Intersessional Meeting of the Global Climate Action Programs (GCAP) Sub-Committee

Virtual

Tuesday, January 30, 2024

KENYA (REI) INVESTMENT PLAN

CLIMATE INVESTMENT FUNDS
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GCAP/SC.IS.3/02
January 25, 2023

PROPOSED DECISION

(To be added)

REPUBLIC OF KENYA

MINISTRY OF ENERGY & PETROLEUM

STATE DEPARTMENT FOR ENERGY

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KAWI HOUSE
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NAIROBI

Ref. No. MOE/CONF/1/91/32

23rd November, 2023

Dr. Chris K. Kiptoo, CBS
Principal Secretary
The National Treasury
Harambee Avenue, Treasury Building
P.O. Box 30007-00100
NAIROBI

Dear PS,

SUBMISSION OF KENYA'S INVESTMENT PLAN FOR CLIMATE INVESTMENTS FUNDS RENEWABLE ENERGY INTEGRATION (REI) PROGRAM

As you are aware, Kenya was invited, among 5 other countries in the world, to participate in the Climate Investments Fund - Renewable Energy Integration (CIF-REI) Program by developing an investment plan commensurate to an indicative allocation of up to USD 70 million of resources based on the country's needs assessment.

A CIF National Committee from the Ministry and energy sector agencies was constituted in January 2023 to prepare the Investment Plan with the guidance of the Multilateral Development Banks (MDBs) led by the World Bank. The committee prepared the draft Investment Plan and a stakeholders' consultative workshop was held on 3rd October 2023 to invite comments from various stakeholders. The committee also received and incorporated comments from an Independent Reviewer on the document.

The Ministry is now pleased to submit the Country's Investment plan (IP) to support renewable energy integration by accelerating the uptake of variable renewable energy and enhance grid flexibility and reliability.

This investment plan is considered as a tool to leverage on achieving our goal of 100% transition to clean energy and catalyse socio-economic development across the various sectors. The proposed plan aims to enhance grid flexibility and reliability, promoting technology and market innovation and facilitate open access for renewable energy.

The Investment Plan will leverage USD 70 million in CIF resources to mobilize resources from the World Bank, African Development Bank and International Finance Corporation, other development partners and the private sector in the amount of USD 242.97 million for a combined investment of USD 312.97 million to achieve this objective.

The purpose of this letter therefore is to forward the Investment Plan for your information and for onward submission to the Climate Investment Funds Administrative Unit on or before the deadline date, **28th November, 2023.**

The forwarding address is:

Luis Tineo
Chief Executive Officer
Climate Investment Funds (CIF)
P.O. BOX 1818 H Street, NW,
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Alex K. Wachira
PRINCIPAL SECRETARY

Encl.

Copy to: **Davis Chirchir**
Cabinet Secretary
Ministry of Energy and Petroleum
NAIROBI

Keith Hansen
Country Director, Kenya
World Bank

REPUBLIC OF KENYA

MINISTRY OF ENERGY & PETROLEUM

CLIMATE INVESTMENT FUNDS

CLIMATE INVESTMENT FUNDS
RENEWABLE ENERGY INTEGRATION PROGRAM
INVESTMENT PLAN FOR KENYA

October 2023

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ACRONYMS, ABBREVIATIONS AND DEFINITIONS

