

# Climate change and sustainable development in the Kenyan electricity sector

Impacts of electricity sector development on Kenya's NDC



# Climate change and sustainable development in the Kenyan electricity sector

## Impacts of electricity sector development on Kenya's NDC

---

### Authors

Marie-Jeanne Kurdziel, Thomas Day, Lukas Kahlen, Tessa Schiefer

**Acknowledgements:** We are grateful for the input from our local consultant Tom Owino for revising this report and providing valuable feedback. Furthermore, we would like to extend special thanks for the input of all our partners throughout the A2A project in Kenya.

### Project number

215025

© Ambition to Action



Supported by:



based on a decision of the German Bundestag

This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag



Download the report

[www.ambitiontoaction.net/](http://www.ambitiontoaction.net/)

---

# Contents

<b>Abbreviations .....</b>	<b>ii</b>
<b>Introduction.....</b>	<b>1</b>
<b>1. National climate change and sustainable development objectives.....</b>	<b>2</b>
1.1. Climate change and sustainable development .....	2
1.2. Kenya's commitment to the Paris Agreement .....	2
1.3. Legislative and policy framework .....	4
<b>2. Electricity sector profile.....</b>	<b>6</b>
2.1. Current status and trends.....	6
2.2. Key institutions and stakeholders .....	6
2.3. Overview of the planning process .....	8
2.4. Projected development .....	10
<b>3. Current outlook for climate change mitigation in the electricity sector .....</b>	<b>11</b>
3.1. Development of greenhouse gas emissions.....	11
3.2. Implications for national climate change objectives.....	12
3.3. Planned climate change mitigation actions.....	14
3.4. Alignment of climate and electricity sector planning processes.....	15
<b>4. Prospects for low-carbon and sustainable development in the electricity sector .....</b>	<b>18</b>
4.1. The role of geothermal and coal – Implications for climate and sustainable development.....	19
4.2. The role of renewable energy mini-grids – Implications for climate and sustainable development..	22
<b>5. Mainstreaming climate change and sustainable development in the electricity sector .....</b>	<b>25</b>
5.1. The concept of mainstreaming.....	25
5.2. Mainstreaming climate change in the electricity sector .....	26
5.3. Assessment of mainstreaming progress in the electricity sector.....	30
<b>6. Recommendations for next steps .....</b>	<b>32</b>
6.1. Achieving enhanced alignment in planning processes.....	32
6.2. Updating the Nationally Determined Contribution.....	34
6.3. Charting out a Paris compatible pathway for the electricity sector.....	35
<b>Annex I – Tools for the assessment of sustainable development benefits .....</b>	<b>37</b>
SDG Climate Action Nexus tool (SCAN-tool).....	38
The Economic Impact Model for Electricity Supply (EIM-ES) .....	39
The Air Pollution Impact Model for Electricity Supply (AIRPOLIM-ES).....	40
<b>References.....</b>	<b>43</b>

# Abbreviations

<b>A2A</b>	Ambition to Action
<b>AMDA</b>	Africa Mini-Grid Developers Association
<b>AIRPOLIM-ES</b>	Air Pollution Impact Model for Electricity Supply
<b>BMU</b>	The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Nukleare Sicherheit)
<b>CCD</b>	Climate Change Directorate
<b>CCTWG</b>	Climate Change Thematic Working Group
<b>CO<sub>2</sub></b>	Carbon Dioxide
<b>COP</b>	Conference of the Parties
<b>CPEBR</b>	Climate and Public Expenditure Budget Review
<b>EIM-ES</b>	Economic Impact Model for Electricity Supply
<b>EPRA</b>	Energy and Petroleum Regulatory Authority
<b>FIT</b>	Feed-In Tariff
<b>GDC</b>	Geothermal Development Company
<b>GHG</b>	Greenhouse Gas
<b>GIS</b>	Geographic Information System
<b>GIZ</b>	German Corporation for International Cooperation (Gesellschaft für Internationale Zusammenarbeit)
<b>GW</b>	Gigawatt
<b>GWh</b>	Gigawatt hours
<b>IKI</b>	International Climate Initiative (Internationale Klimaschutz Initiative)
<b>IPP</b>	Independent Power Producer
<b>KenGen</b>	Kenya Electricity Generating Company
<b>KenInvest</b>	Kenya Investment Authority
<b>KEPSA</b>	Kenya Private Sector Alliance
<b>KES</b>	Kenyan Shilling
<b>KETRACO</b>	Kenya Electricity Transmission Company Limited
<b>KNBS</b>	Kenya National Bureau of Statistics
<b>NPEA</b>	Nuclear Power and Energy Agency



<b>KNES</b>	Kenya National Electrification Strategy
<b>KPLC</b>	Kenya Power and Lighting Company
<b>kW</b>	Kilowatt
<b>kWh</b>	Kilowatt hours
<b>LCOE</b>	Levelized Cost of Electricity
<b>LCPDP</b>	Least Cost Power Development Plan
<b>LIPS OP/XP</b>	Lahmeyer International Power System Operation Planning/ Expansion Planning
<b>MENR</b>	Ministry of Environment and Natural Resources
<b>MoE</b>	Ministry of Energy
<b>MRV</b>	Monitoring, Reporting, Verification
<b>MTP</b>	Medium Term Plan
<b>MW</b>	Megawatt
<b>MWh</b>	Megawatt hours
<b>MtCO<sub>2</sub>eq</b>	Metric tons of carbon dioxide equivalent
<b>NCCAP</b>	National Climate Change Action Plan
<b>NDC</b>	Nationally Determined Contribution
<b>NGO</b>	Non-governmental organisation
<b>O&amp;M</b>	Operation and Maintenance
<b>PGTMP</b>	Power Generation and Transmission Masterplan
<b>PM</b>	Particulate Matter
<b>PPA</b>	Power Purchase Agreement
<b>PSMTP</b>	Power Sector Medium Term Plan
<b>PV</b>	Photovoltaic
<b>REREC</b>	Rural Electrification and Renewable Energy Corporation
<b>SCAN</b>	SDG Climate Action Nexus
<b>SDG</b>	Sustainable Development Goals
<b>StARCK+</b>	Strengthening Adaptation and Resilience to Climate Change in Kenya
<b>UNFCCC</b>	United Nations Framework Convention on Climate Change
<b>USD</b>	US Dollar

## Introduction

This report draws together the key strands of analysis and results from analytical and capacity support activities undertaken as part of the “Ambition to Action” (A2A) project in Kenya between March 2017 and December 2019. Overall, the A2A project supported NDC processes in partner countries with a view to accelerating implementation of current NDCs and inform the setting of more ambitious NDC targets for upcoming NDC cycles. The underlying rationale of the project was to support policymakers to better understand the broader implications of higher ambition in key NDC sectors by comparing alternative sector pathways in terms of their socio-economic impacts and technical implications. The analysis involved the development of assessment tools to allow for the quantification of impacts, or so-called co-benefits, and was undertaken in close consultation with local experts.

Reflecting the importance of the sector for the Kenyan NDC, the project activities focussed on the electricity sector. The current development of the electricity sector plays a key role for the evolution of national emissions and hence for the efforts to decarbonise the economy long term. Formally, the project was anchored at the Climate Change Directorate (CCD) within the Ministry of Environment and Forestry (MoEF) which coordinates the NDC process. However, given the sector focus, the project engaged deeply with electricity sector stakeholders on both the government and non-government sides. In particular, the project engaged with the Renewable Energy Directorate of the Ministry of Energy (MoE) which is the NDC focal point for the energy sector; and with the Energy and Petroleum Regulatory Authority (EPRA) who is the regulating entity in the sector. Beyond that, the project worked with several local organisations and companies, including Kenya Power (national electric utility company), KenGen (the largest power producing company in Kenya), civil society organisations, such as deCOALonize (local NGO aiming to keep the coal industry out of Kenya) and several other sector related stakeholders.

The objective of this report is to integrate the insights gained throughout the project to inform policy planning in the electricity sector, targeting policy makers and other interested stakeholders. More specifically, the insights aim to feed into the discussions around more ambitious climate targets for successive NDCs, aligned with the country’s sustainable development agenda, and the long-term strategy to be presented to the Government of Kenya and the international community under the Paris Agreement. As such the report will discuss the following:

Section 1 focuses on Kenya’s objectives for climate change and sustainable development, reflecting the current debate and existing institutional framework. Section 2 provides an overview of the electricity sector, including the planning process and projected growth of the sector. In Section 3, the sector’s development in terms of emissions is examined and implications for climate change objectives and planning are outlined. Section 4 summarises the results of two technology focus studies that map out alternative pathways for the electricity sector and respective implications for sustainable development. Section 5 deals with the subject of mainstreaming climate change in sector processes and activities and how mainstreaming is implemented in the electricity sector and beyond. Section 6 gives short recommendations for next steps in Kenya’s NDC process, with a focus on the electricity sector.

# 1. National climate change and sustainable development objectives

## 1.1. Climate change and sustainable development

Kenya is one of the fastest growing economies in Sub-Saharan Africa and is considered by some as one of the world's major new emerging economies (World Bank, 2015). Economic growth dominates the political discourse, with several ambitious flagship projects obtaining a high degree of political priority as a means of achieving targets for annual economic growth.

Through various national strategy documents, Kenya recognises the importance of sustainable development for its economic growth ambitions. Kenya's long-term development plan – Kenya Vision 2030 – sets out the country's target to become a “newly industrialising, middle-income country [by 2030], providing high quality of life to all its citizens in a clean and secure environment” (MENR, 2017b). The Third Medium Term Plan for 2018-2022 (MTP III) – Kenya's implementation plan for the Vision 2030 – indicates that the 17 Global Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda for Sustainable Development have been mainstreamed into that plan. The MTP III prioritises implementation of the “Big Four” initiatives, which include boosting manufacturing, providing affordable housing, enhancing food and nutrition, and achieving universal access to healthcare.

Synergies between sustainable development objectives and climate change actions are increasingly recognised in national strategy documents: climate change is referred to extensively throughout the MTP III, mostly pertaining to resilience and adaptation to the negative impacts of climate change, but links to climate change mitigation are also identified. Climate change mitigation actions in various sectors can entail synergies with Kenya's “Big Four” initiatives and continued increase in the volume of available international climate finance mean that this climate change actions can provide a vehicle for the delivery of other development objectives. The increasing recognition of those links indicates that the priority afforded to climate change mitigation actions in national strategic planning is likely to continue to increase.

At a higher level, both the Vision 2030 and the MTP III reaffirm Kenya's objective to mainstream climate change and sustainable development, and to continue to play a critical role in shaping the global environmental agenda (MENR, 2017b).

## 1.2. Kenya's commitment to the Paris Agreement

In December 2015, representatives of 196 nations negotiated a global agreement for responding to the threat of climate change, at the 21st Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) in Paris. The major objectives of the Paris Agreement are to strengthen the global response to climate change by keeping a global temperature rise well below 2 °C above pre-industrial levels, pursue efforts to limit the temperature increase even further to 1.5 °C, and to strengthen the ability of countries to deal with climate change impacts. The Paris Agreement officially came

into force in November 2016 after at least 55 Parties representing at least 55% of global greenhouse gas (GHG) emissions had ratified the Agreement. Kenya ratified the Paris Agreement at the end of 2016.

**As a country with high vulnerability to the impacts of climate change, Kenya stands at the international level for strong and ambitious action** from the Parties of the UNFCCC in keeping global temperature rise below 1.5 °C, whilst recognising that developed countries should take the lead in mitigation efforts due to the principle of common but differentiated responsibilities and respective capabilities (Republic of Kenya, 2015). Reaffirming this position, Kenya is an active member of the Climate Vulnerable Forum, and the Vulnerable Twenty (V20) Group, bringing together nations that are hit hard by climate change impacts to advocate for more ambitious mitigation action and support provisions in international climate agreements.

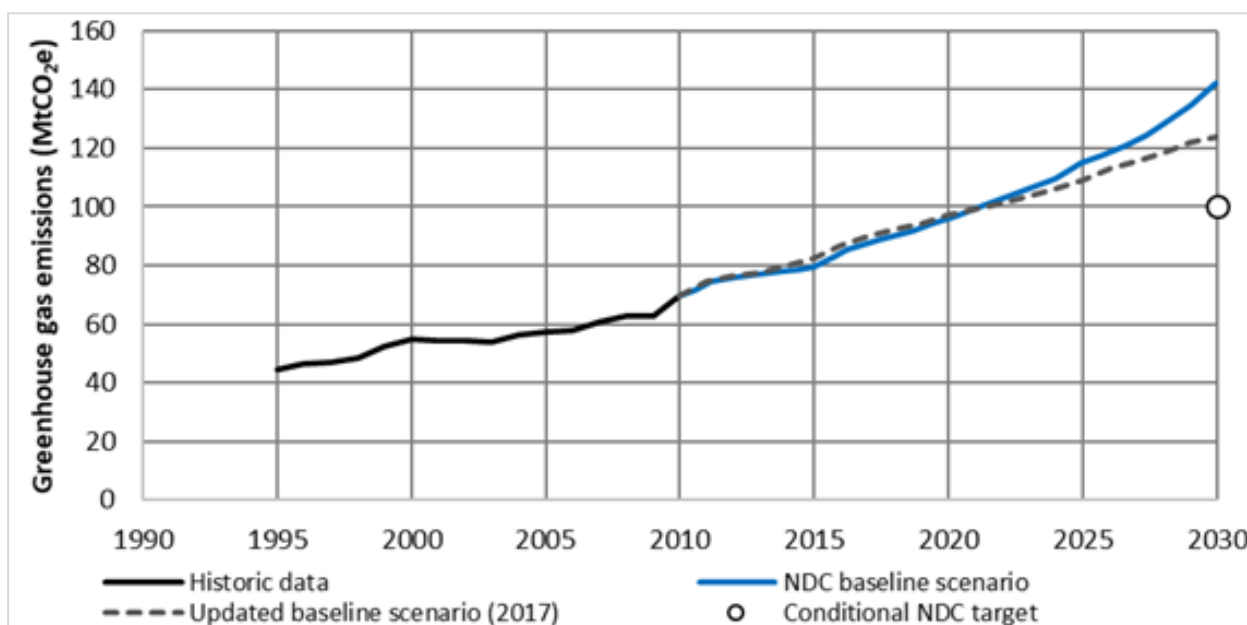
**The objectives of the Paris Agreement have considerable implications for the decarbonisation of the electricity supply sector.** Having agreed to peak GHG emissions as soon as possible and to achieve net-zero emissions in the second half of the century, compliance with the Agreement will require all Parties to restrict short-term investments in fossil fuel power generation technologies to the absolute minimum required, and to transition to a 100% renewable energy-based electricity supply sector in the medium- to long-term. Recognising this need, 50 of the Parties most vulnerable to climate change impacts, including Kenya, vowed at COP22 in November 2016 to strive towards 100% renewable energy by 2050 (Climate Vulnerable Forum, 2016). Kenya is expected to communicate a long-term low emissions development strategy, outlining how the country could transition to a net-zero emissions economy in the second half of the century. Due to current technology availability, the decarbonisation of the electricity supply sector is likely to precede equivalent action in other sectors, in most countries (UNEP, 2016).

**Presently, Kenya's contribution to the Paris Agreement is represented by the country's Nationally Determined Contribution (NDC),** outlining Kenya's planned climate change action up to 2030. The NDC was developed in an inter-ministerial process using the 2013-2017 National Climate Change Action Plan (NCCAP) as an input. 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, between which there are synergies (MENR, 2015). The conditional NDC mitigation target is a 30% reduction below Business as Usual (BAU) in 2030 and is referenced to a BAU scenario of 143 MtCO<sub>2</sub>e in 2030, indicating a targeted emissions level of 100 MtCO<sub>2</sub>e in 2030, as shown in Figure 1. 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. Further details on this updated baseline and the contribution of the electricity sector for achievement of the NDC are given in section 3.

**Kenya will be required to prepare and communicate a revised NDC to the UNFCCC by 2020** which will be based on the technical analysis underlying the new 2018-2022 National Climate Change Action Plan (NCCAP), and other available inputs. Kenya confirmed in June 2019 that it is planning to enhance and update its NDC by 2020 (WRI, 2019). This report – compiled from the analysis of the Ambition to Action project – may provide a good basis from which to update the information in the NDC for the electricity sector.



