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Implementation of Nationally Determined Contributions

Kenya Country Report

For our Environment

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Implementation of Nationally Determined Contributions

Kenya Country Report

by

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Introduction to the project

This country report is part of the "Implementation of Nationally Determined Contributions" (NDCs) project (FKZ 3716 4111 80), which considers NDC implementation in 10 countries: Colombia, Ethiopia, Georgia, Indonesia, Iran, Kenya, Marshall Islands, Morocco, Peru, and Viet Nam. This project places a special emphasis on identifying potential barriers to NDC implementation and mitigation potentials which could go beyond the current NDCs.

The country reports analyze the NDCs in terms of their robustness and coherence with other national or sectoral plans and targets, and put them into the context of additional mitigation potentials and other national circumstances. For countries where coal plays a critical role in consumption or national production, the analysis covers further details on this sector, including the economic relevance and local impacts of coal production or consumption. The content is based on available literature from research and public sector information on policies and institutions.

To be able to analyze the content in more detail, the authors focus the research on a number of relevant fields of action. The fields of action were selected based on historic and projected sectoral emissions development, comprehensive literature on GHG mitigation potentials, identified barriers and emissions reductions as well as feasibility, costs, and co-benefits.

The project was suggested and is financed by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, supervised by the German Environment Agency and carried out by independent think tanks - NewClimate Institute and Wuppertal Institute. The country reports are a continuation of similar previous efforts (project numbers 3713 41 102, 3711 41 120, 360 16 022, 364 01 003 and 363 01 128) and aim to inform policy makers and the interested public about the implementation of NDCs in individual countries. The choice of countries is based on developing countries with which Germany works closely on climate change topics.

The country reports are scientific in nature, and all suggestions are derived by the authors from careful analysis, having in mind the individual backgrounds of countries. They aim to increase knowledge about implementation of mitigation potentials to meet the globally agreed goal of staying within a temperature increase of 1.5°C or well below 2°C above preindustrial levels, without intending to prescribe specific policies.

Overview

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List of abbreviations

ASAL	Arid and Semi-Arid Land
BAU	Business as Usual
BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
BMZ	German Federal Ministry for Economic Cooperation and Development
CAHOSCC	Committee of African Heads of State and Government on Climate Change
CDM	Clean Development Mechanism
CSA	Climate Smart Agriculture
DKTI	Deutsche Klimatechnologie-Initiative
GCM	General Circulation Model
IKI	International Climate Initiative
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPPs	Independent Power Producers
KFS	Kenya Forest Service
LPG	Liquid Propane Gas
LULUCF	Land Use, Land Use Change, and Forestry
MENR	Ministry of Environment and Natural Resources
MOEP	Ministry of Energy and Petroleum
MRV	Monitoring, Reporting, and Verification System
$MtCO_2e$	Mega tonnes carbon dioxide equivalent
NAMA	Nationally Appropriate Mitigation Actions
NCCAP	National Climate Change Action Plan
NCCC	National Climate Change Council
NDC	Nationally Determined Contribution
PGTMP	Power Generation and Transmission Master Plan
PV	Photovoltaic
REA	Rural Electrification Authority
REDD+	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
SNC	Second National Communication
UNFCCC	United Nations Framework Convention on Climate Change

1 Part I: Summary

1.1 Country background

Kenya's **population** has grown 91% since 1990, and is expected to continue growing, with increasing urbanization. 45% of the population lives under the national poverty line and unemployment is widespread, particularly among youth. Population growth has put pressure on natural resources, including forests and water.

Kenya is classified as a water scarce country, and 80% of the country is Arid and Semi-Arid Lands, commonly referred to as the ASALs. Kenya is **vulnerable to climate change**, particularly its projected impact on water resources. Kenya's geographical location on the East African rift gives it a high potential for geothermal energy, and it also has potential for wind and solar generation. Kenya's hydroelectricity infrastructure is vulnerable to drought, and there is little potential for expansion.

The agricultural and forestry sectors make up the largest share of Kenya's **economy** (25%), and are vulnerable to climate change, partially because of their dependency on water. Kenya is categorized as a lower middle-income country and had a GDP/capita of 1368 USD/capita in 2014, although recent economic growth has disproportionately benefited the wealthy. Vision 2030 is Kenya's long-term **development** strategy, the economic pillar of which aims for 10% economic growth annually. Actual economic growth between 2012 and 2016 was between 5 and 6%.

Politically, Kenya is a unitary state with a multi-party **political system**. Power at the federal level is divided between the executive, a bicameral legislature, and the judiciary. In 2010, a new constitution created a devolved two-tier government, which consists of a national government and 47 county governments. Corruption is a challenge, and Transparency International's corruption perceptions index ranked Kenya 145th out of 176 countries in 2016.

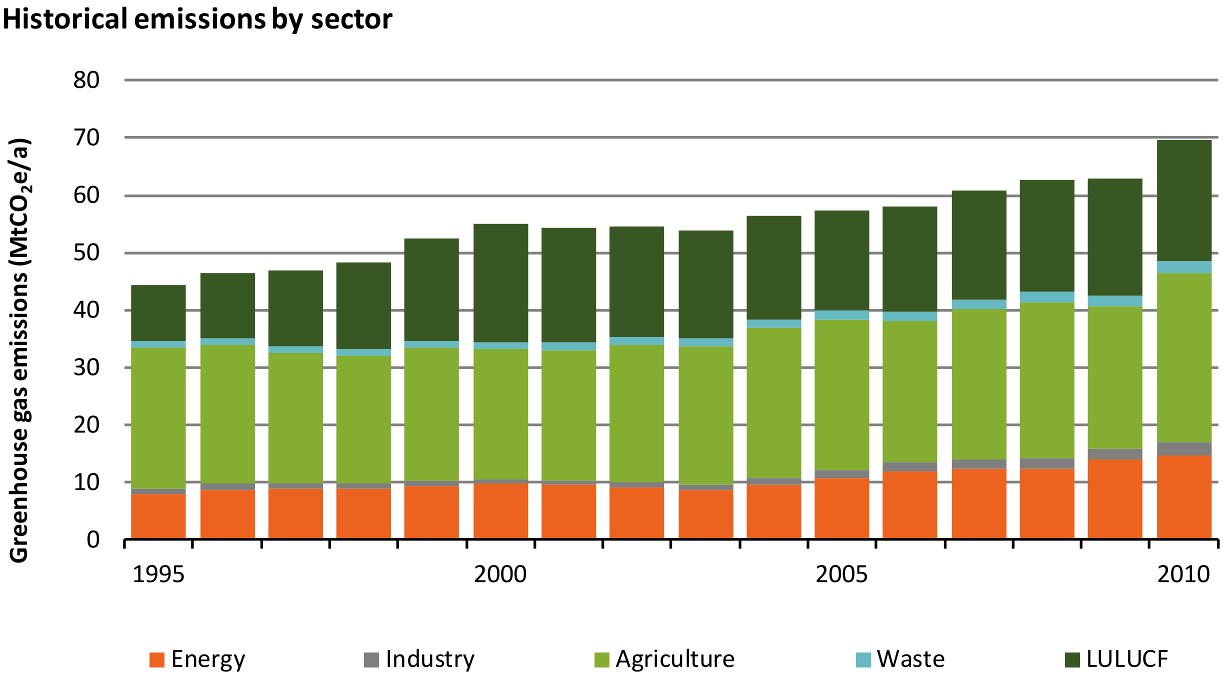
Kenya's overarching national **climate change legislation** is the Climate Change Act (2016), which seeks to mainstream climate change planning in all sectors and at all levels of government. The act created the National Climate Change Council, which will provide overarching coordination, and the Climate Change Fund. All climate action (including addressing the NDC) will be planned and implemented through the National Climate Change Action Plans (NCCAP) which will be reviewed every five years. The next NCCAP is due in June 2018.

1.2 Emissions and energy use

Historically, the agriculture and Land Use, Land Use Change, and Forestry (LULUCF) sectors have been Kenya's largest sources of greenhouse gas emissions (Government of Kenya 2015). Emissions in the agriculture sector are primarily from livestock, while emissions in the LULUCF sector are from deforestation driven by wood harvesting for cooking and heating and land clearing for agriculture (Stiebert and Owino 2015). Biomass made up two-thirds of Kenya's primary energy supply in 2014, most of which was used residentially (IEA 2016a).

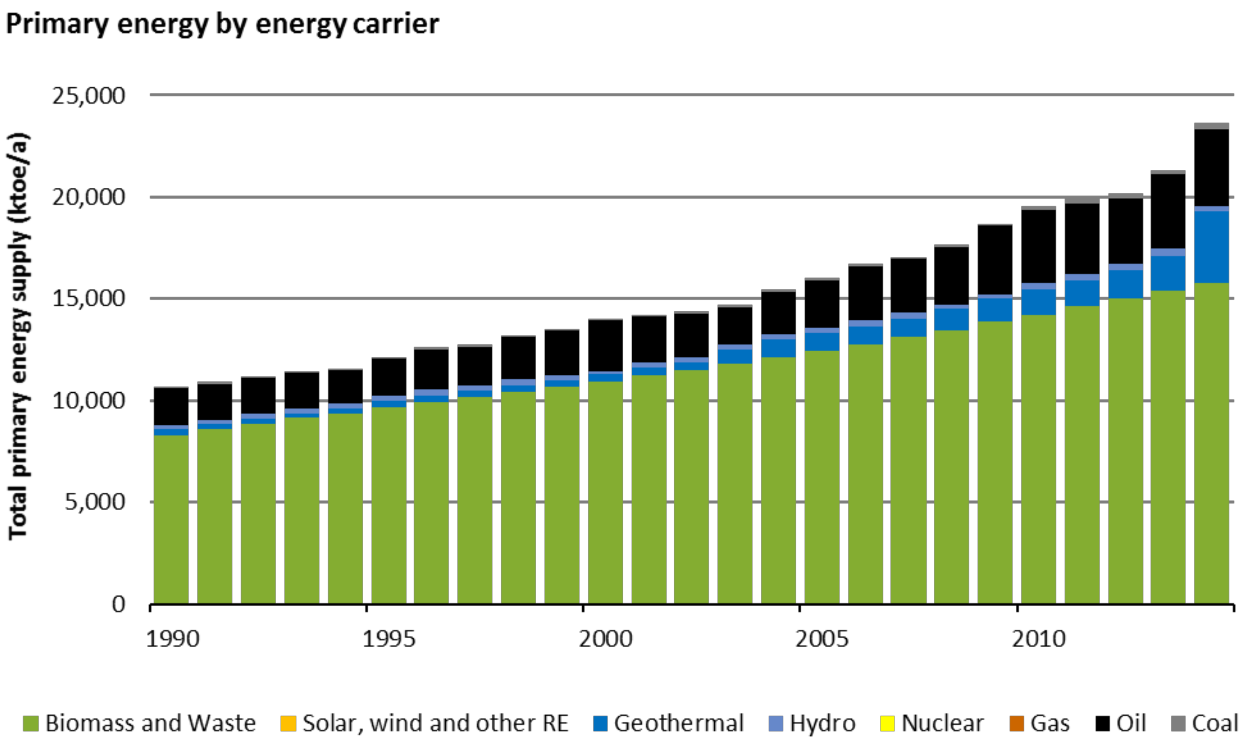
In the future, emissions are projected to rise in all sectors, particularly from electricity generation (MENR 2017b). Emissions from electricity generation are projected to grow significantly due to very optimistic demand scenarios and added fossil fuel capacity, including coal. Renewable energy, primarily geothermal and hydro, accounted for 86% of electricity generation in 2015/2016, and 300 MW of new wind energy capacity were built in 2017 (KPLC 2017a). However, the Kenyan government also licensed a 1050 MW coal plant to be built in Lamu, despite an ongoing legal case over its potential environmental and social impacts, which, if built, could see Kenya's emissions from the electricity sector rise 600% above 2010 levels. Alternative supply and demand scenarios suggest that Kenya could meet its future electricity demand with renewables capacity, keeping emissions from the electricity sector low, and achieving the NDC target (the authors based on Lahmeyer International, 2016).

Figure 1: Kenya's emissions profile



Greenhouse gas inventory data from Kenya's Second National Communication Government of Kenya (2015)

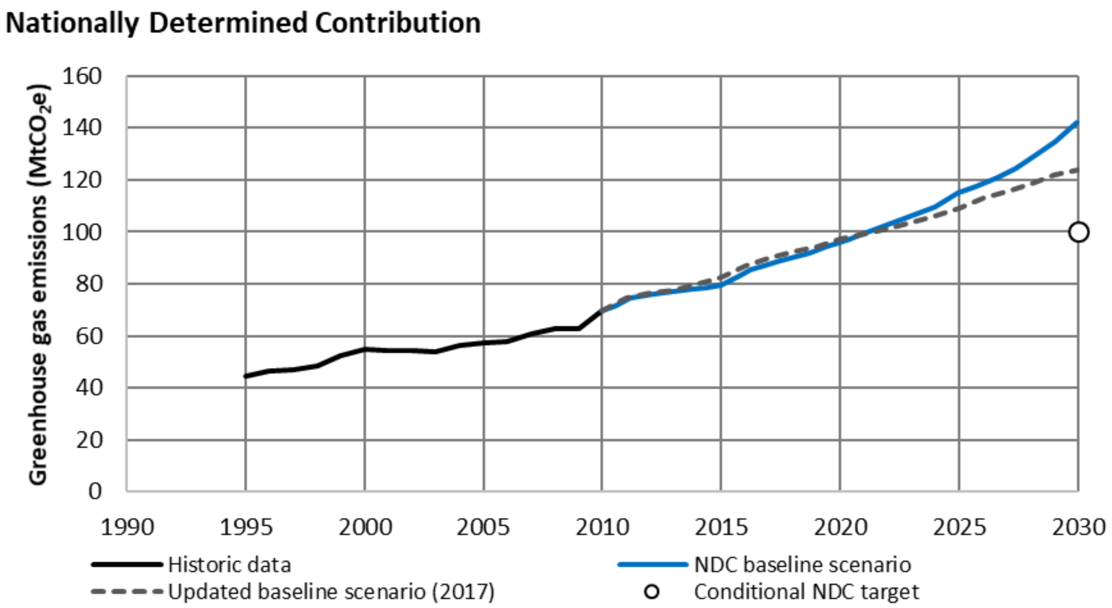
Figure 2: Kenya's historical energy profile



Data sources: IEA (2016a)

1.3 NDC and ongoing activities

Figure 3: Kenya's projected emissions and NDC targets (incl. emissions from LULUCF)



Data sources: Government of Kenya (2015); MENR (2015), (2017b)

Kenya's NDC includes both mitigation and adaptation measures and notes that Kenya's capacity to undertake strong mitigation actions is dependent on support for implementation of the adaptation actions (MENR 2015). The NDC mitigation target is a 30% reduction below Business as Usual (BAU) in 2030, and is referenced to a BAU scenario of 143 $MtCO_2e$ in 2030, indicating a target of 100 $MtCO_2e$ in 2030. Meeting the NDC target would see Kenya's emissions rise 43% from 2010 levels.

In 2017, the Ministry of Environment and Natural Resources (MENR) updated the emissions projections for Kenya based on updated inventory data, new electricity forecasts, and new economic growth projections, bringing the country 43% of the way toward meeting the NDC target. Despite the updated baseline, the government clarified that the NDC target remains referenced to the BAU scenario specified in the NDC.

Sectoral analysis of how Kenya can achieve its NDC target expects the forestry sector to make the largest contributions, followed by the electricity generation and energy demand sectors (MENR 2017c).

1.4 Mitigation potential and barriers

Kenya conducted an economy wide analysis of technical mitigation potentials in preparation for the National Climate Change Action Plan (2013 – 2017) (NCCAP), which found that emissions could be reduced by 60% below BAU in 2030 (Government of Kenya 2013). The NDC target expected to take advantage of half of this technical potential. Further work since the NDC was submitted has clarified how the NDC target can be achieved by dividing emissions reductions among sectors (MENR 2017c).

In this study, we look further into the following three areas of mitigation action in Kenya, assessing mitigation measures and their emissions reduction potential, co-benefits, and barriers to implementation:

1. Reforestation, afforestation and decreasing deforestation
2. Efficient biomass and renewable energy cookstoves

3. Accelerating renewable electricity

These areas of action were selected for further analysis because they are in the sectors with the largest technical and implementable mitigation potentials based on the NCCAP and the NDC sectoral analysis (MENR 2017d). Furthermore, each area of action has significant co-benefits, including sustainable development and climate change adaptation benefits. Together, these three fields of action could lead to emissions reductions of at least 60 MtCO_2e in 2030 as compared to the NDC baseline, and possibly even higher reductions.