ACE:	Area Control Error
AGC:	Automatic Generation Control
AfDB:	African Development Bank
AFD:	Agence Française de Développement (French Development Agency)
AI:	Artificial Intelligence
BAU:	Business as Usual
BESS:	Battery Energy Storage Systems
CCAK:	Clean Cooking Association of Kenya
CIF:	Climate Investment Funds
CIF-REI:	Climate Investment Fund - Renewable Energy Integration
CO_2eq.:	Carbon dioxide equivalent
CTF:	Clean Technology Fund
C&I:	Control & Instrumentation
DC:	Direct Current
DCS:	Distributed Control System
DISCOs:	Distribution Service Companies
EAPP:	Eastern Africa Power Pool
E-cooking:	Electric cooking
EIA:	Environmental Impact Assessment
EIB:	European Investment Bank
ESAK:	Electricity Sector Association of Kenya
EV:	Electric Vehicle
EPRA:	Energy and Petroleum Regulatory Authority
ESIA:	Environmental and Social Impact Assessment
FCDO	The UK Foreign, Commonwealth & Development Office
FiT:	Feed-in-Tariff
GAP:	Gender Action Plan
GDC:	Geothermal Development Company
GDP:	Gross Domestic Product
GGA:	Gender Gap Assessment
GH_2:	Green Hydrogen
GHG:	Greenhouse Gas(es)
GIZ	German Agency for International Cooperation
GOK:	Government of Kenya
GPS:	Global Positioning System
HVDC:	High Voltage Direct Current
ICCP:	Inter-control Centre Control Protocol
IEC:	International Electrotechnical Commission
IFC:	International Finance Corporation
IESR:	Institute of Energy Studies and Research
INEP:	Integrated National Energy Plan

IP:	Investment Plan
IPP:	Independent Power Producer
IRF:	Integrated Results Framework
IT:	Information Technology
ISO:	Independent System Operator
JICA:	Japan International Cooperation Agency
KenGen:	Kenya Electricity Generating Company
KEBS:	Kenya Bureau of Standards
KES:	Kenya Shillings
KETRACO:	Kenya Electricity Transmission Company
KfW:	Kreditanstalt für Wiederaufbau
km:	Kilometre
KMD:	Kenya Meteorological Department
KNBS:	Kenya National Bureau of Statistics
KNDGC:	Kenya National Distribution Grid Code
KNTGC:	Kenya National Transmission Grid Code
KPLC:	Kenya Power and Lighting Company PLC
KSH:	Kenya Shillings
kWh:	Kilowatt-hour
kV:	Kilovolt
LCOE:	Levelised Cost of Electricity
LCPDP:	Least Cost Power Development Plan
LPG:	Liquefied Petroleum Gas
LTS:	Long Term Strategy
MDB:	Multilateral Development Bank
MEL:	Monitoring, Evaluation and Learning
MoE:	Ministry of Energy
MoEP:	Ministry of Energy and Petroleum
MTP:	Medium Term Plan
$MtCO_2eq$.:	Million tonnes CO_2 equivalent
MW:	Megawatt
MWh:	Megawatt-hour
MVA:	Megavolt-Ampere
NEMA:	National Environment Management Authority
NAP:	National Adaptation Plan
NCC:	National Control Centre
NCCAP:	National Climate Change Action Plan
NCCRS:	National Climate Change Response Strategy
NDC:	Nationally Determined Contribution
NSCC:	National System Control Centre
O&M:	Operation & Maintenance
PPP:	Public Private Partnership
PSP:	Pump Storage Plants

PV: Photovoltaic

RE: Renewable Energy

REI: Renewable Energy Integration

REIP: Renewable Energy Integration Program

REREC: Rural Electrification and Renewable Energy Corporation

RIA: Regulatory Impact Assessment

RTU: Remote Terminal Unit

R&D: Research and Development

SAIFI: System Average Interruption Frequency Index

SAPP: Southern Africa Power Pool

SCADA: Supervisory Control and Data Acquisition

SDE: State Department for Energy

SDG: Sustainable Development Goals

SDH: Synchronous Digital Hierarchy

SEforAll: Sustainable Energy for All

SME: Small & Medium Enterprises

SREP: Scaling-up Renewable Energy Program

SS: Substation

STEM: Science, Technology, Engineering and Mathematics

SVC: Static Var Compensators

TA: Technical Assistance

TL: Transmission Line

ToU: Time of Use

TVET: Technical and Vocational Education and Training

UNIDO: United Nations Industrial Development Organization

UNFCCC: United Nations Framework Convention on Climate Change

USc: United States Dollars cents

USD: United States Dollars

VRE: Variable Renewable Energy

WB: World Bank

E-mobility: The principle of using electric propulsion for a wide range of transportation types; includes electric bicycles, scooters and vehicles. Also, Electromobility.

Prosumer: A residential, commercial or industrial customer supplied by a Licensee and generates electricity, on the customer's side of the meter, using a Renewable Energy source whose capacity does not exceed 1 MW;

SDG 5: Achieve gender equality and empower all women and girls.