Figure 1: Kenya's NDC in the context of a projected baseline scenario for emissions (graph based on Government of Kenya, 2015; MENR, 2015, 2017)



### 1.3. Legislative and policy framework

Table 1 presents elements of Kenya's legal and policy framework that are of most relevance to climate change mitigation in the electricity sector (Government of Kenya, 2018a).

Table 1: Selected overview of Kenya's legal and policy framework for climate change mitigation

International commitments	
<b>Ratification of the Paris Agreement (2016)</b>	Kenya ratified the Paris Agreement - a global agreement for responding to the threat of climate change - in 2016. The objectives of the Paris Agreement have considerable implications for the decarbonisation of Kenya's electricity sector (see section 1.2).
<b>Nationally Determined Contribution (NDC) (2016)</b>	Kenya's NDC under the Paris Agreement includes mitigation and adaptation contributions. The mitigation contribution "seeks to abate Kenya's GHG emissions by 30% by 2030, relative to the business as usual scenario of 143 MtCO <sub>2</sub> e". The achievement of Kenya's NDC is subject to international support in the form of finance, investment, technology development and transfer, and capacity development.
National legislation	
<b>Climate Change Act (2016)</b>	The Climate Change Act (No. 11 of 2016) is the first comprehensive legal framework for climate change governance in Kenya. The objective of the Act is to "enhance climate change resilience and low carbon development for sustainable development of Kenya". The Act establishes the National Climate Change Council, Climate Change Directorate, and Climate Change Fund, and requires the preparation and/or update of the National Climate Change Action Plan every five years.

National strategy	
<b>Kenya Vision 2030 (2008) and its Medium-Term Plans (MTP)</b>	Kenya Vision 2030, the country's development blueprint, which is implemented through five-year Medium-Term Plans (MTPs), recognised climate change as a risk that could slow the country's development. Climate change actions were identified in the Second Medium-Term Plan (MTP II) (2013-2017). The Third Medium-Term Plan (MTP III) (2018-2022) recognised climate change as a cross-cutting thematic area, and mainstreamed climate change actions in sector plans.
<b>Kenya's National Climate Change Response Strategy (2010)</b>	Kenya's National Climate Change Response Strategy was the first national policy document on climate change. It sought to advance the integration of climate change adaptation and mitigation into all government planning, budgeting, and development objectives.
<b>National Climate Change Action Plan (NCCAP)</b>	Kenya's National Climate Change Action Plan is a five-year plan that seeks to further Kenya's development goals in a low carbon climate resilient manner. It is the implementing vehicle for the country's NDC. The current plan sets out adaptation, mitigation, and enabling actions for the 2018-2022 period.
<b>National Climate Finance Policy (2018)</b>	The National Climate Finance Policy promotes the establishment of legal, institutional, and reporting frameworks for access to, and management of climate finance. The goal of the policy is to further Kenya's national development goals through enhanced mobilisation of climate finance that contributes to low carbon climate resilient development goals.
<b>National Climate Change Framework Policy (2018)</b>	The National Climate Change Framework Policy aims at ensuring the integration of climate change considerations into planning, budgeting, implementation, and decision-making at the National and County levels, and across all sectors.

*Source: Reproduced and adapted from the 2018-2022 NCCAP (Government of Kenya, 2018a), including authors' own additions.*

## 2. Electricity sector profile

### 2.1. Current status and trends

Kenya is at an important crossroads in its electricity sector planning, facing decisions on how to work towards achieving the target of universal access to electricity by 2022 and low-carbon climate resilient development of the sector, while simultaneously developing reliable and cost-effective electricity supply infrastructure in the face of increasing energy demand.

As of June 2018, the installed grid capacity in Kenya was 2,351 MW, with a peak load of 1,802 MW (ABiQ, 2019). The energy mix in Kenya is dominated by renewable energy technologies, which account for 85% of installed capacity (ABiQ, 2019; IRENA, 2019). While it is the country's aim to be powered entirely by green energy by 2020 (Capital FM Kenya, 2018), plans for potential new thermal power plants remain under development.

According to the 2016/2017 Kenya Power Annual Report, electricity access stood at 70.3% in 2017. However, there are various definitions of electricity access, and estimates of this figure vary considerably depending on the definition applied: another estimate based on a nationwide survey indicates a lower figure of 57% (Infotrak, 2017). Irrespective of the exact number, electrification rates have increased significantly in recent years, rising from only 36% in 2014. Still there is some way to go to achieve the government's target of universal electricity access by 2022 (KPLC, 2017; Newell et al., 2014).

In order to enhance performance and fulfil its role in driving development as outlined in Kenya's Vision 2030, the electricity supply sector is pursuing a range of objectives including expanding generation capacity, increasing electrification rates, improving the reliability of electricity supply, and addressing the financial sustainability of the sector while at the same time reducing electricity prices for the end user (Eberhard, Gratwick, Morella, & Antmann, 2016; Newell & Phillips, 2016).

### 2.2. Key institutions and stakeholders

Table 2 presents an overview of key institutions and stakeholders for Kenya's electricity sector.

*Table 2: Key institutions and stakeholders for the electricity sector in Kenya*

Policy, regulation and other government agencies	
<b>Ministry of Energy (MoE)</b>	The Ministry of Energy (MoE) is in charge of making and articulating energy policies to create an enabling environment for efficient operation and growth of the sector.
<b>Energy and Petroleum Regulatory Authority (EPRA) (formerly Energy Regulatory Commission – ERC)</b>	The Energy and Petroleum Regulatory Authority (EPRA) – previously the Energy Regulatory Commission (ERC) – is responsible for regulation and licencing in the energy sector. Functions include tariff setting and oversight, coordination of the development of the Integrated National Energy Plan, monitoring and enforcement of sector regulations.

<b>Rural Electrification and Renewable Energy Corporation (REREC) (formerly Rural Electrification Agency – REA)</b>	The Rural Electrification Agency (REA) was established in 2007 with a mandate of implementing the Rural Electrification Programme, through connecting public facilities and surrounding “last mile” homes. In 2019, the new Energy Act established the Rural Electrification and Renewable Energy Corporation (REREC) as a successor of REA. This combines the fields of rural electrification and renewable energy under one authority and creates a body tasked with developing renewable energy infrastructure at a more localised level.
<b>Renewable Energy Resource Advisory Committee (RERAC)</b>	The Renewable Energy Resource Advisory Committee (RERAC) was created under the Energy Act 2019. RERAC is an inter-ministerial committee which is composed of the Principal Secretary in the Ministry of Energy, the CEO of REREC, the managing director of GDC and the managing director of KenGen, among others. The Committee advises the Cabinet Secretary for Energy on, inter alia, criteria for the allocation of renewable resources, licensing of renewable energy resource areas, and management and development of renewable energy sources.
<b>Energy and Petroleum Tribunal (EPT) (formerly Energy Tribunal –ET)</b>	The Energy and Petroleum Tribunal (EPT) is the successor to the Energy Tribunal (ET), a quasi-judicial body with the mandate to hear appeals to decisions made by EPRA. The new Energy Act provides that EPT may hear and determine disputes and appeals relating to energy and petroleum that arise under the Energy Act and other written laws.
<b>Generation</b>	
<b>Kenya Electricity Generating Company (KenGen)</b>	KenGen is the main player in electricity generation, with an installed capacity of 1,610 MW in 2017. KenGen is 70% owned by the Government of Kenya. The Company accounts for approximately 69% of the installed capacity from various power generation sources that include hydropower, thermal, geothermal and wind.
<b>Independent Power Producers (IPPs)</b>	Independent Power Producers are private investors in the power sector involved in generation, either on a large scale or for the development of renewable energy under the Feed-in-Tariff. As of June 2017, they accounted for 696 MW, approximately 30% of the country’s installed capacity.
<b>Geothermal Development Company (GDC)</b>	Geothermal Development Company is a fully government-owned Special Purpose Vehicle (SPV) intended to undertake surface exploration of geothermal fields, undertake exploratory, appraisal and production drilling and manage proven steam fields as well as enter into steam sales agreements with investors in the power.
<b>Nuclear Power and Energy Agency (NPEA), formerly Kenya Nuclear Electricity Board (KNEB)</b>	The Nuclear Power and Energy Agency (NPEA), formerly Kenya Nuclear Electricity Board (KNEB), is a State Corporation established under the Energy Act 2019. It is charged with the responsibility of promoting and implementing Kenya’s Nuclear Power Programme, carrying out research and development for the energy sector. To date, no nuclear plant has been built and potential generation from this source is still in the future.

Distribution	
<b>Kenya Power and Lighting Company (KPLC)</b>	KPLC purchases power from all power generators on the basis of negotiated Power Purchase Agreements for onward transmission, distribution and supply to consumers. It is governed by the State Corporations Act and is responsible for most of the existing transmission and distribution systems in Kenya. KPLC is owned 50.1% by the National Social Security Fund (NSSF) and the Government of Kenya together.
<b>Kenya Electricity Transmission Company (KETRACO)</b>	KETRACO has a mandate to plan, design, construct, own, operate and maintain new high voltage (132kV and above) electricity transmission infrastructure that will form the backbone of the National Transmission Grid & regional inter-connections. KETRACO is 100% owned by the Government of Kenya.
<b>Private distribution companies</b>	Private Distribution Companies are proposed under the new Energy Act of 2019, with the intention to enhance distribution competition and hence improve efficiency. It is envisaged that future power distribution will involve purchase of bulk power from the generators. With KETRACO facilitating the transmission, power generators will be able to sell power directly to consumers.

*Source: Reproduced and adapted from the 2017-2037 LCPDP (Republic of Kenya, 2018b), Power Africa (2016) and Roedl & Partner (2019).*

## 2.3. Overview of the planning process

To pursue Kenya's electrification objectives, the electricity sector, under the leadership of the Ministry of Energy (MoE), has established a set of planning processes represented in various official documents. The major planning process is the Least Cost Power Development Plan (LCPDP) process. The LCPDP Committee was established in 2009. It is headed by the Energy and Petroleum Regulatory Authority (EPRA) and made up of parties relevant for electricity sector planning in Kenya (see Table 3).

The LCPDP Committee is tasked with developing an up to date LCPDP on a biennial basis to deal with capacity planning, demand projections and transmission investment requirements over a 20-year period.

The latest plan from the LCPDP Committee is the 2017-2037 LCPDP (Government of Kenya, 2018b). Previous programmes and planning documents which are superseded by the 2017-2037 LCPDP include the 2011-2031 LCPDP, the 5000+ MW programme launched in 2013, the 2015-2020 Power Sector Medium Term Plan (PSMTP), and the 2015-2035 Power Generation and Transmission Masterplan (PGTMP).



Table 3: LCPDP Committee

LCPDP Committee		
Lead institutions	Power sector institutions	Institutions with oversight role
<b>Economic Department of the Energy and Petroleum Regulatory Authority (EPRA)</b>	Ministry of Energy (MoE) Kenya Power and Lighting Co. (KPLC/Kenya Power) Kenya Electricity Transmission Co. (KETRACO) Kenya Electricity Generation Co. (KenGen) Geothermal Development Company (GDC) Rural Electrification and Renewable Energy Corporation (REREC) Nuclear Power and Energy Agency (NPEA) Renewable Energy Resource Advisory Committee (RERAC) Energy and Petroleum Tribunal (EPT)	Kenya Vision 2030 Kenya Investment Authority (KenInvest) Kenya Private Sector Alliance (KEPSA) Kenya National Bureau of Statistics (KNBS)

Source: Reproduced and adapted from the 2017-2037 LCPDP (Government of Kenya, 2018b), including authors' own additions.

The 2017-2037 LCPDP borrowed heavily on technical parameters from the 2015-2035 PGTMP, prepared by Tractebel Engineering (formerly Lahmeyer International). In 2016, when Tractebel was contracted as a consultancy by MoE to develop the PGTMP, their team also introduced and provided training to the LCPDP Committee on Tractebel's in-house generation expansion optimisation tool for short- and long-term planning, known as **Lahmeyer International Power System Operation Planning/ Expansion Planning (LIPS-OP/XP)** tool. Adjustments were made to the tool in order to achieve a specific fit with the Kenyan power system. Following the PGTMP process, the LCPDP Committee was able to use the tool for the subsequent LCPDP update (2017-2037 LCPDP). This latest LCPDP also put into consideration the reforms in the energy sector and legislative framework following the adoption of the new Constitution in 2010 (Government of Kenya, 2018b).

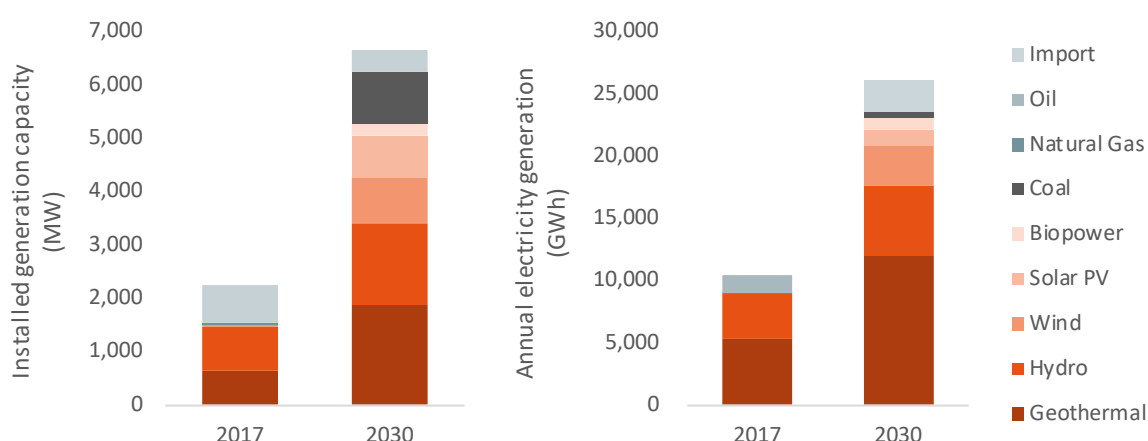
To monitor the committed projects in the sector, performance data from ongoing projects was collected and analysed as input into the LCPDP process. Different LCPDP scenarios were developed, some of which include significant addition of GHG emitting technologies such as coal and natural gas plants, which has specific implications for Kenya's climate change mitigation objectives (see section 3).

## 2.4. Projected development

The 2017-2037 LCPDP sets out the cost-optimal plan for the expansion of generation capacity, to meet the projected growth in electricity demand in the coming two decades under various scenarios.

Under the *Reference Scenario*<sup>1</sup> of the 2017-2037 LCPDP, installed capacity is forecast to grow from 2,235 MW in 2017 to 7,213 MW in 2030, with capacity distributed more evenly across a greater number of generation technologies than in 2017. The use of diesel turbines is expected to decline substantially to almost zero by 2020. Another major aspect of the projections is the introduction of a 981 MW coal plant in 2024, although continued legal and economic issues surrounding this particular project make its realisation uncertain. Electricity generation is forecast under this *Reference Scenario* to grow from 10,406 GWh in 2017 to 26,098 GWh in 2030 (Government of Kenya, 2018b).

*Figure 2: Installed capacity and electricity generation 2017-2030 according to the Reference Scenario of the 2017-2037 LCPDP.*



When compared to previous planning documents such as the 2011-2031 LCPDP and the 2015-2035 PGTMP, the most notable difference is the substantial downward revision of the demand and supply projections contained in the 2017-2037 LCPDP. When comparing the 2030 projections of the 2011-2031 LCPDP and the 2017-2037 LCPDP for installed capacity, electricity generation and peak demand, in all three cases the latest LCPDP projections are roughly one third of those of the older LCPDP, which has significant implications for the sector. Electricity demand forecasts were considerably decreased, due partly to lower than anticipated economic growth rates and delays in the Vision 2030 flagship projects. However, the economic growth rates used in the *Reference Scenario* are still relatively high and based on the assumption that Vision 2030 flagship projects will drive electricity demand and economic growth considerably. Realistic projections are important for planning the sustainable development of the sector, to avoid the risks associated with a mismatch between demand and supply, and to better equip the sector to contribute to the development objectives of the country.

<sup>1</sup> The reference scenario of the LCPDP projects electricity demand based on continuation of historical growth; the LCPDP also includes a high demand scenario, based on the Vision 2030 growth projections and implementation of the flagship projects.

A significant omission from the 2017-2037 LCPDP is the absence of off-grid electricity supply solutions and building-integrated renewables in the projected capacity mix. Despite evidence suggesting that these technology options could make substantial contributions to the future development of the sector<sup>2</sup>, off-grid and building-integrated solutions are omitted.

