1.5°C
NATIONAL
PATHWAY
EXPLORER

CLIMATE ANALYTICS

NATIONAL 1.5°C COMPATIBLE EMISSIONS PATHWAYS AND CONSISTENT POWER SECTOR BENCHMARKS IN AFRICA

Botswana, Egypt, Ethiopia, Ghana, Kenya, Nigeria, Senegal and South Africa

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SUPPLEMENTARY MATERIAL

Supplementary material and background data can be consulted on the dedicated webtool:
https://1p5ndc-pathways.climateanalytics.org/

A digital copy of this report along with supporting appendices is available at:
www.climateanalytics.org/publications

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CLIMATE ANALYTICS

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SUMMARY

Africa, one of the most vulnerable continents, has contributed the least to greenhouse gas emissions (GHG) globally. The spotlight will be on the region in 2022 with Egypt hosting the UN climate summit COP27 at the end of the year. Limiting global warming to 1.5°C by the end of the century is imperative to reduce impacts of climate change, especially on the most vulnerable communities. This study aims at providing key decarbonisation benchmarks necessary for countries to align with 1.5°C compatible pathways.

In 2019, the continent's share of global emissions was around 7%, excluding the emissions from land use, land use change and forestry (LULUCF). The biggest emitters in the region are South Africa, Nigeria, Egypt, Algeria and Ethiopia. Since 1990, however, Africa's emissions (excluding LULUCF) have increased faster than the global average. The energy sector is the largest source of emissions in Africa excluding LULUCF, making up about 55% of the total in 2019, followed by agriculture. Without stronger commitments to low-carbon growth and sufficient support from developed countries, Africa's emissions could increase substantially.

LULUCF emissions play an important role in Africa, contributing an estimated 2.2 GtCO2e to the continent's emissions, about 40% of total emissions. Africa is home to about one fifth of the world's forests. Forests are critical resources for many communities, with over 60% of Africans directly or indirectly dependent on forests in their everyday life. However, between 2015 and 2020, Africa lost up to 4.4 million hectares of forest per year, driven primarily by shifting agriculture.

Coal-based power generation dominated the power mix in Africa up until about nine years ago, when it was overtaken by gas-based power generation. Coal still accounted for around 30% of the continent's power mix in 2019. As of July 2021, there is around 49GW of installed coal capacity across the continent and the current pipeline of new coal power plants is close to half of it. While most of the operating capacities are located in South Africa and Morocco, future coal expansion is expected to be more distributed, with capacity increasing in Zimbabwe, Botswana and Mozambique. The majority of gas power plants are still relatively young and are still expected to be running in the coming decades.

As the world engages on a transition to a low carbon economy, the expected impact on fossil fuel producers is reduced demand and lower prices for their products. Companies and investors are starting to take these risks into account in their strategy and make divestment decisions considering the financial risks in the context of decarbonisation. When looking at the top nine petrostates dependant on oil and gas revenues, more than 370 million people (of which over half are in Nigeria) could be at risk of being impacted by decreasing fossil fuel demand.

A recurring argument that African countries should leap-frog fossil fuelled developmental stages and move directly to the use of renewables has become louder as renewables have become cheaper to deploy. Countries will need to implement innovative ideas to ensure a just transition to low-carbon societies. Both the opportunities and costs (social, economic) of the transition must be fairly distributed, so that no particular group of people is disadvantaged in comparison to others, merely because they have been hitherto employed in fossil fuel extraction or related carbon-intensive industries.

Cost-effective and 1.5°C compatible domestic emissions pathways indicate that total global greenhouse gas emissions peak around 2020 and decrease rapidly, reducing CO2 emissions by 45% by 2030 globally. In the Middle-East and Africa region, these pathways reach net zero CO2 by 2050 and net zero GHG by 2070.

SUMMARY

The analysis of the regional implications for coal from 19 Paris compatible modelled pathways assessed by the IPCC Special Report 1.5°C indicates that coal should be phased out in Middle-East and Africa by 2034 (median value, ranging between 2031 and 2042 across the different pathways).

Scaling up international finance in Africa is needed to support decarbonisation and help unlock ambition. In 2020, only 3% of total climate finance commitments (domestic and international) went to Africa and the Middle East, and climate finance is not necessarily distributed between countries in a way that reflects their needs. At COP26, the African Group of negotiators along with a group of 24 “like minded” countries, opened discussions on the post-2025 climate finance goal, pushing developed countries to commit to mobilise USD 1.3 trillion per year. As discussions on the new goal continue this year, it is clear that a substantial increase in the availability and accessibility of funding will be required for countries in Africa to reduce their emissions in line with domestic pathways compatible with the Paris Agreement.

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Introduction

As part of the Paris Agreement, 193 governments have put forward targets (nationally determined contributions, NDCs) to limit the global average temperature increase to 1.5°C with the aim to 'significantly reduce the risks and impacts of climate change'. To date, their combined effect is not sufficient to achieve this goal. At the moment, they put the world on a path to approximately 2.4°C of warming (Climate Action Tracker, 2021a) – almost double the agreed limit.

In their successive NDCs, governments are required to put forward more ambitious emissions reduction targets that should align with the Paris Agreement. The Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5°C showed not only why governments must act urgently to prevent higher levels of warming, but also how emissions need to, and can be reduced, towards at least 45% by 2030 compared to 2010. By mid-century, emissions will need to be brought to net zero to limit global warming to 1.5°C. Developing countries will require support to translate these global trajectories to action.

Africa is vulnerable to climate change and its impacts are already felt by communities across the continent, although it has contributed the least to global greenhouse gas emissions. 2022 will be an important year for the region, with Egypt hosting COP27, and hoping to lead the discussions on issues that matter the most to the region, such as Loss and Damage and climate finance. While this analysis focuses on mitigation ambition and the required efforts to limit climate change for the assessed countries, it is in full recognition that these other elements are crucial for driving the transformation of African economies.

This analysis aims to be a resource to empower a broad range of national stakeholders, including civil society, in understanding decarbonisation pathways in line with the 1.5°C limit. These pathways, assessed with other lines of scientific evidence, exhibit how a selection of countries in Africa can update their 2030 targets (NDCs) and develop long-term, low-carbon development strategies in line with the Paris Agreement, living up to their promises to prevent dangerous climate change. This report draws on the analyses from the 1.5°C national pathway explorer for eight African countries.

The analysis looks at the power sector decarbonisation and is framed around two timelines: the short term (by 2030), and the long term (by mid-century). Sectoral benchmarks consistent with the analysed emissions pathways will be updated and provided through the 1.5°C national pathways explorer online tool throughout 2022; this report provides those for the power sector.

The report begins with an introduction of the regional context of Africa, focusing on emissions overview and energy consumption. A power sector overview is then provided, followed by an assessment on the vulnerability of fossil fuel dependent states. Section 2 outlines the perspectives analysed here – domestic action – and the main characteristics of IPCC SR1.5 global pathways for the African region. Finally, Section 3 provides a series of country profiles, emissions and sectoral benchmarks derived from the IPCC SR1.5 pathways and other lines of evidence. Eight countries are analysed here: Botswana, Egypt, Ethiopia, Ghana, Kenya, Nigeria, Senegal, and South Africa.

1 Regional context: Africa

1.1 Emissions overview

Africa's historical and current contributions to global greenhouse gas emissions are low. When excluding land use, land use change and forestry (LULUCF), Africa's emissions accounted for 7% of global emissions in 2019 (Gütschow, J.; Günther, A.; Jeffery, L.; Gieseke, 2021). On a per capita basis, most African countries also emit less than the global average, particularly in Sub-Saharan Africa. In 2018, Sub-Saharan Africa emitted 0.764 tCO_2 per capita compared to a global average of 4.484 tCO_2 per capita (World Bank, n.d.).

However, Africa's emissions (excluding LULUCF) have increased 82% from 1990 to 2019, more than the global average of 52%. This growth has mostly been driven by rapid population growth and by rising consumption of fossil fuels. Emissions risk increasing significantly without commitment to low-carbon growth and sufficient support from developed countries.

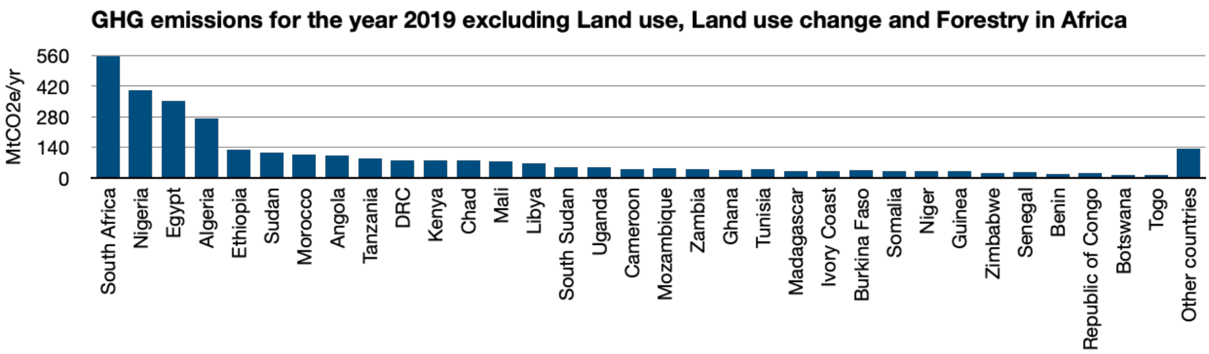

Figure 1: Greenhouse gas emissions in African countries for the year 2019 excluding Land use, Land use change and Forestry. Source: (Gütschow, J.; Günther, A.; Jeffery, L.; Gieseke, 2021)

The energy sector is the largest source of emissions in Africa when the LULUCF sector is excluded, contributing about 55% to total emissions in 2019, followed by agriculture (32%) (Gütschow, J.; Günther, A.; Jeffery, L.; Gieseke, 2021). Industrial processes contributed just 5% in the same year. Despite making up more than half of Africa's emissions, the share of energy emissions in Africa remains low compared to the global average. This signals significant risk for emissions growth in the sector depending on what energy sources are used to close the energy access gap and meet growing demands.

Emissions profiles across subregions and countries vary greatly. In Northern Africa, energy emissions play a greater role than in Sub-Saharan Africa where agriculture emissions are more significant. As shown in Figure 1, only a handful of countries are responsible for the majority of Africa's emissions. The top three emitters, also Africa's largest economies, South Africa, Nigeria, and Egypt, produced about 40% of the continent's emissions in 2019 (excluding LULUCF). Compared to the regional average, energy emissions in these countries contribute more to their national emissions (excluding LULUCF): 78%, 66%, and 67% for South Africa, Nigeria, and Egypt, respectively. While South Africa and Egypt are highly reliant on fossil fuels, Nigeria sources most of its primary energy from traditional biomass given its low electrification rates and access to clean cooking, meaning that the sector has risk of future emissions growth.

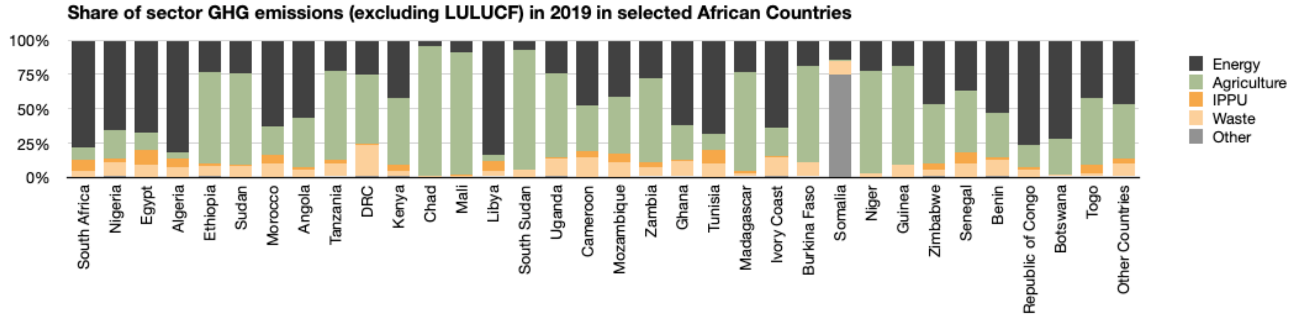

Figure 2: Breakdown of greenhouse gas emissions per sector across different countries in Africa for the year 2019 excluding Land use, Land use change and Forestry. Source: (Gütschow, J.; Günther, A.; Jeffery, L.; Gieseke, 2021).

LULUCF emissions play an important role in Africa, contributing an estimated 2.2 GtCO2e to the continent's emissions, equalling to about 40% of total emissions (Bouchene et al., 2021). Africa is home to approximately one fifth of the world's forests and almost one third of "other wooded lands"[1]; the Congo Basin located in Central Africa is the world's second largest rainforest (Mansourian & Berrahmouni, 2021a), after the Amazon. Forests are critical resources for many communities, with over 60% of Africans directly or indirectly dependent on them. However, between 2015 and 2020, Africa lost up to 4.4 million hectares of forest annually, driven primarily by shifting agriculture (Harris et al., 2020; Mansourian & Berrahmouni, 2021b). Furthermore, up to 65% of productive land is degraded and desertification affects 45% of Africa's land area. Large scale regional initiatives are underway, along with government commitments, to restore degraded lands and increase tree cover, such as AFR100, the Pan-African Agenda on Ecosystem Restoration the Great Green Wall for the Sahara, and Sahel Initiative.

1.2 Primary energy overview

Africa's primary energy demand is mostly met by the use of biomass, accounting for around 45% of total primary energy in 2019, and 53% from fossil fuels (oil, natural gas and coal) (IEA, 2020; Irena, 2014). In final energy consumption, electricity played a relatively small role in 2019, accounting for 9% of total final energy consumption for the continent (IEA, 2021). Under 1.5°C compatible pathways, the share of decarbonised electricity is expected to grow as a means to decarbonise the energy system (see section 1.3 and section 2). This shift will intrinsically be linked to the development of electricity access across the continent.

With the exception of Northern Africa, mostly dominated by gas and oil, as well as South Africa and Botswana, mostly dominated by coal, most of the continent's households rely on traditional biomass as their primary energy source for cooking, more predominant in rural areas, which also has severe impacts on health (PBL, 2018). The use of traditional biomass (such as charcoal or firewood) is mostly driven by its low cost, availability, and the in ability to access other sources of energy.

In Northern African countries, predominantly gas producers, primary energy mix is mostly dominated by natural gas. For example, gas accounts for 63% of Algeria's total primary energy, and 52% of Egypt's total primary energy. Neighbouring countries such as Tunisia and Libya have their primary energy mix mostly dominated by gas and oil, accounting for 48% and 41%, for Tunisia, and 44% and 53%, for Libya of total primary energy in 2017.

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[1] As defined by the Food and Agriculture Organization, "Other Wooded Land is land with a canopy cover of 5-10 percent of trees able to reach a height of 5 m in situ; or a canopy cover of more than 10 percent when smaller trees, shrubs and bushes are included."

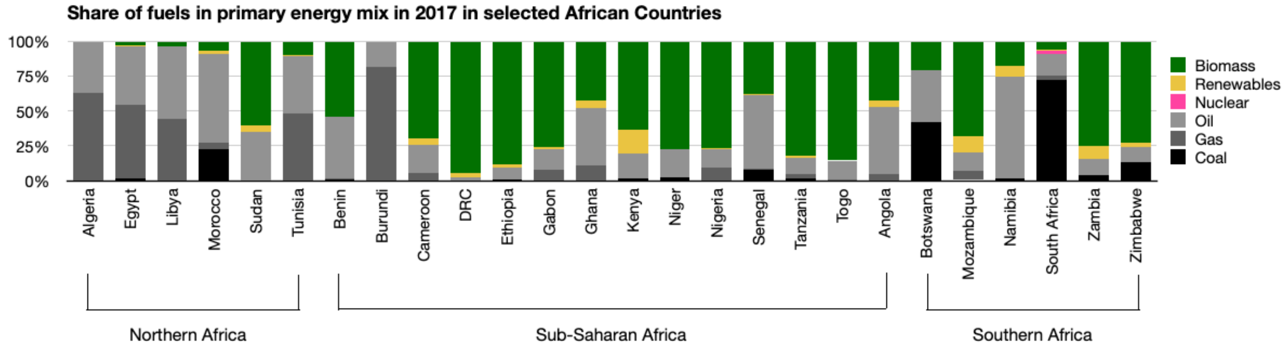

Figure 3: Share of fuels in primary energy demand from a selection of African countries in the year 2017. *Countries available on the IEA World Energy Balances 2020. Source: IEA World Energy Balances 2020*

Sub-Saharan African countries are characterised by a strong reliance on the use of biomass within their primary energy mixes, mostly used in households, but also for energy production. Southern African countries, especially South Africa - a major producer and exporter of coal - as well as Botswana and Zimbabwe are heavily reliant on coal.

1.3 Power sector overview

The composition of the power mix varies between countries (Figure 4) and regions within Africa, influenced mostly by the presence or lack of fossil resources in the countries and their electrification rate. Central and Eastern Africa's power mixes are based mostly on renewable energy (predominantly hydropower) – which make up slightly less than 45% of the power mix. Northern Africa's power mix consisted of almost 90% fossil fuels and Western and Southern Africa relied on fossil fuels for around 45% of their power mix in 2019 (IRENA 2021).

In 2017, approximately 84% of Africa's CO_2 emissions from electricity generation was produced by six countries – South Africa, Egypt, Algeria, Morocco, Libya, and Nigeria (IRENA 2021), all major coal, oil or gas producers.

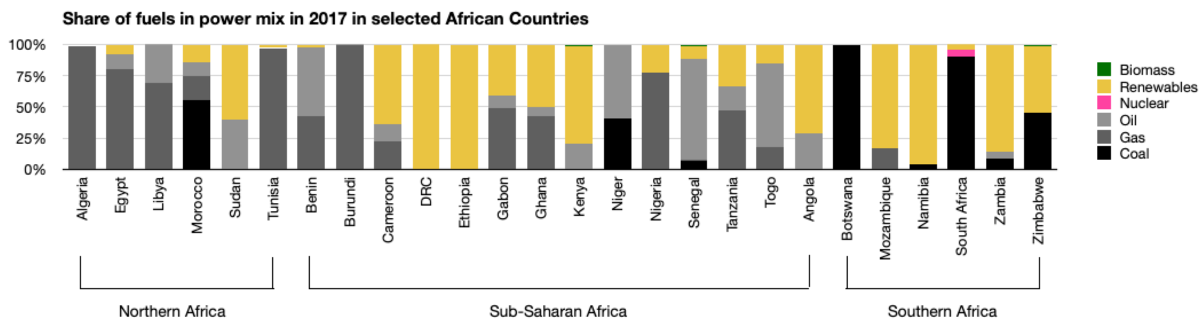

Figure 4: Shares of fuel in the power generation mix of selected countries in Africa in 2017. *Countries available on the IEA World Energy Balances 2020. Source:*(IEA, 2020).

1.3.1 *The role of coal*

While it has historically dominated the power mix, the share of coal-based power generation in Africa has been overtaken by gas-based power generation over the past decade (IEA, 2020). Nevertheless, coal still accounted for around 30% of the continent's power mix in 2019.[2] As of July 2021, there was around 49 GW of installed coal capacity across the continent. The current pipeline of new coal, including power plants that are under construction or have been announced or permitted – is equivalent in size to about half of the current operating capacities (see figure 5). Most coal units in operation are less than 40 years old, so they could be expected to be running through 2030, additional to the planned capacities (Global Energy Monitor 2021).

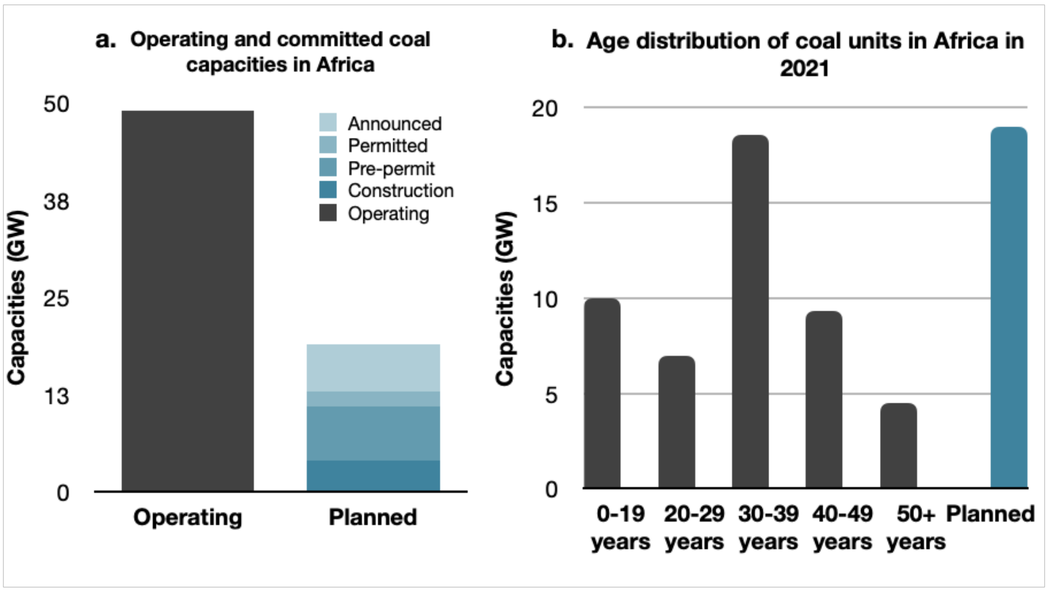

Figure 5: a. Operating and potential coal-based power generation based on capacities currently operating, under construction, announced and permitted. b. Distribution of ages of capacities installed. See annex I for countries included in the region. Source: (Global Energy Monitor, 2021a)

While most of the operating coal plants are located in South Africa, followed by Morocco (see figure 6), coal expansion is expected to be distributed across more countries in the future, with Zimbabwe, Botswana and Mozambique accounting for a significant share of the coal pipeline (Global Energy Monitor 2021), and risking stranding their assets. Some multinational fossil fuel companies, fearing divestments from their major investors, are already preparing the ground by selling their existing capacities to local companies[3], and in doing so transferring their stranded assets and the related costs.

