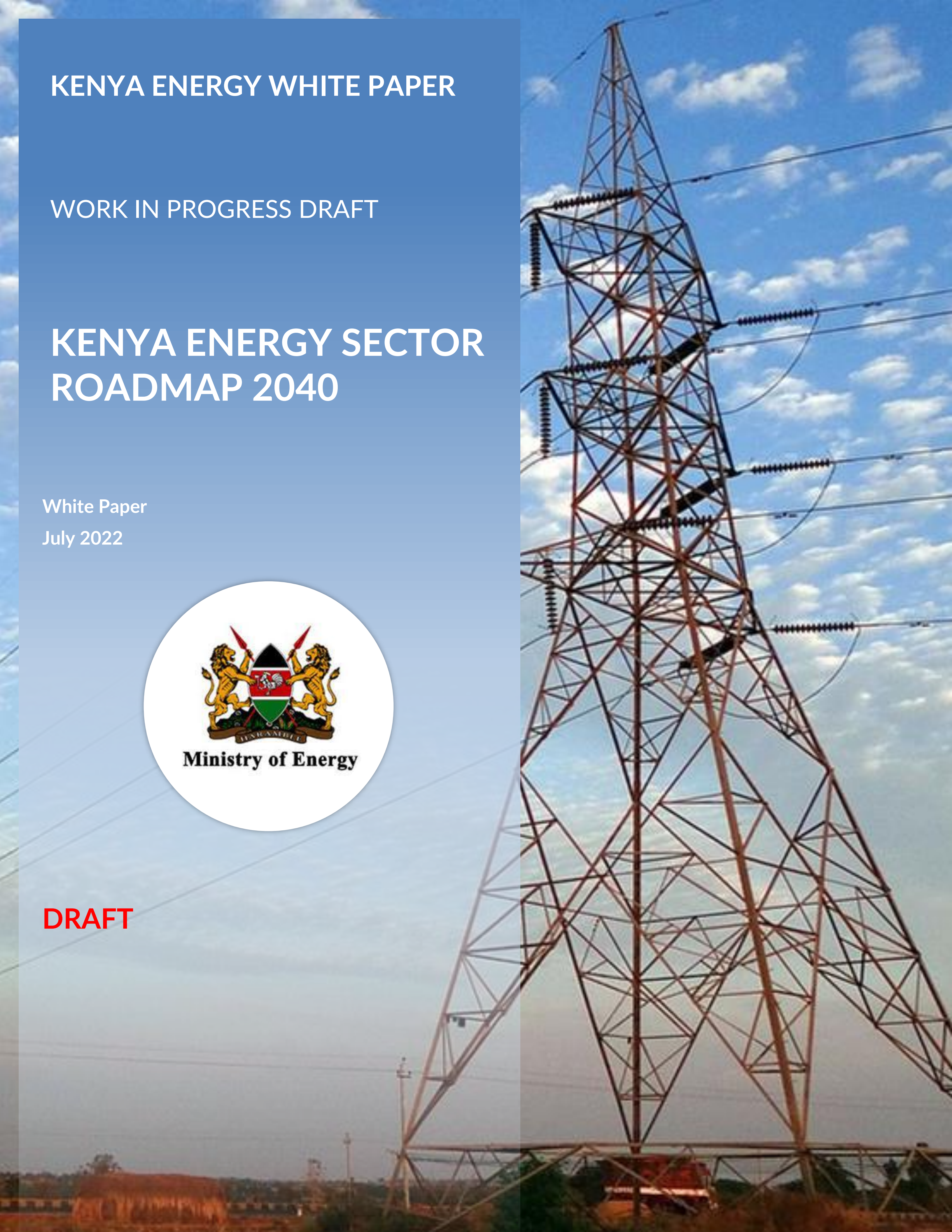

KENYA ENERGY WHITE PAPER

WORK IN PROGRESS DRAFT

KENYA ENERGY SECTOR ROADMAP 2040

White Paper

July 2022

Ministry of Energy

DRAFT

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MINISTERIAL FOREWORD

Transforming the lives of Kenyans through clean and affordable energy

Energy is a public good and a key enabler for productivity at every level of society in Kenya. Kenyans have a collective aspiration to transform the country into a thriving middle-income economy that works for all. Affordable and reliable energy is at the heart of achieving these socio-economic goals and that is why it has been central to the current national development blueprint, Vision 2030.

The challenges witnessed across the globe in the last few years including those brought on by climate change show that there is an urgent need to end the reliance on fossil fuels. The global economy is reliant on fossil fuels which are not only causing irreversible damage to the planet but are also highly susceptible to supply chain disruptions and price fluctuations. Economies, especially those in the developing world will not truly achieve the momentum and true independence they need to grow if they continue with this path.

Kenya has played a leading role in global efforts aimed at conserving the environment. Kenya is no stranger to taking a front seat in global affairs. Starting with the establishment of the UNEP Headquarters in Nairobi in the late 70s through to the efforts of Prof Wangari Mathai and the Greenbelt Movement. It is now time to amplify that voice to lead the green energy transition journey with bold and ambitious actions that can inspire other nations to do the same. The country is endowed with all the renewable energy resources required to achieve its economic and social transformational objectives. Kenya has the human capacity, global networks, and goodwill from a wide range of stakeholders necessary to drive this change.

I am delighted to present the Kenya Energy White Paper which puts forward a transformational agenda for accelerating Kenya's low-carbon transition ambitions while ensuring the delivery of power that is reliable and affordable to all. The paper will focus on laying out the overarching approach to achieving Kenya's energy ambitions and considering how Kenya can leverage renewable energy to give the country an edge over the rest of the region and the world. The White Paper also articulates the critical shifts that we will need to employ. These shifts can be defined as a mix of market and non-market levers needed at the right pace and scale to ensure the systemic change in the energy ecosystem. This paper has been developed through a concerted effort of a dedicated task force drawn from the various energy institutions with the support of various local and international experts.

I am confident that this White Paper will be a key component in Kenya's development journey for the next few decades.

AMB Dr. Monica Juma (Oxon), EGH
Cabinet Secretary, Ministry of Energy

ACRONYMS

BRT	Bus Rapid Transport
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CO_2	Carbon dioxide
DAC	Direct Air Carbon Capture
DFI	Development Finance Institutions
EIA	Energy Information Administration
EPRA	Energy and Petroleum Regulatory Authority
EU	European Union
EV	Electric Vehicle
FCC	Fuel Cost Charge
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GW	Gigawatt
GWh	Gigawatt Hour
ICT	Information and Communication Technology
KETRACO	Kenya Electricity Transmission Company
KPLC	Kenya Power and Lighting Company
KV	Kilovolt
kWh	Kilowatt Hour
LCPDP	Least Cost Power Development Plan
$MTCO_2e$	Metric tons of carbon dioxide equivalent
MVA	Megavolt Amperes
MW	Megawatt
NDC	Nationally Determined Contributions
NuPEA	Nuclear Power and Energy Agency
OPEX	Operational Expenditure
PAYGO	Pay as you go
PULSE	Productive Uses Leveraging Solar Energy
REREC	Rural Electrification and Renewable Energy Corporation
SAGA	Semi-Autonomous Government Agencies
SEZ	Special Economic Zone
SME	Small and Medium Enterprises
TWh	Terawatt hour
UNEP	United Nations Environment Program
USD	United States Dollar
VRE	Variable Renewable Energy

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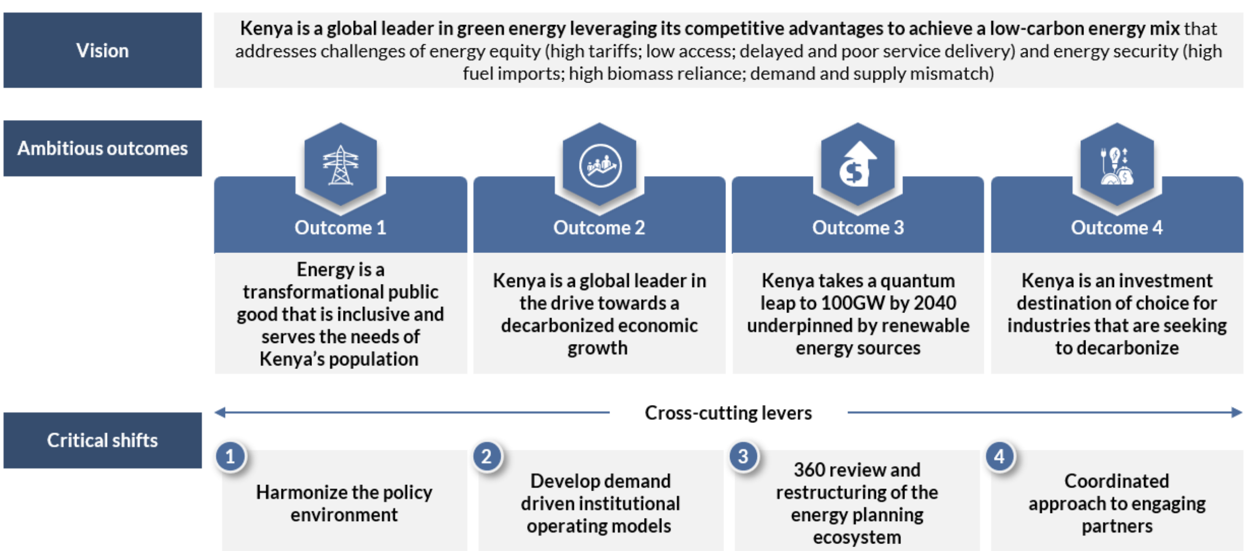
EXECUTIVE SUMMARY

As Kenya seeks to attain middle-income status in the next decade, the Energy Sector White Paper presents an avenue to attain inclusive and equitable economic growth through the provision of affordable, reliable, and sustainable energy. The White Paper is a blueprint that can support the country's long-term vision setting, planning, and implementation of national development goals between 2022 to 2040. This White Paper builds upon the numerous national economic and energy sector policies developed in the last decade and reinforces the energy sector's goal to chart a transformative path toward a clean energy future. The paper will articulate Kenya's energy journey so far and outline the pathways necessary to achieve the envisioned energy goals. It will also lay out the critical shifts that will be required to bring about systemic change and unlock unprecedented growth in the sector.

This White Paper has been developed by a joint Taskforce drawn from the various energy institutions in Kenya with support from external consultants both at the local, regional, and global levels. To strengthen insights and analysis, the taskforce team also engaged various stakeholders in the energy space across the world. The Ministry of Energy provided the overall policy steers to ensure the paper was articulating an ambitious strategy that was aligned with the Government's broader national development goals. The outcomes outlined in the White Paper have been developed through the assessment of the current state of play in the energy sector and a rigorous evaluation of the opportunities that Kenya should tap into.

The White Paper proposes four outcomes that will propel Kenya into a global leader in green energy while ensuring Kenyans have the energy to power their productivity. These outcomes are articulated as bold statements of intent with supporting analysis and insight on how they shall be achieved. These outcomes are coupled with measurable pathways that can be used to monitor progress. They can be summarized as follows:

Illustration 1: Kenya's energy sector vision, ambitious outcomes, and critical shifts



- **<u>Outcome 1:</u> Establish energy as a transformational public good that is inclusive and serves the needs of Kenya's population.** An energy system that is consumer-focused and inclusive, ensuring that all Kenyans have access to clean, affordable, and modern energy that improves their livelihoods and enables them to be an active participant in nation building
    - 100% access to electricity by 2030
    - 50% reduction in household electricity bills by 2040
    - Increased per capita consumption to be at par with upper middle-income economies by 2040
    - 100% access for micro and small enterprises
- **<u>Outcome 2:</u> Establish Kenya as a global leader in the drive towards decarbonized economic growth.** Stimulate the efficient use of clean energy in Kenya at both industrial and household level
    - Low-carbon electricity at the core
    - Smart power grids to enhance efficiency
    - End reliance on back-up generators and their emissions impact by re-capturing demand and replacing with non-emitting solutions
    - 50% reduction in unsustainable household biomass use by 2040
    - Decarbonize high carbon-emitting demand sectors
    - Use green energy to create competitive advantage in decarbonized sectors e.g., green hydrogen, Direct Air capture and storage
- **<u>Outcome 3:</u> Drive Kenya to take a quantum leap to 100 GW installed capacity by 2040 underpinned by renewable energy sources.** Tapping all the renewable resources Kenya must increase the installed capacity from 3 GW to 100 GW and attract more than USD 300 billion worth of green energy investments
    - Increase capacity generation to 100 GW by 2040 - Kenya is the Regional Green Pioneer of new energy sector technologies
    - Attract USD 300 billion in green energy investment
    - Diversify funding pools for energy investments including mobilizing innovative green financing and domestic funds to de-risk local projects and stimulate investor appetite
- **<u>Outcome 4:</u> Establish Kenya as an investment destination of choice for industries that are seeking to decarbonize.** Kenya positions itself to ensure the country can capitalize on opportunities in renewable energy especially in attracting energy-intensive sectors seeking to decarbonize
    - Attract new high-growth high-energy intensive industries by improving the country's business environment
    - Stimulate additional bankable clean energy demand from traditional sectors including development of industrial parks and agro-processing zones
    - Leverage Kenya's competitive advantage to tap into regional power pools
    - Stimulate a 24-hour economy

Underpinning the achievement will be four critical shifts that ensure a systemic change in the energy sector. The critical shifts outline four market and non-market levers that are essential for Kenya to deliver an energy context where the articulated outcomes are achievable. The below four levers answer the question "what needs to be different and how?" for Kenya to achieve the desired end state.

- **Harmonize the policy environment** to insulate the country from risk while facilitating the delivery of low-cost energy and fostering a competitive market environment
- **Develop demand driven institutional operating models** configured to foster robust governance and optimize cost efficiencies while being customer focused
- **360 review and restructuring of the energy planning ecosystem** that considers management of energy assets and demand shifts to ensure compatibility with the national economic growth agenda
- **Coordinated approach to engaging partners** to strengthen collaboration and ensure the country has a well-defined strategy for resource mobilization

The outcomes articulated in this White Paper are bold ambitions that will require a radical shift in approach in how the energy sector and ecosystem function. Between 2012 and 2022, Kenya has increased its installed capacity from 1.6 GW to close to 3 GW, this represents a yearly average of 140 MW. The outcome presented by this White Paper seeks to increase the installed capacity from 3 GW to 100 GW in 18 years, these averages to more than 5 GW a year. This is an extremely bold and ambitious target, but it is achievable as there is precedent and Kenya is endowed with all the resources needed. However, there must be a completely different approach to how the country runs the energy ecosystem.

1. INTRODUCTION

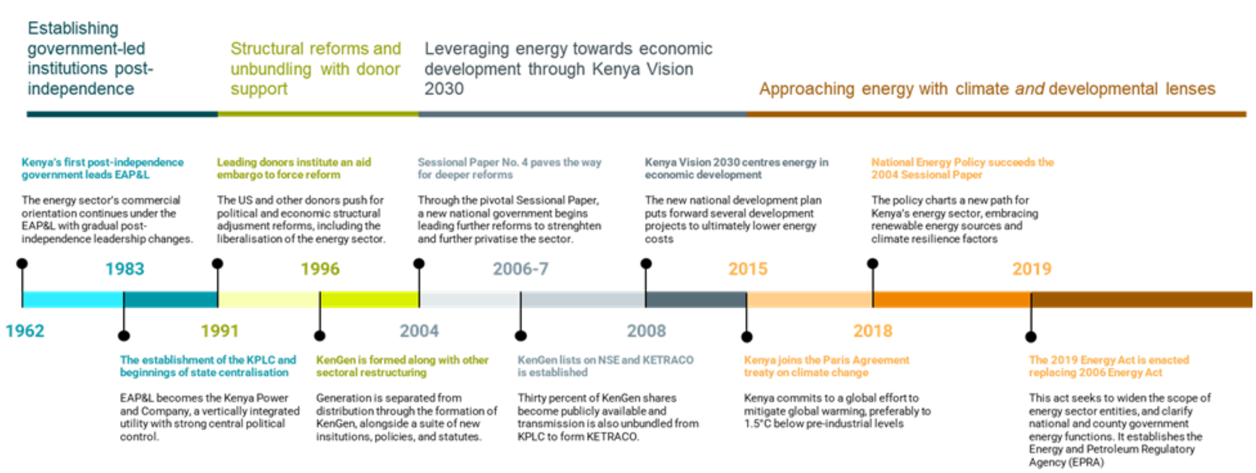
1.1 Kenya's journey to date

Across the globe, climate change is driving a major transformation in how energy is generated and consumed. As the world races to reduce greenhouse emissions, technological innovations, renewable energy deployment, new energy regulations, and changing consumer behavior will be the key megatrends that will shape the future of energy policies. The United States Energy Information Administration (EIA) projects that global energy consumption will increase nearly 50% over the next 30 years. This increased energy consumption will coincide with the fast-approaching peak for fossil fuel demand which could come as early as 2025 if countries honor their net-zero pledges.[1] This will ultimately have a significant impact on the energy sector as new energy investments will increasingly focus on renewable sources of energy. This presents a huge opportunity for green energy-focused economies as the market for clean energy technologies could exceed USD 1 trillion a year by 2050.

It is within this context that Kenya must take stock of its energy journey and state clear and bold ambitions about how the country will anchor itself as a leader in the global energy transition. Taking an active and global role in clean energy is not without precedent, Kenya's participation can trace back to the establishment of UNEP's global headquarters in Nairobi in the 70s. Later, environment champions such as Wangari Maathai and the Green Belt Movement had a significant impact on amplifying the message on the effects of climate change especially on developing economies such as Kenya.

The sectoral reforms undertaken in the energy sector have already resulted in Kenya having one of the cleanest electricity grids in the world. As illustrated below, the reforms which mostly began in the late 90s, resulted in the restructuring of the different institutions to be more market-oriented and specialized. There have also been several laws enacted during this period with the latest being the Energy Act 2019 which among other things gives counties greater devolved responsibilities and established new institutions such as the Energy and Petroleum Regulatory Agency (EPRA), the Rural Electrification and Renewable Energy Corporation (REREC) and the Nuclear Power and Energy Agency (NuPEA).

Illustration 2: Kenya energy reforms timeline



[1] International Energy Agency (IEA)

It is clear how impactful having the right kind of strategy has been on Kenya's energy sector since independence. A well-articulated strategy at this critical juncture in Kenya's energy journey sets the scene for even stronger public institutions that can bring in the right kind of partnerships to catalyze investment in a sector that will be at the center of its economic and social transformation over the next two decades.

1.2 Energy sector at crossroads

1.2.1. State of Kenya's energy sector

Kenya has in the last two decades made significant strides in utilizing various renewable energy sources to improve reliability, increase capacity and reduce the cost of electricity. Renewable energy sources currently account for more than 92% of Kenya's generation capacity up from less than 60% a decade ago.[2] Over 70% of Kenyans have gained access to electricity through government-led electrification efforts. Investments in renewable energy have been enabled by successful efforts to mobilize both public and private sector investment. For instance, between 2014 and 2017 alone, State Department of Energy expenditure grew by 43%.[3] In 2020 alone, there was over USD 147 million worth of energy sector investment with private sector participation. Kenya's renewable energy sector attracted USD 1.14 billion of investment in 2018.[4] Lake Turkana Wind Power is a prime example of this, Africa's largest wind farm at 310 MW (13% of Kenya's national grid). Significant investments have also been made in geothermal power generation, as well as small-scale solar systems.

These strides have largely been driven by policy initiatives such as Vision 2030 and The Big Four Agenda as well as legislation such as the Energy Act of 2006 and the subsequent Act of 2019. Furthermore, sector-specific policies have set in place measures to harmonize the energy sector in addressing cost and access. Enhancing the efficiency of energy market systems remains a key priority with a shift towards liberalization, devolution, and public-private partnerships. The government is committed to simultaneously increasing generation by tapping the country's vast renewable energy resources while increasing energy consumption specifically from the highly productive sectors.

1.2.2. Challenges in the energy sector

To move further along this journey, Kenya needs to solve the main challenges in the energy sector which mainly revolve around energy equity and energy security. In this context, energy equity is defined as the access to affordable, sufficient, safe, and reliable energy for domestic and commercial use while energy security is defined as the ability of Kenya to meet its current and future energy demand. A breakdown of these challenges below provides insight into how the White Paper shall articulate and propose solutions to these challenges.

Energy equity

- **Electricity prices in Kenya are some of the highest across the continent and are above the global average.** On average, Kenyans are paying 22 USD cents/kWh compared to a global average of 13 USD cents/kWh. This negatively impacts Kenya's competitiveness when it comes to attracting highly productive and energy-intensive sectors. Additionally, most households can only use

[2] EPRA, Energy Statistics Report, 2021
[3] Republic of Kenya, Energy, Infrastructure and Information, Communications Technology (EII) Sector MTEF Budget Report Financial Year 2018/19 – 2020/21
[4] World Bank, Private Participation in Infrastructure Project Database

electricity for limited applications such as lighting and powering appliances with biomass and fossil fuels being used for cooking needs

- **Despite high connectivity rates, populations in remote areas do not have access to the national grid.** This is mainly due to the cost of access to these remote areas which is deemed unsustainable
- **Delayed and poor service delivery discourages customers in the power sector**. Customers sometimes must wait for more than 6 months to receive services they have already paid for

Energy Security

- **Kenya is heavily reliant on imported fossil fuels to power critical sectors of the economy.** Geopolitical tensions and fluctuating commodity prices have created uncertainty for Kenya's energy sector. Fuel imports makeup about 20% of Kenya's total import bill and heavily impact the valuation of the Kenyan shilling
- **More than 60% of households use biomass for their cooking needs**. There has been slow adoption of clean cooking technologies with the aggregate number of households relying on open fire-cooking which has increased in the last 20 years. Most peri-urban and rural Kenyans rely on wood, charcoal, and harmful kerosene for their cooking needs which not only degrade the environment but also have a negative impact on human health
- **Low productive use of energy means Kenya cannot adequately balance energy demand and energy supply.** Kenya's per capita power consumption is less than 200 kWh which means Kenya's energy productivity is not remotely competitive with regional and global peers

1.3 Kenya at an inflection point

1.3.1. Trends and opportunities in the energy sector

There are key trends at the global level that will drive an increase in future energy demand. These shifts will foster the energy transition to a greener and more sustainable economy. The race towards net-zero by 2050 is estimated to require USD 125 Trillion with USD 75 Trillion directed towards clean energy projects. Additionally, the most productive and energy-consuming industries are under increased pressure from internal and external stakeholders to decarbonize. Most of these industries are in developed countries which still have a high reliance on thermal sources of energy. In the effort to decarbonize, these countries will need to pay for the cost of decommissioning existing thermal plants while building new renewable energy plants.

1.3.2. Kenya's competitive positioning

Kenya is well-positioned to take lead in the global energy transition building on its energy journey to attract significant investments not just in generation capacity but also in increasing productive use of green energy. To achieve this, Kenya should utilize its competitive advantages in the following areas:

- **It possesses abundant and diverse renewable energy resources.** Kenya has a large and mostly untapped supply of renewables including geothermal, wind, solar, and hydro resources, with high generation capacity factors amounting to over 150 GW. These can provide a competitive edge in international markets as Kenya has limited reliance on fossil fuels and can onboard new green energy demand centers without needing to decommission any plants.

- **It has an increasingly favorable business environment.** Kenya's energy sector remains a top attraction for private sector capital in sub-Saharan Africa and offers attractive financial returns for investors compared to other countries in the region. Kenya also ranks 56 out of 190 as of early 2020 in the ease of doing business index developed by the World Bank (having risen 80 places in just 5 years)
- **It has cemented itself as an emerging technology and innovation hub.** Popularly known as the Silicon Savannah, Kenya is the region's hub for Financial, Communication, and Transportation services driven by ICT. It is also an attractive space for entrepreneurs, innovators, investors, and technologists, including new energy technologies such as green hydrogen and serves as the cradle for innovation in the region. Kenya also has a digitally literate and ICT savvy population that offers a competitive advantage for innovative business models
- **It has continued government commitment.** The Government of Kenya is committed to the allocation of resources and reforms to support energy sector development as an enabler as highlighted in the Least Cost Power Development Plan (LCPDP), the Big 4 agenda, Vision 2030, and broader economic growth strategies
- **Its long-term strategy toward global net-zero.** Kenya recognizes that focus on green energy is not only a commitment through our NDC but will be a major driver of global competitiveness. Kenya is seeking to position herself as a major driver of global decarbonization
- **Its expertise and technical know-how on renewables.** Through our willingness to embrace new and emerging technologies, Kenya has built the necessary skills, expertise, and technical know-how on legacy and emerging technologies that will allow us to leapfrog into our green energy future

1.4 The White Paper mandate

Kenya needs to take bolder steps essential in laying the necessary groundwork and precipitating the progress of furthering its green energy ambitions. This paper puts forward a transformational agenda for accelerating Kenya's low-carbon transition ambitions while ensuring the delivery of power that is reliable and affordable to all. The paper will build upon the policies, strategies, and laws that have been developed in the last few decades and ultimately seeks to unchain the country from approaching sectoral reforms through step-changes but rather by radical and ambitious leaps into the future.

1.5 What the White Paper is not

The White Paper will focus on laying out the overarching approach to achieving Kenya's energy ambitions. The White Paper does not position itself as a policy document but will propose the type of policies that will be needed to achieve the country's energy objectives. The paper will also not dive into the specifics of achievement of these different outcomes or allocating owners to the same. Particularly in Outcome 3 and 4, the Paper does not outline sequencing or detail the planning of the projected power demand and supply.

1.6 Overview of key outcomes

This White Paper details a comprehensive and bold approach to achieving transformational outcomes in the Kenya energy sector, re-imagining an energy trajectory that will offer critical service to our people, and business, and drive our economy; in an affordable, reliable, and sustainable manner.