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

SDG 13: Take urgent action to combat climate change and its impact

Vision 2030: Kenya's economic blueprint which aims to transform the country into a newly industrialising middle-income country providing a high quality of life to all its citizens in a clean and secure environment.

1. PROPOSAL SUMMARY

1.1. Introduction

Kenya is a dynamic and growing economy, which recognises the nexus between Energy, Climate Change and People, and the critical role of achieving the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change. Kenya's fourth Medium Term Plan (MTP IV)[1] recognises that Energy plays a key role in enhancing adaptive capacity, resilience to climate change and resource use efficiency across the different sectors. Decarbonisation of the energy sector and corresponding sectors requires urgent action to enable Kenya to achieve 100% clean energy on the Kenyan grid by 2030, 100% access to clean cooking by 2028 and help keep the country on track to meet its commitment goal of Net Zero by 2050. The Renewable Energy Integration (REI) Program will help enable Kenya to meet her updated Nationally Determined Contributions (NDC) goal to abate Greenhouse Gas (GHG) Emissions by 32% by 2030 relative to the Business as Usual (BAU) scenario of 143 $MtCO_2eq$ in line with her sustainable development agenda.

Kenya's clean energy transition will contribute to achieving universal and affordable energy access, including clean cooking; accelerating renewable energy deployment; providing sustainable heat and power to key industries/sectors for Kenya's socio-economic transformation, and maximising energy efficiency. This entails promoting multiple renewable energy technologies to support energy access as well as clean cooking solutions. A clean energy grid will also be the key driving factor to transform other key sectors of the economy – such as transport, agriculture and industry – which otherwise would contribute to a higher GHG-emissions footprint. Migrating such sectors over time to the use of clean electricity rather than continued reliance on more emissions-intensive fuels will also help position Kenya well on the trajectory towards its 2050 Net Zero goal. As an example, as more Kenyan households shift from using unsustainable biomass such as firewood for cooking to using e-cooking instead, this transition will help reduce deforestation and promote biodiversity, among other development benefits. Achieving 100% net grid energy, especially in a context of growing demand, will require optimal use of the country's renewable resources through a flexible grid to enable a transition to 100% clean electricity that is both affordable and ensures reliable and secure energy supply in a context of growing electricity demand.

[1] Kenya's Energy Sub Sector Fourth Medium Term Plan - 2023-2027

Kenya's Least Cost Power Development Plan (LCPDP) 2022-2041 has realistic demand growth assumptions,[2] re-affirming the optimistic ambitious demand growth assumptions under LCPDPs existing prior to 2021. Expanding clean and renewable energy supply on the grid to meet growing demand for electricity is key to the low-carbon transformation of Kenya's economy to Net Zero by 2050.[3] Kenya has had a long history of attracting private sector investment in generation from Independent Power Producers (IPPs). A feed-in tariff (FiT) Policy was first introduced in 2008 to promote the development of renewables; however, many of such additions were based on earlier assumptions, and a proposed competitive auction framework for solar and wind investments has replaced the FiT policy.

Kenya's remarkable success with increasing penetration of renewable energy on the grid has historically benefited from the strong contribution of hydro and geothermal resources to power generation. Along with hydro imports, the share of renewable energy in the grid in 2023 averaged 90%. However, annual hydro generation fluctuates greatly from year to year, partly due to increased climate change and variability. While geothermal energy reliably supplies a firm base load to the grid, it is curtailed during night-time hours when demand for power is half what it is during peak hours, and Kenya has had to continue to rely on thermals to meet peak and shoulder demand. Achieving 100% net grid energy, especially in a context of growing demand, will require optimal use of the country's renewable resources through a flexible grid to enable a transition to 100% clean electricity that is both affordable and ensures reliable and secure energy supply.

Several constraints related to reliability and flexibility in the transmission grid need to be addressed to integrate and expand the dispatch of variable renewable energy. Integrating variable wind and solar has become increasingly important in achieving the country's 100% renewable energy goal and ensuring the security and reliability of energy supply in the context of a) increasingly variable annual hydro generation enhanced by climate change, (b) along with inadequate flexible must-run capacity; and (c) long lead time for project deliveries/(developing additional n-1 transmission capacity).

