



Climate Action Tracker

Natural Gas in Africa

Why fossil fuels cannot sustainably meet the
continent's growing energy demand

May 2022



Summary

Natural gas is on the rise globally & in Africa—the opposite of what’s needed to meet the Paris Agreement

Fossil fuel use is on the rise, with 70% of the increase in fossil CO₂ emissions projected to come from natural gas by 2030 if current policies are not strengthened to align with the Paris Agreement goal to limit global warming to 1.5°C.

- ▶ To meet the objectives of the Paris Agreement:
 - ▷ No new investments should be made into natural gas exploration and production.
 - ▷ Unabated gas-fired power generation needs to be phased out by 2050 globally, and in many countries by 2040.
 - ▷ Total gas demand would need to decrease by 21%–61% from 2020 levels by 2050.
- ▶ Africa, like most parts of the world, has plans to significantly expand natural gas production and consumption. This is likely to drive up currently lower emissions levels on the continent. Africa is home to nearly 9% of the world’s gas reserves and produces around 6% of global natural gas.

The risks of relying on natural gas are ever more apparent

- ▶ The current natural gas infrastructure already supplies the volumes required globally, and any addition is at risk of becoming a stranded asset.
- ▶ Development strategies that rely on natural gas production and exports are risky, as the world is transitioning to zero emissions and future gas demand is subject to large uncertainties. Jobs in the fossil fuel industry are not secure: employment is estimated to fall by around 75% by 2050 under the ILO’s well below 2°C scenario.
- ▶ Exploiting oil and gas resources has even proven to be counterproductive to development objectives in some instances: fossil fuel exporters in Africa experience slower economic growth compared to other countries on the continent.

Transitioning to renewable energy has multiple benefits

- ▶ Africa has vast renewable energy resources that can supply the continent’s growing energy demand. These resources could also support new export value chains, for example in the form of renewable electricity or green hydrogen.
- ▶ Wind and solar energy are already the cheapest sources of electricity—with new installations becoming increasingly competitive even when replacing existing fossil fuel plants.

International support and climate finance is needed to make this transition happen

- ▶ Developed countries, international companies and multilateral financial institutions need to urgently stop financing fossil fuels.
- ▶ In parallel, developed countries need to significantly ramp up international climate finance and support the energy transition in developing countries.

Case study summaries



Egypt

Egypt is responsible for over a third of total natural gas consumption in Africa. Close to 70% of its gas is used for electricity production. The government has plans to expand natural gas production and to increase natural gas infrastructure across many sectors, including electricity and transport.

Egypt does not need to rely on gas to meet its energy needs, as it has abundant and cost-effective renewable energy resources. Increasing renewable energy in the power sector would lead to multiple benefits, including higher employment generation and reduced air pollution. It could also support Egypt's ambition to become a net electricity exporter.

Our analysis shows that a high share of renewables in the power sector (82% in 2035) could create an additional 1.8 million jobs compared to the government's 2035 Energy Strategy—translating to nearly 130,000 additional jobs per year.

A high share of renewable energy (82% by 2035) could also avoid more than 5,300 premature deaths linked to air pollution from natural gas in the next two decades compared to the 2035 Energy Strategy, which foresees over 50% of electricity to be generated with gas in 2035.



Nigeria

A majority of Nigerians rely on traditional biomass, with very limited access to electricity and clean cooking. Even when connected to the grid, Nigerians face frequent and prolonged blackouts, often due to gas supply shortages.

The government has declared this decade to be the “Decade of Gas”, with plans to continue investing in gas infrastructure, which brings risks of stranded assets and locking the energy sector into carbon intensive infrastructure, when it should be investing in ever-cheaper renewables.

Nigeria is currently the 17th largest natural gas producer in the world, although it has struggled to attract investment in recent years. While Nigeria has made progress reducing gas flaring, this is still a significant source of emissions, along with fugitive methane emissions in the gas supply chain.

Our analysis shows that if Nigeria was to align its electricity sector to 1.5°C-compatible pathways, and increase its share of renewables, it could create, on average, more than 3,400 job years per MWh per year compared to the current gas-based strategy, creating only about 1,300 annual job years per MWh.



Senegal

Following significant oil and gas discoveries, Senegal has adopted a Gas-to-Power Strategy to shift from a power system dependent on expensive oil imports to one dependent on gas.

However, for Senegal to exploit its gas reserves, it needs to build significant infrastructure that would be at risk of becoming stranded assets as the world moves to net zero emissions. Further, for new markets to attract finance for gas infrastructure, countries often have to agree to take on much of the risk through unfavourable agreements such as “take-or-pay” schemes.

Finances planned for gas expansion could be channelled to renewables, which are cheaper and could provide sustainable jobs, increase access to energy, and improve local air quality.

Our analysis shows that if Senegal does not pursue natural gas and increases renewable energy in the power mix in line with 1.5°C pathways, it could create on average 6,700 job years per MWh annually compared to 1,500 job years under current policies from 2021 to 2030.



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1 Introduction

For decades, the world has used fossil resources, contributing to large parts of the Global North being able to build their wealth, while exploiting the Global South. Today, many countries in both hemispheres find themselves dependent on fossil fuels, which are not only increasingly costly compared to renewable energy (IRENA, 2021), but also closely interlinked with geopolitical tensions and considerable risks in terms of energy security, economic stability and development objectives.

Still, fossil fuels are on the rise, with 70% of the increase in fossil CO₂ emissions projected to come from natural gas under current policies by 2030 (Hare et al., 2021). Gas production and consumption is expected to roughly triple in Sub-Saharan Africa under the IEA's stated policies scenario by 2040, and increase in North Africa by about 50% (IEA, 2019). Substantial investments, often by international companies, are anticipated to provide this growth (see more detail in chapter 2—"The need for sustainable energy in Africa"). This would have major implications for Africa's greenhouse gas emissions and sustainable development ambitions.

Africa is still only responsible for a relatively low share of global emissions: as a continent, its emissions were estimated at 7% of global emissions in 2019, excluding land use, land use change and forestry (Gütschow, J.; Günther, A.; Jeffery, L.; Gieseke, 2021), whereas the continent is home to 17% of the world's population (UN, n.d.). This picture is likely to change if planned fossil fuel projects are implemented.

Some see gas as an enabler of development, with gas power plants an option to quickly meet the demand for electricity (Ramachandran, 2021), and exploiting domestic resources a chance to generate income. But increasingly, others warn about the risks of investing in natural gas—for the climate, but also for sustainable development (Climate Action Tracker, 2017; Hare et al., 2021; Muttitt et al., 2021; NewClimate Institute, 2021; Sims et al., 2021; Wang & Diamond, 2021).

In this report we look at the benefits of creating sustainable energy systems in Africa, with a focus on the role of natural gas and renewable energy. The report highlights the risks of relying on natural gas, as compared to scenarios that ramp up the contribution of renewable energy.

The diversity of the countries on the African continent, and their respective energy profiles, requires a closer look at individual circumstances. This report focuses on three countries—Egypt, Nigeria and Senegal. We present these countries' gas expansion plans in the energy sector, and the risks related to an increased reliance on natural gas.

Egypt and Nigeria are two of Africa's largest natural gas producers and consumers. Senegal is an example of a country that is currently not dependent on natural gas production or exports but could well be in the future as a result of recent natural gas discoveries.

We also quantify employment benefits of electricity sector scenarios with a high share of renewable energy and a low share of natural gas for these three countries. For Egypt, we have conducted analysis on the health-related benefits that come with lowering gas-based electricity generation. The issues outlined for these three countries could, in variations, apply to other countries as well—in Africa and possibly beyond.

Though this report focuses on Africa, the authors would like to emphasise the need to phase out fossil fuels globally and the responsibility of the Global North to take the lead, through rapidly and deeply decarbonising their own energy systems, stopping public and private finance for fossil fuels in other countries, and supporting developing nations through finance, knowledge and technology transfer in their transition to a sustainable, zero emissions pathway.

From a global perspective – implications of an increased reliance on natural gas

Natural gas production is largely concentrated in two countries, Russia and the US, who together produce about 40% of the world’s natural gas (U.S. Energy Information Administration, 2022). Other major producers are, in this order: Iran, Canada, Qatar, China, Norway, Saudi Arabia, Australia, and Algeria (ibid). Most gas-producing countries consume relevant shares of their production themselves, but many also export gas to other countries through pipeline or as liquefied natural gas (LNG) by ship. Countries with the largest natural gas imports are Japan, Germany, Mexico and the United Kingdom. Figure 1 illustrates trade movements of pipeline gas and LNG in 2020.

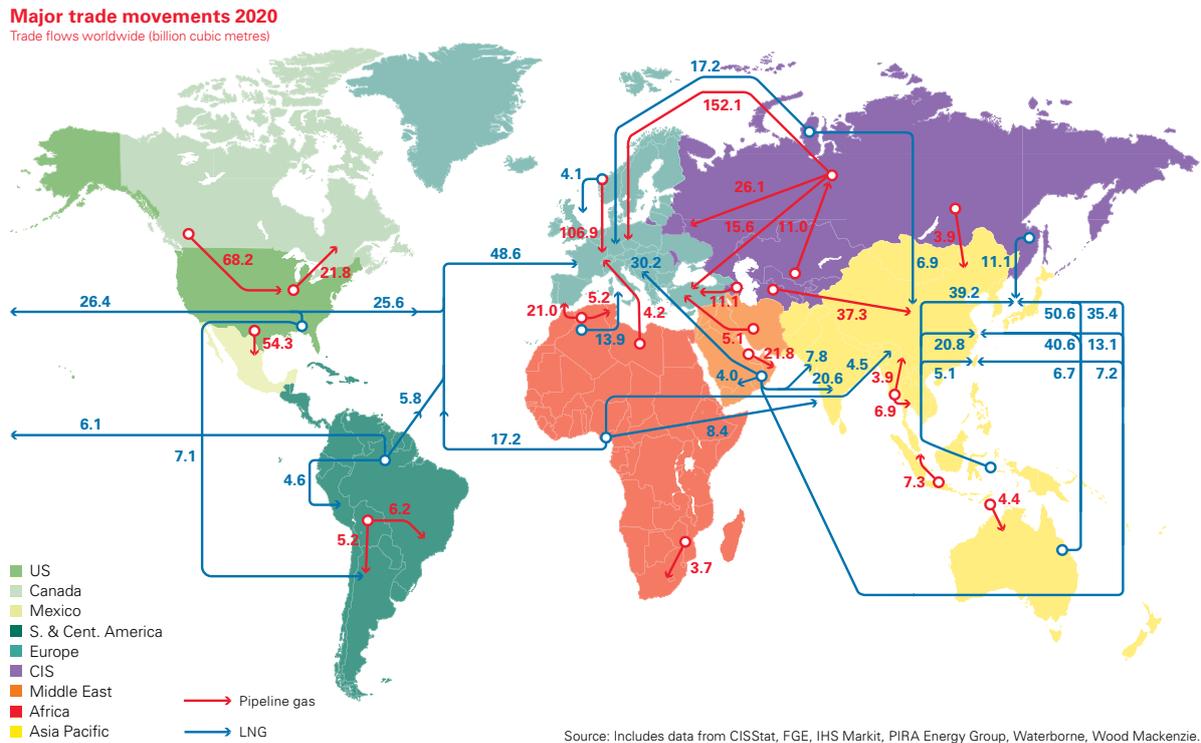


Figure 1: Natural gas trade movements in 2020. Source: BP, 2021.

Prices for natural gas are volatile and extremely sensitive to national and geopolitical developments. Prices in the European Union, for example, sharply increased to all-time-high levels in March 2022 following Russia’s illegal invasion of Ukraine.

Globally, the consumption of natural gas continues to grow with no signs of slowing down. The latest IPCC report states gas consumption grew by 15% between 2015 and 2019 (IPCC, 2022). This goes against scenarios that are compatible with the Paris Agreement’s 1.5°C temperature limit, which show that unabated natural gas in primary energy supply should already have peaked globally (Hare et al., 2021).

The combustion of gas is responsible for about 20% of global energy-related CO₂ emissions—or 7.2 GtCO₂e in 2019 (IEA, 2021a), and there are additional methane emissions from the extraction and transportation of natural gas. Extraction and use of natural gas comes with substantial additional threats to the environment, for example local pollution, water scarcity and, in the case of fracking, risks of earthquakes (Union of Concerned Scientists, 2014).

Under Paris-compatible scenarios, unabated gas-fired power generation is largely phased out by 2050 globally, and in many countries by 2040 (Hare et al., 2021). Overall, gas demand would decrease by 21% to 61% from 2020 levels by 2050 in scenarios limiting warming to 1.5°C, with no or limited overshoot (IPCC, 2022). Paris Agreement-compatible scenarios lead to a strong and fast uptake of renewable energy, along with the electrification of energy demand (ibid). The current infrastructure already supplies the natural gas volumes required, and any addition is at risk of becoming a stranded asset (Sims et al., 2021).

Globally, employment in the fossil fuel industry is estimated to fall by around 75% by 2050 under a well below 2°C scenario, with about 80% of employment losses associated with declining upstream fossil fuel production (Pai et al., 2021). Job creation in the renewable energy industry, particularly solar PV and wind, is expected to more than compensate for employment loss in the fossil fuel industry. Indeed, the global energy transition could create up to 25 million new jobs by 2030, while only between six and seven million jobs are expected to be lost (IRENA & ILO, 2021).

2 The need for sustainable energy in Africa

Access to clean energy is a key requisite for development, including on the African continent. Reliable and affordable access to clean energy in the residential sector, for example, unlocks opportunities for emissions-free cooking, improved education and reduced indoor air pollution.

In the industrial sector, reliable energy supply is a requirement for stable supply chains and the production of goods, which in turn can improve the investment environment in the sector. In the agricultural and commercial sector, for example, reliable access to energy allows for complete cooling chains, thus decreasing food loss.

Today, final energy consumption in Africa is at 0.47 tonnes of oil equivalent (or ~20 GJ) per capita, 65% below the global average (IEA, 2021d). Access to electricity is still, on average, below 50% in Sub-Saharan Africa, and close to 100% in North Africa and the Middle East (World Bank, 2022). The use of traditional biomass remains a concern with respect to health impacts, gender equality, biodiversity and as a driver of deforestation. Access to clean cooking is still below 20% in Sub-Saharan Africa (World Bank, 2021a).

Clean energy supply needs to increase rapidly over the next few years in Africa to allow for sustainable development in the continent. The IEA estimates that electricity consumption in Sub-Saharan Africa, excluding South Africa, will quadruple between 2018 and 2040 under the stated policies scenario, and even increase to 7.5 times the 2018 value in the IEA's "Africa Case" scenario (IEA, 2019). The "Africa Case" shows increased access to electricity, which in turn leads to higher domestic consumption and economic growth¹, demanding further energy.

Increasing the supply of energy in an economically, environmentally and socially sustainable manner is a great challenge, but it is also a key to unlocking an equitable energy system that allows African economies to prosper. The expansion of the energy sector requires substantial investments in energy infrastructure over the next decade, independently of whether one considers a low-carbon pathway. This can be an opportunity to leapfrog large fossil systems to avoid economic risks and locking-in emissions intensive infrastructure. Further, the resilience of the infrastructure is increasingly relevant in light of rising temperature levels.

Renewables are cost effective, and can support sustainable job creation

Electricity generation based on renewable energy has become cost-competitive, at least for new installations and sometimes even for replacing existing fossil-based generation. IRENA states that;

"Although the higher cost of capital and logistics may result in somewhat higher-than-average costs for renewables and storage in certain parts of Africa than elsewhere, this is often offset to some extent by the excellent resources available across the continent." (IRENA, 2020).

Abundant renewable energy resources are not only sufficient to cover the increasing energy demand in Africa, but they could also contribute to creating new value chains, such as through renewable electricity or green hydrogen exports (ibid.).

¹ Note that in both scenarios, per capita electricity consumption remains far below the global average. The IEA forecasts from 2019 do not foresee a relevant share of electricity consumption from electric vehicles. Those have been on the rise since then, and it seems likely that in the medium run, this technology will also become predominant in Africa, further increasing the need for electricity.

The right policy framework can enable the region to participate in the installation and maintenance of renewable energy—more easily than fossil energy extraction. Participation is possible, for example, through labour, investment and the provision of land—activities that lead to a direct return of income to the population.

To ensure this transition happens, topics like tackling investment readiness and technology transfer are of utmost importance.

For African countries, employment potentials in the emerging renewable energy industry are attractive. By 2030, job gains from solar PV, wind, hydropower, as well as bioenergy in Africa could amount to around 4.8 million short-term jobs and 370,000 medium to long-term employment opportunities (PwC, 2021).