### 3. Current outlook for climate change mitigation in the electricity sector

#### 3.1. Development of greenhouse gas emissions

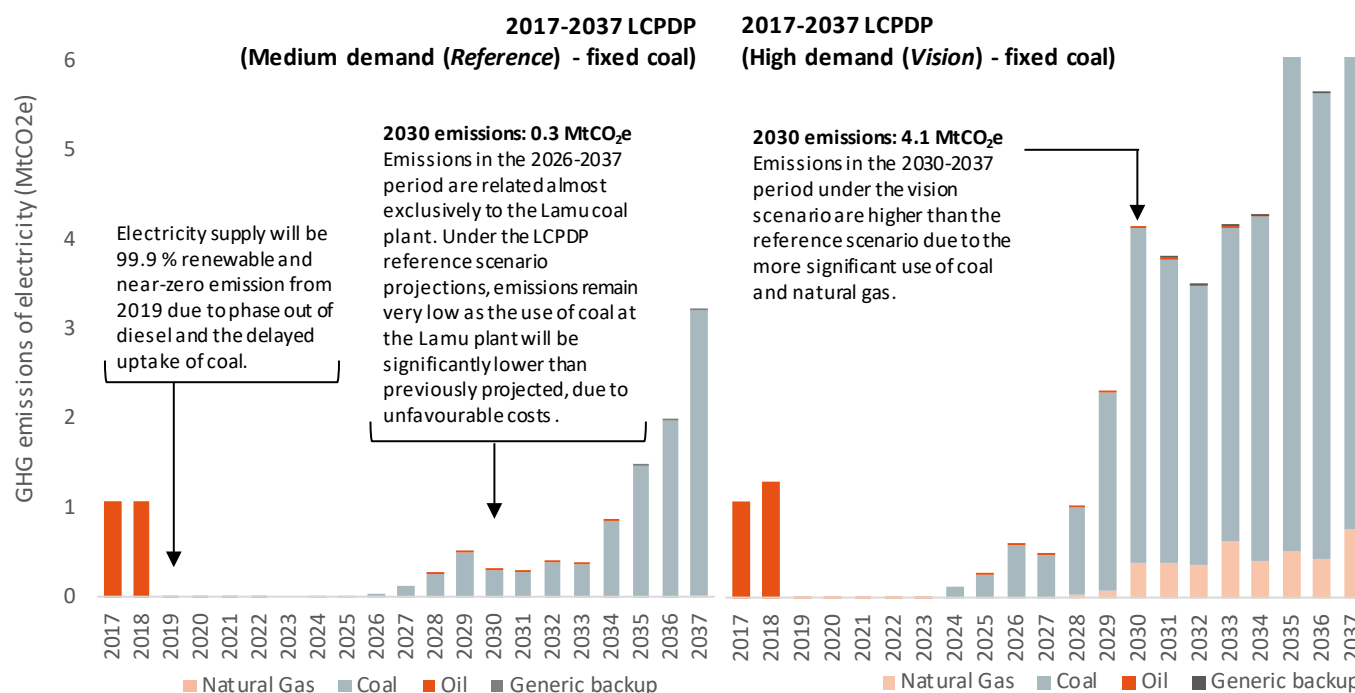
The combustion of fossil fuels for power generation produces GHG emissions, a primary cause of climate change. Whilst Kenya's electricity generation mix has a relatively low emissions intensity, medium speed diesel and natural gas are significant emitters of GHG emissions. Coal combustion, which is planned to play a role in the electricity generation mix as of 2024, is also a significant source of GHG emissions.

Figure 3 indicates the implications of two different electricity sector development pathways under the 2017-2037 LCPDP for GHG emissions, in the period up to 2037. In both pathways, emissions will reduce to near-zero by 2019 due to the phase out of inefficient medium speed diesel plants. Emissions will increase again in 2026 (in the *Reference Scenario*) or in 2024 (in the *Vision Scenario*) due to the planned opening of the coal power plant in Lamu. However, even after the opening of the 981 MW coal plant, the LCPDP generation projections show very limited use of coal for generation under the *Reference Scenario*, leading to annual emissions of 0.3 MtCO<sub>2</sub>e in 2030. Under the LCPDP *Vision Scenario*, emissions would increase to 4.1 MtCO<sub>2</sub>e in 2030.

This trend is in stark contrast to historical estimates from the 2011-2031 LCPDP report, in which major new investments in coal, oil and gas were projected to increase electricity sector emissions to over 40 MtCO<sub>2</sub>e. Adjusted demand forecasts and increased installation of wind, solar PV and geothermal technologies have brought the electricity sector more in line with national climate change objectives.

<sup>2</sup>Mini-grids: An output from the Ambition to Action project, "The role of renewable energy mini-grids in Kenya's electricity sector", finds that the potential application of mini-grids in Kenya could be 60 times greater than the current plans of the 2017 Kenya National Electrification Strategy, and that there is a significant role for solar home systems, reducing annual on-grid electricity demand by more than 2% (NewClimate Institute, 2019). Building integrated renewables: Solar water heating systems, a legal requirements for new building developments, will increasingly replace electricity for heating in buildings, reducing on-grid electricity demand.

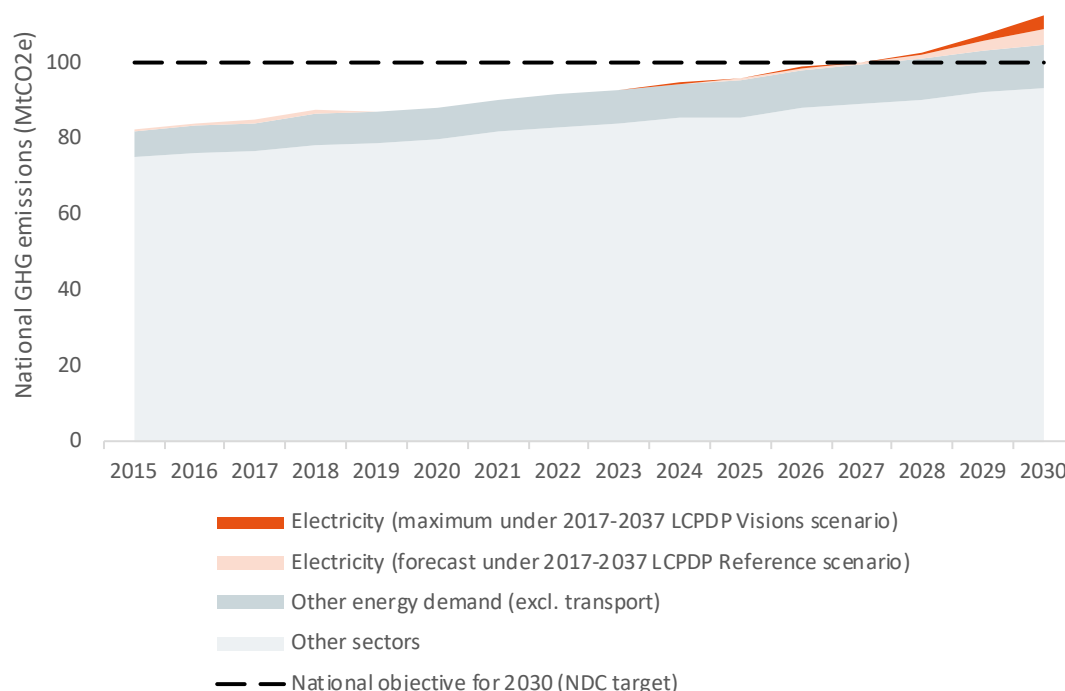
Figure 3: GHG emissions from the 2017-2037 LCPDP scenario. The left chart shows the LCPDP generation plan with the medium (reference) demand profile, and right chart with the high (vision) demand profile. Both charts represent the fixed medium term (fixed coal) scenario for supply.



### 3.2. Implications for national climate change objectives

Figure 4 shows how the projected electricity supply sector emissions in the period 2015-2030 relate to the national target for limiting the growth of GHG emissions to 100 MtCO<sub>2</sub>e by 2030 (Kenya's NDC), when combined with the emissions from other sectors. It shows that under any of the projected generation pathways of the 2017-2037 LCPDP, emissions from the electricity sector would remain very low and would have an insignificant impact on national GHG emissions up to 2027. However, under the *Vision Scenario* – a growth in GHG emissions from electricity after 2027 would push total national GHG emissions to 108.7 MtCO<sub>2</sub>e in 2030, 9% higher than the 2030 limit of 100 MtCO<sub>2</sub>e, with electricity supply accounting for approximately 4% of these national GHG emissions.

Figure 4: Total GHG emissions from all sectors in Kenya with the LCPDP reference and vision scenarios.



The 2017-2037 LCPDP projections have significant implications for mitigation options in the electricity sector. The current context shows that emissions from this sector will be lower than previously estimated, and that there is limited scope for further mitigation measures, if the role of coal remains low, as projected in the latest LCPDP *Reference Scenario*.

The projections in Figure 3 show that the main measure required to ensure near-zero emissions from the electricity sector would be the restricted use or avoided installation of coal and natural gas capacity, through further expansion of other electricity supply options, including the promotion of more self-generation from renewable sources, and/or energy efficiency improvements. Annual emissions in the years around 2030 could deviate between zero and 9.1 MtCO<sub>2</sub>e, depending entirely on the utilisation rate of the installed coal and natural gas capacities. Thus, the mitigation potential of alternative technologies would be a maximum of 9.1 MtCO<sub>2</sub>e per year if they displaced the entire generation from coal and natural gas capacities.

According to the NDC Sector Analysis<sup>3</sup>, a government report that examines options to deliver on Kenya's contribution in six mitigation sectors, the priority mitigation action for the electricity sector is the expansion of geothermal generation, envisioning a total of 5,510 MW geothermal capacity by 2030 (MENR, 2017b). The estimated emissions abatement potential of this capacity expansion is 15.2 MtCO<sub>2</sub>e by 2030. However, according to the 2017-2037 LCPDP, this target will not be met as total installed capacity of geothermal generation by 2030 is projected to be 1,896 MW (under the *Reference Scenario*) (Government of Kenya, 2018b).

Notwithstanding this missed target for geothermal energy, climate change mitigation targets would be met at the electricity sector level and also almost at the national level, if developments proceed along the lines

<sup>3</sup> The NDC Sector Analysis Report is available at: <http://www.starckplus.com/documents/ta/ndc/NDC%20Sector%20Analysis%20Report%202017.pdf> (accessed 02/12/2019).



of the LCPDP *Reference Scenario*: with very limited use of coal and no use of natural gas. In that case, only moderate further reductions from other sectors would be required to meet the national objective for 2030, as shown in Figure 4.

### 3.3. Planned climate change mitigation actions

Kenya's 2018-2022 NCCAP outlines a number of measures under planning or implementation for climate change mitigation in the electricity sector.

A fundamental weakness in the 2018-2022 NCCAP, which undermines the relevance of some of the listed actions, is the lack of alignment of that plan with the 2017-2037 LCPDP, as discussed in detail in section 3.4: the 2018-2022 NCCAP estimates that the listed actions may reduce emissions by 9.2 MtCO<sub>2</sub>e per year, although the 2017-2037 LCPDP indicates that emissions from the sector are not likely to rise above 4.1 MtCO<sub>2</sub>e by 2030 in any scenario.

Despite this misalignment, the 2018-2022 NCCAP still provides a useful indication of the areas for action that are currently prioritised by the energy sector stakeholders who participated in the development of the plan. The following mitigation actions, related to the electricity sector, were identified in the document:

- **Increased renewable energy for electricity generation and captive energy**, including an additional 2.4 GW installed capacity of various renewable technologies by 2023, with a particular focus on geothermal.
- **Improved energy efficiency**, including the targets to reduce electricity distribution losses from 18% to 14%, and to distribute 3.3 million compact fluorescent lightbulbs<sup>4</sup> to households, by 2023.
- **Research and capacity building** to enable an enhanced response to climate change action in the future, including research on emerging technology trends, various training and public awareness programmes.

These actions, particularly the primary action to increase renewable energy capacity, are roughly in line with expected sector developments under the LCPDP *Reference Scenario*. As such, they do not imply any significant emission reduction compared to the projected emissions from the power sector under the LCPDP pathway, as set out in section 3.1.

<sup>4</sup> Considering the availability of LED technology, LED could be used instead of fluorescent lightbulbs for remaining households, allowing for even deeper emission cuts.

## 3.4. Alignment of climate and electricity sector planning processes

### 3.4.1. Alignment of existing documents and plans

In January 2017, MENR, with support from the Strengthening Adaptation and Resilience to Climate Change in Kenya (StARCK+) programme, released an assessment report containing an updated emissions baseline to inform how sectors could contribute to meeting Kenya's NDC.<sup>5</sup> The update does not change the official NDC target, but rather provides up-to-date information to inform how sectors can contribute to implementing the NDC.

Table 4 summarises the changes in emissions baselines for the country and the electricity sector for 2015 and 2030. According to the updated baseline, total emissions in 2030 drop from 143.6 MtCO<sub>2</sub>e as indicated in the NDC, to 123.9 MtCO<sub>2</sub>e. Electricity supply constitutes the biggest change in the updated baseline, moving from projected 41.6 MtCO<sub>2</sub>e in 2030 to 19.4 MtCO<sub>2</sub>e in 2030. Based on these new figures, the Baseline Update Report proposed emissions reduction targets of 5.2-9.3 MtCO<sub>2</sub>e below the new sector baseline as a potential fair share from the electricity sector for achieving the NDC (MENR, 2017a).

However, the scenarios in the 2017-2037 LCPDP indicate that both the *Reference* and *Vision* pathway for the sector would actually lead to a far lower volume of GHG emissions than the forecasts of the Baseline Update Report suggest. Under the *Reference Scenario*, emissions from the electricity sector would be only 0.3 MtCO<sub>2</sub>e in 2030 (Republic of Kenya, 2018c). This is based on the much lower demand and supply projections contained in the LCPDP, which project a phase out of the medium speed diesel engines, replaced by scaling up geothermal, biomass cogeneration and wind power; and a very restricted amount of generation from new coal capacity, due to its economic unfavorability compared to other planned generation options. The emissions associated with the *Vision Scenario* are 4.1 MtCO<sub>2</sub>e in 2030, which although being higher than the *Reference Scenario* is still well below the revised baseline of 19.4 MtCO<sub>2</sub>e as in the Baseline Update Report.

The extent of the misalignment of the Baseline Update Report with the LCPDP is such that, if the electricity sector developed along the pathway that the LCPDP projects, the sector alone could be responsible for most of the necessary emission reductions for achieving the national NDC target of 100 MtCO<sub>2</sub>e in 2030.

This misalignment has important implications for mitigation activities in the sector, which are currently being planned with incomplete information.