[2] https://www.iea.org/data-and-statistics/data-browser?country=WEOAFRICA&fuel=Electricity%20and%20heat&indicator=ElecGenByFuel
[3] https://mg.co.za/article/2019-09-13-00-coal-divestment-hits-south-africa/

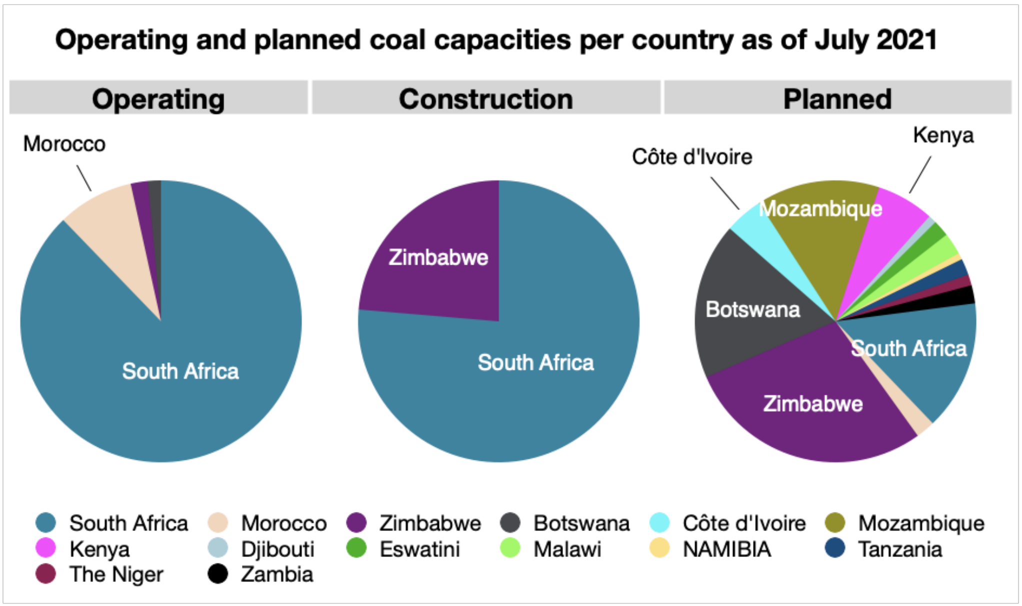

Figure 6: Coal-based power capacities per country based on capacities currently operating, under construction, announced and permitted. See annex I for countries included in the region. Source:(Global Energy Monitor, 2021a).

1.3.2 *The role of gas*

Over the past decade, gas-based power generation has taken over coal, reaching a total operating capacity of 106 GW as of July 2021 and a planned pipeline of around half of this (Global Energy Monitor 2021). The majority of operating gas power plants are still relatively young, less than 30 years old, and are expected to be running in the next two decades (Global Energy Monitor, 2021b). The rising trend in gas production in Africa is expected to continue under current policies, given the recent discovery of gas reserves on the continent. Over 25 countries in Africa have proven gas reserves, and in Sub-Saharan Africa, 10 out of the 13 countries with gas power generation capacity are using their own domestic gas production (Africa Energy Chamber, 2021).

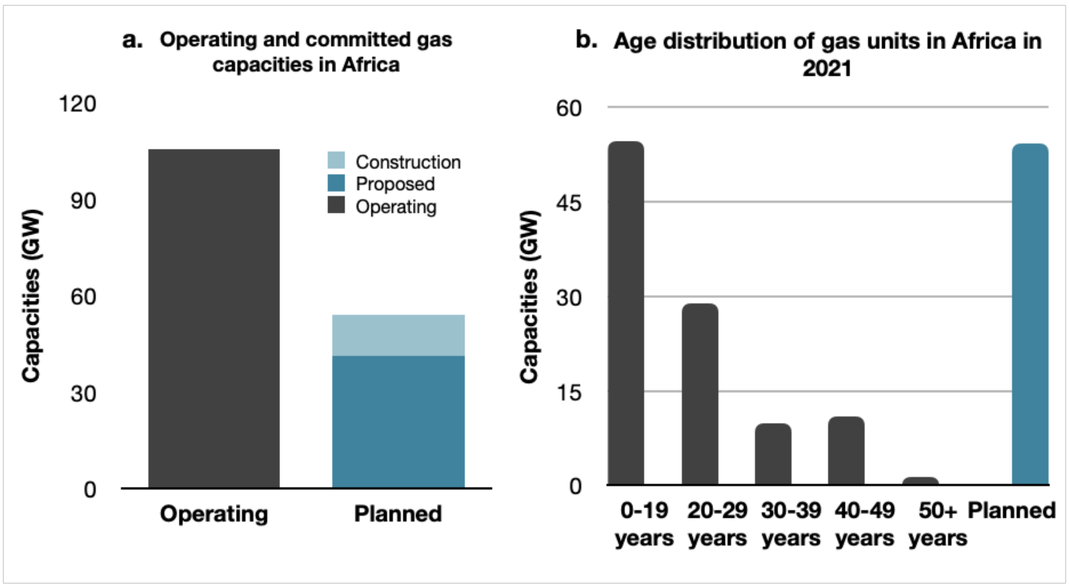

Figure 7: a. Operating and potential gas-based power generation based on capacities currently operating, in construction and proposed. b. Distribution of ages of capacities installed. See annex I for countries included in the region. Source: (Global Gas Plant Tracker, 2021)

Current operating capacities are spread across the continent's main producers of natural gas – namely Egypt, Algeria, Nigeria, and Libya. Algeria has the most capacity under construction and South Africa is expected to play an important role in the future pipeline, accounting for around a third of planned gas capacity (Global Energy Monitor 2021).

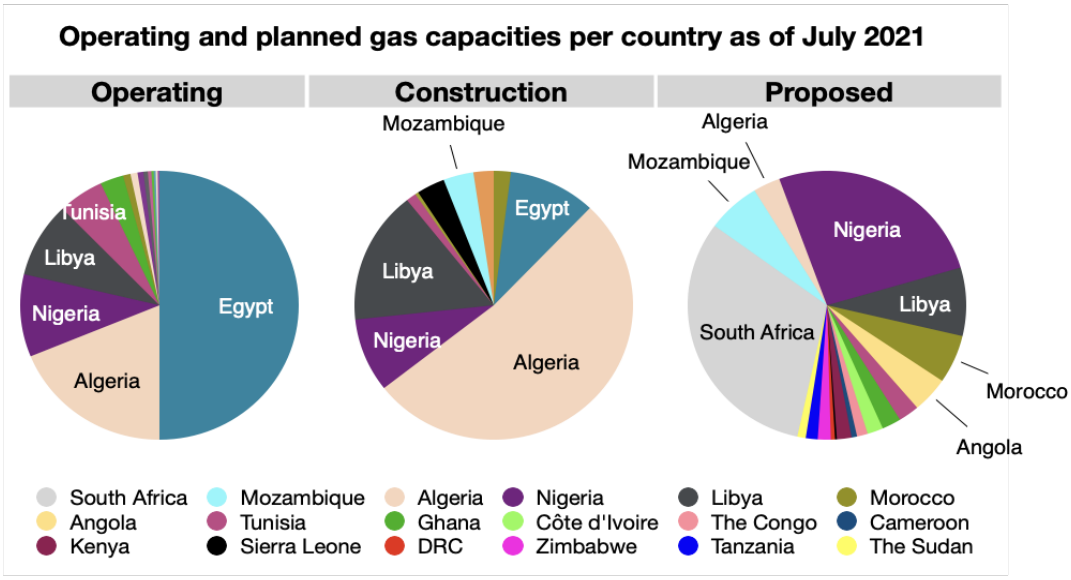

Figure 8: Gas-based power capacities per country based on capacities currently operating, under construction and proposed. See annex I for countries included in the region. Source: (Global Gas Plant Tracker, 2021).

While the new gas pipeline in Africa is close to half of the existing capacities which are already relatively young, our analysis of 1.5°C compatible pathways, both at the global and national levels, reveals that if planned gas power plants were to be built, they would likely end up as stranded assets. Civil society contestation against the exploration of shale gas has been growing in the past years, especially in South Africa, where in 2017 the high court ruled against regulation governing proposed shale gas fracking.[4]

1.4 The vulnerability of fossil fuels dependant countries in a world shifting to low-carbon economies

The world's declared commitment to a low-carbon transition has so far not decreased the use of fossil fuels in many countries. However, some countries have increased their renewable energy uptake, resulting in a growth of renewable energy generation by 58% between 2011 and 2019, mostly in Asia, followed by Europe and North America (IRENA, 2021). While this transition is very slow paced, it will steer a reduction in fossil fuel demand and lower prices impacting fossil fuel revenues (The Carbon Tracker Initiative, 2021a). Lower fossil fuel prices and higher extraction costs reduced revenues from fossil fuel exports in Africa by a third in 2019 compared to 2012 (IRENA, 2022).

Companies and investors are starting to take these risks into account in their strategies leading to divestment decisions when considering the financial risks for decarbonisation (Hunt & Weber, 2019;

[4] https://www.reuters.com/article/safrica-shale-idINL8N1MU1SY

Life After Coal, 2020). Countries whose economies are heavily reliant on fossil fuel revenues also face substantial risks. Most (~ 75%) of Africa's crude oil is exported (AFREC 2020). The top five oil producing countries in Africa in 2020 were Nigeria and Angola in Sub-Saharan Africa, and Algeria, Libya and Egypt in Northern Africa (BP 2021). Together, they produce 80% of Africa's crude oil (AFREC 2020). Between 2015 and 2018, 56% of Angola's government revenues came from oil and gas sales, followed by the Congo (54%) and Nigeria (45%) (see figure 9) (The Carbon Tracker Initiative, 2021a). Declining demand for fossil fuels could impact more than 370 million inhabitants of the top nine petrostates, dependent on oil and gas revenues. Nigeria alone accounts for around 200 million people in 2018 (UN World Population, 2021). Many of these countries are also experiencing high population growth, increasing the number of people to be impacted to declining country revenues (UN World Population, 2021).

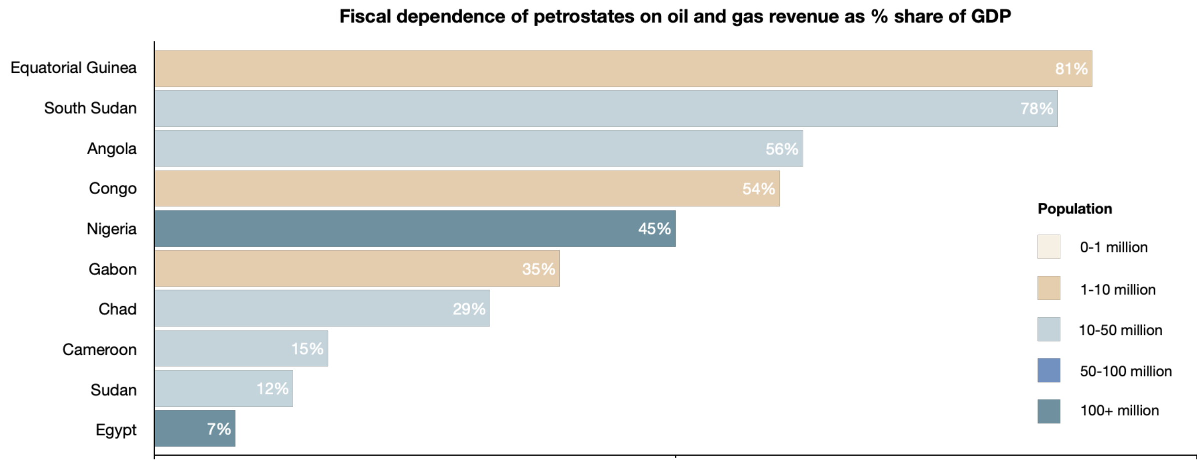

Figure 9: Fiscal dependence of selected petrostates in Africa defined as the share of government oil and gas revenues of total governments revenues (2015-2018 average). Source: Adapted from (The Carbon Tracker Initiative, 2021a)

A recent study on the impact of a low-carbon scenario on government revenues from oil and gas production indicates that government revenues in Africa could, in a world shifting to a low carbon scenario, drop by 58% over a period 2021-2040 compared to industry expectations (The Carbon Tracker Initiative, 2021b). The resilience of governments to such revenue losses will vary between countries, depending on macroeconomic and political parameters. The Carbon Tracker Initiative study indicates that South Sudan, Equatorial Guinea and Angola are among the most vulnerable countries to low-demand in oil and gas, followed by Congo, Nigeria, Chad and Gabon (The Carbon Tracker Initiative, 2021b).

The same risks apply to countries not yet reliant on fossil revenues but aiming to exploit their newly discovered fossil fuel reserves. For example, Ghana has indicated intentions to scale up its natural gas capacity — and possibly develop its first coal power plant. In a world shifting away from coal, combined with the recent USD 13.2 billion investment in the Jubilee, TEN and Sankofa gas fields, Ghana risks locking in high-carbon infrastructure and creating stranded assets (Climate Analytics, 2021). Similarly, Senegal aims to exploit its oil and gas reserves from 2022 onwards, having made the discovery of major offshore natural gas reserves between 2015 and 2017 (Climate Analytics, 2021). While the country would aim to mostly use it for domestic growing demand on electrification, relying on optimistic revenue projections that are not in line with a decreasing trend in demand for oil and gas may lead countries to invest heavily upfront into infrastructures which might end up stranded in the future with no return on investments. The carbon tracker initiative study indicates that in a low-carbon scenario, Ghana could lose 70% of its expected revenue between 2021 and 2040 and Senegal more than 50% (The Carbon Tracker Initiative, 2021b).

While some countries could see the exploitation of oil and gas reserve as an opportunity to address existing and pressing socio-economic challenges, this may not necessarily be the case. Fossil fuels are starting to show a slowdown in demand, and this trend is expected to continue, and likely having negative impacts on economies that rely on these sectors. The decreasing costs of renewable energy and the flexibility of decentralised systems could be an opportunity for countries to improve energy access and promote economic development.

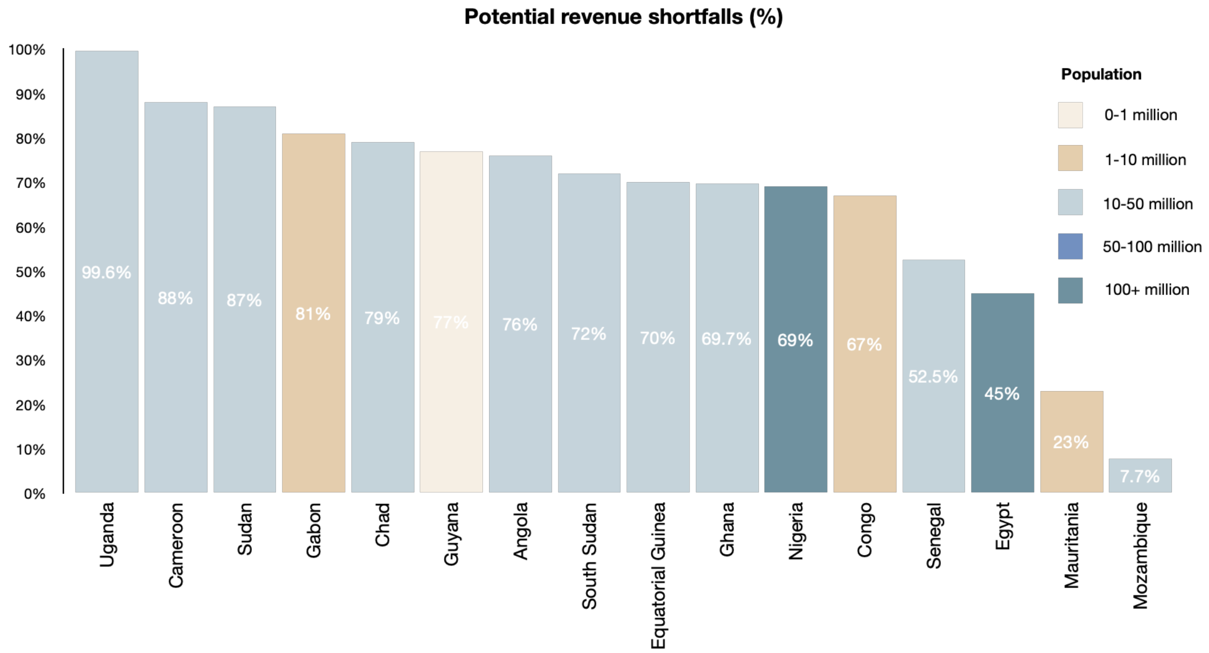

Figure 10: Potential oil and gas revenues shortfall for governments in a 'low-carbon economy scenario' compared to industry expectations between 2021 and 2040. Selected existing petrostates and 'emerging petrostates' (Mozambique, Mauritania, Senegal, Ghana, Uganda). Source: Adapted from (The Carbon Tracker Initiative, 2021a)

As the world moves to a decarbonised economy, countries vulnerable to revenue loss will need to diversity their economies and plan for other sources of revenue in order to sustain growth and development. Support will be needed for these countries to transition to new revenue streams. It is important that governments consider investing in technologies of the future, such as renewable energies, instead of investing in fossil fuel infrastructure which will end up as stranded assets, leading to high financial vulnerability.

2 A sustainable energy system consistent with the Paris Agreement

2.1 Domestic action

In 2015, countries adopted the Paris Agreement and agreed to *"[…] strengthen the global response to the threat of climate change […], including by holding the increase in the global average temperature to well below 2°C […] and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels"* (UNFCCC, 2015b).

Article 4.1 of the Paris Agreement outlines key operational steps to be taken to enable the achievement of the long-term temperature goal:

- To reach *"global peaking of greenhouse gas emissions as soon as possible"*
- *"To undertake rapid reductions thereafter in accordance with best available science"*
- *"To achieve a balance between anthropogenic emissions by sources and removals by sinks in the second half of this century"*

All parties of the Paris Agreement are expected to contribute to the achievement of this goal by taking climate action. The Agreement further affirms that action taken for implementation should "*reflect equity and the principle of common but differentiated responsibilities and respective capabilities* (CBDR)".

This implies that in order to make a fair contribution to meeting the Paris Agreement's goals, developed countries need to both take domestic emissions reduction action and assist developing countries to reduce their emissions. This means that a developed country's total NDC "fair share" action range is the total sum of domestic reductions – which should at a minimum be in line with a cost-effective domestic 1.5°C compatible pathway for that country – plus support for emissions reductions action overseas. Support can be in the form of climate finance or other support for mitigation, consistent with the Paris Agreement (Climate Action Tracker 2018).

For Africa and other developing countries, emissions reductions in line with a globally cost-effective 1.5°C compatible pathway are not expected to be achieved domestically without international support. The fair share and equity considerations embedded in the Paris Agreement imply that without support, a developing country would only be expected to reduce its emissions to its "fair share" range. Any gap between this fair share range and the 1.5°C compatible domestic pathway could likely only be bridged with support from developed countries in one form or another. If a developing country's current policy pathway lies above its fair share range, then it should take further action domestically to bring its emissions to at least this range.

While there are several equity principles which are relevant to mitigation under the Paris Agreement, the 1.5°C compatible pathways considered in this report are not aligned with a given equity principle**.** They are, however, aligned with the notion of "**highest plausible ambition**" in that they represent transitions that are technically and economically feasible. These pathways take into account present day characteristics, such as the current infrastructure (e.g. emissions intensity of the economy) of individual countries. It is important that the results presented in this report are considered in the context of equity and the financial and other forms of support that developing countries will need to enable the rapid transitions necessary in a 1.5°C compatible world.

2.2 Global mitigation pathways consistent with the Paris Agreement long-term temperature goal

The IPCC Special Report on 1.5°C (SR1.5) outlines pathways for limiting global warming to 1.5°C and assesses global, regional, and sectoral transformations in the near-, mid-, and long-term, as well as synergies and trade-offs for sustainable development (IPCC, 2018a). SR1.5 defines Paris Agreement compatible pathways as those that limit warming to 1.5°C with no or limited overshoot (<0.1°C). In these pathways, the increase of global average temperature above its pre-industrial level is limited to below 1.6°C for the whole twenty-first century and below 1.5°C by 2100 (typically 1.3°C).

In these 1.5°C mitigation pathways, total greenhouse gas emissions peak around 2020 and decrease rapidly, reducing CO_2 emissions by 45% by 2030 and reaching net zero CO_2 by 2050 and net zero GHG by around 2070 globally.

Key global decarbonisation benchmarks

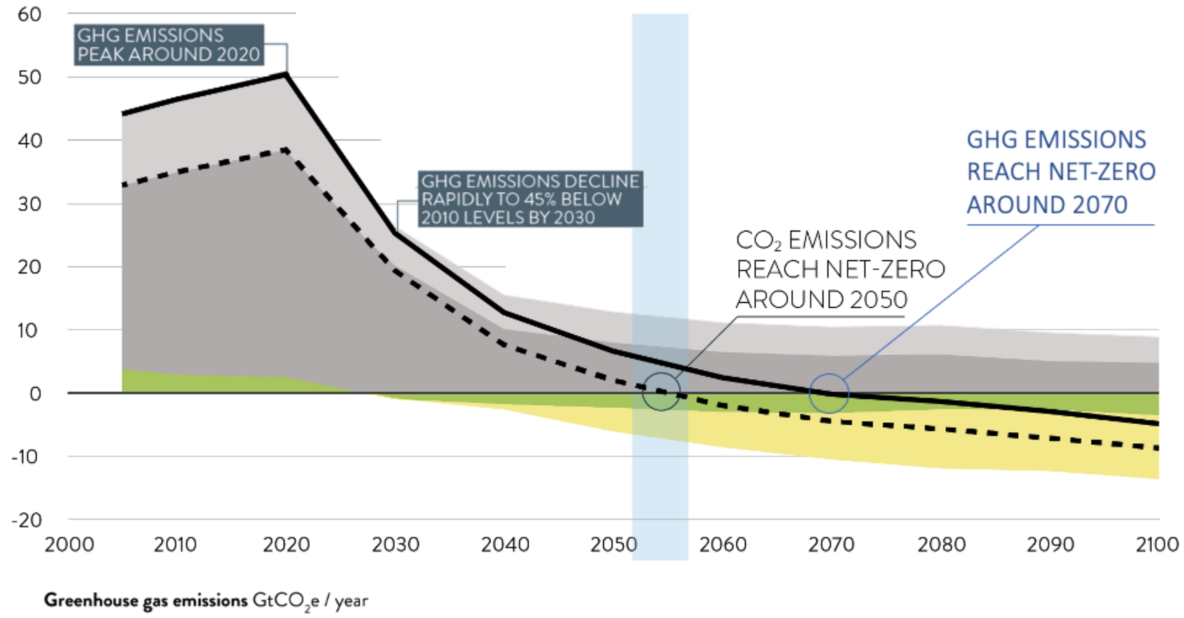

Figure 11: Illustration of the key global decarbonisation benchmarks in line with the Paris Agreement. This representative pathway is the median across all 1.5°C compatible pathways from the IPCC SR1.5 that reach levels of Carbon Dioxide Removal (CDR) below the upper end of estimates for sustainable, technical and economic potential around 2050 from SR1.5 in the sector of Agriculture, Forestry and Land-Use (AFOLU), as well as via Bioenergy combined with Carbon Capture and Storage (BECCS). Source: (Schaeffer et al., 2019).