Investment in renewable energy value chains can unlock significant co-benefits for local development by growing the economy and creating more and potentially higher-quality employment opportunities in developing countries (Jaeger et al., 2021), particularly where countries are able to domestically manufacture renewable energy equipment, the most labour-intensive renewable energy value chain component, which is expected to create around 36% of new jobs until 2050 (Pai et al., 2021).

The same benefits do not apply to oil & gas extraction

Investments in oil and gas extraction do not offer benefits comparable to renewables. Upstream oil and gas production is not very labour intensive—as opposed to, for example, upstream coal production (Morris, 2017). Even in resource-abundant countries, the extractive oil and gas industry is usually a minor direct employer, as exploration and production tend to be technology-intensive (United Nations, 2021) and require only few, although high-skilled, jobs (Pickard & Scott, n.d.).

Direct jobs associated with the construction of oil and gas production plants tend to be of short term only (Pickard & Scott, n.d.) and of low quality due to limited safety precautions and exposure to health risks (United Nations, 2021). While in developed countries the extractive oil and gas industry often creates significant indirect employment through auxiliary service industries, indirect employment creation is significantly lower in countries where gas production is operated by multinational companies, leaving only a limited number of quality job opportunities to local communities. For example, Egypt's largest gas producer is the Italian multinational oil and gas company Eni (Szymczak, 2021), while Senegal and Mauritania's newly discovered gas field Tortue/Ahmeyim will be operated by BP (BP, 2018).

Generally, jobs in the extractive oil and gas industry, and to a lesser extent in its auxiliary service industries, are also less stable, as employment fluctuates in correlation with oil and gas prices (Herrera et al., 2017). Limited abundance of skilled labour in local labour markets represents a key barrier to localising employment creation in extractive industries, specifically for jobs with high skill requirements (Suleman & Zaato, 2021).

Profit maximising multinational oil and gas producers may provide suboptimal knowledge transfer in the absence of appropriate local content and capacity building regulation. The extractive oil and gas industry also does not provide gender-neutral employment opportunities (Cooper, 2020). Women account for a minority of the oil and gas sector workforce and are especially underrepresented in senior and executive roles (Pickard & Scott, n.d.).

3 Natural gas and energy systems in Africa

Approximately 52% of energy in Africa is supplied by fossil fuels, and 45% by biomass. The remaining energy supply is mostly covered by hydropower. Solar and wind contribute less than 1% of primary energy supply on the continent (IEA, 2021d).

Fossil fuels have supplied about 80% of electricity in the last decade. Renewables have started growing more recently, currently generating about 3% of electricity on average. It is important to note large variations by country – for example, Ethiopia’s electricity grid is supplied exclusively by hydropower, solar and wind, and is largely biomass-based for non-electric energy use (ibid).

Africa held nearly 9% of global natural gas reserves and produced around 6% of global natural gas in 2019 (U.S. Energy Information Administration, 2022). Many countries with reserves are only starting to exploit them, and since the 1990s, gas production in Africa has roughly tripled (ibid).

Figure 2 shows that over the last decade, Algeria, Egypt and Nigeria covered roughly 85% of Africa’s natural gas production and 6% of global production (U.S. Energy Information Administration, 2022). Almost 40% of the gas produced in Africa is exported to Europe, China or India. However, the share of exports has continuously decreased over recent decades, as domestic gas consumption in African countries has increased.



AFRICA Natural gas production

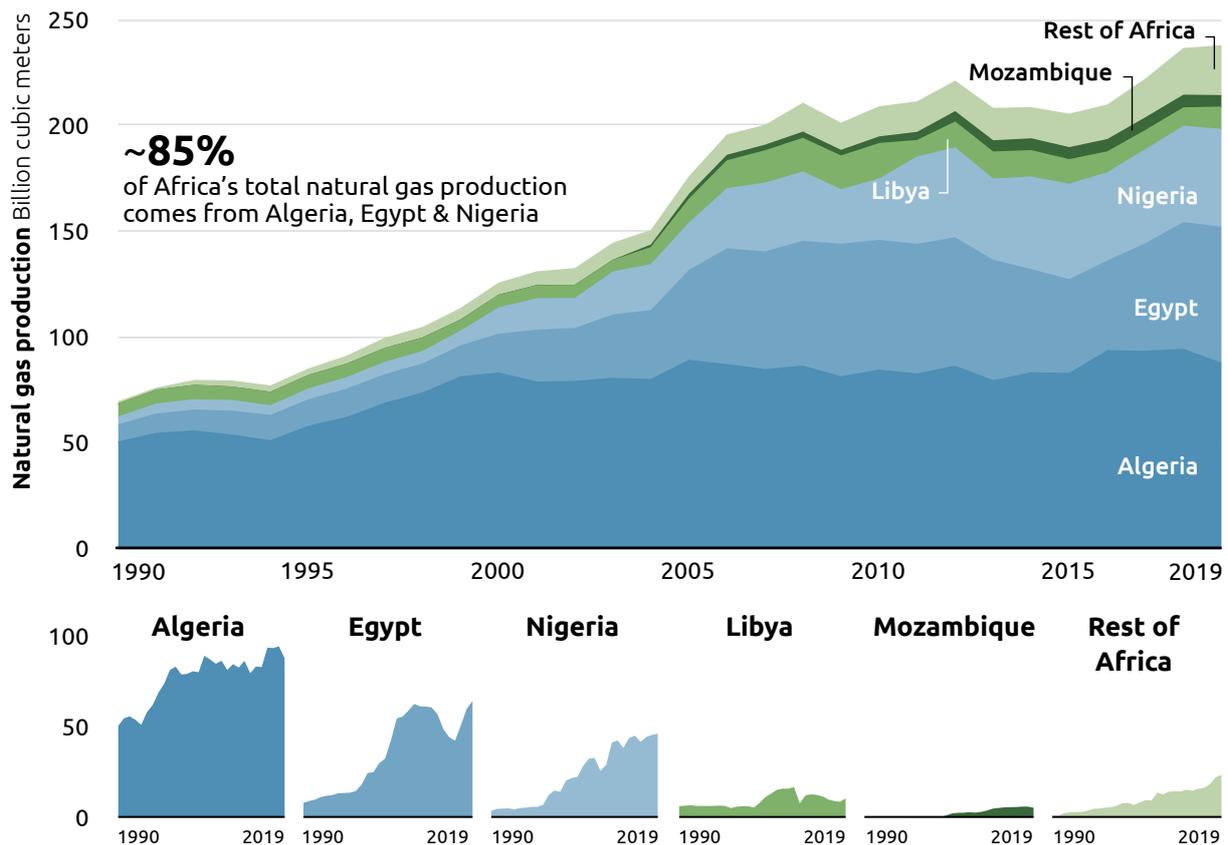


Figure 2: Natural gas production in Africa in 1990–2019. Source: U.S. Energy Information Administration, 2022.

Various African countries have large natural gas reserves. Nigeria and Algeria, two of the largest producers, have recorded large reserves for decades, while Mozambique has discovered reserves more recently (see Figure 3). In many African countries, exploiting these reserves is seen as a quick win to generate income and provide access to energy.

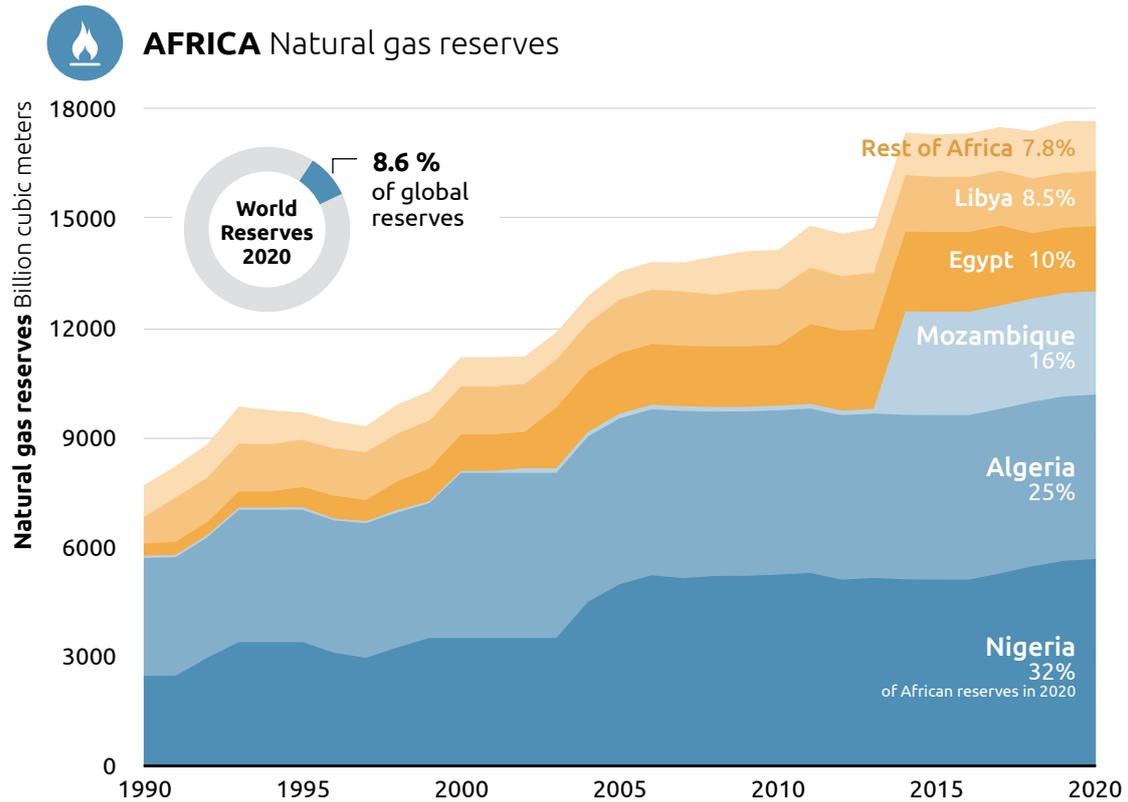


Figure 3: Natural gas reserves in Africa in 1990–2020. Source: U.S. Energy Information Administration, 2022.

Many African countries are considering the expansion – or building of – natural gas-related infrastructure. According to the Global Energy Monitor, there are currently 16 operating gas fields in Africa (most of which are in Egypt and Nigeria), one in development (in Egypt) and 19 discovered (most of which are in Tanzania and Mozambique). Additionally, there are seven fields with both oil and gas extraction discovered or in development in Africa, on top of the 150 already in operation (Global Energy Monitor, 2022b).

There are also about 22,000 km of planned gas pipelines in Africa, most which are located in South Africa, Mozambique and Nigeria. There are also significant plans to build LNG export capacities (for a total of 60 million tonnes per year) and LNG import capacities (around 20 million tonnes per year), as depicted in Figure 4.

In the electricity generation sector, there are 55 GW of new gas power plants in development (proposed or under construction) in Africa, most of which are in South Africa (13 GW) and Nigeria (15 GW).



AFRICA

Expansion of natural gas infrastructure and use

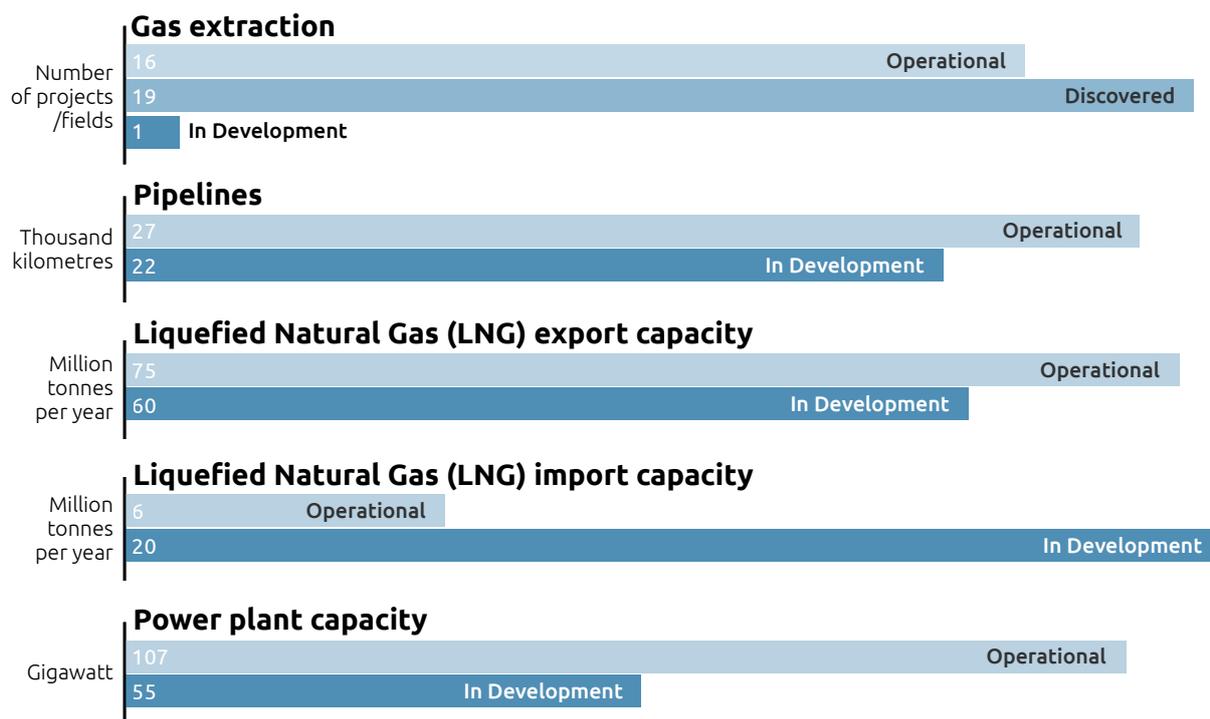


Figure 4: Natural gas infrastructure in operation and development in Africa. Note that gas extraction includes fields for gas production only. There are additional projects in operation and development with co-production of oil and gas. Sources: Global Energy Monitor, 2022b, 2022a.

Risks of natural gas infrastructure investments

At first sight, selling “free” natural resources to generate resource rents may seem like an attractive solution for increasing the wealth of a country, and ultimately the well-being of its population. However, observing the developments in African countries that already produce fossil fuels shows a different picture: African fossil fuel exporters experience slower economic growth compared to other countries on the continent, and countries that heavily depend on fossil fuel extraction often experience the “resource curse”, where their development outcomes worsen “as a result of corruption, increased militarisation, and political repression” (Bassey & Lemos, 2022).

A NewClimate report summarises some of the risks of large-scale fossil extraction and export as follows:

“Capital-intensive natural resource projects in developing countries often drive an influx of large volumes of foreign investment, but the lack of domestic expertise means that much of this value is recycled back to foreign suppliers, technicians, and investors. In addition, the resulting appreciation of the domestic currency can negatively impact other export-oriented industries/sectors, as it renders their exports less competitive (Dutch disease).

Commodity price volatility, as well as the absence of strong institutions capable of limiting destructive rent-seeking effects, can be other factors that often contribute to the correlation between high natural resource wealth and low growth.” (NewClimate Institute, 2021)

Mozambique is one such example: the large-scale development of natural gas resources, which was intended to be a central pillar of Mozambique’s development strategy, has resulted in a wealth of challenges and adverse effects to the country and its economy (Gaventa, 2021).

Once the demand for natural gas drops as an effect of the transition to low-carbon economies, there is a high chance of oversupply, which would lead to lower market prices and drive out producers, starting with the highest-cost producers.

The IEA's Net Zero by 2050 report has a clear message on fossil fuel supplies. Specifically on gas, it indicates that no new natural gas fields should be developed, and that many of the LNG liquefaction facilities currently under construction or being planned are not needed (IEA, 2021c).

International finance for natural gas

Much of the financing for fossil energy in Africa today comes from international sources: private banks from the Global North provide financing, international corporates develop infrastructure to exploit the fossil resources, and even multilateral development banks continue investing in oil and gas (BBC News, 2022; MarketWatch, 2022; NewClimate Institute, 2021).

The World Bank has decided to no longer fund upstream oil and gas projects as of 2020 (World Bank Group, 2017). The European Investment Bank has decided to no longer support any unabated fossil fuel projects as of 2022. It finances natural gas-fired electricity generation projects only if they are below a certain threshold of emissions intensity, which means they would require the yet unproven carbon capture and storage technology at scale (EIB, 2019). This should be a signal of the risk countries are taking when considering developing new gas fields.

4 Natural gas and renewable energy in Egypt

Egypt, host of this year's COP27 UN climate conference, is scaling up its domestic natural gas production and use, risking locking itself in to complete economic dependence on natural gas and a high-carbon pathway. This trend could be accentuated, as Europe is looking to import LNG from Egypt to replace Russian natural gas. Egypt is moving away from plans to build up coal-fired electricity and is pursuing renewable energy investments, but these are still at a smaller scale than gas.