The first field of action: "**Reforestation, afforestation, and reducing deforestation**," has a technical emissions reduction potential of over 40 MtCO_2e in 2030, including carbon sinks from growing forests. Measures that increase forest cover have climate resilience and adaptation co-benefits, including securing water resources and reducing the risk of flooding and landslides. Further economic benefits include supporting the tourism industry, providing employment opportunities, and potentially enabling carbon payments. Awareness of the importance of forests in Kenya is high among policy makers and certain communities, and the constitution stipulates that forests should cover 10% of Kenya's land area (forest area was ~7% in 2010). However, Kenya has found it difficult to reconcile its forest goals with the energy and nutrition demands of a growing population, while the amount of land is fixed. Major barriers to decreasing deforestation are the prevalence of biomass use for cooking and heating, increasing population, human settlement, and agriculture, together with inadequate data availability to monitor changes in forest cover. Furthermore, much of previously forested land is settled or used for grazing livestock, meaning that for restoration projects that require limiting access to tracts of forest, pastoralists need to be compensated for not being able to graze their animals on the land, either through alternative grazing areas or alternative livelihoods.

The second field of action: "**Efficient, biomass and renewable energy cookstoves**," is a priority for addressing deforestation and has the potential to reduce emissions by at least 5.6 MtCO_2e in 2030, although this could be higher with expanded implementation of ethanol cookstoves, which use no wood or charcoal whatsoever. Instead, the renewable ethanol fuel is produced as a by-product of Kenya's sugar manufacturing industry. These measures have negative costs over time because increased stove efficiency saves money on fuel. More efficient wood and charcoal cookstoves, and better yet, ethanol stoves, reduce not only CO_2 emissions from deforestation, but also black carbon emissions from cooking. The stoves improve indoor air quality, which has strong positive health benefits, particularly for women and children, who tend to spend more time in the kitchen, and improves the standard of living. Further co-benefits include employment opportunities from producing stoves and fuel in Kenya and energy independence. The main barrier for expanding improved cookstoves is upfront investment – many families cannot afford even a modest investment for an improved stove, although pilot projects have shown that low or no-interest loans are an effective way to overcome this barrier. In the case of ethanol stoves, a distribution network for ethanol fuel is needed to accelerate implementation.

The third field of action: "**Accelerating renewable electricity**," includes measures that the NCCAP analysis found would decrease emissions in 2030 by 16 MtCO_2e, as compared to the NDC baseline. However, the low-carbon scenario in the NCCAP still includes coal generation, and therefore the potential could be even higher if Kenya's future electricity demand were met entirely with renewables – 42 MtCO_2e as compared to the NDC baseline in 2030. On grid, this concretely means pragmatically expanding geothermal, wind, and solar capacity to meet demand, and there is also potential to use distributed solar systems to bring electricity to rural homes that are far removed from a grid connection. Investing in geothermal, wind, and solar energy could lower costs for consumers, improve energy security by avoiding fuel imports, create employment opportunities, and enhance climate resilience by reducing reliance on hydropower. Renewable sources of electricity additionally have much lower environmental and health impacts than coal-fired power plants. Distributed solar systems can improve rural livelihoods by providing access to electricity, which can be used for income generating activities, pumping safe drinking water, and providing indoor lighting and mobile phone charging, among other benefits. Barriers to implementation include building transmission infrastructure, land disputes, and upfront financing for exploration and development.

Addressing further challenges, such as widespread poverty, unemployment, and corruption will be an important part of a successful low carbon development pathway.

2 Part II: Full country analysis

2.1 Country background

2.1.1 Geography

Figure 4: Map of Kenya

Source: Google Maps

Kenya spans the equator, stretching between 5°S and 5°N latitudes, and 34°E and 42°E longitudes. With an area of 582,646 km², it is slightly smaller than France, and borders Somalia, Ethiopia, South Sudan, Uganda, and Tanzania. To the southeast, Kenya has 536 km of coastline on the Indian Ocean.

Elevation in Kenya reaches from sea level at the south-eastern coast to 5,200 m at peak of Mount Kenya near the centre of the country. The landscape can be divided into lowlands and uplands, with the moister uplands in the western part of the country housing the bulk of Kenya's population and farmland. The Great Rift Valley runs through western Kenya, contributing to its significant potential for geothermal energy.

85% of Kenya's land area is arid and semi-arid land, commonly referred to as the ASALs. These areas house only 20% of the population, but produce 70% of Kenya's livestock (Government of Kenya 2015).

Rainfall in Kenya is strongly seasonal, and most parts of Kenya have two wet periods – the "Long Rains," from March to May, and the "Short Rains" from October to December. The rains are separated by a hot and dry period from mid-December to mid-March and a cooler dry period from June to September.

2.1.2 Population

In 2014, Kenya's population was 45 million, having increased by 91% since 1990 (World Bank 2017). Approximately two-thirds of Kenyans live in rural areas. The population is growing rapidly, and fast urbanization has contributed to increasing urban poverty and declining food production (Government of Kenya 2015).

45% of the population lives under the national poverty line, in the sense of being unable to buy enough food to meet daily nutritional requirements and meet basic non-food needs. Recent economic growth has disproportionately benefited the wealthier population. Poverty is more common in rural areas, and in the ASALs, poverty levels are above 70%. Unemployment is widespread, particularly for youth – 61% of youth (ages 15-29) are unemployed (Government of Kenya 2015).

Kenya's population is ethnically diverse, with 43 different ethnic groups. The largest groups are the Kikuyu, Luhya, Luo, Kamba, and Kalenjin, which together make up 66% of Kenya's population. Politically, ethnicity often determines party allegiance (Maina 2017).

Table 1: Key socio-economic figures

Indicator	Kenya	% change since 1990	World	Germany	Year
Population [million]	**45**	*91%*	7261	81	2014
GDP [2017 billion USD]	**61**	*616%*	78630	3879	2014
GDP/Cap [2017 USD/cap]	**1368**	*274%*	10,829	47,903	2014
HDI [0 – 1]	**0.55**	*16%*	-	0.92	2014
Electrification rate [%]	**63%**[1]	*111%*	85%	100%	2017
GINI index [0 – 100]	**48.5**	-	-	30.1	2005
Corruption index [1 – 6]	**3**	-	2.9	-	2014
Urbanization [% of total]	**25%**	*50%*	53%	75%	2014

Data sources: UNDP (2015); United Nations (2014); ND-GAIN (2017); World Bank (2017), GDP per capita calculated based on World Bank (2017), electrification rate for Kenya from KPLC (2017b)

[1]Kenya's 2017 electrification rate is based on a press release from Kenya Power, Kenya's partially government owned electricity distributor. Kenya's government is working toward 100% electrification by 2020, and is eager to show progress toward that goal. The way that the government defines electrification rate (proximity to a grid connection) is controversial, and studies have shown that many households that are close to a transformer still do not have electricity (Lee et al. 2016). Electricity is expensive for many Kenyans, and many of those who do have a grid connection cannot afford the electricity. Therefore, by other measures, the electrification rate is likely lower. The World Bank estimated the electrification rate to be 36% in 2014.

2.1.3 Economy

Kenya is classified as a lower middle-income country and had a GDP of US$70.5 billion in 2016. Between 2012 and 2016, economic growth was between 5 and 6% (World Bank 2017).

Agriculture and forestry contribute the most of any sector to Kenya's economy, at about 25%. The natural resources sector in total makes up 42% of the GDP (agriculture, forestry, fishing, tourism, water supply, and energy). The services sector contributes approximately 50% (transport and communication, wholesale and retail trade, financial and other services). Industry (manufacturing, construction, mining and quarrying) makes up the rest (Government of Kenya 2015).

Kenya's main exports are tea, coffee, and cut flowers.

Vision 2030 is Kenya's long-term development blueprint and aims to "transform Kenya into a newly industrializing, middle-income country providing a high quality of life to all its citizens by 2030, in a clean and secure environment." The economic pillar of Vision 2030 seeks to achieve an average 10% GDP growth rate/year beginning in 2012 (Government of Kenya 2015).

2.1.4 Political system

Kenya is a unitary state with a multi-party political system, which achieved independence in 1963. In 2010, a new constitution created a devolved two tier government consisting of a national government and county governments. Kenya has 47 autonomous counties, whose governments have defined responsibilities and functions.

The Kenyan constitution separates power between three arms of government: the executive, a bicameral legislature, and the judiciary.

Widespread corruption is a central challenge in Kenya, and the 2016 Transparency International corruption perceptions index ranked Kenya 145th out of 176 countries, with a score of 26 on a scale of 0 to 100, with 0 being highly corrupt. Countries with the same score as Kenya include Cameroon, Gambia, Bangladesh, Madagascar and Nicaragua (Transparency International 2017).

In 2007, Kenya experienced an outbreak of partially ethnically driven violence after elections which led to around 1200 deaths.

2017 Elections

General elections were held on 8 August 2017, with a reported 54% of the vote going to incumbent president Uhuru Kenyatta, of the Jubilee Party. The Kenyan Supreme Court annulled the election results on 1 September 2017, saying that the election was marred by "irregularities and illegalities." Although the head of Kenya's electoral commission said that his proposed changes were not implemented after the August election, making it "difficult to guarantee a free, fair, and credible election" (BBC 2017), new elections were held on 26 October 2017. The incumbent president Kenyatta won the October election with 98% of the vote, after supporters of the opposition candidate, Raila Odinga, boycotted the election and prevented polls from opening in the western part of the country (Reuters 2017).

2.1.5 Energy system

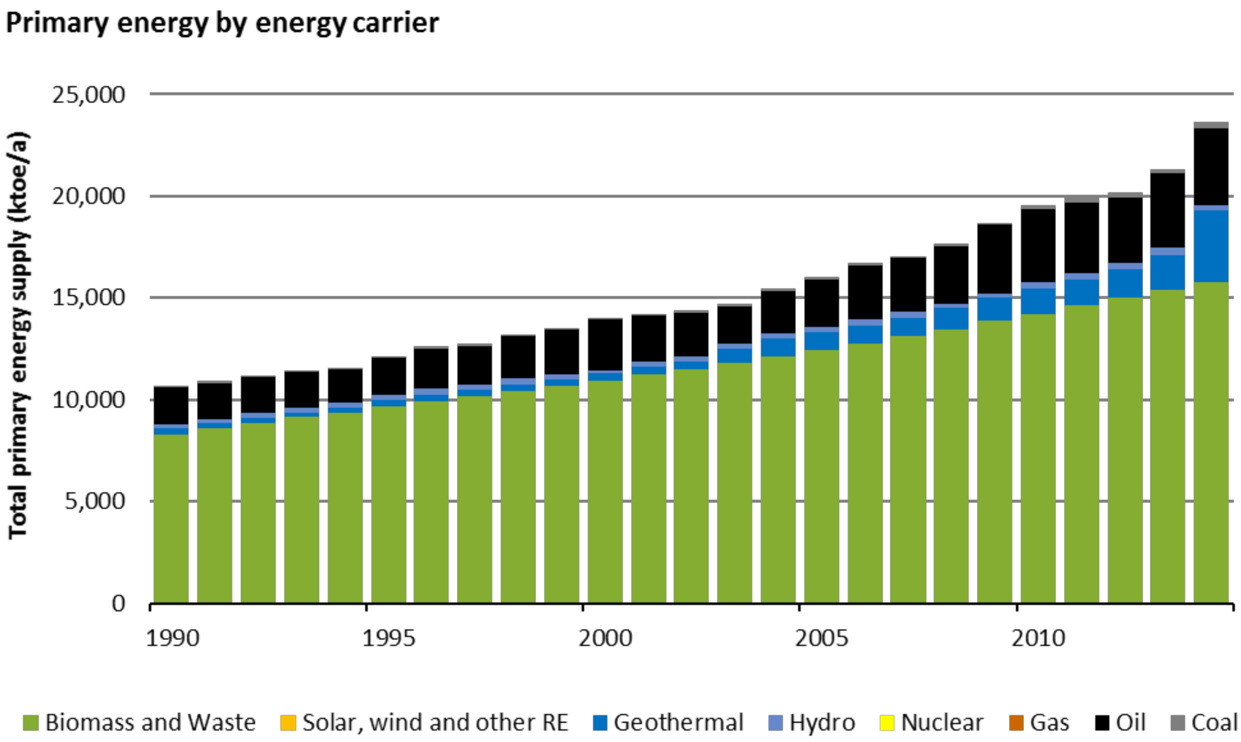
Biomass dominates Kenya's primary energy supply, and made up two thirds of the supply in 2014 (Figure 5) (IEA 2016a). Geothermal energy and oil account for most of the rest of the supply, at 15%

and 16%, respectively. Biomass, mainly wood fuel and charcoal, is used for cooking and is sourced primarily from Kenya's forests, which have as a result suffered significant deforestation over the past decades.

As of 2014, Kenya produced no coal or oil products and imported all of what it used (IEA 2016c). The country had an oil refinery that processed imported crude oil until 2013, when it was shut down. During operation, the refinery products were used mostly for domestic consumption while the balance was exported to Kenya's landlocked neighbours. Now, however, Kenya imports all of its petroleum products. In 2017, multinational Tullow Oil began extracting oil in Kenya, which is slated for small scale export. In the future, additional infrastructure development could lead to increased production and exports, including a pipeline. Kenya has coal reserves in the country, but these have so far not been developed, despite government plans to eventually do so (Otuki 2017b).

In terms of final energy consumption, the residential sector consumes by far the most energy, accounting for 75% of all consumption in 2014. This is followed by the transport sector at 15% and industry at 8% (IEA 2016a).

Figure 5: Kenya's energy profile



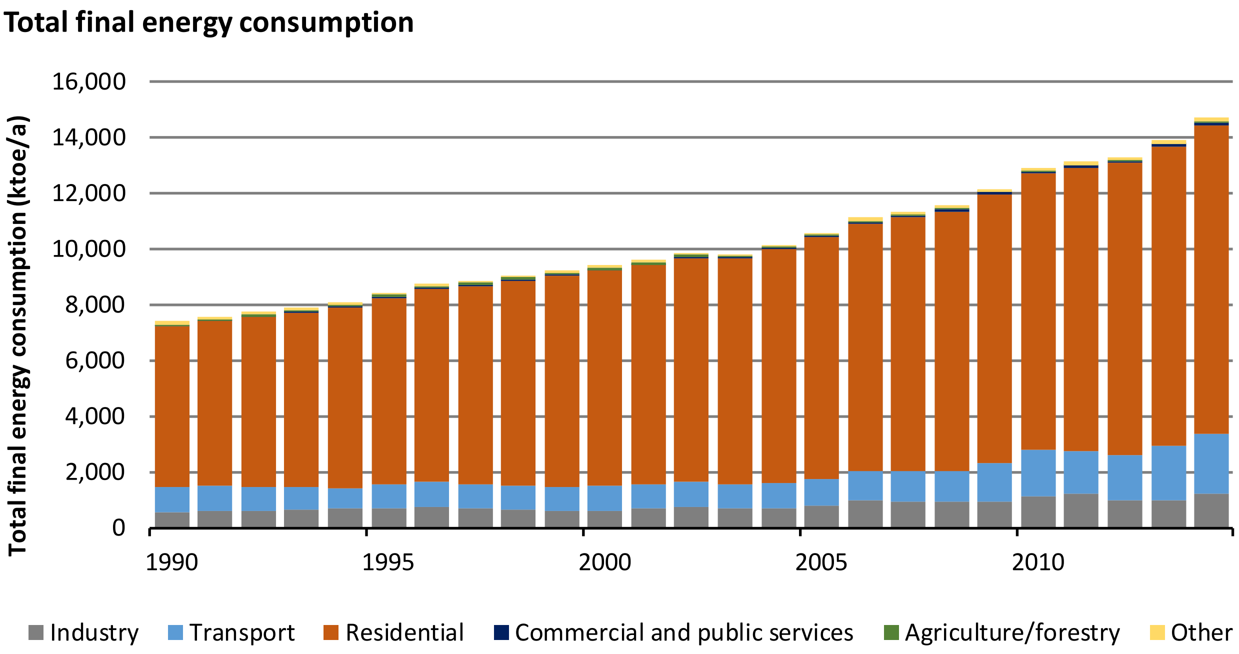
Data sources: IEA (2016a)

Table 2: 2014 total primary energy supply by fuel from IEA

Fuel	Value	Unit	Share in 2014
Biomass and waste	15795	ktoe	67%
Solar, wind and other RE	3.4	ktoe	0%
Geothermal	3489	ktoe	15%
Hydro	285	ktoe	1%
Nuclear	0	ktoe	0%
Gas	0	ktoe	0%
Oil	3725	ktoe	16%
Coal	328	ktoe	1%

Data sources: IEA (2016a)

Figure 6: Kenya's total final energy consumption by sector



Data sources: IEA (2016a)

