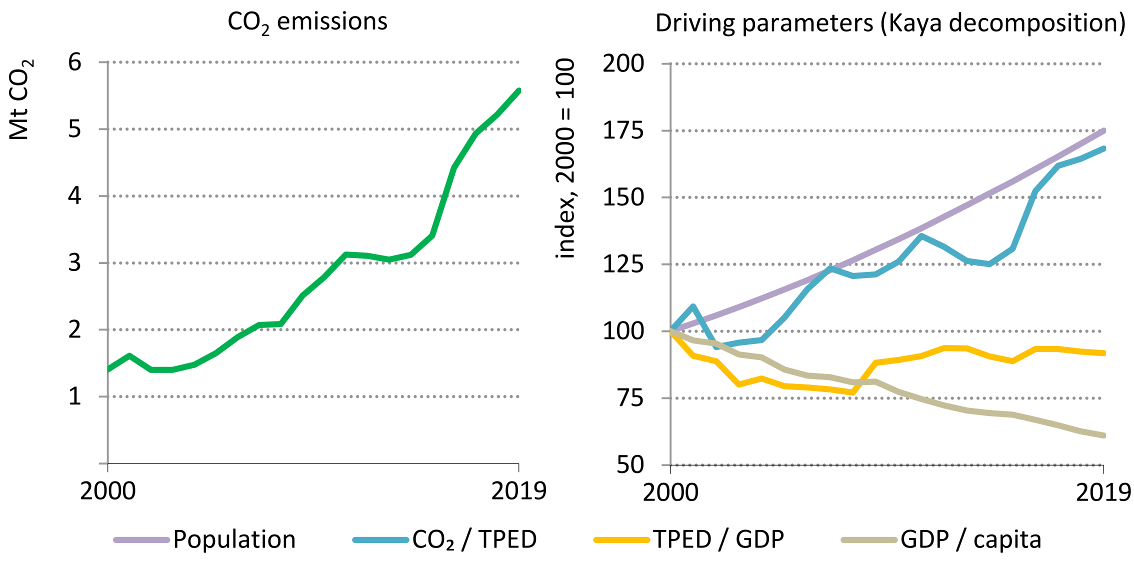
Mali	CO_2 emissions (kt)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total CO_2	**1,406**	**1,650**	**2,784**	**3,408**	**5,218**	**5,578**	**100%**
Coal	-	-	-	-	203	212	4%
Oil	1,406	1,650	2,784	3,408	5,015	5,366	96%
Natural gas	-	-	-	-	-	-	0%
Power sector	**193**	**137**	**910**	**982**	**605**	**655**	**12%**
Final consumption	**796**	**1,067**	**1,642**	**1,457**	**3,122**	**3,301**	**59%**

Figure A.5. Electricity access solutions by type in the Africa Case – Mali



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.
Source: IEA, 2021c.

Figure A.6. Energy-related CO_2 emissions and driving parameters, Mali



Source: IEA, 2021c.