Under 1.5°C compatible pathways based on global least cost pathways, Egypt's share of renewables would increase to nearly 100% of electricity production in 2050, and to 50–84% of total energy supply (Climate Analytics, 2021). Unabated natural gas would need to be completely phased out from electricity production by around 2040. Both primary energy and electricity supply from natural gas need to start declining now in such scenarios.

Our analysis shows that embarking on a low-gas, high renewables pathway decreases economic risks and unlocks multiple benefits. For example, we find that under a scenario with increased renewable energy investments, 65% more jobs are created in the power sector in the time period up to 2035, compared to the planning under the Egyptian government's 2035 Energy Strategy.

4.1 Energy sector overview

Egypt's economy is highly dependent on the fossil fuel industry, which represented nearly a quarter of GDP in 2019–2020 (U.S. ITA, 2021). The energy sector is dominated by fossil fuels, with renewable energy supplying only 5% of total primary energy in 2019 (IEA, 2021d). Natural gas is the single largest contributor to Egypt's energy sector: in 2019, it supplied over half of total energy, as shown in Figure 5 (IEA, 2021d).

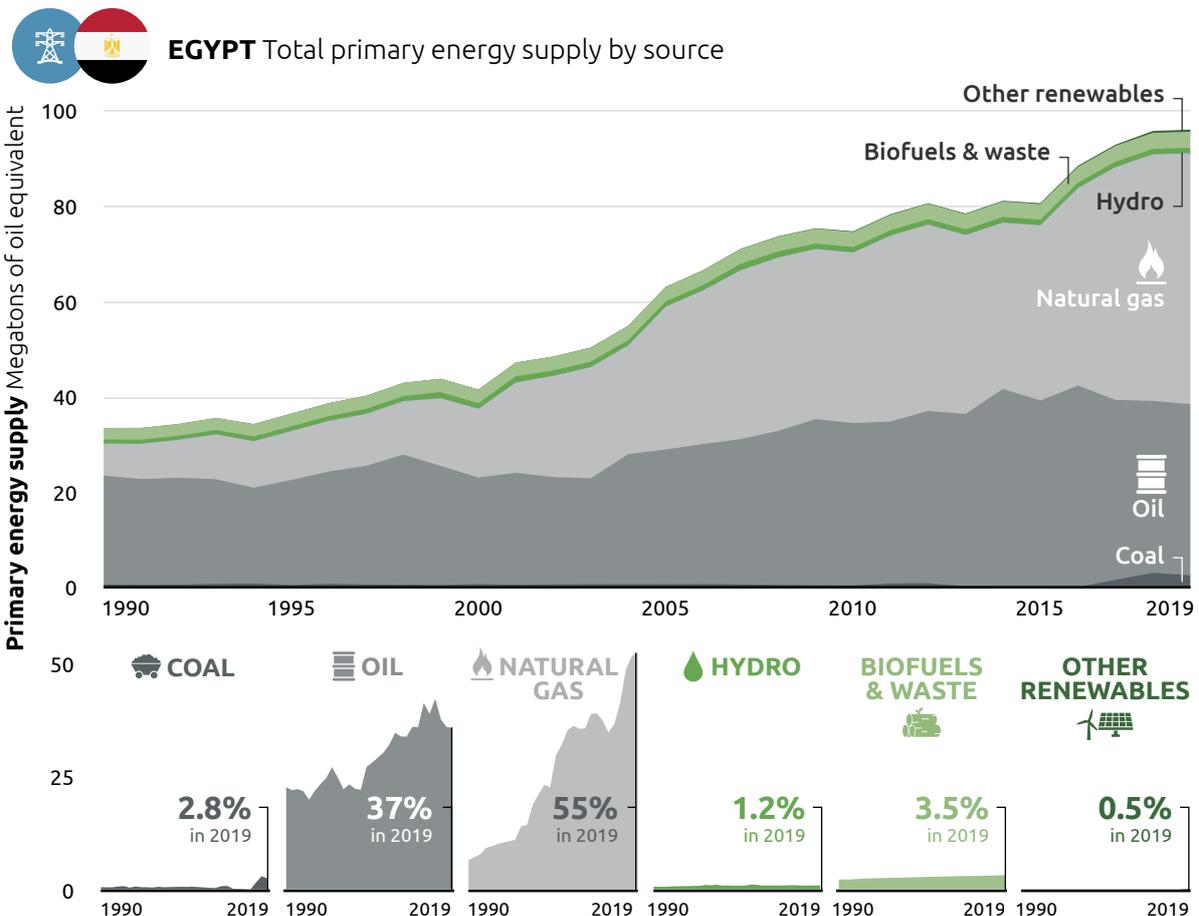


Figure 5: Total primary energy supply by source in Egypt in 1990–2019. Source: IEA, 2021d.

Egypt’s electricity supply is dominated by natural gas, which represented 77% of total electricity production in 2019, as shown in Figure 6 (IEA, 2021d). Renewable energy, excluding hydropower, generated less than 3% of electricity in 2019, with hydropower generating a little less than 7%. While energy access remains a main challenge in many countries in Africa, Egypt has achieved near full access to electricity and clean cooking (World Bank, 2021b).

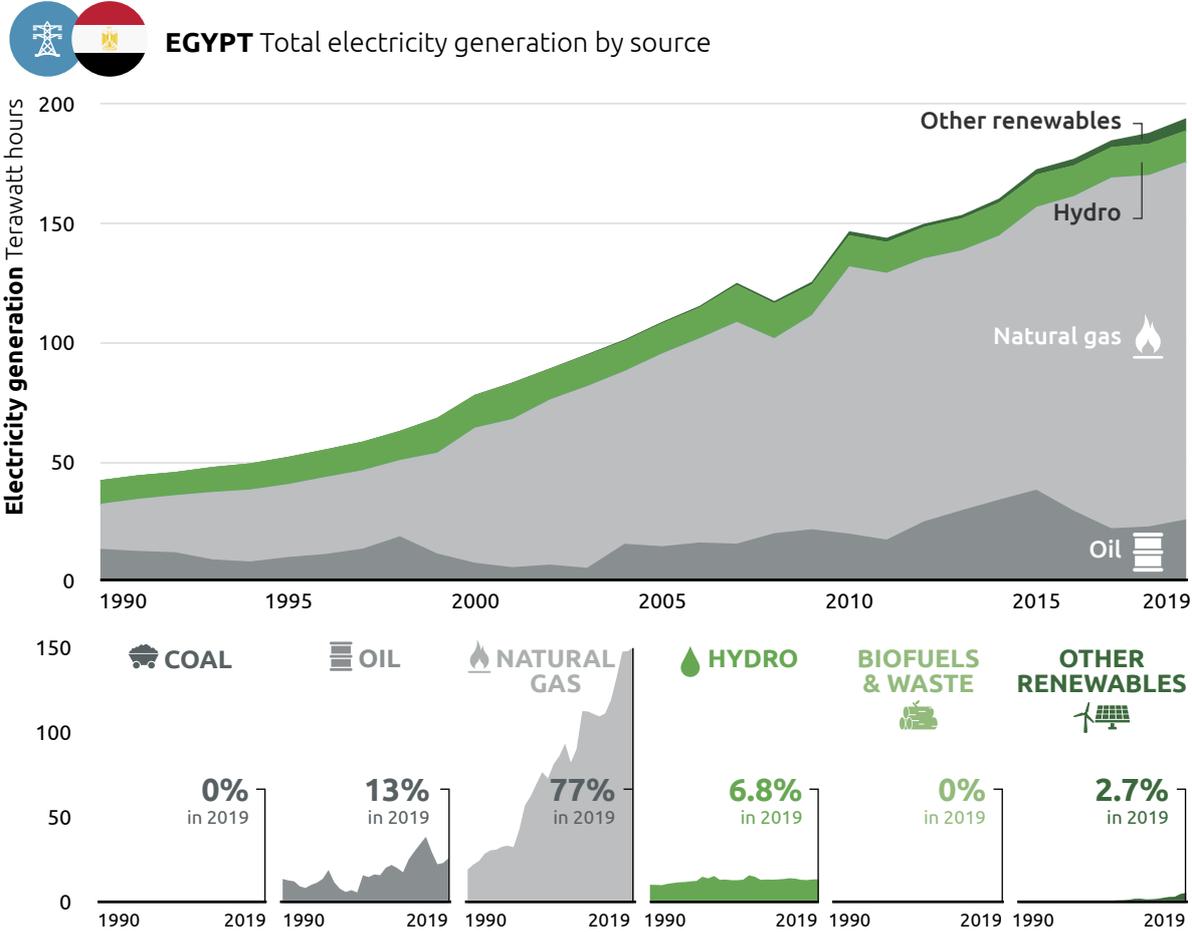


Figure 6: Total electricity supply by source in Egypt in 1990–2019. Source: IEA, 2021d.

One of the Egyptian government’s foremost priorities in the energy sector relates to expanding the production of domestic energy resources, particularly oil and gas but increasingly also renewables. Egypt has, for the most part, been a net energy exporter over the past decades until the 2010s—the only exception being the 1973 oil crisis during which oil exports were halted (World Bank, 2021b). Due to economic and population growth, however, the share of exports dropped after 2010, as energy demand soared while investments into new production stalled.

Energy sector planning

The Egyptian government has not published its overall strategy for the energy sector. From our analysis and research on the government’s priorities, it seems clear that the government is seeking to increase domestic oil and gas production, while developing renewable energy in parallel.

While its plans for the energy sector overall remain unclear, Egypt does have a 2035 strategy for the electricity sector. By 2035, Egypt targets the following breakdown for electricity generation:

- ▶ 65% thermal generation
- ▶ 42% renewable energy
- ▶ 3% nuclear

Up until a few years ago, there were still planned investments in coal-fired power plants but since the major discoveries of domestic gas reserves, coal projects have been shelved. At COP26 in 2021, Egypt joined the Beyond Coal coalition.

From 2010 to 2019, Egypt's total electricity generation increased by 74% (EEHC, 2020). While this has been necessary to meet a quickly growing domestic demand, Egypt is now also considering investments in grid connections to allow for electricity exports to neighbouring countries, such as Saudi Arabia.

Emissions reduction targets

Egypt has neither a specific emissions reduction target for the energy sector, nor an economy-wide reduction target. In fact, Egypt's first Nationally Determined Contribution (NDC) under the Paris Agreement lacks any quantitative emissions reduction targets.

As a host of the international COP27 climate conference in November 2022, it is important for Egypt to submit an updated NDC well ahead of it. This would also provide an important signal for others to follow, as all countries are invited to submit more ambitious targets ahead of COP27.

4.2 Natural gas in Egypt

Egypt is seeking to develop its vast natural gas resources to maximise domestic production, consumption and exports. It ranks among Africa's top countries for many indicators related to natural gas (U.S. Energy Information Administration, 2022). Egypt has:

- ▶ The third largest proven natural gas reserves in Africa, after Nigeria and Algeria
- ▶ The second largest natural gas production, after Algeria
- ▶ The highest natural gas consumption, making up over a third of Africa's total gas consumption
- ▶ The highest CO₂ emissions from natural gas, making up nearly 40% of the continent's total CO₂ emissions linked to natural gas.

Egypt is planning significant investments in natural gas in nearly all sectors—including the power sector, industry and transport. Even with a significant ramp-up of renewable energies, as foreseen in the 2035 Energy Strategy, we expect emissions from natural gas to continue rising due to increased natural gas-based electricity generation to satisfy overall demand.

Upstream production and trade

Egypt's natural gas reserves are estimated at 1,780 bcm (63 Tcf) in 2020 (U.S. Energy Information Administration, 2022). In 2015, the Italian company ENI discovered the Mediterranean's largest offshore gas field in Egypt's waters (Government of Egypt, 2020). The government estimates the reserves at around 850 bcm (30 Tcf)—although these are still unproven, and therefore not included in most official statistics at this stage.

In 2019, Egypt's natural gas production reached a high of 64 bcm. Egypt has significantly ramped up its natural gas production in the past few years following plummeting production in the aftermath of the Egyptian revolution in 2011.

Despite this, Egypt's natural gas exports remain much smaller than in other large producers on the continent, due to steadily increasing domestic demand. However, the Egyptian government has made clear that it intends to increase natural gas exports. Egypt exports natural gas both via pipeline and LNG.

Egypt's LNG exports significantly declined after 2011 but have picked up again in recent years. Egypt has 16.6 bcm of yearly LNG export capacity (12.2 Mt) in the ports of Idku and Damietta (Global Energy Monitor, 2021c). In 2021, Egypt reportedly exported over 9 bcm of LNG (6.8 Mt)—the highest amount since 2010 (Espanol, 2022). Between 2015 and 2018, Egypt had to import significant amounts of LNG to meet domestic demand, but LNG imports stopped in 2018.

Gas flaring has significantly increased in the past ten years, although it remains lower than in other

major gas producing countries in Africa, such as Algeria and Nigeria. As of 2020, gas flaring in Egypt represented close to 9% of total gas flared in Africa (BP, 2021). Vented gas from flaring is a major source of methane emissions. Egypt mentions gas flaring and venting as a mitigation area in its first climate pledge under the Paris Agreement (its first NDC) but it has no specific reduction targets. As of April 2022, Egypt has not signed the Global Methane Pledge, which aims to reduce methane emissions by at least 30% by 2030 compared to 2020 levels (Climate & Clean Air Coalition, 2022).

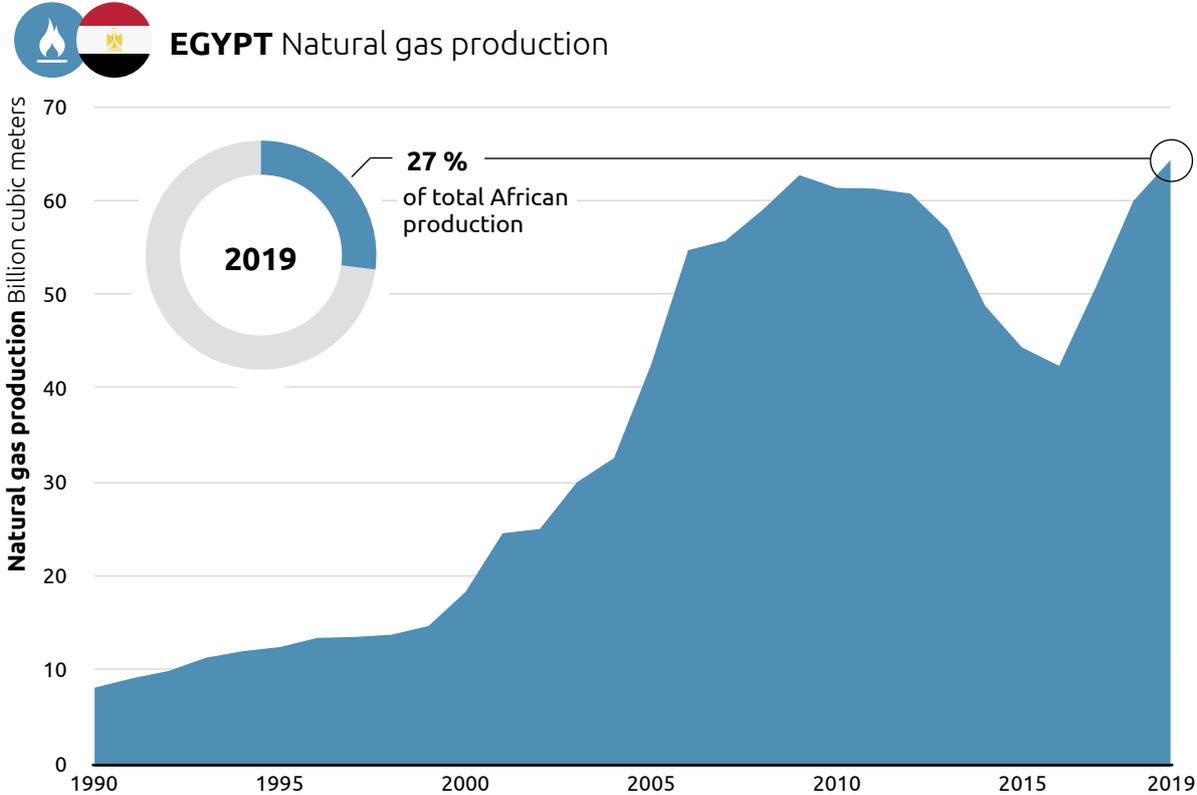


Figure 7: Natural gas production in Egypt in 1990–2019 and share of total production in Africa. Source: U.S. Energy Information Administration, 2022.

Consumption and downstream uses of natural gas

In recent years, Egypt consumed on average nearly 60 bcm of natural gas per year, representing over a third of total natural gas consumption in Africa (U.S. Energy Information Administration, 2022). If consumption remained at this level—and assuming no natural gas exports—Egypt would consume all of its current natural gas reserves in around 30 years, and well earlier if accounting for exports.