All modelled pathways that limit warming to 1.5 °C rely on Carbon Dioxide Removal (CDR) mostly to offset harder-to-abate sectors (such as agriculture, industry processes or aviation). However, the amount of CDR required will depend on the pace of global progress in reducing emissions; early action to rapidly decarbonise and reduce the overall need for CDR will be essential. If deployed at large scale, CDR technologies would entail negative side effects across different dimensions of sustainable development objectives. Additionally, the technological and economic viability of such deployment has not been proven yet, and limited progress has been observed in planning and deploying them at national level (Fyson et al. 2020). In this context, global pathways analysed in this report are filtered to meet global sustainability limits identified by the IPCC SR1.5. The IPCC SR1.5 finds limits for a sustainable use of both CDR options globally by 2050 to be below 5 $GtCO_2$ p.a. for bioenergy with carbon capture and storage (BECCS) and below 3.6 $GtCO_2$ p.a. for sequestration through afforestation/reforestation (AR) while noting uncertainty in the assessment of sustainable use and economic and technical potential in the latter half of the century (IPCC 2018; Fuss et al. 2018).

It is worth highlighting that the pathways assessed in the IPCC SR1.5 were published in scientific literature well ahead of the release of the report, and were therefore mostly developed in 2017, or before. They do not necessarily keep track of current developments in energy markets, disruptive technological developments, consumer choices and policy trajectories. An updated set of scenarios will be assessed in the forthcoming sixth assessment report by the IPCC's working group 3, and these are expected to incorporate recent developments. Once these pathways are available, an update of the national 1.5°C pathways assessed in this report will be needed.

2.3 Implications of the IPCC 1.5°C SR for mitigation pathways and sectoral transformation in Africa

The least-cost modelled pathways assessed in the IPCC SR1.5 generally provide results at the global and regional levels (Huppmann et al., 2018; IPCC, 2018b). At the global level, these pathways reach net zero CO_2 emissions by 2050 and net zero GHG emissions by around 2070, but at the regional level some regions achieve net zero earlier and others later than these global benchmarks. The pace of emissions reductions to 2030 and in the coming decades, and the feasible timeframe for achieving these decarbonisation pathways will be influenced by the progress to date in transitioning to a renewables-based energy system, the capacity to invest in new infrastructure, carbon removal and storage potential, and the share of emissions from harder-to-abate sectors that will require technological innovation to decarbonise. In these models, those countries/regions that have already made good progress in decarbonising their economies will decarbonise at a faster pace than other regions.

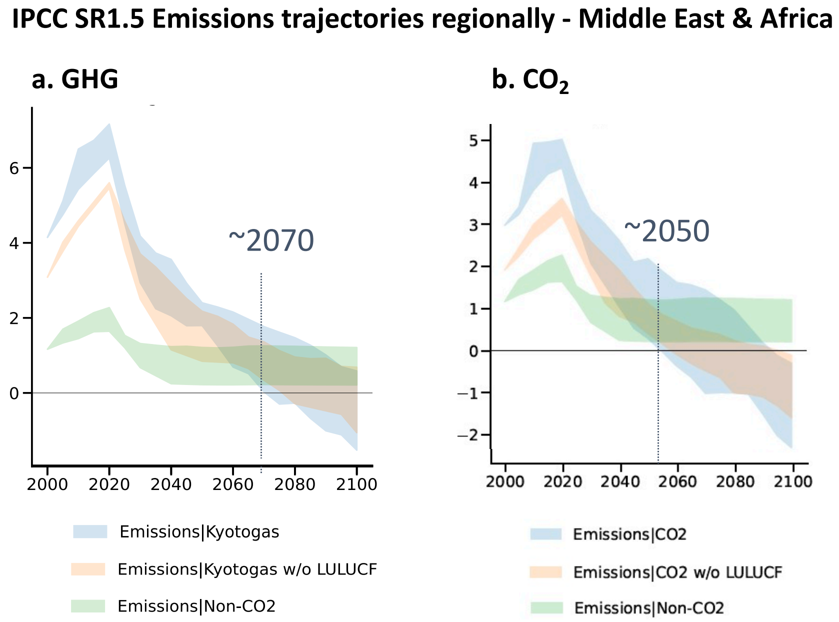

Figure 12 : GHG and CO2 emissions pathways from the IPCC SR1.5 for the Middle East and Africa region, filtered based on the sustainability criteria described in section 2.2.

These models indicate that it will be globally cost effective for the region to peak both GHG and CO_2 emissions during the 2020s, with a rapid decline from 2030. In the second half of the century, negative CO_2 emissions are achieved either in the forestry and land use sector or from carbon dioxide removal technologies to balance remaining non-CO_2 emissions.

It is important to note that the pathways used in this analysis were calculated based on a cost-effective distribution of emissions abatement efforts, and therefore implicitly assume that international support is provided from wealthier countries to those developing countries that need support to decarbonise at such a pace. These pathways do not offer any insights on the scale of financial, technological or other forms of support that will be needed in developing countries, and the achievement of emissions reductions in line with these pathways cannot be considered separately from the availability of such support (see section 2.1 above on the relevance of equity considerations, and section 2.4 below on international support).

Decarbonisation pathways are characterised by a transformation of the energy system mainly through a sharp reduction of the use of fossil fuels in primary energy and in the power sector combined with the electrification of end-use sectors such as transport, industry, and buildings (Schaeffer et al., 2019). The decarbonisation of the power sector, with nearly 80% of energy produced from fossil fuels, will be a key driver to reduce emissions in other sectors of the economy – mostly coal and gas (see section 1.3). Our analysis of Paris Agreement-aligned global and regional coal phase-out requirements indicates that Africa and the Middle-East region should phase out coal around 2034. (Climate Analytics, 2019).

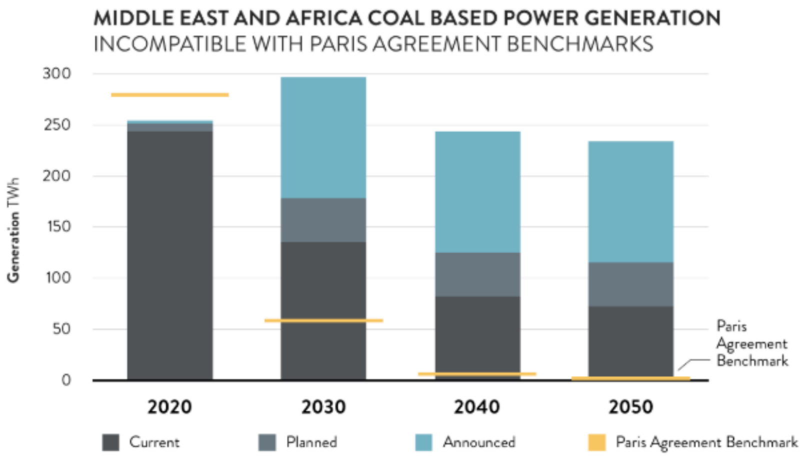

Figure 13: Potential coal generation in Middle East and Africa against Paris Agreement benchmarks. Source : (Climate Analytics, 2019)

The implications of such benchmarks are that Africa, like other regions, need to start planning and implementing policies that will drive emissions reductions. For example, the region needs to immediately cancel investments in new coal power plants (see section 1.3). Models indicate a similar trajectory for power produced from natural gas, roughly ten years behind coal.

2.4 International support needs to be scaled up to support decarbonisation in Africa

Together with capacity building and technology transfer, one of the core objectives of the 2015 Paris Agreement is "*making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development*" [Article 2.1c] (UNFCCC, 2015c). For developing countries, this will require significant contributions from developed countries to support low emissions development. The 2010 Cancun Agreement included a joint commitment by developed countries to mobilise USD 100 billion per year by 2020 to meet the finance needs of developing countries, extended to 2025 in Paris (UNFCCC, 2010, 2015a). At COP26, the African Group of negotiators along with a group of 24 "like minded" countries, opened discussions on the post-2025 climate finance goal, pushing developed countries to commit to mobilise USD 1.3 trillion per year (Farand, 2021). However, the COP concluded with only a commitment to a process to agree on a goal.

Scaling up international finance in Africa is needed to support decarbonisation and help increase ambition. In 2020, only 3% of total climate finance commitments (domestic and international) went to Africa and the Middle East (Strinati et al., 2021). Further, climate finance is not necessarily distributed between countries in a way that reflects their needs (Watson & Schalatek, 2020). In Sub-

Saharan Africa, approximately half of climate funding from multilateral climate funds went to only ten of forty-two countries from 2003-2019, with South Africa receiving the biggest share of 13% (Watson & Schalatek, 2020). In the Middle East and North Africa, Morocco and Egypt received the most from climate funds and 69% of funds in the region went to large-scale wind and solar projects (Watson et al., 2017).

Major economies have the capabilities to ramp up finance commitments. Figure 14 below shows how the Climate Action Tracker rates several developed countries and their climate finance history and commitments as well as international investments in fossil fuels. This shows commitments by most developed countries range from insufficient to highly insufficient.

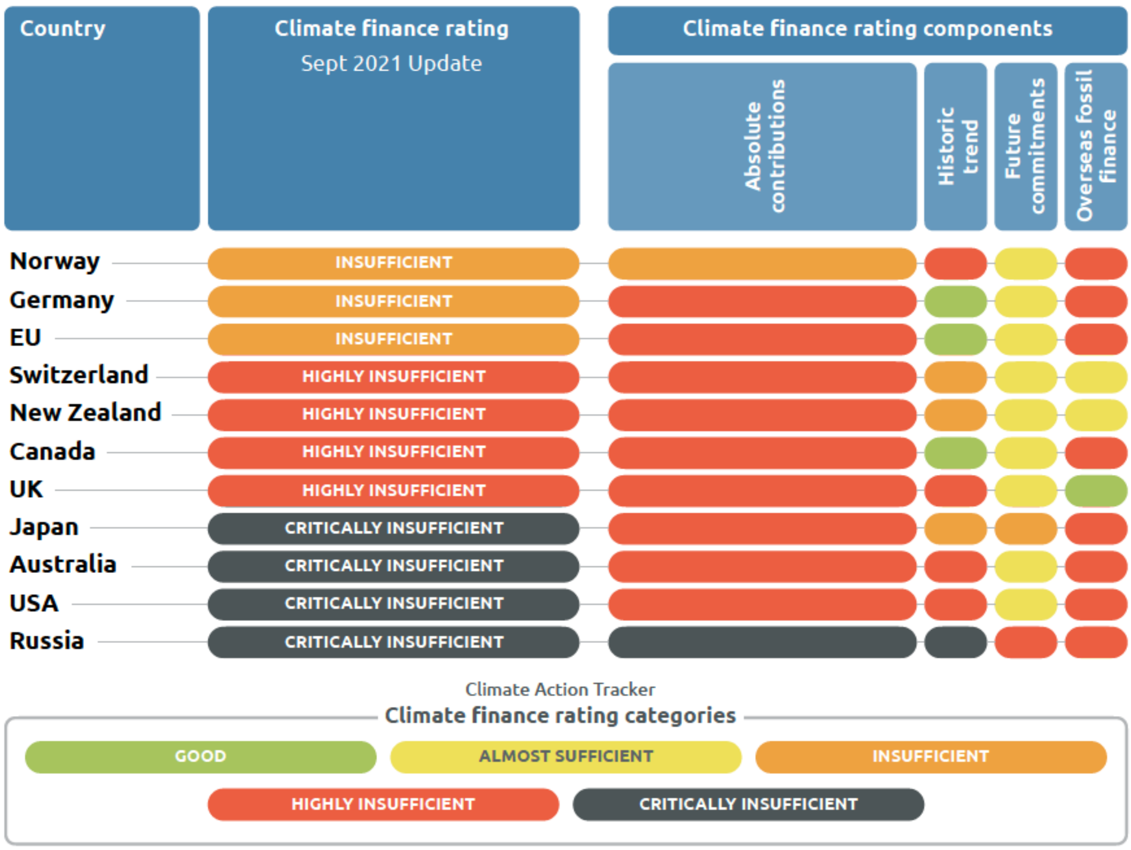

Figure 14: Overview of Climate Action Tracker's climate finance evaluations for the countries rated as of September 2021. The assessment is only focused on mitigation finance for emissions reductions. Source: (Climate Action Tracker, 2021b)

At COP26 in Glasgow, South Africa announced it has secured a USD 8.5 billion finance package from the United Kingdom, France, Germany, the United States, and the European Union to accelerate its transition away from coal (The Presidency of the Republic of South Africa, 2021). A key aspect of the package is the political declaration on the just energy transition, which targets the economic regeneration of coal communities. According to the declaration, the package will consist of grants and concessional finance over the next three to five years to develop renewable energy and new job markets, such as electric vehicle manufacturing and green hydrogen. The announcement was a significant moment not only for its commitment to a just transition, but also for the potential to serve as a new model for mobilising climate finance while encouraging strong ownership by developing countries.

3 Country factsheets

This section provides an assessment of national pathways compatible with the 1.5°C temperature limit derived from the previously introduced global pathways from the IPCC SR1.5. The factsheets for a selection of eight countries include a snapshot of current emissions of the country, national emissions pathways compatible with 1.5°C temperature limit and key decarbonisation benchmarks for the power sector.

Botswana

3.1.1 Current Situation

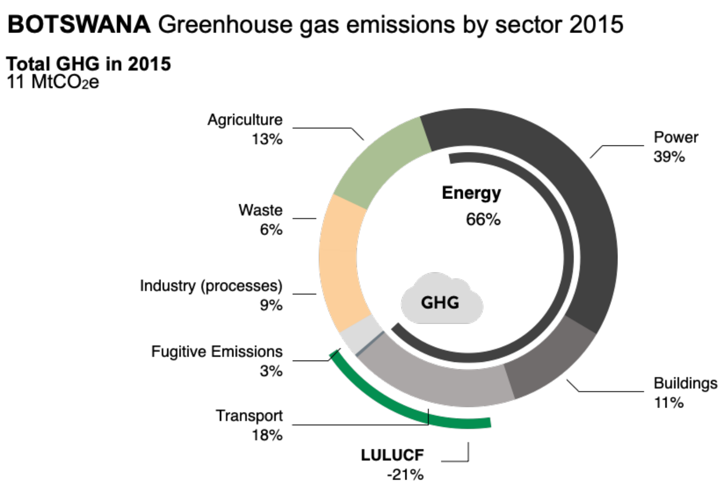

Figure 15: Historical emissions per gas and per sector. Source: Republic of Botswana: First Biennial Update Report (2019).

The agriculture sector has historically played a major part in the total GHG emissions of the country, showing a fluctuating trend from year to year, and discrepancies between different data sources used. According to PRIMAP-Hist data, when excluding LULUCF, the agriculture sector accounted for 53% of Botswana's emissions in 2017, making it the largest contributor to the country's total national emissions, estimated at 18.9 $MtCO_2e$/yr in 2017 (BITC Research Department, 2016).

However, the *First Biennial Update Report to the UNFCCC* indicated that the agriculture sector had a share of around 12% when excluding LULUCF emissions in 2015, highlighting the uncertainties related to agriculture emissions in the country's carbon footprint (Ministry of Environment Natural Resources Convervation and Tourism, 2019).

According to the country's *First Biennial Update Report*, the energy sector contributed the largest share of emissions – 69%. The industrial processes and product use (IPPU) and waste sectors contributed the least amount of emissions, at 9% and 6% respectively (PIK, 2021). The LULUCF sector, while calculated alongside agriculture, served as a carbon sink, absorbing approximately -1.4 $MtCO_2e$/yr in 2015, which is equivalent to around -20% of total national emissions.

Government emissions projections for 2019 show Botswana's GHG emissions rising to 49 $MtCO_2e$/yr, or 81% above 2010 levels, by 2030, under a business as usual scenario – with population growth, economic development, and the energy and agriculture, forestry and other land use (AFOLU) sectors identified as major drivers (Ministry of Environment Natural Resources Conservation and Tourism, 2019).

According to government projections, by 2028, emissions in the energy sector are anticipated to increase to 14 $MtCO_2e$/yr; around 3 $MtCO_2e$/yr in IPPU; and around 0.71 $MtCO_2e$/yr in the waste sector (Ministry of Environment Natural Resources Conservation and Tourism, 2019). Energy supply is projected to rise to between 1017 MW and almost 1400 MW by 2025, with the majority of the projected mix to be sourced from thermal power generators, which are primarily fuelled by coal (Ministry of Environment Natural Resources Convervation and Tourism, 2019), (Government of Botswana, 2017). This rise can be attributed to national goals for enhancing rural electrification, as well as Botswana's intentions to procure strategic petroleum stocks, and increase coal production for power generation and exports (Government of Botswana, 2017). The country's CO_2 sink capacity and resources are also anticipated to decrease due to continued deforestation (Ministry of Environment Natural Resources Convervation and Tourism, 2019). These trends and decisions pose a significant threat to the alignment of Botswana's emissions with a 1.5^{o}C-compatible pathway, and create a risk of costly investment in stranded assets.

The *First Biennial Update Report* (2019) indicates that, in 2011, the residential, transport, and industry sectors are Botswana's largest energy consumers at 42%, 27% and 23% respectively (Ministry of Environment Natural Resources Convervation and Tourism, 2019). In recent years, transport has overtaken the residential sector, accounting for 45% of total final consumption against 32% for residential sector (International Energy Agency, 2021). Fuel wood is also a principal energy source for cooking for 46% of national households, and 77% of rural households (Ministry of Environment Natural Resources Convervation and Tourism, 2019).

Cement and soda ash production drove the majority of industrial processes and product use (IPPU) emissions, while solid waste disposal and wastewater treatment/discharge accounted for the waste sector emissions. In the agriculture, forestry, and other land use (AFOLU) sector, livestock, aggregate sources, and non-CO_2 land emissions were the primary drivers, while land use served as a significant sink (Ministry of Environment Natural Resources Convervation and Tourism, 2019).

With estimated coal reserves of over 212 billion tonnes, Botswana has roughly 66% of Africa's identified untapped coal reserves, and the country is actively seeking investors to exploit this significant resource potential (BITC Research Department, 2016). Coal mines currently in operation have a total annual capacity of approximately 3 million tonnes. Most of the coal is utilised for domestic use, with some being exported to South Africa, Namibia, and Zimbabwe (Benza, 2021). The country has no known petroleum reserves, and therefore imports the fuel and its products, largely from South Africa.

As of 2018, Botswana's primary energy almost entirely consisted of fossil fuels. Coal production and oil imports made up 42% and 37% of the mix respectively, while biofuels – primarily fuel wood – comprised 21% of the total supply (International Energy Agency, 2021). Similarly, the power sector is dominated by coal which accounted for 97% of the power mix in 2020, while oil contributed 2.5% (International Energy Agency, 2021), (United Nations Environment Programme (UNEP), 2015). The role of renewables in the electricity mix remains insignificant (United Nations Environment Programme (UNEP), 2015).

While Botswana has started developing a comprehensive renewable energy strategy with the support of the World Bank, its current projections indicate less than 200 MW out of 1400 MW of energy will be supplied by solar power by 2025 (Government of Botswana, 2017). By comparison, the same projections indicate that 1200 MW of energy will be supplied by coal by 2025.

Similarly, while the country's Third National Communication indicates the intention to eliminate coal subsidies, Botswana aims to expand its monetisation of coal through a *Coal Road Map* for power generation and export, aimed at weaning off petroleum imports and leveraging the coal resources to increase exports to other countries (Government of Botswana, 2017).

In 2020, the country awarded three generation licenses for coal plants with a collective 827 MW capacity (Bungane, 2020). Botswana's state-owned coal mine recently announced intentions to increase capacity by 35%, and the national Investment and Trade Promotion Authority indicates that up to 24 new mines can be opened (Benza, 2021; BITC Research Department, 2016). Considering the broad international recognition of the need to phase out coal in the coming years, these policies pose a large risk of creating high-cost stranded assets in Botswana that will require more aggressive phase-out plans in the future.

3.1.2 Raising ambition

2030 ambition

Botswana's current nationally determined contribution (NDC) targets a 15% reduction in emissions below 2010 levels by 2030 (Government of Botswana, 2016). The NDC covers energy, waste and agriculture sectors but notably excludes methane emissions from enteric fermentation, which accounted for around 15% of total greenhouse gas (GHG) emissions in 2015 (Ministry of Environment Natural Resources Convervation and Tourism, 2019). Industry processes, a sector that accounted for roughly around 10% of emissions in 2015 and is projected to grow, is also not covered by Botswana's NDC (Ministry of Environment Natural Resources Convervation and Tourism, 2019). To be 1.5°C compatible, the country would need to reduce total GHG emissions to be between 12-15 $MtCO_2e$/yr by 2030, which is equivalent to a total emissions reduction of between 46-57% relative to 2010 levels, excluding LULUCF. Botswana could implement a 1.5°C compatible domestic emissions pathway if it received sufficient international support to close the gap between its fair share level and domestic emissions level. While Botswana's NDC does not specify the level of reductions requiring financial support and the level of reductions it aims to reach domestically, it states the need for international support.