To achieve this, Kenya will need to:

ESTABLISH ENERGY AS A TRANSFORMATIONAL PUBLIC GOOD THAT IS INCLUSIVE AND SERVES THE NEEDS OF KENYA'S POPULATION

To do this, it will need to build an energy system that is consumer-driven, inclusive, and ensures that all Kenyans have access to clean, affordable, and modern energy, by measures including:

- **100% access to electricity by 2030**, increasing current connectivity rates to 600,000 to 1 million connections per year and additional investment in off-grid solutions
- **Increase per capita consumption** to be at par with upper-middle-income economies i.e., between 2,500 kWh/capita and 6,500 kWh/capita from the current 164 kWh/capita
- **50% reduction in household electricity bills,** setting a target of less than 9 USD cents/kWh for household electricity costs by 2040
- **100% access for micro and small enterprises,** this is up from the current 30% access rate by 2030

ESTABLISH KENYA AS A GLOBAL LEADER IN THE DRIVE TOWARDS DECARBONIZED ECONOMIC GROWTH

In positioning Kenya as a frontrunner in global green energy markets and leveraging its competitive advantages to accelerate the shift to zero carbon, the country will need to have:

- **Low-carbon electricity at the core**, continue the current shift towards a zero-carbon electricity mix, additionally leveraging alternative energy sources such as natural gas and consolidating the regional power pool connections
- **Smart power grids to enhance efficiency,** including a fully digitally connected electricity system that incorporates generation, and storage
- **End reliance on backup generators and re-capture demand** particularly from stationary fossil-fueled backup generators
- **Achieve a 50% reduction in household biomass use by 2040**, increasing the availability and affordability of clean cooking technology
- **Use Green Energy to create a competitive advantage,** explore the opportunity in high potential technologies such as Direct Air Capture and storage

DRIVE KENYA TO TAKE A QUANTUM LEAP TO 100 GW BY 2040 UNDERPINNED BY RENEWABLE ENERGY SOURCES

To effectively capture the growing investments made globally in green financing by leveraging Kenya's competitiveness in renewables and presence of policy enablers that support the ecosystem; it will need to institute measures including:

- **Increasing capacity generation to 100 GW by 2040,** in Geothermal, Hydropower, Wind, Solar, and developing industrial applications of Hydrogen
- **Attracting USD 300 billion in green energy investment** to increase generation, distribution, and transmission capacity as well as stimulate demand for energy
- **Diversify funding pools for energy investments,** including mobilizing domestic funds to de-risk local projects and stimulate investor appetite and power trading

ESTABLISH KENYA AS AN INVESTMENT DESTINATION OF CHOICE FOR INDUSTRIES THAT ARE SEEKING TO DECARBONIZE

Kenya will also need to identify and attract high potential opportunities, emerging players, and innovative mechanisms for the productive sector in Kenya creating at least 1 million jobs annually by 2030 and 4 million new jobs annually by 2040, through measures including.

- **Attracting new high-growth and energy intensive industries** looking to tap into the country's renewable energy resources such as green steel, green hydrogen, and data centers
- **Stimulating additional demand from traditional sectors** by boosting the productivity of local industries, for example cement manufacturing and low-carbon products
- **Leveraging Kenya's competitive advantage to tap into regional power pools**
- **Stimulating a 24-hour economy,** to boost productivity that accelerates the growth curve for Kenya

2. OUTCOMES AND PATHWAYS

Some reform is needed in the energy sector to re-frame the country's energy transition agenda, to ensure that it is not only consumer-centric but that it also accelerates the path to cost-competitive energy access and security. This White paper identifies four outcomes in this regard which are in alignment with Vision 2030, the Big Four Agenda, and other key development efforts and plans. These outcomes shall inform future policy direction as well as guide the energy sector's partners and stakeholders on programs and plans that would support the transformation of the energy sector in Kenya.

The four outcomes are:

Illustration 3: Kenya's four outcomes

1 Energy is a transformational public good that is inclusive and serves the needs of Kenya's population	2 Kenya is a global leader in the drive towards a decarbonized economic growth	3 Kenya takes a quantum leap to 100GW by 2040 underpinned by renewable energy sources	4 Kenya is an investment destination of choice for industries that are seeking to decarbonize
• 100% access to electricity by 2030 • Reduce household electricity bills by at least 50% by 2040 • Be at par with upper middle-income economies in terms of energy per capita use by 2040 • 100% access for micro and small enterprises	• Low-carbon electricity at the core • Smart power grids to enhance efficiency • End reliance on back-up generators and their emissions impact by re-capturing demand and replacing with non-emitting solutions • 50% reduction in unsustainable household biomass use by 2040 • Decarbonize high carbon-emitting demand sectors • Using green energy to create competitive advantage in decarbonized sectors e.g., green hydrogen, Direct Air capture and storage	• Increase capacity generation to 100 GW by 2040 - Kenya is the Regional Green Pioneer of new energy sector technologies • Attract USD 300 billion in green energy investment • Diversify funding pools for energy investments including mobilizing innovative green financing and domestic funds to de-risk local projects and stimulate investor appetite	• Attract new high-growth high-energy intensive industries by improving the country's business environment • Stimulate additional bankable clean energy demand from traditional sectors including development of industrial parks and agro-processing zones • Leverage Kenya's competitive advantage to tap into regional power pools • Stimulate a 24-hour economy

This section defines the scope of each outcome by outlining the rationale for its selection as well as clear and measurable pathways that can be used to monitor progress along it. It also introduces the critical shifts that are needed to catalyze this transformation. Rigorous stakeholder engagement was key in defining these outcomes and in developing practical targets to capture and measure contributions towards energy sector transformation. While the four selected outcomes are not exhaustive vis a vis the basis of energy sector transformation, engagement established that these were the most critical ones as identified by key Kenyan energy stakeholders.

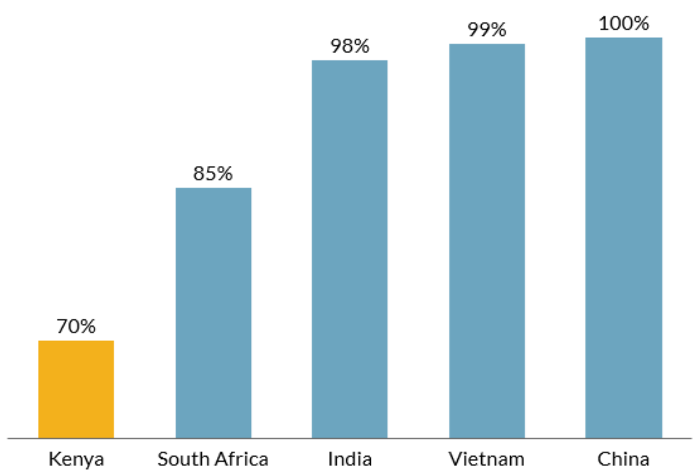
2.1. Outcome 1: Establish energy as a transformational public good

It is undeniable that universal access to clean energy is the foundation of a modern economy, and while Kenya has made significant progress towards this goal, there remain challenges in fully realizing the transformational potential of 100% energy access. Kenya's current household energy access rate is at over 70%[5] with specific consumer segments, such as rural areas and micro/small enterprises still struggling with access to a reliable power supply. In addition, three hundred thousand new households need electricity connections each year. Consequently, a strong shift towards consumer centricity is needed if an all-encompassing sector transformation is to be achieved. This orientation will facilitate the development of an energy system that is inclusive in ensuring that all Kenyans have access to clean, affordable, and reliable modern energy to serve their needs and improve their livelihoods.

Context

In the last decade, Kenya has made significant investments in developing renewable energy sources for incorporation into the electricity generation mix and should continue this trajectory to meet its target of 100% access by 2030. Kenya's growing clean energy supply has helped to increase energy access from 19% at the beginning of the decade to the 70% it stands at today. When compared to its regional peers, Kenya is seen as leading in energy generation with a total of 2,984 MW, but its installed capacity is low when compared to other middle-income countries such as Mexico (75,000 MW), South Africa (58,000 MW) and Turkey (96,000 MW). An accessible energy supply is a prerequisite for improving uptake and consumption. It is therefore imperative that Kenya continues aggressive generation of its main renewable energy sources, namely, Geothermal, Hydropower, Wind, and Solar.

Figure 1: Comparative electricity access rates (% of the population) [6]



However, while energy supply has significantly increased, the goal of achieving 100% clean energy access has been elusive, particularly for off-grid regions. In comparing Kenya to other emerging economies aspiring towards economic ascendancy, such as South Africa (85%), India (98%), and Vietnam (99%), its energy access rates are seen to be low at just over 70%. It is estimated that there are currently more than 6 million households yet to be connected to the grid, with an average of three hundred thousand new households needing a connection every year. Therefore by 2030, there will be 17 million households requiring grid connections. To meet its goal of achieving 100% access, Kenya must commit to increasing household connections rates significantly by 2030.

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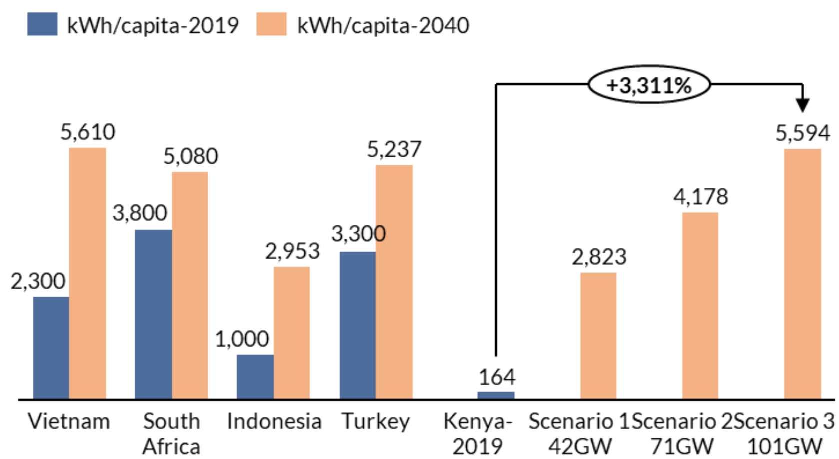
[5] World Bank, Access to electricity (% of population) – Kenya, 2020

[6] The World Bank, World Development Indicators, 2021

In addition, a geographical analysis of connections across the country reveals a connection frequency that increases with proximity to the capital city, likely due to higher population density and economic activity. To mitigate this unintended bias, special attention must be given to regions that have been historically neglected, namely, rural households in the North, Northeastern, and Coastal regions. Understanding the needs of these hitherto marginalized communities is key to establishing the best way to provide access that solves for both economic viability and accelerates the rate of energy access.

It is imperative that Kenya increases per capita consumption, to be at par with upper-middle-income economies and to absorb its growing energy supply. Kenya's per capita energy consumption is 164 kWh which is the highest in East Africa, however, when compared to the average for sub-Saharan Africa at 180 kWh (excluding South Africa), it is relatively low. This comes out even more starkly when compared to other upper middle-income economies such as South Africa (3,800 kWh/capita) and Turkey (3,300 kWh/capita). Kenya will have to increase its energy per capita consumption from 164 kWh/capita to above 3,000 kWh/capita by 2040 which represents a 3,000% increase. This will place it on a comparable footing with regional and global peers as captured in (Figure 2).

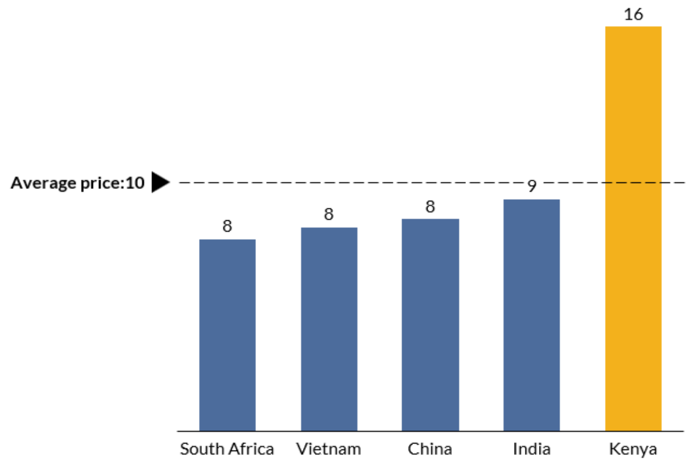
Figure 2: Current and projected power consumption per capita for Kenya and select global peers (kWh/capita; 2019 & 2040)[7]



The cost of energy remains the biggest cross-cutting challenge to universal access, uptake, and per capita consumption in Kenya. Compared to other emerging economies, Kenya's commercial energy costs are high at 16 USD cents kWh. This is more than twice the average price of 1 kWh in South Africa, Vietnam, and China. Household rates are as high as 18 USD cents/kWh. There is a need for Kenya to reduce its electricity bills by at least 50% to realize its industrialization ambitions and encourage the uptake of clean energy. This would mean a reduction of household electricity costs to at least 9 USD cents/kWh by 2040.

[7] IEA, World Energy Atlas, 2019; [2] Divides the projected energy consumption and projected country population in 2040; Enerdata, Global Energy & Climate Outlook 2050; South Africa Department of Energy, Forecasts for electricity demand in South Africa (2017 – 2050),2017; Istanbul International Centre for Energy and Climate, Turkey Energy Outlook, 2020

Figure 3: Comparative prices of 1 kWh (USD cents)[8]



The three major cost drivers of the electricity pricing structure are Base tariffs at ~50% (12 USD cents/kWh) of the total cost, followed by Fuel Cost Charge (22%), and VAT (13%). In analyzing the base tariff, the key cost contributors include Nonfuel Cost of Power Purchase that accounts for over 50% (5 USD cents/kWh), Transmission and Distribution at 36% (3 USD cents/kWh), and system losses at 16% (2 USD cents/kWh). A target reduction of at least 50% would drive down Kenya's electricity costs to 9 USD cents/kWh.

Figure 4: Price build-up across customer categories, as of December 2021 (USD cents/kWh)[9]

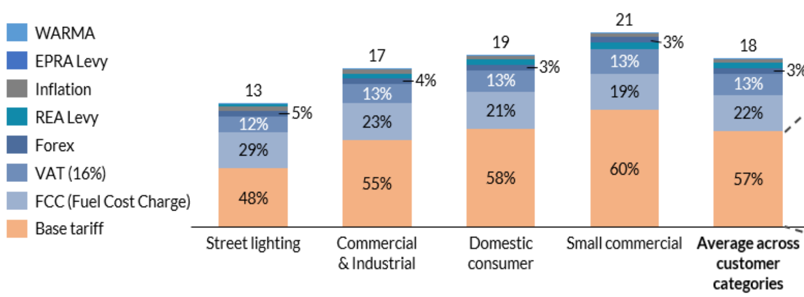
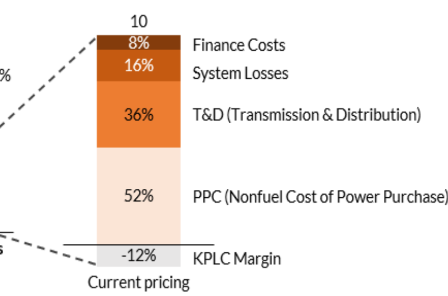


Figure 5: Cost components of the base tariff (USD cents/kWh)[10]



Note: Cost components for customer categories are weighted based on kWh consumption; Nonfuel tariff - Base tariff set by EPRA; FCC - Monthly Fuel Cost Charge for thermal plants; Forex - Monthly Forex adjustment cost; WARMA - Levy for Water Resource Management Authority; Inflation - Monthly inflation adjustment; REA Levy - Levy for Rural Electrification; T&D - Transmission & Distribution Cost; PPC - Nonfuel Cost of Power Purchase (Energy and capacity payment). PPC is the cost associated with buying power from power plants. Our analysis assumes an exchange rate of 117.81 Ksh for 1 USD (June 29, 2022)

The challenges of energy access and cost are especially pronounced in the micro/small enterprise sector, which represents a significant development challenge for Kenya. The Small and Medium Enterprise (SME) sector is the backbone of Kenya's economy, with over 7.41 million SMEs contributing approximately 34% of GDP. Unlicensed/Informal sector SMEs make up more than two-thirds of all SMEs in Kenya and contribute over 80% of employment. The opportunity to grow and industrialize in the sector lies in enhanced energy security and improving the balance of payment deficits concerning fossil fuel-related imports by substituting them with clean energy sources. Initiatives to drive demand focused on SMEs are key in increasing access and uptake as well as in promoting the shift away from fossil fuel. In the achievement of

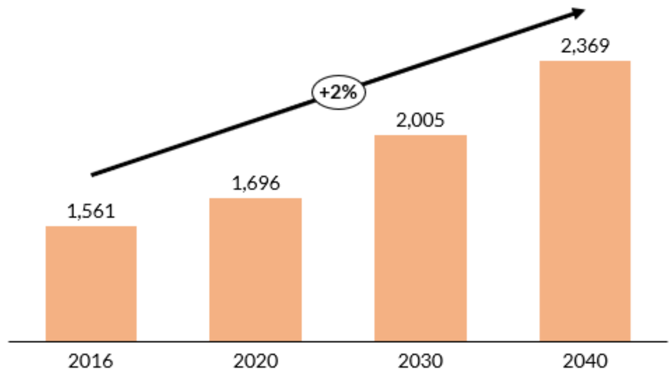
[8] Cable.co.uk, The price of electricity per kWh in 230 countries, 2021

[9] KPLC, 2021; Nation, Kenya Power's system losses hit record high, 2022; Xe Currency Converter, 1 USD to KES - Convert US Dollars to Kenyan Shillings, 2022

[10] Ibid.

these initiatives, Kenya's SME sector can ride on renewable energy towards industrialization, especially for those that are automated, semi-automated, or in need of equipment upgrades. In addition, there are other potential pathways leveraging PULSE products to increase productivity gains for SMEs such as solar refrigeration for cold chain management & solar-powered water pumps for small-scale commercial agriculture.

Figure 6: Projected number of licensed SMEs in Kenya by 2040 considering 2% CAGR* ('000)[11]



Note: *CAGR is Compounded Annual Growth Rate of 2% calculated from historical data of new businesses created. SMEs are estimated to be 90% of all new businesses

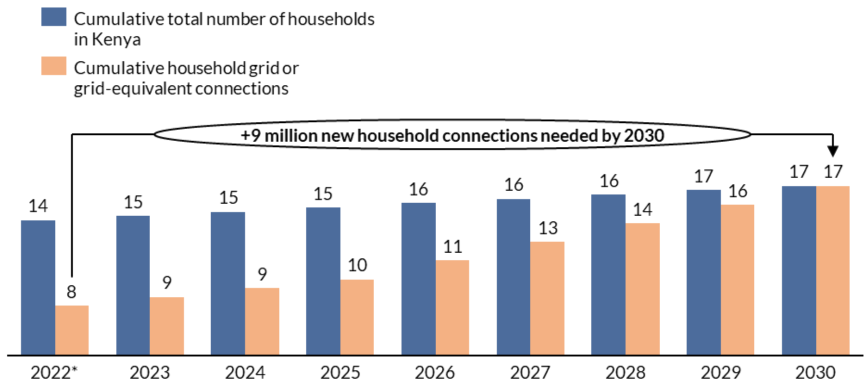
Recommendation

Pathway 1: 100% ACCESS TO ELECTRICITY BY 2030

To achieve 100% access by 2030 Kenya needs to accelerate grid or grid equivalent connections to 1 million connections per annum between 2023 and 2030, with a significant increase after 2030 to accommodate a growing population and the attendant higher demand across the household, industrial, transport, and commercial sectors. It is estimated that Kenya currently has ~14 million households of which ~6 million are not connected to the grid, in addition, an average of three hundred thousand new households needs a connection every year. In analyzing this trajectory, it is evident that by 2030, there will be ~17 million households requiring connections. Therefore, to achieve its 100% access goals, Kenya must commit to connecting over 9 million new households by 2030. This translates into a connection target of one million households every year by 2026.

[11] Kenya National Bureau of Statistics, Micro, Small and Medium Enterprise (MSME) Survey, 2016; Kenya Association of Manufacturers, The Focus on SMEs is a welcome Intervention, n.d.; World Bank Entrepreneurship Database, New businesses registered (number) – Kenya, 2020; Dalberg Analysis

Figure 7: Cumulative household connections required to achieve universal access by 2030 (Million Households)[12]

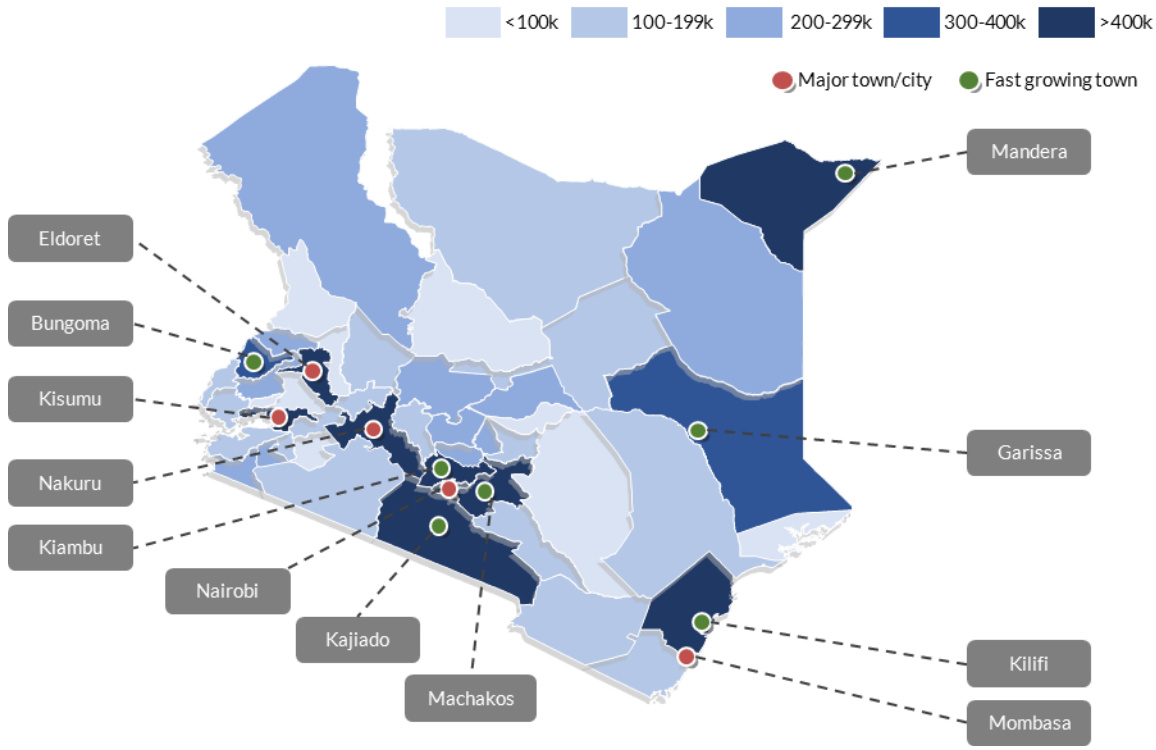


Note: Our analysis assumes a household population is 3.9

Kenya's rapid rate of urbanization together with its need to provide access to remote communities will require not only increased generation capacity but more importantly, a diverse range of solutions. It is estimated that by 2040 about 32 million people or 41% of Kenya's population will be residing in urban areas.[13] The rapid rate of urbanization projected presents an emergent opportunity to transform the lives of its populace through the energy sector. This is because growing urbanization is expected to lead to not only the consumption of more energy because of more consumers but in addition, to a shift in consumption to more economically productive and energy-intensive uses. As the specific growth drivers in each of these urban areas will likely be different, there shall be a need to tailor energy supply to the productive needs of each respective region. The graphic below captures the highest growth urban areas, indicating geographies that will require targeted approaches.

[12] KPLC, Annual Report, 2021; United Nations, World Population prospectus, 2019
[13] KNBS, Population Survey, 2019

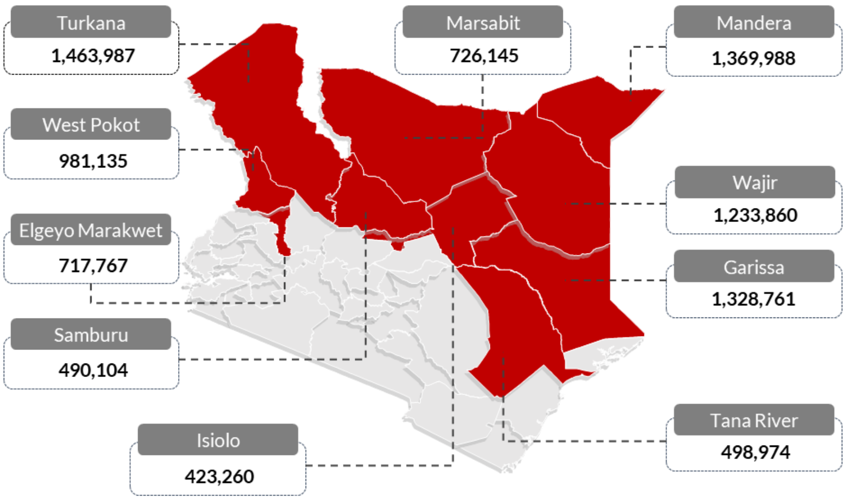
Figure 8: Projected urban county population[1], 2040



Note: Our analysis assumes a constant inter-census growth rate of 2.2%, fast-growing towns defined as towns that are headquarters of counties with an urban population of more than three hundred thousand people by 2040

The use of decentralized energy solutions will be pivotal to accelerating access rates, particularly in sparsely populated and rural areas. The race to 100% access will require that Kenya delivers electricity to households in the most remote parts of the country. Mini-grids and standalone systems continue to offer a smart-integrated, less infrastructure-intensive, and more cost-effective way to connect remote areas, often catalyzing innovation, and investment from the private sector. However, stand-alone renewable mini-grids face challenges of load balancing and storage given capacity and intermittency constraints. In addition, sparse populations with low per capita consumption may make it difficult for mini-grid developers to reach viable returns and therefore these investments may not be initially profitable, but they are expected to spur development that will eventually become sustainable. The facts of the foregoing also mean that for reasons of viability, an initial period of subsidization will have to be undertaken by the Government or other energy stakeholders to see these grids up and running and on their way to profitability.

Figure 9: Projected population of counties with low connections, 2040[14]



The geographic regions highlighted in red capture from the **North, North Eastern, and Coastal regions** of Kenya which represent significantly underserved populations

Note: Projections made using an inter-census growth rate of 2.2%

Urban centers are growing and so is their electricity demand, therefore investment is needed to upgrade the existing distribution network to support the goal of 100% access. Kenya's national transmission and distribution network has expanded four times in just six years, from 59,322 kilometers in 2015 to 243,207 kilometers in 2021. This grid expansion has enabled the connection of over 8 million customers countrywide representing growth in connected customers of 127% since 2014. As more clean energy is added to the energy ecosystem – some of it in remote areas - the upgrading and expansion of the transmission and distribution network will be a key enabler of energy access.