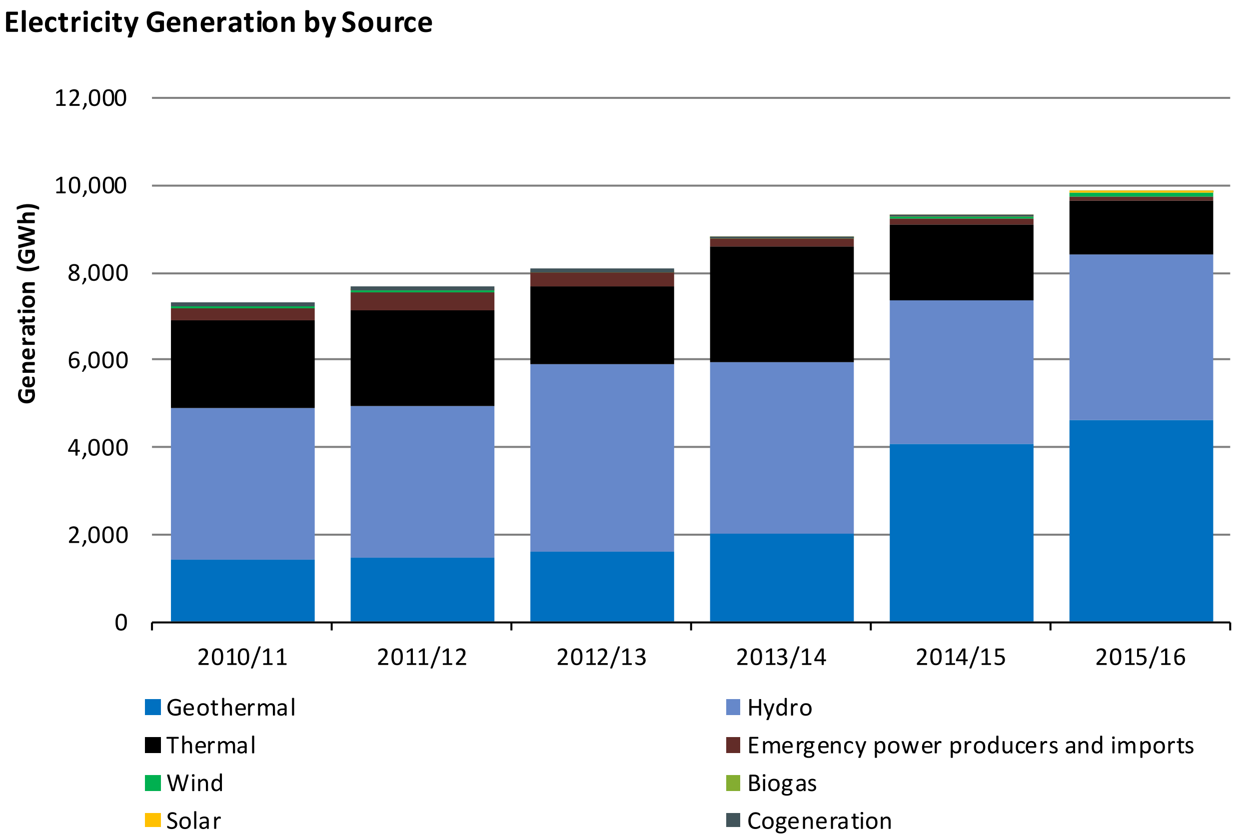
2.1.6 Electricity access and generation

Electricity access in Kenya stood at 36% in 2014, according to World Bank data. In rural areas, this was 12%, whereas in urban areas, it was 68% (World Bank 2017). The Kenyan government has been working to increase electrification rates, for example through its Last Mile Connectivity program, and has set a target of universal access to electricity by 2020. In March 2017, Kenya Power, Kenya's partially government owned electricity distributor, reported that 63% of Kenyan households were connected to the grid (KPLC 2017b). The way that the government defines access to electricity (proximity to a grid connection) is controversial, and studies have shown that many households that are close to a transformer still do not have electricity (Lee et al. 2016). Electricity is expensive for many Kenyans, and many of those who do have a grid connection cannot afford the electricity. Therefore, by other measures, the rate of access to electricity is likely lower.

Kenya's electricity generation can be divided into on-grid and off-grid areas. The on-grid electricity is generated by KenGen and Independent Power Producers (IPPs), and has historically been relatively clean, with 47% of generation from geothermal, 39% from hydro, and 13% from diesel and fuel oil in 2015/2016, with wind, solar, and imports making up the rest (KPLC 2016a) (Figure 7). The Kenyan government plans to more than double its installed capacity by 2021, adding additional wind and geothermal capacity, but also a controversial coal plant, which may not be necessary to meet Kenya's electricity needs. If built, the coal plant will be the first of its kind in East Africa and increase Kenya's CO_2 emissions from electricity production by around 600% (see sections 2.6.3 and 2.7 for further discussion of Kenya's electricity development).

Off-grid electricity has been provided partially through the Rural Electrification Authority (REA), and is often generated with diesel. Looking to the future, the REA plans to electrify off grid areas through solar plants and solar mini-grids for towns, due to the high operation and maintenance costs of running these systems with diesel (REA 2017b).

Figure 7: On grid electricity generation by source between 2010 and 2016



Data source: KPLC (2016a)

2.1.7 Historic emissions

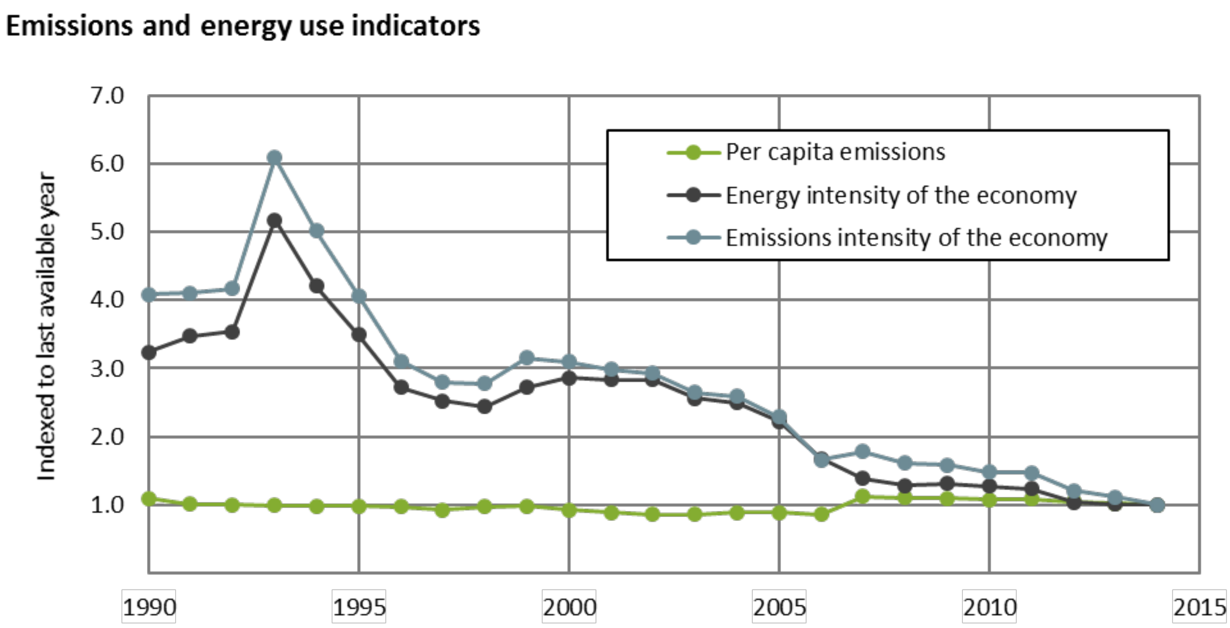
Total emissions increased by 56% in Kenya between 1995 and 2010, the last year of Kenya's national inventory Government of Kenya (2015). Over the same time period, per capita emissions stayed relatively stable, fluctuating between 1.5 and 1.8 $MtCO_2$ per person. Globally, Kenya's emissions made up 0.1% of worldwide emissions in 2012 (Table 3).

Table 3: Key emissions, energy and environmental data

Indicator	Kenya	% change since 1990	World	Germany	Year
GHG/cap [tCO2e/cap]	**1.5**	*-8%*	6.42	10.8	2014
GHG/GDP [tCO2e/mln 2017 USD]	**1,082**	*-76%*	593	225	2014
Energy/GDP [ktoe/mln 2017 USD]	**0.38**	*-69%*	0.17	0.08	2014
Global share of emissions [%]	**0.1%**	*0%*	100%	1.8%	2012
Air pollution index (P2.5)	**16**	*1%*	42	14	2014
Vulnerability index [0 – 1]	**0.53**	-	-	0.23	2014

Data sources: IEA (2016b); World Bank (2017); ND-GAIN (2017); Gütschow et al. (2016). GHG indicators were calculated using PRIMAP data and exclude contributions from the LULUCF sector.

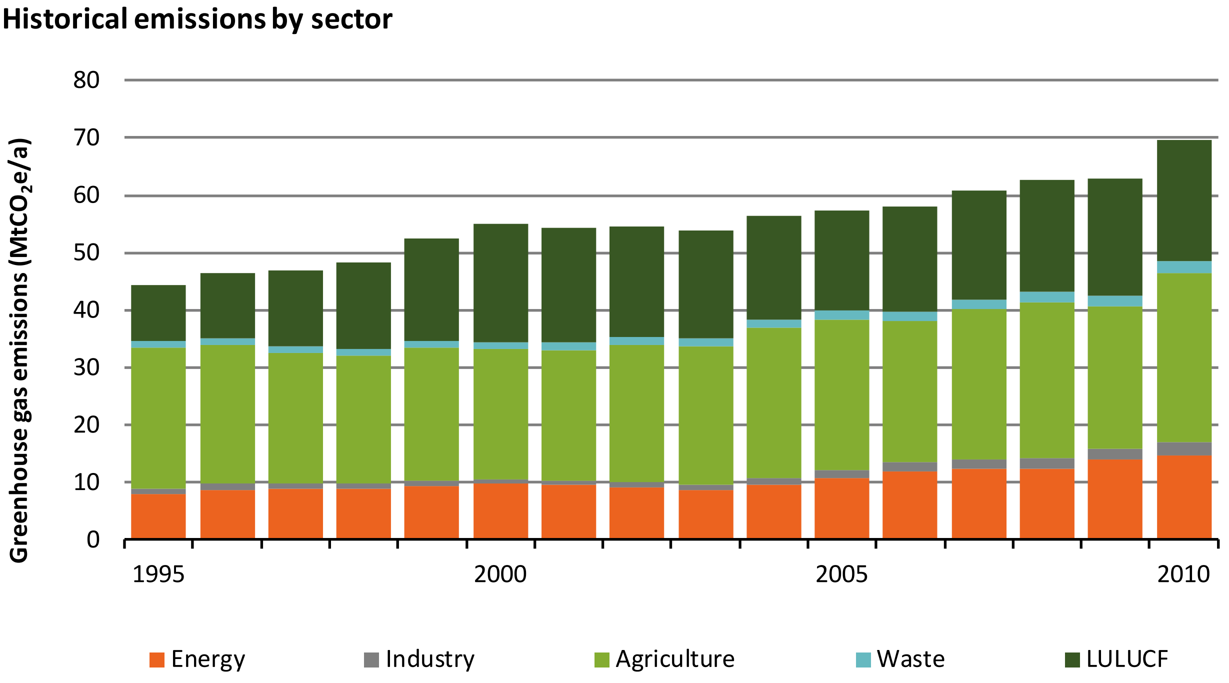
Figure 8: Emissions and energy use intensity over time



Data sources: Gütschow et al. (2016b); IEA (2016a); World Bank (2017). Emissions indicators were calculated using PRIMAP data excluding contributions (emissions or sinks) from the LULUCF sector.

In 2010, the largest source of emissions was from the agriculture sector (43%), followed by the land use, land use change, and forestry (LULUCF) sector (30%), and the energy sector (21%), with waste and industry making relatively minor contributions at 3% each (Stiebert and Owino 2015).

Figure 9: Kenya's historical emissions profile including LULUCF



Greenhouse gas inventory data from Kenya's Second National Communication Government of Kenya (2015)

Table 4: 2010 emissions data from Kenya's Second National Communication

Sector	Value	Unit	Share of total emissions in 2010
Total energy	14.735	$MtCO_2e$	21%
Industry	2.210	$MtCO_2e$	3%
Agriculture	29.577	$MtCO_2e$	43%
Waste	1.898	$MtCO_2e$	3%
Total (excluding LULUCF)	**48.421**	**$MtCO_2e$**	**70%**
LULUCF	21.156	$MtCO_2e$	30%
Total (including LULUCF)	**69.577**	**$MtCO_2e$**	**100%**

Data sources: Kenya's Second National Communication Government of Kenya (2015)

The two largest sources of emissions in the **agriculture** sector are methane emissions from enteric fermentation in livestock (85% of agricultural CH_4 emissions) and nitrous oxide emissions from agricultural soils (90% of N_2O). Methane and nitrous oxide are much more potent greenhouse gases than carbon dioxide.

Road transportation accounts for the largest share of emissions from the **energy** sector at 58%, followed by manufacturing industries and construction (14%), energy industries (11%), and residential use (8%). Commercial use, civil aviation, and agriculture/forestry/fisheries make up the rest.

In the **LULUCF** sector, 80% of carbon dioxide emissions are from forest lands that remain forest lands, primarily from wood harvesting, and 20% are from forests, grasslands, and croplands that have been converted to (other kinds) of croplands.

In the **industry** sector, 87% of emissions were from cement production. In the **waste** sector, the majority of total methane and nitrous oxide emissions came from domestic wastewater, followed by industrial wastewater, and then finally solid waste disposal on land. Carbon dioxide emissions from waste incineration are comparatively low (Stiebert and Owino 2015).

2.1.8 Emissions projections

Looking to the future, under the Business as Usual (BAU) scenario referenced in the NDC, emissions were expected to more than double from 70 $MtCO_2e$ in 2010 to 143 $MtCO_2e$ in 2030 (MENR 2015). This scenario was developed during the preparation of the National Climate Change Action Plan (NCCAP) 2013–2017 (Government of Kenya 2013).

In 2017, The Ministry of Environment and Natural Resources (MENR) updated Kenya's emissions projections, revising the scenario downward based on updated inventory data, new electricity forecasts, and new economic growth projections. Under this updated emissions scenario, emissions will rise less, reaching 124 $MtCO_2e$ in 2030 (MENR 2017b).

In both scenarios, emissions are expected to increase in all sectors, but emissions from electricity generation are expected to rise the most (Table 5, Figure 10). This is due to a projected transition from a renewables dominated electricity sector to a fuel mix that includes both petroleum and coal capacity, in addition to growing demand.

However, the most significant difference between the two scenarios is also in emissions from electricity generation. The NDC BAU scenario included electricity generation projections that were nearly 40% higher than the projections used in the updated scenario, and since much of that generation was expected to be coal powered, the updated emissions are significantly lower, although they still include coal-based generation. The demand projections used in the updated scenario are still much higher than estimates in the Power Generation and Transmission Master Plan (2015-2035), which could mean that future emissions from the electricity sector will be significantly lower, particularly if future demand is met with renewable sources (see section 2.6.3 for further discussion).

Figure 10: Sectoral emissions projections to 2050 – 2017 update

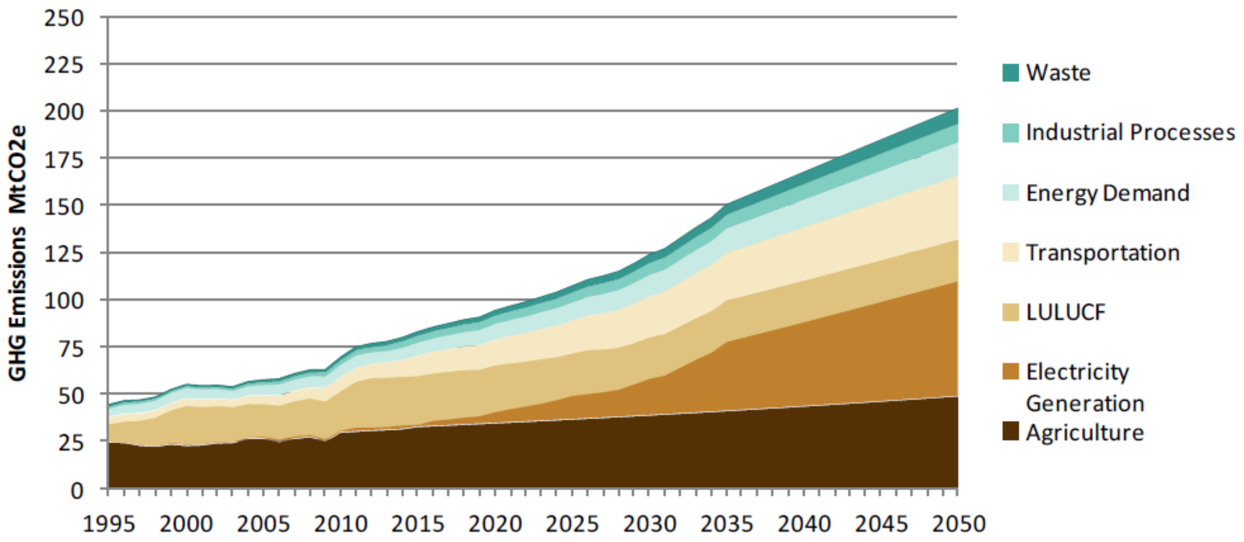


Figure from MENR (2017b). Note that these are updated projections, released after Kenya's NDC was submitted. Projected emissions in 2030 are lower than projected under Kenya's NDC BAU scenario.