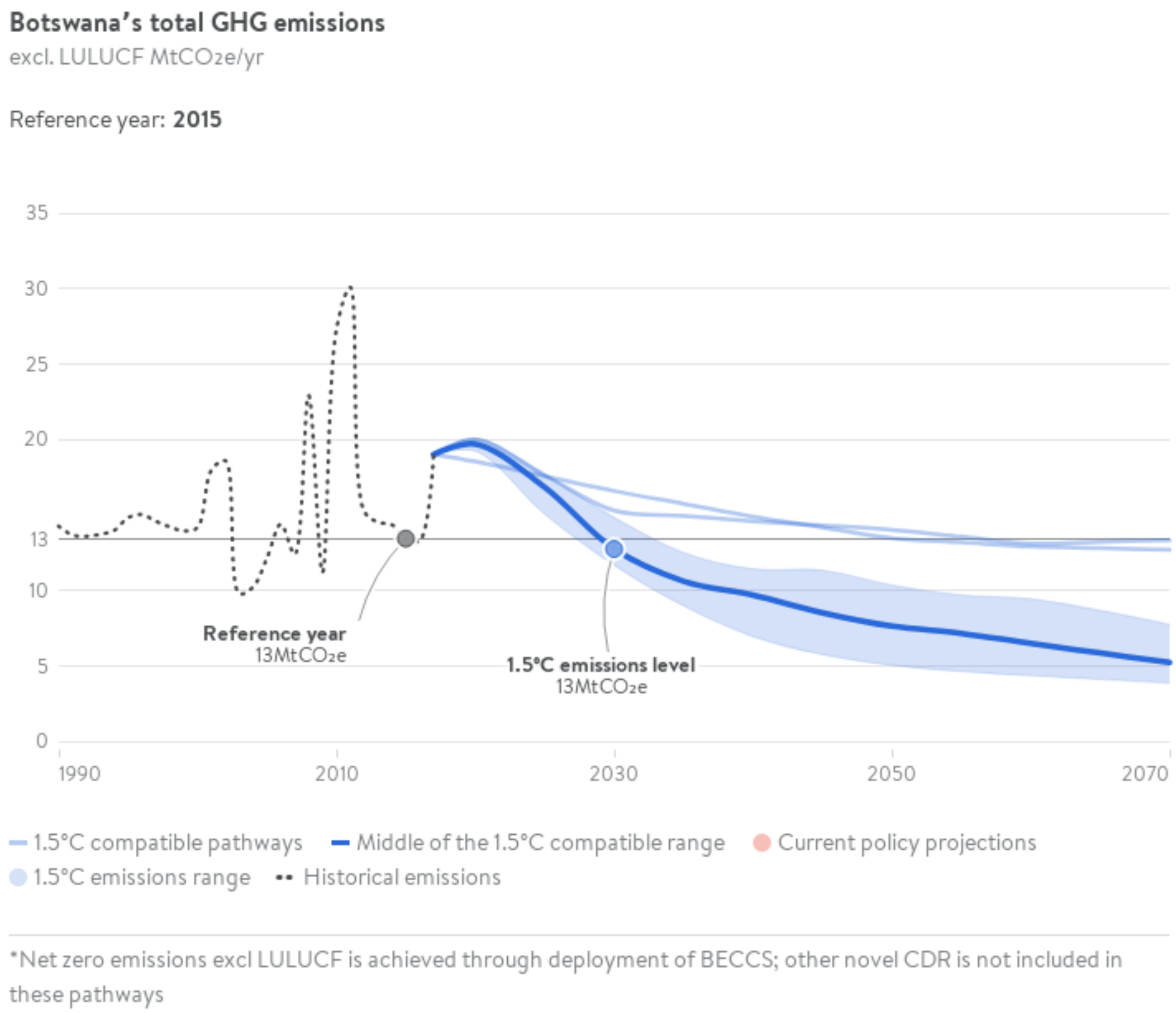

Figure 16: The figure shows national 1.5°C compatible emissions pathways. This is presented through a set of illustrative pathways and a 1.5°C compatible range for total GHG emissions excl. LULUCF. The 1.5°C compatible range is based on global cost-effective pathways assessed by the IPCC SR1.5, defined by the 5th-50th percentiles of the distributions of such pathways which achieve the LTTG of the Paris Agreement. We consider one primary net-negative emission technology in our analysis (BECCS) due to data availability. Net negative emissions from the land-sector (LULUCF) and novel CDR technologies are not included in this analysis due to data limitations from the assessed models. Furthermore, in the global cost-effective model pathways we analyse, such negative emissions sources are usually underestimated in developed country regions, with current-generation models relying on land sinks in developing countries.

Long term pathway

In its NDC, Botswana has indicated that it will develop a long-term low-carbon strategy. This has not been elaborated upon since the submission of the NDC in 2016. The country has further integrated climate change considerations into medium- and longer-term national plans, including the National Development Plan (NDP) (which runs from 2017-2023), and *Vision 2036,* which is the national agenda that will guide the country's development plans and activities for the coming years (Ministry of Environment Natural Resources Conservation and Tourism, 2019). Our analysis of 1.5°C compatible pathways indicates that the country would need to emit no more than 10 $MtCO_2e$/yr by 2050 (excl. LULUCF). This is equivalent to emissions reductions of 62% below 2010 levels by 2050.[5] According to

[5] While global cost-effective pathways assessed by the IPCC Special Report 1.5°C provide useful guidance for an upper limit of emissions trajectories for developed countries, they underestimate the feasible space for such countries to reach net zero earlier. The current generation of models tends to depend strongly on land-use sinks outside of currently developed countries and include fossil fuel use well beyond the time at which these could be phased out, compared to what is

some scenarios, the energy sector would be the first to decarbonise, and offers the greatest potential for emissions reductions. Remaining emissions will mostly come from the agriculture sector alongside minor contributions from the waste and industrial processes sectors.

3.1.3 Decarbonisation of the power sector

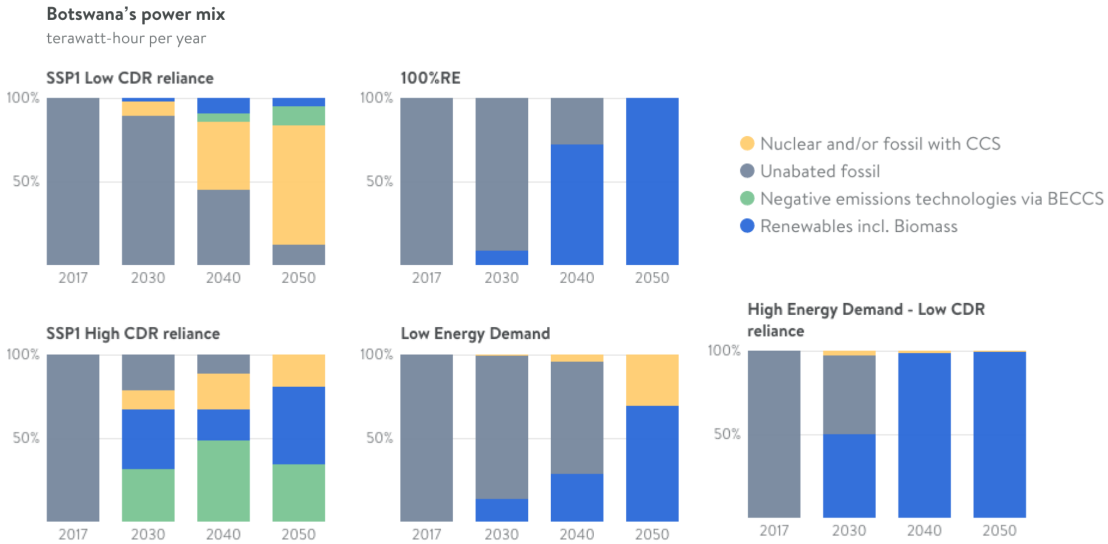

Figure 17: Power mix per technology consistent with 1.5°C compatible emissions pathways.

Botswana's power sector relies overwhelmingly on coal: close to 100% of its power generation is made from coal coming mostly from its own domestic production. Botswana is also an exporter of coal to South Africa, Zimbabwe and Namibia. With estimated coal reserves of over 212 billion tonnes, Botswana has roughly 66% of Africa's identified untapped coal reserves, and the country is actively seeking investors to exploit this significant resource potential (BITC Research Department, 2016). The country is aiming to boost its coal production in the coming years and to increase its coal capacities with a current pipeline of 2.8GW planned to reduce its power imports from South Africa mostly due to the demand from its diamond industry. Botswana has plans to increase its coal exports to cement manufacturers and boiler operators[6] and saw the awarding of three coal plant generation licenses in 2020. Such plans put the country at risk of significant carbon lock-in and subsequent high-value stranded assets in the power sector. Analysed 1.5°C compatible pathways show that Botswana should fully phase out coal from its energy mix by 2030 in some models and by 2040 at the latest. Our analysis shows that renewables could reach 72-99% of the power mix by 2040, and 99-100% by 2050. High uptake of renewable energy could also help facilitate the transition from traditional biofuels to electrification, especially in rural areas (Ministry of Environment Natural Resources Convervation and Tourism, 2019). A 1.5°C compatible grid carbon intensity would need to reach full decarbonisation by 2040, and this would require a reduction of carbon intensity of between 73-114% relative to 2017 levels by 2030. The reduction is achievable through an uptake of renewable energy and carbon dioxide removal approaches such as land sinks or bioenergy with carbon capture and storage. Given

understood from bottom-up approaches. The scientific teams which provide these global pathways constantly improve the technologies represented in their models - and novel CDR technologies are now being included in new studies focused on deep mitigation scenarios meeting the Paris Agreement. A wide assessment database of these new scenarios is not yet available; thus, we rely on available scenarios which focus particularly on BECCS as a net-negative emission technology. Accordingly, we do not yet consider land-sector emissions (LULUCF) and other CDR approaches which developed countries will need to implement in order to counterbalance their remaining emissions and reach net zero GHG are not considered here due to data availability.

[6] https://docs.google.com/spreadsheets/d/1W-gobEQugqTR_PP0iczJCrdaR-vYkJ0DzztSsCJXuKw/edit#gid=822738567

Botswana’s level of land-based sinks and the costly upfront investments of not yet proven carbon dioxide removal technologies, maintaining and increasing these sinks will help the country achieve such decarbonisation pathway. This stands in contrast with Botswana’s current explicit goal of renewable energy contributing only 14.28% of the national power mix by 2025, which is five years before fossil fuel utilisation should be halved (Government of Botswana, 2017).

Table 1: 1.5°C compatible power sector benchmarks. Carbon intensity, renewable generation share, and fossil fuel generation share from illustrative 1.5°C pathways for Botswana

Indicator	Unit	2017	2030	2040	2050	Decarbonised power sector by
Carbon intensity of power	gCO2/kWh	1420	-200 to 380	-400 to 0	-370 to 0	2025 to 2040
	%	-114 to -73%	-128 to 100%	-126 to -100%		
Share of coal	%	100	0 to 39	0 to 1	0	2030
Share of gas	%	0	0	0	0	
Share of renewable energy	%	0	50 to 67	72 to 99	99 to 100	
Share of fossil fuel	%	100	21 to 47	0 to 12	0	

Egypt

3.1.4 Current situation

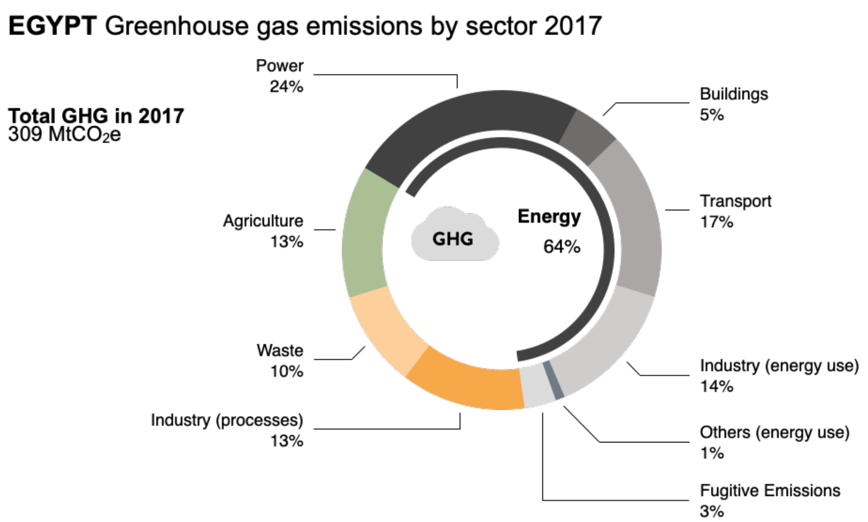

Figure 18: Historical emissions by sector. Sources: PRIMAP-Hist 2019. Energy sub-sectors emissions based on the IEA CO2 Fuel 2019.

The energy sector is Egypt’s highest emitting sector, as the country is still highly dependent on fossil fuels. The power sector makes up the largest share of energy emissions (24%), followed by transport (17%) and industrial energy use (14%). Industry processes and agriculture make up the next highest shares of total emissions, followed by waste.

Egypt’s total emissions fell from 2011 to 2014 coinciding with economic recession following the 2011 and 2013 revolutions (Ministry of Environment, 2018). The reductions came entirely from the energy sector, with energy emissions falling 9%. During this period, Egypt natural gas production in Egypt slowed down, resulting in severe fuel shortages and power outages (Meighan, 2016). Egypt's economy and emissions have since rebounded, with energy emissions increasing 8% from 2014 to 2017. While the impact of COVID-19 on emissions is not yet clear, Egypt's economy grew in 2020 even as the regional economy in Africa contracted by 1.9% (IMF, 2021).

As one of the top natural gas producers, Egypt's primary energy supply is dominated by fossil fuels, with natural gas contributing 53% and oil contributing 42% in 2017. The remaining supply is a mix of coal (2%), biomass (3%) and other renewables (1%).

Egypt relies heavily on natural gas for electricity generation (about 80%). Remaining generation is supplied by oil (12%) and renewables (8%), mostly hydropower, followed by wind, solar, and bioenergy. Egypt's growing power demand and decline in gas production following the 2011 revolution led to power and fuel shortages from 2011 to 2014. With the construction of new capacity, natural gas discoveries, and sector reform Egypt now has a surplus of power capacity with plans to export electricity (European Commission, 2018; Fahmy, 2020; Magdy, 2020).

Egypt's *Vision 2030* set targets for their electricity mix in 2030. The strategy targets a significant increase in coal (to 29% of the power mix) and renewables (35%), the development of nuclear power (9%), and falling shares of oil and gas (27%) (Arab Republic of Egypt, 2016) (IRENA, 2018).

3.1.5 *Raising ambition*

2030 Ambition

Egypt's 2017 conditional NDC does not include an emissions reduction target. Instead, the NDC lists broad actions across the energy (including oil and gas), agricultural, waste, and industrial processes sectors to mitigate emissions. Setting an emissions reduction target would be the first step towards a decarbonisation pathway. In order to be 1.5°C compatible, Egypt would need to peak its GHG emissions immediately and reduce them by 25% below 2015 levels by 2030 so as to reach emissions levels of 221 $MtCO_2e$/yr when excluding LULUCF in 2030. To close its emissions gap, Egypt's NDC states the needs *for financial support from Annex I parties in addition to technology transfer and local capacity building*. Egypt failed to submit an updated NDC ahead of COP26. As the host of COP27, it is important for Egypt to submit an ambitious, quantifiable mitigation target in an updated NDC in 2022.

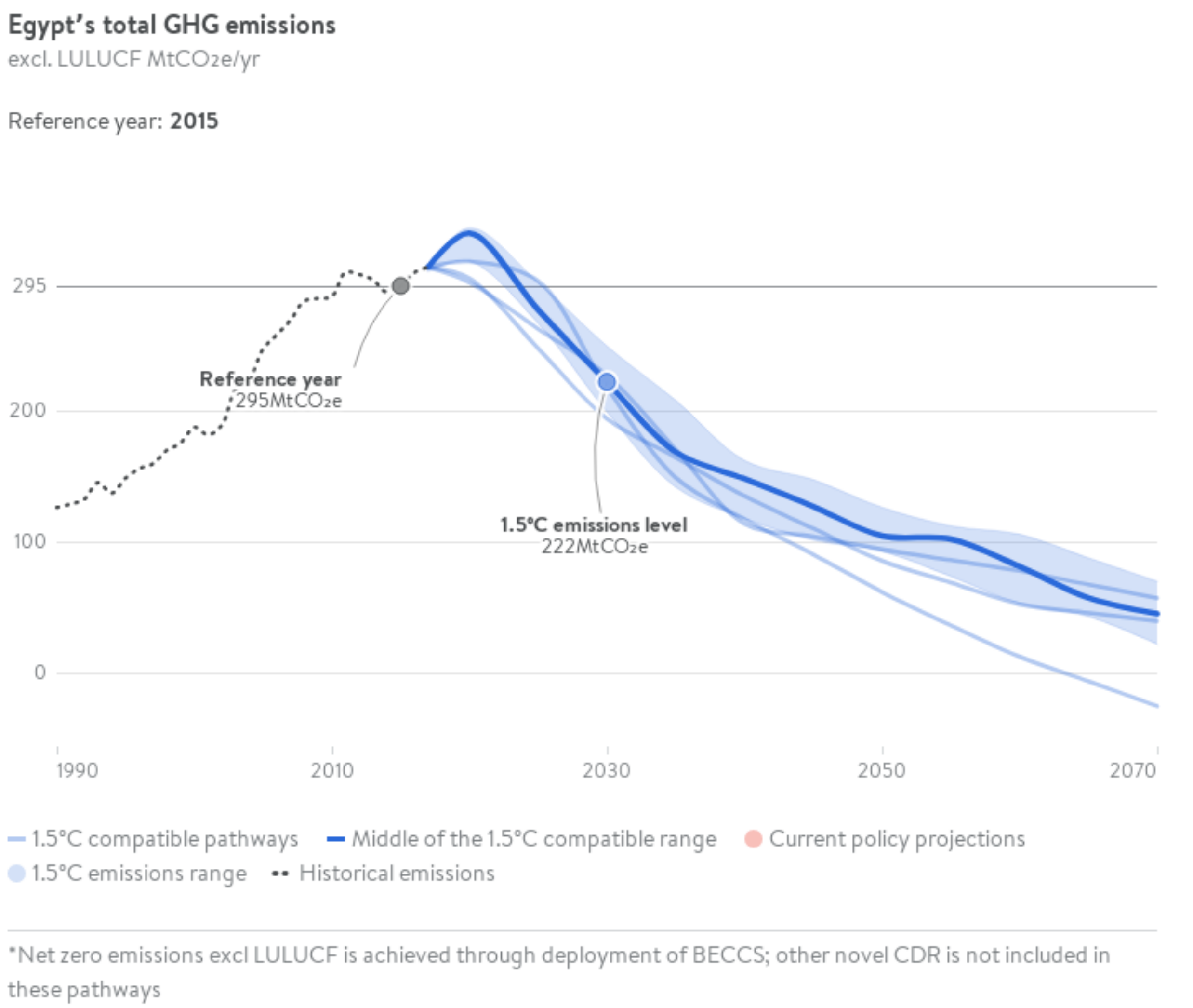

Figure 19: The figure shows national 1.5°C compatible emissions pathways. This is presented through a set of illustrative pathways and a 1.5°C compatible range for total GHG emissions excl. LULUCF. The 1.5°C compatible range is based on global cost-effective pathways assessed by the IPCC SR1.5, defined by the 5th-50th percentiles of the distributions of such pathways which achieve the LTTG of the Paris Agreement. Our analysis considers one primary net-negative emission technology (BECCS) due to data availability. Net negative emissions from the land-sector (LULUCF) and novel CDR technologies are not included in this analysis due to data limitations from the assessed models. Furthermore, in the global cost-effective model pathways we analyse, such negative emissions sources are usually underestimated in developed country regions, due to ´models relying on land sinks in developing countrie

Long term pathway

Egypt does not have a net zero target. At COP26, the government presented its National Climate Change Strategy for 2050[g], however, the strategy does not include a mitigation target. 1.5°C compatible pathways show emissions reductions of 57-70% by 2050 below 2015 levels when excluding LULUCF emissions.[h] On the road to net zero, the country will need to balance remaining emissions

[g] https://egyptian-gazette.com/egypt/egypts-national-climate-change-strategy-2050-launched-at-cop26/

[h] While global cost-effective pathways assessed by the IPCC Special Report 1.5°C provide useful guidance for an upper-limit of emissions trajectories for developed countries, they underestimate the feasible space for such countries to reach net zero earlier. The current generation of models tend to depend strongly on land-use sinks outside of currently developed countries and include fossil fuel use well beyond the time at which these could be phased out, compared to what is understood from bottom-up approaches. The scientific teams which provide these global pathways constantly improve the technologies represented in their models - and novel CDR technologies are now being included in new studies focused on deep mitigation scenarios meeting the Paris Agreement. A wide assessment database of these new scenarios is not yet available; thus, we rely on available scenarios

through the use of carbon dioxide removal approaches, such as land sinks. Achieving net zero CO_2 will depend on the rapid decarbonisation of the power sector, as this is a catalyst for the decarbonisation of other sectors.