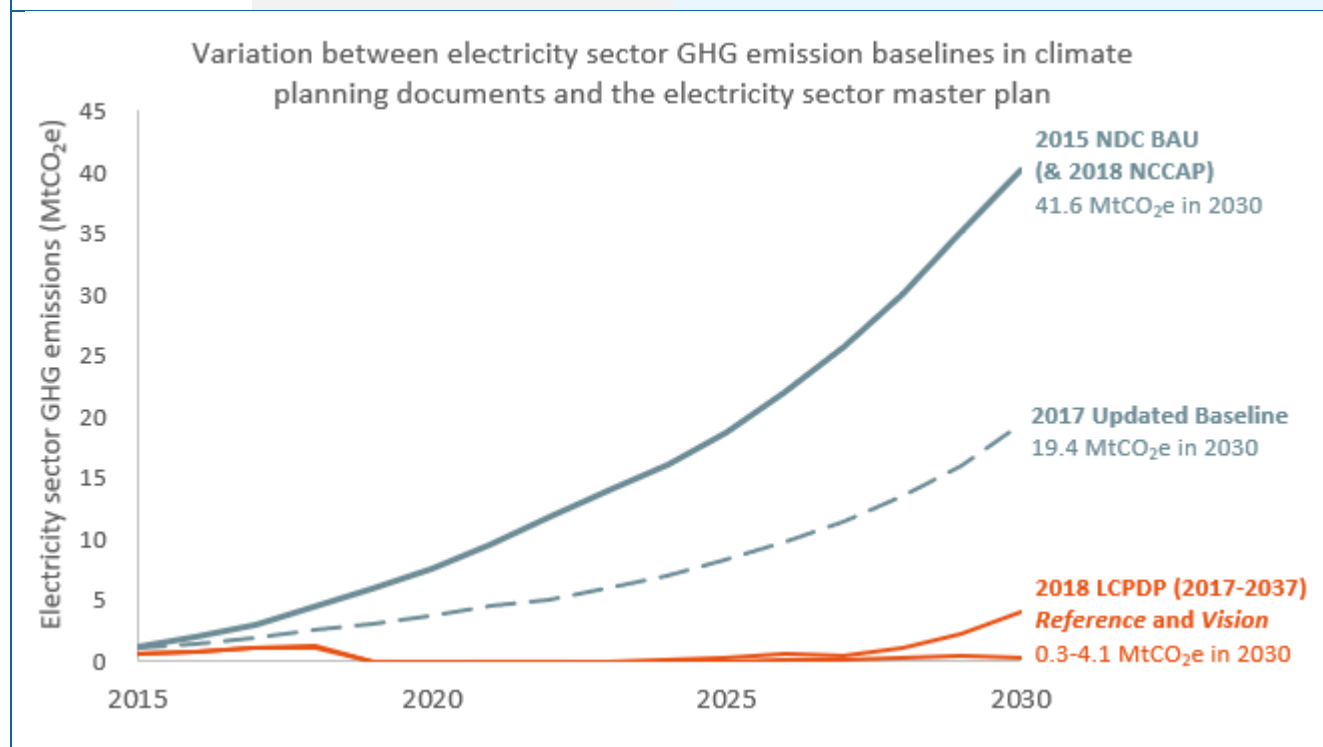
<sup>5</sup> Following the NDC submission in 2016, two assessment reports have been developed and published with support from the StARCK+ programme:

- 1) The **Update of Kenya's Emission Baseline Projections and Impact on NDC Target**, which was published in January 2017 (available at: <http://www.starckplus.com/documents/ta/ndc/UpdateofKenyasEmissionBaselineProjectionsandImpactonNDCTarget.pdf>) (in the following referred to as Baseline Update Report), and
- 2) The **NDC Sector Analysis Report 2017**, which was published in June 2017 (available at: <http://www.starckplus.com/documents/ta/ndc/NDC%20Sector%20Analysis%20Report%202017.pdf>) (referred to as NDC Sector Analysis)

Each report refers to the other as 'companion report'. The Baseline Update Report provides a more detailed data analysis regarding emissions projections per sector, while the NDC Sector Analysis examines the expected emission reduction contributions in six mitigation sectors as well as additional mitigation options to deliver on Kenya's NDC.

Table 4: Comparison of old and current planning documents for emissions from electricity supply sector.

	Climate planning documents		Electricity sector planning documents		
	2014 SNC 2015 NDC BAU 2018 NCCAP	2017 Updated Baseline Report	Old  2013-2033 LCPDP	Current	
				2017-2037 LCPDP (Reference)	2017-2037 LCPDP (Vision)
Total electricity generation in 2030 (GWh)	-	-	81,462	26,098	34,805
Electricity generation from fossil fuels in 2030 (GWh)	-	-	7,257	363	5,281
Emissions from electricity generation in 2030 (MtCO <sub>2</sub> e)	41.6	19.4	-	0.31	4.11
Total national GHG emissions (MtCO <sub>2</sub> e)	143.6	123.9	-	-	-



Sources: Based on analysis of data and visualisations from MENR (2017a) and EPRA (Republic of Kenya, 2018c).

### 3.4.2. Alignment of processes for planning and policy making

The NCCAP and 2016 Climate Change Act allocate responsibilities to MoE to achieve the objectives of Kenya's national climate policy. However, climate change objectives or representatives have, to date, not been well integrated in electricity sector planning processes. The process for the revision of the NDC in 2019 presents opportunities for pursuing enhanced alignment between climate change and electricity sector planning departments. In addition to MoE's Renewable Energy Directorate, involving the economic department of EPRA in the NDC revision process, and involving the Climate Change Directorate (CCD) in the LCPDP update process, could assist in achieving the strategic opportunities and benefits of enhanced alignment. Finally, the consideration of NDC implementation and enhancement as an ongoing process with continuous involvement of all relevant stakeholders is key to ensure alignment of topics in planning and policy making over time.

#### *Climate change planning processes and electricity sector representation*

Both climate policy and planning documents in Kenya formally allocate roles and responsibilities to MoE, as shown in the 2018 NCCAP. The 2018 NCCAP was developed over the course of 6 months in early 2018 and included a synthesis of existing technical analysis as well as an extensive consultation process. A Task Force and different Thematic Working Groups were formed that included representatives from relevant sectors, government ministries, civil society and the private sector. MoE was represented by its Renewable Energy Directorate and tasked in the NCCAP document with a range of responsibilities.

One of the most defining features of climate policy is that it is cross-cutting, and thus dependent on the line ministries to be implemented. The 2016 Climate Change Act was a significant milestone as it allocated climate change functions as line ministry responsibilities, and mandated the CCD as the coordinator of climate change actions to monitor the compliance of line ministries (Government of Kenya, 2016).

From 2019, MoE, like other ministries, will be required to submit annual reports to the National Climate Change Council (to be chaired by the President) to report on the progress achieved by MoE in implementing the duties and functions assigned by the NCCAP. The 2016 Climate Change Act also stipulates the monitoring, reporting and verification (MRV) requirements for line ministries (Government of Kenya, 2016). These and other developments will assist in making it possible to more closely track the implementation of the current NCCAP and future iterations.

The process for the revision of the NDC in 2020 provides opportunities for enhancing alignment between climate and electricity sector policy and planning. To enhance alignment and integration, commensurate investment in capability and resources as well as equipping responsible parties with the necessary authority to achieve coordination and foster political buy-in is vital. The 2018 NCCAP process closely resembled that of the 2013 NCCAP, with the Renewable Energy Directorate representing MoE in the process. For future climate planning processes, including the NDC and future iterations of the NCCAP, involving representatives from the energy sector with responsibility and oversight for overall electricity policy and development – namely EPRA – could offer additional opportunities for strengthening alignment beyond policies for renewable energies. It is not yet determined whether the revision of the NDC in 2020 will be based on old analysis, which is known to be misaligned with sector developments, or whether new analysis on the trajectories and potential targets for the sector will be considered. Given that the 2018 NCCAP is not well aligned with the latest LCPDP (as

described in section 3.4.1), the 2020 NDC revision process may represent a timely opportunity to update this analysis to ensure alignment.

### ***Electricity sector planning processes and climate change planning representation***

Pursuing the objective of enhanced alignment between climate and electricity supply objectives requires a two-way dialogue, in which climate policy can utilise the knowledge and expertise in electricity sector planning processes and vice versa. The 2017-2037 LCPDP is the latest output of Kenya's electricity sector planning. It was developed by the LCPDP Committee, as outlined in section 2.3.

Considering the responsibilities allocated to MoE in the 2018 NCCAP and the 2016 Climate Change Act, one aspect missing in this planning process for the electricity sector is a consideration of targets and commitments related to climate change action. The LCPDP Committee includes no institutions responsible for climate policy, and there is also not a significant role in this Committee for the Renewable Energy Directorate of MoE, which is currently the official climate change focal point in the ministry.

For the first time, GHG emission indicators have been reported in the 2017-2037 LCPDP. EPRA was supported by the Ambition to Action project to evaluate the impact of the LCPDP scenarios for GHG emission trajectories; Chapter 11 of the 2017-2037 LCPDP is dedicated to this reporting. However, climate change mitigation commitments and targets do not yet influence the determination of the LCPDP scenarios. The next iteration of the LCPDP could provide opportunities for more comprehensively integrating climate policy considerations, for instance through the calculation of emissions and the application of a shadow carbon price in the development of the scenarios, so that the sector plan reflects and provides a means to implement what Kenya has committed to in the climate change mitigation targets of Kenya's NDC.

## **4. Prospects for low-carbon and sustainable development in the electricity sector**

The expansion of electricity generation capacities in Kenya to meet the growing demand may lead to significant changes in the country's electricity generation mix. Taking into account the expansion pathways under the 2017-2037 LCPDP and their implications for Kenya's national climate change objectives (see section 3), it is useful to look at the current and potential future role of different power generation technologies and how these influence GHG emissions and other sustainable development objectives. To support electricity sector planning in Kenya that enables universal access to affordable, reliable and sustainable energy by 2022 while maximising Kenya's climate and sustainable development goals, two technology focus studies were published under the A2A project in 2019: "The role of geothermal and coal in Kenya's electricity sector and implications for sustainable development" and "The role of renewable energy mini-grids in Kenya's electricity sector - Evidence of a cost-competitive option for rural electrification and sustainable development".

Two open source Excel tools, developed by NewClimate Institute under the A2A project, have been used to quantify sustainable development impacts of different power generation technologies, including those discussed in the technology focus studies: The Economic Impact Model for Electricity Supply (EIM-ES), a model to estimate the domestic employment and wider economic impacts of investments in new electricity



generation capacity; and the Air Pollution Impact Model for Electricity Supply (AIRPOLIM-ES), a tool to quantify the health impacts of air pollution from different sources of electricity generation and other fuel combustion (see Annex I ).

## 4.1. The role of geothermal and coal – Implications for climate and sustainable development

A major challenge for planners and policymakers in the electricity sector is identifying the optimal combination of electricity generation technologies within different load-factor categories in order to achieve the best match at the lowest cost. The analysis that is summarised below aims at supporting decision making in the electricity sector by comparing the two main power generation technologies that are considered baseload electricity supply options in Kenya, namely, geothermal and coal, and the role that they can play in Kenya's future electricity supply mix. This role is determined by a number of factors, including technical considerations, resource availability, environmental characteristics, economics, and other issues that may act as drivers or pose barriers or risks to the development of this source. Being the electricity sector master plan, the most recent 2017-2037 LCPDP sets a clear direction for the development of the sector and thus serves as a main reference for this study.

While Kenya has a long history of developing geothermal resources, coal has not yet been exploited. Kenya has a high geothermal resource potential of around 10,000 MW along the Kenyan Rift Valley. The current installed geothermal capacity in Kenya is 745 MW, with most of it in the Olkaria fields. However, the Government of Kenya plans to build two coal power plants over the next 30 years: one in Lamu, a 981 MW power plant divided into three units of 327 MW each, to be commissioned by 2024, and a 960 MW power plant in Kitui, which is scheduled for 2034-36. While the plant in Lamu will run on imported coal, the plant in Kitui is predicted to use domestic coal.

The development of these two generation technologies will have a considerable impact on the electricity sector in Kenya, affecting the generation costs, affordability of electricity, and overall flexibility and reliability of electricity supply.

**Generation costs:** Various cost aspects must be considered when comparing the cost of geothermal and coal-based electricity generation. Geothermal power typically involves high **capital expenditure** due to a risky exploration and drilling phase. On the other hand, no fuel costs are incurred, and **operation and maintenance costs** are low and predictable. Coal power plants are less costly in the construction phase, but variable operation and maintenance costs can be significant if the coal is imported. The **cost of capital** for a geothermal project in Kenya is low compared to the capital costs for global coal projects. It is likely that financial support for geothermal projects will further increase and be more easily accessible in the future, while coal financing is being gradually taken out of many portfolios. **Legal and regulatory costs** are currently more predictable for geothermal power generation, with the Energy Act 2019 establishing a royalty scheme for geothermal resource use. For coal-based power generation, regulations are still pending and respective costs, difficult to predict. Little data exists on the **decommissioning costs** of geothermal plants, while for coal plants, these costs range from USD 50,000 to 160,000 per MW. Both geothermal and coal have a high

**capacity factor** and can produce a stable output at a low price. However, the capacity of a plant can be restricted on purpose to balance supply and demand. The projected capacity factor of a plant determines the **Levelized Cost of Electricity (LCOE)**. In the case of Kenya, in the planning period covered by the 2017-2037 LCPDP, the LCOE for geothermal is significantly lower than the one for coal (approx. USD 10 cents/kWh for geothermal vs. USD 29.5 cents/kWh for coal), since coal is expected to run at a very low capacity factor.

**Affordability:** The addition of more geothermal power generation capacity would have advantages over coal-based generation capacity, both in terms of limiting the overall costs of electricity supply and the retail price and ensuring cost stability. While the majority of the geothermal generation costs are fixed costs, with the cost of labour being the only significant variable factor, a substantial portion of the coal power generation costs are variable costs for fuel input. When comparing the type of capital expenditure, it is worth noting that coal power is usually characterised by very large capacity additions, causing significant spikes in capital investment costs over time, while geothermal power plants are typically much smaller and can be developed more gradually according to variations in demand. The introduction of a 981 MW coal plant in 2024 may increase the cost of electricity by up to 50% due to the surplus capacity that this large-scale capacity addition would entail for a period of at least several years. Moreover, in the case of surplus capacity, geothermal power generation is identified in the LCPDP as a higher priority option for dispatch, due to its lower marginal costs compared to coal-based power generation. Kenya's electric utility Kenya Power will have to pay for the Lamu coal power plant's output regardless of whether or not the power is actually purchased, due to the nature of the power purchase agreement (PPA). The PPA includes a particularly high capacity charge of USD 360 million per year, which translates to about KES 100 million per day, in a take-or-pay agreement.

**Flexibility and reliability:** Although geothermal and coal-fired power plants are both considered baseload power plants, geothermal plants can reach higher capacity factors, on average. Although geothermal plants operate most efficiently when running without interruption, similar to coal plants, they can also provide flexible power if contractual terms are modified accordingly. The operation and maintenance costs incurred for a geothermal plant to operate in a more flexible manner depend on the type of technology used. While operating a binary system in a flexible mode does not raise these costs significantly, the flexible operation of a flash or dry steam system may lead to a slight increase, as it involves venting steam. Increasing the flexibility of a coal plant is also technically possible; however, it has an impact on the plant's lifetime and is similarly associated with an increase in operation and maintenance costs. The expansion of geothermal energy in Kenya provides more flexibility to planners, as geothermal power generation is decentralised, and capacity can be added gradually. Given the uncertain sector development, the implementation of a large-scale project like the Lamu plant, on the other hand, might put sector stability, affordability, and sustainability at risk.

Apart from the implications for the sector itself, careful planning in the electricity sector can positively contribute to the achievement of other sustainable development-related objectives that are important to society, such as **employment creation, health, and climate change**.

Investment in electricity generation results in the immediate creation of **direct and indirect employment opportunities**, as well as wider economic effects, during a project's construction and operation phases. A comparison of different generation expansion scenarios, which are based on the 2017-2037 LCPDP, reveals that i) no coal-fired power plant is required in generation expansion planning if sufficient alternative

candidates are provided and expansion sequences are optimised for least-cost options; and ii) the scenario without coal, entailing more geothermal energy and natural gas, leads to more domestic employment creation and investment, while simultaneously being less expensive. A direct comparison of both generation technologies with regard to their impact on job creation shows that geothermal power generation creates three times more domestic employment per MW of new capacity than coal-based power generation. The main reason for these results are the different local shares in the value chain for these two technologies. While geothermal power has a long history in Kenya, and expertise is locally available and sourced, coal development would heavily rely on the foreign labour force, both for construction and operation and maintenance of the plant.

Electricity generation technologies also differ in terms of their impact on **air pollution and human health**. The energy sector in general, including both production and use, is the largest source of man-made air pollution emissions. Geothermal and coal-fired power plant emissions differ significantly, not only in terms of GHG emissions, but also other air pollutants such as particulate matter, sulphur dioxide, and nitrogen oxides. Geothermal power plants emit less than 1% of the air pollutants emitted by coal-fired power plants of equal capacity. The construction and operation of the proposed coal-fired power plants in Kenya would be a major source of air pollution in the country, with significant impacts on human health. A quantitative analysis of the health impacts shows that up to 2065, roughly 1,620 Kenyans would have died prematurely from the associated air pollution if both coal plants in Lamu and Kitui were to be built. For the same timeframe, approximately 270 premature deaths would occur if the capacity of the Lamu plant was reduced to 450 MW in total. These health impacts are further associated with significant costs for the healthcare system.

Apart from these important effects on sustainable development, the plans to develop coal-based power generation in Kenya put the country's **climate target** at risk and create pressure for other sectors to invest in mitigation measures that are often more expensive and difficult to implement. While both geothermal and coal-based power generation result in GHG emissions, the average global estimate for geothermal power production, at 122 gCO<sub>2</sub>/kWh, is much lower than the estimate for coal—670-870 gCO<sub>2</sub>/kWh. In the case of Kenya, emissions calculations for different generation expansion scenarios show that by 2037, almost 3 MtCO<sub>2</sub> could be saved annually if coal were replaced with low-carbon alternatives such as geothermal, complemented by generic backup units. Under the application of a shadow carbon price<sup>6</sup>, the emissions savings could translate to cost savings of USD 160-320 million per year by 2037, depending on the price level.