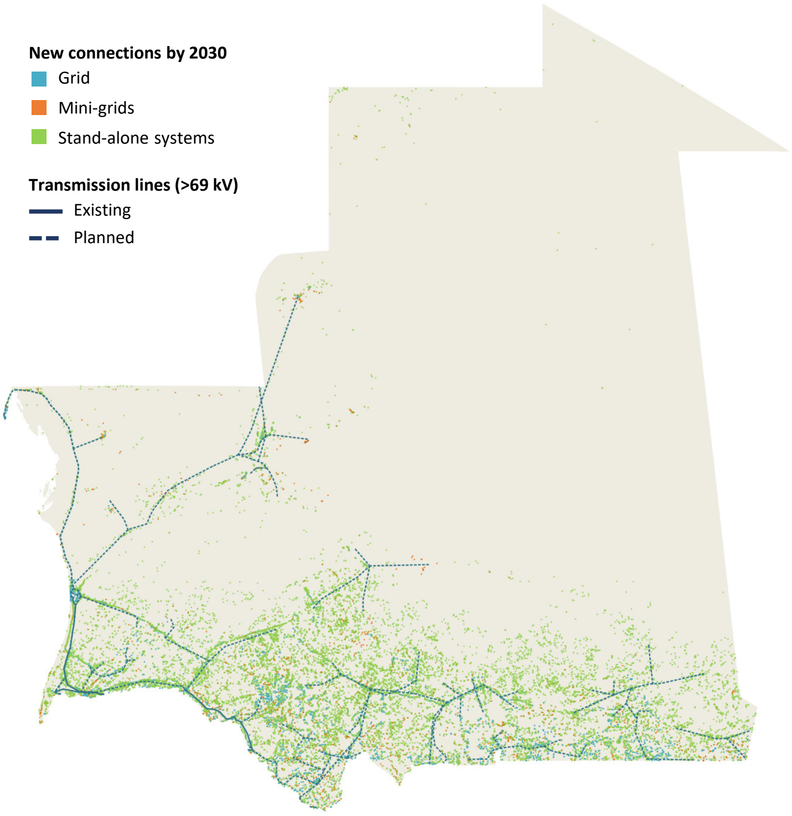
Country profile: Mauritania

	Mauritania Energy demand (ktoe)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total primary energy demand	**703**	**855**	**1,100**	**1,348**	**1,513**	**1,541**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	369	475	670	856	986	1,014	66%
Natural gas	-	-	-	-	-	-	0%
Hydro	-	-	-	-	-	-	0%
Bioenergy	334	380	430	480	508	508	33%
Total final consumption	**-**	**-**	**-**	**11**	**19**	**20**	**1%**
Coal	554	679	859	1,090	1,172	1,226	100%
Oil	-	-	-	-	-	-	0%
Electricity	275	369	499	638	698	743	61%
Bioenergy	33	43	63	124	128	137	11%
Other renewables	247	267	298	329	346	346	28%
Industry	**21**	**25**	**75**	**111**	**131**	**147**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	-	-	47	63	79	88	60%
Electricity	21	25	28	48	52	59	40%
Bioenergy	-	-	-	-	-	-	0%
Transport	**172**	**257**	**350**	**442**	**497**	**529**	**100%**
Oil	172	257	350	442	497	529	100%
Buildings	**362**	**398**	**434**	**537**	**545**	**550**	**100%**
Oil	103	113	102	132	123	126	23%
Electricity	12	18	35	76	76	78	14%
Bioenergy	247	267	298	329	346	346	63%

	Mauritania Electricity generation (GWh)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total generation	**387**	**345**	**751**	**1,509**	**1,556**	**1,680**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	387	345	751	1,379	1,337	1,450	86%
Natural gas	-	-	-	-	-	-	0%
Renewables	-	-	-	130	219	230	14%
Hydro	-	-	-	-	-	-	0%
Bioenergy	-	-	-	-	-	-	0%
Wind	-	-	-	104	104	115	7%
Solar PV	-	-	-	26	115	115	7%

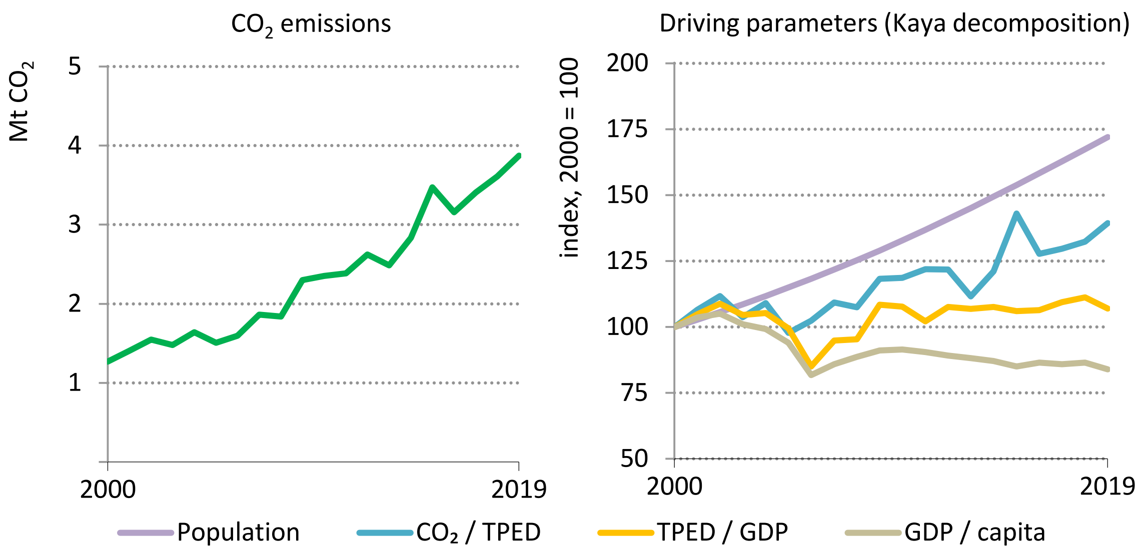
	Mauritania CO_2 emissions (kt)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total CO_2	**1,267**	**1,507**	**2,352**	**3,475**	**3,610**	**3,874**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	1,267	1,507	2,352	3,475	3,610	3,874	100%
Natural gas	-	-	-	-	-	-	0%
Power sector	**402**	**343**	**455**	**530**	**784**	**861**	**22%**
Final consumption	**837**	**1,126**	**1,519**	**1,940**	**2,125**	**2,264**	**58%**

Figure A.7. Electricity access solutions by type in the Africa Case - Mauritania



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.
Source: IEA, 2021c.

Figure A.8. Energy-related CO_2 emissions and driving parameters, Mauritania



Source: IEA, 2021c.