Natural gas is mostly used for electricity production, representing close to 70% of all gas use in Egypt. A significant amount of natural gas is also used in the industry sector and for non-energy uses, such as chemical and petrochemical production. Egypt is a major fertiliser producer and exporter (World Bank, 2021b).

Natural gas use in the transport sector is still low but expected to increase. In 2020, the Egyptian government announced a nationwide programme to convert over 400,000 cars to run on compressed natural gas (CNG) by 2023, bringing the total number of cars running on natural gas to one million. The Central Bank of Egypt is supporting this initiative by providing loans with initial support amounting to nearly USD 1 billion (EIU, 2021). While CNG may be seen as a cleaner alternative to oil-fuelled cars, it is by no means a solution for air pollution. CNG-fuelled cars emit a significant amount of particle pollution—both ultrafine and PM2.5 (Transport & Environment, 2020).

4.3 Investments linked to natural gas

Investments into nearly all areas of the natural gas value chain have increased in recent years in Egypt, and the government is still planning to expand natural gas exploration, production, exports, as well as related mid and downstream infrastructure.

Many of the multilateral development banks invest in Egypt's energy sector, including the AfDB, EBRD, EIB and IsDB—with increasing amounts flowing to renewable energy. This includes, for example, investments in the 1.8 GW Benban Solar Project, one of the world's largest solar power plants (UNFCCC, 2021). The EBRD is currently also supporting the Egyptian government in developing a hydrogen strategy (EBRD, 2022).

At the same time, a large amount of finance to Egypt's natural gas sector has also come from these banks (AfDB, n.d.; EBRD, 2017; EIB, 2004). Beyond multilateral development banks, much of the investment into Egypt's hydrocarbon sector comes from international oil and gas companies. More than 50 international oil and gas companies are reportedly active in Egypt (U.S. ITA, 2021).

Investors are, however, increasingly looking at alignment with the Paris Agreement to guide their decisions. Many international financial institutions have excluded investments into coal from their portfolios and some are now starting to exclude investment into upstream gas and unabated natural gas—including the European Investment Bank, for example.

The following list includes past and planned investments into the different segments of the natural gas value chain in Egypt.

- ▶ **Upstream production:** Egypt's upstream natural gas production has increased again over the past few years, as shown in Figure 7. The Egyptian government has listed opportunities for new investments in the gas fields of Zohr, Nooros, North Alex and West Nile Delta (Government of Egypt, 2022). Some of the main international companies operating and investing in Egypt's upstream gas sector include ENI, BP, Shell, Petronas, Wintershall Dea and Rosneft (Global Energy Monitor, 2021c).
- ▶ **LNG export facilities:** Egypt is not currently planning new investments into LNG export facilities. However, this may change, as the export facilities were running at close to full capacity in 2021 (Ismail, 2021). European countries are also eyeing new LNG imports to replace imports from Russia, with Egyptian LNG being an option for some countries. In April 2022, the Italian company ENI signed a deal with Egypt to increase gas production and exports to Italy (ENI, 2022).
- ▶ **Natural gas pipelines:** Egypt has the most extended pipeline network in Africa, with 2,000 kilometres (Global Energy Monitor, 2021c). The government reports 800 km of pipelines were constructed in 2014–2020 alone (Government of Egypt, n.d.-a). A further 780 km of proposed pipelines are planned to be constructed, which would increase total pipeline infrastructure by around 40% (Global Energy Monitor, 2021c).
- ▶ **Electricity generation:** Egypt's 2035 Energy Strategy still foresees a major role for thermal power plants (55% of total generation)—most of which we expect to be powered with natural gas. Assuming total electricity consumption continues growing at a similar pace as it has in the past, we would still expect major new investments into natural gas-fuelled power plants. If Egypt does start exporting electricity to neighbouring countries such as Saudi Arabia, as the government is planning to, the pressure to build additional natural gas plants for electricity production could increase.
- ▶ **Buildings:** The government aims to connect 19 million residential and commercial buildings to natural gas infrastructure in the next couple of years—up from 12.5 million in 2021.
- ▶ **Transport:** Compressed natural gas (CNG) for the transport sector is expected to increase by 65% from 2021 to 2023 to support Egypt's nationwide initiative to support CNG usage and lower oil consumption (U.S. ITA, 2021).

4.4 Benefits of high renewable energy & low natural gas scenarios

Expanding renewable energy resources and improving energy efficiency can yield significant benefits for Egypt that align well with core sustainable development objectives. A decade ago, the African Development Bank (2012) published a report showcasing these economic and social benefits for Egypt. Key benefits identified—which still apply today—include enhanced energy security, cleaner air, the development of new economic activities and job creation. Since then, the evidence-base for the benefits of shifting to renewable energy systems have strengthened, with a parallel material increase in risks linked to a continued reliance on fossil fuels.

Egypt has excellent preconditions for an electricity sector based on renewable energies thanks to abundant wind and solar resources (Raquel Ersoy & Terrapon-Pfaff, 2021). However, the current level of renewable energy capacity remains low and Egypt has not yet tapped into the full benefits they can offer.

This is notably the case for employment. Renewable energies currently support around 3,900 direct jobs in Egypt, mostly in the solar PV and onshore wind industries (IRENA, 2022b). The number of jobs could dramatically increase in scenarios with higher renewable energy development.

To estimate the employment and air pollution-related impacts linked to different future pathways for the electricity sector, we used the following three scenarios—further information on the assumptions used can be found under section 8.3 in the Annex.

- ▶ “2035 Energy Strategy” — The Egyptian government’s 2035 Energy Strategy, which assumes 42% of renewables and 55% of thermal—likely mostly natural gas-based—generation in 2035;
- ▶ “Increased renewable energy target” — an alternative scenario with 62% of renewable energy and low natural gas and fossil fuel-based generation in 2035. This scenario is in line with the higher 60% renewable energy target announced by the Minister of Electricity in 2020 (Al-Aees, 2020), but which has not yet been translated into an official strategy;
- ▶ “High renewable energy scenario” — in this scenario 82% of Egypt’s electricity is generated with renewable energy in 2035. This share of renewable electricity is within the global range provided in many of the 1.5°C compatible benchmarks for the electricity sector (Climate Action Tracker, 2020).

To quantify the employment impacts we adapted the employment factor approach from Rutovitz et al., (2015). The high (82%) renewable energy scenario supports over 4.5 million ‘job years’— that is, full time equivalent employment for one person for a year—over the period to 2035 (see Figure 8) or, on average, over 320,000 jobs per year. This is an additional 1.8 million job years compared to the government’s current 2035 Energy Strategy pathway that foresees a share of 42% renewables in Egypt’s energy mix, and over 910,000 job years more than projected under the “increased renewable energy target” scenario, where 62% of electricity supply is generated by renewables.

On an annual basis the number of job years in the high renewable energy scenario are nearly two thirds higher than those estimated under Egypt’s 2035 Energy Strategy. And perhaps most critically, the majority of jobs that are supported in scenarios with higher renewable shares are in technologies – particularly solar PV and, to a lesser extent onshore wind – and their respective value chains that will be needed well into the future.

The Egyptian government needs to prioritise developing a resilient, future-proof labour market and industrial competences in renewable technologies. In contrast, higher gas scenarios would instead divert resources into stimulating employment that requires skills and expertise that are not sustainable due to their misalignment over the medium-to-long term with international climate objectives.

Our findings show that the largest share of jobs derive from the construction and installation of solar PV units. Scaling up the deployment of renewables, in particular of solar, leads to a significant increase in jobs.

Over the next 14 years, the 2035 Energy Strategy would stimulate only around 1.7 million job years through the implementation of solar PV, while the increased and high renewable energy scenarios would support over 2.6 and 3.5 million job years, respectively.

Across all three scenarios, the most job creation is expected in the construction and installation sector, reflecting the need to meet a growing demand for electricity. In the 82% renewable scenario the number of construction and installation jobs is twice as high as under Egypt’s 2035 strategy.

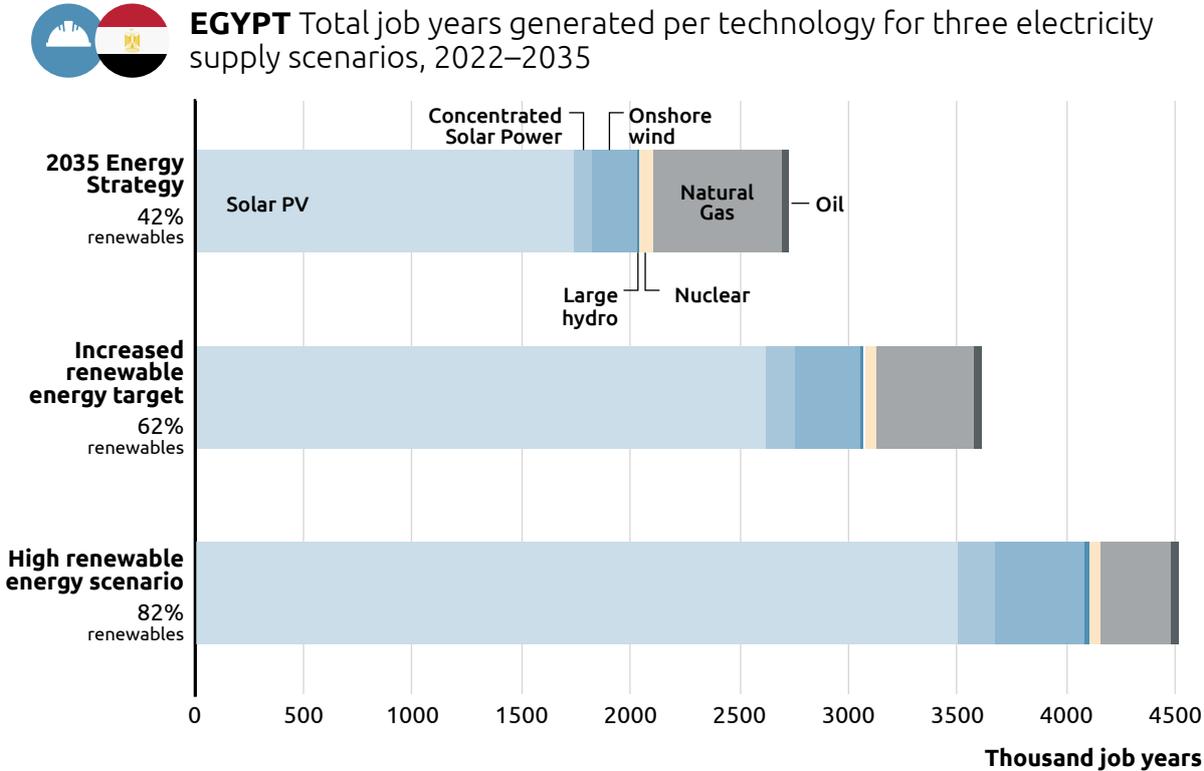


Figure 8: Total job years generated per technology in Egypt under three different electricity supply scenarios in 2022–2035.

In addition to stimulating economic activity and supporting employment, higher shares of renewable energy in the electricity sector also have a positive impact on air quality and health. To quantify the health impacts of Egypt’s gas-fired power plants we applied the air pollution impact model for electricity supply (AIRPOLIM-ES) to the three scenarios.² In the 2035 Energy Strategy scenario 55% of Egypt’s electricity is generated by natural gas-fired power plants, whereas the share of gas in the electricity mix is reduced to 35% under the increased renewable energy scenario and just 15% in the high (82%) renewable energy scenario.

Reducing Egypt’s reliance on gas from 55% to 15% of electricity supply by 2035 can avoid more than 5,300 premature deaths amongst the country’s population in the next two decades (see Figure 9). This translates into 177,000 years of life saved.

The magnitude of these impacts increases significantly when looking at the additional premature deaths caused by Egypt’s gas-fired power plants in neighbouring countries. Considering the health impacts in all countries from air pollution from Egypt’s gas generation, the high (82%) renewable energy pathway would help avoid 12,900 premature deaths compared to the government’s 2035 Energy Strategy. The majority of these deaths occur outside of Egypt in neighbouring countries including Libya, Sudan, Israel, and Jordan.

² The model is freely available under the following link: <https://newclimate.org/2018/11/30/airpolim-es-air-pollution-impact-model-for-electricity-supply/>. Further details of the method and supporting materials are set out under section 8.2 in the Annex.



EGYPT Total number of premature deaths linked to natural gas-fired power plants under three electricity supply scenarios, 2020–2040

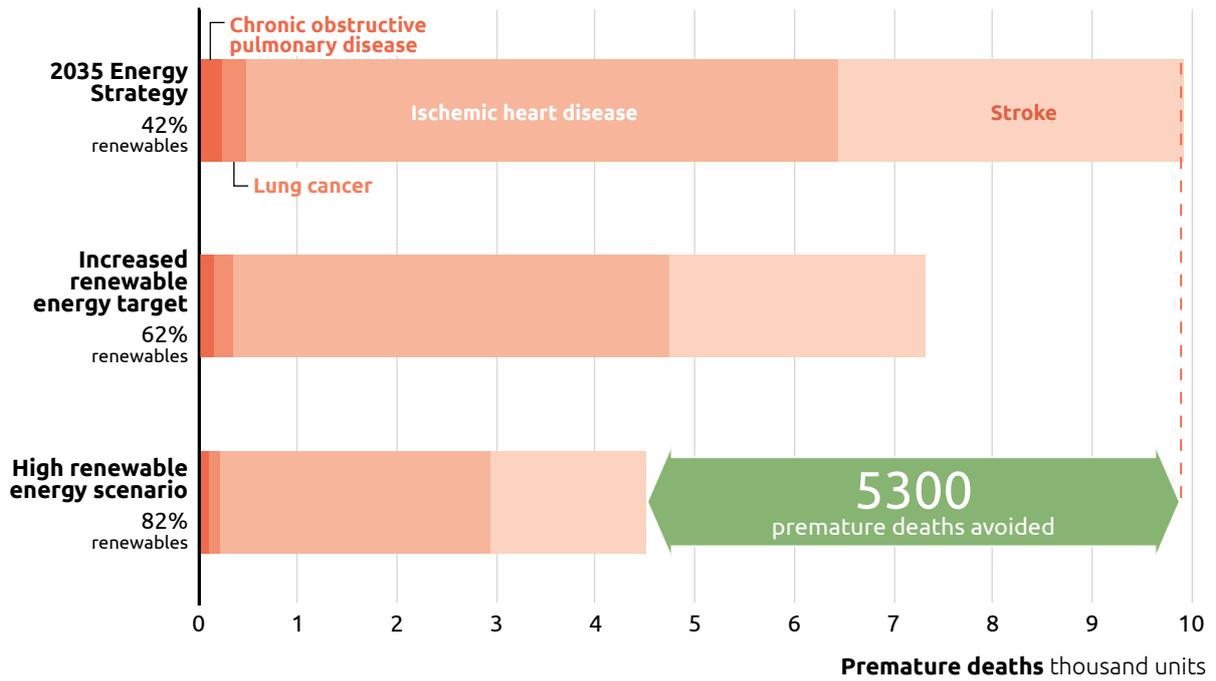


Figure 9: Premature deaths caused by pollution from natural gas-fired power plants in Egypt under three different electricity supply scenarios in 2020–2040

5 Natural gas and renewable energy in Nigeria

At COP26, Nigeria announced its intention to achieve net-zero by 2060, largely enabled by its Energy Transition Plan, but the government has also characterised this decade as the “Decade of Gas”.

To achieve its gas ambitions, Nigeria has plans to build significant gas infrastructure including pipelines, LNG terminals, and gas-fired power stations. Current gas infrastructure, however, is already strained by pipeline vandalism and other supply disruptions, impacting gas exports and supply to power stations.

Continuing to invest in and installing gas infrastructure while the world is shifting away from fossil fuels, and international oil companies are starting to divest, would leave these investments at high risk of becoming stranded assets, and leave Nigeria locked in a carbon intensive energy system that cannot support its economic growth.

Under 1.5°C compatible scenarios, unabated natural gas would need to be phased out of the power sector by 2040 at the latest. By comparison, natural gas in the power sector is expected to increase by 26% from 2019 to 2030 under current policies.

In order to be aligned with a Paris Agreement pathway, Nigeria needs to change its current fossil fuel trajectory by channelling investments planned for gas infrastructure towards the deployment of renewables, which are cheaper, and have other socio-economic benefits. This will support its goal of expanding access to electricity and other development objectives.

In this chapter, we analyse the employment benefits linked to renewable energy in the electricity sector under a 1.5°C compatible pathway, and compare these to employment under a current policy scenario. Under the 1.5°C compatible scenario, Nigeria increases renewable energy generation to about 65% of the power mix by 2030 and creates more than 4.7 million job years from 2020 to 2030—over 100,000 more than under current policies. On average, the 1.5°C compatible scenario creates more than 3,400 job years per MWh per year compared to the current gas-based strategy, which creates only about 1,300 annual job years per MWh.