Pathway 2: 50% REDUCTION IN HOUSEHOLD ELECTRICITY BILLS

Critical to reducing energy costs is the reduction in base tariffs and fuel cost charges (FCC), as this will account for 85% of the targeted reduction in average consumer tariffs. A reduction in energy costs will require a multi-pronged intervention focused on each of the cost drivers but a reduction in base tariffs and FCC represents the biggest opportunity for effecting change. Base tariffs are expected to decrease by 44% which will account for 50% of the total reduction in consumer tariffs; it is key to lobby to ensure that this initiative is actualized in the short term. In addition, phasing out thermal power plants/non-dispatch of thermal plants will remove approximately 80% of the FCC, further lowering tariffs by 3 USD cents/kWh which is expected to account for 35% of the total tariff reduction.

[14] KNBS, population survey 2019

Figure 10: Current vs 2040 reduced pricing of the average customer tariff (USD cents/kWh)[15]

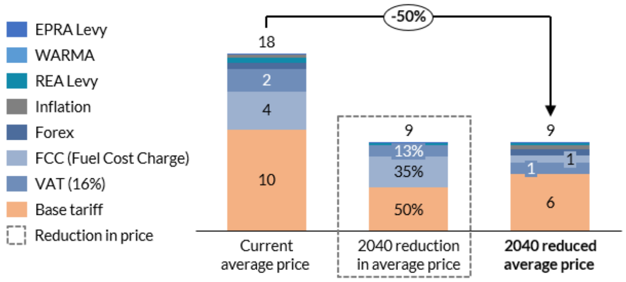
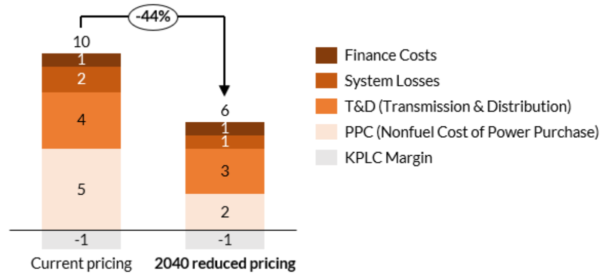


Figure 11: Current vs 2040 reduced pricing of cost components of the base tariff (USD cents/kWh)[16]



Note: Cost components for customer categories are weighted based on kWh consumption; Nonfuel tariff - Base tariff set by EPRA; FCC - Monthly Fuel Cost Charge for thermal plants; Forex - Monthly Forex adjustment cost; WARMA - Levy for Water Resource Management Authority; Inflation - Monthly inflation adjustment; REA Levy - Levy for Rural Electrification; T&D - Transmission & Distribution Cost; PPC - Nonfuel Cost of Power Purchase (Energy and capacity payment). PPC is the cost associated with buying power from power plants. Our analysis assumes an exchange rate of 117.81 Ksh for 1 USD (June 29, 2022)

In addition to interventions focused on reducing the Base Tariffs and FCC, other levers can shift down the cost of energy as captured in the table below:

Table 1: Cost-reducing interventions

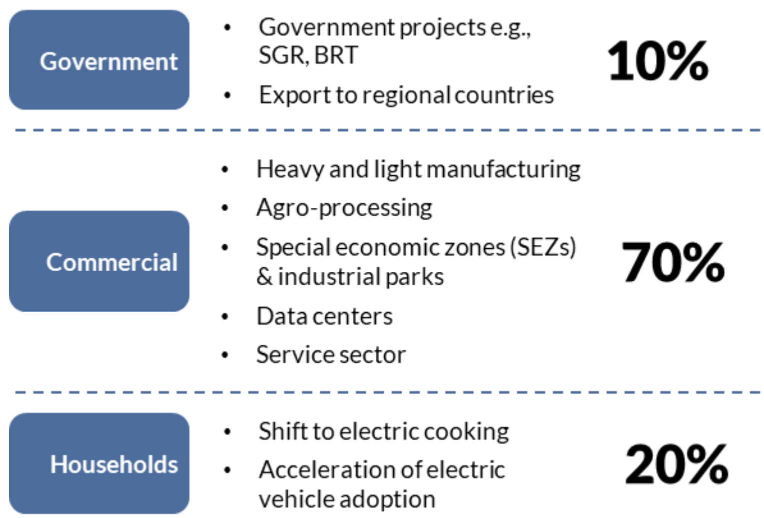
Cost Driver	Intervention	Reduction in Tariffs
Taxes and Levies	Progressively reducing VAT, EPRA levy, and REA levy to 50% of current rates.	**1 USD cent/kWh**
Cost of Power Purchase	Contracting new renewable sources and replacing thermal plants with a combination of firm power sources. In addition, renegotiation of existing PPAs through outright tariff reductions or term extensions to reduce generation costs.	**3 USD cents/kWh**
System Losses	Incorporating smart grids which can reduce both commercial and technical losses by 50%.	**0.8 USD cents/kWh**
Transmission and Distribution Costs	Operational efficiency through incorporating digital technology	**0.7 USD cents/kWh**

[15] KPLC, 2021; Nation, Kenya Power's system losses hit record high, 2022; Xe Currency Converter, 1 USD to KES - Convert US Dollars to Kenyan Shillings, 2022
[16] Ibid.

Pathway 3: INCREASE PRODUCTIVE USE OF ELECTRICITY BY PROVIDING HIGHER ENERGY INTENSITY PER CAPITA

Kenya will need to leverage productive business demand to realize an increase in per capita consumption. It is anticipated that per capita consumption will be driven primarily by an increase in demand from the commercial sector, which will account for ~70% of new demand. Households will account for 20% and the Government at 10% anchored on electrifying infrastructure projects (Illustration 4). Therefore, providing higher energy intensity per capita will support the increase in the productive use of electricity demand. However, for Kenya to provide higher energy intensity per capita, it will have to address challenges around the reliability and affordability of power supply.

Illustration 4: Sector energy demand drivers to meet 100 GW projection



Pathway 4: 100% ACCESS FOR SMALL AND MICRO ENTERPRISE

Lowering production costs for SMEs through cheaper energy offers an opportunity to spur SME productivity and is critical in driving their growth and competitiveness. There is already a plan in motion for Kenya to lower costs to at least 9 USD cents/kWh by 2040 for energy consumers including SMEs. It is, therefore, key to lobby to ensure that this is actualized. In the achievement of this goal, Kenya's SME sector can ride on renewable energy towards industrialization, especially for those that are automated, semi-automated, or in need of equipment upgrades. In addition, there is an opportunity to spur economic growth through cleaner and more efficient production chains, creating opportunities in a wide array of sectors driven by social impact goals. This will result in spillover benefits for the labor market through increased jobs and the growth of inclusive business models. Lastly, SMEs can help integrate different population segments into their business practices and link energy to key sectors such as agriculture - by leveraging Productive Use Leveraging Solar Energy (PULSE) products such as solar refrigeration for cold chain management and solar-powered water pumps - and manufacturing. This will ensure Kenya can reach and elevate the most energy poor along the energy ladder.

Table 2: Recommendations

	Pathways	Specific Outcomes	Critical Enablers
1.	**100% access to electricity by 2030**	1. Increasing current connectivity rates to at least 600,000 connections per year 2. Invest in off-grid solutions to serve historically marginalized groups	• Integrated and flexible energy planning that considers multiple scenarios, and real-time demand shifts and fosters stakeholder collaboration • A stable regulatory environment that encourages investment in the sector and institutional building • System-wide innovation ecosystems that support rapid commercialization of new technologies & nurture new businesses • Modernized infrastructure and preventative asset management that leverages digitalization and data capabilities
2.	**Increase per capita consumption**	3. Set a target above 3,000 kWh per capita by 2040, which will place Kenya at par with other upper-middle economies	
3.	**50% reduction in household electricity bills**	4. Reduce household electricity bills by at least 50% by 2040	
4.	**100% access for micro and small enterprises by 2040**	5. Increase uptake from the current 30% to 100% for micro and small enterprises	

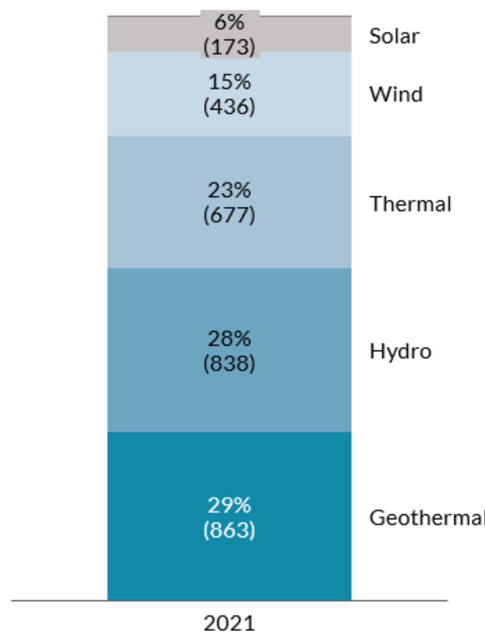
2.2. Outcome 2: Position Kenya as a global leader in decarbonization

Kenya aims to be one of the world's leading low-carbon economies by 2040. In 2015, it furthered its climate commitments by joining the Paris Climate Agreement and committed to reducing its Green House Gas emissions by 30% through Nationally Determined Contributions (NDCs). The 2018 National Energy Policy, along with the Climate Change Act 2016 and Energy Act 2019 have built further momentum towards achieving these NDCs by putting energy efficiency, security, and environmental sustainability at the forefront of Kenya's Energy Transition in effect positioning Kenya at the frontline of the energy transition race. The transition to 100% renewable energy represents the biggest opportunity to sustainably meet domestic market demand while establishing Kenya as the lynchpin to greening the region's power supply and as a global leader in decarbonization.

Context

Kenya has made considerable efforts towards climate mitigation and adaptation in the energy sector, leveraging its competitive advantages in renewables to accelerate the shift to a low carbon economy. Renewable energy sources currently account for over 75% of the country's installed power generation capacity, with geothermal (863 MW), hydro (838 MW), Wind (436 MW), and Solar (173 MW) being the leading contributors. A continued increase in renewable energy supply will underwrite Kenya's transition to low carbon and a clear roadmap is necessary to ensure all stakeholders continue to work towards this goal.

Figure 12: Shift in the renewable energy mix (MW)[17]



The existing generation, transmission, and distribution infrastructure can yet be optimized for efficiency and the delivery of more energy through the implementation of digital technologies. Power sector digitalization involves the integration of various technologies into the systems employed in generation plants, electricity networks, and consumer meters. These digital technologies facilitate the measurement, monitoring, and analysis of data and operations in real-time and this added visibility will provide opportunities for improved system modeling and forecasting to manage the integration of Variable

[17] KNBS, Economic Survey, 2022

Renewable Energies, communication, and control capabilities as well as increased safety of operations. Kenya currently does not have a fully digitized energy system and as such, the digitalization of renewable energies and the incorporation of smart grids and meters present one of the highest priority opportunities.

One challenge in the way of this transition is that of unreliable power generation resulting in an erratic power supply, which in turn necessitates an increase in the use of fossil fuel-based backup generators to meet demand. Several other challenges pertaining to Kenya's grid supply have also been identified low access rates and high electricity costs which have been discussed in Pathway 1 above. In addition, system losses and aging distribution infrastructure continue to pose significant challenges to customer retention with the cumulative technical and commercial electricity losses in 2021 standing at a staggering 22.8% of total electricity produced, meaning that of the 12 GWh of electricity purchased, approximately 2.8 GWh were lost, and thus never billed both due to commercial and technical losses. The System Average Interruption Frequency (SAIFI) and the System Average Interruption Duration (SAIDI) indices provide a snapshot of average interruption frequency and duration. Though both indices have been decreasing over time, Kenya ranks the highest among comparable and competing economies partly due to system losses increasing from 16% in 2010 to 22% in 2021.[18]

Figure 13: System average interruption frequency index (SAIFI) (2014-2019)[19]

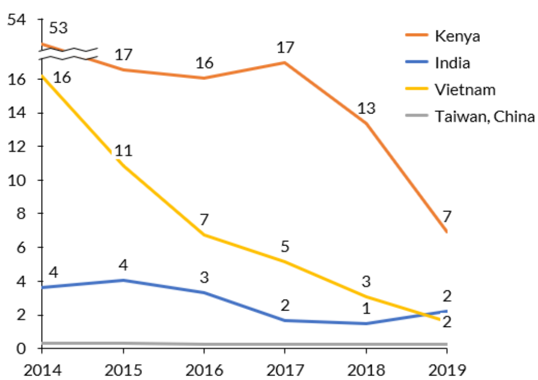
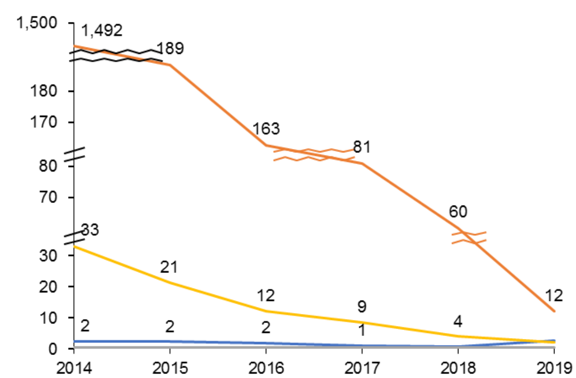


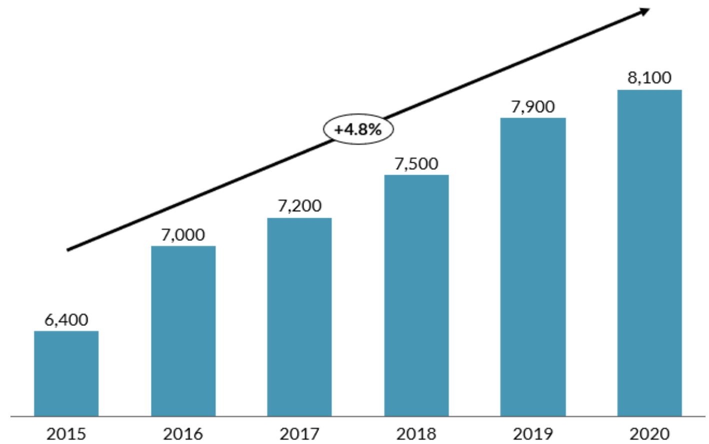
Figure 14: System average interruption duration index (SAIDI) (2014-2019)[20]



The primary outcome of these supply-related challenges is the slowing of electricity uptake by retail consumers and an increase in the installed capacity of backup generators particularly in the commercial and industrial (C&I) sector. The rate of captive energy generation has been steadily increasing at a CAGR of approximately 5% between 2015 and 2020 and is estimated to cost the distributor USD 2 million in lost revenues per year.

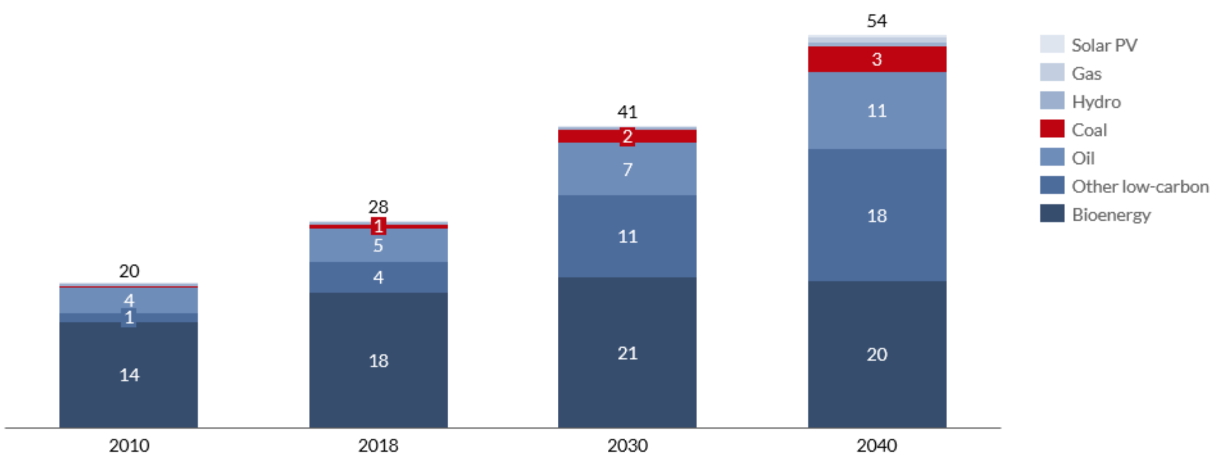
[18] KPLC, Financial Statements 2012-2020
[19] The World Bank, Getting electricity: System average interruption frequency index (SAIFI), 2019
[20] The World Bank, Getting electricity: System average interruption duration index (SAIDI), 2019

Figure 15: Growth in the installed capacity of backup generators (MVA)[21]



As of February 2019, there were 22 captive power plant license holders with a combined installed capacity of 152 MW of power and by June 2020, 8,000 MVA of distribution transformers were in service. C&I customers have at least one standby generator of a capacity equivalent to the transformer serving them. This represents an opportunity to further decarbonize as emissions from fossil fuel-based generators have been historically unregulated despite diesel engines emitting up to 100 times more pollution per kWh than a conventional power plant[22] with the pollution occurring largely in the proximity of buildings where people live and work. Reversing the upward trend of fossil fuel-based captive power generation and tapping into this latent demand potential will certainly contribute to establishing Kenya as a leader in decarbonization.

Figure 16: Kenya's primary energy demand (Mtoe; 2010 - 2040)[23]



Note: Mtoe represents 'megaton of oil equivalent'. Energy balance shows the commodity balances translated into a standard energy unit for all the fuels together from production to final use, for example, gas produced may be transformed into electricity and then consumed by the domestic sector. '2040 STEPS represents forecasts factoring in current policy frameworks; The Africa Case is built on the premise of Agenda 2063, including full access to electricity and clean cooking.'

The use of bioenergy, particularly at the household level, is pervasive despite ongoing electrification efforts. Biomass, particularly wood and charcoal, accounts for approximately 70% of total energy utilized and is predominantly used for cooking. A reduction of reliance on bioenergy would significantly improve the

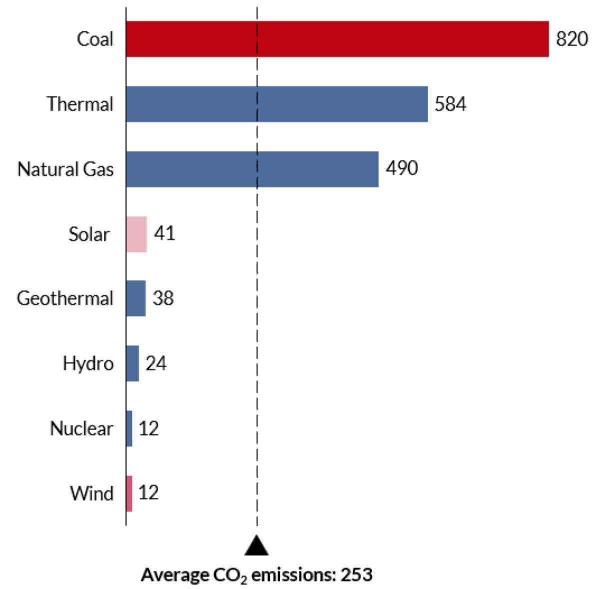
[21] OFGEN, Estimating the installed capacity of backup generators (BUGS), 2021
[22] Environmental Defense, Smaller, Closer, Dirtier: Diesel Backup Generators in California, 2002
[23] Kenya Energy Outlook, IEA, 2019.

health and economic outcomes of Kenyans who rely on it, in addition to realizing a mitigation potential of 25% of Kenya's GHG emissions. The Government has played a significant role in enabling access to clean energy sources, particularly for cooking and lighting, however, the transformation will only occur when a 50% reduction in biomass use is also achieved. This will not only require increased availability and affordability of clean cooking technology but will also necessitate behavioral change interventions to help with understanding and addressing the reluctance in transitioning to cleaner solutions.

Kenya has the option to take a fully green pathway and it should lead the way in the region. This is due to Kenya's competitive advantage with green resources and its willingness to go down a path less trodden to its industrialization. This can be an inspiration and learning step for Kenya and its neighbors in the region seeking an energy-rich and green powered Africa of the future. New and emerging technologies continue to make a renewable future achievable – Some technologies such as sustainable biomass, battery technologies, green hydrogen and nuclear power are not yet incorporated into the projected energy mix under national plans such as the LCPDP. These technologies present additional opportunities for Kenya to tap into as the country scales its ambition for a green and robust energy mix. Legacy resources such as coal and natural gas must be clearly considered as only playing transitional roles and helping the country ramp up the journey to a low carbon energy mix.

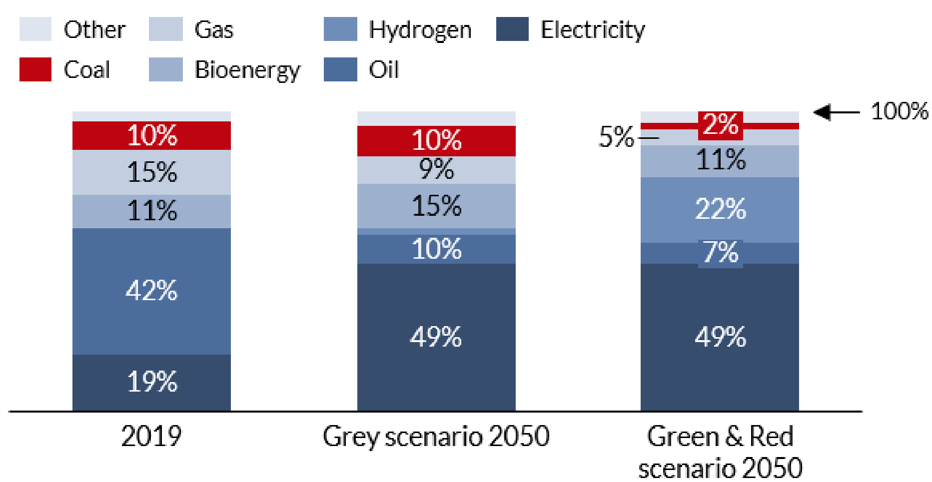
The role of coal should only be transitional because it has the highest greenhouse emissions per kWh of electricity generated – this is three times higher than the average across other plants. As can be seen in Figure 17 below, coal plants have the highest greenhouse emissions compared to other energy plants at 820 gCO_2 equivalent/kWh. Emissions from coal would slow down Kenya's progress towards its 32% emissions reduction target. The current Least Cost Power Development Plan (LCPDP) projects for 12% (981 MW) of the total installed capacity to come from coal by 2040. This would lead to 2.2 million tonnes of greenhouse gas (GHG) emissions annually. Though coal is perceived as a cheap source of power, actual costs for removing emissions are high. Kenya would need to spend 224 million USD/(tonnes*year) for carbon capture if coal is to account for12% of the country's installed capacity. The cost of carbon capture has implications for investors and would increase electricity tariffs for the end-customer. At the projected level of emissions, the equivalent cost for carbon capture is 30,000 USD/(kW*year). To become one of the leading low-carbon economies by 2040, Kenya needs to continue reducing the use of coal. This is essential to ensure low-carbon power generation and facilitate the full decarbonization of high emitting sectors. There are limited avenues that would facilitate sustainable use of coal as a transition fuel, such as high advances in technology that tracks emissions coupled with the development of supporting infrastructure for carbon credits market.

Figure 17: CO_2 emissions per kWh of electricity (gCO_2 equivalent/kWh)[24]



With the decline of global demand and investments in coal, Kenya's low-carbon energy future should target the replacement of the carbon-intensive fossil fuel as a priority. By 2050, the global consumption of coal is projected to decrease to 2% being replaced by renewables as illustrated in the green and red scenarios* highlighted in Figure 18 below. Coal consumption only continues in the grey scenario where it is assumed that carbon capture and storage (CCS) technologies will offer a way forward for coal to be used for heat production in industry.

Figure 18: Total global final energy consumption by consumers (% contribution; 2019 & 2050 scenario)[25]



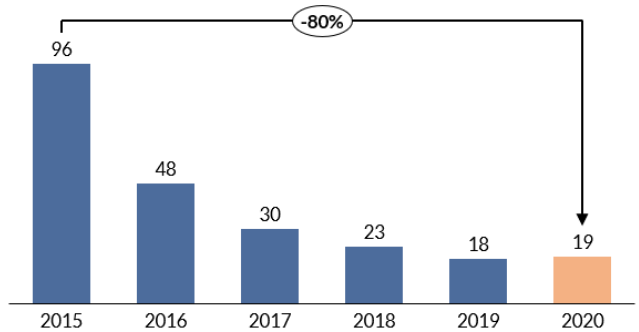
[24] World Nuclear Association, Carbon Dioxide Emissions From Electricity, 2021; Springer Link, Assessment of greenhouse gas emissions from coal and natural gas thermal power plants using life cycle approach, 2013; ESIA, Lamu Coal Power Project: Environmental and Social Impact Assessment, n.d.; Dalberg Analysis

[25] BloombergNEF, New Energy Outlook 2021; IEA, Global Energy Review 2021: Coal; World Economic Forum, Coal demand has seen its biggest drop since World War II. But it's not all good news, 2021

Note: *Grey scenario – Assumes clean electricity and carbon capture and storage (CCS) net-zero pathway; Green scenario – Assumes clean electricity and green hydrogen net-zero pathway; Red scenario – Assumes clean electricity and nuclear net-zero pathway, including hydrogen manufactured using electrolysis powered by nuclear plants

Global investments in coal have significantly decreased between 2015 and 2020. An analysis of the Financial Investment Decisions (FIDs) over this 5-year period shows that there has been an 80% reduction in the number of coal-fired power projects that reach financial close or begin construction. This has been largely driven by several key financial institutions such as the African Development Bank, announcing that they will no longer finance coal projects, and in 2021, China - one of the biggest financiers of coal-fired power - announced that they will no longer be involved in overseas coal projects. Kenya should respond to this market trajectory by prioritizing the replacement of the carbon-intensive fossil fuel and the exploration of green areas in which it has a competitive advantage.