The findings of this analysis illustrate the need for electricity sector planners and decision-makers to carefully evaluate the opportunities and risks involved in the expansion of coal-based power generation, as compared to geothermal power generation. Coal-based power generation is not needed from a security of supply perspective, as the extremely low average capacity factors in the 2017-2037 LCPDP indicate, and the further development of geothermal power generation may have positive effects on the power sector, as well as other sectors.

<sup>6</sup> While there is currently no carbon pricing policy in place in Kenya or at a global level, different institutions, including the World Bank, recommend applying a shadow carbon price to emissions that ranges between USD 40-80 per ton of CO<sub>2</sub> equivalent in 2020 and rises to USD 50-100 per ton of CO<sub>2</sub> equivalent by 2030, increasing by 2.25% per year beyond 2030 (World Bank, 2017).

Based on the full study's findings (see link below), the following aspects can guide the future development of the geothermal sector:

- Considering the power sector requirements and environmental concerns, it is recommended to primarily use **binary steam cycle technology** where possible, as this technology can operate more flexibly without increasing operation and maintenance costs and produces near-zero emissions during operations.
- While it is physically possible for a geothermal power plant to provide a range of ancillary services, traditional PPAs often do not set the right incentives for this. **PPAs need to be adjusted** to ensure that geothermal power plants are compensated, not only for operating as baseload plants, but also for providing reserve capacity.
- As the productivity of geothermal sources can decrease, **site diversification** is essential. Currently, geothermal power is mostly harnessed in the Olkaria fields, and it is estimated that by 2035, half of the geothermal capacity will still be located in this area. Thus, encouraging the development of new geothermal plants in other geothermal fields, such as Suswa, Longonot, Akiira, and Baringo Silali, can reduce site dependency and ensure security of supply.

Link to full report: <https://newclimate.org/2019/11/12/the-role-of-geothermal-and-coal-in-kenyas-electricity-sector-and-implications-for-sustainable-development/>

## 4.2. The role of renewable energy mini-grids – Implications for climate and sustainable development

Even with the global electrification rate rising from 83% in 2010 to 89% in 2017, about 573 million people still lack adequate access to electricity in Sub-Saharan Africa, most of them living in rural areas. Such areas are best served by decentralised systems including mini-grids<sup>7</sup>, since interconnected electric grids require large upfront investments which are sometimes difficult to justify when connecting rural and remote areas with unproven demand and low consumption densities.

Multiple studies have shown that renewable energy mini-grids are the least-cost option for providing electricity to an estimated 100-300 million people in Africa. This development is also due to rapidly decreasing costs of renewable energy technologies, which are now the most cost-effective options for mini-grid deployment in many countries.

The analysis that is summarised below synthesises available analyses on the role and potential of mini-grids in Kenya and explores how this technology can help the country attain its goal of universal electrification by 2022 and also contribute to the achievement of other related development objectives. The synthesis aims to provide policy makers with the required evidence and justification for elevating the position of off-grid solutions in electricity sector development and planning and the political agenda.

<sup>7</sup> The World Bank has adopted the working definition of mini-grids as “electric power generation and distribution systems that provide electricity to just a few customers in a remote settlement or bring power to hundreds of thousands of customers in a town or city. They can be fully isolated from the main grid or connected to it but able to intentionally isolate (“island”) themselves from the grid”.

Mini-grids have a long history in Kenya, with the first installations dating back to the early 1980s. In recent years, several diesel-based mini-grids have been transformed into hybrid diesel-solar or diesel-wind systems, and several fully renewable energy mini-grids have been deployed. The total installed capacity in 2016 was approximately 25.3 MW, most of which consists of public operated mini-grids. However, to date, the overarching strategy for Kenya's electricity sector focuses primarily on national grid extension; mini-grids are included but significantly under-represented in the 2018 Kenya National Electrification Strategy (KNES). The private sector development of mini-grids has also been restricted due to limited policy support, although this may be improved with the proposed mini-grid regulations in the new Energy Act 2019.

The Government of Kenya has set a target for 100% access to electricity by 2022. Progress towards this target in recent years has been encouraging, with electrification rates increasing from 36% in 2014 to an estimated 57-70% in 2017. Overall, approximately four million households still lacked access to electricity in 2017, 3.6 million of which were in rural areas. Options for electrifying these non-connected households include the extension of the national grid to rural areas and the installation of off-grid solutions, including mini-grids and solar home systems. Independent studies have determined that mini-grids may be the most cost-effective option for a large proportion of the remaining non-connected households in rural Kenya. According to one of these studies, renewable energy mini-grids deployed in 2017 in Kenya are estimated to have a total capital cost of approximately USD 1,000 (KES 103,000) per household connection, with significant potential for cost reduction in the near future. The Africa Mini-Grid Developers Association (AMDA) has reported a steady reduction in the average cost per connection across private sector built and operated mini-grids as the market in Kenya and Tanzania has expanded: the cost was USD 1,163 in 2017, decreasing to USD 934 in 2018, with further projected reduction to USD 600–700 in 2020. In contrast, recent investments in grid extension to isolated rural areas have resulted in total costs of up to USD 2,427 (KES 250,000) per household connection. **Although the 2018 KNES estimates that about 38,661 household connections will be best provided through mini-grids in Kenya, several other studies find this figure to be between 660,000 and 2.1 million connections, representing 17-58% of the non-electrified households in rural areas. Based on this range, mini-grids in Kenya could supply between 180 and 570 GWh of electricity in 2030.** Despite mini-grids' significant potential contribution to the total electricity supply, this option is not yet sufficiently integrated into current electricity sector policies or strategies or included in the demand and supply calculations of the 2017-2037 LCPDP. This may be an indication that the potential of mini-grids to contribute to the overall national electricity supply nexus is not yet well understood or could be significantly underestimated.

The potential for upscaling mini-grids in Kenya could be realised through the formulation of a clear policy and corresponding strategy promoting decentralised solutions, including mini-grids, and the integration of this strategy into future updates of the LCPDP. In addition, targeted public interventions could encourage increased private investment in mini-grids; **basic policy interventions, including modest subsidies considerably lower than the current grid connection subsidies in grid extension programmes, could reduce mini-grid project payback periods from over 30 years to just 5.5 years.** Rural electrification has historically depended on public finance and employed centralised distribution approaches. Addressing the inadequate electricity access affecting millions of people across Sub-Saharan Africa within the SDG 7 timeframe requires an incremental approach that strengthens existing forms of electrification and supports complementary



approaches. **Mechanisms for incentivising private investment in mini-grids need to be explored** as one of these approaches.

In addition to being the most cost-effective option for achieving rural electrification in some areas, mini-grids could also have positive economic and social impacts, including synergies with national development objectives and the SDGs:

- **For every 1 MW of mini-grid capacity developed, approximately 800 full-time-equivalent job-years are created for Kenyan workers.** While the total job creation potential for grid extension, the alternative option, would be a similar order of magnitude, it is likely that the proportion of jobs for Kenyan workers and in rural areas will be higher in the case of mini-grid deployment, particularly in terms of jobs created in local construction, community services, ongoing onsite business administration, and other sectors from induced effects. This is especially the case considering regulations require that all solar PV installers – the majority of whom are local experts – be registered with EPRA and the fact that Kenya now has a local solar PV assembly plant in Naivasha.
- **Using the latest technologies, mini-grid development may contribute to increasing the number of households with electricity access and improving the reliability of electricity supply** in rural areas, where national grid-based electricity supply is frequently disrupted by unplanned outages caused by technical issues and extreme weather events.
- **Renewable energy mini-grid development can improve domestic energy security by reducing dependence on fossil fuel imports.** If 180-570 GWh of coal-based generation was displaced by mini-grids, coal imports could be reduced by 55-175 thousand tonnes per year, equivalent to cost savings of USD 5.5-17.3 million (KES 550-1,742 million). This would also reduce the demand for foreign currency and improve the import-export balance.
- **Mini-grids can play an important role in advancing healthcare provision in rural areas.** Lower costs for mini-grids can allow for more connections to medical facilities at the same level of investment. Furthermore, more reliable electricity provision through mini-grids can lead to improved healthcare services in areas not connected to the main grid in terms of capacity, service hours, and the range of services offered.
- **Solar mini-grids contribute to enhanced water security in some locations when used for water pumping and where the solar canopy can be utilised for rainwater capture and storage.** Increased deployment of mini-grids also reduces the need for large thermal plants, which require substantial amounts of cooling water in the generation process.
- **Renewable energy mini-grids offer significant potential for climate change mitigation,** if they displace on-grid fossil fuel power plants. Through offsetting the supply of 180-570 GWh of coal-based electricity, **mini-grids could contribute to reducing emissions by 0.14-0.48 MtCO<sub>2</sub>e per year.** This mitigation potential makes mini-grid development an interesting prospect for consideration in climate change mitigation planning processes, and it may be possible to attract further support for the implementation of measures through climate-related finance.
- **Mini-grids in unelectrified rural areas help improve resilience to the impacts of climate change.** They can offer a degree of autonomy from the national grid and, in the case of climate-related natural

disasters, ensure that the communities they serve continue to have access to electricity and are thus better able to cope with the local effects.

Given mini-grids' cost-effectiveness and proven synergies with sustainable development and national objectives, potential action points, summarised below, have been identified to enable renewable energy mini-grids to progress to the next level and realise the associated benefits. Due to the potential climate change mitigation benefits, international climate finance proposals may also be an option for financing specific actions.

1. Conduct a thorough, up-to-date comparative assessment of the costs of mini-grids and grid extension for rural electrification, considering integration of a shadow carbon price.
2. Formulate a clear strategy for mini-grid development, aligned with grid extension plans.
3. Integrate the strategy for mini-grid development into the next iteration of the KNES.
4. Integrate the strategy for mini-grid development into the next iteration of the LCPDP.
5. Conduct a thorough assessment of rural energy markets to reduce perceived investment risk.
6. Streamline administrative processes for prospective project developers and service providers.
7. Identify the most effective financial instruments to maximise investments in rural electrification.
8. Conduct a comparative analysis of various business and management models.

Link to full report: <https://newclimate.org/2019/11/12/the-role-of-renewable-energy-mini-grids-in-kenyas-electricity-sector/>

## 5. Mainstreaming climate change and sustainable development in the electricity sector

### 5.1. The concept of mainstreaming

In Kenya, the 2016 Climate Change Act and the National Climate Change Framework Policy, together with the 2010 Constitution, provide the legal basis for mainstreaming climate change as a cross-cutting issue into development planning, budgeting and the implementation of sectoral action. The 2016 Climate Change Act defines mainstreaming as *“the integration of climate change actions into decision making and implementation of functions by the sector ministries, state corporations and county governments”*, promoting the consideration of sectoral development and climate change in one integrated approach (Republic of Kenya, 2016). While in earlier development planning, represented through MTPs I and II, climate change was looked at as part of the environment sector, the most recent MTP III (2018-2022) factors in climate change as a cross-cutting thematic area that needs to be mainstreamed in all sectors, at the national and county levels (Republic of Kenya, 2018a). A Climate Change Thematic Working Group (CCTWG) has been created to provide input to Kenya's MTP III.

Since 2016, mainstreaming of climate change into sectors and budgeting processes has been an ongoing topic in Kenya and there are a number of initiatives underway, including a CCD-led coordination process to assist sectors with mainstreaming climate change; as well as a process to develop a mainstreaming manual for the MTP III. Furthermore, a Climate and Public Expenditure Budget Review (CPEBR) has been conducted with support from UNDP, resulting in a guidance note on climate change mainstreaming in the budgetary process. However, despite the institutional progress on mainstreaming, there is little evidence that mainstreaming efforts have been implemented in sector processes and activities to date. Additional resources may be necessary to ensure that climate change is effectively mainstreamed more broadly across government entities and sectors in the country.

## 5.2. Mainstreaming climate change in the electricity sector

To be effective and enforceable, mainstreaming must be cascaded down from the national to the sector level and integrated into sector- and sub-sector plans and strategies.

The energy sector is a key player in the realisation of the long-term development objectives of Kenya as set out in Kenya's Vision 2030, President Kenyatta's Big Four Agenda, and the MTP III. Energy security and planning are thus priorities for the realisation of Kenya's development objectives. Both aspects are guided by MoE who has mandated EPRA to coordinate the LCPDP process.

With the LCPDP being the master planning document for Kenya's power sector, there is an opportunity to mainstream climate change in the LCPDP process. Between 2018 and 2019, different activities have been undertaken by EPRA, with support from the Ambition to Action project, to mainstream climate change in the electricity sector planning processes, as per the requirements of the 2016 Climate Change Act:

### 5.2.1. Reporting on climate change implications in the 2017-2037 LCPDP

For reporting the climate change implications of Kenya's generation expansion planning, an emissions calculation tool was developed by NewClimate Institute to quantify the emissions associated with various power generation scenarios in the 2017-2037 LCPDP.

The **emissions calculation tool** is an excel-based, easy-to-use reporting tool for emissions from the electricity sector, which provides a basis for electricity sector planners to prepare for sector-level reporting requirements under the 2016 Climate Change Act. As GHG emissions are becoming an increasingly important indicator for internal government processes and for accessing sources of international financial support, this tool can visualise sectoral emission trends in the electricity sector and link them to national climate change targets. The tool can furthermore inform decisions on additional mitigation options since emissions can be visualised for all power generation technologies. A decision can be made on scaling down emission intensive generation options while promoting low-carbon technologies, to achieve further emission reductions in the sector.

In the 2017-2037 LCPDP process, the emissions calculation tool was used to assess the climate change impacts of the LCPDP's *Reference* and *Vision Scenarios*, as reported in the LCPDP's Chapter 11 ("Implications of LCPDP Scenarios for National Climate Change Objectives"). This was the first time that a chapter on climate change impacts was included in an LCPDP (Government of Kenya, 2018b).

Chapter 11 includes the following information:

- a) The GHG emissions associated with the LCPDP's *Reference* and *Vision Scenarios*.
- b) An analysis of the trend of GHG emissions from the electricity supply sector.
- c) A comparison of the scenarios' emissions trends with previously calculated projections, e.g. under the NCCAP and NDC.
- d) An analysis of the scenarios' emissions trends in the electricity sector in the context of Kenya's NDC target.
- e) A discussion of further options to reduce GHG emissions in the sector.

The analysis undertaken in Chapter 11 indicates that when following the LCPDP pathways based on the *Reference* and the *Vision Scenarios*, emissions will reduce to near-zero by 2019, and then increase again post-2020 due to the planned introduction of new coal capacity. The main measure required to ensure near-zero emissions from the sector in the long-term would be the restricted use or avoided installation of new coal and natural gas capacity, through further expansion of other low-carbon electricity supply options and/or energy efficiency improvements (see also section 3.1 and 3.2).

### 5.2.2. Integration of GHG emissions information in the LCPDP planning tool

The emissions calculation tool described above was integrated into the LIPS-OP/XP which is being used by the LCPDP Committee in the LCPDP process, for the optimisation of generation expansion planning.<sup>8</sup> The new emissions calculation feature enables the use of the LIPS-OP/XP tool for the assessment of the emissions of different generation expansion scenarios in future iterations of the LCPDP. It furthermore allows the consideration of the climate impacts of Kenya's power system through the inclusion of emissions of different generation technologies in the expansion planning. The emissions calculation tool applies the emission factor of fuels, the power plant efficiencies which are already included in LIPS, and – optional – associated emission costs (a shadow price of carbon) to determine the overall emissions for the expansion plan, and the costs associated with those emissions. This feature can be used to report emissions and costs per power plant as well as total system emissions. The costs associated with these emissions may guide decisions on changing dispatch and expansion planning.

To enable the use of the new emissions calculation feature in LIPS-OP/XP and its correct interpretation, NewClimate Institute, together with Tractebel Engineering, held a 3-day training for the LCPDP Committee, in which the new LIPS tool was installed on the participants' computers. They learned how to use the tool and to understand how the feature may impact electricity supply sector planning, for example in the next cycle of the LCPDP process. The results can inform an assessment of the implications of different electricity supply scenarios for Kenya's climate change objectives, as is laid down in Chapter 11 in the 2017-2037 LCPDP.