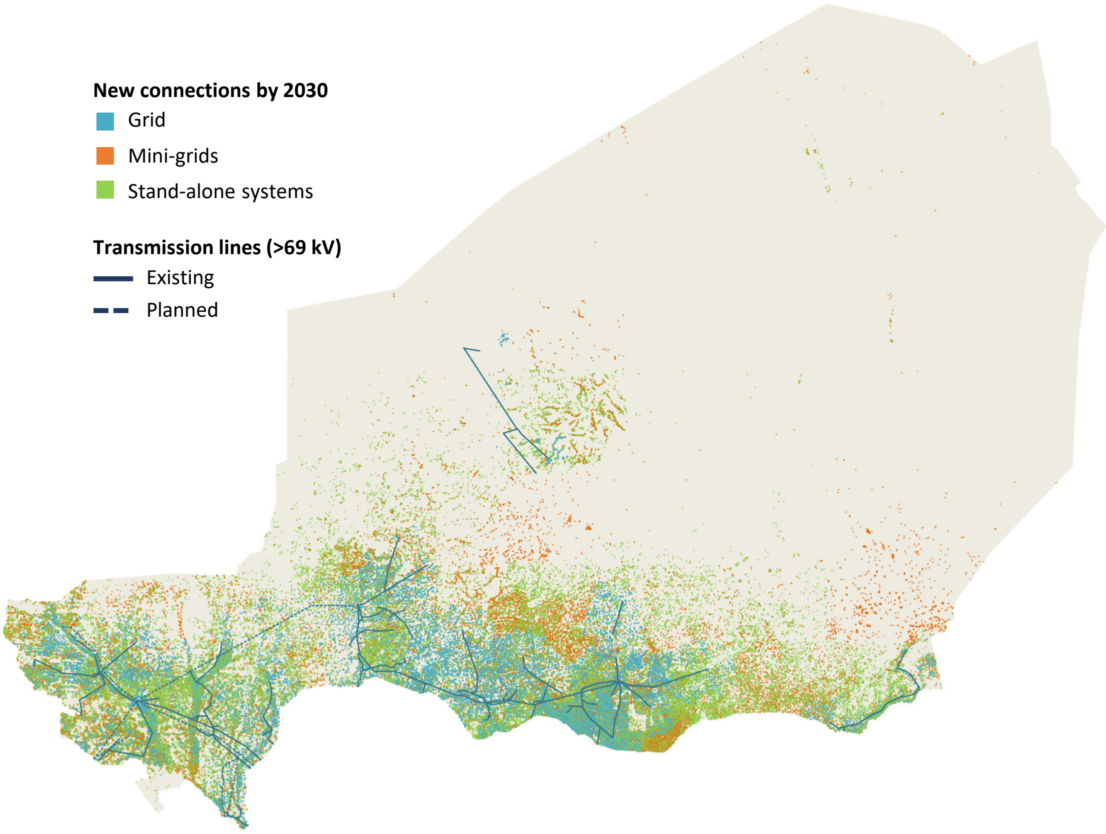
Country profile: Niger

	Niger Energy demand (ktoe)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total primary energy demand	**1,454**	**1,705**	**2,183**	**2,900**	**3,154**	**3,310**	**100%**
Coal	45	50	78	65	64	64	2%
Oil	168	193	394	620	579	631	19%
Natural gas	-	-	-	-	29	32	1%
Hydro	-	-	-	-	-	-	0%
Bioenergy	1,241	1,461	1,711	2,214	2,481	2,581	78%
Total final consumption	**-**	**0**	**0**	**0**	**1**	**2**	**0%**
Coal	1,376	1,626	2,067	2,724	2,941	3,106	100%
Oil	-	-	-	-	-	-	0%
Electricity	146	170	353	495	435	493	16%
Bioenergy	28	39	57	84	96	107	3%
Other renewables	1,202	1,416	1,658	2,145	2,409	2,506	81%
Industry	**25**	**36**	**83**	**89**	**63**	**75**	**100%**
Coal	-	-	-	-	-	-	0%
Oil	13	19	68	65	46	56	75%
Electricity	12	16	15	24	18	19	25%
Bioenergy	-	-	-	-	-	-	0%
Transport	**117**	**135**	**267**	**404**	**346**	**392**	**100%**
Oil	117	135	267	404	346	392	100%
Buildings	**1,230**	**1,448**	**1,706**	**2,228**	**2,532**	**2,639**	**100%**
Oil	12	8	7	23	44	45	2%
Electricity	16	23	42	60	79	88	3%
Bioenergy	1,202	1,416	1,658	2,145	2,409	2,506	95%

	Niger Electricity generation (GWh)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total generation	**206**	**229**	**293**	**531**	**492**	**570**	**100%**
Coal	135	158	202	221	188	204	36%
Oil	71	69	88	306	291	342	60%
Natural gas	-	-	-	-	-	-	0%
Renewables	-	2	3	4	13	24	4%
Hydro	-	-	-	-	-	-	0%
Bioenergy	-	-	-	-	-	-	0%
Wind	-	-	-	-	-	-	0%
Solar PV	-	2	3	4	13	24	4%