3.1.6 Decarbonisation of the power sector

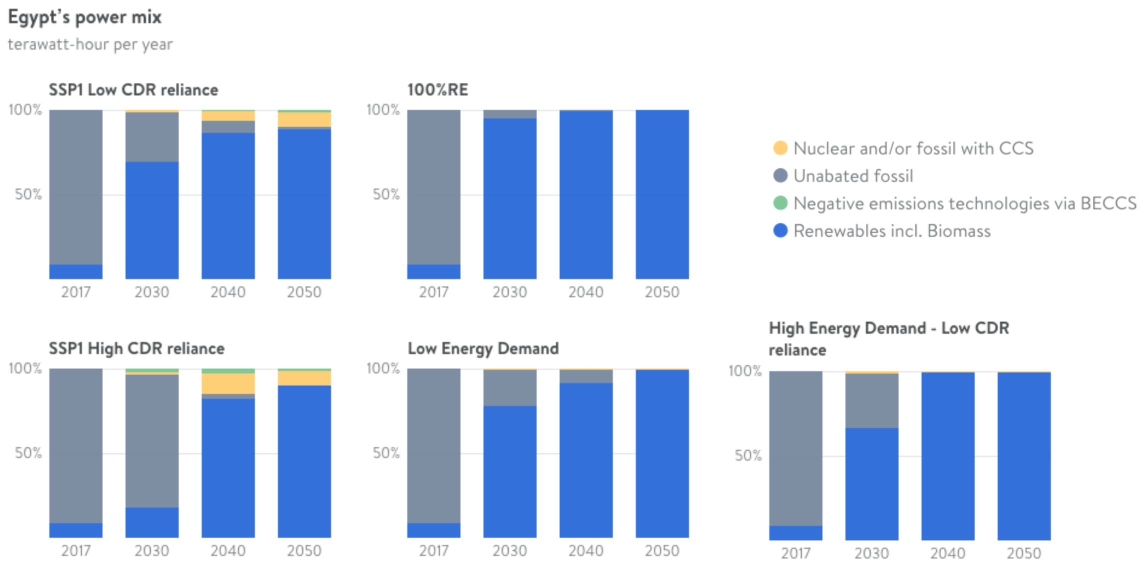

Figure 20: Power mix per technology consistent with 1.5°C compatible emissions pathways.

Fossil fuels accounted for 92% of Egypt's power mix in 2017. Paris-compatible pathways would require the power sector to be fully decarbonised by around 2040 and contribute to negative emissions thereafter. This could be achieved through the phase-out of natural gas in the power sector between 2036 and 2039. Egypt's 2017 NDC includes options for dealing with the emissions from fossil fuels, such as deploying carbon capture and storage (CCS) technologies and upgrading fossil fuel plants. Considering the long lifetimes and decreasing competitiveness of fossil fuel plants, these measures come with the risk of stranded assets and locking into high-cost, high-emission technologies. Decarbonisation of the power sector would need to be supported by a high uptake of renewable energy (including variable renewables, hydro and biomass), from a share of 8% in 2017 to 78–95% by 2030, and reaching 100% before 2050. This stands in strong contrast with the Egyptian Energy Strategy 2035 targeting a share of 42% in power generation by 2035, less than half-way through Paris compatible benchmarks. Considering Egypt's ambition to serve as a regional energy hub exporting electricity to other African countries and Europe, and these countries' increasing appetite for renewable energy, Egypt would benefit from an expansion of renewables in their power sector (European Commission, 2018; Magdy, 2020).

which focus particularly on BECCS as a net-negative emission technology. Accordingly, we do not yet consider land-sector emissions (LULUCF) and other CDR approaches.

Table 2: 1.5°C compatible power sector benchmarks. Carbon intensity, renewable generation share, and fossil fuel generation share from illustrative 1.5°C pathways for Egypt

Indicator	Unit	2017	2030	2040	2050	Decarbonised power sector by
Carbon intensity of power	gCO2/kWh	450	20 to 80	-10 to 0	-20 to 0	2035 to 2039
	%		-95 to -83%	-103 to -100%	-104 to -100%	
Share of coal	%	0	0	0	0	
Share of gas	%	80	5 to 20	0	0	2036 to 2039
Share of renewable energy	%	8	78 to 95	99 to 100	100	
Share of fossil fuel	%	92	5 to 22	0	0	

Ethiopia

3.1.7 Current situation

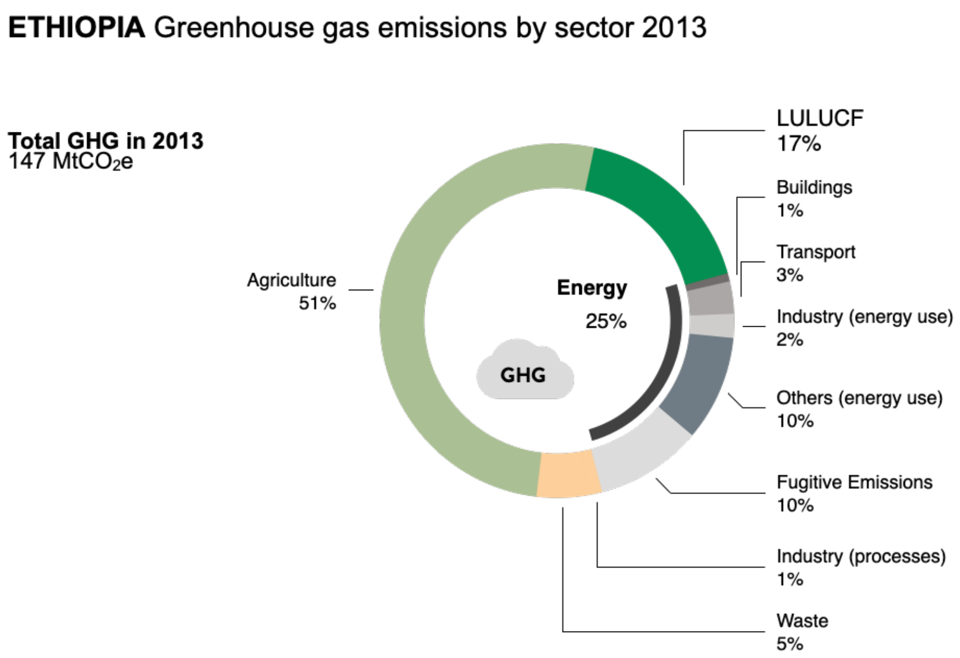

Figure 21: Historical emissions by sector. Sources: PRIMAP-Hist 2019. Energy sub-sectors emissions based on the IEA CO2 Fuel 2019. Inventory year: 2017. LULUCF emissions from the Climate Action Tracker, 2020.

Ethiopia's emissions were at 147 $MtCO_2e$/yr in 2013 and are expected to grow to over 400 $MtCO_2e$/yr by 2030 in a business as usual scenario (Government of Ethiopia, 2020b).

Agriculture is a key emitting sector, accounting for over 50% of emissions in 2013, followed by energy (25%) and LULUCF (17%). Emissions in the agricultural sector are mostly from livestock – estimates put animal head count at over 150 million including cattle, sheep, goats and others. Agriculture is the main contributor to methane and nitrous oxide emissions, with the latter mostly coming from crop cultivation (Government of Ethiopia, 2011).

The energy sector is the second most emitting sector, with emissions mainly driven by the burning of biomass for energy use such as household cooking.

LULUCF emissions account for 17% of total GHG emissions in 2013, and have mostly been from the conversion of forested land for agricultural use and wood fuel consumption. Under business as usual, the key emitting sectors in 2030 are projected to be energy and livestock, contributing 91% of the country's total GHG emissions (Government of Ethiopia, 2020b).

Biomass makes up a large share of Ethiopia's energy mix, accounting for nearly 90% of electricity generation (IEA, 2018). Ethiopia's NDC identifies this as a main concern in its efforts towards sustainable energy for all (IEA, 2018). There is relatively low access to clean and sustainable energy with 2018 data showing that access rates were at 57% in 2017 having risen from 54.25% in 2015.[i] Ethiopia's hydro potential remains among the highest in Africa with a planned 13.5 GW capacity by 2040 (IEA, 2018).

As of 2018, oil and coal accounted for about 9.47% of the total energy supply with oil at 8.59% and coal at 0.88% (IEA, 2018). This is mostly fossil fuel imports to power the transport and industrial sectors. Road transport account for 75% of emissions from the transport sector (Government of Ethiopia, 2019, 2021; World Nuclear News, 2019). Ethiopia recently unveiled its 10-year development plan that outlines energy as a key driver for its development (Government of Ethiopia, 2020a). This was followed by a draft energy policy that prioritises increased access to energy for the poor, and emissions reductions driven by the eradication of the use of biomass (Government of Ethiopia, 2021).

3.1.8 Raising ambition

2030 ambition

Ethiopia's 2020 nationally determined contribution is conditional on international support. Under the NDC, Ethiopia's emissions would increase to 75% above 2015 levels or to 213 $MtCO_2e$/yr by 2030, excluding LULUCF.[j] In July 2021, Ethiopia updated its NDC, which would lead to more remaining emissions by 2030 than its previous NDC, according to the Climate Action Tracker (around 237 MtCO2e/yr in 2030).[k] Current policies projections indicate that Ethiopia is on track to meeting its previous NDC. [l]With international support, Ethiopia will be able to implement its domestic emissions pathway and close the gap between its fair share level and domestic emissions level. Paris compatible pathways show emissions reductions of 10-37% below 2015 levels or 76-110 $MtCO_2e$/yr by 2030 excluding LULUCF.

[i] Government of Ethiopia. The Second Growth and Transformation Plan (GTP II) Midterm Review Report. (2018).
[j] https://climateactiontracker.org/climate-target-update-tracker/ethiopia/2020-12-31/
[k] https://climateactiontracker.org/countries/ethiopia/targets/
[l] https://climateactiontracker.org/countries/ethiopia/2020-07-30/

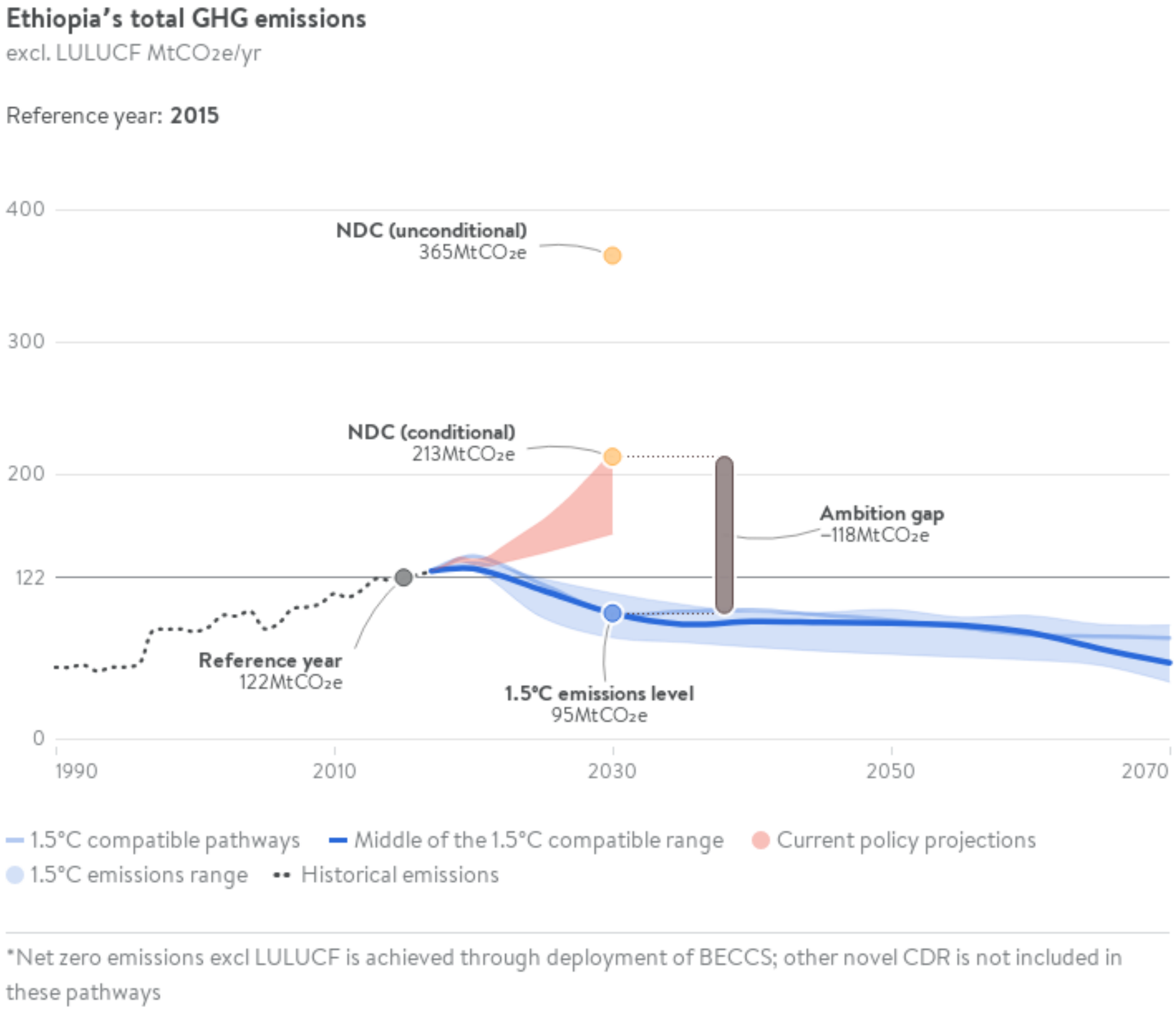

Figure 22: The figure shows national 1.5°C compatible emissions pathways. This is presented through a set of illustrative pathways and a 1.5°C compatible range for total GHG emissions excl. LULUCF. The 1.5°C compatible range is based on global cost-effective pathways assessed by the IPCC SR1.5, defined by the 5th-50th percentiles of the distributions of such pathways which achieve the LTTG of the Paris Agreement. We consider one primary net-negative emission technology in our analysis (BECCS) due to data availability. Net negative emissions from the land-sector (LULUCF) and novel CDR technologies are not included in this analysis due to data limitations from the assessed models. Furthermore, in the global cost-effective model pathways we analyse, such negative emissions sources are usually underestimated in developed country regions, with current-generation models relying on land sinks in developing countries.

Long term pathway

Even though the country aims to become 'carbon neutral', it has not yet announced a net zero CO_2 target year. Its *Low Emission Development Strategy is under development* (Climate Action Tracker, 2020a). 1.5°C compatible pathways show GHG emissions reductions, excluding LULUCF, by 22% (10-37%) below 2015 levels by 2050.[m] Emission reduction measures will need to focus on high emitting sectors such as energy, agriculture, particularly livestock, and biomass for cooking. Intensifying its

[m] While global cost-effective pathways assessed by the IPCC Special Report 1.5°C provide useful guidance for an upper-limit of emissions trajectories for developed countries, they underestimate the feasible space for such countries to reach net zero earlier. The current generation of models tend to depend strongly on land-use sinks outside of currently developed countries and include fossil fuel use well beyond the time at which these could be phased out, compared to what is understood from bottom-up approaches. The scientific teams which provide these global pathways constantly improve the technologies represented in their models - and novel CDR technologies are now being included in new studies focused on deep mitigation scenarios meeting the Paris Agreement. A wide assessment database of these new scenarios is not yet available; thus, we rely on available scenarios which focus particularly on BECCS as a net-negative emission technology. Accordingly, we do not yet consider land-sector emissions (LULUCF) and other CDR approaches which developed countries will need to implement in order to counterbalance their remaining emissions and reach net zero GHG are not considered here due to data availability.

electrification programme for end-use sectors will be one of the key policy areas to steer emissions reductions both in the energy sector and the LULUCF sector.

3.1.9 Decarbonisation of the power sector

Figure 23: Power mix per technology consistent with 1.5°C compatible emissions pathways.

Ethiopia's updated 2021 NDC aims to achieve the vast majority of its reductions in the land use and forestry sector, however this includes reducing residential biomass use for energy which accounted for around 88% of the primary energy mix in 2017 (Climate Action Tracker, 2020a). While Ethiopia already benefits from a close to fully decarbonised power sector with already 100% of domestically produced electricity from renewable energy, the country plans on a renewable-based energy supply to meet the growing demand primarily based on hydropower source through the soon to be ready Grand Ethiopian Renaissance Dam (GERD). While it will be the largest hydropower plant in Africa with 5GW installed capacity, the country may have to plan on a combination of both hydro with variable renewables such as wind and solar to reduce sustainability concerns around additional hydropower (GERD Coordination Office, 2020).

Table 3: 1.5°C compatible power sector benchmarks. Carbon intensity, renewable generation share, and fossil fuel generation share from illustrative 1.5°C pathways for Ethiopia

Indicator	Unit	2017	2030	2040	2050	Decarbonised power sector by
Carbon intensity of power	gCO2/kWh	0	0	0	−10 to 0	2025 to 2040
	%					
Share of coal	%	0	0	0	0	2030
Share of gas	%	0	0	0	0	
Share of renewable energy	%	100	100	100	100	
Share of fossil fuel	%	0	0	0	0	

Ghana

3.1.10 Current situation

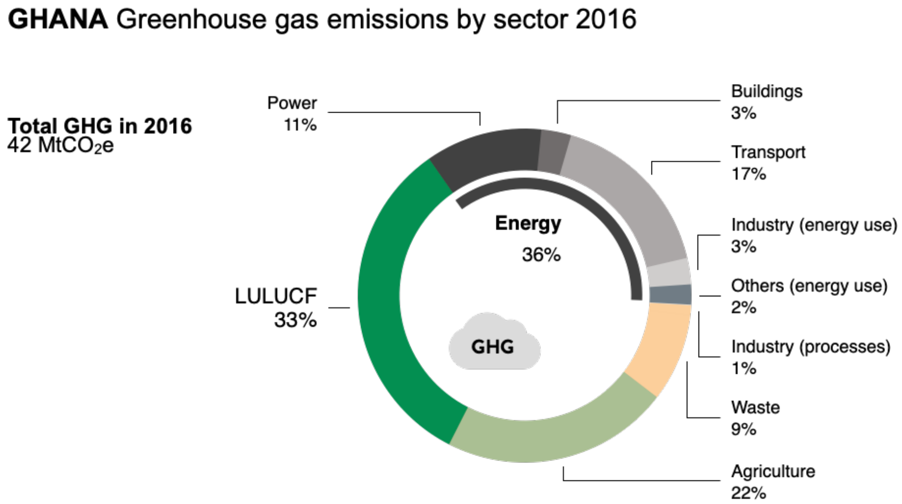

Figure 24: Historical emissions by sector. Sources: Environmental Protection Agency of Ghana. Ghana' s Fourth National Greenhouse Gas Inventory Report to the United Nations Framework Convention on Climate Change. (2019).

Ghana's total GHG emissions (including the LULUCF sector) have increased by 2.1% per annum between 1990 and 2016 (Environmental Protection Agency of Ghana, 2019). Over the same period, however, the national population and economy have expanded at a faster rate than GHG emissions. Therefore, emissions per capita have decreased by 13.7%, while emissions per unit of GDP output have decreased by 59.3% (Environmental Protection Agency of Ghana, 2019). The energy sector is the largest sector of emissions accounting for 36% of total GHG in 2016 (Environmental Protection Agency of Ghana, 2019). The LULUCF sector accounts for 33% of Ghana's total GHGs, with deforestation and the associated expansion of croplands and grasslands being the primary drivers (Environmental Protection Agency of Ghana, 2019). The agricultural sector contributed 22% of total emissions in 2016. Transport and power, mostly dominated by oil and natural gas, respectively, are the main drivers of energy emissions. Livestock and land conversion to cropland are key drivers of agricultural emissions (Environmental Protection Agency of Ghana, 2019). While the waste sector contributed only 9% of emissions between 2012 and 2016, it was the fastest-growing emissions source, followed by the energy, agriculture and LULUCF sectors (Environmental Protection Agency of Ghana, 2019). Under a BAU scenario, a 201% increase in emissions compared to 1990 levels is anticipated by 2030 (a 73% increase since 2016) (Environmental Protection Agency of Ghana, 2019).

The transportation and residential sectors each account for 36% of Ghana's energy consumption. The industrial sector - including mining and mineral resource processing - accounts for 20% of consumption (African Development Bank, 2018a). Ghana's energy fuel mix is dominated by fossil fuels, in part due to national oil reserves developed since 2007 (African Development Bank, 2018a). In 2018, 44% of the total national energy production was sourced from oil, 37% from traditional biomass, 14% from natural gas, and only 5% and 0.03% from hydropower and other renewables respectively (Environmental Protection Agency, 2020). Electricity contributed roughly 13% to national energy consumption in 2016 (African Development Bank, 2018a). More recent estimates indicate that 51% of Ghanaian electricity is powered from thermal fossil fuels (oil and natural gas), while hydropower and other renewables contribute 49.8% and 0.1% of the mix respectively (Environmental Protection Agency, 2020). While Ghana intends to develop its renewable energy capacities up to 1364 MW by 2030, the country is also considering introducing coal plants and increasing electricity generation from natural gas (Ministry of Petroleum, Government of Ghana, 2016). While coal technologies are not yet available in the country, these actions would lock in carbon intensive technologies that would prevent Ghana from aligning with a 1.5°C compatible pathway.

3.1.11 Raising ambition

2030 Ambition

Submitted in 2015, Ghana's first NDC committed to a conditional target of reducing emissions by 45% relative to business as usual (BAU) emission levels in 2030. Excluding LULUCF, this translates to an emissions increase of up to zero to 14% above 2015 levels (or 30-35 $MtCO_2e/yr$) by 2030 (Republic of Ghana, 2015). Ghana submitted an updated NDC in November 2021 which we have not yet assessed. It targets absolute conditional emissions reductions of 39.4 MtCO2e/yr by 2030 below a business-as-usual scenario – or around 40% emissions reductions, indicating that Ghana did not increase its ambition in its updated NDC.

The country is yet to update these commitments. With international support, Ghana will be able to implement its domestic emissions pathway and close the gap between its fair share level and domestic emissions level. Paris compatible pathways show emissions levels of 22-29 $MtCO_2e/yr$ by 2030 or a reduction of 4-26% below 2010 levels by 2030, excluding LULUCF emissions.