<sup>8</sup> In 2018, Tractebel Engineering (formerly Lahmeyer International) was contracted under the A2A project to extend the LIPS-OP/XP tool used in the 2015-2035 PGTMP and the 2017-2037 LCPDP by adding three features to the tool:

- a) Integration of an **emissions calculation feature**, which provides for the estimation of GHG emissions, and which can be used for both reporting emissions and assessing their cost impact;
- b) Development of a **Scenario Comparison Tool**, which facilitates expansion planning analysis by allowing to compare the expansion planning results of various LIPS scenarios and variations of different scenarios in one file, while at the same time providing the results data of various LIPS scenarios for benefits assessment;
- c) Provision of a link to the **Economic Impact Model for Electricity Supply (EIM-ES)**, which can be used to assess and report on employment and wider economic impacts as important sustainable development outcomes in the context of Kenya's power system expansion process.

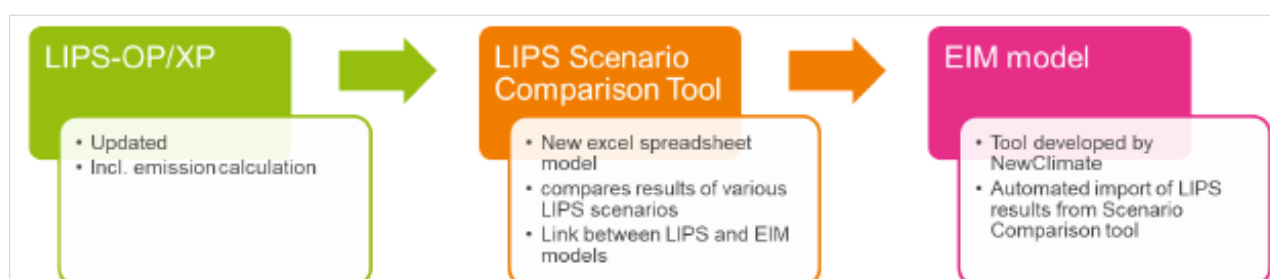
### 5.2.3. Assessment of sustainable development impacts in conjunction with the LCPDP planning tool

It has been demonstrated in many other countries that strategic electricity generation and transmission planning is able to simultaneously reduce emissions and generate job growth. To properly inform the LCPDP planning process, a concrete foundation with appropriate impact assessment tools is needed.

Therefore, the LIPS-OP/XP used in the LCPDP process was linked to the Economic Impact Model for Electricity Supply (EIM-ES) for the assessment of job creation from potential alternative electricity sector pathways.

In order to facilitate the usage of the EIM-ES in combination with LIPS-OP/XP, an *EIM Interface* worksheet has been included in the newly developed LIPS Scenario Comparison Tool, from which the relevant data can be copy-pasted into the *LIPS Input* worksheet added to the EIM-ES. Through the import of LIPS results from the Scenario Comparison Tool into the EIM-ES, different employment indicators as well as wider economic impacts of various LIPS scenarios can be assessed in the context of Kenya's power system expansion process. In future, the Scenario Comparison Tool could be used to report on other sustainable development benefits such as energy security, air pollution and industrial development. A visualisation of new and updated tools developed for emissions calculation and employment impact assessment in the context of the LIPS-OP/XP is presented in Figure 5.

*Figure 5: Overview of changes to the LIPS-OP/XP tool to integrate emissions calculations and sustainable development impacts.*



### 5.2.4. Knowledge exchange and training on climate change related issues

Several activities for knowledge exchange and training on climate change related issues were conducted for electricity sector stakeholders between 2018 and 2019. Such activities included meetings, workshops, trainings and participation in international conferences, facilitated by either MoE or EPRA and supported by NewClimate Institute under the A2A project. The following three events can be highlighted in the context of mainstreaming climate change in the electricity sector, as they accompanied the above described activities:

#### ***Workshop on the integration of climate change and sustainable development outcomes in the LCPDP processes***

The half-day workshop was attended by representatives from the energy sector and CCD. Presentations made by NewClimate Institute covered the proposed approach to the integration of climate change impacts (emissions calculation tool) and sustainable development impacts (EIM-ES) into the LCPDP process. The objective of the workshop was to create awareness and understanding for the respective assessment tools and to obtain feedback from the participants on the suitability and applicability of the tools.

At the end of the workshop, it was agreed that the chosen assessment approach was appropriate for the Kenyan situation and that it was necessary to consider the integration of these tools into the LCPDP process (i.e. into the LIPS-OP/XP tool) as parameters for generation expansion optimisation.

### ***Workshop on the prospects and benefits of geothermal as an alternative to coal for electricity generation in Kenya***

The half-day workshop was hosted by EPRA, facilitated by NewClimate Institute and attended by representatives from the energy sector. Its key objective was to jointly discuss preliminary findings of the recently published study “The role of geothermal and coal in Kenya’s electricity sector and implications for sustainable development”.<sup>9</sup>

The A2A team presented preliminary observations from the qualitative comparison of geothermal and coal-fired power plants along a set of attributes, such as resource profile, capacity and institutional profile, technology profile, cost profile and environmental and socio-cultural profile. The methodological approach was explained, and data gaps and requirements were highlighted. Through guided group discussions, participants were invited to discuss the (perceived) limitations and advantages of geothermal and coal for electricity generation in Kenya and to share their opinion and expertise in order to ensure that the final study results are robust and reliable and would be widely accepted among energy sector stakeholders in Kenya.

In addition to the qualitative analysis, a quantitative comparison of geothermal and coal-fired power plants with a focus on the impact on employment creation was presented. This comparison was based on the EIM-ES and showed the jobs created for geothermal and coal-fired power plants, based on different 2017-2037 LCPDP scenarios. Workshop participants were invited to validate or supplement key input data for the EIM-ES, such as investment costs or local labour shares, in order to further improve the robustness of the results.

### ***Training on the update generation expansion tool LIPS-OP/XP***

A three-day training was conducted by Tractebel Engineering and NewClimate Institute to train members of the LCPDP Committee on the new features of the generation expansion planning tool LIPS-OP/XP. Through the training, the participants learned about the new features, in particular the emissions calculation tool, the Scenario Comparison Tool, and the link to the EIM-ES, and how to use and interpret the results of these tools in the next cycle of the LCPDP process.

Some of the experts from the LCPDP Committee were already experienced with running LIPS-OP/XP from previous planning processes, while others had joined the team only recently and had to catch up on the basics of the LIPS-OP/XP. The training was attended by eleven participants, with six experienced key users of LIPS or planners with some LIPS knowledge and five newcomers to the topic.

The training was evaluated (mid-term and end-term) against the objectives and expectations expressed during the first day. Specific further needs were expressed by the participants, including the following:

- a) The consideration of other sustainable development impacts beyond employment creation in the planning process.
- b) Tools and approaches to consider storage.

---

<sup>9</sup> The study can be downloaded under the following link: [http://ambitiontoaction.net/wp-content/uploads/2019/11/A2A-Kenya\\_Geothermal-study\\_201911.pdf](http://ambitiontoaction.net/wp-content/uploads/2019/11/A2A-Kenya_Geothermal-study_201911.pdf).



- c) The availability of an increased number of dongles to be able to use LIPS-OP/XP more widely.
- d) Recommendations to ensure that the new features have an impact on future planning in the power sector, encompassing a better coordination and consideration of climate change and other sustainable development impacts in planning processes.
- e) The facilitation of trainings with specific allocation of resources.
- f) An increased awareness on how to integrate other cross-cutting topics and their impacts into electricity sector planning.

Overall, participants evaluated the training to be successful. All participants confirmed that they were now familiar with the new features of the planning tools and would be able to use them in the next LCPDP process.

### 5.3. Assessment of mainstreaming progress in the electricity sector

The LCPDP Committee, which is being led and coordinated by EPRA, has developed adequate planning skills, as evidenced by the team's past performance in the LCPDP process and beyond. This capacity has been enhanced through the introduction of the assessment tools for climate change impact and sustainable development objectives of the various LCPDP power generation scenarios. The LCPDP Committee has also been trained on new features of the LIPS-OP/XP and how to use them.

The development of new tools and the trainings conducted to build skills for the application of these tools have been evaluated as very successful by all stakeholders, represented by both participants and trainers. New planning and reporting capacity have been developed by introducing new features and topics to Kenya's electricity sector planners and discussing and adapting these features according to their needs. Together, the activities constitute a big step in the process towards mainstreaming climate change into the LCPDP process and enabling electricity sector planners to assess not only the climate change impacts of the various LCPDP scenarios but also their sustainable development impacts. The analytical work and the tool development as well as discussions and trainings provided a solid basis and new ideas for the next steps to continue the process. This was confirmed during interviews with some of the trainers and an EPRA representative.

The project will not only enable EPRA, and the LCPDP Committee to meet their planning mandate better than required by the 2019 Energy Act, but it will also allow them to assess and report the impacts of various LCPDP scenarios on climate change and sustainable development, as required by the 2016 Climate Change Act.

*Table 5: Assessment of mainstreaming progress in the electricity sector towards fulfilment of the 2016 Climate Change Act*

Clause from 2016 Climate Change Act	Relevance for EPRA	Assessment of progress towards fulfilment of the Climate Change Act clause (contributing actions)
1. Integration of the climate change action plan into sectoral strategies, action plans and other implementation projections (Section 15, paragraph 5a)	Yes	The activities have significantly contributed to the integration of climate change and sustainable development considerations in power planning processes and the energy sector as a whole.
2. Reporting on sectoral GHG emissions for the national inventory (Section 15, paragraph 5b)	Yes	The activities have significantly contributed to the capacity to report GHG emissions in the electricity supply sector for the national inventory.

3. The designation of a unit to coordinate the mainstreaming of climate change, and appointment of a senior officer as head of the unit (Section 15, paragraph 5c)	Yes	Through the coordination of the LCPDP, the mainstreaming of climate change into power sector planning is coordinated by EPRA and the assigned staff. However, a formal assignment for coordination of climate change activities in the power sector is yet to be made.
4. Regular monitoring and review of the performance of the integrated climate change functions through sectoral mandates (Section 15, paragraphs 5d and f) <sup>10</sup>	Yes	The activities have integrated both GHG emissions and some sustainable development assessment and reporting into the power sector planning process. This will facilitate regular monitoring and review of performance.
5. Putting in place and implementing mechanisms for sustainability in performance of sectoral mandates (Section 15, paragraph 5e)	Yes	The activities have helped to put in place and implement mechanisms for sustainability in performance of electricity sectoral mandates. With the sustainable development assessment information, the LCPDP Technical Committee will be able to make informed choices with respect to their sustainable development impacts.
6. Reporting annually to the Council on the status and progress of performance and implementation of all assigned climate change duties (Section 15, paragraph 5f)	Yes	With the GHG emissions calculation tool and the assessment of some sustainable development impacts as achieved through the activities, annual reporting in the electricity supply sector is possible.

The development of the emissions calculation tool, its use in Chapter 11 of the 2017-2037 LCPDP and its subsequent integration in the generation expansion planning tool LIPS-OP/XP has facilitated the reporting of GHG emissions in the electricity supply sector. Furthermore, the staff that is tasked with implementing the electricity sector planning in Kenya has been effectively trained on the application of the tools and is now ready to use them for the next update of the LCPDP. GHG emissions impacts of various generation expansion scenarios can now be assessed, monitored, and reported as required by Section 15, paragraphs 5a, b, d, e and f of the 2016 Climate Change Act. A formal appointment of a senior officer for coordination is, however, required to ensure continuity and institutionalisation.

So far, the assessment of GHG emissions is limited to CO<sub>2</sub> only, which is the main GHG in the power sector. Although considered less important for Kenya's power sector due to limited use of diesel generating units and the current absence of coal, the emissions of other gases and pollutants (SO<sub>x</sub>, NO<sub>x</sub>, particulate matter, and any geothermal specific emissions) could be included in future assessments. For scenario optimisation in the LCPDP process, CO<sub>2</sub> emissions have been included through a carbon price; however, another option would be the consideration of carbon budgets (e.g. annual or total life time).

<sup>10</sup> Such a mandate or coordination unit (as mentioned above) is very important to ensure that the process on mainstreaming that has been initiated is being followed-up and taken to the next level. With frequent changes in positions and processes, the main risk is that what has been started may be difficult to sustain.

In a similar manner, the development and integration of the EIM-ES, together with related trainings, has facilitated the assessment and reporting of sustainable development impacts of various generation scenarios as required by Section 15, paragraphs 5a, b, d, e and f of the 2016 Climate Change Act.

However, the EIM-ES is limited to the assessment of employment impacts only and there is a need for it to be expanded to cover other important sustainable development parameters such as energy security or industrial development. In addition, appropriate reporting formats for international and local reporting need to be agreed and developed for both emissions and sustainable development impacts.

## 6. Recommendations for next steps

### 6.1. Achieving enhanced alignment in planning processes

Horizontal and vertical exchange between ministries and government departments, as well as access to complete information, are key factors in creating an enabling planning environment for low carbon sustainable development. Section 3.4 highlights some significant limitations regarding the current state of misalignment between electricity supply and climate change planning processes. Three aspects deserve mentioning that may offer potential for improved alignment:

**The participation of climate policy planning representatives in electricity sector planning processes could be ensured, and vice versa.** Participation of MoE in climate planning processes, such as the design of the NCCAP or update of the NDC, exists but could be strengthened. Presently, the appointed climate change focal point in MoE is based at the Renewable Energy Directorate. The inclusion of other higher-level energy planning departments in MoE and the Ministry of Petroleum and Mining (formerly combined in one Ministry of Energy and Petroleum – MOEP), as well as targeted training of respective representatives on climate change aspects could be beneficial for strengthening the link to energy planning processes that go beyond renewable energy policy. Likewise, the participation of climate change planning representatives in electricity sector planning processes could be improved: currently no climate change planning representative plays a significant formal role in the process for the formulation of the LCPDPs, although climate change considerations are starting to be integrated into the LCPDP process. Should a direct link be established between CCD and the EPRA Economic Department, for example through the establishment of a climate change desk in this department, then such representation would already be achieved. Alternatively, the existing MoE climate change desk in the Renewable Energy Directorate could be included in the LCPDP Committee to ensure this representation and potential for alignment, or representatives from CCD could play a direct advisory role.

**Climate and electricity sector planning documents could ensure alignment with regards to emission baselines and targets.** Section 3.4.1 indicates that there remains a degree of misalignment on specific sector baselines and targets between climate and electricity sector planning documents. Several potential measures could alleviate the difficulties that lead to this situation, in addition to improving the representation of departments between climate and energy planning processes, as previously discussed:

- Increased awareness and certainty on the latest and most relevant electricity sector planning documents: The multitude of planning documents related to electricity supply has been difficult to navigate in the past, and there remains a degree of uncertainty outside of MoE as to which documents represent the most up to date official government strategy for the electricity sector. The current process of having a single LCPDP document that is updated on a biennial basis is a well-considered approach, but greater awareness could be raised regarding the importance of the outputs from this process, and how they supersede previous documents. It may also be useful to consider the alignment of updating cycles where possible, to ensure that the most up to date sector information feeds into broader development and climate policy planning processes. The annual climate-related reporting by sectors, required under the 2016 Climate Change Act, may offer an opportunity for that.
- Increased use of GHG emissions information included in electricity sector planning documents (LCPDP): For the first time, the 2017-2037 LCPDP included a dedicated section on the implications of the LCPDP scenarios for GHG emissions and climate change mitigation objectives. This information can be directly used in climate change planning processes to ensure alignment of information of emission baselines and mitigation options.
- Establishing longer-term targets for the electricity sector: The LCPDP begins with reference to major national objectives that the plan seeks to fulfil such as the achievement of universal access to electricity. The clear identification of such objectives that are frequently referred to across documents and do not usually change with updates to short- and medium-term plans, can help to increase the recognition of those goals and align information between departments. Section 1.2 explains how by ratifying the Paris Agreement, Kenya is committed to moving towards full decarbonisation of the economy in the second half of the century. This implies the adoption of a long-term GHG emission reduction goal for the sector and it is therefore beneficial to consistently refer to this long-term goal in all relevant planning documents.