Figure 19: Global final investment decisions (FIDs) for coal-fired power plants (GW; 2015 - 2020)[26]



In terms of costs, current opex estimates for a coal plant do not account for carbon capture, and capex costs are higher than solar and wind by 30% and 70%, respectively. Coal has high capex costs compared to renewable energy sources, except for geothermal. Capex costs for coal at 2,500 USD/kW are c.30% higher than wind at 1,900 USD/kW and c.70% higher than solar at 1,500 USD/kW. Actual opex costs for coal are much higher compared to renewables and other energy sources. Coal's opex costs at 66 USD/(kW*year) based off project planning estimates are not reflective of carbon capture costs and compliance fees associated with emissions standards and management of combustion residues for coal plants. For Lamu Unit 1 with a net rated capacity of 327 MW, the cost of carbon capture and storage is estimated at 12,400 USD/(kW*year) which is much higher than the initial opex cost estimates.

[26] IEA, World Energy Investment 2021; Reuters, Nearly all development banks committed to cutting coal investment, data shows, 2021

Figure 20: Comparison of coal versus other energy sources in terms of capex and opex[27]

Decreasing capex costs

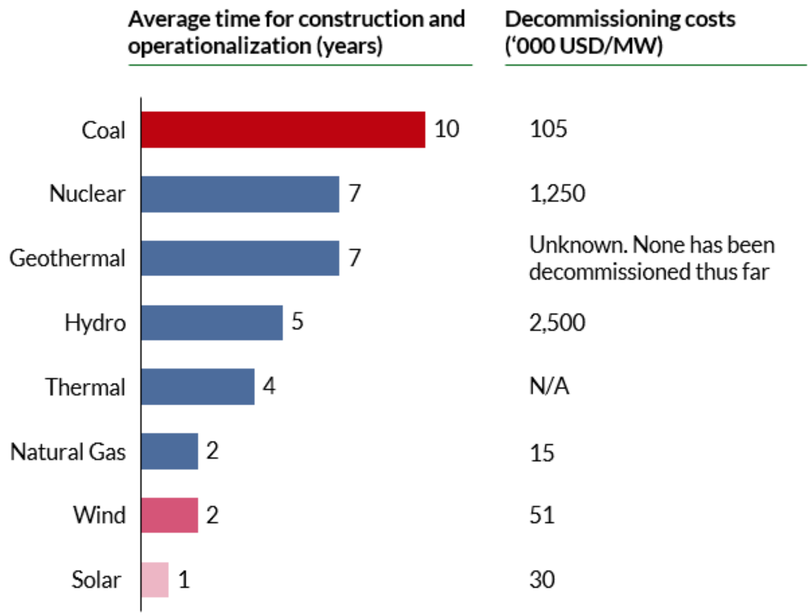
Energy source – Project name	**Geothermal - Olkaria 5**	**Nuclear** - Unit 1	**Hydro** – High Grand Falls	**Coal** - Lamu Unit 1	**Wind** – Meru Phase III	**Solar** – REA Garissa	**Thermal** – Kipevu 3	**Battery** – BESS Nairobi	**Gas** – Dongo Kundu
Capex ('000 USD/kW)	3.4	2.9	2.8	2.5	1.9	1.5	1.5	1.3	1.2
Opex (USD/(kW*year))	152	8	16	66	76	26	32	25	31
Capacity (MW)	158	291	550	327	220	50	115	100	789

Note: BESS – Battery Energy Storage System; For comparison across energy sources, our analysis used projects with the highest net rated capacity. These projects are listed by KenGen and their corresponding data is either estimated or reflective of ongoing operations depending on the implementation status of the project

Coal investments provide lower returns than renewable energy investments due to higher decommissioning costs and longer times for construction and operationalization. On average, coal plants take a longer time to construct and operationalize compared to renewables and other energy sources. Coal takes 10 years while geothermal only needs 7 years (including exploration). Wind and solar plants have the shortest time requirements at 2 years and 1 year, respectively. The effect of long project timelines for coal-fired power plants is exacerbated by global coal phase out agreements. Coal plants are restricted to operate for a shorter amount of time and will therefore have a higher risk of not being profitable in the long run. Across all regions, coal is to be phased out between 2030 and 2040. Africa, specifically, is supposed to phase out coal by 2034. Coal also has the highest decommissioning costs at 105,000 USD/MW compared to renewables. These costs are double the costs of wind at 51,000 USD/MW and three times the cost of solar at 30,000 USD/MW. Globally, investors are becoming increasingly averse to coal alongside divestments by pension funds, insurers, investors, and other financial institutions. For example, the world's second largest pension fund (worth USD 890 billion) has committed to selling USD 8 billion worth of coal holdings. Another example is Norway whose sovereign wealth fund will divest from companies that obtain more than 30% of their wealth from coal. This decision will affect 122 companies which account for 23% of global coal production annually.

[27] KenGen, 2021; Climate Home News, Norway to ditch $8 billion of coal assets in state pension fund, 2015; NewClimate Institute, The role of geothermal and coal in Kenya's electricity sector and implications for sustainable development, 2019; McGINLEY, How Much of Each Energy Source Does It Take to Power Your Home, 2017; EIA, How much carbon dioxide is produced per kilowatt-hour of U.S. electricity generation?, 2021; IEA, Is carbon capture too expensive?, 2021; The Royal Society, Total cost of carbon capture and storage implemented at a regional scale: northeastern and midwestern United States, 2020; ESIA, Lamu Coal Power Project: Environmental and Social Impact Assessment, n.d.; Dalberg Analysis

Figure 21: Comparison of coal versus other energy sources in terms of capex and opex[28]



Note: These costs are high level estimates and do not include costs associated with disposing batteries

Kenya will mainstream climate change mitigation and adaptation efforts to realize its NDC target reduction with a focus on the Electricity generation, agriculture, forestry, and transport sectors. Four sectors are projected to drive baseline greenhouse gas emissions in 2030 (Figure 22). Electricity generation (41 $MtCO_2e$) and agriculture (39 $MtCO_2e$) are the highest, followed by forestry (22 $MtCO_2e$) and transport (21 $MtCO_2e$). Forestry has the highest emissions reduction potential accounting for ~50%, followed by electricity generation, energy demand, and transport. To achieve its NDC targets, Kenya needs to introduce policies and technologies that prioritize mitigation and focus on low carbon development.

[28] Climate Analytics, Global and regional coal phase-out requirements of the Paris Agreement: Insights from the IPCC Special Report on 1.5°C, 2019; Water Power Magazine, Decommissioning dams - costs and trends, 2009; ACS Publications, Decommissioning Orphaned and Abandoned Oil and Gas Wells: New Estimates and Cost Drivers, 2021; Resources for the Future (RFF), Decommissioning US Power Plants: Decisions, Costs, and Key Issues, 2017; Statista, Median construction time required for nuclear reactors worldwide from 1981 to 2020(in months), 2022; IEA, Average power generation construction time (capacity weighted), 2010-2018, 2019; The Sydney Morning Herald, A new coal-fired power plant would cost $3 billion, drive up energy prices and take eight years to build, 2018; Chint Global, Ultimate Guide to Solar Power Plants, n.d.; Renewables First, What is a wind turbine project timeline?, n.d.; AQPER, How long does it take to build a hydroelectric power station?, n.d.; Proceedings, 6th African Rift Geothermal Conference, Geothermal Project Timelines, 2016; M.P. Boyce, in Combined Cycle Systems for Near-Zero Emission Power Generation, 2012; Dalberg Analysis

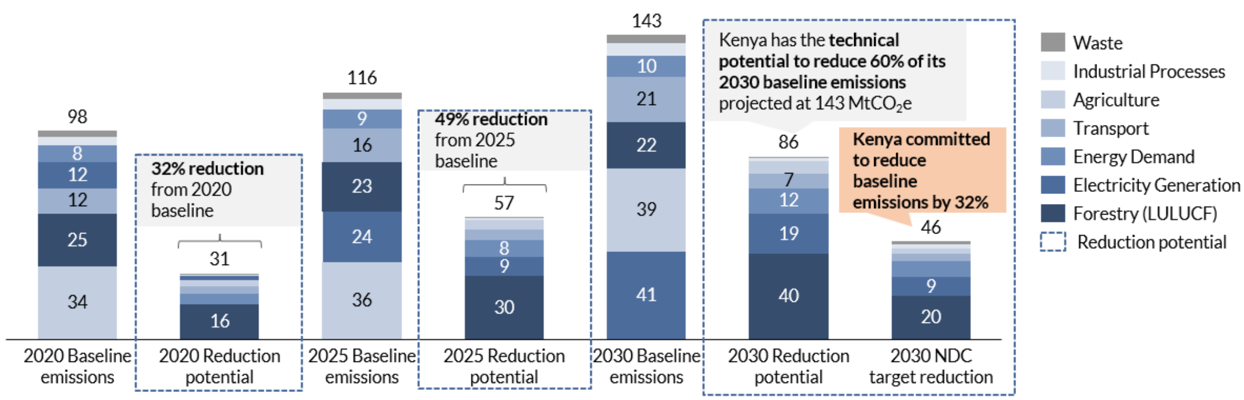
Illustration 5: Kenya's highest Green House Gas Emitting Sectors[29]

	Energy sector (including electricity generation)	**Agriculture sector**	**Forestry sector (LULUCF)**	**Transport sector**	**Industrial sector**
Baseline emission projections by 2030 *(% contribution to total emissions)*	51 $MtCO_2e$ *(36%)*	39 $MtCO_2e$ *(27%)*	22 $MtCO_2e$ *(15%)*	21 $MtCO_2e$ *(15%)*	6 $MtCO_2e$ *(4%)*
Main sub-sector energy drivers of emissions *(projected baseline emissions by 2030)*	• **Electricity generation** *(41 $MtCO_2e$)* • **Energy demand** *(10 $MtCO_2e$)* in manufacturing, commercial, and residential sectors	• **Livestock methane** emissions *(18.8 $MtCO_2e$)* • **Manure** in agricultural soils *(16.2 $MtCO_2e$)* • Others: Conventional tillage; Burning of the savannah and crop residues; Rice cultivation	• **Loss of forest land** *(19 $MtCO_2e$)*. Unsustainable use of charcoal and wood fuel is a major driver of deforestation accounting for a loss of ~10 million m³ of wood every year	• **Light diesel oil passenger vehicles** • **Gasoline passenger vehicles** • **Light diesel oil freight vehicles** • Others: Jet kerosene aviation; Gasoline freight vehicles; Heavy diesel oil navigation	• **Cement manufacturing** *(4.8 $MtCO_2e$)* • Others: Steel; Charcoal; Soda Ash; Lime; Pulp and paper production

Note: Energy sector – Covers electricity generation and energy demand in all the sectors except industry and the transport sector, which is the largest consumer of petroleum products; LULUCF - Land Use, Land-Use Change, and Forestry

Kenya is well positioned to lead in green energy technologies in the region by making incremental investments in spaces where it has a competitive advantage. Six factors give Kenya a competitive advantage in the drive to global decarbonization. These are: the quantity and diversity of renewables; its favorable business environment; its reputation as an emerging technology and innovation hub; strong government commitment; a comprehensive long-term strategy toward global net zero; and strong technical expertise in renewables. Kenya's NDC target reduction was set at 32% (46 $MtCO_2e$), however, with the right policies and technologies in place, it has the technical potential to achieve twice as much and reduce 60% of the projected baseline emissions (equivalent to 86 $MtCO_2e$) by 2030.

Figure 22: Baseline and reduction potential of GHG emission projections ($MtCO_2e$; 2020 – 2030)[30]



Note: LULUCF - Land Use, Land-Use Change, and Forestry; Baseline emissions – Refer to the business-as-usual scenario by 2030 as established in the NCCAP 2013-2017

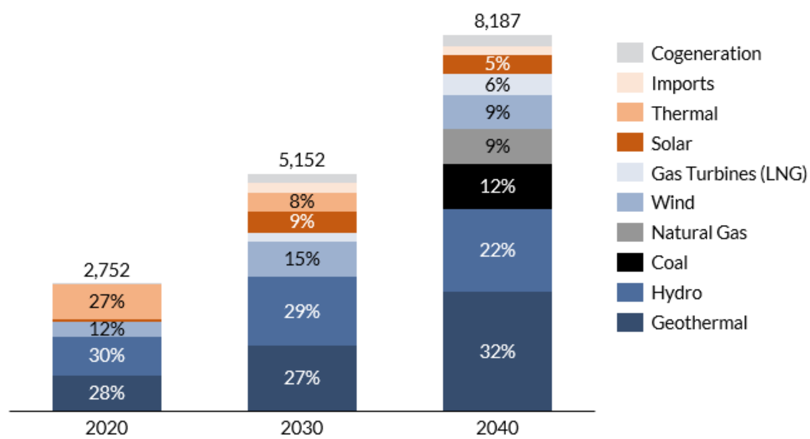
[29] Ministry of Environment and Forestry, National Climate Change Action Plan (NCCAP) 2018-2022: Mitigation and Technical Analysis Report, 2018; USAID, Greenhouse Gas Emissions in Kenya, 2017; SouthSouthNorth, Kenya Ethanol Cooking Fuel Masterplan, 2020
[30] Ministry of Environment and Forestry, National Climate Change Action Plan (NCCAP) 2018-2022: Mitigation and Technical Analysis Report, 2018; Ministry of Environment and Forestry, Submission of Kenya's Updated Nationally Determined Contribution, 2020

Recommendations

Pathway 1: LOW CARBON ELECTRICITY AT THE CORE

The current 2.3 GW installed generation capacity is only a small drop in Kenya's existing renewable energy potential. Forecasts indicate that the country will continue to meet its growing energy demand through a mix of largely renewable energy technologies and following a least-cost approach; the government has prioritized the development of geothermal, wind energy plants, and solar-fed mini-grids for rural electrification. While it is prudent to continue the current generation trajectory, it is important to also develop a strategy for exploring the potential of other alternative sources that may be relevant such as Nuclear, Green Hydrogen, Natural Gas, and Waste to Energy to meet a raised ambition of 100 GW.

Figure 23: Kenya electricity generation by technology (TWh)[31]



Pathway 2: SMART POWER GRIDS TO ENHANCE EFFICIENCY

Kenya should shift from the traditional centralized grid system to a more decentralized and integrated system leveraging smart power grids to maximize the capacity of existing and future grid networks. A smart power grid provides the ability to shift among multiple sources of power generation and various end users. This will provide an efficient, reliable, and low-cost power system, despite the variability and distribution of renewable energy. There are numerous relevant applications of smart grids along the energy value chain as captured in Illustration 6 below.

[31] Least Cost Power Development Plan 2020-2040

Illustration 6: Possible applications of smart grids[32]

Supply	Transmission & Distribution	Users	Technologies and Data
• **Integration of Variable Renewable energy (VRE)** from many sources in order to smoothen the variability of power generation • **Various distributed storage options including batteries,** pumped hydro etc. will help stabilize the supply side • **Decentralized power plants and their coalitions, paired with clear wheeling tariff structures** that allow private developers to offer green captive demand could be powerful in encouraging customers to be prosumers*	• **A smart grid will improve efficiency and reliability of grid semi-conductors** during fault and outage detection, isolation, and location recovery which will help reduce power losses and allow for electrification of various sectors • **Efficient power distribution in Kenya -** A larger connected grid covering a larger geography and incorporating more VRE sources will have a lower coefficient of variation of power	• **Digitalization of the grid using smart metering and two-way metering** to reduce losses, ease detection of bypasses and allow businesses to sell surplus renewable power to the grid • **Smart tariffs** also enable consumers to have more control, choice and flexibility over their energy use depending on temporal needs, urgency and shifts in market prices that reflect supply-demand dynamics • **Smart appliances** in modern households and new consumption	• **Artificial Intelligence (AI), Internet of Things (IoT), distributed ledgers, and other technologies** drive business models, incentivize economic growth, and improve customer experiences • **Real-time data collection** for decision making • **Vehicle-to-Grid technologies and smart charging** for optimal use of available energy for e-mobility

Note: Prosumer is a portmanteau for a customer that consumes and produces their power from distributed energy resources

Kenya aims to reduce system losses to 15% by 2025[33] and elevating this ambition to ~5% by 2040 will realize a saving of up to USD 15.71 million, annually. It is currently recording approximately 22.85% in system losses, meaning that of the 12.1 GW of electricity purchased, approximately 2.765 GW on average is lost, and thus never billed both due to commercial and technical losses. To address this, it is looking to reduce system losses through initiatives such as transformer metering, feeder metering, smart meters, and smart grids. Smart grids can help seal revenue leaks through smart metering technologies and two-way metering that bring in checks in meter bypass and tampering, illegal connections, and the issue of energy balances. Through efforts to prioritize the expansion and accelerated modernization of the grid, Kenya will be able to reduce its system losses by 1% annually, which could translate into savings of at least USD 15.7 million. The pathway captured in Illustration 7 below provides an approach that could result in this saving.

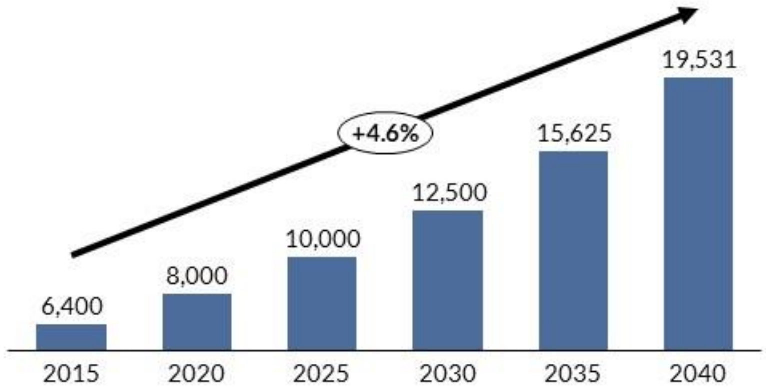
Illustration 7: Kenya's pathway to full digitalization of the grid

Immediate actions (2022-2025)	Medium-term actions (2025 – 2030)	Long –term actions (2030-2040)
• **Upgrading of Supervisory Control and Data Acquisition/Energy Management System** (SCADA/EMS); • **Improvement of Geographical Information System (GIS) utility database** by completing the digitizing and mapping of the grid network • **Auto-shifting of loads** to peak shave and **automatic generation compensators** • **Scaling the roll out of Automatic Meter Reading (AMR) and net metering** for large customers and **smart meters** for small to medium customers	• **Capacity building of institutions** to support smart-grid management • **Equipment replacement** at the Kenya Ports Authority and other key transport and industry bodies with high demand requirements to allow for smart integrations • **Establishment of the Transport Data Centre and Integrated management system** to facilitate transit management and a shift to e-mobility enabled by a green grid • **Develop a system for operators** allowing them to view all powerplants and their auto controls	• **Real-time monitoring** of distributed generation • **Consistent weather forecasting** to aid auto control • **Improve data practices** and **enhance cyber security resilience** • **Promote innovation and digitalization** by leveraging Kenya's ICT layer e.g., fiber optic advances • **Develop regulations** on AI, big data and design of IoT

[32] Kenya National Bureau of Statistics, Economic Survey 2022; International Energy Agency (IEA) Digitalization and Energy, 2017; Stakeholder Interviews; Dalberg Analysis
[33] Ibid.

Pathway 3: END RELIANCE ON BACKUP GENERATORS AND RECAPTURE DEMAND

Figure 24: Kenya electricity generation by technology (TWh)[34]



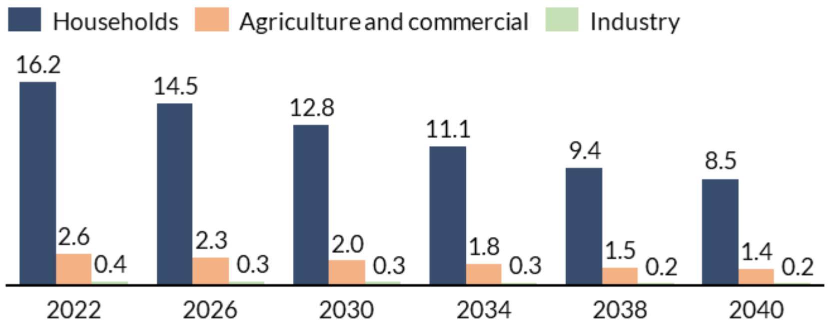
Transformation of the energy sector must include reducing the installed capacity of backup generators to zero. A two-pronged approach will have to be adopted to accomplish this. The first prong will be to reverse the increasing trend of backup generator uptake, which is currently at approximately 5% per annum and represents over 150 MW of installed capacity. This increasing trend is primarily driven by industrial, medical, and school campuses and it is therefore key to understand the motivation across these target groups to develop a strategy for reducing this reliance. The second involves tapping into latent demand which will reduce reliance on backup generators. Latent demand is currently estimated at 10 GW of installed capacity and a similar understanding of the consumer is key to defining a path to capturing this demand.

Pathway 4: 50% REDUCTION IN HOUSEHOLD BIOMASS USE BY 2040

A steep change in the reduction in household biomass use by 2040 will be critical to ensuring that clean energy transforms the livelihoods of everyday Kenyans. The transition to cleaner cooking technologies in Kenya is not happening fast enough with 59% of households still relying on three-stone open fire cooking, compared to 76% in 1999, and with the aggregate number of users having increased 1.5 times to 7.3 million households. To realize transformation, there should be at least a 50% reduction in biomass use by 2040, which translates to a reduction in the consumption of biomass products by 5% every year for the next 18 years.

[34] International Finance Corporation, The Dirty Footprint of the Broken Grid, 2019; Dalberg Analysis

Figure 25: Targeted biomass reduction baseline scenario (Mtoe; 2022-2040)[35]



Note: Assumes 2019 biomass use is the baseline for 2022

Household-level interventions represent a significant opportunity for effecting transformation and to achieve this, it will be key to increase the availability and affordability of clean cooking technologies through various policy reforms and public-private partnerships. It will also be important to explore behavioral change interventions to help consumers appreciate the need for change and in the process address reluctance to transition away from biomass.

Pathway 5: DECARBONIZE HIGH CARBON EMITTING DEMAND SECTORS

Effective development and implementation of policy changes will be the primary driver in decarbonizing high carbon-emitting sectors. It is anticipated that the changes within these sectors may well outpace institutional reforms, potentially leaving policy to lag sectoral advances. Five high carbon-emitting sectors have been identified and there are initiatives that Kenya can begin to implement as it continues to streamline climate change across all Government initiatives. These initiatives are captured below in Illustration 8.

Illustration 8: Initiatives to decarbonize high carbon emitting demand sectors

	Energy sector (including electricity generation)	**Agriculture sector**	**Forestry sector (LULUCF)**	**Transport sector**	**Industrial sector**
Mitigation and adaptation efforts	• **Increase generation capacity, efficiency,** and usage of renewable energy • **Increase connectivity and reliability** of electricity supply by maintaining and expanding electricity infrastructure	• **Increase the area under agroforestry** • **Promote sustainable land management** and efficient production technologies e.g., for rice production, dairy, manure and livestock management • **Increase the use of biogas and renewable fuels** across the value chain e.g., abattoirs and agro-processing • **Adopt climate smart technologies** that enhance soil carbon sequestration	• **Promote the rehabilitation and protection** of natural forests through afforestation, reforestation, and restoration of degraded landscapes • **Encourage sustainable timber production** on privately owned land • **Promote alternative cooking and heating technologies that reduce demand for biomass** e.g., clean cooking • **Enable the adoption of measurement, reporting, and verification** (MRV) technologies e.g., global positioning systems	• **Implement a Mass Rapid Transport System** (Bus Rapid Transit System with Light Rail) • **Electrify rail lines, train technology, freight and passenger vehicles** using renewable energy • **Improve infrastructure** that will enable the shift to electric rail and hybrid electric buses • **Promote engine and fuel efficiency** e.g., for heavy-duty trucks • **Consider low carbon technologies** for aviation and maritime	• **Optimize cement manufacturing** e.g., reduce fossil fuel combustion and energy-related emissions from electricity used to power machinery • **Improve energy efficiency** of industrial processes and promote the use of renewable energy resources for industrial heating • **Promote industrial symbiosis** through infrastructure for waste recovery, reuse, and recycling • **Support carbon capture technology** • **Institute laws that foster carbon trading**

Regarding the decarbonization of the agriculture sector, it is seen that Kenya can choose to leverage a range of initiatives to counter emissions from sources such as methane and manure. The continued growth of the sector is also expected to have a multiplier effect on its sub-sectors such as agro-processing, resulting in increased energy demand. As it stands, the Government has begun the process of establishing six agro-processing zones and Kenya's 10-year agricultural sector development strategy identifies the value addition sub-sector as one of the key levers in its transformation. The considerable growth expected will require a concurrent exploration of opportunities to incorporate green technologies and mitigate greenhouse gas

[35] IEA, Kenya energy outlook,2019; AFREC, Africa energy statistics, 2018

emissions from the sector at large as well as the sub-sectors. Five other sub-sectors are anticipated to drive agricultural emissions and recommendations on how to mitigate them have been provided in Illustration 9.