Table 5: Projected change in sectoral emissions between 2010 and 2030

Sector	2010 ($MtCO_2e$)	Share in 2010 (%)	NDC baseline: 2030 ($MtCO_2e$)	Share in 2030 (%)	Updated baseline: 2030 ($MtCO_2e$)	Share in 2030 (%)
Agriculture	30	*43%*	38.7	*27%*	38.7	*31%*
Electricity Generation	1	*1%*	41.6	*29%*	19.4	*16%*
LULUCF	21	*30%*	22.1	*15%*	22.1	*18%*
Transportation	7	*10%*	21.0	*15%*	21.8	*18%*
Energy Demand	6	*9%*	9.9	*7%*	11.2	*9%*
Industrial Processes	2	*3%*	5.5	*4%*	6.2	*5%*
Waste	2	*3%*	3.7	*3%*	4.7	*4%*
Total	70	*100%*	142.6	*100%*	124	*100%*

Data sources: Government of Kenya (2015); MENR (2017b). The updated baseline is based on new analysis from MENR.

2.1.9 Environment

Kenya is vulnerable to climate change (Government of Kenya 2015), and therefore the government emphasizes the importance of adaptation to climate change in addition to efforts to mitigate greenhouse gas emissions (MENR 2015).

Water resources play a central role in Kenya, particularly for the agricultural sector, which forms the backbone of the Kenyan economy. Kenya is categorized as a water scarce country, and 70% of natural disasters in Kenya result from extreme climatic events – primarily floods and droughts (Government of Kenya 2015). Kenya experienced a drought in 2016 and 2017, which the government declared a national disaster in February 2017. The drought led to livestock deaths and reduced crop yields, and has left 3.4 million people in urgent need of food assistance (DW 2017). During the drought, much of Kenya's hydroelectric infrastructure was inoperable, leading to an increase in diesel generation.

75% of Kenya's renewable water resources stem from five "water towers," mountainous areas that trap rainfall. Deforestation has decreased the effectiveness of the water towers, further threatening already scarce water resources (Macharia 2017).

Climate change is likely to cause changes in water availability in Kenya, and floods and droughts are projected to become increasingly frequent. The population living in the ASALs regions are particularly vulnerable to rainfall variability and drought, due to their dependence on rainfall for their livestock and livelihoods. The economically important agriculture, energy, and tourism sectors are also vulnerable to climate change (Government of Kenya 2015).

2.1.10 UNFCCC negotiations

Kenya is a member of the Committee of African Heads of State and Government on Climate Change (CAHOSCC), the African Group, and the Group of 77 and China.

In her statement during the high level segment of the 23rd Council of Parties (COP) in November 2017, Judi Wakhungu, the Cabinet Secretary of the Kenyan Ministry of Environment and Natural Resources, affirmed Kenya's support for the Paris Agreement, and indicated that Kenya supports the operationalization of the Warsaw International Mechanism on Loss and Damage and appreciates the Marrakech Partnership for Global Climate Action Agenda (Government of Kenya 2017).

2.1.11 Bilateral cooperation with Germany

Kenya is an important partner country for German cooperation. For 2017-2018, the German government committed 252.35 million euro for Kenya, of which 114 million euro is designated for renewable energy. Technical and financial cooperation is provided mainly through the German Federal Ministry for Economic Cooperation and Development (BMZ), and implemented primarily by GIZ and KfW Development Bank (GDC 2017).

The cooperation between Germany and Kenya focuses on the following points (GDC 2017):

- Agriculture and rural development: food security and increased drought resilience
- Water and sanitation: Access to water and sanitation, particularly in growing urban areas, and water resource management (to be phased out)
- Health: creating a sustainable health financing system
- Sustainable economic development and promotion of youth employment and vocational training (to be phased in)

Further cooperation is directed towards renewable energy, energy efficiency, good governance with a focus on fighting corruption, and education (GDC 2017).

Kenya is also a cooperation country through the International Climate Initiative (IKI), under BMUB. Since 2008, IKI has funded 12 projects that included Kenya (IKI 2017).

2.2 Institutional set up

The Climate Change Act (2016) defines the institutional structure for climate action in Kenya (Government of Kenya 2016a). The government is in the process of implementing the structure.

The **National Climate Change Council (NCCC)** will play an overarching national climate change coordination role. Its duties will include approving and overseeing the implementation of the National Climate Change Action Plan; disseminating information on climate change to national and county governments, the public, and other stakeholders; administering the climate change fund, and setting targets to regulate greenhouse gas emissions. The council will be chaired by the president and will consist of not more than nine other members who are appointed by the president. As of December 2017, the National Climate Change Council had not yet convened, as some of the proposed members were not approved by Parliament.

Members of Kenya's National Climate Change Council

- President of Kenya
- Cabinet Secretary for **environment and climate change affairs**
- Cabinet Secretary responsible for the **national treasury**
- Cabinet Secretary for **economic planning**
- Cabinet Secretary for **energy**
- Chairperson of the **council of governors**
- A representative of the **private sector**
- A representative of **civil society**
- A representative of the **marginalized community**
- A representative of the **academia**

The **Climate Change Directorate**, which is within the Ministry of Environment and Natural Resources (MENR), acts as the secretariat to the NCCC, and is the lead government agency on climate change plans and actions. Its duties include providing analytical support on climate change to sector ministries, agencies, and county governments; establishing and managing a national registry for appropriate mitigation actions; and developing low carbon development strategies. The **Cabinet Secretary for Environment and Climate Change Affairs** will formulate and periodically review relevant policies and coordinate international negotiations on climate change related affairs with the Cabinet Secretary responsible for foreign affairs.

Because climate action should be integrated at every level of government in Kenya, **state departments and national government public entities** play an important role in integrating the national climate change action plan into sectoral strategies, action plans, and other implementation projects, as well as reporting on sectoral GHG emissions for the national inventory.

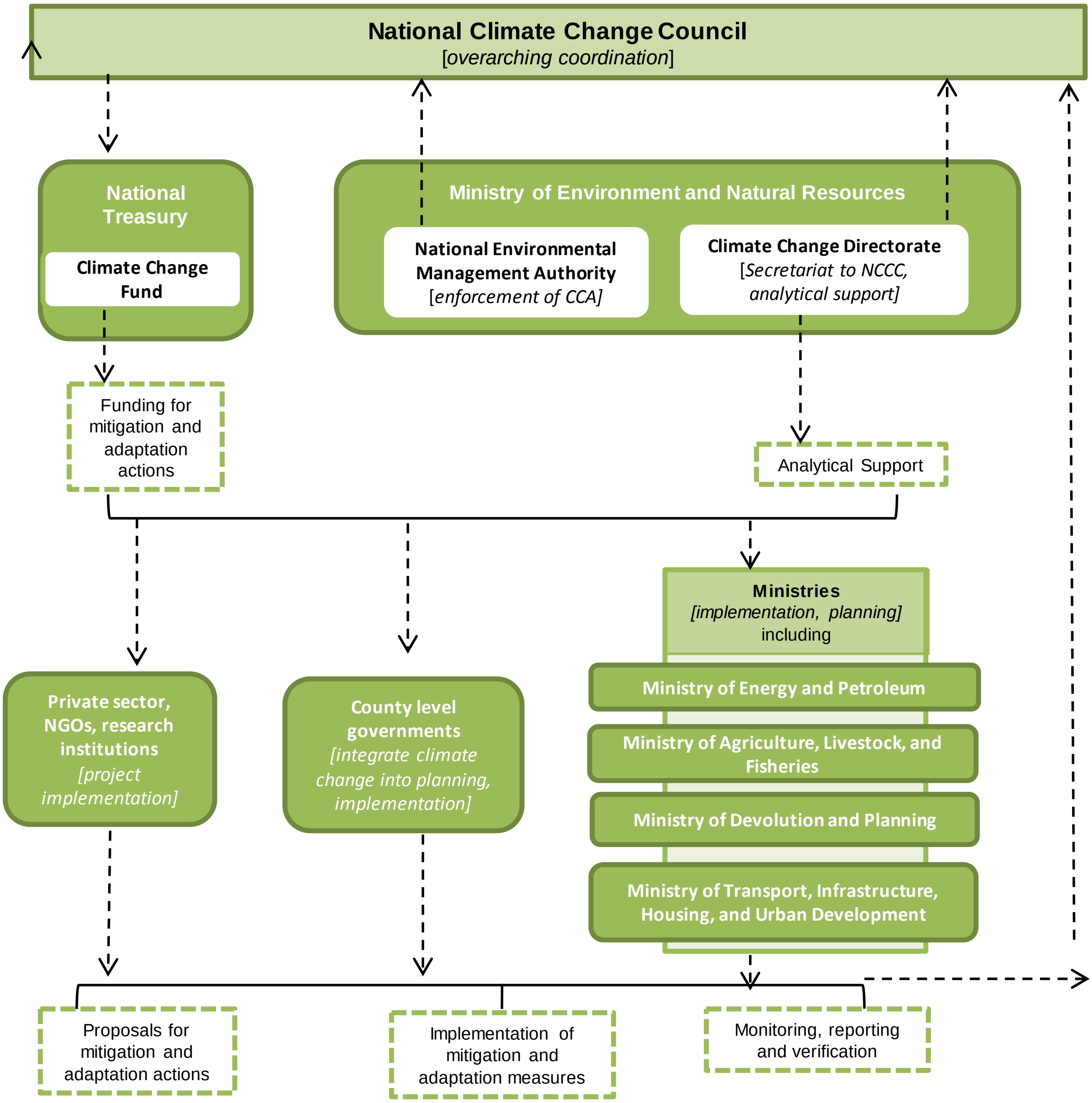
The Act also established the **Climate Change Fund**, which will be administered by the NCCC, and will be vested in the **National Treasury.** The Climate Change Fund will be a financing mechanism for priority climate change actions in Kenya.

To date, the **Ministry of Environment and Natural Resources (MENR)** has been responsible for creating climate policy and coordinating climate change response. It was the lead author of the NDC, the National Climate Change Action Plan 2013 – 2017, and the National Adaptation Plan. MENR formerly housed the National Climate Change Secretariat, which became the Climate Change Directorate, and which was responsible for developing and implementing climate change policies, strategies, and action plans. These responsibilities are now carried out by the Climate Change Directorate. The **National Environment Management Authority** is an institution within the MENR, and lead the preparation of Kenya's Second National Communication. It also serves as the Designated National Authority for the Clean Development Mechanism and a National Implementing Entity for the Green Climate Fund and is charged with enforcing the Climate Change Act.

On sector specific mitigation and adaptation actions, **the Ministry of Energy and Petroleum**; the **Ministry of Transport, Infrastructure, Housing and Urban Development**; the **Ministry of Devolution and Planning**; the **Energy Regulatory Commission, Kenya Forest Service; Ministry of Industrialization, Ministry of Agriculture, Livestock and Fisheries;** and **County Level Governments** play important roles in implementation. Most institutions in the Government of Kenya are required to nominate climate change desk offices, who besides other responsibilities, are responsible for climate change issues in their respective institutions.

Research organizations such as Kenya Agricultural Research Institute, Kenya Forest Service, Kenya Wildlife Service, and universities conduct research and provide data to support mitigation and adaptation actions (Government of Kenya 2015).

Figure 11: Institutional set up for climate action in Kenya



Source: the authors

2.3 MRV of GHG emissions

Kenya's most recent GHG inventory is presented in the Second National Communication (SNC). The inventory was constructed following the IPCC *Revised 1996 Guidelines for National Greenhouse Gas Inventories* and the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.* Carbon dioxide equivalent was calculated using 100 year Global Warming Potentials from the IPCC's Second Assessment Report. The data sources for the activity data used to construct the inventory are clearly documented in the SNC. Inventory data is available for 1995, 2000, 2005, and 2010 in the SNC, with 2010 as the base year.

According to the uncertainty analysis presented in the SNC, the sector with the highest uncertainty in the inventory is the LULUCF sector. The SNC called for the overall understanding of carbon stocks in forests to be improved, and in response, research institutes in Kenya have begun collecting this data, primarily through The System for Land-based Emissions Estimation in Kenya (SLEEK) program. With funding from the Australian government, the Kenyan government implemented this program to develop a robust MRV system to estimate land-based emissions in Kenya. However, as of December 2017, the program had slowed down significantly as the Australian Government funding came to an end.

The SNC also transparently outlines activity data gaps that need to be filled for future inventories, and emphasizes the need for capacity building and training for government staff to be able to collect the data and perform analysis to contribute to the inventory. Some of this training has begun, through local and international programs, but could go further. To date, inventories have been developed with the help of consultants on a project-by-project basis. A sustainable GHG inventory system incorporated into the government would help inform policy and development decisions, meet reporting requirements to the UNFCCC, and prevent knowledge loss between inventory preparations.

Currently, both the transport and energy sectors are working on creating their own sectoral MRV systems, and Conservation International, with GEF CBIT-funding is in the final stages of developing a project to enhance the national MRV system in line with the enhanced transparency framework of the Paris Agreement.

2.4 Description and evaluation of the NDC

Kenya submitted its Intended Nationally Determined Contribution (INDC) on 23 July 2015, and ratified the Paris Agreement on 28 December 2016, at which point its INDC became its Nationally Determined Contribution (NDC). Kenya's NDC contains both mitigation and adaptation components and emphasizes that adaptation is a priority for the country.

Kenya seeks to **reduce emissions by 30% in 2030** as compared to a Business As Usual (BAU) scenario of 143 $MtCO_2e$. This target of 100 $MtCO_2e$ is subject to international support „in the form of finance, investment, technology development and transfer, and capacity building (MENR 2015)." The Kenyan government estimates that over USD 40 billion is required for mitigation and adaptation actions up to 2030, but does not specify which actions this would cover. The target includes emissions from all sectors economy wide, including the Land Use, Land Use Change, and Forestry sector (LULUCF).

Meeting its emissions reductions target would see Kenya's emissions increase by 43% over 2010 levels.

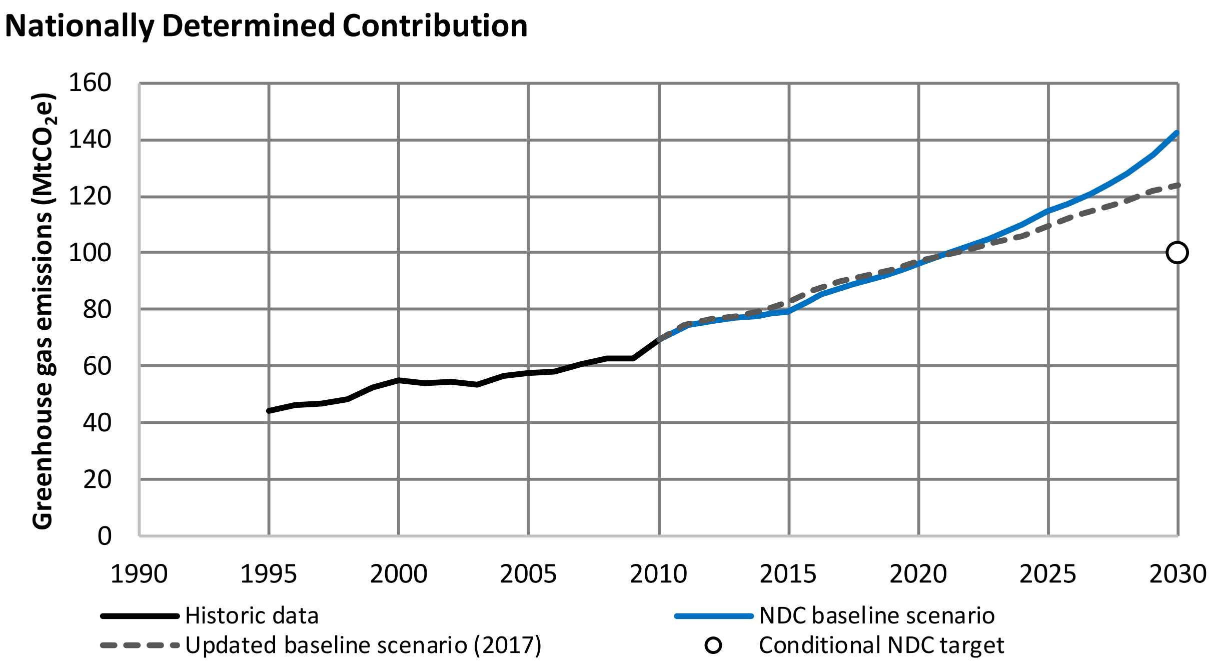
Mitigation Measures in Kenya's NDC

- Expansion in geothermal, solar and wind energy production, other renewables and clean energy options
- Enhancement of energy and resource efficiency across the different sectors
- Make progress towards achieving a tree cover of at least 10% of the land area of Kenya
- Clean energy technologies to reduce overreliance on wood fuels
- Low carbon and efficient transportation systems
- Climate smart agriculture (CSA) in line with the National CSA Framework
- Sustainable waste management systems

Kenya's NDC also lists priority adaptation measures across sectors. Kenya plans to "ensure enhanced resilience to climate change towards attainment of Vision 2030 by mainstreaming climate change adaptation into the Medium Term Plans and implementing adaptation actions." The NDC also notes that Kenya's capacity to undertake strong mitigation actions is dependent on support for implementation of the adaptation actions (MENR 2015).