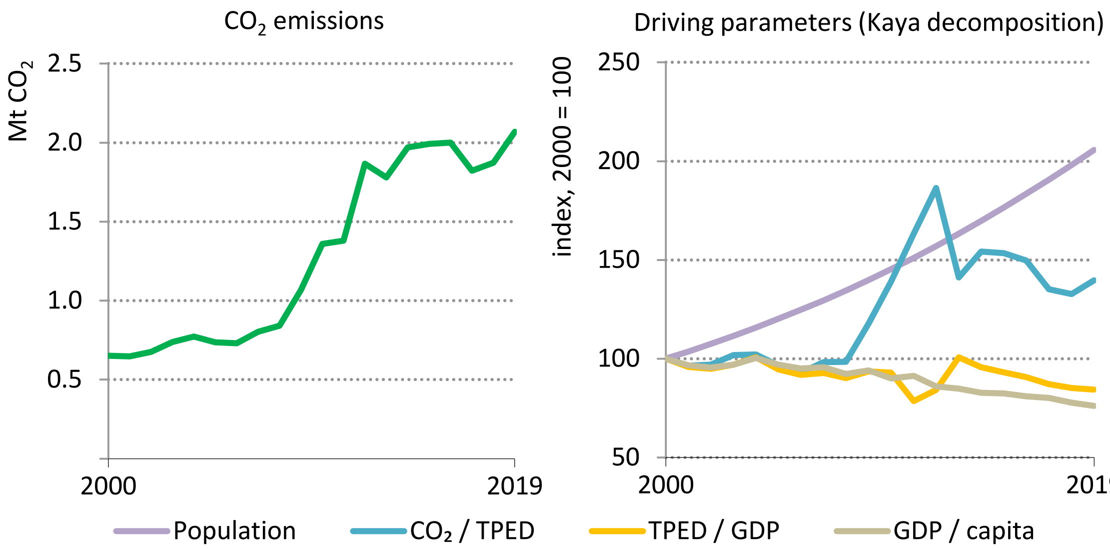
	Niger CO_2 emissions (kt)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total CO_2	**651**	**736**	**1,359**	**1,993**	**1,874**	**2,069**	**100%**
Coal	172	209	275	266	270	254	12%
Oil	479	527	1,084	1,727	1,536	1,742	84%
Natural gas	-	-	-	-	68	73	4%
Power sector	**223**	**235**	**311**	**410**	**389**	**402**	**19%**
Final consumption	**425**	**489**	**1,032**	**1,469**	**1,290**	**1,464**	**71%**

Figure A.9. Electricity access solutions by type in the Africa Case - Niger



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.
Source: IEA, 2021c.

Figure A.10. Energy-related CO_2 emissions and driving parameters, Niger



Source: IEA, 2021c.