Illustration 9: Sub-sectors driving agricultural emissions[36]

Sub-sectors	Recommendations
Livestock methane emissions; Manure in Soil	• **Livestock and manure in soils account for the highest emissions** within the agriculture sector • **Bio-digesters can reduce on-farm methane emissions** from livestock by anaerobically digesting animal waste • **The biogas produced from bio-digesters can also serve as a source of fuel** for industries and households through clean cooking • **Bio-digesters are also a source of organic fertilizers.** Digestates from biogas production can be separated and used as fertilizer on the farm • **Longer term solutions exist within green hydrogen** where applications include production of green ammonia which can then be used to make green fertilizer to meet domestic demand and substitute imports
Irrigation; Storage; Greenhouses	• **Solar-powered irrigation pumps** are readiest to scale given comparative performance to alternatives such as petrol pumps. Estimates show that the cost of running a petrol pump for 10 years amounts to almost 3 times the cost of running a solar irrigation pump (if paid upfront) • **Entrepreneurs capitalizing on the organic demand driven by falling prices and new opportunities offered by PAYGO** are creating innovative business models to reach the most vulnerable farmers offering cost-effective solutions to meet growing demand for food while building farmer resilience to climate change • **Solar appliances for storage and greenhouses** offer an additional avenue for decarbonizing agricultural production and downstream value chain processes that are powered by HFOs for large farms and producers • **Other productive uses leveraging solar energy (PULSE) with use cases for smallholders** include refrigerators, egg incubators to increase poultry productivity, and mills to add value to cereal crops, grains and dried tubers

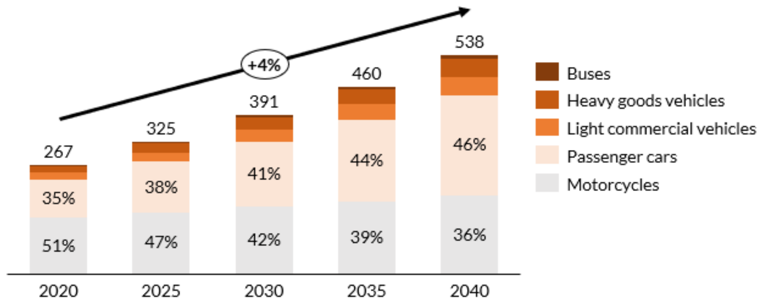
Global Benchmark

A target penetration of 10% is the same as the Philippine's aggressive target penetration rate as outlined in their 2020-2040 Energy Plan. Higher penetration targets such as Indonesia looking at 20% penetration for all public transport by 2025 rely on domestic electric car production which Kenya currently does not have capacity for

Building on increasing momentum in e-mobility, Kenya can push battery-powered EV adoption to achieve at least a 10% displacement of fuel vehicles. New vehicle registrations are projected to grow at a rate of 4% across all categories, with motorcycles and passenger cars accounting for more than 80% of all new registrations (Figure 26). There is potential to re-design how Kenyans move around so that by 2040, 10% of the new vehicle registrations in Kenya are electric. To achieve this target, Kenya will need to grow the number of electric vehicles (EVs) in the country by 29% annually. Starting with motorcycles and passenger cars, and eventually light commercial vehicles. This would take the country from the current 350 electric vehicles (2018) to 53,800 in 2040. A 10% electric vehicle penetration by 2040 would be twice the current government goal of having 5% of all newly registered vehicles being electric by 2025.

[36] Ministry of Environment and Forestry, National Climate Change Action Plan (NCCAP) 2018-2022: Mitigation and Technical Analysis Report, 2018; Siemens Energy, An Introduction into Electrolyzer Technology and P2X Solutions, 2022; UNIDO, Hydrogen Africa Value Chain Report, 2022; European Union – Technical Assistance Facility (EU-TAF), Hydrogen Stakeholders Meeting Notes at Park Inn Hotel on the13th May 2022; USAID, Financing Electrification in Tanzania: The Productive Appliance Opportunity, 2018. Lighting Global, The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa, 2019. REEP, The business case for solar irrigation in Kenya, 2020

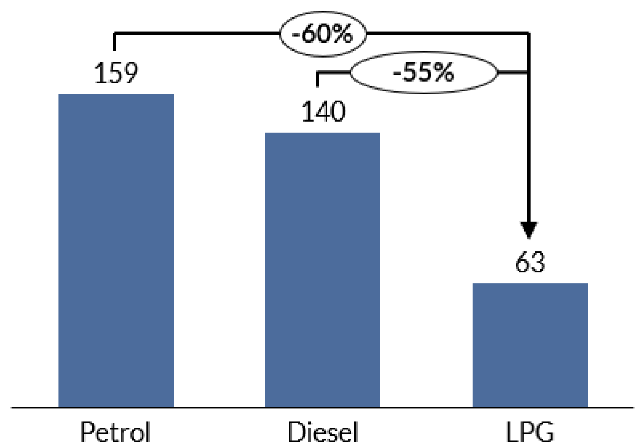
Figure 26: Baseline projection of new vehicle registrations by category ('000 vehicles; 2020 – 2040)[37]



The government is well placed to lead EV adoption as it is the biggest spender on zero-mileage cars in Kenya. In addition, incentives such as reduced taxes and registration fees, competitively priced renewable energy, and increased investment in supporting infrastructure like charging stations will encourage the adoption of electric vehicles. Linkages can also be made to the decentralized solar system that could serve as a distribution network for charging stations. Further opportunities include localizing the e-mobility value chain to increase the affordability of e-vehicles and lower costs of assembly and enabling technologies such as battery storage.

Kenya also has the potential to tap into conversion of petrol and diesel cars to LPG-based vehicles to further reduce transport sector emissions. Globally, there are about 28 million Autogas (automotive liquefied petroleum gas) vehicles, corresponding to a consumption of 27 million tons of Autogas. In 2019, Turkey, Russia, South Korea, Poland, Ukraine, and Italy accounted for approximately 50% of global Autogas consumption. Kenya is among the top 10 countries with the lowest LPG prices and its costs are ~40% lower than the global average price of USD 82 cents/litre. This is particularly important amidst soaring fuel prices in Kenya which make running a car on LPG c.60% cheaper than diesel and petrol.

Figure 27: Kenya comparative price of fuels (Ksh/litre; June 2022)[38]



LPG offers cost savings. Figure 27 above shows the comparative price of fuels in Kenya as of June 2022. The cost of LPG was Ksh 63 per litre compared to Nairobi petrol and diesel prices at Ksh 159 and Ksh 140, respectively. However, the largest drawback is high upfront costs of LPG conversion at Ksh 55,000. Beyond

[37] CEIC, Kenya Road Transport: Number of Motor Vehicles: Registered, 2019
[38] Nation, Would you convert your car to run on cooking gas?, 2020; TV 47, Running your vehicle on LPG at only Ksh60 per litre, 2020; The Autogas Market, 2019; World LPG Association (WLPGA) and Liquid Gas Europe, Autogas Incentive Policies: A country-by-country analysis of why and how governments encourage Autogas and what works, 2020; The Standard, Using gas in vehicles: What you should know before ditching petrol, 2022; Global Petrol Prices, LPG prices, litre, 13-Jun-2022; Nation, No reprieve as fuel prices rise again in new Epra review, 2022; OTOGAS, Conversions, 2022; Stakeholder interviews

cost savings, having a second fuel tank with LPG allows cars to drive longer distances. The average autonomy of an LPG-based car is 500 to 600 kilometers. This number doubles if the vehicle also has a petrol tank. Additionally, LPG-powered vehicles have lower emissions which would further help Kenya achieve its emissions reduction target. LPG-powered cars emit 15% less carbon dioxide, 30% less carbon monoxide, and 50% less nitrogen oxides compared to petrol and diesel vehicles. There is existent demand for LPG-powered vehicles in Kenya with 1,500 cars that have already converted to LPG in the country. Kenya's per capita LPG consumption has risen from 2 kg to 8 kg and is expected to reach 15 kg. EPRA is developing regulations for LPG use in cars with 2 pilots underway with different companies

Pathway 6: USE GREEN ENERGY TO CREATE A COMPETITVE ADVANTAGE AND DECARBONIZE SECTORS

New and emerging technologies will be helpful to Kenya in meeting its decarbonization goals and it must identify those than can be incorporated quickly into its energy system. To unlock the potential of its growing energy system and stay on track on this new sustainable energy journey, a holistic approach that incorporates emerging technologies will need to be utilized. These emerging technologies have an increasing role to play in addressing some of the key pain points within the energy sector and particularly with supply, access, and flexibility (Illustration 10).

Illustration 10: New and Emerging Technologies to explore to decarbonize Kenya's energy mix[39]

Transitional Fuel (grey) — Level of Maturity Score: ◔ Pilot stage · ◑ Emerging · ◕ Medium · ● High

	Relevance for decarbonization efforts	Sector Level of Maturity	Interventions to accelerate scalability	Potential Impact
Battery Storage	Utility scale storage offers many use cases including maintaining system stability and flexibility by integrating intermittent variable renewable energy (VRE) resources	◕ (Medium)	• Rapidly developing sector with good use cases in China and Spain Develop local capacity for adoption of utility scale battery storage • Update regulatory frameworks to support adoption • Implementation of pilot projects to build business case	• Promotion of specialized skills for installation and operation of large storage assets • Medium term opportunities include supporting peaking capacity and supporting increased share of VREs
Green Hydrogen	Supports the growth of heavy industry by integrating renewables for power system balancing	◑ (Emerging)	• Funding of innovative H_2 projects (project or R&D Funding) • Investment in subsidies for electrolyzers • Leverage international climate funds for innovative green H_2 projects	• 5GW electrolyzer capacity in Kenya foreseen by 2040 • Competitive ammonia production costs in Kenya by 2040 • High number of direct and indirect jobs linked to heavy industry transport and buildings
Natural Gas (Transitional Fuel)	Displace heavy fuels and diesel using gas as a low impact transition fuel	● (High)	• Lamu Basin offers potential for exploration in Kenya • Globally the sector is mature, however, Kenya lacks the requisite legal, regulatory and institutional frameworks • Develop policy framework for natural gas development, production and export options	• Promotion of natural gas as a substitution for coal for heat applications in large industrial processes • Additional gas-powered power plants for peaking applications
Small Modular Reactors (SMRs)	Kenya can join the nuclear age to catapult industrial development by deploying SMRs in remote places and support integration of VREs	◑ (Emerging)	• Pilots in China and Russia to learn from • Nuclear technology is something other African countries are also considering and will require regional planning to leverage competitive advantages • Deployment will be cost-intensive and will require government support	• High employment opportunities as embarking on nuclear affects many sectors of the economy • Deployment for SMRs is expected from 2030 onwards - Kenya could develop an ecosystem to support adoption at scale through a comprehensive policy framework
Waste to Energy	Reducing demand for landfill space and addresses public health and environmental concerns associated with open dumpsites	◑ (Emerging)	• Several pilots are under development at Kabira (12MW) and Dandora (45MW) • Kenya energy policy has provisions for this technology – opportunity to support by easing financing challenges for mass adoption	• Offers sustainable solutions for thermal residue utilization significantly reducing waster disposal on landfill sites such as industrial or municipal waste and sludge, and medical waste • Generated output will result in new revenue sources with economic and environmental benefits for the local community
Direct Air Capture (DAC) and Storage	Leveraging Kenya's geological formations, abundant geothermal and other VREs and opportunity for import substitution	◔ (Pilot stage)	• Core technology has been proven, and has millions of USD in private and public investment – 19 DAC plants in operation globally • However, commercialization technology is still at infancy with some ongoing projects e.g., in Naivasha	• Job opportunities for DAC are high as they range in the thousands to cover sectors in construction, steel manufacturing, engineering, cement and chemical manufacturing

Note: H_2 is Green Hydrogen

[39] Ministry of Energy, Updated Least Cost Power Development Plan, 2020-2040; Technical Assistance Facility (TAF) for Sustainable Energy for All Initiative, 2021; Stakeholder Interviews; Dalberg Analysis

Table 3: Conclusion

<table>
<tr><th></th><th>Pathways</th><th>Specific Outcomes</th><th>Critical Enablers</th></tr>
<tr><td>1</td><td>Low-carbon electricity at the core</td><td>1. Continue the current shift towards a zero-carbon electricity mix
2. Leverage natural gas and regional connections</td><td rowspan="6">• Develop a comprehensive decarbonization policy specific to Kenya's geographical and social context to meet the demands of both society and the planet
• Cooperation and coordination in terms of policy design and implementation - stakeholders will need to consider the integrated use of different resources, technologies, or processes to guarantee inclusion
• Flexible and innovation-receptive regulatory frameworks to govern the unchartered waters ahead as well as preserve the essence of Kenya’s identity and ambitions to lead a green energy-powered economy, as highlighted in this White Paper and socio-economic development of communities and enterprises competitiveness in the global market
• Investments in research and development - As technological breakthroughs trigger innovation and shorten the path towards global decarbonization
• Funding option to promote and attract investments in the energy sector</td></tr>
<tr><td>2</td><td>Smart power grids to enhance efficiency</td><td>3. Expansion and upgrade of an interconnected smart power grid to support local and regional electrification
4. Introduction of a national smart meter system</td></tr>
<tr><td>3</td><td>End reliance on backup generators and re-capture demand</td><td>5. Capture/recapture demand is currently met by stationary fossil-fueled backup generators</td></tr>
<tr><td>4</td><td>50% reduction in household biomass use by 2040</td><td>6. Reduce Kenya’s consumption of biomass products by 5% every year for the next 18 years
7. Increasing the availability of clean and affordable cooking technology</td></tr>
<tr><td>5</td><td>Decarbonize high carbon-emitting demand sectors</td><td>8. Explore the opportunity in high potential sectors such as transport and agriculture</td></tr>
<tr><td>6</td><td>Using Green Energy to create a competitive advantage and decarbonize sectors</td><td>9. Production of Green Hydrogen and Ammonia
10. Direct Air Capture and Storage</td></tr>
</table>

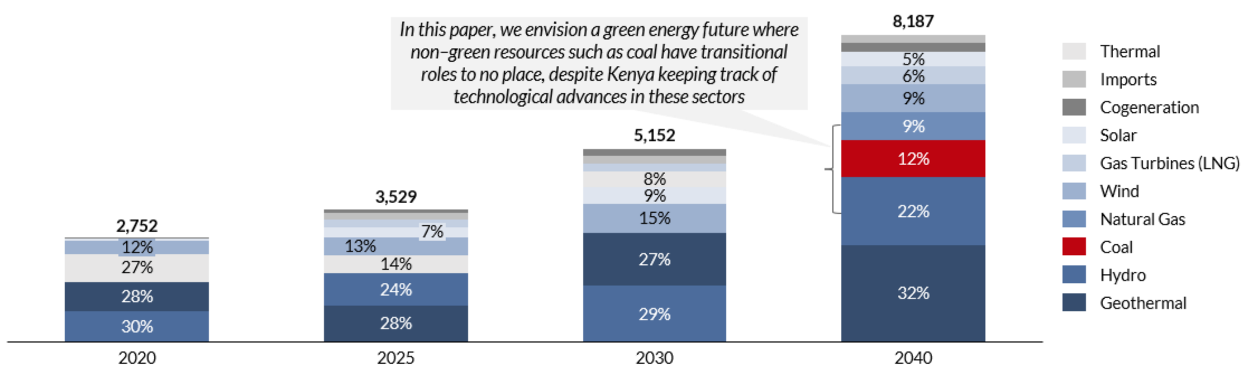
2.3. Outcome 3: Kenya takes a quantum leap to 100 GW by 2040 underpinned by renewable energy sources

Kenya has an opportunity to emerge as a global green energy leader by setting a bold and ambitious target of 100 GW of installed capacity by 2040. It currently has 2.4 GW of installed capacity, which represents approximately 2% of its potential in this regard. If Kenya decides to embark on a fully green pathway to its industrialization, it will have a chance to play a shepherding role regionally, in the drive to global decarbonization. In doing so it will show leadership and vision as the first green-powered African country of the future, demonstrating to the world at large its commitment to taking more decisive action in transitioning to clean energy and achieving inclusive green growth. However, this expansion in generation capacity will require a systemic shift and significant financing.

Context

There are existing plans to expand renewable generation capacity as highlighted by various government strategies and particularly the Least Cost Power Development Plan (LCPDP). The LCPDP as the Ministry of Energy's primary planning document for the electricity and renewable energy sub-sectors articulates the midterm and long-term objectives regarding demand forecasting, generation planning, transmission planning, simulations, and tariff evolution. The 2020-2040 Least Cost Power Development Plan (LCPDP) projects that installed electricity capacity will grow to 8,186 MW by the year 2040, across both renewable and non-renewable sources. This White Paper will build on the targets set out in the LCPDP with an emphasis on a strictly renewable energy mix and more aggressive installed capacity targets.

Figure 28: LCPDP planned projects – Installed Capacity (MW)[40]



Note: Solar includes utility solar and off-grid solar potential. Wind considers off-shore wind. The total installed generation capacity excludes thermal generation and co-generation. Our analysis only factors in renewable sources

Kenya needs to increase its generation capacity to 100 GW by 2040 to be on par with middle-income economies and to establish itself as a Regional Green Pioneer in new green energy technologies. A more ambitious stance must be adopted on capacity generation targets. As a start, it would require the most accelerated trajectory possible which is a sevenfold multiplication of the targets set out in the LCPDP Vision Demand scenario. The Vision Scenario sets a modest target of 13.8 GW which is based on development patterns described in the Vision 2030 growth projections as well as the implementation of flagship projects. An aggressive shift in perspective is therefore needed to appreciate the effort and resources required to hit a 100 GW installed capacity target. There is also a case to be made about the impact of increasing the

[40] Kenya Vision 2030; Least Cost Power Development Plan 2020-2040; Dalberg Analysis

installed capacity on the economy. As shown in Illustration 12, economies with higher installed capacity also show positive markers in regard to GDP per capita and as well as the productive use of energy.

Illustration 11: Supply Side Scenarios 2023-2040

Rate of increase from vision Demand Scenario in the LCPDP as baseline	Baseline	3x	5x	7x
Scenario target	13.8 GW	42 GW	71 GW	100 GW
Investment to develop	USD 39 Billion	USD 85 Billion	USD 142 Billion	USD 188 Billion
Scenario description	**Current Planned Trajectory** Net-zero commitments achieved by leading countries through purposeful policies. Countries that follow this trajectory transition at a slower pace	**Lightly Accelerated Trajectory** Further acceleration of transition driven by country-specific commitments, though financial and technological restraints remain	**Moderately Accelerated Trajectory** Includes offshore wind and 10 GW natural gas Energy mix driven by available potential The goal is to achieve & maintain a highly decarbonized energy mix while ensuring energy security	**Highly Accelerated Trajectory** Includes offshore wind, 15 GW natural gas, and 10 GW battery storage to support solar and wind Fully exploited variable energy potential with renewables leveraged for baseload

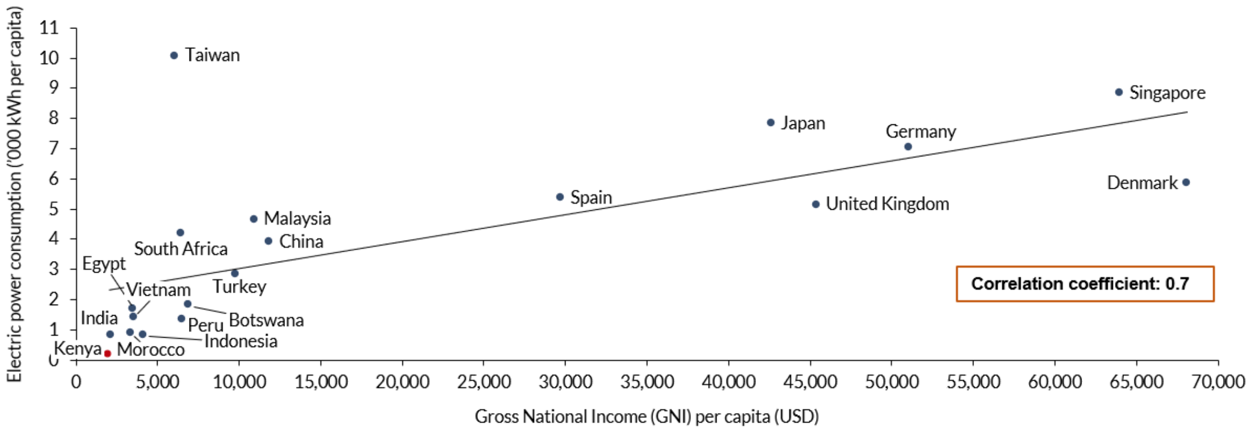
Illustration 12: Country comparison under the different supply side scenarios[41]

Rate of increase from Vision Demand Scenario in the LCPDP as baseline	Baseline	3x	5x	7x
Scenario target (kWh/Capita)	13.8 GW (927)	42 GW (2,823)	71 GW (4,178)	100 GW (5,594)
Economies with comparable capacity	Peru	Taiwan	Indonesia	Turkey
Country context	**Installed Capacity:** 13 GW **Population:** 34 Million **kWh/capita:** 1,600 **Energy mix** • **Thermal:** 58% • **Hydro:** 35% • **Renewable:** 7%	**Installed Capacity:** 50 GW **Population:** 24 Million **kWh/capita:** 11,200 **Energy mix** • **Thermal:** 76% • **Nuclear:** 14% • **Renewable:** 10%	**Installed Capacity:** 74 GW **Population:** 274 Million **kWh/capita:** 1,000 **Energy mix** • **Thermal:** 77% • **Renewable:** 14% • **Hydro:** 9%	**Installed Capacity:** 100 GW **Population:** 86 Million **kWh/capita:** 3,873 **Energy mix** • **Thermal:** 46% • **Hydro:** 32% • **Renewable:** 22%

Further analysis also shows a strong correlation between increased electricity consumption and a rise in income levels. Figure 29 below shows that electricity consumption increases with the rise in income. Except for Taiwan, the selected countries for this analysis show a very strong correlation between per capita gross national income and electricity consumption with a positive coefficient of 0.7. Kenya needs to invest heavily in ensuring economic expansion and GDP growth beyond the energy sector, in order to become a 100 GW economy with per capita consumption of 5,594 kWh by 2040. Kenya's roadmap towards a low-carbon energy mix requires a concerted effort across sectors to ensure sufficient demand for the projected increase in capacity.

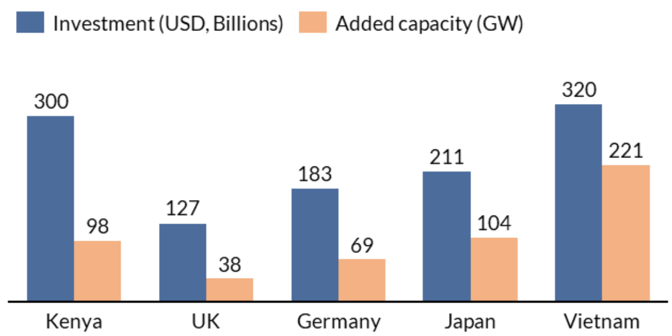
[41] IEA, Energy Atlas, 2019; IMF Indicators; EIA

Figure 29: Correlation between income and electric power consumption (USD per capita; '000 kWh per capita)[42]



There has been significant investment in various renewable energy sources through successful mobilization of public and private sector investment. By 2018 Kenya had attracted USD 1.2 Billion into its renewable energy sector, however, the aspirations articulated in this paper will require mobilization of an unprecedented USD 300 billion to 2040. USD 188 billion is projected for capex and USD 44 billion is budgeted for transmission and distribution infrastructure, with the remaining USD 68 billion targeted towards stimulating demand. While this sum may look daunting, it accounts for only 0.4% of total global investment planned for clean energy investments to 2040 and is comparable to other countries that have similarly scaled their renewable energy generation capacity in the past such as Germany, Japan, and Vietnam.

Figure 30: Comparison of the renewable energy investments cost per GW (Billion USD/GW)[43]



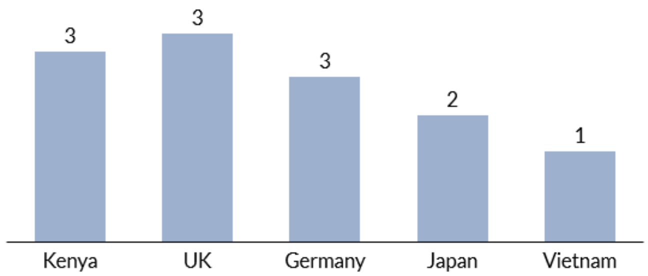
Note: Added capacity refers to the additional capacity supplemented following the corresponding investment

For Kenya to reach the 100 GW target by 2040, it will need to develop a portfolio of bankable energy projects with a cumulative value of approximately USD 300 billion based on the investment cost per GW estimates available. There is currently a strong global drive to reduce the effects of climate change and achieve sustainable net zero growth by 2050 and this is bolstering the momentum of the global energy transformation. This transformation will require massive resource mobilization; It is estimated that USD 95 to USD 120 trillion will be required between 2015 and 2050 for the world to achieve its net zero

[42] World Data, Energy consumption in Taiwan, n.d.; CEIC Data, Taiwan Gross National Income: USD: Per Capita, 2017; The World Bank, GNI per capita, Atlas method (current US$), 2021; The World Bank, Electric power consumption (kWh per capita), 2014
[43] Japan Agency for Natural Resources (ENECHO METI) and Energy; German Ministry of Economic Affairs and Energy; UK Department for Business, Energy & Industrial Energy; BloombergNEF, Global trends in renewable energy investment,2020; IRENA, Global Energy Transformation: A Roadmap to 2050, 2018; Enerdata, Vietnam's installed capacity should increase by 145% in 2019-2030, 2021

objectives.[44] Clean energy investments are expected to cost USD 75 trillion, which translates to an average of USD 2 trillion annually over 35 years.