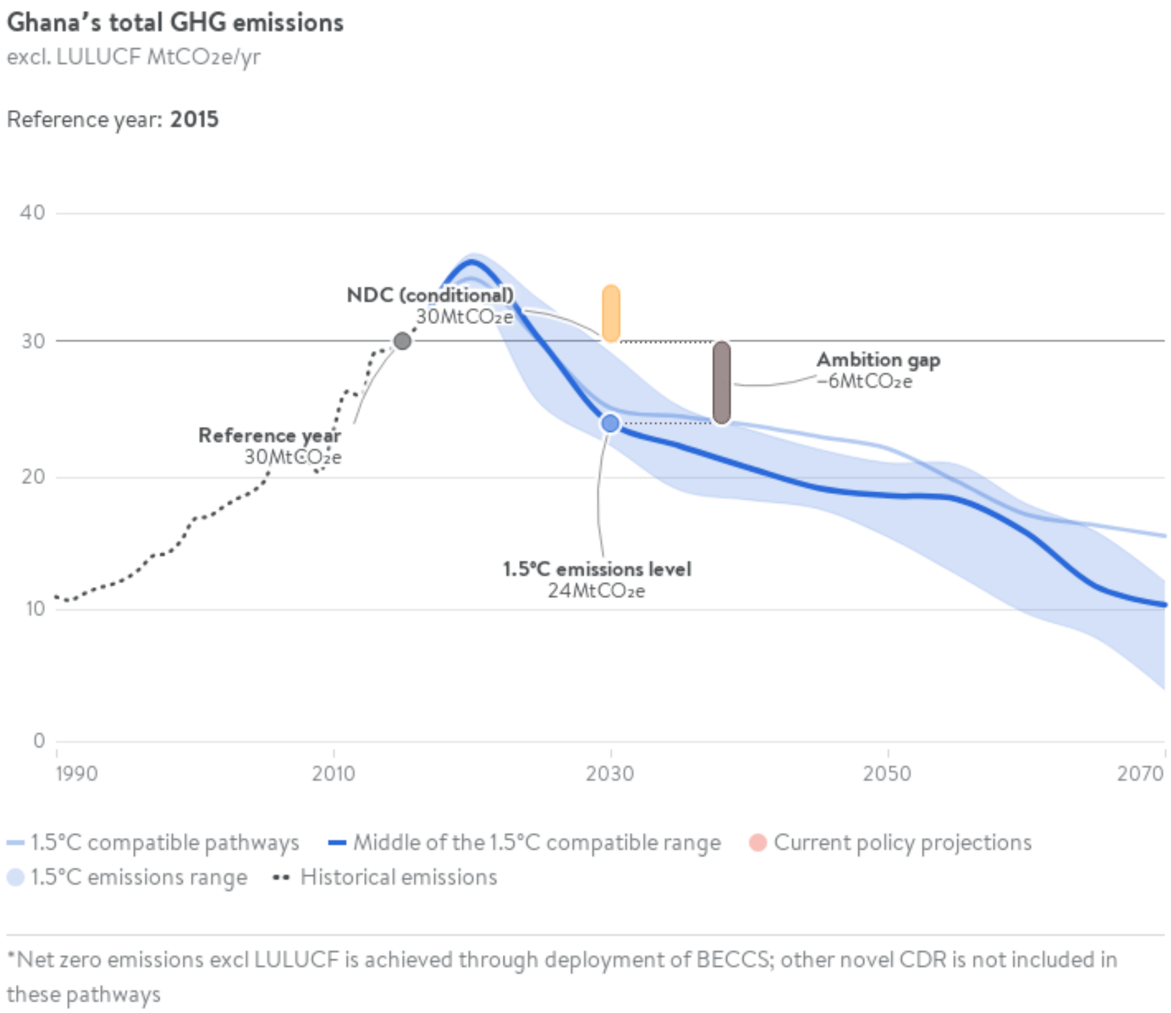

Figure 25: The figure shows national 1.5°C compatible emissions pathways. This is presented through a set of illustrative pathways and a 1.5°C compatible range for total GHG emissions excl. LULUCF. The 1.5°C compatible range is based on global cost-effective pathways assessed by the IPCC SR1.5, defined by the 5th-50th percentiles of the distributions of such pathways which achieve the LTTG of the Paris Agreement. We consider one primary net-negative emission technology in our analysis (BECCS) due to data availability. Net negative emissions from the land-sector (LULUCF) and novel CDR technologies are not included in this analysis due to data limitations from the assessed models. Furthermore, in the global cost-effective model pathways we analyse, such negative emissions sources are usually underestimated in developed country regions, with current-generation models relying on land sinks in developing countries.

Long term pathway

As of December 2021, Ghana has not articulated a long-term or net zero strategy. Long-term 1.5°C compatible pathways indicate that Ghana would need to reduce its GHG emissions to 15-21 $MtCO_2e/yr$ by 2050, which is equivalent to a 30-50% reduction in emissions compared to 2015, excluding LULUCF emissions. On the road towards net zero, Ghana will need to balance its remaining emissions through the development of carbon dioxide removal approaches. Given the high level of LULUCF emissions in Ghana, this will mean reducing its land sector emissions to further contribute to negative emissions.

3.1.12 Decarbonisation of the power sector

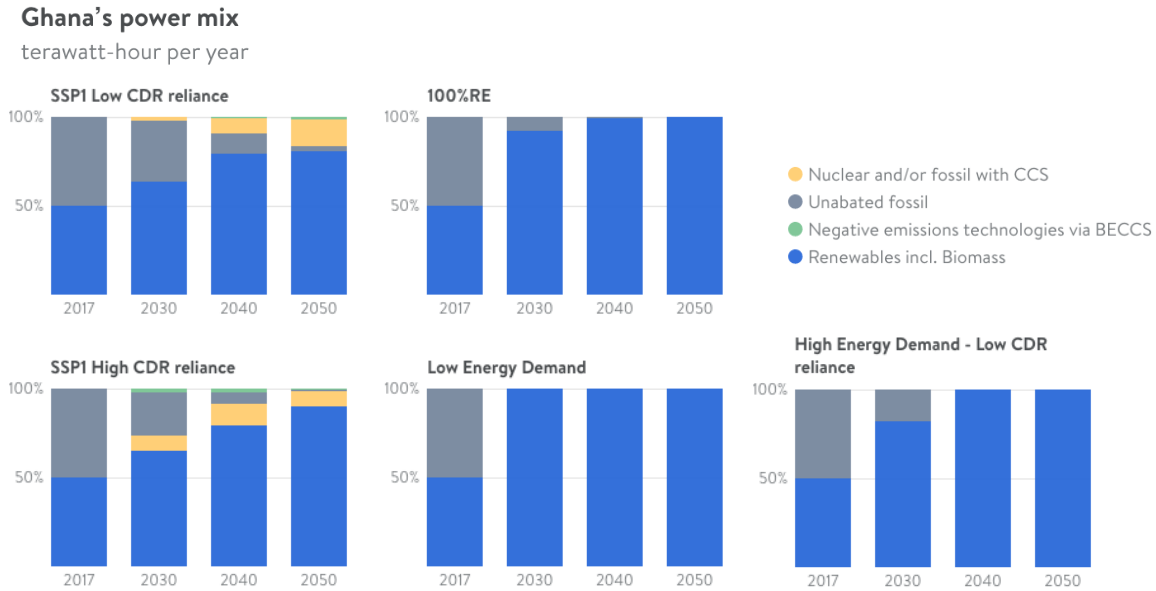

Figure 26: Power mix per technology consistent with 1.5°C compatible emissions pathways.

Ghana aims to increase its renewable energy capacity in the power mix from 43 MW in 2015 to 1364 MW in 2030 (Ministry of Energy, Government of Ghana, 2019). It has further committed to scaling up the share of renewable energy in its national energy mix up to 10% by the same year (Republic of Ghana, 2015). A 1.5°C pathway would require natural gas and oil — contributing 43% and 7% of power supply respectively in 2017 — to be phased out between 2029 and 2035. This will drive the full decarbonisation of power sector by 2035. However, Ghana has indicated intentions to scale up its natural gas capacity — and possibly develop its first coal power plant (Ministry of Petroleum, Government of Ghana, 2016). Combined with the recent USD 13.2 billion investment in the Jubilee, TEN and Sankofa gas fields, Ghana risks locking in high carbon infrastructure and creating stranded assets (Government of Ghana, 2018). While Ghana's renewable energy commitments are encouraging, they fall far short of what is required to be 1.5°C compatible, which would need renewables to account for at least 92% of Ghana's electricity mix by 2030, and 100% by 2040. Plans to upscale natural gas capacity further undermines Ghana's future 1.5°C compatible emissions pathway.

Table 4: 1.5°C compatible power sector benchmarks. Carbon intensity, renewable generation share, and fossil fuel generation share from illustrative 1.5°C pathways for Ghana

Indicator	Unit	2017	2030	2040	2050	Decarbonised power sector by
Carbon intensity of power	gCO2/kWh	310	0 to 40	0	0	2030 to 2035
	%		−100 to −88%	−100%	−101 to −100%	
Share of coal	%	0	0	0	0	
Share of gas	%	43	0 to 8	0	0	2029 to 2035
Share of renewable energy	%	50	92 to 100	100	100	
Share of fossil fuel	%	50	0 to 8	0	0	

Kenya

3.1.13 Current situation

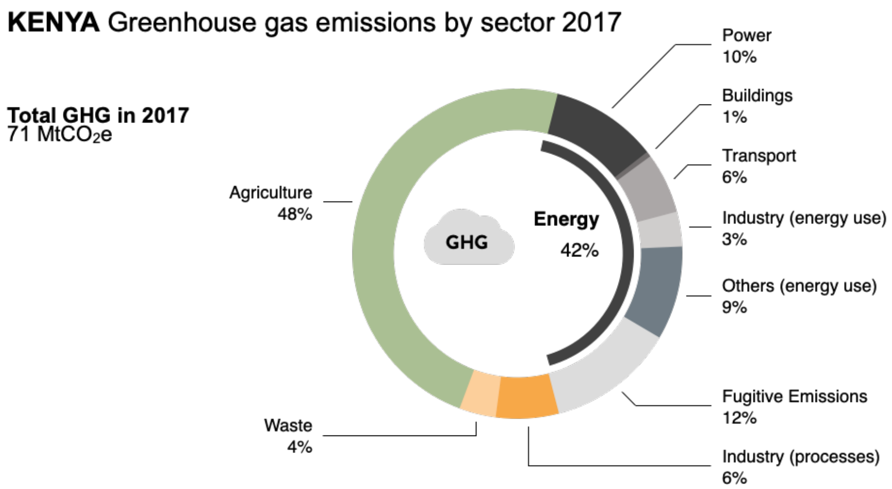

Figure 27: Historical emissions by sector. Sources: PRIMAP-Hist 2019. Energy sub-sectors emissions based on the IEA CO2 Fuel 2019. Inventory year: 2017.

Kenya's emissions were 83.1MtCo_2eq/yr in 2010 and are projected to be around 70-106 MtCo_2eq/ by 2030 under current policies (Ministry of Environment and Forestry, 2020). Agriculture is the largest emitter of greenhouse gases in Kenya, accounting for 39% in 2010, followed by energy and LULUCF at 30% and 25%, respectively. Agriculture emissions are dominated by methane (CH_4) and nitrous oxide (N_2O) from livestock and crops (Ministry of Environment and Forestry, 2020). The dairy sector is the main driver of emissions within agriculture contributing to around 3.5% of total national GDP in 2017 (CIAT & World Bank, 2015; FAO & New Zealand Agricultural Greenhouse Gas Research Centre., 2017). Energy sector emissions are mainly from combustion, thermal plants for power generation, use of fossil fuels in the transport sector as well as kerosene for household cooking, lighting and heating and other biomass in cooking and heating among others (Ministry of Energy and Clean Cooking Association of Kenya, 2019; Ministry of Environment and Forestry, 2020). LULUCF emissions are mostly from land conversion for agriculture, deforestation and burning of crop waste and remains in agricultural land (Government of Kenya, 2018b). It is projected that LULUCF will be the second-largest emitting sector after agriculture by 2030 (Government of Kenya, 2018b, 2018a).

More than 60% of primary energy in Kenya comes from biomass use, the majority from traditional biomass used for heating and cooking appliances, followed by oil consumption, mostly in the transport sector (IEA, 2020). In its 2020 Voluntary National Report (VNR) on Sustainable development goals (SDGs), Kenya reported that in 2019, 75% of its population still relied on unclean fuels, mostly traditional biomass, charcoal and kerosene (Republic of Kenya, 2020). In addition to emitting greenhouse gases, the use of unclean fuels also causes respiratory illnesses mostly among women and children who are responsible for household cooking (FAO & New Zealand Agricultural Greenhouse Gas Research Centre., 2017; Oparaocha & Clancy, 2004) . A 2019 cooking survey report by the Ministry of Energy found that only 3% of the population had access to electric cooking appliances and out of this just 2.9% used electricity for cooking (Ministry of Energy and Clean Cooking Association of Kenya, 2019). 30% of the population used liquefied petroleum gas (LPG) for cooking in combination with other sources mainly firewood and charcoal (Ministry of Energy and Clean Cooking Association of

Kenya, 2019).[n] The country has prioritised access to electricity and other, non-electric, cooking in its policies which include distribution of affordable gas cylinders through the Mwananchi gas project, to low-income households, development of off-grid solar through the KOSAP project, promotion of electric cooking and biogas uptake among other strategies (Government of Kenya, 2018a; Ministry of Energy, 2018). In 2019 Kenya adopted the Energy Act (2019) that sets out key provisions in the energy sector as envisioned by the 2018 Energy Policy and Vision 2030 (Third Medium Term - MTPIII) reiterating its vision of low-carbon energy development and universal access to sustainable energy for all by 2030.

3.1.14 Raising ambition

2030 Ambition

Kenya's updated nationally determined contribution (NDC) targets a 32% emissions reduction below BAU by 2030 with 79% of mitigation conditional on international support. This translates to a conditional target of 102% above 2010 emission levels or 108 $MtCO_2e$/yr by 2030, excluding LULUCF.[1] With international support, Kenya will be able to implement its domestic emissions pathway and close the gap between its fair share level and domestic emissions level. Paris compatible pathways show emissions levels of 40-53 $MtCO_2e$/yr by 2030 or a reduction of 1-26% below 2010 levels by 2030, excluding LULUCF emissions. Current policies indicate that Kenya is on track to meeting its conditional NDC commitment. The level of uncertainties on LULUCF emissions might strongly influence the target compatibility with Paris compatible pathways.

[n] %'s include stacking which is a common feature of household cooking in Kenya.

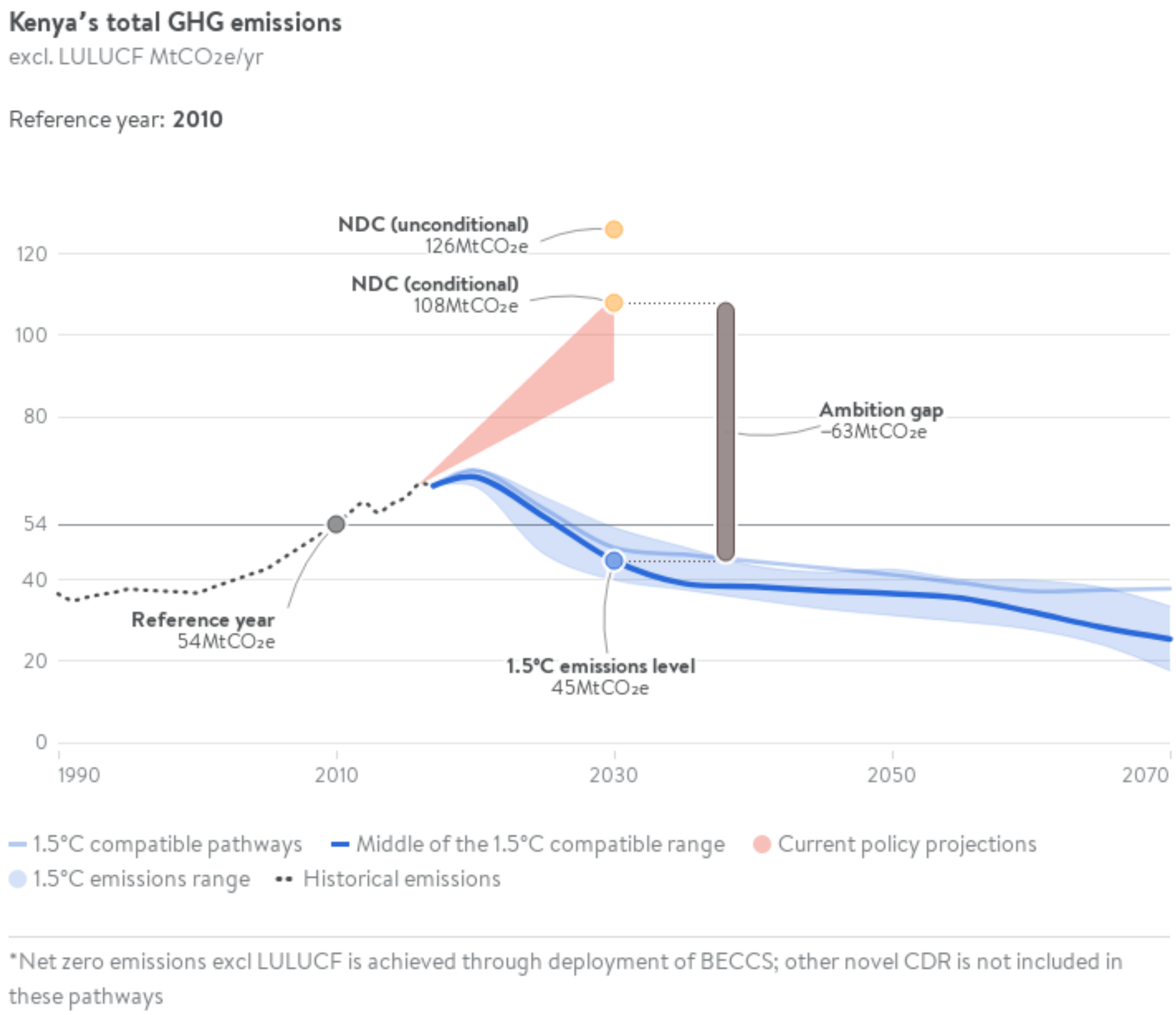

Figure 28: The figure shows national 1.5°C compatible emissions pathways. This is presented through a set of illustrative pathways and a 1.5°C compatible range for total GHG emissions excl. LULUCF. The 1.5°C compatible range is based on global cost-effective pathways assessed by the IPCC SR1.5, defined by the 5th-50th percentiles of the distributions of such pathways which achieve the LTTG of the Paris Agreement. We consider one primary net-negative emission technology in our analysis (BECCS) due to data availability. Net negative emissions from the land-sector (LULUCF) and novel CDR technologies are not included in this analysis due to data limitations from the assessed models. Furthermore, in the global cost-effective model pathways we analyse, such negative emissions sources are usually underestimated in developed country regions, with current-generation models relying on land sinks in developing countries.

Long term pathway

Kenya's NDC only alludes to a net-zero target by 2050 stating that the NDC implementation 'is part of a transformation to a ***low-emission society by 2050'*** (Ministry of Environment and Forestry, 2020)**.** It is hoped that its next climate change action plan will provide further details on this. On a net-zero trajectory, 1.5°C compatible pathway would require for Kenya´s remaining GHG emissions level to be below 36 (32-42) $MtCo_2e/yr$ by 2050 or 33(22-41%) below 2010 levels excluding LULUCF. Reducing LULUCF emissions for the sector to become a sink will be key for the country to reach net zero GHG emissions and in the long term to balance its remaining emissions.[o] Measures in the agricultural and

[o] While global cost-effective pathways assessed by the IPCC Special Report 1.5°C provide useful guidance for an upper-limit of emissions trajectories for countries, they underestimate the feasible space for developed countries to reach net zero earlier. The current generation of models tend to depend strongly on land-use sinks outside of currently developed countries and include fossil fuel use well beyond the time at which these could be phased out, compared to what is understood from bottom-up approaches. The scientific teams which provide these global pathways constantly

energy sectors are key in achieving decarbonisation. The use of biomass in cooking is especially a key area of focus that will enable transition to a clean and sustainable energy for cooking and drive emissions reductions in the forestry sector (CIAT & World Bank, 2015). Abandoning plans on coal and other fossil fuel development whilst increasing the development of renewable energy sources will aid the country to align its climate action with ´ a Paris compatible pathway.

3.1.15 Decarbonisation of the power sector

Figure 29: Power mix per technology consistent with 1.5°C compatible emissions pathways.

Renewable energy makes up about 90% of Kenya's power mix, with geothermal at 49%, followed by hydro at 40% (Ministry of Energy, 2020). This is expected to rise to 100% by 2030 with plans to increase geothermal by 123% from the current 860 MW to 1925MW by 2030 (Geothermal Development Company, 2021). Increasing a decarbonised and affordable electricity mix will be key to meet electricity demand on a sustainable path and reduce reliance on gas fuel for non-electric cooking as prioritised by the country currently. While Kenya is well positioned to soon reach a fully decarbonised power mix, this is likely to change should the planned coal capacity be implemented (Government of Kenya, 2018c). Its only proposed coal plant experienced massive opposition and a court case stopped its further development (Save Lamu & others v NEMA in the National Environmental Tribunal, 2019). Development of the coal plant will jeopardise plans of achieving 100% renewable power by 2030, face the risk of high-cost stranded assets and be locked-in in a carbon intensive pathway.

improve the technologies represented in their models - and novel CDR technologies are now being included in new studies focused on deep mitigation scenarios meeting the Paris Agreement. A wide assessment database of these new scenarios is not yet available; thus, we rely on available scenarios which focus particularly on BECCS as a net-negative emission technology. Accordingly, we do not yet consider land-sector emissions (LULUCF) and other CDR approaches which developed countries will need to implement in order to counterbalance their remaining emissions and reach net zero GHG are not considered here due to data availability.