5.1 Energy sector overview

Nigeria’s energy sector suffers from a critical undersupply of energy, and limited access to electricity and clean cooking, resulting in a high reliance on traditional biomass as the dominant energy source (IEA, 2021d).

Oil makes up the next largest share of the energy supply at about 15%, primarily used in the transport sector (IEA, 2021d). Natural gas is the third largest supplier of energy at 10%, used largely in the power and industry sectors (see Figure 10).

The oil and gas industry is Nigeria’s largest source of revenue. In 2019, 56% of the government’s revenue, and over 80% of export earnings, came from oil and gas (Central Bank of Nigeria, 2020b; Oyekanmi, 2021). At the same time, Nigeria imports much of the processed petroleum and gas products for domestic use, such as liquefied petroleum gas (LPG) and premium motor spirit (PMS), with the latter heavily subsidised by the government (Argus Media, 2021; Enengedi, 2022). High reliance on these fuels leaves Nigeria vulnerable to volatile oil and gas prices and supply disruptions.

Nigeria’s undersupply of energy also impacts grid reliability: Nigeria experiences more frequent and prolonged blackouts and higher reliance on oil-fired back-up generators than any other country in Africa (IEA, 2019).



NIGERIA Total primary energy supply by source

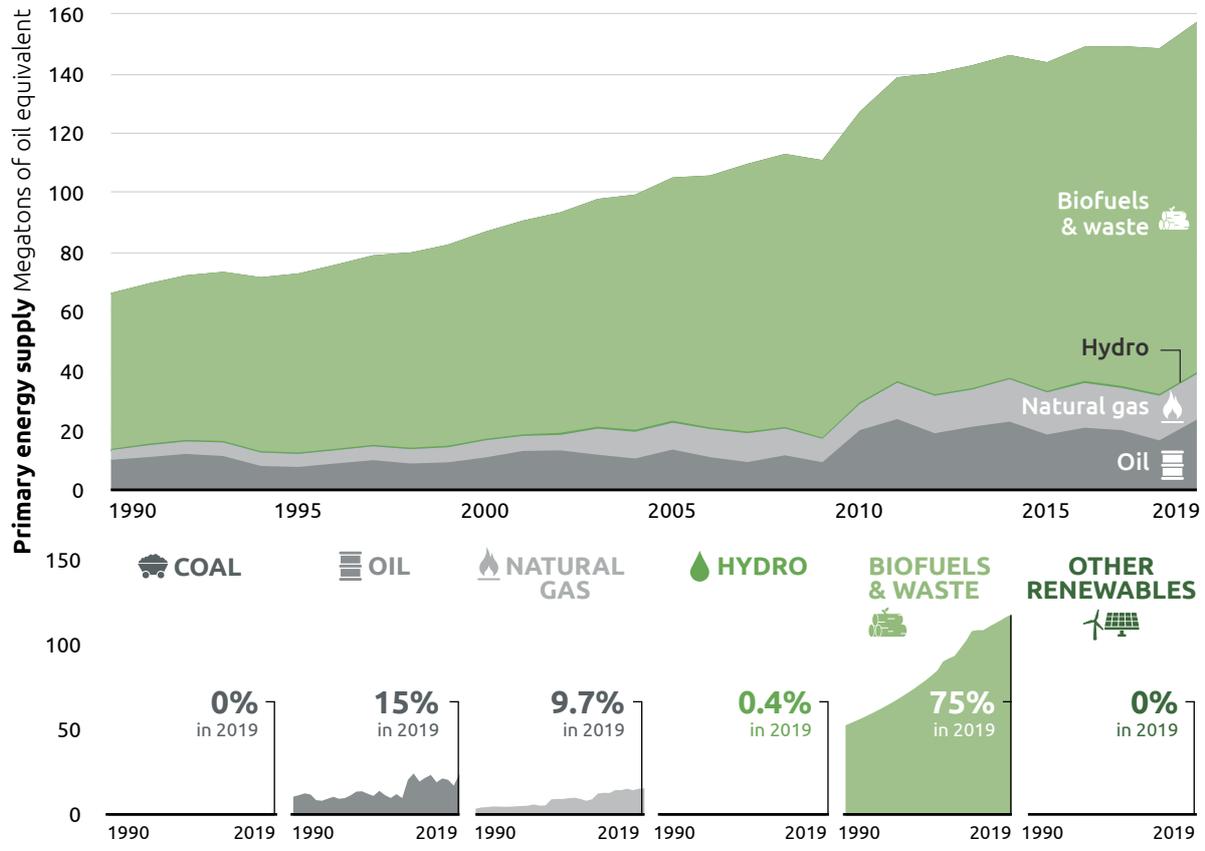


Figure 10: Total primary energy supply by source in Nigeria in 1990–2019. Source: IEA, 2021d.

Nigeria’s power sector is primarily supplied by natural gas (78% in 2019) with the remainder supplied mostly by hydropower, as shown in Figure 11 (IEA, 2021d). While the government has set targets for increased renewable capacity and generation, Nigeria is not on track to meet these targets (Federal Republic of Nigeria, 2016; Ministry of Power, 2015).



NIGERIA Total electricity generation by source

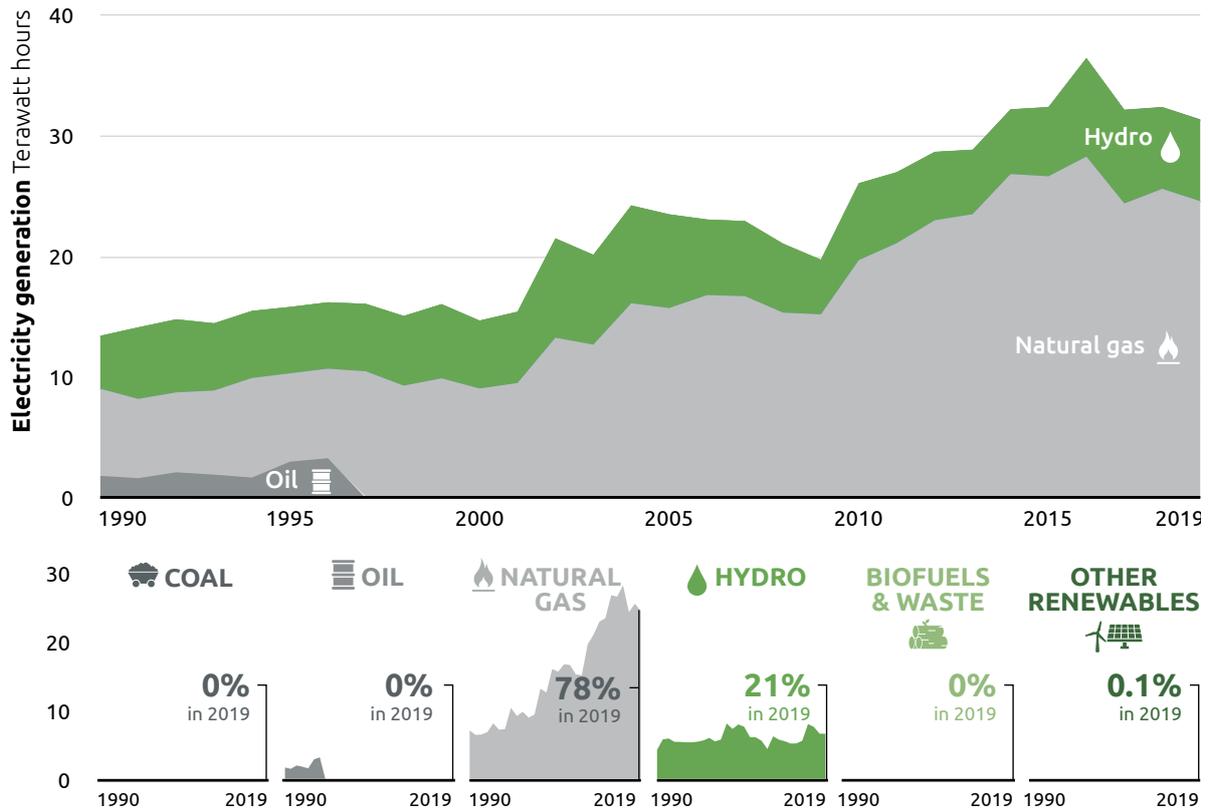


Figure 11: Electricity generation by source in Nigeria in 1990–2019. Source: IEA, 2021d.

Facing these challenges, Nigeria’s government has declared this the ‘Decade of Gas’ and emphasised the role of natural gas as a ‘transition fuel’ (Cyril Widdershoven, 2021; Jeremiah, 2022). However, the government’s exact plans for natural gas remain unclear. At COP26, the government launched Nigeria’s Energy Transition Plan as a roadmap to achieve its ambition to reach net zero emissions by 2060, highlighting the key role of gas (Varin, 2021).

Ramping up gas investments, however, may lock Nigeria into higher emissions and increase the risk of stranded assets. Under 1.5°C compatible pathways based on downscaled global models, unabated natural gas in the power sector would need to be phased out by 2040 at the latest (Climate Analytics, 2021). This phase out would be enabled by rapid electrification and uptake of renewables, reaching 100% by 2040.

Significant investments are needed to support Nigeria’s transition to a decarbonised economy. According to Nigeria’s 2021 NDC update, USD 177bn of domestic and international investment is needed over 10 years to achieve Nigeria’s conditional mitigation target, of which USD 122bn would target the power sector (Federal Government of Nigeria, 2021). Nigeria received a relatively large share of the international public clean energy finance provided to developing countries from 2010 to 2018, mainly for the 305 MW Mambilla hydropower project; however, international support is still far below what is needed to meet Nigeria’s conditional NDC target and development goals (IEA et al., 2021).

Energy sector planning

While the Energy Transition Plan is not yet publicly available, President Buhari noted Nigeria’s continued use of gas until 2040 would not detract from the Paris Agreement goals (Varin, 2021). However, Nigeria’s Long-Term Vision for 2050 (LTV) anticipates gas will be used as a major “transition fuel” for the next two to three decades, potentially going beyond 2040 (DCC, 2021). At the Nigeria International Energy Summit in March 2022, the Minister of State for Petroleum said the country is aiming to make natural gas the dominant primary energy source for the medium to long term (Jeremiah, 2022).

Short- and medium-term economic plans also emphasise the role of gas across sectors. At the start of the COVID-19 pandemic, the government adopted the Economic Sustainability Plan (ESP) for the period 2020–2023 (Economic Sustainability Committee, 2020). The ESP included the National Gas Expansion Programme to promote use of compressed natural gas (CNG) and LPG, largely for transport, cooking, and industrial use. The National Development Plan (NDP) for 2021–2025 targets increased gas generation capacity in the power sector and an almost 90% increase in gas production by 2025 (Federal Ministry of Finance Budget and National Planning, 2021).

These plans also include objectives for renewable energy, mainly as a mechanism for expanding electricity access. The ESP includes the Solar Power Strategy to create 250,000 jobs while providing solar power to five million households by 2023 (Economic Sustainability Committee, 2020). The NDP also plans to expand electricity access to those in rural and remote locations, largely via renewable energy sources through a combination of off-grid and mini-grid solutions (Federal Ministry of Finance Budget and National Planning, 2021).

Prior to the Energy Transition Plan, Nigeria's most recent policy document outlining plans for the energy sector was the 2018 draft National Energy Policy (draft NEP) (Energy Commission of Nigeria, 2018). Under the draft NEP, the government anticipated an increase in all fossil fuel use, and notably a significant revival of Nigeria's coal industry, with coal reaching 30% of the energy supply by 2030. Despite announced and planned coal projects, this goal has ultimately been abandoned in favour of gas, with no new coal generation materialising.

At the same time, the government has missed its targets for renewable energy development and electrification goals. Nigeria is not on track to meet its renewable capacity goal under the 2015 National Renewable Energy and Energy Efficiency Policy without rapidly accelerating renewable capacity development (IRENA, 2022a; Ministry of Power, 2015). Nigeria has also missed its target to provide access to electricity for 75% of the population by 2020, achieving only 55% in 2019 (IEA et al., 2021; Rural Electrification Agency, n.d.).

5.2 Natural gas in Nigeria

In recent years, the Nigerian government has pushed its plans to use natural gas as a “transition fuel” (Jeremiah, 2022; Varin, 2021). The 2017 National Gas Policy aims to “move Nigeria from a crude oil export-based economy to an attractive oil and gas-based industrial economy” (Federal Republic of Nigeria, 2017). The government aims to increase domestic use of natural gas across most sectors, particularly transport, power, and industry, driven by an increase in gas production (DLPGOV, n.d.; Economic Sustainability Committee, 2020; Federal Ministry of Finance Budget and National Planning, 2021; Federal Republic of Nigeria, 2017).

Nigeria is currently the 17th largest natural gas producer in the world. In 2020, Nigeria produced approximately 45 bcm of gas, about a third of which was exported (IEA, 2021b). Natural gas is largely used in the industrial sector as well as for power generation. The long-awaited 2021 Petroleum Industry Act (PIA) aims to reform Nigeria's oil and gas sector and spur international investment (Federal Republic of Nigeria, 2021a).

Upstream production and midstream infrastructure

Nigeria has the largest natural gas reserves in Africa, with over 5,600 bcm in 2019 accounting for almost a third of Africa's reserves and 2.8% of global reserves (U.S. Energy Information Administration, 2022). In 2021, the Minister of State for Petroleum said the government was working to increase these reserves threefold (The Guardian, 2021).

One way the government is pursuing this is through the Frontier Exploration Fund, established by the 2021 PIA. This would divert 30% of NNPC Limited's³ profit from its production sharing contracts, profit sharing contracts and risk service contracts to support oil and gas exploration where there have been no previous exploration activities (Federal Republic of Nigeria, 2021a).

3 The Nigeria National Petroleum Company (NNPC) has been the state-owned oil and gas company since 1977. It is now being privatised and reestablished as NNPC Limited—as stipulated in the PIA.

Most of the natural gas produced in Nigeria is associated gas, found alongside oil reserves. Gas is largely produced by international oil companies (IOCs) working through petroleum joint ventures with the NNPC. Some of these IOCs have begun to divest from their Nigerian oil assets, with Nigerian firms beginning to take over these assets, but they face multiple challenges (Ashurst, 2022; This Day, 2021). For example, the IOCs have largely retained their deep-water oil assets, while domestic companies are acquiring onshore assets vulnerable to theft.

Natural gas production in Nigeria has increased substantially in the last two decades; however, 9% of the gas produced in 2019 was flared and 36% was reinjected to maintain pressure in oil wells or reduce flaring. The high levels of flaring have been an ongoing issue for decades and are largely due to a lack of infrastructure to capture the associated gas during oil production (Federal Republic of Nigeria, 2021b).

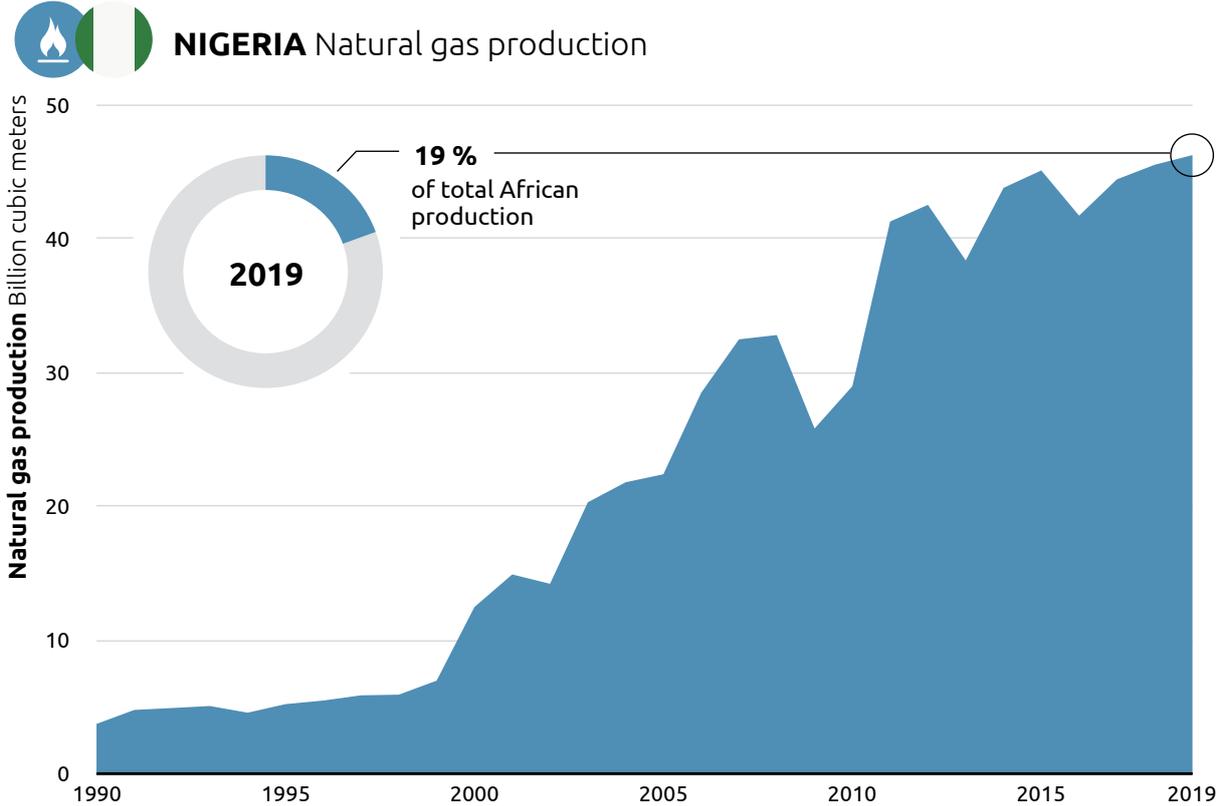


Figure 12: Natural gas production in Nigeria in 1990–2019. Source: U.S. Energy Information Administration, 2022.