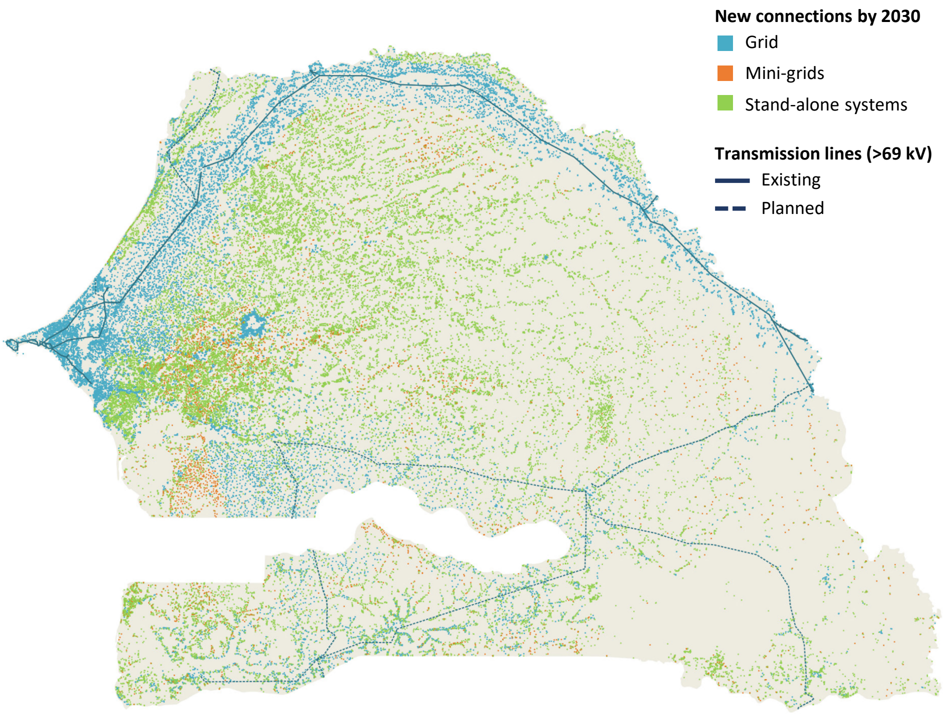
Country profile: Senegal

	Senegal Energy demand (ktoe)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total primary energy demand	**2,370**	**2,732**	**3,915**	**4,293**	**4,314**	**4,759**	**100%**
Coal	-	94	178	375	430	424	9%
Oil	1,206	1,432	1,695	2,269	2,237	2,553	54%
Natural gas	1	14	21	20	11	12	0%
Hydro	-	-	-	-	-	-	0%
Bioenergy	1,164	1,192	2,021	1,629	1,615	1,743	37%
Total final consumption	**0**	**0**	**0**	**0**	**22**	**27**	**1%**
Coal	1,471	1,722	2,556	2,894	2,545	2,803	100%
Oil	-	94	178	303	268	225	8%
Electricity	713	801	921	1,167	1,040	1,192	43%
Bioenergy	80	146	218	298	343	374	13%
Other renewables	678	681	1,239	1,126	895	1,012	36%
Industry	**184**	**275**	**325**	**546**	**396**	**486**	**100%**
Coal	-	94	178	303	268	225	46%
Oil	159	131	65	138	25	17	3%
Electricity	25	49	60	82	91	148	30%
Bioenergy	-	-	23	23	11	97	20%
Transport	**385**	**478**	**672**	**886**	**816**	**980**	**100%**
Oil	385	478	672	886	816	980	100%
Buildings	**863**	**942**	**1,515**	**1,462**	**1,333**	**1,337**	**100%**
Oil	129	165	140	142	198	195	15%
Electricity	55	97	158	216	251	226	17%
Bioenergy	678	681	1,216	1,103	884	915	68%

	Senegal Electricity generation (GWh)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total generation	**1,497**	**2,403**	**2,987**	**4,116**	**4,584**	**5,150**	**100%**
Coal	-	-	-	200	494	764	15%
Oil	1,441	2,284	2,826	3,757	3,709	3,895	76%
Natural gas	3	65	84	82	40	58	1%
Renewables	53	54	77	77	341	432	8%
Hydro	-	-	-	-	-	-	0%
Bioenergy	51	51	74	73	89	118	2%
Wind	-	-	-	-	-	23	0%
Solar PV	2	3	3	4	252	291	6%

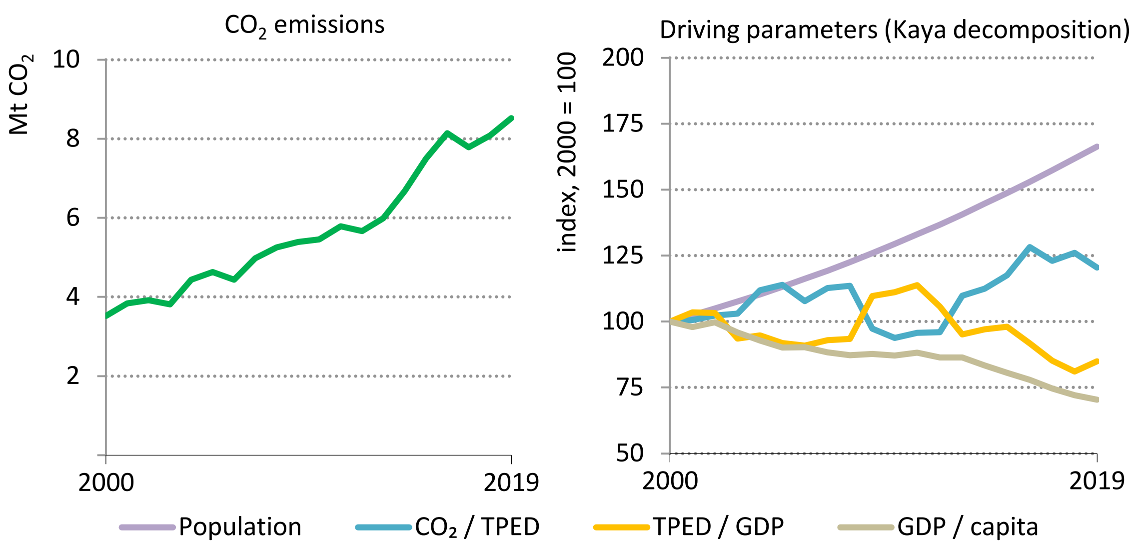
	Senegal CO_2 emissions (kt)						Shares (%)
	2000	2005	2010	2015	2018	2019	2019
Total CO_2	**3,521**	**4,626**	**5,458**	**7,497**	**8,080**	**8,520**	**100%**
Coal	-	373	704	1,483	1,703	1,678	20%
Oil	3,520	4,220	4,706	5,966	6,352	6,813	80%
Natural gas	1	34	49	48	25	28	0%
Power sector	**1,302**	**1,610**	**1,832**	**2,107**	**3,052**	**2,968**	**35%**
Final consumption	**2,026**	**2,687**	**3,345**	**4,742**	**4,146**	**4,450**	**52%**

Figure A.11. Electricity access solutions by type in the Africa Case - Senegal



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.
Source: IEA, 2021c.