In 2017, MENR released updated emissions projections for Kenya. The updated baseline projects economy wide emissions of 124 $MtCO_2e$ in 2030, bringing Kenya already 43% of the way to meeting its target (MENR 2017b). The Government of Kenya clarifies that the NDC target remains referenced to BAU emissions of 143 $MtCO_2$ in 2030, meaning a target of 100 $MtCO_2e$ in 2030.

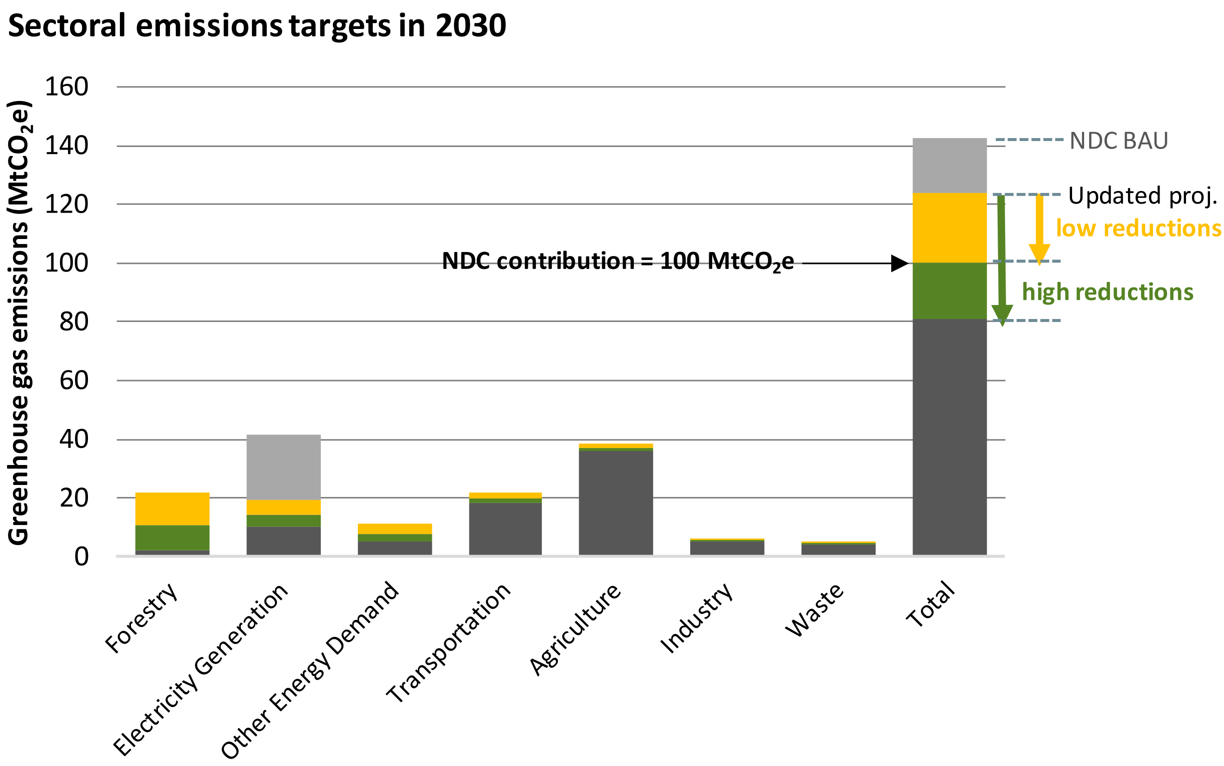
Figure 12: Kenya's NDC mitigation target



Data sources: Government of Kenya (2015); MENR (2015, 2017b)

The Government of Kenya has also published a sectoral analysis of the NDC, which will serve as an input to Kenya's next NCCAP (MENR 2017d). For each sector, the report looks at mitigation potentials and sets a low range of emissions reductions and a high range of emissions reductions for the sector (Figure 13). The sum of the low reductions, when referenced to the updated emissions scenario, reaches the NDC target of 100 $MtCO_2e$ in 2030, an increase of 43% above 2010 levels. However, if all sectors were to implement their high reductions, emissions would be 20% lower than the NDC target, at 80 $MtCO_2e$, representing an increase of 14% above 2010 levels.

Figure 13: Sectoral contributions to the NDC target



Data sources: (MENR 2017b)

The forestry sector is expected to make the largest contributions to meeting the NDC targets, followed by the electricity generation and energy demand sectors (Figure 13).

2.5 Climate change mitigation policies and strategies

Kenya's overarching national climate change legislation is the **Climate Change Act (2016)**. The act seeks to mainstream climate change planning in all sectors and at all levels of government. This includes integrating climate change planning into development planning and budgeting. The act also established the National Climate Change Council and a climate change fund to finance priority climate change actions (Government of Kenya 2016a). The Climate Change Act was passed after the NDC was submitted, and therefore is not referenced in the NDC document. However, according to the Climate Change Act, all climate action (including addressing the NDC) will be planned and implemented through the **National Climate Change Action Plans** which will be reviewed and updated every five years, with biennial implementation reviews in between. Further plans and strategies that are referenced in the NDC are:

Vision 2030 is Kenya's guiding development plan. The goal of the plan is "to transform Kenya into a newly industrialising, middle-income country providing a high quality of life to all its citizens by 2030, in a clean and secure environment (Government of Kenya 2015)." Vision 2030 is a priority in Kenya.

Many other strategies reference it, and there is concern that the effects of climate change could threaten the realisation of some of the Vision 2030 goals (Government of Kenya 2015). Vision 2030 is implemented through 5 year Medium Term Plans.

The **Constitution of Kenya (2010)** guarantees every citizen a clean and healthy environment as a fundamental right under the Bill of Rights. It also has a requirement that forests should cover at least 10% of Kenya's land area (MENR 2016a).

The **National Climate Change Response Strategy (2010)** was Kenya's first national climate change policy and official acknowledgement that climate change posed a serious threat to Kenya's development. It has improved understanding of climate change issues in Kenya, and has guided policy decisions (Government of Kenya 2015).

The **National Climate Change Action Plan (2013 – 2017)** identifies priority adaptation and mitigation actions for climate change. The plan is to be updated every five years, with a biennial review of implementation (Government of Kenya 2013).

Kenya has a number of other strategies, plans, and policies related to climate change (for a comprehensive list, see (MENR 2016a)). These include:

- National Adaptation Plan (2015-2030)
- Draft National Climate Change Framework Policy
- Draft National Policy on Climate Finance
- Green Economy Strategy and Implementation Plan
- Draft Wildlife Adaptation Strategy
- Climate Smart Agriculture Strategy

Kenya has one funded (Nationally Appropriate Mitigation Actions) **NAMA support project** to develop a Mass Rapid Transport System for Nairobi. Partners in the project include the Ministry of Transport and Infrastructure, MENR, Kenya Urban Roads Authority, KfW Development Bank and GIZ. Funding is provided by the International NAMA Facility (MENR 2016a).

Kenya has developed or is in the process of developing other NAMA proposals to attract investment in the following areas (MENR 2016a):

- Biogas Market Development for Low-Carbon Energy Access in Kenya
- Clean cookstoves and solar lighting
- Dairy efficiency
- Geothermal development acceleration
- Sustainable charcoal production
- Circular Economy Solid Waste Management Approach for Urban Areas in Kenya
- A second Bus Rapid Transit program in Nairobi

2.6 Additional mitigation potential

In 2013, Kenya launched its first National Climate Change Action Plan (NCCAP) for the period 2013 – 2017 (Government of Kenya 2013). Among other things, the plan comprehensively assessed the low-carbon development options for the country in the six IPCC emissions sectors using a top-down, economy-wide, energy and emissions model and a bottom up assessment of mitigation opportunities for the country.

According to the BAU scenario developed in the NCCAP 2013, which is also referenced as the basis for the NDC, Kenya's emissions are projected to rise to 143 $MtCO_2e$ in 2030. Emissions are projected to rise in all sectors, with the largest percentage increase in the electricity generation sector (see Figure 14 and Table 5).

Figure 14: Sectoral emissions projections to 2050 - NDC BAU scenario

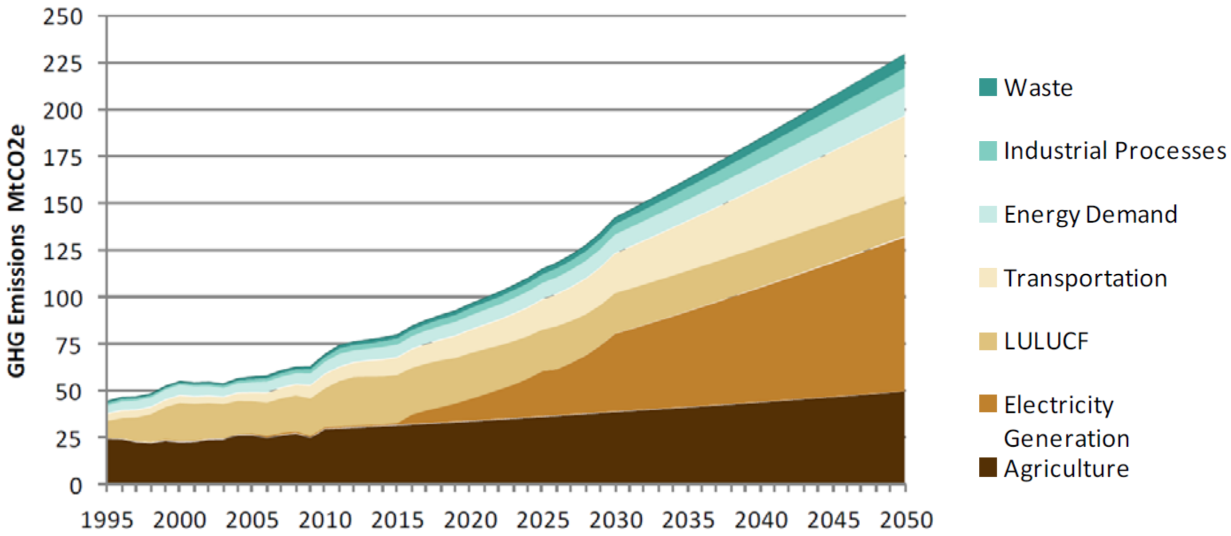


Figure from (MENR 2017b)

Although MENR updated emissions projections for Kenya in 2017, the available data on quantitative potential emissions reductions in Kenya are based on the NDC BAU scenario. Therefore, this section will discuss potentials in the context of the NDC BAU scenario. The updated emissions projections and the NDC BAU emissions projections are similar for all sectors except for electricity generation. The emissions reductions discussed here are therefore likely to be consistent with the most recent emissions projections in all sectors, except for the electricity generation sector. In the electricity generation sector, emissions projections are now lower, and the reduction potential is accordingly also likely to be lower.

The analysis for the NCCAP identified a low-carbon development pathway, based on technical mitigation potentials in each sector. Collectively, the maximum technical reduction potential was estimated as 60% of the BAU scenario emission projections of 143 $MtCO_2e$ by 2030 (see Figure 15 and Table 6). The NDC, which commits to a 30% reduction below BAU, is based on the assumption that Kenya can meet half of the collective technical mitigation potential. The technical mitigation potentials for each sector are summarised in Table 6.

Figure 15: Technical mitigation potentials by sector

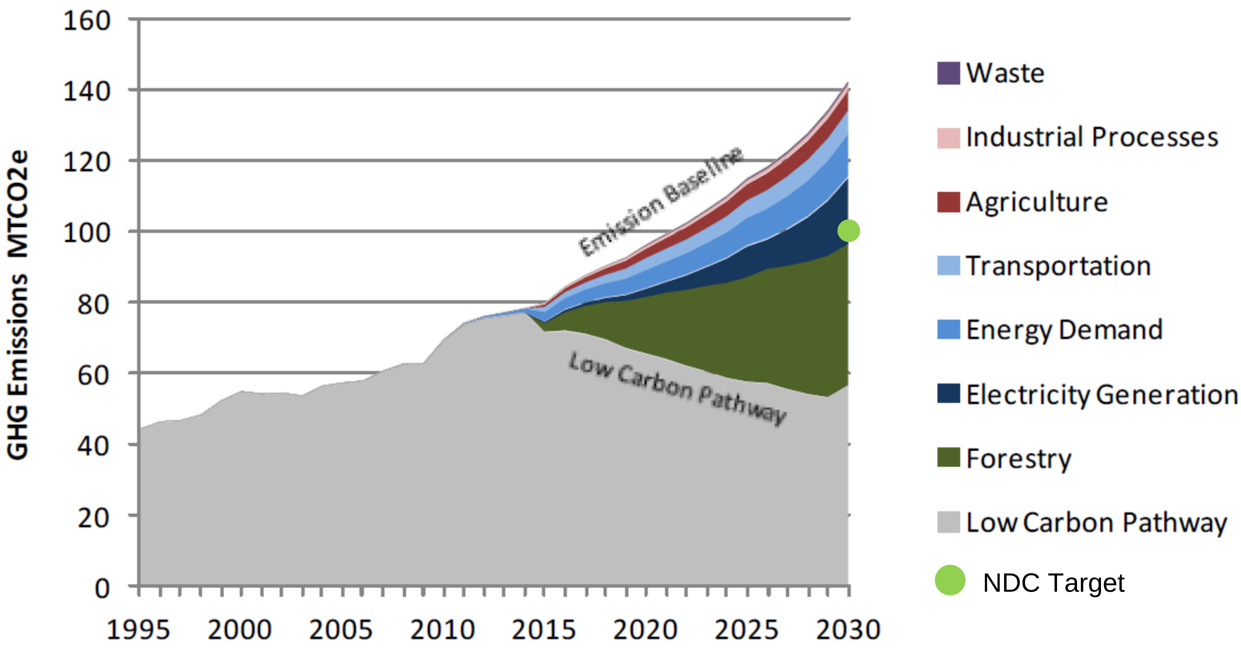


Figure modified from Kenya's NCCAP 2013 Government of Kenya (2013). Baseline emissions are the NDC BAU scenario.

Based on these projections, and the analysis of technical mitigation potentials, the Kenyan government identified the following six priority actions for low carbon development in the NCCAP (Government of Kenya 2013):

- Restoration of degraded forests
- Reforestation
- Agroforestry
- Accelerated geothermal development
- Improved and liquid propane gas (LPG) cookstoves
- Bus rapid transit system and light rail corridors for greater Nairobi

Through the StARCK+ project, the Government of Kenya, through the MENR, has performed further detailed sectoral analysis to clarify how Kenya can achieve its NDC commitment. The sectoral analyses further analyse the mitigation measures identified in each sector, with the aim to „unpack the numbers, update with available data and information, assess what is doable and achievable, and to prioritize actions and sectors (MENR 2017a)." Whereas the NCCAP analysis was based on purely technical mitigation potentials, the NDC analysis also considered what would be practical and achievable, setting high and low emissions reductions targets for each sector. The technical potentials were not updated as part of the NDC analysis, and further work needs to be undertaken to update the technical potentials (MENR 2017b).

Table 6: Sectoral technical mitigation potentials

Sector	Emissions in 2030 ($MtCO_2e/a$) – NDC BAU	Emissions in 2030 ($MtCO_2e/a$) – Updated projections	Technical mitigation potential[1] ($MtCO_2e/a$)	Low emissions reductions target to meet NDC ($MtCO_2e/a$	High emissions reductions target to meet NDC ($MtCO_2e/a$)
Agriculture	38.7	38.7	**5.5**	1.5	2.77
Electricity Generation	41.6	19.4	**18.6**	5.2	9.3
Forestry	22.1	22.1	**40.2**	11.3	20.1
Transportation	21.0	21.8	**6.9**	1.9	3.5
Energy Demand	9.9	11.2	**12.1**	3.4	6.1
Industrial Processes	5.5	6.2	**1.6**	0.4	0.78
Waste	3.7	4.7	**0.8**	0.2	0.39
Total	142.6	124.0	**85.8**	24.0	42.9

Table after MENR (2017b).