High levels of flaring and gas reinjection means just over half of gas production goes to market, with 22% consumed domestically and 32% exported primarily as LNG. Regionally, the highest share of Nigeria’s LNG exports goes to Europe (15% Spain, 13% France, 17% other), followed by Asia Pacific (15% India, 5% China, 20% other) (U.S. Energy Information Administration, 2020).

Nigeria’s natural gas production is concentrated primarily in the Niger Delta in the south, with some offshore drilling in the Gulf of Guinea. Exploration activities in the oil and gas sector are now mostly focused on deep and ultra-deep offshore drilling as well as some onshore activities in the Chad Basin to the North (Federal Republic of Nigeria, 2021b). Oil and gas activities and pollution in the Niger Delta have underpinned the region’s long history of unrest and insecurity.

Natural gas is exported from Nigeria primarily via the West African Gas Pipeline and as LNG. The West African Gas Pipeline connects Nigeria’s gas production to Benin, Togo, and Ghana for export. Nigeria currently has LNG production capacity roughly equal to 10% of the world’s LNG supply and is aiming to increase this significantly (Eboh, 2022).

Several other projects are underway to boost Nigeria’s gas exports. Two major pipelines, often considered ‘rival pipelines’, have been in the works for decades: the Trans-Saharan Gas Pipeline and the Nigeria-Morocco Gas Pipeline.

The Trans-Saharan Gas Pipeline would pass through Niger and Algeria to open up gas from the three countries to European markets (Global Energy Monitor, 2022e). Following Russia's illegal invasion of Ukraine, the three countries signed an agreement in February 2022 to restart development of the project.

The Nigeria-Morocco Gas Pipeline would potentially extend the West African Gas Pipeline to every country along the West African coast, and end in Morocco and Spain (Global Energy Monitor, 2022d). The government has also signed an agreement with Equatorial Guinea to supply gas from Nigeria's offshore resources to Equatorial Guinea's gas processing and liquefaction facilities, for domestic and export markets (Obiezu, 2022).

Downstream uses of natural gas

Natural gas in Nigeria's primary energy supply has increased almost threefold since 2000. However, it still only made up about 10% of Nigeria's primary energy supply in 2019. It is largely used in the industrial sector and for power generation, supplying about 78% of electricity in 2019. Nigeria's domestic natural gas supply comes entirely from domestic production (U.S. Energy Information Administration, 2022).

Nigeria's power grid is extremely vulnerable to supply disruptions with frequent blackouts and load shedding. Severe power disruptions occurred in early 2022 (Emodi & Diemuodeke, 2022; Uzoho, 2022). Several reasons contributed to the collapses, including low rainfall impacting the smaller share of hydropower in the power mix and low supply of gas that powers the bulk of the grid, due to pipeline vandalism and other supply chain issues. Despite challenges guaranteeing gas supply for existing generation, Nigeria is continuing to build more gas plants (Global Gas Plant Tracker, 2021).

Nigeria's energy strategy aims to widely expand the use of natural gas across sectors. The National Gas Expansion Programme, launched in 2020, aims to make compressed natural gas (CNG) the primary fuel in the transport sector and LPG the primary fuel for clean cooking, captive power, and industrial complexes (Central Bank of Nigeria, 2020a). Nigeria's LPG Expansion Implementation Plan (LEIP) aims to increase LPG use for clean cooking from just 5% of households to 90% of households by 2030.

Natural gas emissions

CO₂ emissions from natural gas make up over a quarter of Nigeria's total CO₂ emissions (U.S. Energy Information Administration, 2022). In 2016, fugitive emissions from the oil and gas sector, including emissions from flaring, venting, and methane leaks, accounted for about one third of greenhouse gas emissions in Nigeria's energy sector, dominated by methane (94%). In fact, about 11% of Nigeria's energy emissions in 2016 were from fugitive methane emissions linked to the gas industry (Federal Ministry of Environment, 2020).

Gas flaring during oil and gas production is a significant source of emissions in Nigeria and has significant health, environmental and social impacts on host communities. While Nigeria has a long way to go to meet its target to end gas flaring by 2030, the government has made significant progress. Between 2000 and 2020, gas flaring decreased by 70% largely due to new laws and regulations (Ogunleye et al., 2019).

5.3 Investments linked to natural gas

Nigeria has struggled to attract investment in the oil and gas sector. Between 2015 and 2019, Nigeria only attracted 4% of investments made in Africa's oil and gas industry, despite having the largest gas reserves on the continent (KPMG in Nigeria, 2021). The Petroleum Industry Act (PIA), passed into law in 2021, aims to address challenges in the oil and gas industry and boost investment; however, whether the PIA will have the desired impact amid divestment announcements from IOCs and financial institutions is uncertain.

Despite challenges in attracting investment, Nigeria is ranked seventh globally in capital expenditures for gas projects in construction or pre-construction, amounting to an estimated USD 32bn (Browning et al., 2021). Further, NNPC is the fifth largest pipeline developer in the world, based on kilometres of pipeline planned and under construction⁴ (Langenbrunner et al., 2022).

⁴ NNPC is state-owned, but as of February 2022 the process to transfer assets to the newly formed private company, NNPC Limited, has begun.

Large natural gas projects have faced challenges from the early stages of development, with many failing to materialise in the recent past, often at great cost. The planned Brass LNG Terminals 1 & 2 were originally agreed upon in 2003 but have gone through major delays, as multiple companies dropped out (Global Energy Monitor, 2021a). In 2017, the project was restarted as USD 1bn had already been spent; however, companies have again dropped out. Similarly, the government has spent USD 600m on the Okolola LNG Terminal project, but this has also been delayed, with no updates since 2013 (Global Energy Monitor, 2021b).

After their construction, natural gas pipelines face new risks in Nigeria. The success of the West African Gas Pipeline has been hampered by insurgency, vandalism, over-costed infrastructure, supply shortages and defaults on payments from importing countries (Federal Republic of Nigeria, 2017; Greenhalgh, 2021).

Because of insurgency in the Niger Delta, the pipeline has not been able to operate at full capacity. The proposed Nigeria-Morocco Gas Pipeline, an extension of the West African Gas Pipeline, is expected to face the same risks (Greenhalgh, 2021). The proposed Trans-Saharan Gas Pipeline also faces opposition by the Nigerian militant group Movement for the Emancipation of the Niger Delta and would transverse territory plagued by extremists, including Boko Haram in northern Nigeria (Global Energy Monitor, 2022e).

As natural gas produced in Nigeria is almost entirely associated gas produced from oil resources, the divestment of IOCs from their assets in Nigeria poses a risk to the government's planned expansion of gas and investments in gas infrastructure. While the global energy transition is often cited as the driver of this divestment, oil and gas assets in Nigeria have become increasingly difficult to manage due to the risks stated above.

From January 2021 to February 2022, it was reported that Nigeria lost as much as USD 3.3bn to vandalism. As operators work to secure oil production, associated natural gas produced from these assets and supply to domestic markets can also be impacted (Money Central, 2022).

Further, these assets are at high risk of becoming stranded, as economies transition away from fossil fuels. Analysis of 1.5°C compatible scenarios show unabated natural gas in the primary energy supply should already have peaked and be declining globally, and that it needs to drop by more than 65% below 2020 levels by 2040 (Hare et al., 2021).

Pipelines can have long construction times and are typically expected to operate for more than 40 years—in other words, often going beyond mid-century net zero emissions objectives. The Nigeria-Morocco Gas Pipeline, for example, is not expected to come online until 2046 to supply European markets; however, the future of European gas demand is uncertain, especially given current development where European countries are exploring ways in which they can become energy independent (Global Energy Monitor, 2022d). High gas demand would also not be compatible with the European Climate Law, which set the EU's target to reach "climate neutrality" by 2050 (European Parliament and the Council of the European Union, 2021).

5.4 Benefits of high renewable energy & low natural gas

Employment benefits in the power sector

An important consideration for the implementation of climate mitigation policies is the impact on the economy, particularly on jobs and livelihoods. In Nigeria, unemployment has increased steadily to over 30% of the working age population since the end of 2014 when unemployment was only just over 5% (National Bureau of Statistics, 2021). The majority of jobs are in the informal sector, with only about 10% of the working age population employed in formal wage labour (ILO, 2020).

In 2021, the Nigerian government released a Green Jobs Assessment Report that assesses the impact of climate measures in Nigeria's NDC on employment, GDP and emissions (Federal Republic of Nigeria et al., 2021). The report found that policies to increase power generation had the largest impact on total jobs created. Comparing jobs created in a high renewables scenario to a high gas scenario, the report found the high renewables scenario resulted in significantly more jobs.

To estimate the benefits linked to renewable energy in the electricity sector under a 1.5°C compatible scenario, we adapted the employment factor approach from Rutovitz et al., (2015) and calculated the employment impacts under a current policies scenario and a 1.5°C compatible scenario⁵ (for more information on the assumptions and data sources see section 8.1 in the Annex).

Under current policies, the share of natural gas decreases; however, total gas generation increases by 26% compared to 2019. Under the 1.5°C compatible scenario, Nigeria increases renewable energy generation to about 65% of the power mix by 2030 and creates 4.7 million job years from 2020 to 2030, about 4 million more than under current policies.

When comparing the 1.5°C compatible scenario with current policies, it is important to note the 1.5°C compatible scenario assumes much higher electrification rates as end use sectors are decarbonised, resulting in higher total installed capacity and thus jobs. However, on a per MWh basis, the higher renewable scenario also produces more jobs. From 2020 to 2030, the 1.5°C compatible scenario produces on average over 3,400 job years per MWh per year while the current policies scenario produces about 1,300 job years per MWh per year, as shown in Figure 13.

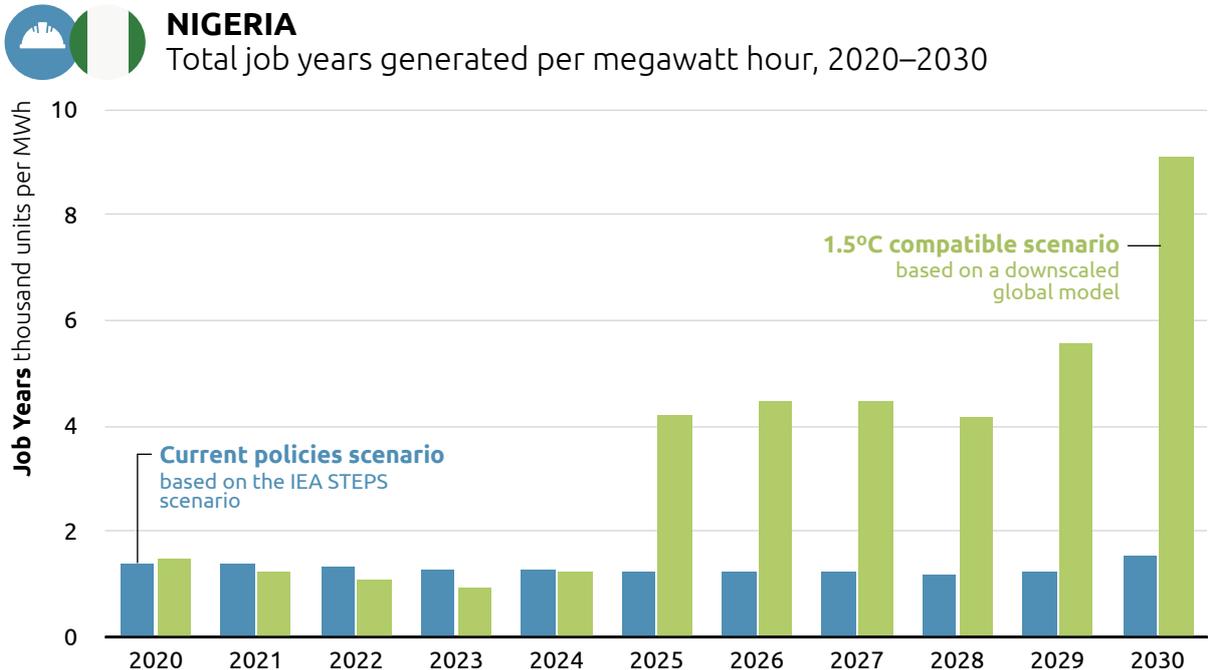


Figure 13: Job years generated per MWh under a 1.5°C compatible and current policies scenario in Nigeria in 2020–2030.

Job years per MWh increase later in the decade, as the share of renewables amongst new capacity increases in the 1.5°C compatible scenario. Renewables tend to drive higher levels of employment in the manufacturing and construction sectors, when measured both in terms of capacity (per MW) or output (per MWh). The increasing role of the solar PV roll-out, in particular, leads to the rising number of job years per MWh in the 1.5°C scenario.

While our analysis only considers jobs in the near term, implications for longer time horizons should be considered. Pursuing a “Decade of Gas” and continuing to invest in gas for the next two to three decades would lock Nigeria into fossil technology and labour skills that are not sustainable in the medium to long term. Prioritising a shift to renewable energy now would develop labour market skills and expertise in technologies that will still be viable in the long term.

5 For Nigeria, we have assessed the employment benefits of two scenarios: (1) a current policies scenario based on IEA’s Stated Policies Scenario (STEPS) from the 2021 World Energy Outlook, and (2) a 1.5°C compatible scenario based on the global model REMIND (REMIND_1.7 CEMICS-1.5-CDR8), both downscaled at national levels from the 1.5°C national pathway explorer (Climate Analytics, 2021).

6 Natural gas and renewable energy in Senegal

In 2018, Senegal adopted a Gas-to-Power Strategy following significant oil and gas discoveries. This strategy aims to shift to natural gas as Senegal's main fuel for power generation to reduce reliance on expensive oil imports, bring down electricity prices and move away from costly energy subsidies.

For Senegal to exploit its natural gas reserves, it would need to build significant infrastructure, including pipelines, LNG terminals and gas-fired power stations. Investing in new fossil infrastructure is a risky strategy, as the world moves to a net zero pathway.

Investment planned for gas expansion could be channelled to renewables, which are cheaper and could provide sustainable jobs, increase access to energy, and improve local air quality.

Senegal's planned gas expansion is not compatible with the Paris Agreement. Under 1.5°C compatible scenarios, natural gas is not developed as a power source. As natural gas plays a minimal role in current power generation, phasing out unabated gas is achieved early in the decade.

In this report we analyse the employment benefits linked to renewable energy in the electricity sector under a 1.5°C compatible pathway and compare these to employment under a current policy scenario.

Under the 1.5°C compatible scenario, Senegal does not pursue natural gas, and increases renewable energy generation to about 88% of the power mix by 2030, creating over 1.4 million job years from 2021 to 2030. On a per MWh basis the 1.5°C compatible scenario creates on average about 6,700 job years annually during this time period, compared to 1,500 job years under the current policies scenario.

6.1 Energy sector overview

In Senegal, oil is the largest source of energy, supplying 54% of primary energy in 2019, as shown in Figure 14 (IEA, 2021d). Oil is primarily used in the transport sector and for power generation. Liquefied petroleum gas (LPG) is also used for cooking by about 30% of the population. Senegal relies on imports for its oil consumption, placing a significant burden on its economy. Refined petroleum and crude petroleum were the first and third largest imports in the country, totalling about 16% of imports by value in 2020 (OEC, 2022).

The next largest source is bioenergy, largely traditional biomass, supplying 37% of primary energy in 2019. Almost 70% of households in Senegal rely on charcoal and other forms of solid biomass for cooking. Coal makes up the next largest share (9%) followed by non-biomass renewables (1%). Natural gas currently plays a negligible role in Senegal's energy mix, at less than 1%.