Figure A.12. Energy-related CO_2 emissions and driving parameters, Senegal



Source: IEA, 2021c.

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Annex C: Data References

General note

This annex includes references of databases and publications used to provide input data to this report. The IEA's own databases of energy and economic statistics provide much of the data used in the report, with IEA statistics on energy supply, transformation and demand, carbon dioxide emissions from fuel combustion, end-user prices and splits of energy demand, forming the bedrock of the modelling and analysis carried out for this report.

Additional data from a wide range of external sources were also used to compliment IEA data and provide additional detail. This list of databases and publications is comprehensive, but not exhaustive.

IEA databases and publications

IEA (2021, forthcoming), *World Energy Statistics and Balances*, IEA, Paris, https://www.iea.org/subscribe-to-data-services/world-energy-balances-and-statistics.

IEA (2021, forthcoming), *CO_2 Emissions from Fuel Combustion*, IEA, Paris, https://www.iea.org/subscribe-to-data-services/co2-emissions-statistics.

IEA (2021, forthcoming), *IEA Energy Prices*, IEA, Paris, https://www.iea.org/subscribe-to-data-services/prices-and-taxes.

External databases and publications

Socio-economic variables

IMF (International Monetary Fund) (2020), *World Economic Outlook: June 2020 update*, https://www.imf.org/en/Publications/WEO/Issues/2020/06/24/WEOUpdateJune2020.

UN DESA (United Nations Department of Economic and Social Affairs) (2019), *World Population Prospects 2019*

https://www.un.org/development/desa/publications/world-population-prospects-2019-highlights.html.

Country notes

Burkina Faso

General notes:

Burkina Faso data are available from 2000 onwards. In the 2021 edition, the IEA Secretariat obtained new data for the period 2010- 2018 from the Système d'Information Energétique de l'Union Economique et Monétaire Ouest-Africaine (SIE UEMOA). Fuelwood production and charcoal consumption is based on official data in 2002 and using the official growth rate afterwards until 2012. The charcoal efficiency factor in mass unit varies from 12% to 16% between 2002 to 2012 based on official figures. Later figures are based on SIE-UEMOA published figures.

Data for 2019 are estimated on a trend based on the latest figures published by AFREC.

Sources:

Sources 2000 to 2019:

- Direct communication with the Ministère de l'Energie, Ouagadougou.
- *SIE UEMOA*, Ouagadougou, https://sie-uemoa.org/#statistiques, (accessed February 2021).
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- IEA Secretariat estimates.

Sources for biofuels and waste:

- *SIE UEMOA*, Ouagadougou, https://sie-uemoa.org/#statistiques, (accessed February 2021).
- *AFREC Energy Database*, African Energy Commission, Algiers, 2019.
- *Forestry Statistics*, FAO, Rome, http://www.fao.org/faostat, (accessed October 2020).
- IEA Secretariat estimates.

Chad

General notes:

Chad data are available from 1971 onwards. Prior to 2000, all data are based on the United Nations Statistics Division data and IEA Secretariat estimates.

Sources:

Sources 1971 to 2019:

- Direct communication with the Ministry of Energy and Petroleum.
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Mali

General notes:

Mali data are available from 2000 onwards. In the 2021 edition, data for year 2019 are estimated on the basis of the latest figures published by AFREC. More than 99% of the aviation gasoline has been reclassified as jet kerosene due to new information made available by the Ministère de l'Economie.

In the 2020 edition, the IEA Secretariat obtained new data for the period 2010-2018 from the SIE UEMOA. Breaks in the time series may occur between 2009 and 2010.

Sources:

Sources 2000 to 2019:

- Direct communication with the Ministère de l'Energie et de l'Eau, Bamako.

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Sources for biofuels and waste

- *Energy questionnaire*, African Energy Commission, Algiers, 2000 to 2015
- IEA Secretariat estimates.

Mauritania

General notes

Mauritania data are available from 1971 onwards. Prior to 2000, all data are based on the United Nations Statistics Division data and IEA Secretariat estimates. Sources:

Sources up to 2019:

- Direct communication with the Ministry of Oil, Mines and Energy (MPEM).
- Direct communication with the Downstream Petroleum Sector Regulatory Authority.
- *Annuaire statistique*, Agence Nationale de la Statistique et de l'Analyse Démographique et Economique, http://ansade.mr/index.php/publications/statistiques, (accessed December 2020).
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- IEA Secretariat estimates.

Niger

General notes

Data for Niger are available from 1971 onwards. Data prior to 2000 were added in the 2021 edition and sourced from the United Nations Statistics Division (UNSD). This addition led to breaks in the time series between 2000 and 2001, particularly in the solid biofuels time series. In previous editions, data for this time period was included in the “Other Africa” region.