The system has a high and inflexible must-run capacity compared to the considerably low off-peak demand which leads to frequent generation curtailment during the low load period, including venting of a substantial amount of geothermal steam. As some parts of the system experience electricity surpluses leading to curtailment, other parts of the country experience shortages during peak hours, leading to higher costs due to continued reliance on thermal generation.

The lack of adequate spinning reserves and high dependence on radial transmission lines connecting large renewable generation assets with distant load centres or on other congested

[2] These were prior actions in the World Bank-financed development policy operations: Accelerating Reforms for an Inclusive and Resilient Recovery DPF (P175251) and Accelerating Reforms for an Inclusive and Resilient Recovery DPF 2 (P176903).
[3] https://energy.go.ke/electrical-power-development-0

lines create imbalances, making the power system vulnerable to both planned and unplanned outages. In this context, while integrating wind and solar on the grid has become increasingly important to meeting the country's 100% renewable energy goal, there's need for targeted investment to assure the security and reliability of energy supply. In the absence of adequate and robust transmission connectivity, local generation based on high-cost fossil fuel has to be used to supplement grid supply in these areas. Improved transmission connectivity and system reinforcements will allow for the dispatch of renewable energy to the major load centres replacing the expensive and emissions-intensive fossil fuel-based generation, helping in the achievement of the country's clean energy goals as well as reduction in the cost of supply and improvement in the quality of supply, including for industries in these regions. For these reasons, Kenya's Renewable Energy Integration (REI) program entails promoting and enabling greater use of multiple kinds of renewable energy technologies -- including those that can help integrate Variable Renewable Energy (VRE) – to meet growing electricity demand, support energy access as well as promote demand for clean cooking and e-mobility solutions.

Kenya's clean energy transition will contribute to achieving universal and affordable energy access, including clean cooking; accelerating renewable energy deployment; providing sustainable heat and power for Kenya's socio-economic transformation, and maximising resource utilisation and energy efficiency. This entails promoting multiple renewable energy technologies to support energy access as well as clean cooking solutions. A clean energy grid will also be the key driving factor to transform other key sectors of the economy – such as transport, agriculture and industry – which otherwise would contribute to a higher GHG-emissions footprint. Migrating such sectors over time to the use of clean electricity – rather than continued reliance on more emissions-intensive fuels – will also help position Kenya well on the trajectory towards its 2050 Net Zero goal.

The Kenya REI Program's Gender Strategy is committed to the promotion of gender equality in the sector – including enhancing women's voice and representation in major sector institutions – and identifies key gender gaps to be addressed. In particular, it emphasises improving human endowments, removing constraints on increased female participation in the labour market including in Science, Technology, Engineering, and Math (STEM) fields, and enhancing women's voice through strategically supporting female participation in leadership and decision-making positions in the energy sector. The design of the Program and its constituent Projects will include targeted interventions to improve female employment and career growth opportunities in the project implementing agencies - KPLC, KETRACO, REREC, KenGen and in GDC building on the earlier work done in the sector. Finally, it will also enable the scaling-up of e-cooking as part of Kenya's overall clean cooking initiatives. Gearing up to supply and support e-cooking can free up valuable time for women and girls to pursue education or economic opportunities – and safeguard their health – rather than spend time on collecting firewood or breathing in unhealthy air while fanning household fires.

The proposed cost of implementation of Kenya's investment plan is summarised in Table 1.