[1]Note that the technical mitigation potentials were calculated in the context of the NDC BAU. These have not been updated to reflect the updated emissions projections. The sector in which the technical potential would be most likely to change is in electricity generation, because the emissions projections have changed significantly.

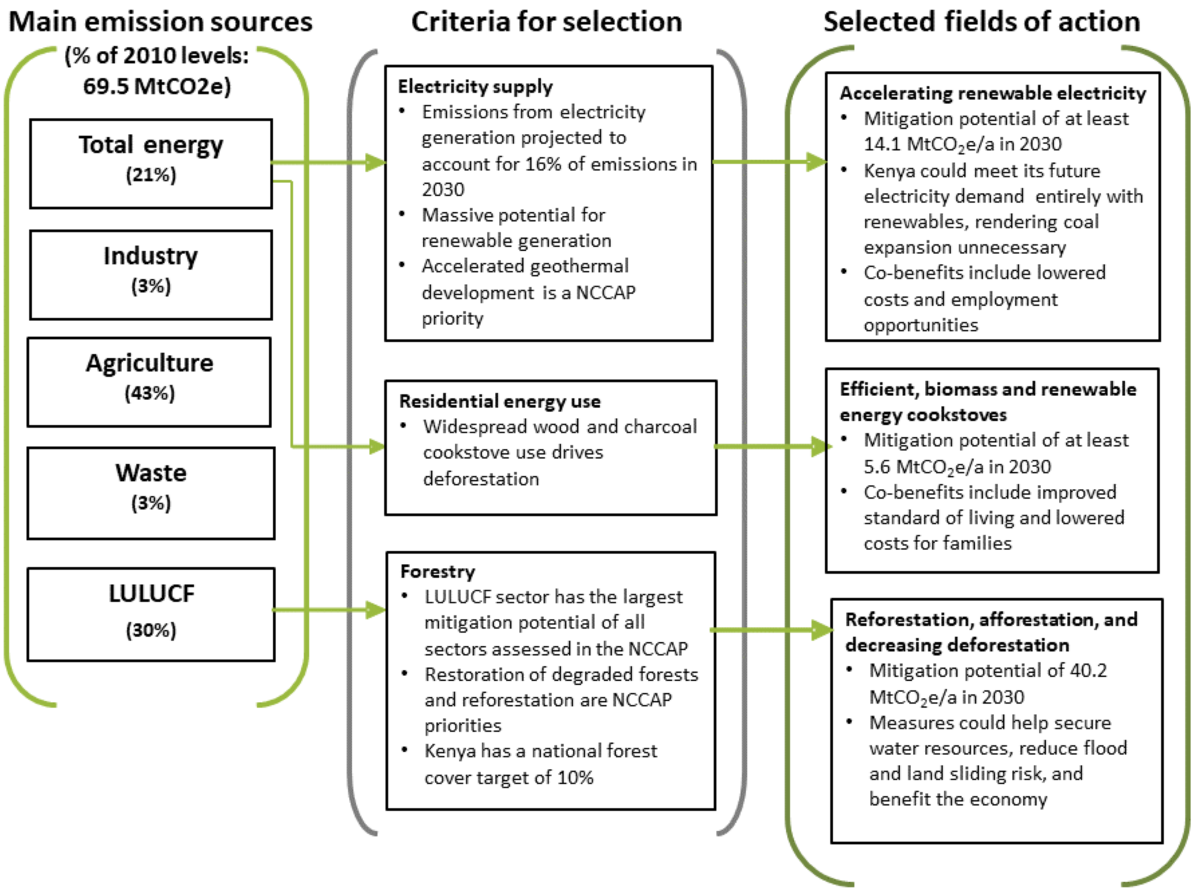
In this study, we look further into the following three areas of mitigation action in Kenya, assessing mitigation measures and their emissions reduction potential, co-benefits, and barriers to implementation:

1. Reforestation, afforestation and decreasing deforestation
2. Efficient biomass and renewable energy cookstoves
3. Accelerating renewable electricity

These areas of action were selected for further analysis because they are in the sectors with the largest technical and implementable mitigation potentials based on the NCCAP and the NDC sectoral analysis (MENR 2017d). Furthermore, each area of action has significant co-benefits, including sustainable development and climate change adaptation benefits.

We did not select measures in the waste, industry, agriculture or transportation sectors because the scope of this study is limited to three areas of action and the NDC sectoral analysis did not show these sectors to have as significant mitigation potentials. However, there is certainly potential in these sectors, and the interested reader should consult (MENR 2017d) for further information.

Figure 16: Selection methodology for fields of action



Source: the authors. Mitigation potentials are based on MENR (2017b).

2.6.1 Reforestation, afforestation and decreasing deforestation

Considerable deforestation has occurred over the past 20 to 30 years in Kenya, primarily due to conversion of forest land to agriculture and human settlements, unsustainable use of forest products, forest fires, and shifting cultivation. The Land Use, Land Use Change, and Forestry (LULUCF) sector is the second largest contributor to Kenya's greenhouse gas emissions (after agriculture), and accounted for 32% of total emissions in 2015, largely due to deforestation (Ministry of Natural Resources and Environment 2017). In its economy-wide analysis of mitigation potentials, analysis for the NCCAP found that measures in the forestry sector that contribute to reforestation and reducing deforestation have an annual mitigation potential of 40.2 $MtCO_2e$, the largest of any sector (MENR 2017c).

At independence in 1963, forests occupied an estimated 11% of Kenya's land area (Government of Kenya 2015). By 2010, forests occupied only 7% (MENR 2016b). Kenya's Constitution requires that the state work to achieve and maintain tree cover on at least 10% of Kenya's land area. The NDC, as well as the National Forest Programme and the Vision 2030, reiterates this goal (MENR 2015).

Emissions sources:

When trees are cut down or otherwise destroyed, the carbon that they store is in most cases released to the atmosphere. Conversely, when trees grow, they sequester carbon from the atmosphere. In Kenya, the main sources of emissions from the LULUCF sector are (Government of Kenya 2015):

- Conversion of forest land and woodlands to farm land (20% of 2010 emissions from LULUCF)
- Wood removals for fuelwood, charcoal production, and commercial uses (i.e. paper production, industrial wood) (80% of 2010 emissions from LULUCF)
- Forest fires (not applicable in 2010)

Mitigation measures:

The NCCAP identified three mitigation measures in the forestry sector (Government of Kenya 2013; Stiebert et al. 2012). All three of these measures have highly positive impacts for sustainability in the areas of climate change adaptation, the environment, and improved land management (Stiebert et al. 2012).

Restoration of forests on degraded lands. Degraded lands are previously forested areas where tree cover has been reduced to the extent that forests can no longer regenerate themselves. Through consultations with the Kenya Forest Service (KFS), the NCCAP determined that approximately 960,000 hectares could be restored through natural regeneration of degraded lands through conservation and sustainable management by 2030. The technical mitigation potential of this measure is 32.6 $MtCO_2e$ in 2030 (MENR 2017c; Stiebert et al. 2012). Important actions include accelerating natural forest regeneration by reducing soil degradation and competition with weedy species and reducing disturbances such as grazing, wood harvesting, and fires. Additionally, protection and conservation actions such as limiting or prohibiting access to forests, community management programs, and enforcement and monitoring efforts are necessary to restore forests (MENR 2017c).

Reforestation of degraded forests. An additional 240,000 hectares of forest land could be restored by 2030 through tree planting in areas where forest has been converted to non-forested land through human activities. The technical mitigation potential of this measure is 6.1 $MtCO_2e$ in 2030 (MENR 2017c; Stiebert et al. 2012). A complementary measure is agroforestry, where trees are planted on farms.

Reducing deforestation and forest degradation. In order to achieve its goal of 10% forest land cover, Kenya will necessarily need to decrease and eventually reverse deforestation. Analysis for the NCCAP determined that the technical mitigation potential is 1.6 $MtCO_2e$ in 2030, which assumes a 50% reduction in deforestation rates by 2030 (Stiebert et al. 2012). Importantly, this potential reflects the carbon that could be sequestered in the preserved forest lands, but does not include reduced emissions from cutting down trees for other end uses, such as for charcoal production and cooking. In the analysis, these emissions reductions were assigned to the end use sectors, such as energy demand. Therefore, important actions to reduce deforestation also include moving toward sustainable biomass consumption and charcoal production, improved biomass cookstoves, and addressing other deforestation drivers such as agriculture (see section 2.6.2 for further details on the role of biomass consumption).

Co-benefits:

Measures that increase forest cover have numerous co-benefits, including **climate resilience and adaptation** benefits.

In Kenya, high, forested areas called water towers and other forested catchment areas supply 75% of renewable surface **water resources** (MENR 2016b). Forests help to regulate storm water, allowing rainwater to infiltrate into the ground and therefore replenishing both groundwater and stream water, while also **reducing the risk of flooding**. This helps to safeguard water for both agriculture and domestic use, which rural populations depend on (Stiebert et al. 2012). As water availability is likely to be further impacted by climate change, safeguarding water resources contributes to increased climate resilience.

Increasing forest cover also **reduces erosion and soil loss**. Landsliding is more likely on deforested slopes, and reforestation of these degraded slopes can **reduce the risk of landslides**.

Forests provide **natural habitat** for animals, which supports the **tourism** industry. Forests also provide the bulk of **traditional medicines**.

Particularly in the arid and semi-arid land (ASAL) regions in Kenya, a dryland forest conservation approach could produce important **economic benefits** through forest products including timber, gums and resin, and charcoal (MENR 2017c).

The forest industry in total (both formal and informal) provides **employment** for about 750,000 Kenyans (MENR 2016b).

Finally, **carbon payments** are possible through, for example, REDD+ (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) programs, which could support income for local communities. The Kenyan Government is currently in the process of formulating a national REDD+ strategy.

Good practice examples and ongoing actions:

Many projects related to forests are underway in Kenya, implemented by KFS, MENR, Kenya Wildlife Service (KWS), NGOs, charities, and private landowners (for a comprehensive list, see MENR, 2017). Innovative approaches by the Kenya Forest Service include promotion of participatory forest management through Community Forest Associations (CFAs), the Plantation Enterprise and Livelihood Improvement Scheme, which allows CFAs to plant food crops alongside trees for a rotational period of 3 years, promotion of forest farmer field schools to educate farmers on tree planting and farm forestry, and encouraging sustainable charcoal through the formation of charcoal producers' associations.

One of the longest running forest conservation projects in Kenya is the Kasigau Corridor REDD project, started in 2005, which aims to protect nearly 500,000 acres of dryland forests between the Tsavo East and Tsavo West National Parks in southeastern Kenya. The project is expected to avoid emissions of 54 $MtCO_2e$ over its 30 year life (Code Redd 2017).

The System for Land Based Emissions Estimation in Kenya (SLEEK) program aimed to create a system to estimate and track CO_2 emissions in the land sector and provide data to drive development. The programme was intended to serve as Kenya's MRV system for the land use sector and to help provide access to international financing. The project collected significant data on the land use sector, but further work is still required. However, as of November 2017, the program has slowed significantly because of lack of funding.

Relevant policies:

Chapter 5 of the **Kenyan Constitution** requires that the state work to achieve and maintain a tree cover of at least 10% of the total land area.

The **Forest Policy, 2014** sets policy objectives related to forests. The overarching goal of the policy is "sustainable development, management, utilization and conservation of forest resources and equitable sharing of accrued benefits for the present and future generations of the people of Kenya (MENR 2014).

The **Draft National Forest Policy, 2015** introduces a number of initiatives to improve and develop the forest resource base through integration of good governance, transparency, and accountability, equity and poverty reduction in the forestry sector.

The **Forest Conservation and Management Act, 2016** is administered by the Kenya Forest Service and sets the legal framework to "provide for the development and sustainable management" of forest resources (Government of Kenya 2016b).

The **National Forest Programme (NFP) 2016 – 2030** guides forest development in Kenya and was developed to "increase forest cover, boost the forest sector's contribution to the national economy, enhance resilience to climate change, and improve livelihoods". The overarching goal is "to develop and sustainably manage, conserve, restore and utilize forests and allied resources for socio-economic growth and climate resilience." The program reiterates the national goal of having a minimum of 10% tree cover by 2030 (MENR 2016b).

2.6.1.1 Barriers to implementation of reforestation, afforestation and decreasing deforestation

Awareness of the importance of forests in Kenya is high among policy makers and some communities. However, Kenya has found it difficult to reconcile its forest goals with the energy and nutrition demands of a growing population, while the amount of land is fixed.

A major barrier to decreasing deforestation is the prevalence of **biomass use for energy**. Over 80% of the national energy supply is met with wood fuel. Charcoal provides the domestic energy for 82% of urban and 34% of rural households (MENR 2016b). In rural households, most of the other energy needs are met by burning wood directly. Efficient, renewable energy cookstoves, considered in the next section, are critical to reducing the demand for unsustainably harvested wood products in order to stop deforestation. Efficient and sustainable charcoal production is equally important in reducing deforestation.

So far, **adequate data availability** to monitor changes in forest cover has been a barrier to effectively implementing mitigation measures in the forestry sector. The SLEEK program collected some of this data, but has temporarily been put on hold due to lack of funding.

Lack of financing for implementing mitigation measures is a significant barrier across all sectors. In the forestry sector, some portion of financing could be possible through REDD+, but projects require significant MRV efforts, and additional financing is likely to be needed. The Kenyan government is in the process of developing a national REDD strategy.

Unclear land tenure means that it is not always clear who owns the land that would need to be reforested or restored. Conflicts over land ownership can hinder potential restoration projects.

Lack of political will and enforcement is a challenge for measures that aim to limit access to forest areas to allow for regeneration and to prevent illegal logging and charcoal burning.

A critical aspect for successfully implementing mitigation measures is **community involvement and benefit schemes**. For some restoration projects, access to forests must be restricted for longer periods (5 to 10 years). Restricting access to forests can be detrimental to the livelihoods of people who depend on them, meaning that the community must agree to the measures and also benefit from them. In some cases, lands where forests could be restored are currently used for grazing. Pastoralists who graze their animals on the land need increased education and awareness, and also to somehow be compensated for not being able to graze their animals on the land, either through alternative grazing areas or alternative livelihoods (Stiebert et al. 2012). Successful forest enhancement programmes could integrate poverty alleviation and job creation among forest-resident communities.

2.6.2 Efficient, biomass and renewable energy cookstoves

Biomass, primarily used for cooking and heating, makes up 90% of the rural primary energy supply and 85% of the urban supply in Kenya (Government of Kenya 2015). Introducing more efficient biomass, and also renewable energy cookstoves, is therefore a priority to address both GHG emissions and deforestation. Research for the NCCAP found that improved wood and charcoal cookstoves have an emissions reduction potential of 5.6 $MtCO_2e$ in 2030, and significant co-benefits, including improved standard of living and health benefits from better indoor air quality (Saidi, Stiebert, and Würtenberger 2012). Ethanol cookstoves, which are being piloted in Kenya, may have an even larger emissions reduction potential, and more significant co-benefits. These mitigation measures have overall negative costs (Saidi, Stiebert, and Würtenberger 2012).

In urban areas, simple manufactured but relatively inefficient cookstoves are typically used, whereas in rural areas, people primarily use traditional open "three stone" fires (Saidi, Stiebert, and Würtenberger 2012) (see Figure 17). 82% of the urban population uses charcoal for cooking, whereas 87% of the rural population uses fuelwood for cooking (MENR and MOEP 2017). In urban areas, middle to lower income Kenyans use mostly charcoal for cooking. Middle income Kenyans often use a mix of liquefied petroleum gas (LPG), kerosene and charcoal for cooking. Cooking with electricity is uncommon, partially due to comparatively high electricity prices. In rural areas, residents traditionally collected deadwood from forests for cooking. Now, as forests have been overharvested for firewood, people must go further from their homes to collect wood for cooking, and firewood is mostly from cut-down trees. Firewood is also purchased in markets. This wood has been cut and split for sale.

Analysis for the NCCAP also identified using LPG for cooking as a way to reduce emissions from deforestation (Saidi, Stiebert, and Würtenberger 2012). However, because LPG is a fossil fuel, it still emits carbon dioxide when burned and is not sustainable. It has multiple barriers to implementation of its own, including the high cost of equipment and gas, safety considerations, widespread unavailability, and social and behavioural preferences.

Recently, ethanol stoves have been piloted in some urban areas, including Nairobi, with significant success. Preliminary data and experience shows that there is a big potential for ethanol fuel as a replacement for both charcoal and kerosene in urban Kenya. The ethanol is produced from molasses, a sugar production by-product.

Figure 17: Comparison of wood, charcoal, and ethanol cookstove types

From left to right: A traditional three stone fire, a charcoal cookstove, and an improved charcoal cookstove. Photos from Smeets, Johnson, and Ballard-Tremeer (2012) and cleancookstoves.org.

An ethanol cookstove of the variety used in Kenya. Photo from cleancookstoves.org.