At the time of preparation of the 2021 edition, no official data were available from Niger for 2017 to 2019. As a consequence, the statistics and balances for these years were created based on available economic indicators from the United Nations Statistics Division (UNSD) and newly available energy data from the Système d'Informations Energétiques de l'Union Economique et Monétaire Ouest-Africaine (SIE-UEMOA). Data for 2017 to 2019 were revised to reflect this new source. Electricity flows, diesel flows, crude oil production and LPG consumption in electricity plants have also been revised for 2016.

Natural gas production and consumption in electricity plants for 2018 and 2019 and LPG consumption in autoproducer electricity plants for 2010 to 2019 are new in the 2021 edition.

At the time of preparation of the 2021 edition, electricity generation data in GWh were not available for individual secondary oil products. Consequently, total electricity generation from oil products was reported under non-specified oil products for all years. The division of electricity generation by main activity producers and autoproducers was also not available for 2016 to 2019 and has been estimated based on 2015 data.

In the 2019 edition, the IEA secretariat started to estimate domestic aviation. The revisions made to integrate this information lead to breaks in the time series between 2000 and 2001.

Sources:

Sources up to 2019:

- Système d'Informations Energétiques de l'Union Economique et Monétaire Ouest-Africaine (SIE-UEMOA), UEMOA Commission, Ouagadougou, (accessed in February 2021).

- United Nations Statistical Division (various editions up to 2020), The United Nations Energy Statistics Database, https://unstats.un.org/unsd/energystats/data/, (accessed in February 2021).
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- Direct communication with the Ministry of Energy and Oil, Niamey.
- IEA Secretariat estimates.

Sources for biofuels and waste:

- Système d'Informations Energétiques de l'Union Economique et Monétaire Ouest-Africaine (SIE-UEMOA), UEMOA Commission, Ouagadougou, (accessed February 2021).
- Direct communication with the Ministry of Energy and Oil, Niamey.
- IEA Secretariat estimates.

Senegal

General notes:

Data for Senegal are available from 1971 onwards.

Senegal is one of the ten countries that benefit from EU Support to the IEA Data for Affordable and Sustainable Energy System for sub-Saharan Africa.

In the 2021 edition, previously reported hydroelectricity production was revised as imports from 2009 onwards, as the dam is not located within the borders of the country.

In addition, in the 2021 edition, the electricity output was split per oil product from 2017 onwards due to new information. As a result of the improvements in the data collection system, the final consumption of electricity was monitored more accurately in 2019. This may lead in breaks in the time series between 2018 and 2019.

Finally, in the 2021 edition, the quantities of diesel used to ignite the power plants were reported for the first time, related to the 2019 diesel consumption.

In the 2020 edition, data for 2017 were revised based on new data received from the Ministère de l’Energie et des Mines.

In the 2018 edition, data for 2014 and 2015 were revised based on information received from the Ministère de l'Energie et des Mines.

In the 2014 edition, the time series for solid biofuels were revised from 2009 onwards based on newly available information. Breaks in the time series may occur between 2008 and 2009.

Sources:

Sources 2009 to 2019:

- Direct communication with Ministère de l'Energie et des Mines, Dakar.
- *Bilans énergétiques du Sénégal* 2009 to 2019, Direction de l'Energie, Dakar.
- IEA Secretariat estimates.

Sources 2008:

- *Bulletin mensuel des statistiques économiques*, Agence national de la Statistique et de la Démographie (ANSD), Dakar, March 2009.
- Direct communication with Ministère de l'Energie, Dakar.

Sources 2000 to 2007:

- *Bilans énergétiques du Sénégal* 2003, 2004, 2005, 2006, Direction de l'Energie, Dakar.
- IEA Secretariat estimates.

Sources 1992 to 1999:

- Direct communication with Ministère de l'Energie, des Mines et de l'Industrie, Direction de l'Energie, Dakar, 1997 to 2002.
- Direct communication with Ministère de l'Energie, des Mines et de l'Hydraulique, Comité National des Hydrocarbures, Dakar, 2002.
- Direct communication with Société Africaine de raffinage, Mbao.
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- *Report of Senegal on the Inventory of Greenhouse Gases Sources,* Ministère de l'Environnement et de la Protection de la Nature, Dakar, 1994.
- Direct communication with ENDA - Energy Program, Dakar, 1997.
- *The United Nations Energy Statistics Database*, United Nations Statistical Division, New York.

Sources up to 1991:

- *Situation Economique 1985,* Ministère de l'Economie et des Finances, Direction de la Statistique, Dakar, 1986.

Other sources :

In addition to the data above, findings and insights were collected during a *Clean Energy Transitions in the Sahel Region Stakeholder Workshop* (held 28 January 2021), gathering government representatives as well as experts from international organisations, the private sector and academia active in the energy sector in the Sahel. The report also includes insights based on multiple country consultations held with the six Sahelian focus countries.