Table 1: Investment Plan Financing Summary

Financing Source		**CIF-REI (MUSD)**	**Leverage (MUSD)**			
Component ↓			**WB & AFDB (Public Sector)**	**IFC (Private Sector)**	**Private Sector**	**Subtotal per Component**
1	Enhancing Grid Flexibility	34.227	103.785	25.00	65.00	228.012
2	Enhancing grid reliability	16.316	25.383	-	-	41.70
3	Technology and Market Innovation	19.182 (14.457 + 4.725**)	23.801	-	-	42.983
4	Facilitating Open Access for Renewables	0.275**	-	-	-	0.275
Sub total		**64.999 + 5****	**152.970**	**25.00**	**65.00**	**312.97**
Total		**69.999**	**242.97**			

***CIF funding includes technical assistance grant funding of USD 5.0M[4]*

The results and indicators presented in Table 5 will play a crucial role in monitoring and evaluating the success of the REI program. These metrics will help track program achievements, CIF outcomes, co-benefits, and progress toward Sustainable Development Goals. The program's objectives

[4] Kenya, which is at a high-risk of debt distress, is eligible to receive 100 percent of CIF financing as grant. CIF Financial Terms and Conditions Policy - Fy24

include enhancing grid flexibility, improving reliability, promoting renewable energy technology and market innovation, and facilitating open access to renewables. The Integrated Results Framework (IRF) will enable tracking and reporting progress towards the program's outcomes and objectives, such as achieving 100% Clean Energy by 2030, enhancing grid reliability, improving gender mainstreaming, developing gazette regulations and policies, and capacity building.

Integrated Results Framework Table

CIF-level Impacts	Indicators	Baseline	Targets
Catalyse Kenya's transformation to 100% Clean Energy by 2030	Clean Energy dispatch (%)	89%	100%
Number of beneficiaries	Annual Capacity building (No)	200	1,000
	Direct Use projects commercialised (No)	1	3
Volume of co-finance leveraged[5]	Volume of co-finance leveraged (USD)	0	CIF 70 MUSD public & Private funding **242.97 MUSD** ratios 1:3
REI Program-level Impacts	**Indicators**	**Baseline**	**Targets**
Concessional climate finance to demonstrate that investments intended to enhance system flexibility, reliability and support energy affordability can enable a transition to 100% clean energy by 2030 and place the country on a long term economy-wide low carbon transformation.	VRE Capacity on Grid (%)	20%	30%
	Reduce Levelised Cost of Electricity (USD cents)	9.24	8.68
Improved policies and regulations	Number of new gazetted or amended policies and regulations that are related to RE integration	0	4

1.2. Objectives

The objective of Kenya's Investment Plan (IP) is to enhance the integration and higher utilisation of Renewable Energy (RE) on the Kenyan grid, thereby enabling the country's

[5] This is based on the maximum CIF funding of 70 MUSD.

transition to 100% clean energy by 2030. The program will enable the scaling up of renewable energy development in Kenya consistent with Kenya's LCPDP, by addressing key barriers and catalysing additional financial resources with the aim of enabling full transition to clean power generation by 2030. The program will contribute to improving grid stability, power quality and reliability, and will also enable projections for real-time and day-ahead power trade as envisaged by the Eastern Africa region to enhance system resilience.

Kenya's energy system currently faces several challenges which cause planned and unplanned outages and voltage issues. Generation surpluses from geothermal and wind generation at night are not dispatched because of inadequate demand during those hours, even as the country struggles to meet shoulder and peak loads during evening hours. Kenya's REI program entails the adoption of enabling technologies to scale up renewable energy uptake on the grid, with the aim of enhancing system design and operation, increasing competition and allowing generators open access to the power market, and enhancing infrastructure to be renewable energy-ready.

Kenya's REI Program will support the addition of technology and capabilities to enhance dispatch planning and system operation efficiency and will provide the enabling infrastructure, technology and innovation to enhance grid stability and flexibility to integrate VREs. In particular, the addition of Automatic Generation Control (AGC) with Supervisory Control and Data Acquisition (SCADA) and Hydromet Forecasting will enhance dispatch planning and system operation efficiency, while Battery Energy Storage Systems (BESS) and reactive power compensation devices projects will provide the enabling infrastructure/technology and innovation to enhance grid stability and flexibility for Integration of VREs.

Kenya's REI program will enable future private sector investment in innovative storage technologies, including for BESS in the short-to-medium term, and to assess needs to support the development of complementary pumped hydro (which has a much longer lead-time). Insights on the proposed private sector investment in BESS will be informed by the experience of KenGen, which is currently planning the implementation of 100 MW/1 hour battery storage financed by the World Bank and the Green Climate Fund (GCF). Kenya's REI will support the establishment of a competitive process to procure BESS and/or hybrid investments, with full specification of requirements, including choice of technology, supply of battery along with electro-mechanical and civil works contractor(s), warranties, and long-term service agreements. Consideration will be given to structuring and providing risk mitigation security to attract qualified bidders for the procurement process.