Table 5: 1.5°C compatible power sector benchmarks. Carbon intensity, renewable generation share, and fossil fuel generation share from illustrative 1.5°C pathways for Kenya

Indicator	Unit	2017	2030	2040	2050	Decarbonised power sector by
Carbon intensity of power	gCO2/kWh	180	0	0	−40 to 0	2025 to 2028
	%		−100 to −99%	−100%	−121 to −100%	
Share of coal	%	0	0	0	0	
Share of gas	%	0	0	0	0	
Share of renewable energy	%	80	100	100	100	
Share of fossil fuel	%	20	0	0	0	

Nigeria

3.1.16 Current situation

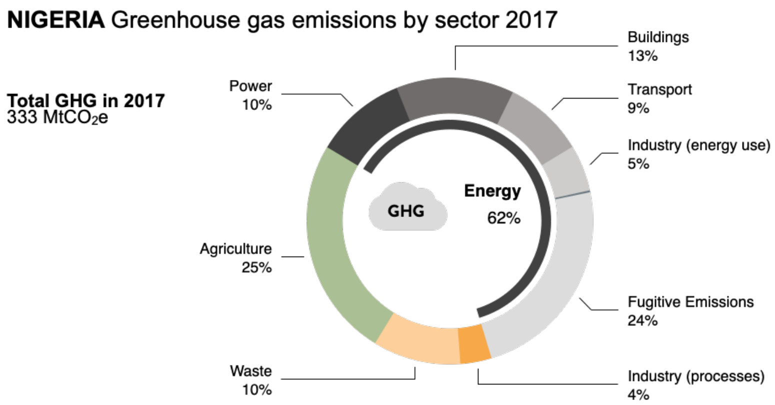

Figure 30: Historical emissions by sector. Sources: PRIMAP-Hist 2019 dataset. Breakdown of combustion emissions are based on the 3rd National Communication of Nigeria (2020).

3.1.17 Raising ambition

2030 Ambition

Nigeria submitted its updated NDC in July 2021. The update targets emission reductions of 20% below BAU by 2030 (incl. LULUCF) unconditionally and up to 47% below BAU by 2030, conditional on international support. This is a slight increase from Nigeria's interim updated NDC which had recommitted to the targets put forward in the 2017 NDC of 45% emission reductions below BAU but noted that the final mitigation ambition was not yet decided (Federal Republic of Nigeria, 2021). Taking historical data and BAU revisions from the update into account, Nigeria's conditional target translates to an emissions level of 213-276 MtCO2e/yr by 2030 or 14 - 34% below 2015 levels, excluding LULUCF (around 33% below 2015 levels for Nigeria's interim NDC).[p]

[p] See the Climate Action Tracker for assumptions.

Nigeria's conditional NDC is well in line with a 1.5°C compatible domestic emissions range, requiring an emissions reduction of 13% to 35% below 2015 levels excl. LULUCF (or 210-281 $MtCO_2e$/yr by 2030 excl. LULUCF). The level of uncertainties around LULUCF emissions, which could potentially account for 25-50% of the country's carbon footprint, might strongly influence the target's compatibility with 1.5°C pathways. The implementation of Nigeria's domestic emissions pathway will be made possible with and through international support to close the gap between its fair share level and domestic emissions level.

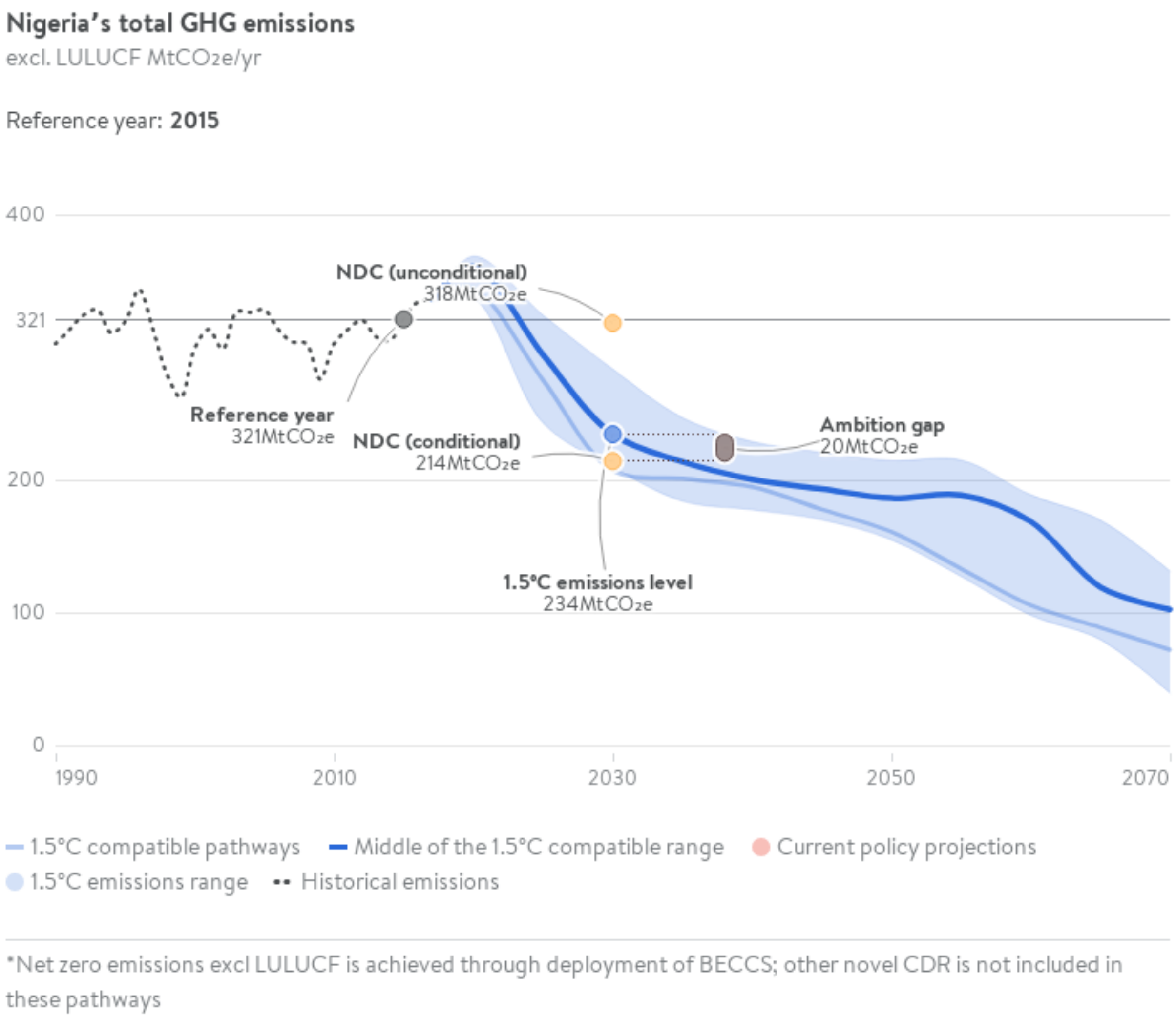

Figure 31: The figure shows national 1.5°C compatible emissions pathways. This is presented through a set of illustrative pathways and a 1.5°C compatible range for total GHG emissions excl. LULUCF. The 1.5°C compatible range is based on global cost-effective pathways assessed by the IPCC SR1.5, defined by the 5th-50th percentiles of the distributions of such pathways which achieve the LTTG of the Paris Agreement. We consider one primary net-negative emission technology in our analysis (BECCS) due to data availability. Net negative emissions from the land-sector (LULUCF) and novel CDR technologies are not included in this analysis due to data limitations from the assessed models. Furthermore, in the global cost-effective model pathways we analyse, such negative emissions sources are usually underestimated in developed country regions, with current-generation models relying on land sinks in developing countries.

Long term pathway

In November 2021, Nigeria adopted a net zero target for 2050 to 2070 with passage of the Climate Change Bill. The bill aims to set five-year carbon budgets under a National Climate Change Action Plan to be ratified by the Federal Executive Council. Additionally, at COP26, President Buhari further committed to net zero emissions by 2060. Nigeria also submitted its Long-Term Strategy (LTS) in December 2021. The LTS includes an emission reduction goal of 50% by 2050 and a move towards net zero emissions across all sectors. Given the ambition to achieve net zero by 2050 at the earliest under the new climate law, the LTS is not in line with these ambitions. Notably, for critical sectors including energy, oil and gas, waste, and cities, the LTS doesn't aim to achieve net zero until the end of the century.

1.5°C compatible pathways show GHG emissions reductions of 42% (33-54%) by 2050 below 2015 levels or 186 (147-215) $MtCO_2e$ (excl. LULUCF) by 2050.[q] While there is high uncertainty on the level of LULUCF emissions, strong efforts to reduce LULUCF emissions will be needed for the country to reach net zero GHG emissions and balance its remaining emissions with the land sector. CO_2 emissions reductions will be enabled largely by the rapid decarbonisation of the power sector, which is also a catalyst for decarbonisation of other sectors. Reductions in the transport and industry sectors would then be the next priority, as they are significant contributors to Nigeria's emissions.

3.1.18 Decarbonisation of the power sector

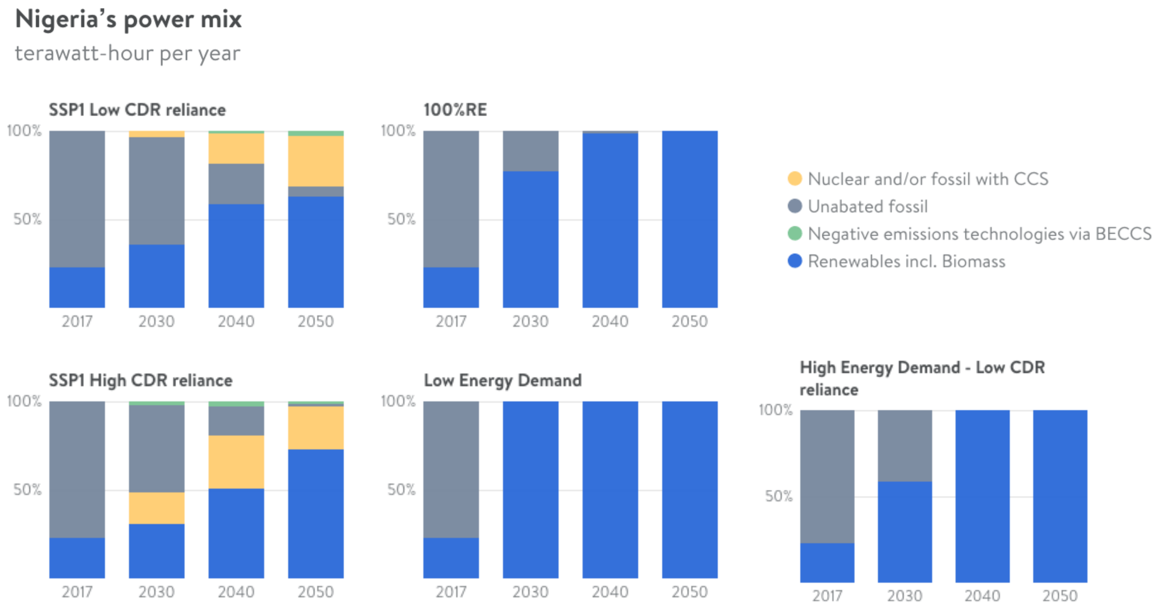

Figure 32: Power mix per technology consistent with 1.5°C compatible emissions pathways.

To be on a 1.5°C compatible pathway, the share of renewable energy in the power mix would need to ramp up from 23% in 2017 to at least 77% by 2030 and 100% by 2050. Nigeria's current target for renewable energy generation in the power sector is 30% by 2030 (Federal Ministry of Power, n.d.).

[q] While global cost-effective pathways assessed by the IPCC Special Report 1.5°C provide useful guidance for an upper-limit of emissions trajectories for developed countries, they underestimate the feasible space for such countries to reach net zero earlier. The current generation of models tend to depend strongly on land-use sinks outside of currently developed countries and include fossil fuel use well beyond the time at which these could be phased out, compared to what is understood from bottom-up approaches. The scientific teams which provide these global pathways constantly improve the technologies represented in their models - and novel CDR technologies are now being included in new studies focused on deep mitigation scenarios meeting the Paris Agreement. A wide assessment database of these new scenarios is not yet available; thus, we rely on available scenarios which focus particularly on BECCS as a net-negative emission technology. Accordingly, we do not yet consider land-sector emissions (LULUCF) and other CDR approaches.

Off-grid renewable energy solutions represent an opportunity to increase renewable-based electricity while expanding electricity access in rural areas, securing reliability of the grid and reducing transmission and distribution losses. In 2017, Nigeria implemented mini-grid regulations providing guidance for systems up to 1 MW and interconnected mini-grids. Phasing out gas in the power sector between 2030 and 2040 would enable the required power sector transformation, to a carbon intensity between zero and 10 gCO2/kWh by 2040. In President Buhari's speech at COP26 in which he committed Nigeria to achieving net zero emissions by 2060, he stated Nigeria can continue using gas until 2040 without compromising the goals of the Paris Agreement. While this is within our 1.5C benchmark range for a gas phase-out, pathways do not show significant expansion of gas before exiting the power mix, with the exception of one scenario. Coal does not currently contribute to the power mix and would not expand in a 1.5°C compatible pathway. Nigeria's 2018 draft revised National Energy Policy includes plans to pursue coal-fired generation in the power sector (Energy Commission of Nigeria, 2018). Considering the long lifetimes and decreasing competitiveness of coal and gas-power plants, delaying decarbonisation comes with significant risks to investors, of stranded assets, as well as risk to society of locking into high-cost, high-emission technologies.

Table 6: 1.5°C compatible power sector benchmarks. Carbon intensity, renewable generation share, and fossil fuel generation share from illustrative 1.5°C pathways for Nigeria

Indicator	Unit	2017	2030	2040	2050	Decarbonised power sector by
Carbon intensity of power	gCO2/kWh	310	0 to 110	0	0	2030 to 2040
	%		−100 to −64%	−100%	−100%	
Share of coal	%	0	0	0	0	
Share of gas	%	77	0 to 23	0	0	2030 to 2040
Share of renewable energy	%	23	77 to 100	100	100	
Share of fossil fuel	%	77	0 to 23	0	0	

Senegal

3.1.19 Current situation

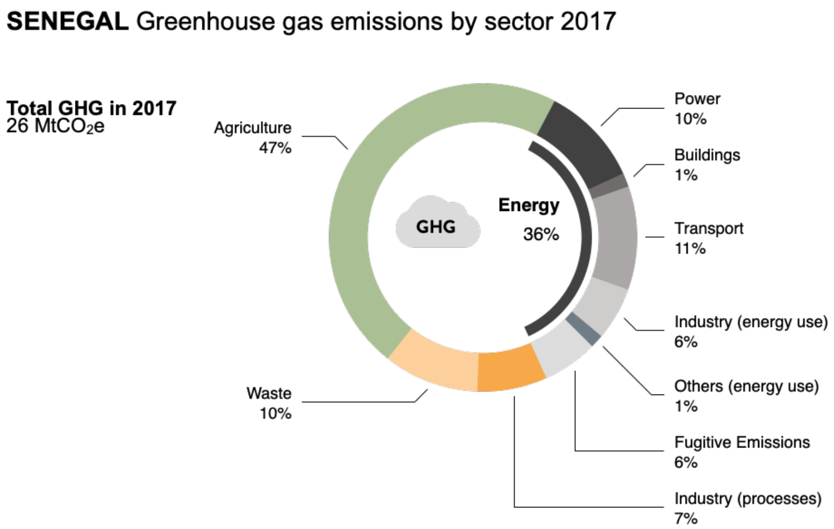

Figure 33 Historical emissions by sector. Sources: PRIMAP-Hist 2019. Energy sub-sectors emissions based on the IEA CO2 Fuel 2019. Inventory year: 2017.

In Senegal, the agriculture and energy sectors are the two main sources of emissions representing 47% and 36% of total emissions in 2017, respectively, excluding LULUCF. Emissions from the agriculture sector will continue to increase through 2030 with enteric fermentation remaining the major category of emissions from this sector (Republic of Senegal, 2020).

Though the agriculture sector represented almost half of Senegal's emissions in 2017, the energy sector is expected to replace agriculture as the largest source of emissions in the country by 2022, representing more than 50% of the country's emissions (Republic of Senegal, 2020). This is mostly driven by an increase in energy demand through growing population and expanding energy access. Absolute energy emissions have increased by approximately 110% since 2010 (Republic of Senegal, 2020). Within the energy sector, the power and transport sectors make up the largest shares of CO_2 emissions.

The remaining sources of emissions are waste and industrial processes. While emissions from the waste sector are projected to slightly increase, emissions from industrial processes are expected to remain stable between 2025 and 2030 (Republic of Senegal, 2020).

The residential and transportation sectors account for 47% and 32% respectively of Senegal's energy consumption, while the industrial sector accounted for 15% of consumption in 2018 (Ministère du Pétrole et des Énergies, 2019). The total final energy consumption increased from 1.69 Mtoe (Tchanche, 2021) in 2000 to 2.715 Mtoe in 2014 (Ministère du Pétrole et des Énergies, 2019), and was mostly driven by the residential sector (Tchanche, 2021). Increased energy demand is a result of successful energy access policies with almost 70% of the population connected as of 2019 (IEA, 2019) and the goal of achieving full access by 2025 (Republic of Senegal, 2020).

Senegal's total national production of energy is dominated by biofuels (predominantly from woody biomass such as firewood and charcoal but also livestock dung) mostly used for cooking appliances and heating. In 2014, biofuel generated 96% of the national energy production with 2% each sourced from gas and hydropower (African Development Bank, 2018b). Senegal imports all fossil fuels used in the country (Tchanche, 2021) with a considerable share of its export revenue going towards paying this bill (in 2018, 48% of its export revenue went towards honouring its import bill) (Ministère du Pétrole et des Énergies, 2019). In 2018, Senegal's energy supply was dominated by imported petroleum products (53%) and locally produced biomass (35%) (Ministère du Pétrole et des Énergies, 2019).

In 2018, electricity contributed approximately 12% to total final national energy consumption (Ministère du Pétrole et des Énergies, 2019). Oil generated approximately 84% of electricity with an additional 9% coming from hydropower, 4% from gas, and 2% from non-hydro renewable energy (African Development Bank, 2018b). While Senegal intends to develop a cumulative installed capacity in solar energy of 235 MW, 150MW in wind energy, and 314 MW in hydropower by 2030, the country is also exploring options for exploiting the oil and natural gas reserves which have been recently discovered (Republic of Senegal, 2020). The exploitation of its oil field, one of the most important in West Africa, should take off from 2023 (Dieng, 2020). Local companies are working on a partnership with British Petroleum (BP) (Dieng, 2020).

3.1.20 Raising ambition

2030 ambition

Senegal's 2020 NDC targets a conditional GHG emission reduction of 29.5% below business-as-usual levels by 2030 (excl. LULUCF), which translates into emissions reductions of 24-59% above 2010 by 2030, or around 28-36 $MtCO_2e$/yr (excl. LULUCF) (Republic of Senegal, 2020). With international support, Senegal’s domestic emissions pathway can be implemented to close the gap between its fair share level and domestic emissions level. Senegal’s 1.5°C compatible domestic emissions reduction levels in 2030 would be 2-23% below 2010 levels or 18-22 $MtCO_2e$/yr (excluding LULUCF).

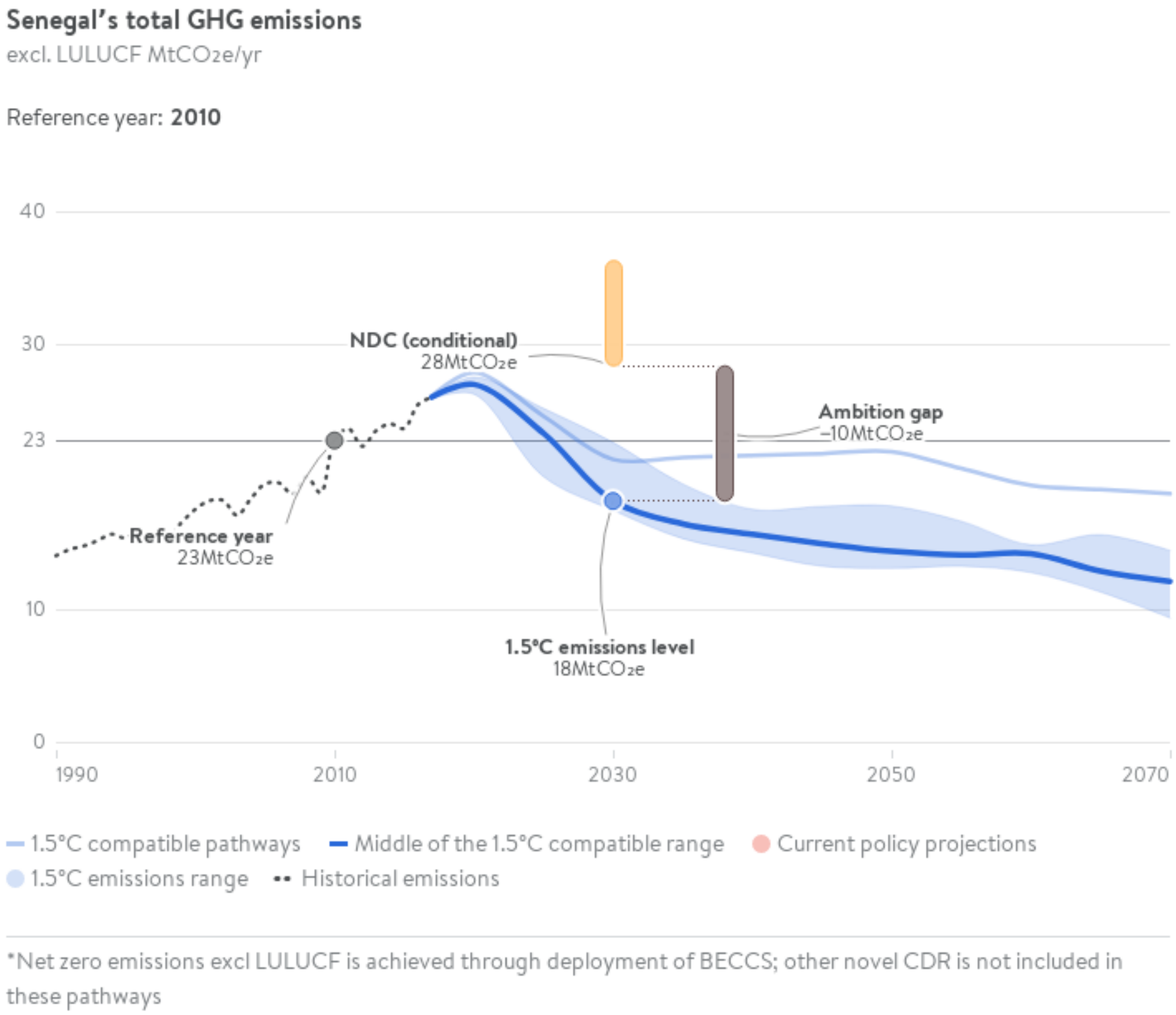

Figure 34: The figure shows national 1.5°C compatible emissions pathways. This is presented through a set of illustrative pathways and a 1.5°C compatible range for total GHG emissions excl. LULUCF. The 1.5°C compatible range is based on global cost-effective pathways assessed by the IPCC SR1.5, defined by the 5th-50th percentiles of the distributions of such pathways which achieve the LTTG of the Paris Agreement. We consider one primary net-negative emission technology in our analysis (BECCS) due to data availability. Net negative emissions from the land-sector (LULUCF) and novel CDR technologies are not included in this analysis due to data limitations from the assessed models. Furthermore, in the global cost-effective model pathways we analyse, such negative emissions sources are usually underestimated in developed country regions, with current-generation models relying on land sinks in developing countries.