Figure 31: Comparison of the renewable energy investments cost per GW (Billion USD/GW)[45]

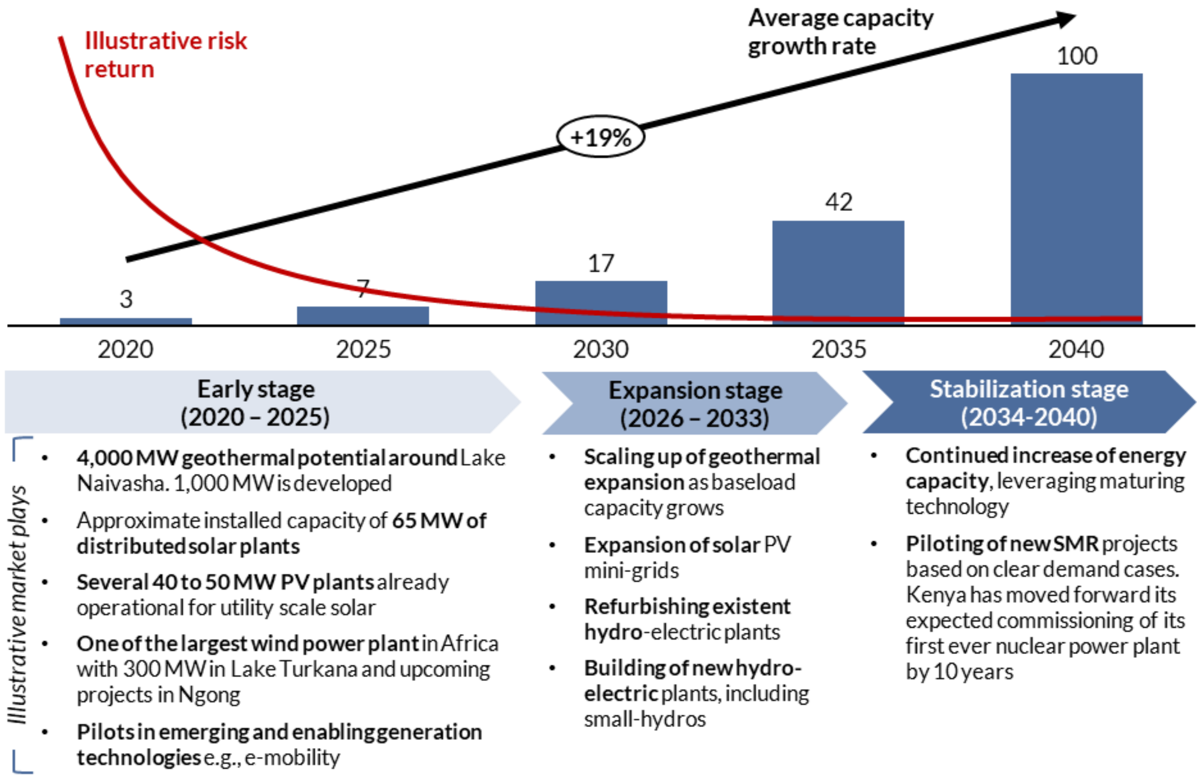


Kenya has a maturing renewable energy sector and is consistently ranked among the world's top 40 markets with attractive renewable energy investments.[46] In Africa, Kenya is ranked 2nd in the attractiveness index for foreign direct investment.[47] A comparison of the renewable energy investment cost per GW of installed capacity further demonstrates Kenya's competitiveness relative to more developed nations such as Japan and Germany.

Kenya must consider a diverse funding pool for energy investment if it is to meet its targets and steps taken to achieve this should include mobilizing domestic funds to de-risk local projects and stimulate investor appetite. Institutional investors, both foreign and domestic, are the main actors financing investment in Kenya's energy space. In addition, the sector is well supported with over 20 active donors/DFIs deploying a range of financing tools such as grants, mixed grants, and loans on a variety of projects ranging from large infrastructure to consumer awareness. However, policy uncertainty and long project delivery times continue to hamper the sector's ability to attract investment at the expected levels. This manifests itself in subpar engagement from local and international banks, some types of institutional investors, as well as pooled investment vehicles such as green funds. To attract diverse institutional investors, the pipeline of renewable energy investment projects has to shift from small size and high risk-high return investments to large size and medium-risk- moderate return investments. It is anticipated that the risk of investment opportunities will decrease as installed capacity increases from 3 GW to 100 GW as demonstrated in Figure 32 below.

[44] IRENA, Global Energy Transformation: A Roadmap to 2050, 2018
[45] Dalberg analysis
[46] EY, Renewable Energy Country Attractiveness Index (RECAI): 58th Edition Top 40 Ranking, 2021
[47] KenInvest, Investor Guide for Kenya: Agro-processing and light manufacturing sectors, 2018; GoLegal, SA & Kenya ranked second in EY Foreign Direct Investment report, 2017

Figure 32: Kenya's renewable energy sector growth with illustrative risk-return mapping[48]



Multiple countries across the world are ahead on their energy transformation journeys that Kenya can learn from. Vietnam is one example of these countries as the country aims to add more than 200 GW to its generation capacity by 2045.[49] Vietnam is the largest power generator in Southeast Asia and had an installed generation capacity of c.69 GW in 2020. Wind and solar accounted for 25% of the energy mix. Coal and hydro accounted for the largest percentage at 32% and 28%, respectively. Vietnam aims to increase its installed capacity to 277 GW by 2045 and 137 GW by 2030. This means that the country will need to increase its generation by 300% (208 GW) by 2045 and 99% (68 GW) by 2030. To achieve its target, Vietnam aims to increase the share of wind and solar to 44% and decrease the share of coal to 18% of the total capacity. The country also plans to forego the development of any new coal-fired power plants to become carbon neutral by 2050. To stabilize intermittent supply from variable renewable energy sources, Vietnam will increase the role of storage devices over the same period to 1% in 2030 and 3% in 2045. Vietnam's increased generation corresponds to a GDP growth of 6 – 6.5% over the next decade to increase its GDP 2-fold to USD 486 billion by 2030. The country plans to increase its GDP 9-fold to USD 2.5 trillion by 2045. Illustrations 13 and 14 show other global and regional peers that have shown that a rapid path towards economic transformation is achievable and recognize the need for greener pathways to future growth.

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[48] European Union – Technical Assistance Facility (EU-TAF), Hydrogen Stakeholders Meeting Notes at Park Inn Hotel on the13th May 2022; AfDB, Lake Turkana Wind Power Project: The largest wind farm project in Africa, 2015

[49] Enerdata, Vietnam's installed capacity should increase by 145% in 2019-2030, 2021; Reuters, Vietnam eyes doubling of power generation capacity by 2030, 2021; Pinsent Masons, Vietnam plans to double power generation capacity by 2030, 2022; Vietnam Briefing, Vietnam's Power Development Plan Draft Incorporates Renewables, Reduces Coal, 2022; International Trade Administration (ITA), Vietnam – Country Commercial Guide: Power Generation, Transmission, and Distribution, 2021; ACCEPT, Renewable Energy Development in Vietnam, 2021; The World Bank, GDP (current US$) – Vietnam; Vietnam Plus, Vietnam's economy to surpass Singapore's by 2030: DBS Bank, 2021; Hanoi Times, Vietnam's GDP per capita to reach US$18,000 by 2045: PM, 2018

Illustration 13: Global economies that Kenya can learn from[50]

	Economic Performance and Socio-economic	Energy Sector Mix and Growth Targets
Singapore	• **Singapore is considered as one of the economic powerhouses of the 20th century.** It has grown its economy four-fold between 2000 and 2020 to reach USD 340 Billion despite the economic effects of COVID • Despite minimal land and natural resources, **Singapore has transformed with growth being driven by its manufacturing and financial sector** • **Impressively, the rapid growth in the economy has trickled down to the average Singaporean benefitting almost 6 million population** through employment, education, housing etc.	• **Singapore currently has an installed capacity of 12 GW and system peak demand of 7,376 MW.** In 2020, year on year annual system demand fell by c.2% due to decreased business activity as a result of COVID measures, but this is expected to pick up and grow by ~3% annually • **Singapore is looking to expand its low carbon/renewable installed capacity.** The country is planning to incorporate 2 GW solar PV capacity by 2030 and increase the share of gas to 95% of the power mix • **The country is also planning to import 4 GW of low carbon electricity by 2035** from Malaysia (where households have up to 3 times lower household electricity prices) and Indonesia • **Electricity demand is expected to grow by c.3% annually by 2032** including demand from new sectors such as data centers
Malaysia	• **Malaysia has been one of the best performing economies in Asia.** In the 1980s & 90s, the economy experienced rapid growth that averaged almost 8% annually. In 2020, GDP stood at **USD 337 Billion for a population of 32 million people** • **This rapid growth has supported accelerated economic and social development in the country.** Since its independence in the 60s, there has been a nine-fold increase in per capita income leapfrogging the country to upper-middle income status • **The Government of Malaysia has articulated even bolder growth ambitions for the country,** as outlined in its Shared Prosperity Vision 2030 and 12th Malaysia Plan. These anchor future growth on regional inclusion, the role of SMEs, human capital, and social well-being	• **Malaysia's current energy mix is largely made up of oil and gas (c.72%).** With total installed capacity of 36 GW in 2020, renewables account for ~8 GW including hydro (72%), solar (17%) and biofuels (11%) • **Malaysia has significantly scaled solar capacity over the past decade, with the technology expected to dominate its renewable energy market in the future.** Net installed capacity of Solar increased from 229 MW to 1,493 MW in 5 years between 2015 and 2020. The country aims to install an additional 9 GW of solar by 2050 • **In recent years, Malaysia has also emerged as a hub for manufacturing solar PV cells, wafers, and modules.** This localization of the technology supports the substantial growth of solar installations within the country to meet government and sector targets

[50] World Bank Indicators. International Energy Agency, 2021. IRENA, Malaysia Asia Renewable Energy Report, 2021. Modor Intelligence, 2021, Malaysia Renewable Energy Market growth and trends. Dalberg Analysis

Illustration 14: Regional peers who have embarked on a green energy transition[51]

		Economic Performance and Socio-economic	Energy Sector Mix and Growth Plans
Regional Peers thinking of green pathways to industrialization	South Africa	• **South Africa is the third largest economy in Africa. However, the economy has experienced negative growth in the last decade** with GDP falling by 2% in the last decade from USD 434 Billion in 2012 to the current 426 Billion. South Africa still has a highly developed economy with a strong financial, manufacturing and extractive sector • **The population trends are similar to the rest of Africa** with an increase from 44 million in 2000 to 61 million in 2021	• **South Africa has an installed capacity of 58GW but is heavily reliant on thermal sources of power such as coal for its generation capacity.** Currently thermal sources account for over 80% of the generation capacity with renewables accounting for about 15% • **Through its Just Energy Transition Plans, the country has set out on a plan to replace its coal plants with renewable energy plants by 2050.** The country's energy producer, Eskom has 8GW of renewable energy projects in the pipeline under this program with more in plan
	Egypt	• **Egypt is the second largest economy in Africa,** with GDP growing by 56% in the last decade from USD 278 Billion in 2012 to the current 435 Billion. Egypt's economic growth has been strong and resilient since the economic reforms initiated in 2016 • **The country has the third highest population in Africa** after Nigeria and Ethiopia with 106 million people as of 2016	• **Egypt has an installed capacity of 57GW but is heavily reliant on fossil-fuel derived thermal power for its generation capacity.** Currently thermal sources account for over 90% of the generation capacity with hydropower and renewables accounting for 10% • **Egypt launched its renewable energy strategy in 2014 that seeks to make renewable energy 42% of the country's installed capacity by 2035**. Egypt's ambitious energy policy calls for 61 GW of installed capacity from renewable sources
	Morocco	• **Morocco is the fifth largest economy in Africa.** Its GDP grew by 40% between 2012 and 2021 from USD 93 billion to USD 133 billion. The country's GDP growth rebounded to 7.4% in 2021 following a contraction by 6.3% in 2020 • **Over the last 20 years, Morocco's population increased by ~30%** from 29 million in 2000 to 37 million in 2021 • The country also has the second highest ranking of doing business in Africa and presents lessons in liberalizing xxx	• **In 2012, Morocco had an installed capacity of 6.6 GW which grew to 10.5 GW in 2021** following a corresponding investment of USD 5 billion • **Morocco is heavily dependent on coal and thermal** which account for more than 65% (7GW) of total generation • **Currently, wind and solar account for 20% (2 GW) of the total generation.** In 2009, Morocco set to have renewable energy account for 42% (6 GW) of installed capacity by 2020. In 2015, this goal was revised to 52% (13 GW) capacity from renewable energy by 2030

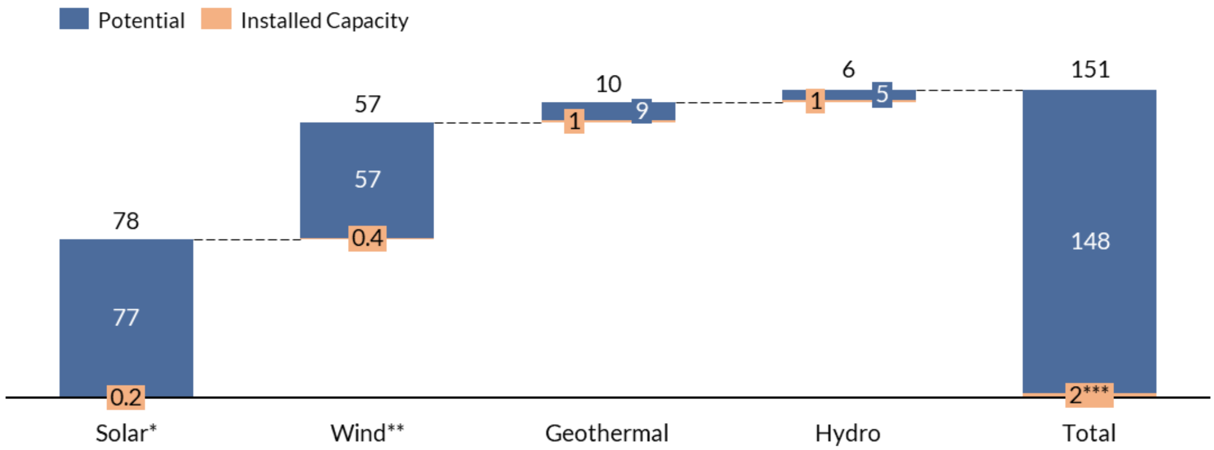
Recommendations

Pathway 1: INCREASE CAPACITY GENERATION TO 100 GW BY 2040

Kenya is currently tapping into approximately 2% of its renewable energy generation potential, which means that there is vast scope for development. It has 2.4 GW of installed capacity in its renewable energy mix consisting of geothermal (0.9 GW), hydro (0.8 GW), wind (0.4 GW), and solar (0.2 GW). To attain its target of 100 GW, Kenya would have to realize the full potential of its renewable energy reserves which are estimated at 10 GW for Geothermal and 6 GW for Hydro – according to the LCPDP. Further, the wind potential is estimated at 57.1 GW based on recent polygon assessments in high potential areas, while solar is estimated at 77.6 GW. The solar potential estimate draws from two sources, first, the Solar and Wind Energy Assessment which estimates 638,790 TWh solar, and second, recent solar polygon assessments in high potential areas such as Eldoret and Meru. Off-grid solar offers even greater generation potential that this analysis has not quantified, and it is therefore imperative that continued on-site data measurement is conducted in each priority location, across all renewable energy sources to understand their viability.

[51] IMF & World Bank Indicators; IEA; ESKOM, Dalberg Analysis; ESCWA, Case Study on Policy Reforms to Promote Renewable Energy in Morocco, 2018; Inside Arabia, Morocco's Global Leadership in Energy Capacity Does Not Extend to Its Poor, 2020; REEEP, Morocco, 2013; IRENA, Energy Profile: Morocco, 2021; Statista, African countries with the highest Gross Domestic Product (GDP) in 2021, 2022

Figure 33: Installed generation capacity and existing potential for renewables (GW)[52]



Note: * Solar potential estimates exclude off-grid and rooftop solar estimates. **Wind considers on-shore wind. The total installed generation capacity excludes thermal generation and co-generation. Our analysis only factors in renewable sources

Kenya is capable of increasing its generation capacity to 100 GW using a low-carbon energy mix. To achieve this target by 2040 and assuming a starting point of 3 GW, an average annual increase in the generation of approximately 20% is necessary. In addition, Kenya will need to continue leveraging conventional renewable sources such as geothermal, hydro, wind, and solar, while continually exploring new emerging technologies in nuclear, battery storage, sustainable biomass, green hydrogen, and natural gas.

Pathway 2: ATTRACT USD 300 BILLION IN GREEN ENERGY INVESTMENT

The 100 GW target necessitates the attraction of at least USD 230 billion by 2040 to finance increased capacity generation, transmission, and distribution. This figure represents USD 188 billion of projected capex financing with the remaining USD 44 billion being used to service transmission and distribution needs as illustrated in Illustration 15. Analysis of the capex investment required across key renewable energy sources shows that onshore wind, natural gas, hydro and geothermal are the more cost-competitive options per GW as captured in Figure 34 below. This fact ties in well with Kenya's current installed capacity trajectory and highlights the need for urgency in the development of our natural gas reserves.

[52] Ministry of Energy, Updated Least Cost Power Development Plan, 2020-2040; Kenya Country Report, Solar and Wind Energy Resource Assessment, 2008; EPRA, Statistics Report, 2021; KNBS, Economic Survey 2022; EPRA, Solar Energy, n.d.; Dalberg Analysis

Illustration 15: Funding needed to meet the 100 GW target

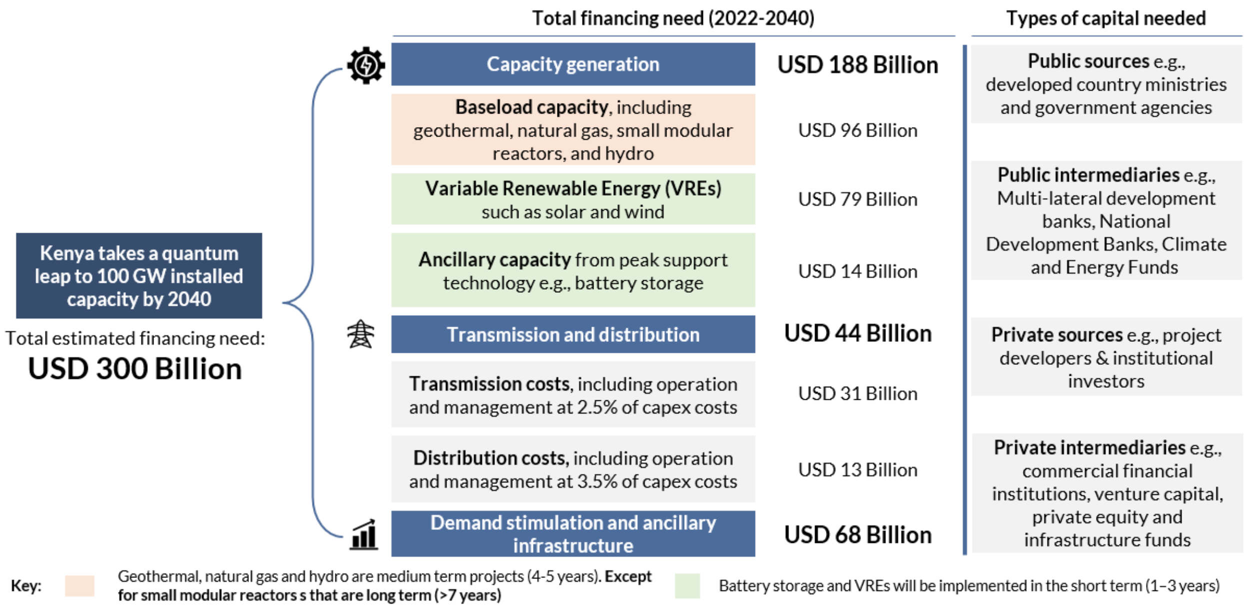
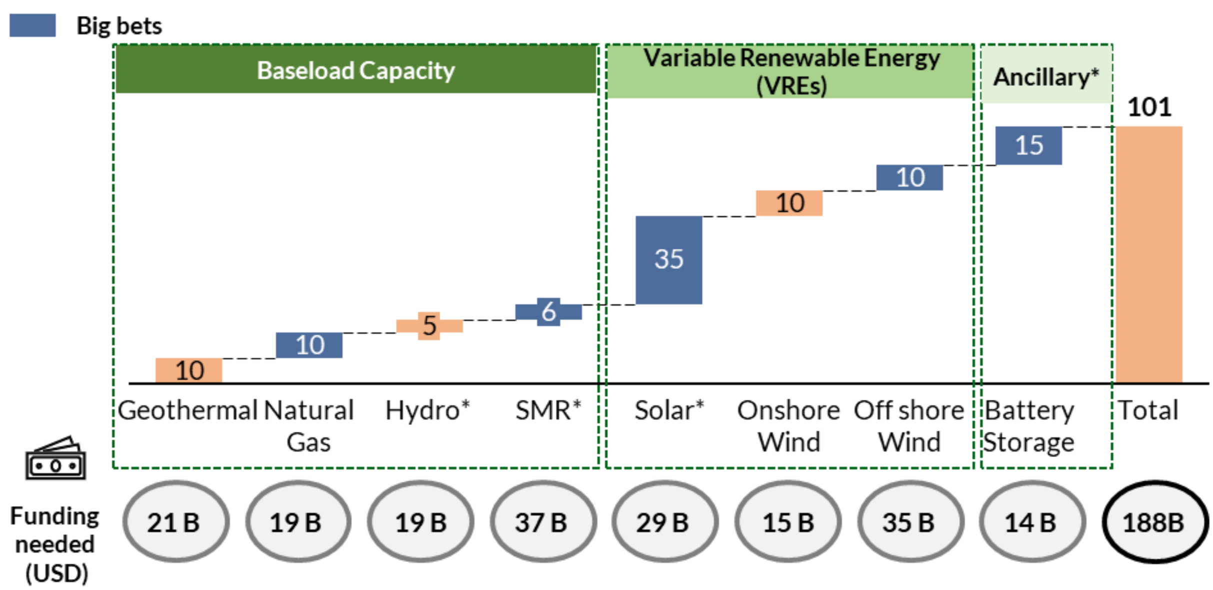


Figure 34: Energy mix to meet ~100 GW target[53]



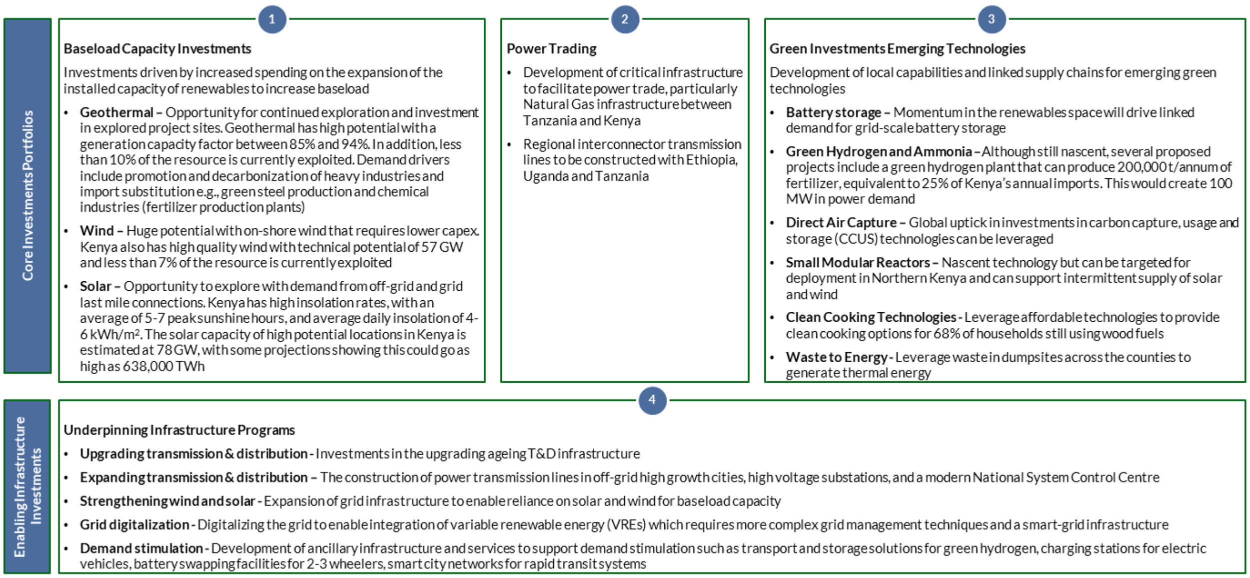
Note: * Including utility solar, capacity for captive use, and residential solar systems, *Including pumped storage *SMR stands for Small Modular Reactors. *Ancillary capacity will be provided by peak support technology such as battery storage.

Kenya's energy sector has the potential to offer a wide range of bankable projects and investments. An analysis of current and emerging opportunities results in the broad categorization of these into four potential categories. The first of these is baseload capacity investments which entail spending on expanding the installed capacity of renewables. The second is power trading which involves the buying and selling of

[53] Ministry of Energy, Updated Least Cost Power Development Plan, 2020-2040; Kenya Country Report, Solar and Wind Energy Resource Assessment; 2008; Stakeholder Interviews; Dalberg Analysis

power. The third is green emerging technologies which explore opportunities within the range of green technologies that can support or result from a green economy. Rounding up the categories is enabling infrastructure investments which looks at the development of infrastructure that supports the green transition.

Illustration 16: Key Energy Investment Portfolios for Kenya 2023- 2040



There are significant baseload capacity investment opportunities in the exploration and development of energy projects, particularly in geothermal, solar, and wind projects which together represent a combined 143.1 GW of potential capacity captured below.

Table 4: Capacity Investments

Baseload Capacity Investments		
	Rationale	**Demand Driver**
Geothermal	• High generation capacity factor of 85-95% • Less than 10% of the resource is currently explored	• The push to decarbonize heavy industries • Import substitution potential through, for example, green steel production and chemical industries such as fertilizer production plants
Solar	• Kenya has high insolation rates, with an average of 5-7 peak sunshine hours and average daily insolation of 4-6 kWh/m^2 • High potential locations in Kenya are estimated at 78 GW, with some projections showing this could go as high as 638,000 TWh	• Off-grid and grid last mile connections
Wind	• Kenya has high-quality wind with a technical potential of 57 GW	• Relatively low capex

	• Less than 7% of resource potential currently exploited	

A target of ~100 GW installed capacity would position Kenya to successfully power trade, initially with regional partners and as the enabling infrastructure investment increases, beyond the region. Accordingly, the infrastructure to facilitate power trade is critical. As Kenya looks to leverage natural gas as a transitional fuel from heavy fuel oil, an immediate investment opportunity is in Natural Gas infrastructure between Tanzania and Kenya. The second key investment opportunity is in the development of interconnector transmission lines between Ethiopia, Uganda, and Tanzania which will not only further Kenya's efforts to power trade but also be an integral part of the East African power pool. Enabling infrastructure investment will buttress the 100 GW target and given identified energy supply challenges, a focus on optimizing the grid represents an immediate opportunity. In addition, emerging green technologies represent a core investment portfolio. A focus on developing local capabilities and linked supply chains will unlock the catalytic potential of this green energy transformation.