Emissions sources:

Greenhouse gas emissions from charcoal and fuelwood cookstoves come from two sources:

- Methane and nitrous oxide from incomplete combustion (methane is 25 times more potent as a greenhouse gas than carbon dioxide, and nitrous oxide is 298 times more potent than carbon dioxide (IPCC 2007))
- Carbon dioxide emissions from unsustainable biomass harvesting (see Section 2.6.1 for further details)

Mitigation measures:

Expanding improved wood and charcoal cookstoves. Analysis for the NCCAP found that introducing improved (more efficient) cookstoves could mitigate 5.6 $MtCO_2e$ annually in 2030, and has high positive effects on standard of living, health, and lower deforestation (Saidi, Stiebert, and Würtenberger 2012). Improved cookstoves are available that use less than half the amount of charcoal relative to the baseline cookstove, but uptake has been slow (MENR and MOEP 2017).

The mitigation potential of 5.6 $MtCO_2e$ annually in 2030 is based on two important assumptions: first, that 35% of the biomass burned is unsustainably produced, and second, that improved cookstoves that use 50% less biomass than standard stoves are universally taken up by 2030. The 5.6 $MtCO_2e$ potential does not include emissions reductions of CH_4, N_2O, or black carbon (Saidi, Stiebert, and Würtenberger 2012).

This means that the technical mitigation potential could be higher, particularly if taking into account the possibility of fuel switching from unsustainable biomass to sustainable biomass. There is an important feedback between more efficient cookstoves and sustainable biomass harvesting, in that reducing biomass consumption could increase the share of sustainable biomass in the fuel mix. If, instead of 35% of biomass being unsustainable, as is assumed in the NCCAP reference scenario, all biomass became sustainable in the low-carbon scenario as a result of reduced biomass consumption, emissions would be lowered further.

Introducing ethanol cookstoves. Ethanol cookstoves are a new and promising alternative to charcoal, fuelwood, kerosene, or LPG cookstoves, that could have significant emissions reductions potential. The ethanol is produced as a by-product of Kenya's sugar manufacturing industry and is cost-competitive with charcoal, kerosene, and LPG. Ethanol burns much more cleanly than wood, charcoal, or kerosene, and can be produced sustainably, unlike LPG and kerosene. Ethanol also has a significant sustainable development contribution to the sugar supply chain, including sugar cane farmers.

The technical mitigation potential of introducing ethanol cookstoves has not been quantified, but it is likely to be higher than that of expanding improved wood and charcoal cookstoves because the stoves eliminate the use of wood products completely, contributing to decreased deforestation. A recent report on the development value of ethanol stoves in Kenya found that ethanol stoves can reduce CO_2 emissions by 10.39 tCO_2/household annually, and reduce black carbon emissions by 3.22 kg/household annually (Norstebo 2016). Ethanol stoves are significantly more efficient than wood or charcoal cookstoves, with thermal efficiencies of 65%, as compared to 10% for a three-stone fire and 20-25% for an improved wood or charcoal cookstove (Norstebo 2016). Ethanol stoves have a particularly high chance for success in urban areas where a network for fuel supply could be established and where residents already purchase charcoal, gas, or kerosene fuels.

Co-benefits:

Charcoal prices have risen significantly in Kenya over the past years, reaching record high prices of 81.86 Ksh/tin (~0.66 Euro/tin) in November 2017 (enough for approximately one day's cooking). This is partially in response to rising LPG prices, which have resulted in decreased demand for gas (Otuki 2017c). Improved cookstoves can **save families money,** particularly in urban areas where charcoal use is widespread. For approximately one day of cooking, ethanol fuel costs around 30 Ksh, which is similar to kerosene, and significantly cheaper than LPG or charcoal, which would cost around 75 Ksh and 80 Ksh/day, respectively. More efficient charcoal cookstoves can also save money by reducing the amount of charcoal needed.

Incomplete combustion of fuelwood or charcoal produces carbon monoxide, methane, particulate matter, and nitrous oxide, all of which cause respiratory health problems, which are exacerbated when stoves are used indoors (Saidi, Stiebert, and Würtenberger 2012). More than 14,000 Kenyans die every year from medical conditions related to indoor air pollution (MENR and MOEP 2017). Women and children are disproportionately affected because they typically spend more time cooking or in the kitchen. Improved fuelwood and charcoal cookstoves provide more complete combustion and therefore reduce the emissions of poisonous gases and fine particulate matter. Ethanol cookstoves reduce the problem even further, as they burn very cleanly, and have been shown to **improve indoor air quality** by up to 68% (Lefebvre 2016). Replacing traditional cookstoves with either more efficient charcoal stoves, or better yet, ethanol stoves, has **positive health benefits**.

Improved cookstoves can have a strongly positive effect on **standard of living,** with a particularly strong benefit for **women and children**. Some models of improved stoves cook faster, which saves time (Norstebo 2016). In rural areas, where predominately women and girls collect fuelwood for cooking, more efficient stoves, or ethanol stoves, reduce the amount of time spent collecting wood. This time can then be invested in other income generating activities or schoolwork. Additionally, living in a home with reduced smoke is more comfortable.

If wood is harvested sustainably for charcoal stoves, for example through sustainable agroforestry programs, and ethanol is produced sustainably for ethanol stoves, these fuels can contribute to **energy independence** because the fuel is produced in Kenya.

Improved cookstoves can be, and are currently being, manufactured in Kenya, which provides **employment opportunities**. Burn Manufacturing and Envirofit have established local factories to manufacture the Jiko Koa and Super Saver, respectively, which are popular improved cookstove models. With additional output, there would be a large opportunity for export in East Africa (Saidi, Stiebert, and Würtenberger 2012). Ethanol cookstoves are not yet manufactured in Kenya, but theoretically could be, and a number of organisations are exploring this possibility.

Deforestation, as described in detail in section 2.6.1, is closely related to overharvesting of wood for cooking and charcoal production. Improved cookstoves that use less wood or charcoal, or ethanol cookstoves that use no wood whatsoever, are key to **reducing deforestation**.

Good practice examples and ongoing actions:

ClimateCare, in partnership with Safi International, has conducted pilot projects in Kibera, a neighbourhood of Nairobi, and Kisumu, a city in western Kenya, to start a market for ethanol cookstoves. Over the course of the program, 5082 ethanol stoves were sold (Lefebvre 2016). A key aspect of the project was an innovative revolving fund to provide interest free loans for families to purchase the stove. The fund was initially supported through grants, but replenishes itself through the sale of carbon credits from reduced emissions (ClimateCare 2017).

The Kenya Country Programme of Energizing Development (2006 – 2019) is a project implemented by MOEP, with support from GIZ and SNV. The stoves component of the project promotes uptake of clean cooking technologies. GIZ estimates that by mid-2016, 5 million people had access to improved cooking facilities. Each stove saves 1.09 tonnes of firewood per year (GIZ 2017a).

Relevant policies:

The **Kenya Constitution's** Bill of Rights addresses several economic-social-environmental co-benefits associated with healthcare related particulate emissions and a clean and healthy environment.

The **Vision 2030** prioritizes the growth of energy generation and increased efficiency in energy consumption. Promoting the development of an indigenous clean cookstove industry in Kenya, especially in rural areas, is seen as a concrete contribution to fulfilling Vision 2030's goal of increasing national GDP growth as well as providing enhanced equity and wealth creation opportunities for the poor through creation of meaningful employment in rural areas.

Draft National Energy and Petroleum Policy: This policy aims to establish strategies and mechanisms to eliminate wood fuel, charcoal and kerosene as a household energy source by 2022. It also should "support and promote conversion of cook stoves to uptake modern and clean fuels in households and institutions (MOEP 2015)." It also promotes efficient conversion and cleaner utilization of biomass energy, alternative sources of energy and technologies as substitutes for biomass and pilot implementation of a bioethanol programme.

The government has **removed the value-added tax (VAT)** on clean cookstoves and parts, and **reduced the import duty** from 25% to 10% on clean cookstoves (MENR and MOEP 2017). .

The **Forest (Charcoal) Regulations (2009)** mandated the formation of Charcoal Producer Associations, which were to be licensed by KFS to facilitate sustainable charcoal production. These regulations had low or no compliance (Bauner et al. 2016).

The **Energy Bill (2015)** established the Rural Electrification and Renewable Energy Corporation. The corporation is to be responsible for developing and promoting renewable energy and technologies, including biomass, bio-ethanol, charcoal, and fuel-wood, among others. It also covers the production, transport and distribution of biomass for energy purposes.

2.6.2.1 Barriers to implementation of efficient, biomass and renewable energy cookstoves

Although there are multiple competing clean cookstove technologies on the market in Kenya, uptake has been slow (MENR and MOEP 2017).

The first major barrier to implementing improved cookstoves is **available upfront investment**. For low income households, even a modest investment for a cookstove is not available, even though the improved stove saves money for fuel over time (Saidi, Stiebert, and Würtenberger 2012). In 2017, the upfront cost of a Safi International ethanol cooker was 4800 Ksh (~39 euros) and the upfront cost of a Burn Jiko Koa improved charcoal cookstove was 4500 Ksh (~37 euros). Providing no or low interest loans is a way to overcome this barrier, that has been proven to function in Kenya in pilot project testing (ClimateCare 2017).

An additional barrier is **lack of consumer trust** in the quality of improved cookstoves (Saidi, Stiebert, and Würtenberger 2012). There are multiple manufacturers of cookstoves, and consumers are not convinced that the cookstove that they would purchase is of high quality and will deliver the promised energy savings. The government is considering setting standards for improved cookstoves, but these could be difficult to enforce.

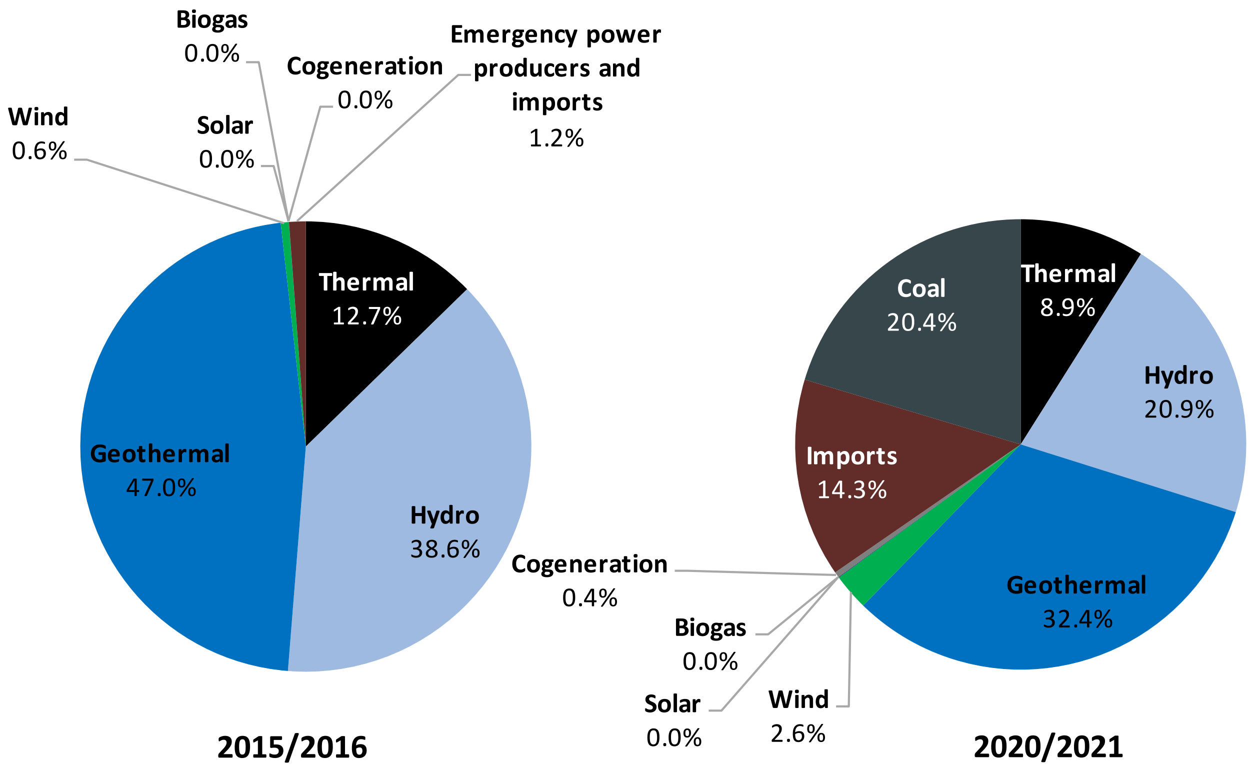
In the case of ethanol stoves, a **distribution network for ethanol** fuel needs to be established. Currently, ethanol is sold in 1 litre bottles, which result in a packaging surcharge, and is only sold in some shops. Kerosene, by comparison, is available at any petrol station and can be filled in any amount in a customer's own container. **Investment** in the ethanol fuel distribution network will be required to facilitate uptake of ethanol stoves. Furthermore, there is currently a small price incentive for sugar manufacturers to produce beverage ethanol instead of fuel ethanol, which has led to a focus on beverage ethanol production. Fuel ethanol production will need to increase to meet the needs of a growing market.

2.6.3 Accelerating renewable electricity

Kenya has massive potential for renewable electricity production, and up until now, Kenya's electricity generation has been dominated by hydro and geothermal sources (Figure 7). However, the Kenyan Government has recently approved plans to build a 1050 MW coal fired power plant, the first in East Africa, which will double Kenya's CO_2 emissions from the energy sector if built, and could lead to extreme overcapacities in the electricity system. Analysis for the NCCAP found that expanding geothermal power has a mitigation potential of 14.1 $MtCO_2e$ in 2030 (Cameron, Würtenberger, and Stiebert 2012), and this potential could be even higher if coal plants are not built as a result of expanded renewables capacity. Indeed, if electricity were to be generated only with renewables in 2030, the NDC target could be met without implementing any further mitigation measures. Geothermal energy in particular has the potential to provide a steady base electricity supply, improving climate change resilience, and would also increase energy security by reducing imports and simultaneously lowering electricity costs. Additionally, innovative projects to bring distributed solar electricity to rural households that are not connected to the grid, either through individual household units or mini-grids, have shown promise in Kenya, and have the potential to improve rural livelihoods.

The Kenyan government acknowledges that "meeting future demand for electricity in Kenya and keeping the average emission intensity of the grid low enough to meet the NDC target will require substantial deployment of renewable energy technologies (MENR and MOEP 2017)."

Figure 18: Share of energy sources in electricity generation in 2015/16 and 2020/21



Data sources: KPLC (2016a, 2016b). Generation in 2015/2016 was 7.3 TWh, and is projected to increase to 9.8 TWh in 2020/2021. However, these generation values and shares are based on a very optimistic demand scenario and would look different if demand grew under a scenario that were consistent with historical trends.

Emissions sources:

In 2010, emissions from electricity generation made up just 1.4% of Kenya's total emissions (Government of Kenya 2015). This share, however, is projected to rise to 16% of emissions in 2030 under Kenya's updated emissions scenario, due to the **planned increase in generation from fossil fuels, including coal** (MENR 2017b) (see Figure 10 and Table 5). This increase in capacity may, however, not be necessary, which would keep Kenya's emissions from the electricity sector low.

In 2016, installed grid capacity for electricity generation was 2,270 MW, whereas peak demand was 1,585 MW (KPLC 2016a). This consisted of 36% thermal (diesel and fuel oil), 35% hydro, and 27% geothermal, with about 1% each of wind and cogeneration (KPLC 2016b) (Figure 19).

The demand for electricity in Kenya is rising, but has so far risen much more slowly than projected. Emissions projections for the NCCAP, which were also used for the NDC, assumed that installed capacity would increase to 5,687 MW by 2020 and over 11,000 MW by 2030 (Cameron, Würtenberger, and Stiebert 2012). In the updated emissions projections, installed capacity is expected to be similar in

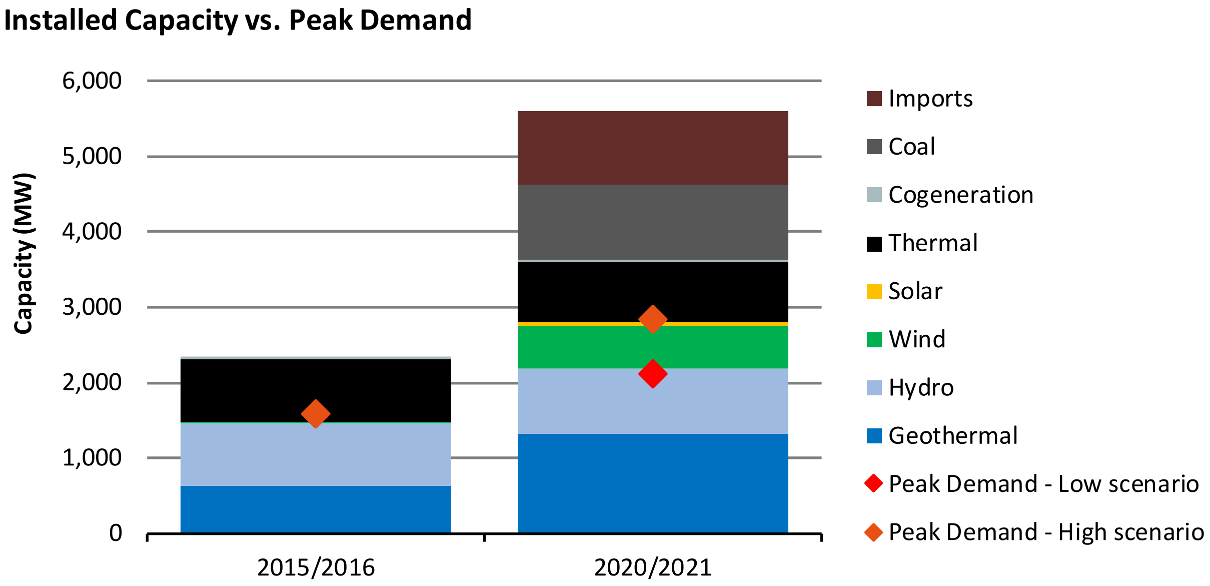
2020 and lower in 2030, at under 9,000 MW (MENR 2017d). This has led to a decrease in emissions from the electricity sector by half in 2030 between the two scenarios.