**Evidence on broader sustainable development impacts could be integrated into electricity sector planning processes.** Realising synergies between the SDGs and electricity sector objectives can lead to more cost-effective planning, to deliver progress across multiple national objectives in parallel. This requires a more thorough understanding of the links between electricity sector plans and their potential impacts on other development objectives, such as industrial development, employment, energy security and water scarcity, amongst others. The identification of these links can allow for the identification of relevant people and groups to be involved in, or consulted, in the LCPDP development process. There is a broad consensus for the full consideration of these aspects, which would require that they are considered in the determination of the electricity sector *Reference* and *Vision Scenarios*, rather than the determination of these scenarios being based only on direct investment costs, as is currently the case. To consider broader impacts and progress towards goals of other development objectives, tools are needed to calculate the impact of scenarios for major development indicators. Under the A2A project, methodologies and tools related to economic impacts and air pollution have been developed in collaboration with national experts and governmental representatives, that could assist MoE to assess and integrate these considerations. As well as assisting

holistic planning processes, the identification of such impacts and synergies could be relevant as a means of helping to strengthen international support proposals, where relevant.

## 6.2. Updating the Nationally Determined Contribution

As a signatory to the Paris Agreement, Kenya is required to prepare, communicate and maintain successive actions that the country plans to undertake to address climate change, as laid down in its NDC. The ambition mechanism established in the Paris Agreement furthermore provides that Kenya, like all Parties, submits an updated NDC by 2020 and at least every five years thereafter.

In line with these requirements, a process has been initiated in 2019 to update Kenya's NDC to the Paris Agreement in early 2020 and to develop a Long-Term Strategy (LTS) for low carbon development of the economy. This process is led by CCD and supported, amongst others, by the German Federal Ministry for Economic Cooperation and Development (BMZ) under the NDC Assist Programme.

Given that previous climate change documents have been significantly misaligned with real developments and planning in the electricity sector, and that this proves a considerable barrier for climate change mitigation planning, **the NDC update process should be approached as an opportunity for re-alignment**. This requires that the current trajectory of emissions from the sector, as per planned developments in the sector, is reflected in the NDC analysis, and that the targets and actions derived for the NDC make sense against this background. In addition, the NDC update process should foster the alignment of the NDC with the Sustainable Development Goals (SDGs) and other national development objectives to ensure broad mainstreaming of climate change issues throughout Kenya's development agenda.

**Section 3 of this document provides the most current comparative analysis of climate and energy planning documents, as of December 2019, and can be used as a starting point to ensure this re-alignment** during this NDC update process. Other published climate-related documents, including the 2017 Baseline Update Report and the Mitigation Technical Analysis Report (MTAR) that underpins the 2018-2022 NCCAP, contain representations of energy sector forecasts that are no longer up to date, and their use as a starting point for analysis in the electricity sector would lead to the continuation of considerable misalignment. Experience from several countries shows that it can be useful to involve relevant stakeholders in discussions and consultations around the revision of sector baselines in order to perform a reality check and ensure the stakeholders' buy-in and support throughout the process.

Due to the short timeframe in which Kenya's first NDC had to be compiled in 2016, no provisions were made to institutionalise the process and ensure continuity for the enhancement and implementation of the NDC in the future. While it seems that the planned NDC update follows the same pattern, this new process offers the opportunity to establish critical institutions and permanent, well trained technical teams that allow for the NDC update and other related processes to continue on an ongoing basis and beyond the delivery of the NDC document.

## 6.3. Charting out a Paris compatible pathway for the electricity sector

### ***Paris compatible development pathways***

According to the *IPCC Special Report on Global Warming of 1.5°C* which was published in 2018, global CO<sub>2</sub> emissions need to decrease, on average, by about 45% from 2010 levels by 2030 and reach 'net zero' by around 2050 in order to reach the Paris Agreement's long-term temperature goal (IPCC, 2018). Additionally, global GHG emissions (including all global warming gases) need to peak as soon as possible and decline quickly (Rogelj et al., 2018).

While the IPCC Special Report highlights the urgency to act across all sectors, several studies consider variations between sectors regarding the speed and depth of decarbonisation needed. For some sectors, it will be less feasible to achieve zero emissions by 2050 (e.g. agriculture, industry, aviation), which means that other sectors with proven mitigation options (e.g. electricity supply) need to do more to achieve the Paris goal.

Multiple pathway analyses focus on energy as the most significant source of GHG emissions. In the energy sector, and specifically in electricity supply, more options are readily available than in other sectors. Hence, it is critical that this sector moves quickly and efficiently in the near-term. The IPCC Special Report highlights four key indicators for the decarbonisation of the energy sector (IPCC, 2018):

- a) Limitation of the increase of final energy demand;
- b) Reduction in the carbon intensity of electricity supply;
- c) Increase in the share of final energy provided by electricity; and
- d) Reduction in the carbon intensity of final energy other than electricity.

Looking at the electricity sector in particular, a reduction in the carbon intensity of electricity and an increase in the share of final energy provided by electricity are paramount to achieve effective and timely decarbonisation of this sub-sector.

The Climate Action Tracker (CAT) translates this challenge in its *10 Steps to Limit Warming to 1.5°C* into specific goals for electricity generation and the development of coal power: in the electricity sector, the growth rate of renewable energy and other low-carbon power technologies must be sustained until 2025 to reach 100% by 2050. No new coal plants can be built and emissions from existing coal power must be reduced by at least 30% by 2025 (Climate Action Tracker, 2016).

### ***Paris compatibility of Kenya's electricity sector***

As described in section 3, Kenya's current electricity generation mix has a relatively low emissions intensity. The LCPDP highlights two scenarios for electricity sector development (*Reference* and *Visions Scenario*), both of which describe a pathway of decreasing emissions until reaching near-zero in 2019, mainly due to the phase out of medium-speed diesel plants. Thus in 2020, Kenya's electricity supply will be almost 100% renewable based. This would place Kenya as a forerunner for Paris compatible electricity sector development in the region and globally.

However, while the development of Kenya's electricity sector can be considered fully Paris compatible today and over the coming five years, the planned introduction of coal-based power generation, starting in 2026 in



the *Reference Scenario* and in 2024 in the *Vision Scenario*, threatens to abruptly increase emissions from electricity generation again and puts the Paris compatible sector development at risk.

According to recent independent analysis on the *Global and regional phase-out requirements of the Paris Agreement*, building coal-fired power plants in Kenya is inconsistent with the Paris Agreement's 1.5°C target. Paris compatible pathways for Middle East and Africa require a reduction in coal-based power generation by 80% below 2010 levels by 2030 and a phase-out of coal by 2034 (Yanguas Parra et al., 2019).

Against this background, section 3 confirms that the principal measure to ensure that electricity sector development remains Paris compatible in Kenya is the avoided installation of coal capacity and the restricted use of additional natural gas capacity. This could be compensated through the expansion of other electricity supply options, first and foremost geothermal power, as laid down in section 4; as well as through enhanced promotion of auto-generation from renewable sources and energy efficiency improvements. Thorough assessment of low-carbon electricity generation technologies in the Kenyan context suggests that the expansion of alternatives to coal power is not only technically feasible but also economically attractive. These options promise to deliver universal electricity at low cost while maximising other sustainable development objectives, including job creation and clean air.

The results of the IPCC Special Report create a sense of urgency and momentum for all countries to raise their ambition, strengthen their NDCs and effectively accelerate the implementation of the Paris Agreement in order to reach the long-term temperature goal. It also becomes clear that current national pledges under the Paris Agreement are not enough to stay on track toward this goal. By setting out a Paris compatible development trajectory and long-term vision for its electricity sector, Kenya would position itself as a global leader and may become an especially attractive recipient of climate finance. National and multilateral development banks are aligning their investment activities with the Paris Agreement, and an increasing number of banks from the private sector are making similar commitments. Many of these sources of climate finance now look for sector scale examples of Paris aligned infrastructure development, and Kenya's electricity sector finds itself in an excellent position to respond to this.

Finally, the development of an LTS that is aligned with the Paris Agreement can provide a clear vision for the development direction of Kenya's economy and society, as well as certainty and transparency to sector stakeholders. This can be used as a starting point for more reliable and consistent sector planning in the short- and medium-term and can be picked up in broader sustainable development planning including under Kenya Vision 2030 and the Big Four Agenda.

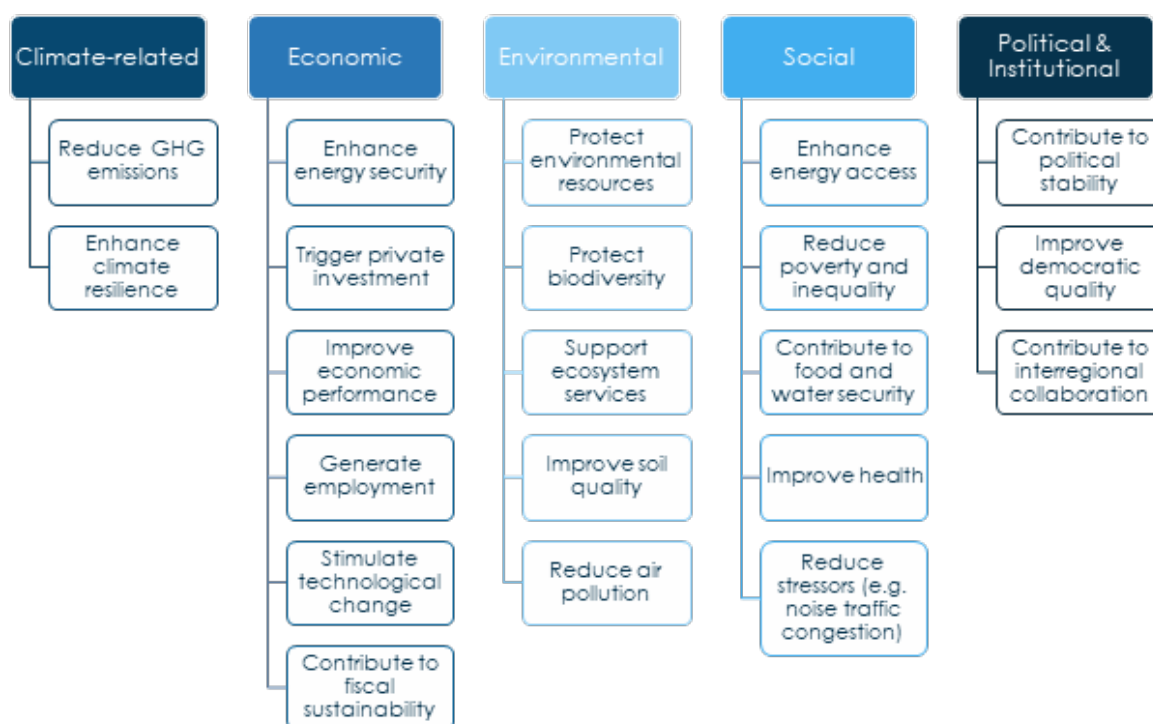
## Annex I – Tools for the assessment of sustainable development benefits

The Paris Agreement sets out a framework to address the global problem of climate change and limit temperature rise to well below 2°C above industrial levels. Achieving this goal requires rapid structural change across all economic sectors – notably the transition to low carbon energy systems is a fundamental component of efforts to mitigate climate change. Growth in energy demand and the transition to low carbon technologies require large investments in capital, land and labour. The scale of the investment and the beneficiaries of these financial flows depend on a wide range of factors such as the choice of technology, location, rate of deployment, and capacity of local supply chains, among many others.

It is important that policy makers carefully consider the wider socio-economic and environmental impacts of their approach to tackling climate change, which can lead to a wide range of so-called “co-benefits” through improved air and water quality; more secure, accessible and sustainable energy supplies; and opportunities for economic growth and job creation in new sectors. As with any transition, there will likely be those that stand to gain more and those that are potentially disadvantaged. An analysis of the likely magnitude and distribution of future impacts can help policy makers to prepare the skills and capacities required to support the transition, to ensure that those losing out as a result of the change are appropriately compensated and to best facilitate a just transition that works for all.

Policies that primarily target the electricity sector can positively contribute to the achievement of other sustainable development-related objectives that are important to society. Figure 6 gives a comprehensive overview of different types of benefits. These are increasingly considered in international policy making and are gaining political and economic momentum. The integration of multiple (development) objectives in policies can strengthen the support for such policies and increase the cost-effectiveness of their implementation.

Figure 6: Types of sustainable development benefits (derived from Mayrhofer and Gupta, 2015)



The following paragraphs present three tools that can support the qualitative and quantitative assessment of different sustainable development impacts of energy sector pathways.

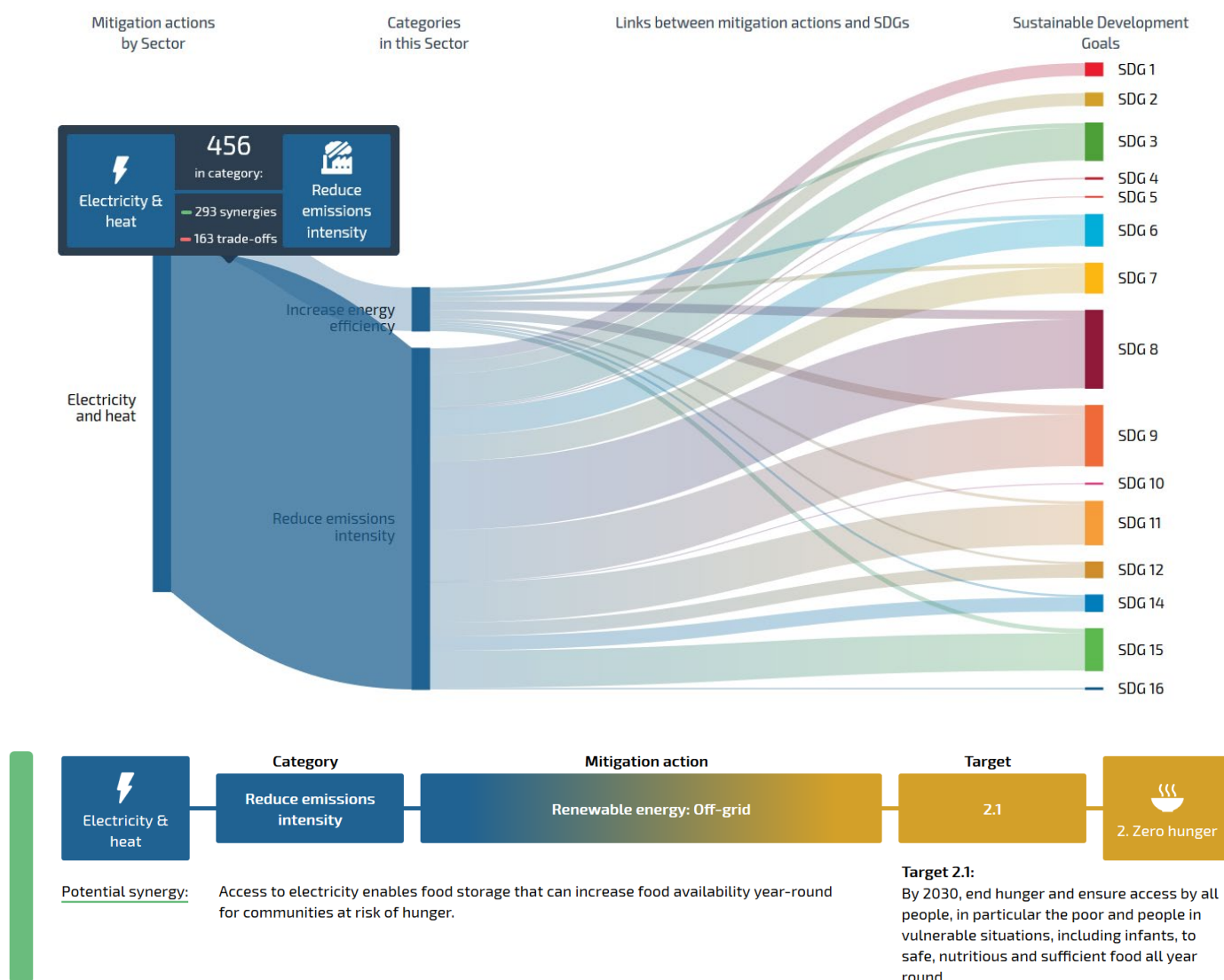
### SDG Climate Action Nexus tool (SCAN-tool)<sup>11</sup>

The SDG Climate Action Nexus tool (SCAN-tool) is designed to provide high-level guidance on how climate actions can impact achievement of the SDGs. The tool aims to be user-friendly and practical and is meant to support policy makers across different departments and state levels to achieve greater policy coherence. Further, it can improve the efficiency of implementation by providing them with an initial indication of which climate actions may impact - positively or negatively - specific SDG targets. Figure 7 illustrates how the reduction of the emissions intensity in the electricity sector is linked to the SDGs and shows an example of a potential synergy with SDG 2 *Zero Hunger*.