The program intends to put in place a policy and regulatory framework to guide the development of the sector, including for future private sector investment in innovative storage technologies. This includes assessing the system's needs to provide sufficient clean energy generation capacity to support the country's plans to develop sustainable e-mobility and e-cooking business models and to enable the country's green hydrogen and green ammonia investments.

The program will inform and power the development of infrastructure such as fast charging stations and battery swapping stations across major towns in the country that will lead to a higher uptake of Electric Vehicles, including for mass rapid transport systems. Similarly, the use of electric pressure cookers and other appliances will help shift some of the demand to non-peak and night-time hours. The program will also seek information on the state of distributed captive power and its technical impacts leading to the development of future frameworks and refinement of the current draft policies and regulations.

Kenya's REI program will seek to better balance energy demand and supply in the grid by utilising Time of Use Tariff for small commercial consumers in addition to supporting innovation in clean energy use to supply industry near geothermal fields with low enthalpy steam. It will seek to encourage Small and Medium Enterprises (SME) and women-owned enterprises in such areas, and to develop human capacity for the energy sector (especially among women) through the establishment of Renewable Energy Centres of Excellence and Renewable Energy Laboratory Centres focused on deployment, integration and operation of geothermal, wind, biofuels, and solar technologies. As a leading example, successful implementation of industrial parks or green clusters near geothermal fields will create productive uses for the steam and reduce the need for fossil fuels for thermal energy, while reducing the supply-demand imbalance. Since the costs of producing steam are normally passed through to the off-taker via provisions for power capacity charges in geothermal steam supply agreements and Power Purchase Agreements (PPAs), optimal utilisation of the resource contributes to greater affordability, efficiency, and sustainability of the system.

In addition, the program will facilitate the creation of a competitive environment in the power market to enhance efficiency, and reliability and improve the quality of service within the electricity sector; provide for non-discriminatory open access to the transmission/distribution system; promote the development and use of renewable energy including the establishment of Renewable Energy Centres of Excellence and mobilise the private sector to harness renewable energy resources on the grid.

Through the 2020 Bioenergy Strategy, the Government of Kenya (GoK) is committed to achieving the target of its population enjoying access to modern bioenergy services - including 100% access to clean cooking by 2028 - two years ahead of the schedule set out in the Kenya Sustainable Energy for All (SEforAll) Action Agenda. However, despite these advancements, women still bear a significant burden in terms of lack of access to clean cooking fuels, a challenge faced by many countries.

Significant gender gaps still exist in Kenya's energy sector despite the Constitution of Kenya and existing enabling policy and legal frameworks that support gender equality and the empowerment of women. Some key gaps include the absence of structural and systemic integration of gender equality units/departments at the MoEP and in the energy sector institutions and this program will contribute to addressing some of the noted opportunities for innovation and capacity gaps in the efforts to address the needs of the energy sector through the RE Centres of Excellence. The Program will therefore develop innovations through the Energy Sector RE Centres of Excellence to enhance professional training and internship programs with special focus on female technical staff and university graduate female students in STEM fields to expand utilisation of Renewable Energy as well as increase women's employment in energy utilities, including in managerial roles

1.3. Expected Outcomes

The program will facilitate enhanced integration of renewable energy to reduce greenhouse gas (GHG) emissions in pursuit of the country's Nationally Determined Contributions (NDC) goal and the ambition to have 100% clean energy by 2030 and place it well on the trajectory to achieving Net Zero by 2050 as defined by Kenya's Long-Term Low Emission Development Strategy (LTS[6]). In recent years, 85-93% of annual electricity generation has come from renewables depending on the hydro cycle and the availability of geothermal and other variable renewable resources. Achieving the ambitious goal of 100% renewable energy in the context of growing electricity demand will require the power system to be more flexible and resilient. The expected new demand drivers include electric cooking (e.g. the use of time-of-day pricing to encourage the use of e-pressure cookers during night-time hours) and promote the national goal to achieve 100% clean cooking` by 2028, and wide adoption of electric mobility in the country based on the government's initiatives. The program will support the system to accommodate a greater share of renewables to meet the growing demand without compromising on power system security and stability.