However, in the Power Generation and Transmission Master Plan (2015-2035) (PGTMP), even under the most ambitious scenario including flagship projects, peak demand is projected to reach only 2,845 MW by 2020, and 6,833 MW by 2030. Under a more conservative scenario, in line with historical trends, peak demand will reach 2,116 MW in 2020 and 3,618 in 2030 (Lahmeyer International 2016).

The most recent plans from Kenya Power intend to increase domestic installed capacity to 4624 MW by 2021, with the largest additions coming from geothermal, wind, and coal (Figure 19). However, when comparing this capacity to projected peak demand from the PGTMP, it is clear that even under an ambitious scenario including flagship projects and increased grid access, the **peak demand could be mostly met with renewables** (Figure 19).

Emissions from the electricity sector in 2030 are therefore possibly overestimated in both the NDC BAU scenario and the updated emissions scenario, and if generation is fully covered by renewables, **emissions from electricity generation could be kept near zero**.

Figure 19: Installed capacity for electricity generation in 2015/16 and 2020/21



Data sources: KPLC (2016a, 2016b); Lahmeyer International (2016). Installed capacity values are based on KPLC data and projections, whereas the peak demand scenarios are based on the PGTMP.

Mitigation measures:

Grid connected geothermal, wind, and solar energy. Analysis for the NCCAP found that expanding geothermal power has a technical mitigation potential of 14.1 $MtCO_2$, and expanding wind power has an additional potential of 1.4 $MtCO_2e$ (Cameron, Würtenberger, and Stiebert 2012). These potentials, however, are based on very high assumptions of demand growth, as described above, and the scenarios on which they are based still include coal capacity. Geothermal and wind have both been expanding over the past years, and are projected to continue to do so, as will solar (Figure 7 and Figure 19). Indeed, a 300 MW wind project was completed in 2017, and additional geothermal capacity is on the way. Kenya's future electricity needs could be entirely met through renewables, and if this is the case, emissions from the electricity sector would remain near zero. If electricity were produced only with renewables in 2030, referenced to the NDC BAU scenario, **42 $MtCO_2e$ of emissions could by avoided in 2030, meeting the NDC target with this single measure.**

Distributed solar electricity. Many rural Kenyan households are far removed from a grid connection, and connecting these last homes will be challenging, despite government efforts to expand the grid to these users. An alternative option that is showing promise is distributed solar electricity. Off grid solar photovoltaic (PV) systems provide enough energy for lighting and operating electronic devices, such as a radio and a mobile phone charger. These lights replace the kerosene lanterns that are typically used in rural Kenya. Alternatively, renewables powered mini-grids can bring electricity to groups of rural homes. Mini-grids have an over 30-year history in Kenya, but have traditionally been diesel powered. Recent efforts have focused on hybridising some of these systems with renewables, and building new renewables powered systems can increase electricity access while keeping emissions low.

Co-benefits:

Modelling conducted in preparation of the Power Generation and Transmission Master Plan (2015-2035) showed that wind and geothermal electricity have the lowest levelized costs of any source of electricity in Kenya. Geothermal has a modelled levelized cost of 8.06 USDcent/kWh at the Suswa location and wind has a levelized cost of 8.96 USDcent/kWh at the Lake Turkana facility. Lamu coal, in comparison, has a levelized cost of 11.36 USDcent/kWh, nuclear of 21.46 USDcent/kWh, and gas turbine generation of 35.53 USDcent/kWh (Lahmeyer International 2016). Investing in renewable sources of electricity could therefore lead to **lower costs for consumers** in the future than investing in, for example, coal capacity. Kenyans additionally pay a separate fuel charge on their electricity bill, which fluctuates with global fuel prices. Since renewable sources do not require fuel, this charge could be removed, leading to more stable electricity prices.

Developing renewable energy sources in Kenya **improves energy security** because there is no reliance on imported fossil fuels. Kenya currently does not produce coal or petroleum products, and therefore will need to continue to import fuels. Kenya has recently discovered coal and petroleum reserves in the country, and the government plans to develop these resources (MOEP 2015).

Increasing production from geothermal, wind, and solar could reduce the country's reliance on hydro electricity generation. This is important for **climate resilience**, as droughts in Kenya are expected to become more frequent as a result of climate change (Government of Kenya 2015). As a result of the drought in 2017, hydro plants were nearly inoperable, which led to increased generation from diesel and increased electricity prices (MENR and MOEP 2017).

Investing in renewable sources of electricity has the potential to create new **employment opportunities** (MENR and MOEP 2017).

Distributed solar systems increase **access to electricity**. This access has the potential to **improve rural livelihoods** through income generating activities, children being able to do their homework, storing food and medicine at home, and supplying water pumps that provide safe drinking water.

Renewable sources of electricity have much **lower environmental and health impacts** than coal-fired power plants. Continuing to expand renewable sources in lieu of building coal capacity will contribute to cleaner air and avoid detrimental impacts to coastal ecosystems (see section 2.7 for further discussion).

Good practice examples and ongoing actions:

There are many renewable energy projects underway in Kenya. The main electricity producer is state owned KenGen, producing about 75% of Kenya's electricity. Independent power producers produce an additional 20%, with imports and distributed generation covering the rest.

In the financial year between June 2016 and June 2017, **317.5 MW of new generation capacity was installed in Kenya, all of it from renewable sources** (KPLC 2017a)**.** Of this, 300 MW was wind power installed by Lake Turkana Wind Power. This capacity had, however, as of November 2017, not been connected to the grid because the transmission infrastructure had not been completed. 10 MW was additional geothermal capacity, and the remaining 7.5 MW was hydro.

In the past, geothermal development in Kenya has been mostly led by KenGen, and US-based Ormat Technologies was the only private investor operating geothermal power plants in Kenya. However, in October 2017, the China-based Kaishan Group announced that it will start drilling steam wells in southwestern Kenya (Otuki 2017a).

There are a number of other internationally supported projects focused on renewable energy development in Kenya, for example one GIZ project to support on-grid renewable energy with a focus on wind energy and another to promote solar-hybrid mini-grids, both funded through BMZ (GIZ 2017b). The German KfW Development Bank, and its subsidiary DEG together with GIZ, have committed hundreds of millions of euros to energy projects in Kenya (Begisheva 2018). Additionally, Kenya is supported by the Ambition to Action project, funded by IKI, to increase knowledge of the synergies between energy sector pathways and climate and development objectives and more.

Distributed solar initiatives have helped raise the number of households with access to solar electricity from 3% in 2013 to 15% in 2016 (MENR and MOEP 2017). These include private sector businesses such as M-Kopa, Sunlar and Go Solar Systems. One innovative aspect of the M-Kopa system is that it allows customers to "pay-as-you-go," purchasing credits through Safaricom's M-Pesa mobile money platform, a service common in Kenya that uses mobile phones to transfer money (MENR 2016a). Many residents in rural Kenya have access to only limited funds per day, and would make daily trips to purchase kerosene to fuel their lanterns. The pay-as-you-go solar systems replace this practice, while allowing customers to make small payments over time.

The Kenyan Rural Electrification Authority is running the Kenya Off-Grid Solar Access Project (KOSAP), a project funded by the World Bank to increase access to electricity services in underserved counties in Kenya. This project includes the development of mini-grids, stand alone solar systems and solar water pumps for households and community facilities (REA 2017a).

Relevant policies:

Draft National Energy and Petroleum Policy: The "overall objective of the energy and petroleum policy is to ensure affordable, competitive, sustainable and reliable supply of energy to meet national and county development needs at least cost, while protecting and conserving the environment (MOEP 2015)." The draft proposes to encourage investment in the geothermal subsector, but also to exploit domestic petroleum and coal reserves.

The **Energy Bill 2015,** which would operationalize aspects of the Draft National Energy and Petroleum Policy, was passed by National Assembly on 23.11.2016, and has been forwarded to the Senate for consideration.

Least Cost Power Development Plans (LCPDPs) – The LCPDPs are MOEP's power implementation plans. The plan includes demand forecast scenarios for electricity demand and transmission expansion plans. The most recent of these is the Power Generation and Transmission Master Plan (2015-2035) (Lahmeyer International 2016).

Kenya has had a **Feed in Tarif** (FiT) for renewable energy since 2008. FiT values are differentiated for small renewable projects (up to 10 MW), and large projects above 10 MW. The FiT values were last updated in 2012, and the government may soon move away from the FiT in favour of a competitive **tendering scheme**.

2.6.3.1 Barriers to implementation of accelerating renewable electricity

Transmission infrastructure from generation sites to demand centres is a barrier to accelerating renewable electricity. Generation sites tend to be distributed farther away from population centres, which means that infrastructure needs to be built to transfer the electricity. This was a particular challenge for the 300 MW Lake Turkana Wind project that was completed in 2017. This capacity will remain idle until 2018 because the transmission infrastructure that will connect the farm to end users has not yet been installed, although it was due to be completed in October 2017. The Kenyan government could be responsible for 6.6 million USD/month in payment for idle capacity if the transmission line is not completed by April 2018 (Muchira 2017).

Land disputes have been cited as holding up two different recent renewable energy projects in Kenya: the infrastructure project to connect the Turkana Wind park to the grid (Jacobsen 2017), and the Kinangop Wind Park, a 60 MW wind park that was planned but never constructed after the developer pulled out, citing months of delay by locals that refused to cede land for the project (Wasuna 2016).

Upfront financing for exploration and development continues to be a barrier. In the case of geothermal in particular, significant financing is required for exploration, and drilling is perceived to be risky among some investors, although once built, the wells provide a consistent, low-cost energy. Risk reduction programmes could help to increase investment. Additionally, the Feed-in-Tariff policy in Kenya has not been updated since 2012, although renewables prices globally have fallen significantly since that time. The government's plan to replace it with a competitive auctioning system could help increase investments.

For geothermal, wind, and solar electricity generation **technology needs** are still present (MENR and MOEP 2017).

Local expertise needs to be developed both to build up renewable resources and to maintain them over time (Cameron, Würtenberger, and Stiebert 2012).

Demand side costs are a significant barrier to increasing access to grid connected electricity. Many households that were previously not connected to the grid would not be able to afford either a grid connection or to purchase electricity from it. An advantage of "pay-as-you-go" distributed solar systems is that residents can pay small amounts over time for access to electricity. This model is also possible for mini-grid systems.

Coordination between national and international actors for effective long term planning could be improved. Currently there are around 14 international donor organisations with development interests in the energy and power sector operating in Kenya, for example the World Bank, GIZ, KfW, JICA, and the Chinese goverment (Lahmeyer International 2016).

2.7 Assessment of the relevance and perspective of coal use

Kenya currently does not generate any electricity from coal (KPLC 2016a). The coal that it does use, which made up less than 1% of its total primary energy supply in 2014, is used in industrial applications (IEA 2016a). Government plans would change that.

The Draft National Energy and Petroleum Policy states that "coal is an affordable, competitive, reliable and easily accessible source of energy, especially for electricity generation." It stipulates that the Kenyan "Government shall promote an intensive coal exploration programme and efficient utilisation of coal resources while minimising the environmental impacts associated with its use (MOEP 2015)." Coal reserves have been discovered in the Mui Basin in south central Kenya, but mining work has not commenced.

In May 2017, **the Kenyan government approved plans for a USD 2 billion coal plant in Lamu**, in southeastern Kenya, despite an ongoing legal case over its potential environmental and social impacts. The plant would add 1050 MW of capacity to Kenya's grid (45% of 2015 capacity), and is already accounted for in Kenya Power's latest energy forecast, although the capacity may not be necessary to meet Kenya's electricity demand (Figure 19). Kenya Power expects 20% of electricity generation from coal in 2020, up from 0% in 2016 (Figure 18). The plant would be built and operated by Amu Power Company, a joint-venture of Gulf Energy and Centum Investment, and is financed with Chinese, and Kenyan capital (Rosen 2017). Since Kenya does not currently produce coal, it will need to import all coal to feed the plant, primarily from South Africa. President Uhuru Kenyatta signed the agreement for the plant in Beijing during the Belt and Road Forum for International Cooperation (Wesangula 2017).

According to the Environmental and Social Impact Analysis for the project, the plant would generate approximately 9 $MtCO_2e$ of emissions annually (Kurrent Technologies 2016). In 2010, Kenya's emissions from electricity generation in the entire country were 1.4 $MtCO_2e$ (Government of Kenya 2015). This means that **emissions from this single plant will be over six times higher than the entire electricity sector in 2010**.

Amu Power estimated that electricity generated from the coal plant would cost Kenyans 7.12 USD cent/kWh, based an assumed coal price of 50 USD/ton, a price that is lower than any seen in the past decade. In a sworn testimony, the former chairman of the ERC Hindpal Jabbal argued that the true cost of the electricity would be at least 42% higher, at 10.08 USD cent/kWh, assuming a more realistic coal price of 100 USD/ton (as of November 2017, the global average price of coal was 96.75 USD) (Jabbal 2016). Projected levelized costs of electricity from Kenya's Power Generation and Transmission Master Plan (2015-2035), show that at a 10% discount rate and including necessary transmission infrastructure, Lamu coal electricity would cost 11.36 USD cent/kWh, whereas the Lake Turkana wind would cost 8.96 USD cent/kWh, and geothermal from the Suswa Phase I project would cost only 8.06 USD cent/kWh (Lahmeyer International 2016). This means that **electricity generated at Lamu will cost 21% more than wind and 29% more than geothermal per kWh.**

The Lamu Old Town is a Unesco world heritage site, recognized as the oldest Swahili settlement in East Africa. Local residents are concerned that warm effluent from the plant and seepage from the open air ash pit will ruin the local fishing industry, which supports 75% of the town's population, and are worried about health effects from particulate matter and other pollutants from the plant. Tourism could also decline, and the plant may negatively impact coral reefs, mangrove channels, and three species of sea turtles that nest near Lamu (Rosen 2017).

2.8 Conclusions

Kenya recognises that climate change could threaten the achievement of its development goals, and has therefore prioritised climate change action through numerous plans, strategies, and the 2016 Climate Change Act. Kenya is vulnerable to climate change, particularly its impacts on water resources, and emphasizes the need for both mitigation and adaptation action and support in its NDC. For mitigation options in Kenya to be successful, they will need to contribute to the country's development goals and/or climate change adaptation.

Fortunately, Kenya has high potential for low-carbon development, and first steps at both governmental and grassroots levels could be scaled up to achieve not just the NDC commitment, but further emissions reductions that improve the livelihoods of millions of citizens. Measures to reduce deforestation and restore forests have the potential to abate one-third of Kenya's projected emissions in 2030, while securing water resources and improving climate resilience. Introducing renewable energy ethanol cookstoves and more efficient biomass cookstoves can reduce not only CO_2 emissions from deforestation, but also black carbon, improving indoor air-quality, saving lives, and saving families money. Finally, Kenya's geographical location has given it access to massive geothermal, wind, hydro, and solar energy potential, which could make it possible for Kenya to meet its future electricity needs entirely with renewable energy, while creating employment opportunities, lowering costs, and avoiding the negative environmental and health impacts associated with fossil fuels like coal. Electricity produced at the planned Lamu coal plant, the first of its kind in East Africa, is likely to cost more than renewable sources and may be unnecessary to meet Kenya's electricity demand.

In order to realize its potential for low-carbon development, Kenya will need support to overcome substantial barriers, including a finance deficit (or lack of capacity to secure and effectively use available funding) for projects both at the governmental and individual level and a lack of infrastructure, for example electricity transmission lines and a distribution network for ethanol fuel. Addressing further challenges, such as widespread poverty, unemployment, and corruption will be an important part of a successful low carbon development pathway.

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