The SCAN-tool can also inform the process of putting forward increasingly ambitious pledges of climate action. A better understanding of how climate action can reinforce the achievement of the SDG targets and national development objectives may increase countries' confidence to put forward more ambitious NDCs and improve political buy-in.

<sup>11</sup> The SCAN-tool and associated materials can be found at [http://ambitiontoaction.net/scan\\_tool/](http://ambitiontoaction.net/scan_tool/).

Figure 7: SCAN-tool: Linkages between reducing emissions intensity and the SDGs



## The Economic Impact Model for Electricity Supply (EIM-ES)<sup>12</sup>

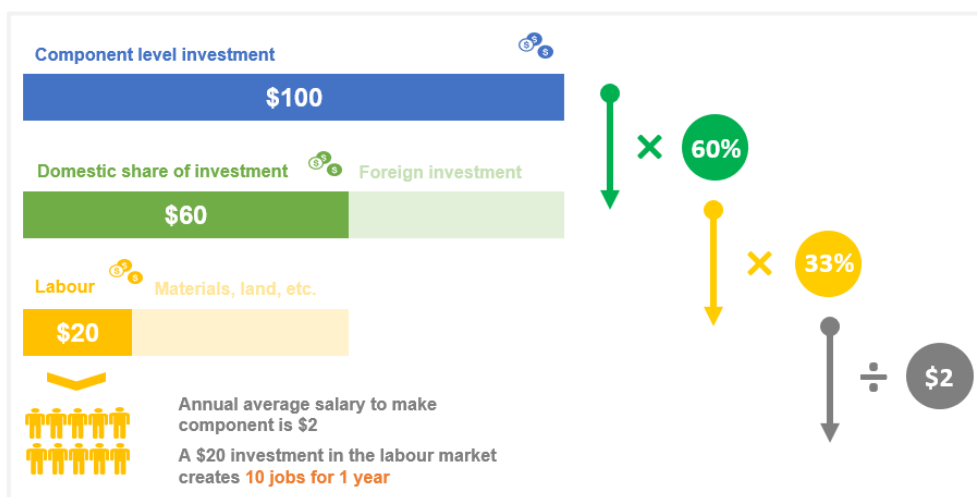
The EIM-ES is a spreadsheet-based economic model used to estimate the *domestic* employment impacts of investments in new electricity generation capacity within a country. The model covers all relevant electricity generation technologies – both low carbon and fossil fuel-based plants – in order to provide an assessment of employment creation under different future pathways for the development of the electricity sector. The technology coverage is simple to adjust within the model and can be tailored to the country of interest.

The analysis is based on investment cost data, disaggregated, where possible, into its component parts for new electricity generation capacity. Based on input data and underlying assumptions, the model calculates the share of each investment that is spent domestically and the share of that domestic investment that is directed to the labour market. The direct employment impact is then estimated by dividing the domestic

<sup>12</sup> The EIM-ES and associated materials can be found at <https://newclimate.org/2018/11/30/eim-es-economic-impact-model-for-electricity-supply/>.

labour market investment by an average annual salary that is representative for the work carried out. The model apportions the direct jobs created over time based on assumptions related to the duration of the various tasks and services. For example, construction jobs may last for 2 to 5 years, depending on the technology. Jobs created to provide operation and maintenance (O&M) services typically cover a much longer period of time, tied to the expected lifetime of the asset.

Figure 8: Overview of the approach to estimating direct employment impacts



**Direct** employment creation over time is the key focus of the model (e.g. for manufacturing equipment, construction of plants, professional services, etc.). In addition, the tool calculates indirect and induced employment impacts by drawing on input-output tables for the economy. Input-output tables reflect the interdependencies of sectors across the economy, based on national statistics, and provide an order of magnitude of the wider economic impacts of investment in electricity generation. **Indirect** jobs refer to those created in secondary sectors upstream in the supply chain (e.g. in the metallurgical or mining industries). **Induced** jobs are created across all economic sectors as a result of an investment stimulus (e.g. the salaries of those that directly and indirectly benefit from the investments are spent on other, unrelated activities, such as housing, restaurants, healthcare, etc.).

The level of accuracy of the analysis depends somewhat on the quality of data inputs and the extent to which they reflect the country-specific context. Where country-specific data points are either missing or unreliable, we can draw on regional and international information, adjusted, where relevant, to the target country. The model is designed to enable sensitivity analysis on key data inputs to evaluate the extent to which they influence the final results.

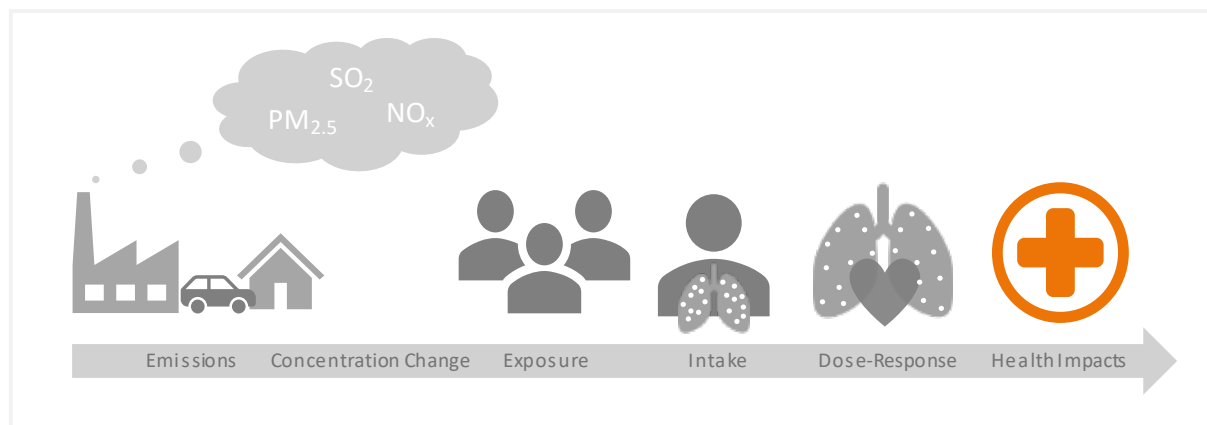
## The Air Pollution Impact Model for Electricity Supply (AIRPOLIM-ES)<sup>13</sup>

The AIRPOLIM-ES is a spreadsheet-based model that uses an accessible methodology for quantifying the health impacts of air pollution from different sources of electricity generation and other fuel combustion. The first version of this tool focuses on electricity generation from coal- and gas-fired power plants. It

<sup>13</sup> The AIRPOLIM-ES and associated materials can be found at <https://newclimate.org/2018/11/30/airpolim-es-air-pollution-impact-model-for-electricity-supply/>.

calculates the impacts on mortality from four adulthood diseases: lung cancer, chronic obstructive pulmonary disease, ischemic heart disease, and strokes, the prevalence of which is increased through exposure to air pollution.

*Figure 9: From air pollution to health impacts*



The health impact assessment is based on emissions of particulate matter (PM<sub>2.5</sub>), NO<sub>x</sub>, and SO<sub>2</sub>. The model estimates the annual and lifetime electricity generation (GWh) for each plant, as well as the corresponding emissions of air pollutants using plant-specific data and emission factors. Depending on the type of emissions control equipment installed, the model multiplies the estimated fuel consumption with the corresponding country-specific emission factor. Where more detailed information is available, plant-specific emission factors can be entered into the model to improve accuracy.

The exposed population living within four distance bands (0–100 km, 100–500 km, 500–1,000 km, and 1,000–3,300 km) from each power plant is estimated using open-source Geographic Information System (GIS) software, also considering population growth. The model uses the intake fraction concept to estimate the change in PM<sub>2.5</sub> concentration in the ambient air based on the calculated pollutant emissions. Intake fractions indicate the grams of PM<sub>2.5</sub> inhaled per ton of PM<sub>2.5</sub>, NO<sub>x</sub>, and SO<sub>2</sub> emissions. These fractions - drawn from literature based on air dispersion modelling – enable estimation of the change in PM<sub>2.5</sub> concentration. In order to estimate the intake fractions for the three pollutants, the model applies coefficients from a widely cited study from Zhou et al. (2006). One limitation of this approach is that the coefficients do not account for location-specific characteristics such as stack-height or meteorological conditions; nevertheless, Zhou et al. show that population exposure by distance is by far the most significant determinant of the level of intake of pollutants.

To calculate the increased mortality risk per additional ton of pollutant emissions, the estimated change in PM<sub>2.5</sub> concentration is multiplied with the respective concentration-response function. Concentration-response functions are estimated based on long-term medical cohort studies and indicate the increase in cause-specific mortalities per 10 microgrammes per cubic metre increase in PM<sub>2.5</sub>. The Global Burden of Disease project provides mortality rates by disease for different age groups at the country level. The model obtains age-weighted mortality rates by disease using the share of the country's population in each age class. The risk estimates, age-weighted mortality rates, and exposed population are combined to calculate the



number of premature deaths per ton of pollutant for each cause of death. Finally, these numbers are multiplied with the estimated pollutant emissions to obtain the total premature deaths per pollutant and cause for each power plant. Premature death refers to deaths that are attributed to exposure to a risk factor, e.g. air pollution, and could be delayed if the risk factor was eliminated.

# References

- ABiQ. (2019). Kenya Power Sector Report Q2 2019. Retrieved November 15, 2019, from <https://www.abiq.io/kenya-power-sector-q2-2019/>
- Capital FM Kenya. (2018). Kenya targets green energy sufficiency by 2020, President Kenyatta says - Capital Business.
- Climate Action Tracker. (2016). *The ten most important short-term steps to limit warming to 1.5°C*. Climate Action Tracker (Climate Analytics, Ecofys, NewClimate Institute).
- Eberhard, A., Gratwick, K., Morella, E., & Antmann, P. (2016). *Independent Power Projects in Sub-Saharan Africa Lessons from Five Key Countries*. Washington: International Bank for Reconstruction and Development / The World Bank.
- Government of Kenya. (2015). *Kenya Second National Communication to the United Nations Framework Convention on Climate Change*. Retrieved from <http://unfccc.int/resource/docs/natc/kennc2.pdf> (accessed 20.09.17)
- Government of Kenya. Climate Change Act 2016 (2016). <https://doi.org/10.1136/bmj.39469.569815.47>
- Government of Kenya. (2018a). *National Climate Change Action Plan 2018-2022* (Vol. I). Nairobi: Ministry of Environment and Forestry.
- Government of Kenya. (2018b). *Updated Least Cost Power Development Plan (LCPDP) Study Period: 2017-2037*. Retrieved from <http://www.unesco.org/education/edurights/media/docs/446808882707702aafc616d3a2cec918bfc186fc.pdf>
- Infotrak. (2017). *43% Of Kenyans Have No Access To Electricity, Research Shows* / Biznews. Retrieved from <http://biznews.co.ke/2017/03/29/43-of-kenyans-have-no-access-to-electricity-research-shows/>
- IPCC. (2018). *IPCC special report on the impacts of global warming of 1.5°C - Summary for policy makers*. Intergovernmental Panel on Climate Change (IPCC). Retrieved from <http://www.ipcc.ch/report/sr15/>
- IRENA. (2019). Renewable Electricity Capacity and Generation Statistics. Retrieved from <http://resourceirena.irena.org/gateway/dashboard/?topic=4&subTopic=54>
- KPLC. (2017). *Kenya Power - Annual Report and Financial Statements for the year ended 30 June 2017*. Retrieved from [http://kplc.co.ke/AR2017/KPLC 2016 - 2017 Annual Report-.pdf](http://kplc.co.ke/AR2017/KPLC%202016-2017%20Annual%20Report.pdf)
- Mayrhofer, J., & Gupta, J. (2015). The politics of co-benefits in India's energy sector. *Environment and Planning*, 34(7). Retrieved from <https://doi.org/10.1177/0263774X15619629>
- MENR. (2015). *Kenya's Intended Nationally Determined Contribution*. Retrieved from [http://www.environment.go.ke/wp-content/uploads/2015/07/Kenya\\_INDC\\_20150723.pdf](http://www.environment.go.ke/wp-content/uploads/2015/07/Kenya_INDC_20150723.pdf)
- MENR. (2017a). *Kenya's Nationally Determined Contribution (NDC): Update of Kenya's Emission Baseline Projections and Impact on NDC Target*. Retrieved from <http://www.starckplus.com/documents/ta/ndc/UpdateofKenyasEmissionBaselineProjectionsandImpactonNDCTarget.pdf> (accessed 17.10.2017)
- MENR. (2017b). *Nationally Determined Contribution - Sector Analysis Report*. Retrieved from [http://www.starckplus.com/documents/ta/ndc/NDC Sector Analysis Report 2017.pdf](http://www.starckplus.com/documents/ta/ndc/NDC%20Sector%20Analysis%20Report%202017.pdf)
- NewClimate Institute. (2019). *The role of renewable energy mini-grids in Kenya's electricity sector*. Cologne.

- Newell, P., & Phillips, J. (2016). Neoliberal energy transitions in the South : Kenyan experiences. *Geoforum*, 74, 39–48. <https://doi.org/10.1016/j.geoforum.2016.05.009>
- Newell, P., Phillips, J., Pueyo, A., Kirumba, E., Ozor, N., & Urama, K. (2014). The Political Economy of Low Carbon Energy in Kenya. *IDS Working Papers*, 2014(445), 1–38. <https://doi.org/10.1111/j.2040-0209.2014.00445.x>
- Power Africa. (2016). *Development of Kenya's power sector 2015-2020*.
- Republic of Kenya. The Climate Change Act (2016). Retrieved from [http://www.environment.go.ke/wp-content/uploads/2018/08/The\\_Kenya\\_Climate\\_Change\\_Act\\_2016.pdf](http://www.environment.go.ke/wp-content/uploads/2018/08/The_Kenya_Climate_Change_Act_2016.pdf)
- Republic of Kenya. (2018a). *Third Medium Term Plan 2018 - 2022*. Retrieved from <http://vision2030.go.ke/inc/uploads/2019/01/THIRD-MEDIUM-TERM-PLAN-2018-2022.pdf>
- Republic of Kenya. (2018b). *Updated Least Cost Power Development Plan: Study Period 2017-2037*. Retrieved from <http://gak.co.ke/wp-content/uploads/2019/02/Updated-Least-Cost-Power-Development-Plan-2017-2022-min.pdf>
- Republic of Kenya. (2018c). *Updated Least Cost Power Development Plan: Study Period 2017-2037*.
- Roedl & Partner. (2019). Highlights of Kenya's Energy Act 2019 | Rödl & Partner. Retrieved December 16, 2019, from <https://www.roedl.com/insights/erneuerbare-energien/2019-05/highlights-of-kenyas-energy-act-2019>
- Rogelj, J., Shindell, D., Jiang, K., Fifita, S., Forster, P., Ginzburg, V., ... Vilarino, M. V. (2018). Mitigation Pathways Compatible With 1.5°C in the Context of Sustainable Development. In *Global warming of 1.5°C. An IPCC Special Report [...]* (p. 82pp). IPCC. Retrieved from [https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15\\_Chapter2\\_Low\\_Res.pdf](https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter2_Low_Res.pdf)
- World Bank. (2017). *Guidance note on shadow price of carbon in economic analysis*. Retrieved from <http://documents.worldbank.org/curated/en/621721519940107694/Guidance-note-on-shadow-price-of-carbon-in-economic-analysis>
- WRI. (2019). Kenya will strengthen its national climate plan in 2020. Retrieved November 13, 2019, from <https://twitter.com/WRIClimate/status/1142753951948972032>
- Yanguas Parra, P. A., Ganti, G., Brecha, R., Hare, B., Schaeffer, M., & Fuentes, U. (2019). *Global and regional coal phase-out requirements of the Paris Agreement: Insights from the IPCC Special Report on 1.5°C*. Retrieved from [https://climateanalytics.org/media/report\\_coal\\_phase\\_out\\_2019.pdf](https://climateanalytics.org/media/report_coal_phase_out_2019.pdf)

Marie-Jeanne Kurdziel

NewClimate Institute

Project manager

[m.kurdziel@newclimate.org](mailto:m.kurdziel@newclimate.org)

T +49 221 999 833-14

Lukas Kahlen

NewClimate Institute

Project manager

[l.kahlen@newclimate.org](mailto:l.kahlen@newclimate.org)

T +49 30 208 49 27-51

---