Table 5: Emerging technologies

Green Investments Emerging Technologies	Enabling Infrastructure Investments
Battery storage – Momentum in the renewables space will drive linked demand for grid-scale battery storage in particular	**Upgrading transmission and distribution-** Investments in the upgrading of aging transmission and distribution infrastructure
Green Hydrogen and Ammonia – Although still nascent, several proposed projects include a green hydrogen plant that can produce 200,000 t/annum of fertilizer which is 25% of Kenya's annual imports, and create 100 MW of power demand	**Expanding transmission and distribution –** The construction of power transmission lines in off-grid high-growth cities, high voltage substations, and a modern National System Control Centre
Direct Air Capture – Global uptick in investments in Carbon Capture, Usage and Storage (CCUS) technologies can be leveraged	**Strengthening wind and solar -** Expansion of grid infrastructure to enable reliance on solar and wind for baseload
Nuclear/Small Modular Reactors – Nascent technology but can be targeted for deployment in Northern Kenya and can support the intermittent supply of solar and wind	**Grid digitalization -** Digitizing the grid to enable integration of VREs as this necessitates more complex grid management techniques and preferably a smart-grid infrastructure
Clean Cooking Technologies - Leverage affordable clean cooking technologies to provide clean cooking options for 68% of households still using wood fuels	**Demand stimulation -** Development of ancillary infrastructure and services to support demand stimulation – transport and storage solutions for green hydrogen, charging stations for electric vehicles, battery swapping facilities for 2-3 wheelers, smart city networks for rapid transit systems

Waste to Energy - Leverage waste in dumpsites across the counties to generate thermal energy. Several pilots are under development at Kabira (12 MW) and Dandora (45 MW)	

Pathway 3: DIVERSIFY FUNDING POOLS FOR ENERGY INVESTMENT

To consolidate USD 300 billion in investments, Kenya needs to promote and attract investments in the sector through private, public, and pooled investment channels. Private investment channels are the preferred investment path for institutional investors such as pension funds and insurance companies. The common pathways for these private investors include taking up corporate bonds or equity shares in contrast with the Public Investment channels' pathway which is direct investment. Institutional investors in Kenya have traditionally underinvested in the energy sector despite being well-positioned to bridge financing requirements; This stands in opposition to the fact that renewable energy projects align well with their investment profile of low-risk, long-duration assets. It will therefore be key for the Kenyan government to facilitate more private and public investments by highlighting their potential as captured in the current assets under management tabulation (Illustration 17) and by addressing the perception of high risk and limited expertise which serves to further restrict the flow of investment.

Illustration 17: Total Assets Under Management (AUM) for Domestic Institutional Investor[54]

	Assets under management	Current investment mix	Barriers for investment in energy	Mitigation strategies
Pension funds	USD 13.07 Billion	• Government securities - 45% • Property - 18% • Equities - 16% • Guaranteed funds - 16% • Other - 5%	• **High perceived risk** because of the lack of performance data about the renewable energy sector • **Currency risk** resulting from the need to finance projects in USD which exposes the investor to currency devaluation • **Fragmentation of the institutional investor market** with numerous small funds that individually are not able to invest because they lack scale and capacity • **Lack of experience and expertise in structuring new investment vehicles.** Financial institutions may not have the requisite tools and frameworks to assess renewable energy investments • **Limited policy and regulatory incentives.** There is no public policy that drives or incentivizes investments in green energy	• Build renewable energy data platforms to provide visibility on sector performance • Create a foreign exchange hedging facility • Consolidate the sector and created pooled funds and special purpose vehicles (SPVs) for energy investments • Provide structured market support to develop institutional investment vehicles • Raise awareness and provide technical training across the financial services sector • Develop market-wide cohesive policy and regulation
Insurance companies	USD 6.13 Billion	• Government securities - 67% • Property - 13% • Equities - 6% • Fixed deposits - 7% • Other - 7%		
Collective investment schemes	USD 0.9 Billion	• Government securities - 44% • Fixed deposits - 36% • Equities - 5% • Cash deposits - 11% • Other - 4%		

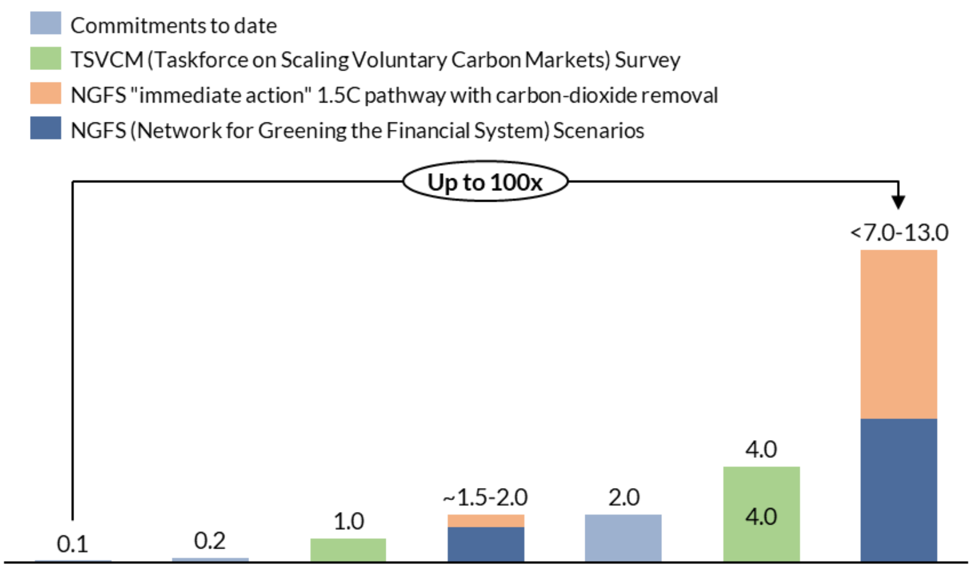
Note: Collective Investment Schemes refers to investment funds, mutual funds, or any other type of pooled funds under management

There are no Pooled investment vehicles or investment funds that currently exist in Kenya as products due to limited demand from institutional investors and the retail market. It is therefore key to explore how to create models of pooled funds that are relevant for the market, and this can be done at two levels, first, by moving small funds to umbrella funds, and second, by moving the segregated money into large funds into pooled investment vehicles. It is also important to bolster the Kenya green climate fund to enable it to offer direct financing to new energy technologies such as direct air capture and green hydrogen to de-risk them and accelerate private capital flows.

[54] Retirement Benefits Authority, annual report, 2021; Insurance Regulatory Authority, annual report, 2021; Capital Markets Authority, CIS reports, 2020 Collective Investment Schemes refers to investment funds, mutual funds or any other type of pooled funds under management

The Voluntary Carbon Credits market, projected to be worth $50bn by 2030 also offers a less traditional pathway to financing Kenya's decarbonization ambitions. The market for carbon credits purchased voluntarily could be worth upward of $50 billion by 2030 and overall demand for carbon credits could increase by a factor of 100 by 2050 as captured in Figure 35. Kenya should therefore seek to attract "sell-side" industries for carbon credits and particularly renewable energy projects. Examples of these are solar thermal heating/electricity, solar photovoltaic, wind energy, hydropower, biogas heating/electricity - and energy efficiency projects - such as improved cookstoves, water filtration/purification systems, energy saving lamps/fluorescent lamps. Kenya can therefore augment funding for its energy transition by leveraging carbon credits.

Figure 35: Global demand scenarios for voluntary carbon credits by 2030 and 2050 (Gigatons)[55]



Notes: Commitments to scale - These amounts reflect the demand established by climate commitments of more than 700 large companies. They are lower bounds because they do not account for likely growth in commitments and do not represent all companies worldwide; TSVCM - Taskforce on Scaling Voluntary Carbon Markets. These amounts reflect demand based on a survey of subject-matter experts in the TSVCM; NGFS - Network for Greening the Financial System. These amounts reflect demand based on carbon-dioxide removal and sequestration requirements under the NGFS's 1.5°C and 2.0°C scenarios. Both amounts reflect an assumption that all carbon-dioxide removal and sequestration results from carbon credits purchased on the voluntary market (whereas some removal and sequestration will result from carbon credits purchased in compliance markets and some will result from efforts other than carbon-offsetting projects)

[55] A blueprint for scaling voluntary carbon markets to meet the climate challenge, 2021

Table 5: Conclusion

	Pathways	Specific Outcomes	Critical Enablers
1	**Increase capacity generation to 100 GW by 2040**	1. The average increase in generation capacity at a rate of approximately 20% per annum to 2040	• A stable regulatory & policy environment coupled with the political commitment that encourages investment in the sector • Promoting local currency-denominated financing to reduce the cost of capital • Attracting and matching the right kind of capital into the energy sector • Strategic partnerships & collaboration that support the sector reform agenda such as leveraging blended financing with instruments such as guarantees, credit lines etc.
2	**Attract USD 300 billion in green energy investment**	2. 40% average annual increase of renewable energy investment to 2040	
3	**Diversify funding pools for energy investments**	3. Tap into traditional and non-traditional investment sources 4. Mobilize domestic funds to de-risk local projects and stimulate investor appetite	

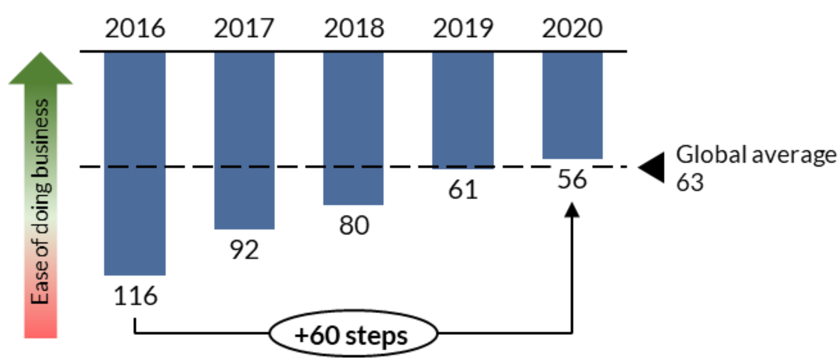
2.4. Outcome 4: Kenya is an investment destination of choice for industries that are seeking to decarbonize

A new global energy economy is coming into view, brought forth by policy action, technological innovation, and the increasing urgency of the need to tackle climate change[56]. As the world races to reduce greenhouse emissions, several key megatrends will shape the future of energy, namely, renewable energy deployment, new energy regulations, changing consumer behavior, and emerging green technologies. An energy transition in Kenya to 100 GW by 2040 thus has the potential to be both a major economic disruptor and an opportunity. Kenya can leverage its geographic advantage and clean energy abundance to identify and attract high potential opportunities, emerging players, and innovative mechanisms in the global shift to decarbonization. This will stimulate and accelerate bankable demand that can meet Kenya's increasing green energy supply.

Context

Kenya has made significant gains in establishing itself as an investment destination of choice and this is most pronounced in its improved Ease of Doing Business rankings. Kenya's ease of doing business ranking has improved by 60 places in the last 5 years largely driven by a more efficient business environment and strong legal institutions (Figure 36). It is currently the second highest ranking country in East Africa, at number 56 out of 190 countries globally but overall, Sub-Saharan Africa remains one of the weakest performing regions in the doing business ranking with large economies such as South Africa, Ghana, and Nigeria at 84, 118, and 131 respectively. The region scores better in criteria relating to getting access to credit but ranks poorly in areas related to electricity access and cross-border trading. A 100 GW renewable energy target coupled with a conducive business environment will likely make Kenya an investment destination of choice.

Figure 36; Kenya's Doing Business Ranking Historical Performance (Rankings done for 190 economies for 2017-2022)[57]

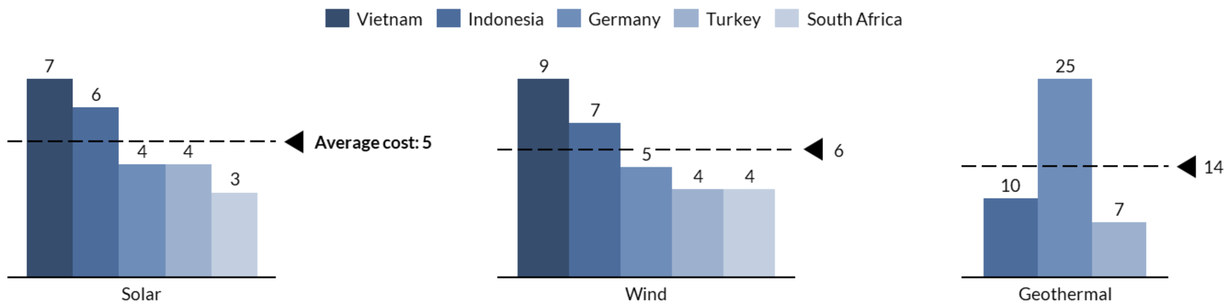


The structure of Kenya's renewable energy generation cost is still not well defined, and this inconsistency continues to limit its global competitiveness. Energy costs vary significantly based on specific projects and this has been a key barrier to the power distributor's ability to purchase and sell power at a globally competitive rate. An analysis of current projects demonstrates the average generation cost across Geothermal, Solar, and Wind as captured in Figure 37. While Kenya's generation costs are not the highest, there is much room for improvement towards establishing itself as a cost leader. A generation cost in the

[56] International Energy Agency (IEA), World Energy Outlook 2021, 2021
[57] World Bank Doing Business Survey 2020

range of 3 – 7 USD cents/kWh across renewable sources would enable Kenya to be competitive with global and regional peers.

Figure 37: Comparison of renewable energy generation costs (USD cents per kWh)[58]



There are concerns that Kenya's traditional sectors are not growing fast enough to absorb increasing generation capacity and more investment and support is necessary. Kenya must stimulate additional demand within traditional sectors such as with industry and residential consumers, while concurrently attracting external high-growth high-energy intensive industries. The expansion of traditional sectors will provide steady demand for energy while reducing Kenya's dependency on imported goods and services. It is therefore important to understand the local opportunities by mapping the potential of counties and regions for the development of, for example, industrial parks and agro-processing zones. Further, it is key that challenges around access and affordability of power are comprehensively addressed because the patterns and projections envisaged in this paper will only be achievable if the country can increase the average consumption and utilization of energy.

The development of robust regional interconnection ecosystems will be a vital enabler in stimulating the demand for Kenya's green energy. Increased power exchange within the African power pools has the potential to enhance grid stability and allow for the introduction of more renewable technologies, even where there are intermittency challenges. Effective working pools will further enable the provision of a cost-effective energy supply, support industrial and socio-economic development in regional markets and help drive global decarbonization. Africa currently has many planned interconnectors making up various geographical power pools and it is vital to develop robust frameworks to continue to support power exchange through these interconnections.

[58] Tilleke & Gibbins, New Incentives for Solar Power Projects in Vietnam, 2020; Vietnam Briefing, How Can Investors Seize Vietnam's Wind Power Potential, 2022; Think GeoEnergy, Is geothermal valued fairly in power tariffs in Indonesia, 2021; DW, Solar and Wind Power in Germany, 2022; PV Magazine, Turkey sets fixed tariff for licensed PV projects, 2021; IPP Renewables, Renewable Energy IPP Procurement Programme, 2021

Figure 38: Existing and Planned Interconnections between African Power Pools[59]

Increased utilization of off-peak power at reduced costs will help attract high energy-intensive industries such as heavy manufacturing and data centers to drive demand. The fact that Kenya's energy is from renewable sources will be key in attracting industrial users seeking to decarbonize and such sectors include steel, aluminum, and hydrogen producers, data centers, and crypto miners. Kenya must explore how to facilitate a 24- hour economy as this will create a conducive environment for commercial businesses to thrive by taking advantage of cheaper power costs. The growth realized by attracting these additional sectors will in turn create more jobs, generate wealth, and lead overall to more development of the economy, which is important for Kenya as it looks to leapfrog to middle-income status.

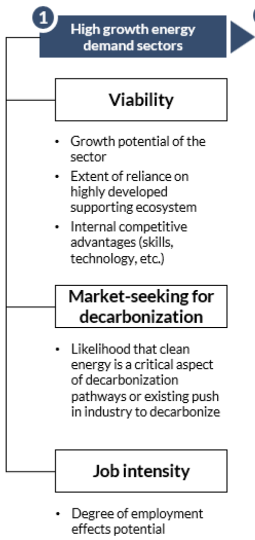
Recommendations

Kenya will leverage its competitive advantage in renewables and its conducive business environment to attract high growth and high-intensity energy demand sectors. Kenya will need to invest in identifying sectors that can support its 100 GW ambition and three critical criteria have been developed to support this process. The first criterion is the sector's viability which considers the global size of the market and its growth prospects. To rank opportunities, their growth potential, level of reliance on highly developed supporting ecosystems, and strong competitive advantage in technical skills, and technology, among others will be evaluated. The second criterion is its market-seeking potential which identifies sectors that are looking for cost-competitive renewable energy sources as a pathway to decarbonization or those that have a high concentration of risk in their supply chain and could benefit from diversification into other markets. This criterion will therefore assess their market concentration risk, a mix of upstream and downstream value chains, and incentive for seeking pathways to decarbonization. The third criterion is the sector's job intensity, and this looks at its economic growth ambitions and particularly its potential to generate jobs.

[59] Aurecon, SAPP-EAPP Interconnector Impact Study: Updated Final Draft Report, 2018

These three criteria were used to rank six illustrative sectors, and while this list is not exhaustive, it indicates relatively new and high-potential industries that Kenya should look to attract.

Illustration 18: Illustrative High Priority Sectors[60]



Illustrative list of high energy-intensive priority sectors*

Sub-sector	Viability	Decarbonisation Appetite	Job Intensity	Notes
Electrolysers (Green Hydrogen)	High	High	High	The global market for green hydrogen is expected to grow by a CAGR of up to 50% between 202 and 2030. Production through electrolyzers in places with abundant natural resources will enable supply at affordable costs, including T&D*. Globally, hydrogen through electrolyzers is expected to reduce nearly a fifth of carbon emissions and will require investment of USD 20-25 billion annually
Data Centres	High	High	Medium	The sector is expected to grow with a CAGR of c.5% between 2021 and 2027 alone. Global demand for electricity from data centers was between 200 -250 TwH, representing ~1% of total demand. Similarly, energy used for cryptocurrency mining was c.100 TwH in 2020
Electric Arc Furnace Steel Plants (Green Steel)	Medium	Medium	High	Kenya ranks among the top 15 steel importers worldwide at 2.2 Mt in 2020. A 100 MW electric arc steel furnace could produce 1 million tonnes of steel per annum. Existing iron ore deposits need to be evaluated to facilitate commercial exploitation
E-mobility	Medium	High	High	Home charging stations to power electric vehicles (EVs) will be needed in households and supporting charging infrastructure will be needed across the grid, including local manufacturing of EV components such as batteries. There are also opportunities to electrify the rail network and public transport, and to decarbonize the long-haul air travel and shipping
Aluminium Electrolysis	Medium	Medium	High	Currently, aluminium is mostly imported from China using fossil fuels and production costs are still high because of the unavailability of raw materials such as bauxite. Assessment of regional markets offer an opportunity for Kenya to leverage this
Mining (e.g., Titanium, soda ash, gold)	Medium	Medium	High	Kenya is vastly underexplored for minerals. Mining currently contributes less than 1% to Kenya's GDP. The production of titanium ore minerals, soda ash and gold have the highest value at Ksh 26 billion, 2 billion, and 1 billion, respectively. Kenya could (i) expand its mining sector with the recent discovery of rare earth deposits in the coastal region estimated to be worth USD 62 billion; and (ii) position itself as a mineral processing destination for regional countries like DRC, Tanzania, and Uganda

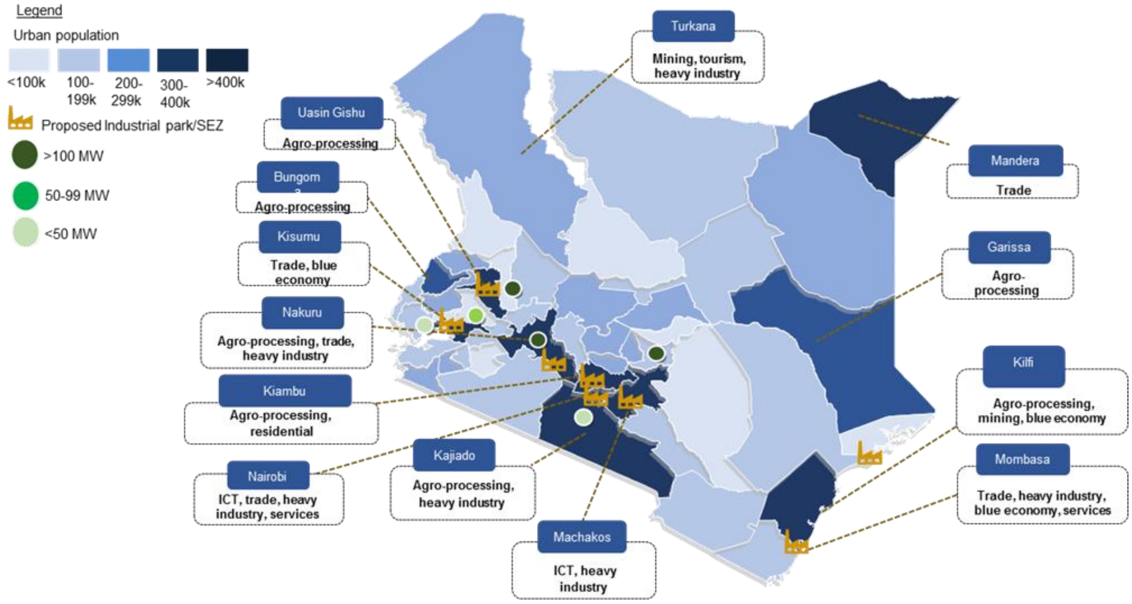
Note: *List of potential high energy intensive sectors is non-exhaustive; *T&D stands for transmission and distribution

In addition to attracting new sectors into the market, Kenya will need to stimulate additional demand from its traditional sectors. The next 5 examples provide the rationale for growing these key sectors, namely, Industrial parks, industrial agro-processing, cement manufacturing, local manufacturing, and the steel sector.

New industrial parks and agro-processing zones are possible in counties around Kenya, depending on existing resources and competitive advantages. Counties have varied drivers that underpin their growth such as natural resources, infrastructure, and availability of skilled labour. Industrial parks and special economic zones (SEZs) have the potential to attract investors looking to leverage the opportunities within each county and it is therefore imperative that as counties continue to grow, Kenya taps into the specific potential of each and develops industrial parks and SEZs to match this potential. Figure 39 maps thirteen counties with the fastest growing urban population and key growth drivers.

[60] Kenya Association of Manufacturing Deep Dive report, 2018; Kenya National Energy Efficiency and Conservation strategy 2020; KNBS, Economic Survey 2022; Ministry of Mining, Kenya Mining Investment Handbook, 2016; Stakeholder Interviews; Dalberg Analysis

Figure 39: Current proposed industrial parks and their proximity to renewable power generation plants; Projected urban county population to 2040 with potential growth drivers[61]

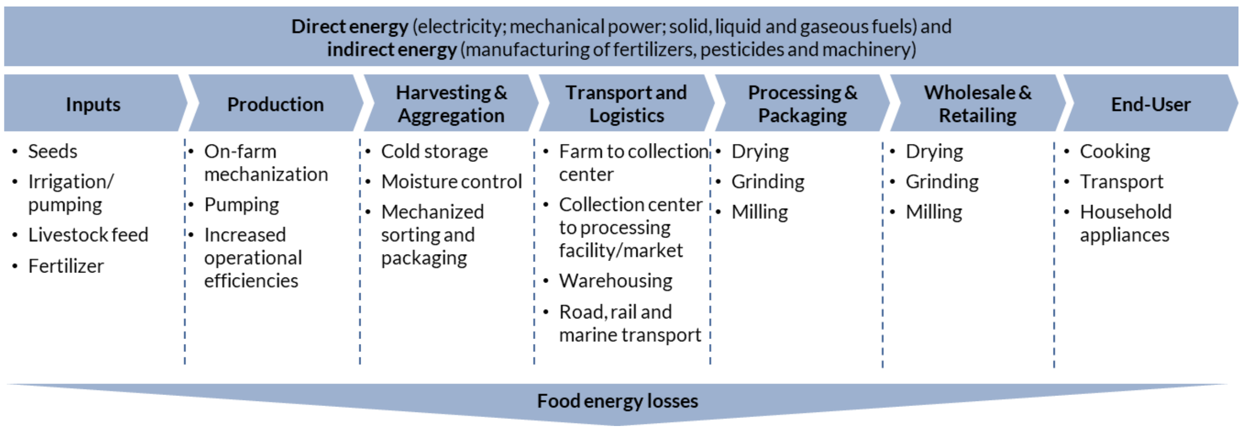


The Kenyan government and the private sector have proposed setting up several industrial parks around the country, most of which are located along the Northern Transport Corridors of Kenya which passes through 12 of the 47 counties. New parks being set up around the country should consider the benefits of co-location to renewable energy sites as clustering allows them to leverage existing infrastructure.

Industrial agro-processing players currently using non-renewable fuels will need to switch to cleaner fuels to stimulate demand for productive use of green energy. Agriculture remains the largest contributor to GDP at ~23%. In 2021, total employment in the sector surpassed pre-pandemic levels as total employment outside small-scale agriculture grew by 5.3% to 18.3 million. This upward growth trajectory is anticipated to continue as more SEZs and industrial parks come online. It is therefore imperative to understand the productive use cases of energy for both smallholder farmers and larger players in the value chain. This will help unlock opportunities for productive use of energy on a large scale.

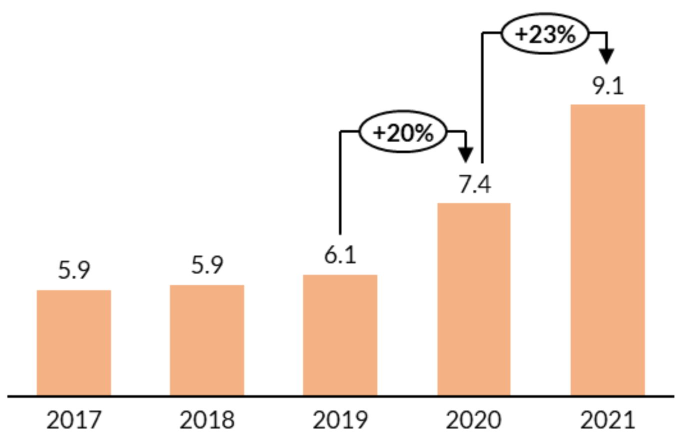
[61] KNBS, Population Survey, 2019; Projections assumes a constant inter-census growth rate of 2.2% till 2040; KenGen, Special Economic Zone (SEZ) Authority of Kenya

Illustration 19: Opportunities for clean technology and renewable energy for agri-food systems and value chains



Cement manufacturing will drive energy demand due to the expansion of the construction sector which has been growing at a rapid rate of 7% between 2017 and 2021. The construction sector continues to be a prominent contributor to Kenya's GDP accounting for 7% in 2021 and growing at an average rate of 7% between 2017 and 2021. The drivers of this growth are government investments in infrastructure and expansion of the real-estate sector. It can be seen that cement consumption increased by 23% to 9 million tons in 2021 (Figure 40). Increased cement use leads to high energy demand for cement manufacturing. As the Kenyan economy grows, historical trends in cement consumption are projected to continue.