Long term pathway

1.5°C compatible pathways for Senegal show remaining GHG emissions levels of 37% below 2010 levels or around 14 $MtCO_2e/yr$ by 2050 excluding LULUCF, and have close to zero CO_2 emissions left.[r] On the road to net zero emissions, remaining emissions will need to be balanced by negative emissions from carbon dioxide removal approaches such as those in the land sector. For example, shifting away

[r] While global cost-effective pathways assessed by the IPCC Special Report 1.5°C provide useful guidance for an upper-limit of emissions trajectories for developed countries, they underestimate the feasible space for such countries to reach net zero earlier. The current generation of models tend to depend strongly on land-use sinks outside of currently developed countries and include fossil fuel use well beyond the time at which these could be phased out, compared to what is understood from bottom-up approaches. The scientific teams which provide these global pathways constantly improve the technologies represented in their models - and novel CDR technologies are now being included in new studies focused on deep mitigation scenarios meeting the Paris Agreement. A wide assessment database of these new scenarios is not yet available; thus, we rely on available scenarios which focus particularly on BECCS as a net-negative emission technology. Accordingly, we do not yet consider land-sector emissions (LULUCF) and other CDR approaches.

from traditional biomass use in primary energy will steer emissions reductions in the LULUCF sector by reducing deforestation and sustaining land-based sinks.

3.1.21 Decarbonisation of the power sector

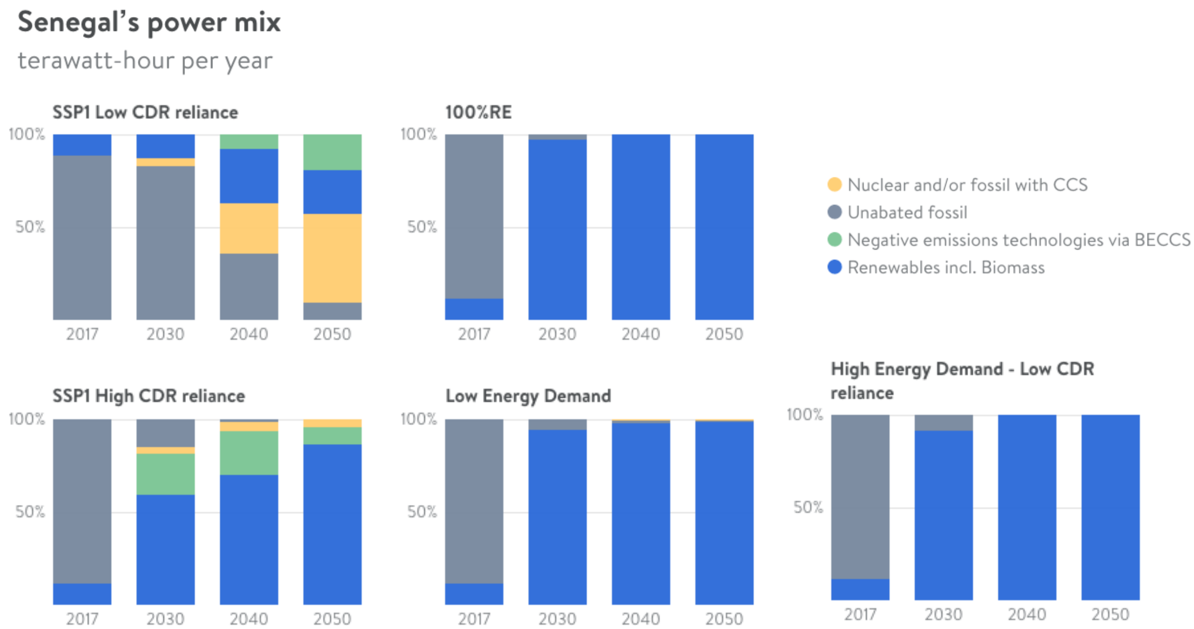

Figure 35: Power mix per technology consistent with 1.5°C compatible emissions pathways.

Under 1.5°C compatible pathways, Senegal's power mix sees a high uptake of renewable energy (including solar, wind, hydro and modern biomass) from a share of 11% in 2017 to 94-97% by 2030, and a sharp reduction of fossil fuels, mostly oil, from 89% in 2017 to 3-5% by 2030. Coal and gas have played a minor role in Senegal's power mix, and in 1.5°C compatible pathways they rapidly phase out, with a shift to 100% renewables by 2040 at the latest. A zero-emissions power sector is reached by 2035 at the latest, mostly driven by the phase-out of oil. Transitioning from oil to renewable energy is an opportunity for the country to shift towards a low carbon energy system with additional co-benefits such as job creation and affordable electricity. It is also a major lever to reduce government expenditure on oil imports. In contrast to Senegal's plans to start exploiting its oil and gas reserves, a shift to Senegal's underexploited renewable energy solar potential would prevent locking in a carbon intensive pathway and the risk of stranded assets. It would also increase the country's energy security as Senegal predominately imports oil for energy consumption. In 2018, traditional biomass (fuelwood and charcoal) accounted for 82% of total residential energy consumption (slightly less than half of Senegal's total final energy consumption). Promoting electric transportation and cooking technologies that run on clean energy would significantly curb household biomass combustion and reduce fossil fuel usage.

Table 7: 1.5°C compatible power sector benchmarks. Carbon intensity, renewable generation share, and fossil fuel generation share from illustrative 1.5°C pathways for Senegal

Indicator	Unit	2017	2030	2040	2050	Decarbonised power sector by
Carbon intensity of power	gCO2/kWh	490	−90 to 20	−220 to 0	−100 to −20	2024 to 2035
	%		−119 to −96%	−146 to −100%	−121 to −104%	
Share of coal	%	7	1 to 2	0	0	2033
Share of gas	%	1	0 to 1	0	0	2018 to 2023
Share of renewable energy	%	11	95 to 97	100	100	
Share of fossil fuel	%	89	3 to 5	0	0	

South Africa

3.1.22 Current situation

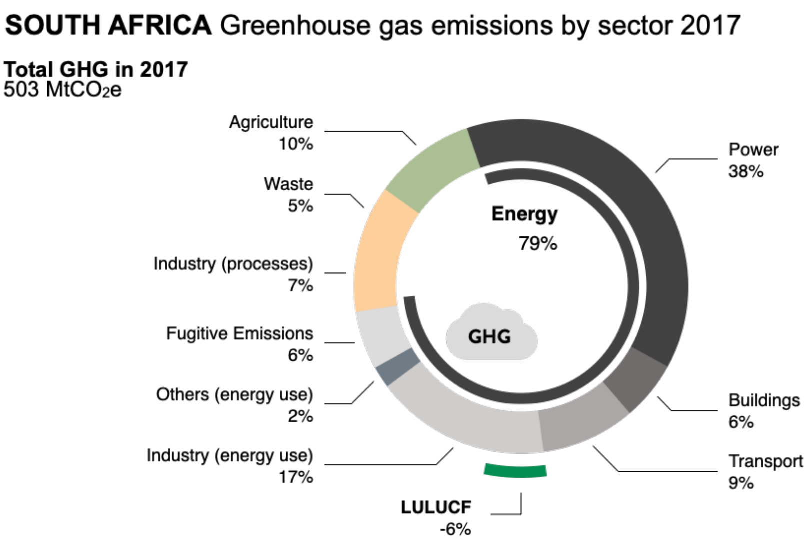

Figure 36: Historical emissions by sector. Sources: Historical emissions from PRIMAP-Hist 2019. Energy sub-sectors emissions based on the IEA CO2 Fuel 2019. LULUCF emissions: latest available data as reported by the Climate Action Tracker 2020 update. Latest available data as reported by the Climate Action Tracker (2020 update)

Between 2000 and 2015 the average annual growth of South Africa's net GHG emissions (including forestry and other land uses) was 1.43%, (Department of Environmental Affairs, 2019) with the energy sector being the dominant contributor (78% of emissions in 2017). South Africa's GHG emissions are predominantly CO_2 from fuel combustion, while Methane (CH_4) and Nitrous Oxide (N_2O) combined constitute less than a quarter of emissions (Department of Environmental Affairs, 2019). The power sector produces 38% of total GHG emissions (excluding LULUCF), followed by industry (energy use), transport and buildings sectors (Climate Analytics, 2020).

Mining, mineral beneficiation and coal-to-liquid fuel processing industries are the main drivers of industrial energy-related CO_2 emissions, which are directly related to the extraction and combustion of fossil fuels. These industries accounted for approximately 17% of total GHG emissions in 2017.

The LULUCF sector provided a small, but increasing sink for emissions between 2009 and 2017 as a result of growing forest cover and a decline in wood losses, as a result of increasing electrification (Department of Environment Forestry and Fisheries, 2020).

South Africa's primary energy supply is dominated by domestic coal, crude oil (mostly imported), renewables, gas and nuclear (Department of Energy, 2019a). Despite a rapid increase in renewables driven by early rounds of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP(Eberhard & Naude, 2017)), the proportion of renewables in the overall energy mix remains a tiny ~6.8% in 2017, while around 75% of total primary energy supply is from coal (Climate Analytics, 2020).

Historically, the development of South Africa's economy was driven by the exploitation of cheap coal. Energy intensive industries like iron, steel, chemicals, petrochemicals and mining still dominate its energy demand profile. The industry and transport sectors together consumed about 70% of energy supplied in 2016 (Department of Energy, 2019a).

In October 2020, the government announced a post-covid economic recovery plan. This plan does not support low carbon development, as it continues support for carbon-intensive sectors like coal, oil and gas, and mining (Climate Action Tracker, 2020b).

3.1.23 Raising ambition

2030 Ambition

In September 2021, the Government submitted its updated NDC of targeting 350-420 $MtCO_2e$/yr including LULUCF by 2030, conditional on international support. The updated NDC translates into emissions reductions of 20-33% below 2010 levels (or 366-436 $MtCO_2e$/yr excluding LULUCF). (Climate Action Tracker, 2021c) This is an increase in ambition compared to the South Africa's draft updated NDC circulated for public consultation in March 2021(Department of Environment Forestry and Fisheries, 2021) A 1.5°C compatible domestic emissions pathway would require a 39% reduction below 2010 levels (or 334 $MtCO_2e$/yr by 2030), excluding LULUCF.

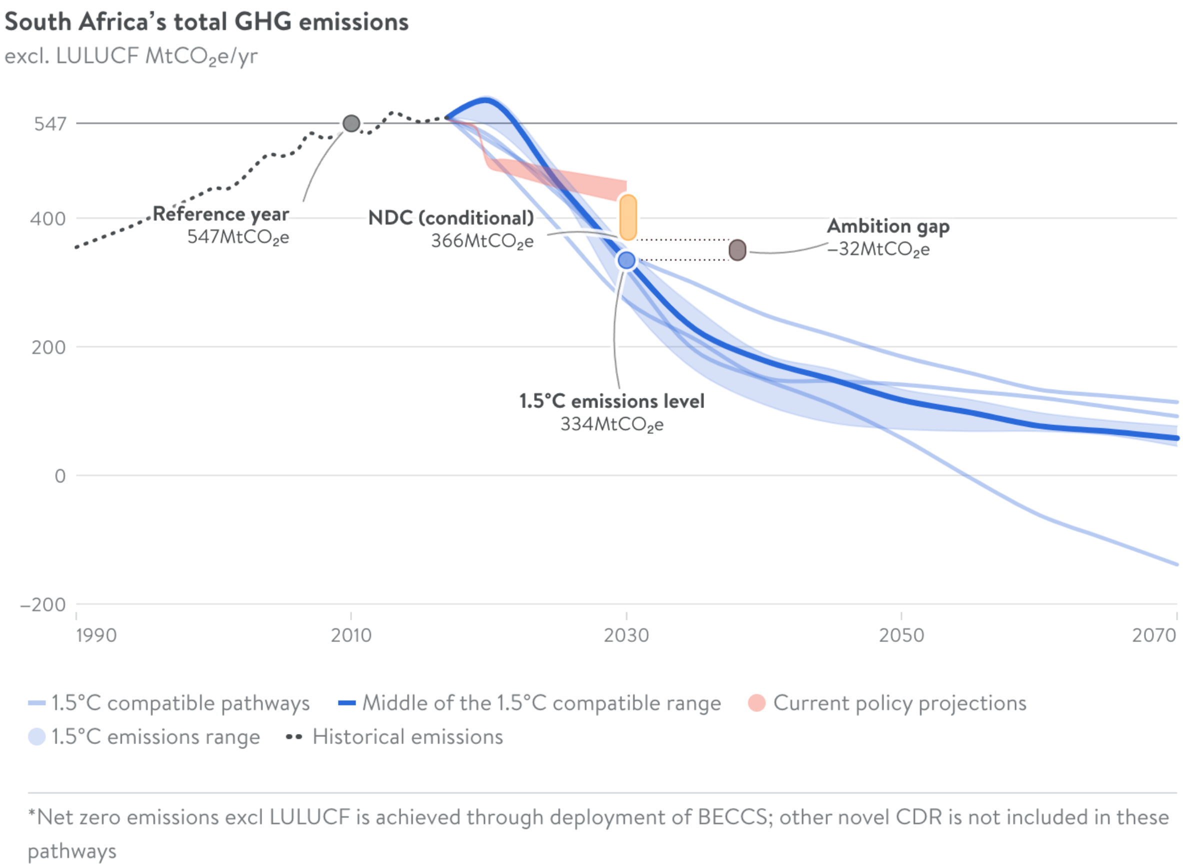

Figure 37: The figure shows national 1.5°C compatible emissions pathways. This is presented through a set of illustrative pathways and a 1.5°C compatible range for total GHG emissions excl. LULUCF. The 1.5°C compatible range is based on global cost-effective pathways assessed by the IPCC SR1.5, defined by the 5th-50th percentiles of the distributions of such pathways which achieve the LTTG of the Paris Agreement. We consider one primary net-negative emissions technology in our analysis (BECCS) due to data availability. Net negative emissions from the land-sector (LULUCF) and novel CDR technologies are not included in this analysis due to data limitations from the assessed models. Furthermore, in the global cost-effective model pathways we analyse, such negative emissions sources are usually underestimated in developed country regions, with current-generation models relying on land sinks in developing countries.

Long term pathway

South Africa's Low Emissions Development Strategy (LEDS) targets an emissions level of 212-428 $MtCO_2e$/yr including LULUCF by 2050, translating to 229-445 $MtCO_2e$/yr excluding LULUCF or 19-58% below 2010 levels (Climate Action Tracker, 2020b) (Republic of South Africa, 2020). Our analysis of 1.5°C compatible pathways for South Africa shows a required reduction in total GHG emissions of 76-87% by 2050 from 2010 levels, when excluding LULUCF, or emissions of 72-134 $MtCO_2e$ by 2050, more than half of the country's current long-term target.[19] A comprehensive restructuring of South Africa's economy away from its historical dependence on fossil fuels is required to reach a 1.5°C compatible emissions trajectory.

[19] While global cost-effective pathways assessed by the IPCC Special Report 1.5°C provide useful guidance for an upper-limit of emissions trajectories for developed countries, they underestimate the feasible space for such countries to reach net zero earlier. The current generation of models tend to depend strongly on land-use sinks outside of currently developed countries and include fossil fuel use well beyond the time at which these could be phased out, compared to what is understood from bottom-up approaches. The scientific teams which provide these global pathways constantly improve the technologies represented in their models - and novel CDR technologies are now being included in new studies focused on deep mitigation scenarios meeting the Paris Agreement. A wide assessment database of these new scenarios is not yet available; thus, we rely on available scenarios which focus particularly on BECCS as a net-negative emission technology. Accordingly, we do not yet consider land-sector emissions (LULUCF) and other CDR approaches.

3.1.24 Decarbonisation of the power sector

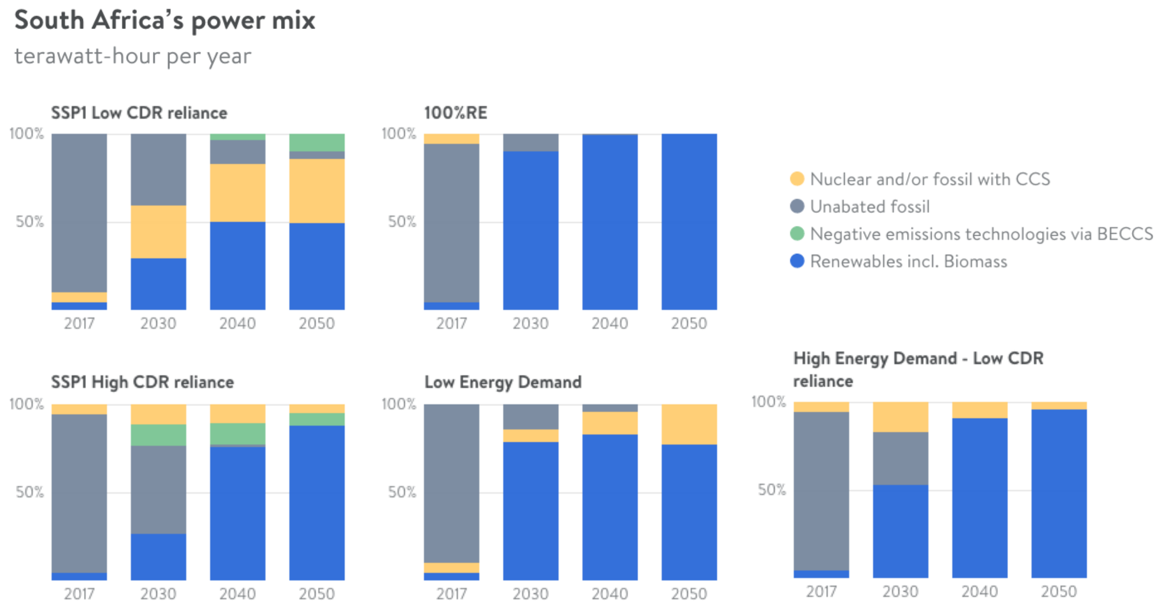

Figure 38: Power mix per technology consistent with 1.5°C compatible emissions pathways.

As the largest emitting sector, the power sector will be critical in the decarbonisation of the South African economy. For the sector to be on a 1.5°C compatible pathway it would need to phase out coal by 2033, and be fully decarbonised by 2035-2040. To achieve this phase-out would require very substantial just transition measures given the high workforce involved in the coal sector.The country's electricity plan (IRP2019) does not include a near-term phase-out of coal, instead it commissions another 1.5 GW of new capacity, which by 2030 would see coal make up 43% of total installed generation capacity, down from 65.5% in 2018 (Department of Energy, 2019b). South Africa has huge renewables potential, in particular for solar and wind power. While the proposed procurement of 6800 MW of renewables in the IRP2019 is promising, renewable power generation to date (4% in 2017) falls far short of what is required to reach 1.5°C compatibility: 78-90% by 2030 and 96-100% by 2050. Current plans to decommission ageing coal plants are insufficient and undermined by plans for new fossil fuel capacity.

Table 8: 1.5°C compatible power sector benchmarks. Carbon intensity, renewable generation share, and fossil fuel generation share from illustrative 1.5°C pathways for South Africa

Indicator	Unit	2017	2030	2040	2050	Decarbonised power sector by
Carbon intensity of power	gCO_2/kWh	850	80 to 140	−120 to 0	−80 to −20	2036 to 2040
	%		−91 to −83%	−114 to −100%	−110 to −102%	
Share of coal	%	90	10 to 14	0	0	2033
Share of gas	%	0	0	0	0	
Share of renewable energy	%	4	78 to 90	91 to 99	96 to 100	
Share of fossil fuel	%	90	10 to 14	0 to 1	0	

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5 Annex I: Countries in region 'Africa'

Countries considered in the region Africa:

Algeria
Angola
Benin
Botswana
Burkina Faso
Burundi
Cameroon
Cabo Verde
The Central African Republic
Chad
The Comoros
The Congo
The Democratic Republic of the Congo
Ivory Coast
Djibouti
Egypt
Equatorial Guinea
Eritrea
Eswatini
Ethiopia
Gabon
Ghana
Guinea
Guinea-Bissau
Kenya
Lesotho
Liberia
Libya
Madagascar
Mali
Malawi
Mauritania
Mauritius
Morocco
Mozambique
Namibia
The Niger
Nigeria
Rwanda
Sao Tome and Principe
Senegal
Seychelles
Sierra leone
Somalia
South Africa
South Sudan
The Sudan
The Gambia
Tanzania
Togo
Tunisia
Uganda
Western Sahara
Zambia
Zimbabwe

ABOUT CLIMATE ANALYTICS

Climate Analytics is a non-profit climate science and policy institute based in Berlin, Germany with offices in New York, USA, Lomé, Togo, Perth, Australia, Kathmandu, Nepal and Port of Spain, Trinidad and Tobago. It seeks to empower those most vulnerable – Small Island Developing States and Least Developed Countries – to use the best science and analysis available in the international climate negotiations, as well as in developing policies and institutional capacity to adapt to climate change. Climate Analytics undertakes extensive research on the 1.5°C temperature limit in the Paris Agreement, evaluates progress on climate action and shows governments how they can act on their policies to keep global warming to this limit.

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