Abbreviations and acronyms

AC	Africa Case
AEO	Africa Energy Outlook
AEGF	Africa Energy Guarantee Facility
AfCFTA	African Continental Free Trade Area
AFD	Agence française de développement
AfDB	African Developpment Bank
AFREC	African Energy Commission
ANSD	Agence Nationale de la Statistique et de la Démographie or National Statistics and Demographics Agency of Senegal
ARC	African Risk Capacity
ASER	Agence Sénégalaise d'Électrification Rurale or Senegalese Rural Electrification Agency
ATI	African Trade Insurance
AU	African Union
AUC	African Union Commission
BIOLpg	Bio Liquefied Petroleum Gas
BOAD	West African Development Bank
BRT	bus rapid transport
CAAGR	Compounded Average Annual Growth Rate
CAGR	Compound annual growth rate
CCGT	Combined Cycle Gas Turbine plant
CNG	compressed natural gas
CO_2	carbon dioxide
CCRT	Catastrophe Containment and Relief Trust
CH_4	methane
CIO	Climate Investor One
CLASP	Collaborative Labeling and Appliance Standards Program
CNG	compressed natural gas
CNPC	China National Petroleum Corporation
COMELEC	Comité Maghrébin de l'Electricité or Maghreb Electricity Committee and North African Power Pool
CRRF	Comprehensive Refugee Response Framework
CSP	concentrated solar power
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
ECREEE	Centre for Renewable Energy and Energy Efficiency
EIB	European Investment Bank
EITI	Extractive Industries Transparency Initiative
EU	European Union
EV	Electric Vehicles
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FID	Final Investment Decision
FMNR	farmer managed natural regeneration

FMO	Nederlandse Financierings-Maatschappij voor Ontwikkelingslanden or Entrepreneurial Development Bank of The Netherlands
GCC	Gulf Cooperation Council
GCF	Green Climate Fund
GDP	gross domestic product
GGFR	Global Gas Flaring Reduction Partnership
GHG	greenhouse gas
GTA	Grand Tortue Ahmeyim
G6	Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal
G5	Burkina Faso, Chad, Mali, Mauritania, and Niger
HFO	heavy fuel oil
ICE	internal combustion engine
ICT	information communication technology
IDPs	internally displaced people
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IFIs	International Financing Institutions
INSD	Institut National de la Statistique et de la Démographie or the National Institute of Statistics and Demography of Burkina Faso
IOCs	International Oil Companies
IOM	International Organization for Migration
IPCC	Intergovernmental Panel on Climate Change
IMF	International Monetary Fund
IRENA	International Renewable Energy Agency
K-CEP	Kigali Cooling Efficiency Program
LC3	limestone calcined clay cement
LDCs	Least Developed Countries
LEAP	Long-Term Joint EU-AU Research and Innovation Partnership
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MDBs	multilateral development banks
MEPS	minimum energy performance standards
MENA	Middle East and North Africa
MPEM	Ministry of Oil, Mines and Energy of Mauritania
MSW	municipal solid waste
NDCs	Nationally Determined Contributions
NESAP	Niger Solar Electricity Access Project
NGO	non-governmental organization
NIGELEC	Société nigérienne d'électricité or National Electricity Company of Niger
NOC	National Oil Company
N_2O	nitrous oxide
NZE	Net Zero Emissions scenario
OMVS	Senegal River Development Organisation
ONAS	National Office of Sanitation of Senegal
OPEX	operational expenditure
OSS	L’Observatoire du Sahara et du Sahel

PASER	Plan d'Action Sénégalais d'Électrification Rurale or Senegalese Rural Electrification Action Plan
PCOA	Put or Call Option Agreement
POAUE	Operational Programme for Universal Electricity Access
PNER	Programme National D'Électricité Rurale or National Rural Electrification Programme
PPA	Power Purchase Agreement
PPPs	public-private partnerships
PRS	Product Registration System
PSE	Plan Sénégal Emergent
PV	photovoltaic
RE	renewable energy
REDES	Network for the Emergence and Development of Ecovillages in the SahelRLSF Regional Liquidity Support Facility
SDG	Sustainable Development Goal (rep)
SDS	Sustainable Development Scenario
SEAD	Super Efficient Equipment Appliance Deployment
SEforALL	Sustainable Energy for All
SEED	Soutien Energétique et Environnemental dans la région de Diffa
SENELEC	Société Nationale d'Électricité du Sénégal or National Electricity Company of Senegal
SO_2	sulphur dioxide
SSA	sub-Saharan Africa
UNHCR	United Nations High Commissioner for Refugees
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
US	United States
USAID	United States Agency for International Development
VAT	value added tax
WAM	West African Monsoon
WAPP	West Africa Power Pool
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization

Glossary

bbl	barrel
bbl/d	barrels per day
°C	Celsius
gCO_2	gram of carbon dioxide
gCO_2/kWh	grams of carbon dioxide per kilowatt-hour
GJ	gigajoule
GW	gigawatt
GWh	gigawatt hour

ktoe	kilotonnes of oil equivalent
kWh	kilowatt-hour
lge	litres of gasoline
MW	megawatt
Mtoe	million tonnes of oil equivalent
ppm	parts per million

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