SENEGAL Total primary energy supply by source

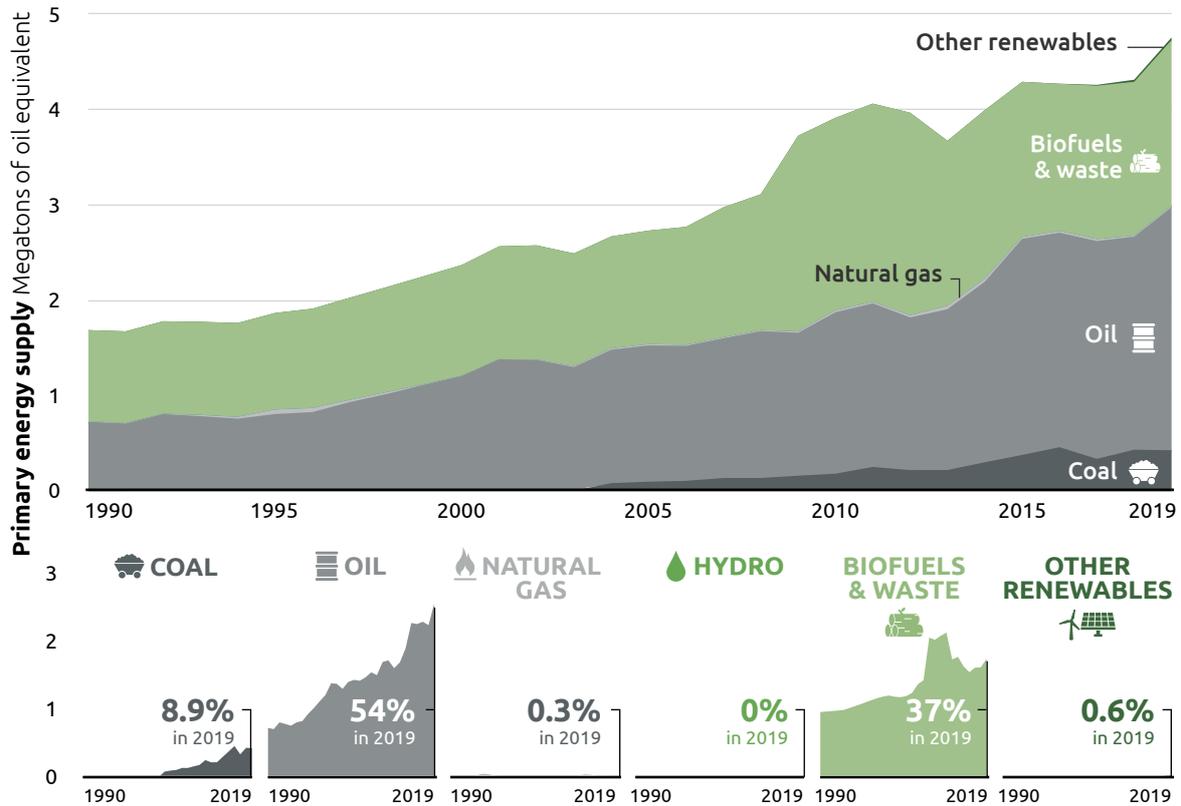


Figure 14: Total primary energy supply by source in Senegal in 1990–2019. Source: IEA, 2021d.

Senegal’s electricity mix is also dominated by oil, which supplied three quarters of electricity generation in 2019 (see Figure 15). Since Senegal is dependent on oil imports, the high share of oil in the power mix results in a high cost of electricity, the ninth highest in Africa, which is subsidised by the government (Benson, 2022; US ITA, 2020). Coal is the next largest source providing 15% of the electricity mix, followed by solar PV providing 6%.

Senegal has made significant progress in expanding access to electricity, increasing it from about 55% in 2010 to 70% of the population by 2019 (World Bank, 2015).



SENEGAL Total electricity supply by source

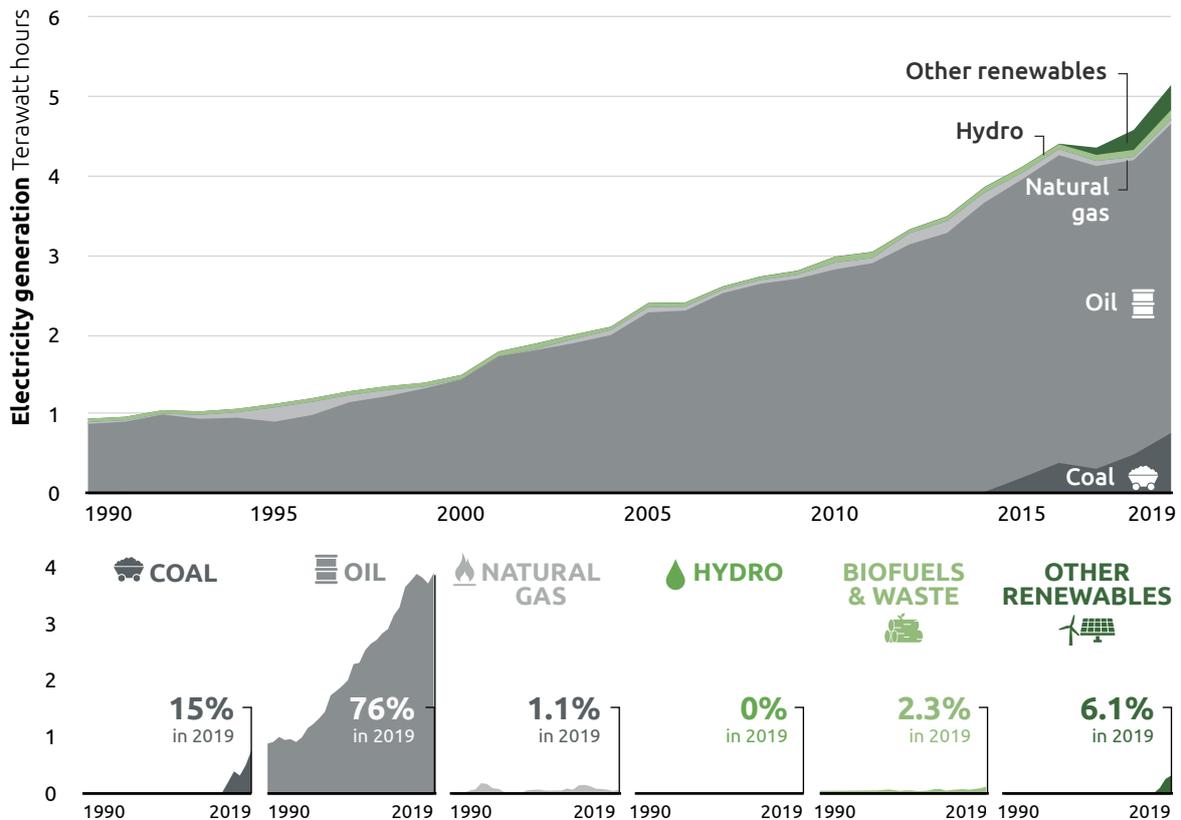


Figure 15: Total electricity generation by source in Senegal in 1990–2019. Source: IEA, 2021d.

While natural gas is currently insignificant in Senegal’s energy and electricity mixes, the country has recently made major discoveries of natural gas, and plans to produce and consume more of this resource (Ministry of Petroleum and Energy, 2018).

If all plans go ahead, this would have significant implications on Senegal’s transition to a low carbon economy and society, with potential negative economic consequences resulting from stranded assets and a loss of jobs.

Under 1.5°C compatible scenarios, natural gas would not be pursued in the power sector. As natural gas currently makes up only about 1% of the electricity mix, it would have a very early phase out in the early 2020s (Climate Analytics, 2021). Instead, renewable energy could be ramped up, reaching 100% of the power mix by 2040.

Energy sector planning

Senegal’s ten-year plan for the period 2014–2023, Plan Sénégal Émergent (PSE), aims to turn Senegal into an emerging economy by 2035 through a series of socio-economic reforms (Ministry of Economy Finance and Planning, 2018; Ministry of Economy Planning and Cooperation, n.d.). Based on the PSE, the government issued a “gas-to-power” strategy in 2018, where Senegal would develop recently discovered gas reserves with the objectives of increasing “energy independence”, reducing state fuel subsidies and energy costs, and achieving universal energy access by 2025 (Ministry of Petroleum and Energy, 2018; Ouki, 2020).

The government is also targeting increased renewable energy. The second phase of the PSE for 2019–2023 aims to increase renewable energy in the power mix to 29% by 2023 (Ministry of Economy Finance and Planning, 2018). This target would be more ambitious than the ones in Senegal’s National Renewable Energy Action Plan (PANER) of reaching 20% of electricity generation from renewable resources by 2020 and 23% by 2030 (including medium and large hydropower) (MEDER & CEREEC, 2015). While Senegal has added some renewable capacity, it fell short of the 2020 target (Senelec, 2021).

Through its Universal Access to Electricity Programme, the government is also targeting 100% access to electricity by 2025. Senegal's National Rural Electrification Programme aims to achieve this goal by reaching 95% of the rural population through grid extension, 4% through solar or solar-diesel hybrid mini-grids and the rest through solar home systems (World Bank, 2018).

6.2 Natural gas in Senegal

Historically, natural gas production and consumption in Senegal has been minimal. However, in 2018, the Senegalese government adopted a "Gas-to-Power" strategy following a number of significant gas discoveries (Ministry of Petroleum and Energy, 2018). The strategy aims to use domestic gas resources to reduce reliance on expensive oil imports for the power sector and to establish Senegal as an LNG export hub.

These plans would require significant investment in natural gas infrastructure across the supply chain, including LNG terminals, pipelines and power stations. Increasing gas capacity in the power sector is expected to be achieved through the conversion of oil-fired and, to a lesser extent, coal-fired power stations to gas.

Upstream production and midstream infrastructure

Senegal's gas production has declined, providing limited supply to domestic power and cement companies (Ouki, 2020). From 2014 to 2017, however, significant gas discoveries were made in Senegal. It is expected that the natural gas that could be produced from these reserves would be more than sufficient to meet projected domestic demand (Ouki, 2020).

One of the largest natural gas discoveries, the Greater Tortue Ahmeyim (GTA) gas field, spans across Senegal and Mauritania's offshore waters. Senegal's share of the GTA gas field is estimated to hold natural gas reserves of 283 bcm (Miguel Artacho, 2021). The GTA gas field is the deepest offshore project currently underway in Sub-Saharan Africa and has faced a backlash due to its proximity to the largest known cold-water reef, given its potential negative impact on the ecosystem (Jones & Howard, 2021; Miguel Artacho, 2021).

The GTA gas field development project is expected to come online in 2023 and includes a floating LNG terminal to produce gas for export, as well as for domestic use in Senegal and Mauritania (Global Energy Monitor, 2022c).

Other gas development projects are also expected to begin operations in the coming years. Gas production from the Sangomar Offshore Profond block is scheduled to come online in 2024, with all of the production allocated to the domestic market (Ouki, 2020). The Teranga and Yakaar gas fields in the Cayar Offshore Profond are also expected to begin production in 2024, initially supplying domestic markets with the potential to be part of an LNG hub at a later stage (Ouki, 2020; Saadi, 2021). To connect new production with future domestic demand, largely for power generation, Senegal has a number of pipelines planned (Enerdata, 2020; Ouki, 2020).

Under the IEA's Stated Policies Scenario (STEPS), Senegal's annual gas production reaches 9.5 bcm in 2040. The first phase of the GTA project is expected to produce 2.3 million tonnes per year (mtpa) of LNG for export (about 3.2 bcm per year) (Miguel Artacho, 2021).

Downstream uses of natural gas

Senegal expects to direct its new supply of natural gas for use in the power sector, through the government's Gas-to-Power Strategy. It aims to achieve this strategy in part through the use of dual fuel power plants that can be supplied by liquid or gas fuels (Ouki, 2020). Some operating thermal plants in Senegal are already capable of operating on fuel oil or natural gas, while others are expected to be converted to—or constructed as—dual fuel.

Under the IEA's STEPS for Senegal, natural gas generation in the power mix increases from 1% in 2018 to 33% in 2030 (IEA, 2019). While some plans, such as the operation of the GTA project, have been slightly delayed by the COVID-19 pandemic, Senegal's stated policies still indicate a significant shift towards gas-fired generation.

Natural gas is also expected to be used outside the power sector in a limited capacity, mainly for cement kilns and other industries located near planned gas infrastructure (Ouki, 2020). Senegal's NDC mentions the use of gas for the industry sector (Republique du Sénégal, 2020).

6.3 Investments linked to natural gas

Senegal has been relatively successful in attracting investments for its energy sector. In 2020, it was one of the few countries in Africa to increase its foreign direct investment inflows, which were up by 39% (UNCTAD, 2021). This was due to increased energy sector investments, primarily in the budding oil and gas industry, as well as renewables, whereas non-energy sectors saw a decrease in investments.

However, there are still several challenges to implementing the Gas-to-Power Strategy. Despite increased inflows in 2020, uncertainty remains over the sources of financing to fully implement the Gas-to-Power Strategy (William Davis and David Mihalyi, 2021).

Following Russia's illegal invasion of Ukraine, the European Union has started looking also to African countries like Senegal to cut reliance on Russian gas rather than no-regret options that don't undermine climate goals (Ancygier & Wilson, 2022; Krukowska, 2022). In May 2022, German Chancellor Scholz announced intentions for Germany to invest in Senegalese gas to reduce dependence on Russian gas (Tagesschau, 2022). This announcement is a stark reversal of Germany's commitment from COP26 to stop financing fossil fuels in other countries (UK Government, 2021) and one that will contribute to locking Senegal in high carbon infrastructure for many decades.

Uncertainty in international natural gas markets also increases the risk of gas projects becoming stranded assets. As Senegal's domestic gas market is relatively small compared to the reserves under development, even considering the government's gas strategy, the viability of gas development projects will still depend on sustained LNG exports (Ouki, 2020).

Significant infrastructure, such as pipelines and the conversion of oil-fired power plants, needs to be completed to ensure domestic gas demand can offset supply. "Take-or-pay" schemes, where the country commits to pay for an agreed amount of produced gas even if unused, are common to secure investment (William Davis and David Mihalyi, 2021). However, if infrastructure is not completed or demand is lower than forecast, a country can be locked-in to expensive penalties to producers.

Ghana, for example, spent an estimated 7% of its annual budget by 2020 on payments for unused gas when transmission infrastructure was not completed on time. While it is not clear if Senegal will use a "take-or-pay" approach, this is standard industry practice to secure investment, particularly when much of the needed infrastructure is not yet built (William Davis and David Mihalyi, 2021).

6.4 Benefits of high renewable energy & low natural gas

Creating jobs has been a challenge for the Senegalese government. Unemployment in Senegal increased to 24% in the fourth quarter of 2021, an increase of nearly 8 percentage points compared to the same time the year before (ANSD, 2022). Further, about 90% of workers are employed in the informal sector (Bureau international du Travail, 2020). In 2020, a lack of jobs and border closings exacerbated by COVID-19 helped fuel an emigration surge from Senegal, with many risking their lives to reach Europe by sea (Peyton, 2020; Ziegelmayr, 2021). The energy transition represents an opportunity for Senegal to create sustainable jobs in renewable energy.

To estimate the benefits linked to renewable energy in the electricity sector under a 1.5°C compatible scenario, we adapted the employment factor approach from Rutovitz et al., (2015) and calculated the employment impacts under a current policies scenario and a 1.5°C compatible scenario⁶ (for more information on the assumptions and data sources see section 8.1 in the Annex).

6 For Senegal, we have assessed the employment benefits of two scenarios: (1) a current policies scenario based on IEA's Stated Policies Scenario (STEPS) from the 2019 Africa Energy Outlook, and (2) a 1.5°C compatible scenario based on the global model REMIND (REMIND_1.7 CEMICS-1.5-CDR8) downscaled at national levels from the 1.5°C national pathway explorer (Climate Analytics, 2021; IEA, 2019)

Under our current policies scenario, natural gas in the power system increases rapidly from 1% of generation in 2019 to 43% by 2030 under the government’s Gas-to-Power Strategy. In this scenario, average annual growth in non-biomass renewable energy generation from 2021 to 2030 is about 14% compared to 20% from 2015 to 2020, indicating a slowdown in renewables development.

Under our 1.5°C compatible scenario, natural gas is not developed as a key power source for Senegal. Instead, a significant increase in non-biomass renewables to 88% of the power system allows Senegal to shift away from expensive oil imports.

This shift creates over 1.4 million job years. It is important to note the 1.5°C compatible scenario assumes much higher electrification rates, as end use sectors are decarbonised, resulting in higher total installed capacity and thus jobs.