Figure 40: Historical Cement consumption 2017-21 (Million Tonnes)[62]

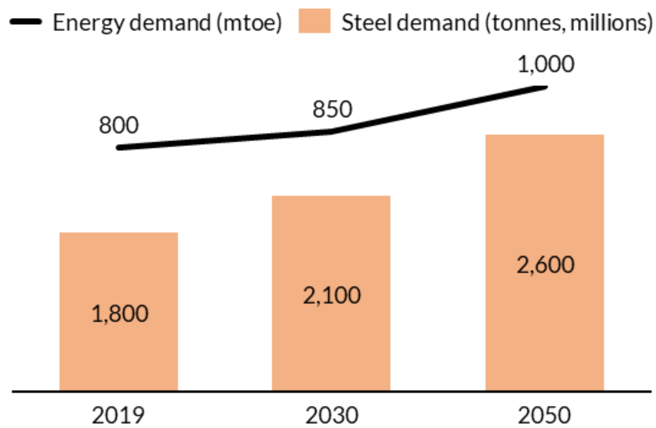


Stimulating local manufacturing of low-carbon products will be crucial to increasing access to affordable options for consumers and reducing Kenya's import bill. Kenya's manufacturing sector's share of GDP has mostly stagnated at approximately 9% between 2017 and 2021 while the import bill has been increasing at a rate of 4% within the same period. In 2021 Kenya imported ~$19 billion worth of goods, most of which comprised of foodstuffs, machinery, and construction materials. Kenya can position itself as a leading regional market for manufacturing goods by demonstrating to companies and investors the business case for local production of these goods utilizing green energy. The government can lead the way in this transition by enacting a green procurement policy where it commits to purchasing low-carbon goods and services.

[62] KNBS, Economic Survey 2022

Kenya's steel sector has been growing at a rapid rate in the last 5 years, driven by expansion in real estate and investments in infrastructure. The iron and steel industry in Kenya forms ~13% of the manufacturing sector and this share is projected to increase as the country embarks on development activities articulated in various development agendas such as Vision 2030. The Kenya economic survey shows that steel imports have grown by 22% between 2017 and 2021. In 2021, Kenya imported more than USD 1 Billion of iron and steel into the country and there is an opportunity to reduce this import bill by producing high-quality steel locally.

Figure 41: Global demand projections for iron and steel (Million Tonnes; 2019-2050)[63]



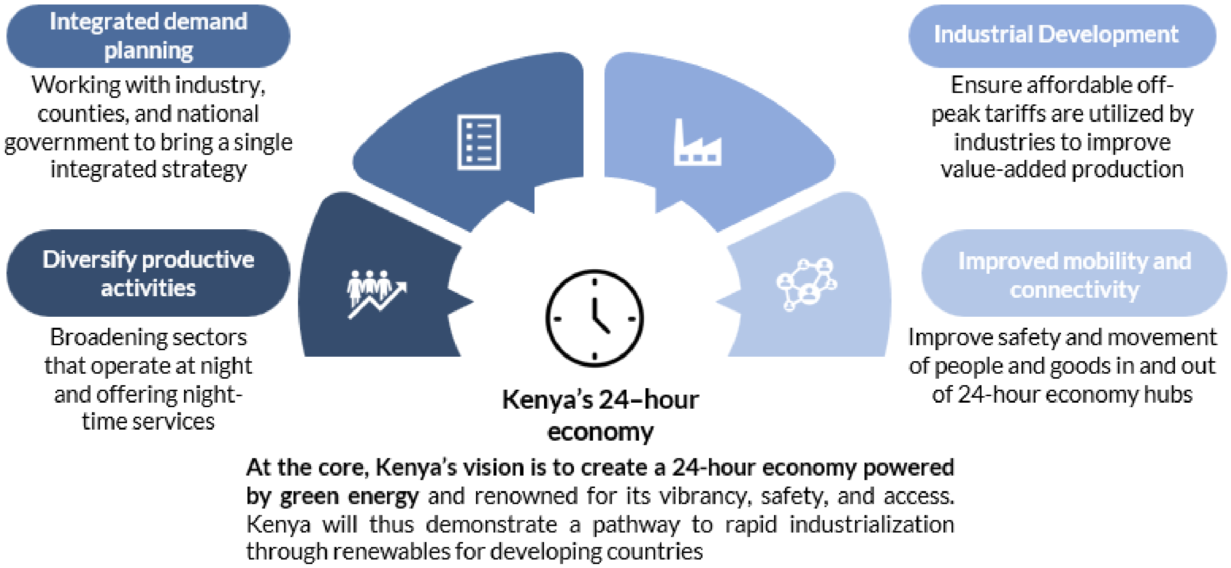
At the global level, steel demand is expected to grow by a steady 25% between 2019 and 2050. However, steel is one of the heavily polluting industries and it is estimated that the sector discharged more than 3.3 billion tonnes of greenhouse gases in 2021. There is a concerted effort to decarbonize the sector with emissions expected to drop by 30% by 2050. This presents an opportunity for Kenya to position itself as a destination for green steel production in the region

> **Time of Use (ToU) tariff**
> A ToU tariff would realise reduced costs of production for commercial industrial consumers who utilize electricity when it is available more cheaply which is usually during off peak hours. A 24 hour economy is necessary for this model to work successfully

A 24-hour green energy-powered economy is necessary to meet the varied demands of consumers who will utilize 100 GW of Energy. Four pillars are envisioned as core in supporting the development of a 24-hour green economy as captured in Illustration 21. The first is integrated demand planning which involves working with industry, counties, and national government to develop a single strategy that adequately addresses key pain points for energy consumers. The second is diversifying productive activities and particularly broadening sectors operating in the evenings by offering night-time services. The third is industrial development which ensures affordable off-peak tariffs are utilized by industries to improve value-added production, and the last is improved mobility and connectivity which addresses improved safety and movement of people and goods in and out of the 24-hour economy hub.

[63] IEA, Iron and Steel Technology Roadmap, 2019

Illustration 21: 24-hour Economy Pillars



It will be necessary for Kenya to map and explore the abundant energy demand beyond its borders and leverage its competitive advantage to tap into Africa's power pools. Developing robust regional interconnection ecosystems will be a vital enabler in stimulating demand for Kenya's green energy. There are some plans already underway to facilitate regional connections. For example, the Kenya-Ethiopia line, which is expected to be completed in 2022, the Isinya-Singida 220KV, and the Lessos-Tororo 220KV interconnectors which are nearing completion. The immediate opportunity is in integrating smart regional planning frameworks and processes to allow Kenya to take advantage of regional markets. The emphasis within these frameworks will be on (i) catering to the technical elements and this is specifically on the interconnections; (ii) focusing on commercial elements and looking at how to create necessary market mechanisms to enable trade; and (iii) fostering partnerships by defining an engagement framework for participating countries.

Below is the illustrative demand in a 100 GW economy whose consumption is driven by new sectors such as green steel, green hydrogen, and data centers that accelerate growth. Illustration 22 shows sector demand drivers for scenario 1 where Kenya will stimulate demand for its increased supply of green energy by anchoring on consumption from new heavy industries seeking to decarbonize, local traditional industries, as well as households going through urbanization.

Illustration 22: Illustrative sector demand drivers to meet 100 GW projection

New Low Carbon Heavy Industrial Demand			
Area	**Consumption per unit** (MW)	**Units**	**Total** (MW)
Desalination of seawater in coastal regions)	100	20	**2,000**
Electrolysers (Green Hydrogen)	50	90	**4,500**
Data Centres	50	100	**5,000**
Electric Arc Furnace Steel Plants (Green Steel)	100	50	**5,000**
Aluminium Smelting/Electrolysis	1,000	3	**3,000**
	Total		**19,500**
Commercial, National and Traditional Industry			
Lapset			**252**
SGR (Mombasa to Malaba)			**200**
Nairobi Commuter Rail Service			**15**
Commercial and general industrial			**7,000**
	Total		**7,467**
Residential			
Includes enhanced home consumption as the economy moves to middle/upper income and there is increased urbanisation and home vehicle charging			**6,000**
	Total national demand in 2040 (MW)		**32,967**
	***Available capacity excluding reserve (MW)**		**33,256**

Note: *Available capacity is lower than installed capacity because we are accounting for the low-capacity factor of variable renewable energy (VRE) sources like wind and solar. Our estimates aim for total national demand to be comparable to available capacity which reflects the supply of power that will always be available on demand irrespective of seasonality of VREs

Table 6: Conclusion

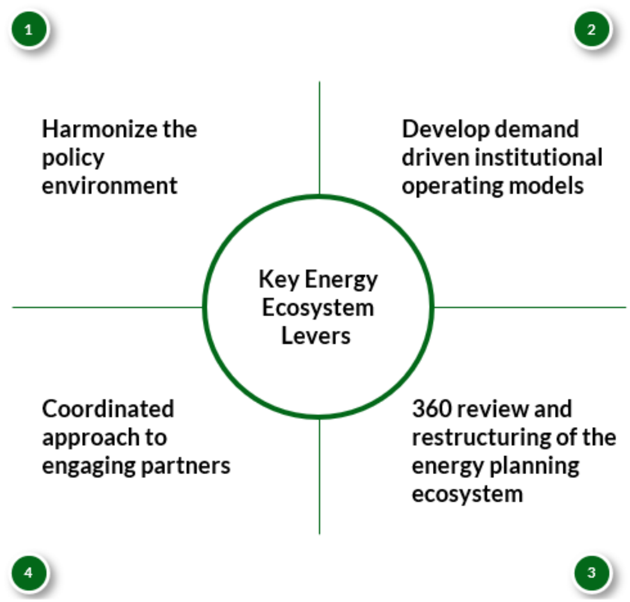
	Pathways	Specific Outcomes	Critical Enablers
1	**Attract high-growth high-energy intensive industries**	1. Benchmark renewable energy prices with regional and global peers 2. Position Kenya as a preferred investment destination for emerging green sectors	• Integrated and flexible energy planning that considers multiple scenarios, and real-time demand shifts and fosters stakeholder collaboration • Resilient and modernized energy infrastructure that leverages digitalization and data capabilities • A stable regulatory & policy environment coupled with the political commitment that encourages investment in the sector • Robust institutional governance & capability
2	**Stimulate additional demand from traditional sectors**	3. Stimulate the growth of Industrial parks, industrial agro-processing, cement manufacturing, local manufacturing, and the steel sector. 4. Map the potential of counties and regions for the development of industrial parks and agro-processing zones	

3	**Stimulating a 24-hour economy**	5. Increase utilization of off-peak power at reduced costs	building creates strong institutions that can collaborate in driving Kenya's energy journey
4	**Leverage Kenya's competitive advantage to tap into regional power pools**	6. Develop a robust regional interconnection ecosystem	

3. CRITICAL SHIFTS AND INITIAL HIGH-LEVEL ROADMAP TEASER

In this White Paper, Kenya articulates bold ambitions that position energy at the center of its economic transformation. To achieve these ambitions, Kenya will need to employ the right mix of market and non-market levers while ensuring that they are properly sequenced at the right pace and scale. This White Paper identifies four levers (Illustration 23) that, if successfully implemented, would allow Kenya to achieve the desired end state articulated in the outcomes and pathways chapter.

Illustration 23: The four critical shifts for Kenya's energy transformation



3.1. Critical Shift 1: Harmonize the policy environment

Kenya's energy policy framework must deliver low-cost energy while insulating the country from risk and facilitating an environment for the mobilization of private capital into transitional energy projects. Capital mobilization must be a key influencer for policy decisions and interventions should reflect the following principles:

1. **Alignment of sectoral strategies and policies.** It is imperative that different ministries work together when developing national or sector strategies and policies to ensure harmonization and that the country is moving in one direction
2. **Development of new and refinement of existing targeted investment incentives for the deployment of renewables** i.e., feed-in tariffs and feed-in premiums, weighted with the duration of power purchase agreements and public tenders to mobilize investment flows in renewables
3. **Providing readily accessible information** on renewable energy regulations and the state of their implementation, including visibility on ongoing projects
4. **Adaptive regulatory environment** that delivers well-designed and time-bound support policies when needed. This involves leveraging a market-oriented continuous feedback loop so that policy is forward-looking and responsive to changing market dynamics

5. **Removing disincentives to low-carbon investment by redirecting government expenditure and eliminating climate-incompatible** and inefficient subsidies, and other forms of support that encourage the consumption and production of fossil fuels. Examples include subsidy reforms towards more targeted and pro-poor subsidies, and public procurement mandates for quotas of public procurement allocated to green projects or used as green finance

Illustration 24: Key actions towards harmonizing the policy environment

Action	Description	Barriers to implementation	Solutions	Key owner
Establishment of multi-sectoral taskforce on energy	Establishing a taskforce drawn from other sectors to align and harmonize national and sectoral strategies	• A siloed approach to policy development and implementation • Sector taskforce fatigue	• Strengthening of delivery directorates, such as Vision 2030 and President's Delivery Unit (PDU), to coordinate policy development and implementation	Office of the President
Liberalisation of the retail market	Market regulation that enables liberalization of distribution to foster accelerated last mile connectivity and encourage healthy competition	• Pushback from power distributors who have opposed similar initiatives in the past • Emergence of energy cartels	• A full study on the impact of market liberalization on the energy sector	EPRA
Regulatory framework for a one-stop shop clearing house for IPPs	Establish an independent and centralized one-stop-shop clearing house for energy projects to enhance efficiencies, foster transparency and reduce contracting time for projects	• Complex process of moving the different components away from different ministries to one location	• Learning from countries that have successfully set up such offices such as South Africa	Ministry of Energy
Renegotiation of Power Purchase Agreements (PPA)	Renegotiation of power purchase agreements to optimize fixed capacity charges in PPAs and mitigate transference of costs to consumers	• Pushback from IPPs to negotiate existing contracts • Reduced attractiveness for projects	• Implement the recommendations of the PPA Taskforce Report on PPA contracts	KPLC
Regulatory framework for subsidy reforms	Redirecting fuel levies to support a shift away from fossil fuels and encourage more pro-poor design	• Kenya is reliant on subsidies to manage energy costs	• Alternative tax schedule on energy products to promote adoption of clean energy	Treasury

3.2. Critical Shift 2: Develop demand-driven institutional operating models

The Kenyan energy landscape will expand significantly as generation increases to 100 GW and energy institutions must evolve to deal with this complexity. Kenya needs competitive institutional models that foster robust governance and optimize cost efficiencies while being consumer focused.

1. **Institutions are internally configured to serve customer needs in a financially sustainable manner.** Reconfiguration of institutional operating models should seek to reduce operational complexities while optimizing cost-to-serve for different consumer segments. This can unlock opportunities such as the ability to mobilize cheaper sources of finance to serve low-income customer segments
2. **Institutions have world-class capabilities to compete effectively in the market** while leveraging partnerships for non-core capabilities. Capability development to ensure world-class personnel, operating procedures, and technologies would be key to enabling market competitiveness and financial sustainability of energy institutions

3. **Institutions can tap into synergies across agencies for more efficient delivery** of linked services to customers and realization of efficiency gains across operations
4. **Enhancing institutional governance and strengthening accountability,** by improving regulations, incentives, and implementation or enforcement of policies. This should reduce complexity and duplication of processes across multiple levels of governance which will in turn lower transaction costs and create a favorable market environment

Illustration 25: Key actions towards developing demand-driven institutional operating models

Action	Description	Barriers to implementation	Solutions	Key owner
Reconfiguration of KPLC and REREC	Reconfigure KPLC and REREC across consumer segments so that KPLC is positioned to serve large commercial and industrial consumers, while REREC is positioned to serve the social mandate for household consumers. Evaluate the appropriate operating model configuration to unlock cost and efficiencies in KPLC and REREC	• Incapacity of REREC to absorb significant increments in operational scope and budget • Lack of support from key institutions • Lack of clear visibility of country's distribution assets	• Capacity building of REREC staff with secondment of KPLC staff to assist with transition • Full audit of KPLC's distribution assets	Ministry of Energy, REREC and KPLC
Embedding Institutional Operational Excellence	Develop a strategy for enhancing operational capabilities across energy institutions to foster robust governance and operational excellence. This may consider the establishment of an Energy Operational Center of Excellence that centrally develops an operational strategy that aligns people, processes and assets, and provides dedicated energy-sector governance and financial transparency	• Difficulty in securing additional resources for a separate agency to do work that is typically undertaken by internal resources within energy institutions	• Secondment of staff from energy institutions to the energy operational center of excellence	Ministry of Energy, Energy SAGA CEOs

3.3. Critical Shift 3: 360 review and restructuring of the energy planning ecosystem

An energy system that delivers growth at the pace and magnitude that Kenya is pursuing needs to be driven by strong integrated planning capabilities underpinned by rigorous demand-side planning to ensure compatibility with the national economic growth agenda. This planning must consider multiple scenarios, demand shifts, and management of energy assets. To achieve effective integrated energy planning, Kenya should pursue the following principles:

1. **Increased inter-agency collaboration** so that supply-side planning is matched with equally rigorous demand-side planning to ensure that energy system decisions are compatible with the national economic growth agenda. Cross-sectoral planning in energy prevents duplication and maximizes resources
2. **Effective stakeholder engagement**. Bringing stakeholders earlier into the energy planning process to ensure their input is well captured and articulated

3. **Data driven decision making**. Utilization of digital tools to centralize the energy planning process for optimal resource management and collection of relevant data for decision making
4. **Effective whole-life asset management of the energy system**. This will require a significant shift in the management of energy assets towards an energy ecosystem approach that weaves a contiguous thread through the asset lifecycle. Increasing penetration of renewables and distributed energy resources means that energy utilities will have more assets and asset lifecycles will become increasingly complex
5. **Promoting consumer participation, including incentives for consumer behavioral change and raising awareness of climate change and carbon footprints, and individual responsibility for action.** Paying particular attention to the livelihoods of vulnerable populations is key in driving an inclusive energy transition

Illustration 26: Key actions towards a 360 review and restructuring of the energy planning ecosystem

Action	Description	Barriers to implementation	Solutions	Key owner
Support the establishment of a Central Inter-Agency Planning Unit	There has been momentum to establish a Central Inter-Agency Planning Unit that fosters effective knowledge management and institutional coordination. The unit would aggregate information across supply and demand-side energy sector stakeholders and standardize energy data management for planning purposes	• Difficulty securing adequate resources for an additional agency within the energy sector • Lack of buy-in from stakeholders across sectors	• Support the reconstitution of the LCPDP taskforce as a permanent central planning unit • Engage stakeholders from the on-set and throughout the process of establishing the Planning Unit	Ministry of Energy, Ministry of Industrialization
Development of an energy digitalization strategy	Develop a digitalization strategy and establish a Central Energy data system that allows for two-way management of the energy network	• Poor adoption of technology and digitalization tools that could help with data recording and real-time and proactive management • Poor understanding of risks involved with cybersecurity management	• Support the accelerated adoption of relevant technology and shift towards a digitalized power system • Learn from peers and establish up-to-date cybersecurity procedures	Ministry of Energy
Whole-life asset management practices	Shift to a long-term and integrated approach to management of generation, transmission, and distribution infrastructure			
Develop a consumer engagement strategy	Relevant agencies for energy consumer affairs should educate consumers on the advantages of adopting energy efficient processes particularly for industrial & commercial sectors	• Lack of incentives that encourage relevant actors to be more transparent with their data	• Provide incentives that encourage transparency and data sharing among public and private actors	Ministry or Energy

3.4. Critical Shift 4: Coordinated approach to engaging partners

The aspirations articulated in this paper will require a well-coordinated approach to strengthen collaboration with a wider range of partners to mobilize resources for the energy transition. This can be accomplished through:

1. **Clear Energy Sector Investment Strategy** articulating the government's priorities and funding requirements. The strategy should be synchronized with broader economic planning such as industrialization growth stimulation and skills development

2. **Aligning Foreign Direct Investment (FDI) objectives with the green growth agenda**. Development finance can be channeled to support sector growth ambitions in a better coordinated fashion. This is important considering the role DFIs play in accompanying private investors, via direct financing, blended finance tools, or risk-sharing mechanisms
3. **Accelerating the development of a cohesive, market-wide policy and regulations for long-term sustainable investment**. Fiscal incentives supporting inclusive green investment could catalyze this process. Regulatory initiatives must also embed ESG integration and reporting, including the development of a green taxonomy and improved effectiveness of regulatory enforcement that are aligned with green-seeking investor requirements
4. **Maximize investment return to decrease investment risk and unlock domestic capital pools** including pension and insurance funds. This would increase local-currency-denominated capital, mitigate foreign exchange risk, and potentially reduce the cost of capital. This would in turn stimulate private finance for green investments
5. **Improving financial market policy, to facilitate access to financing for renewable projects**, including strengthening financial sector coordination to ensure access to affordable financing. Government should also seek to support the establishment of new and augmentation of existing appropriate financing vehicles and institutions, such as blended finance and green bonds

Illustration 27: Key actions towards a coordinated approach to engaging partners

Action	Description	Barriers to implementation	Solutions	Key owner
Kenya Energy Sector Investment Strategy	Develop a sector investment strategy to mobilize diversified flows of capital to clean energy initiatives and the broader energy sector. The strategy must also capture relevant policies and regulations aimed at stimulating investment in the sector	• Lack of buy-in from other sectors as this must be a cross-sectoral effort	• Early engagement of relevant stakeholders to ensure collaboration and strategy co-creation	Heads of different ministries and key leaders across sectors
Development of an energy sector collaboration framework	The collaboration framework should define principles and priority areas of partnership to ensure they are mission-aligned and translate into tangible outcomes for the energy sector			
Establishing a "one-stop-shop" for investment promotion and facilitation	Establishing a central mechanism to better coordinate the investment actions of leading development finance players in the energy sector. Such a platform would centralize project funding channels so that project proposals could be treated in a more integrated and efficient way. This would lower transaction costs for both applicants and financiers and ultimately catalyze the flow of capital to clean energy initiatives. A central platform would also facilitate the matching of bankable projects with potential investors, to reduce friction in market processes	• Bureaucracy and poor collaboration and coordination between institutions	• Streamlining administrative and policy processes, and clearly stipulating the functions of different institutions	Ministry of Industrialization , Ministry of Energy

4. CONCLUSIONS AND SUMMARY OF KEY RECOMMENDATIONS

4.1 Conclusions

The transformational outcomes articulated in this White Paper present an ambitious leap for the Energy sector and the country as a whole. The White Paper considers the global energy transition as an opportunity to place a big bet on a developing economy, like Kenya, to be a leader in renewable energy. This paper offers the country a moment of self-reflection on what has been achieved so far and how a vibrant energy sector can be the foundation for Kenya's next phase of growth.

Momentum towards achieving the defined outcomes and pathways, including implementation of the critical shifts will require a concerted effort across sectors and beyond national borders. To become a global leader in green energy, Kenya will need to rally stakeholders across sectors behind one aligned vision to realize targeted investments towards increased generation capacity and expansion of energy consumption. The industrialization sector will particularly be a key actor in the materialization of the projected demand and supply scenarios. Additionally, Kenya's vision necessitates that the country explores opportunities and leverages its competitive advantage within and beyond its regional context.

4.2 Summary of key recommendations

Outcome 1: Establish energy as a transformational public good

While Kenya has significantly improved access to energy for its citizens, affordability and reliability remain a challenge. The proposed recommendations provide a pathway in which Kenya will ensure that every household has access to the energy it needs to power their productivity. These recommendations include, (i) utilizing decentralized energy solutions to increase connectivity rates to a yearly average of 1.3 million households; (ii) reducing energy costs by 50% to ensure Kenya is globally competitive; and (iii) increasing the productivity rate of MSMEs by ensuring 100% access to electricity.

Outcome 2: Position Kenya as a global leader in decarbonization

Kenya's has one of the cleanest electricity grids with 92% of power generated from renewable energy. However, there is still some reliance on other energy sources such as petroleum and biofuels which continue to be a source of greenhouse gases further aggravating the climate crisis. To achieve a low-carbon economy, the paper proposes several recommendations. These recommendations include, (i) fully tapping into the renewable potential for power generation and incorporating emerging technologies such as green hydrogen and waste-to-energy in power generation; (ii) utilizing digital tools to efficiently manage the grid to reduce system losses; (iii) transitioning the 150 MW of installed fossil fuels powered generators to renewable energy, and reducing household use of biomass fuels such as wood and fossil fuels such as kerosene by 50%; (iv) decarbonizing the traditionally high emitting sectors such as steel and cement as well as increasing the adoption of electric mobility technologies and utilizing emerging technologies.

Outcome 3: Kenya takes a quantum leap to 100 GW installed capacity by 2040 underpinned by renewable energy sources

Kenya should tap into the trillions of dollars of global capital ear marked for green energy investments to increase its installed capacity from 3 GW to 100 GW by 2040. This ambition will place Kenya in uncharted territory as it will be operating at a level comparable to developed economies. To achieve this, the paper recommends several actions including, (i) installing an average of 5 GW generation capacity annually for the next 18 years and onwards; and (ii) tapping into global and local pools of capital to attract USD 300 billion of energy investments for generation, transmission and distribution, and demand stimulation.

Outcomes 4: Kenya is an investment destination of choice for industries that are seeking to decarbonize

There has been an unprecedented global convergence of capital as industries seek to channel all new investments into 'green' production in the race to Net Zero. To position itself as an attractive destination for these investments, Kenya should (i) ensure its energy prices are globally competitive; (ii) simplify the process for new businesses setting up in the country; (iii) set up industrial parks close to power generation sites; and (iv) incentivize a 24-hour economy