However, on a per MWh basis, the higher renewable scenario also produces more jobs. From 2021 to 2030, the 1.5°C compatible scenario creates, on average, more than 6,700 job years per MWh per year compared to the current gas-based strategy, which creates only about 1,500 annual job years per MWh, as shown in Figure 16. Job years per MWh remain higher in the 1.5°C scenario compared to the current policies scenario due to a high share of natural gas amongst capacity additions in the latter. Renewable energy projects tend to support higher levels of employment in the manufacturing and construction sectors than natural gas plants, when measured both in terms of capacity (per MW) or output (per MWh). The vast expansion of solar PV in the 1.5°C compatible scenario would create significant numbers of construction and installation jobs in the Senegalese economy.



SENEGAL

Total job years generated per megawatt hour, 2021–2030

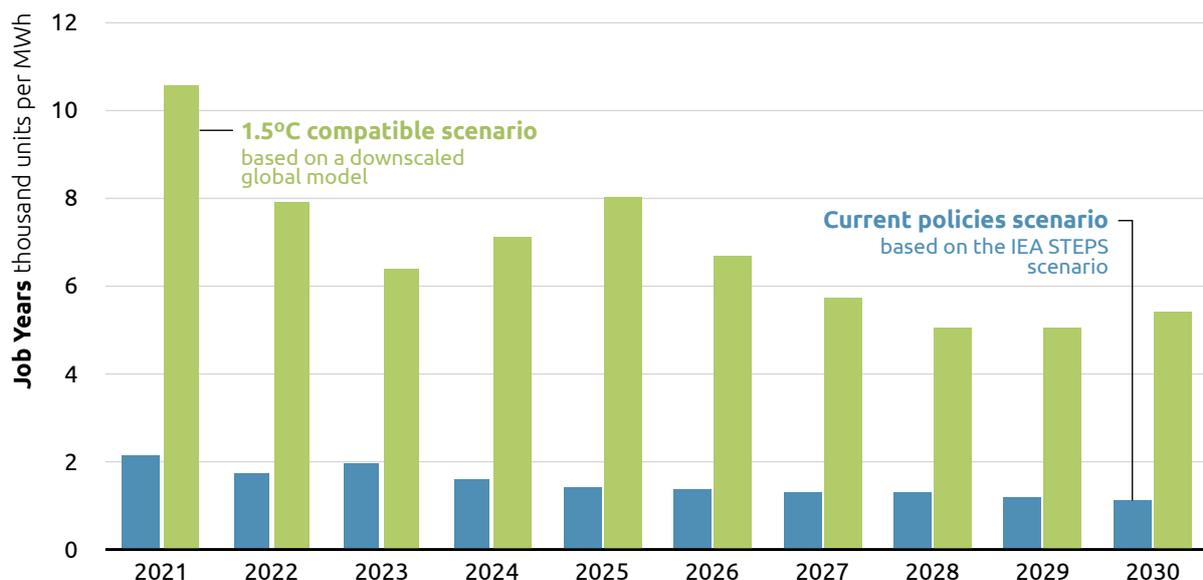


Figure 16: Job years generated per MWh under a 1.5°C compatible scenario and current policies scenario in Senegal in 2021–2030.

Implications for shifting to gas over longer time horizons should also be considered. In the case of Senegal, there is currently no significant gas industry established. Rather than investing in a new gas market and labour skills development for gas, Senegal could instead prioritise developing labour markets for more resilient renewable technologies that will not need to be phased out. Senegal will need international support to enable the development of renewable energy markets and relevant skills.

Energy systems in Africa need to drastically expand to meet the growing demand for access to clean energy and a sustainable economic development. Current energy systems, which are largely based on biomass and fossil energy, are both insufficient and inadequate to do this.

Current plans in the region are mainly based on expanding fossil fuels, with many countries working on the exploration and development of natural gas fields. Supplying the demand through fossil fuels comes with multiple risks and disadvantages, beyond accelerating the climate emergency.

Some of these include flows of money to international corporates—mostly to the Global North—with little benefit to local populations, and macro-economic issues linked to high oil and gas price volatility. Continued investments into natural gas could lock African countries into technologies and value chains that are on track to becoming obsolete, as the world transitions to zero emissions, which could in turn increase unemployment and economic vulnerability.

To reduce the destructive global reliance on fossil fuels, developed countries and development banks urgently need to stop financing all fossil fuel projects. Our research shows that the extraction, transportation and use of natural gas is limited in time and includes significant economic and societal risks. The argument of providing affordable energy quickly through fossil fuels no longer holds, as renewable energy technology has become cost-competitive, even without a carbon price.

Our case studies show that for Africa, building economic development on renewables rather than on fossil fuels holds several benefits:

- ▶ **Renewable energy installation, operation and maintenance offers employment benefits over natural gas:** in all three countries—Egypt, Nigeria and Senegal—pathways with higher renewable energy generate more employment than those with a higher reliance on natural gas.
- ▶ **Renewable energy is the cheapest source of energy:** exploration, expanding pipelines and LNG terminals come with large-scale investments at the risk of stranding when the world phases out fossil fuels. Where governments participate in such investments, they risk the loss of public resources.
- ▶ **Renewable energy also offers longer term, sustainable export opportunities:** abundant solar and wind resources in most African countries can not only supply local energy needs, but they could also make it possible for these countries to develop new value chains and export opportunities—for example through renewable electricity or green hydrogen.
- ▶ **Renewable energy is more suited to support other development priorities:** renewable energy installations are usually smaller and more decentralised than fossil fuel-based installations, and countries can more easily build up their own manufacturing capacities and labour force. If supporting policies are set up well, renewable energy allows for more people to benefit.

Even though it comes with multiple benefits, moving to a 1.5°C compatible pathway requires a deep and rapid shift of current systems, which presents numerous challenges. Given its abundant renewable resources, Africa has the potential to transition to renewable energy systems very fast, but it should not face this challenge alone. Developed countries need to massively ramp up financial support to allow access to renewable energy technologies, related infrastructure and capacity building.

8 Annex - Benefits analysis methodology

8.1 Employment factor analysis for electricity supply

Approach

To estimate employment opportunities of different future pathways for the electricity sector, we apply 'job factors' to the scenario data. These factors are derived from academic research into the number of jobs created or supported across different technologies and geographies. They are typically expressed in full time equivalent jobs per unit of capacity (jobs / MW) or unit of fuel consumption (jobs / PJ) for a defined duration. For consistency, and to facilitate comparison between scenarios and technologies, we estimate all employment impacts in units of full-time 'job years', i.e. a full-time job for one person that lasts for one year.

We estimate the number of *direct* jobs supported by activities including: fuel supply (where relevant), manufacturing of component parts, construction of new facilities, operational and maintenance of electricity generation units, and decommissioning at the end of their operational use.

The analysis does not include the wider *indirect* and *induced* jobs that are typically stimulated by these investments further upstream in the supply chains (e.g. the production of steel as an input to the manufacturing of component parts) and more broadly throughout the economy. The analysis also does not include employment impacts in the transmission and distribution of electricity between where it is generated and consumed.

Our findings therefore represent an underestimate of the full employment impacts of investments in electricity supply in the respective countries, but remain consistent and suitable to facilitate a comparison of impacts across different future pathways.

Employment estimates are specific to the country of interest (i.e. we do not estimate potential employment impacts in third countries, such as those from which component parts are imported) and calculated for each year of the modelling horizon for each technology (e.g. natural gas, biomass, solar PV, hydropower, etc.) and categorisations of the type of job (e.g. manufacturing, construction, operation, etc.).

This allows us to understand the relative contributions of different technology choices to job creation, the types of skills needed from the domestic workforce and how employment is (or is not) sustained over time for different groups, e.g. jobs in natural gas fuel supply, or solar PV installation. In this application, due to data limitations, we apply the same job factors to all future years, without making adjustments for global, or local, learning effects that may evolve at the technology level.

Data sources

The key data input to the employment analysis are the job factors. These are based on analyses by Ram et al., (2022) and Rutovitz et al., (2015), which set out region-specific job factor estimates for key electricity generation technologies based on job factor methodology. In order to process the scenario data (annual generating capacity and output per technology) we also use global default estimates of the typical lifetime and efficiency of technologies, based on a study by Kost et al., (2021).

Limitations

The 'job factor' approach offers a relatively simple means of deriving employment estimates to give a sense of the order of magnitude of potential impacts and enable comparison between different future pathways, or scenarios. There are, however, a number of limitations to the accuracy of the analysis, in particular which may not fully capture the specificities of individual country circumstances.

For example, all job factors are based on regional adjustments to estimates for North America, rather than national data. For Egypt we apply the regional adjustments for the Middle East and North Africa (MENA) region, and for Nigeria and Senegal, we apply the adjustments for the Sub-Saharan Africa region.

A further key limitation of the analysis is that adjustments to account for the local share of manufacturing [and fuel supply] jobs – i.e. to reflect how much of the manufacturing is carried out domestically, rather than imported from abroad – are generic to all technologies, so do not differentiate between, for example, natural gas plant and solar PV unit supply chains.

Finally, as the scenarios are defined at the level of headline technology types (e.g. coal, natural gas, biomass, hydro, solar PV) granular information on unit level capacity additions and retirements from one year to the next is not fully captured in all instances. In all cases capacity additions and retirements are calculated by the aggregated difference between operating capacity in each year.

This simple approach can underestimate the number of job years in the decommissioning of retiring plants, as well as manufacturing of parts and construction of replacement units. However, we do not anticipate this is a particularly material issue in the context of the analysis countries, where significant expansion of electricity generation is anticipated.

8.2 Health impact analysis for electricity supply

To quantify the health impacts of air pollution from gas-fired power plants we use the Air Pollution Impact Model for Electricity Supply ([AIRPOLIM-ES](#)).

The model estimates the impact on mortality from four adulthood diseases: lung cancer, chronic obstructive pulmonary disease, ischemic heart disease, and stroke, whose prevalence is increased with the intake of pollution (WHO, 2016).

The tool estimates health impacts for existing and planned gas-fired power plants based on unit specific information, including their capacity, location and, where available, emission factors of different pollutants. In the analysis here, due to data limitations, all gas-fired power plants have the same emission control equipment installed.

We use information on existing and planned gas plants for each country from the Global Gas Plant Tracker, maintained by the Global Energy Monitor. In scenarios in which the aggregated national capacity of gas plants exceed the total volume of both units in operation and those within the planning pipeline, we distribute the additional capacity expansions equally across all plants in the Global Gas Plant Tracker data for the purpose of identifying the location of the source of the emissions and the population exposed to these pollutants.

Further information on the tool, method, data sources and limitations are available in the methodology note, as well as accompanying resources, here: <https://newclimate.org/2018/11/30/airpolim-es-air-pollution-impact-model-for-electricity-supply/>

8.3 Assumptions for electricity generation scenarios in Egypt, Nigeria and Senegal

Egypt

For Egypt, we have assessed the benefits linked to employment and air quality based on three electricity generation scenarios. The 2035 Energy Strategy uses the government's own targets for the generation share of each technology in 2035. We have assumed all 'thermal' generation from the government's strategy to be based on natural gas in 2035. The 'increased renewable energy target' and 'high renewable energy' scenarios assume renewable energy to contribute 62% and 82% of total electricity generation respectively in 2035. In both of these scenarios, we have used the same assumptions for nuclear energy and hydropower as in the government's 2035 Energy Strategy due to limits to hydropower potential and long construction times for nuclear. A summary of these three electricity generation scenarios can be found in Table 1.

We have used electricity generation projections from IRENA's Renewable Energy Roadmap (REmap) scenario for Egypt across the three scenarios in 2022–2035. In this scenario, total generation increasing by around 60% from today's levels to 350 TWh (IRENA, 2018b). We then extended this data

to 2035 using 2026–2030 growth rates from the REmap scenario. We have derived technology-specific generation using values presented in Table 1. To determine capacity installation scenarios, we have used capacity factors from IRENA’s Renewable Energy Outlook Report for Egypt (IRENA, 2018b) and applied these to the electricity generation scenarios.

Historical data for renewable energy capacity is taken from IRENA’s 2022 Renewable Capacity Statistics (IRENA, 2022a). For non-renewable capacity and for historical electricity generation, we have used data from Egypt’s Ministry of Electricity and Renewable Energy (Government of Egypt, n.d.-b).

Table 1: Share of electricity generation per technology in three different electricity supply scenarios in Egypt in 2035.

Share of total electricity generation per technology in 2035	2035 energy strategy	Increased renewable target	High renewables scenarios
	42% Renewable Energy	62% Renewable Energy	82% Renewable Energy
Onshore wind	14%	33%	44%
Solar PV	22%	21%	28%
CSP	4%	6%	8%
Hydropower	2%	2%	2%
Thermal (mostly natural gas)	55%	35%	15%
Nuclear	3%	3%	3%

Nigeria

For Nigeria, we have assessed the employment benefits of two scenarios: (1) a current policies scenario based on IEA’s Stated Policies Scenario (STEPS) from the 2021 World Energy Outlook, and (2) a 1.5°C compatible scenario based on the global model REMIND (REMIND_1.7 CEMICS-1.5-CDR8), both downscaled at national levels from the 1.5°C national pathway explorer (Climate Analytics, 2021). For both scenarios, historical capacity and generation data for 2019 are from the IRENA’s 2022 Renewable Capacity Statistics (IRENA, 2022a).

As downscaled results for both the STEPS scenario and the downscaled REMIND pathway do not give a technology specific breakdown of non-biomass renewable capacity and generation, we assumed a split of non-biomass renewable capacity based on the renewable capacity targets presented in Nigeria’s updated Nationally Determined Contribution (NDC). Given the high share of large hydropower capacity in Nigeria’s renewable target and feasibility constraints with deploying significant hydro capacity, the amount of additional large hydropower capacity was capped at 12 GW, equal to the targeted capacity in Nigeria’s NDC.

Table 2: Share of electricity generation per technology in two different electricity supply scenarios in Nigeria in 2030.

Share of total electricity generation per technology in 2030	Current policies	1.5°C compatible scenario
Onshore wind	3%	10%
Solar PV	5%	25%
Large hydropower	31%	20%
Small hydropower	3%	11%
Biomass	1%	<1%
Thermal (mostly natural gas)	58%	35%

Senegal

For Senegal, we have assessed the employment benefits of two scenarios: (1) a current policies scenario based on IEA's Stated Policies Scenario (STEPS) from the 2019 Africa Energy Outlook, and (2) a 1.5°C compatible scenario based on the global model REMIND (REMIND_1.7 CEMICS-1.5-CDR8) downscaled at national levels from the 1.5°C national pathway explorer (Climate Analytics, 2021; IEA, 2019). While the STEPS scenario includes some generation from back-up generators, this was not considered as it is not specified in the 1.5°C compatible scenario.

For both scenarios, historical capacity and generation data are from Senelec, the state-owned electricity company of Senegal, supplemented in some cases with plant-specific information from Global Energy Monitor (Global Gas Plant Tracker, 2021; Senelec, 2021). Adjustments were made to the current policies scenario to account for the fact that the 235 MW Karpowership fuel oil and LNG power station came online in 2019, which is not reflected in STEPS.

As for Nigeria, the 1.5°C compatible scenario does not give a technology specific breakdown of non-biomass renewable capacity and generation. For this, we used the same split in renewable generation as given in IEA STEPS. We then calculated renewable capacity using capacity factors. For thermal and hydropower capacity, country-specific capacity factors were calculated using capacity and generation data provided by Senelec. Where possible, Senelec and Global Energy Monitor data were used to account for instances where plants were not operational for a full year (Global Gas Plant Tracker, 2021; Senelec, 2021). For solar PV and wind, country specific capacity factors were taken from a 2018 IRENA report (IRENA, 2018a).

Table 3: Share of electricity generation per technology in two different electricity supply scenarios in Senegal in 2030

Share of total electricity generation per technology in 2030	Current policies	1.5°C compatible scenario
Onshore wind	9%	23%
Solar PV	10%	36%
Hydropower	8%	27%
Biomass	2%	2%
Gas	20%	2%
Coal	8%	6%



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The Consortium



The Climate Action Tracker (CAT) is an independent scientific analysis produced by two research organisations tracking climate action since 2009. We track progress towards the globally agreed aim of holding warming well below 2°C, and pursuing efforts to limit warming to 1.5°C.

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Climate Analytics is a non-profit climate science and policy institute based in Berlin, Germany with offices in New York, USA, Lomé, Togo and Perth, Australia, which brings together interdisciplinary expertise in the scientific and policy aspects of climate change. Climate Analytics aims to synthesise and advance scientific knowledge in the area of climate, and by linking scientific and policy analysis provide state-of-the-art solutions to global and national climate change policy challenges.

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NewClimate Institute is a non-profit institute established in 2014. NewClimate Institute supports research and implementation of action against climate change around the globe, covering the topics international climate negotiations, tracking climate action, climate and development, climate finance and carbon market mechanisms. NewClimate Institute aims at connecting up-to-date research with the real world decision making processes.

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