The following additional outcomes are also expected:

- Enhanced power system security with the increased share of renewables, improved system dispatch and operation efficiency, and increased grid reliability.
- Reduced Levelised Cost of Electricity (LCOE) from USD 9.24 cents to USD 8.68 cents[7] through optimised power system dispatch with full utilisation of RE on the grid, and reduced energy losses supported by the use of Smart energy meters.
- Enhanced uptake and optimal usage of renewable energy driven by accelerated adoption of clean cooking and e-mobility stimulated through research and development for rapid technology transfer and integration of Renewable Energy to the grid.

[6] Kenya's Long-Term Low Emission Development Strategy

[7] LCPDP 2022 - 2041

- More optimal Supply-Energy balance by productive use of steam produced for generation by geothermal but not dispatched as a result of low night-time demand.

- Accelerated conclusion of national policies and regulations including, The draft Energy (Electricity Market, Bulk Supply and Open Access) Regulations, The draft Energy (Renewable Energy Resources) Regulations, The draft Energy (Feed-in Tariff) Regulations and The draft Energy Auctions Policy, for promoting the integration of RE into the interconnected grid system through innovative and competitive means so as to achieve 100% Clean Energy dispatch by 2030.

- Accelerate Gender mainstreaming in the energy sector, for gender-inclusive human resource development and deployment with practical exposure to trainees through attachment, internship, fellowship and mentorship programs for girls and boys, the youth, women and men.

1.4. Program Criteria, Priorities, and Budget

The IP prioritises projects included within one or more of the following categories from the CIF-REI Program, assessed and defined by the Government of Kenya (GoK) with the assistance and support of Multilateral Development Banks (MDBs) in the following way:

- **Enhancing grid flexibility:** The program aims to improve grid stability, power quality and flexibility, enabling projections for real-time and day-ahead power trade envisaged by the Eastern Africa region, under the Eastern Africa Power Pool (EAPP), as well as provide ancillary services to the power system. This will lead to increased power system flexibility and reliability in a cost-effective manner by managing the variability and uncertainty to increase uptake and penetration of renewable energy without curtailment of renewable generation. The intervention entails the implementation of Automatic Generation Control (AGC), Hydromet Forecasting, Battery Energy Storage Systems (BESS) and reactive power compensation devices projects.

- **Enhancing grid reliability:** The program aims at the development of enabling infrastructure in order to ensure adequate and reliable power grid capacity, including the distribution automation necessary to support the total evacuation and utilisation of generated renewable energy. Any interruption of the network particularly in sections lacking n-1 redundancy affects evacuation of power and may lead to curtailment of generation from renewable energy sources with a high probability of reverting to conventional thermal power generation. Smart grid development, acquisition of strategic spares, mobile substations and automation of conditional O&M will enhance power quality, supply reliability and grid security, and enhance RE absorption capacity.

The program will provide an enabling environment to minimise grid imbalances, especially in variable renewable energy distributed generation through implementation of distribution automation. In addition, harnessing more renewable energy in the country's energy mix is expected to reduce the cost of energy in the long run, leveraging on the reduced cost of clean energy technologies. This program supports Kenya's goal to attain a 100% clean energy transition for the power grid by 2030.

Automation of condition monitoring of power systems will provide real-time monitoring of critical power system equipment, reduce operation and maintenance costs and ease planning for equipment retirement and decommissioning by leveraging on the health indices determined from Enterprise Asset Management (EAM) data analytics. With the extensive network, maintenance is becoming a critical component towards ensuring security in evacuation and supply of electric energy generated from renewable energy sources.

In addition, the program will support the deployment of Smart Meters to enhance supply efficiency by minimising energy losses. Higher efficiency would result in lower overall electricity tariffs and achievement of the set targets for the distribution utility in the current electricity tariff[8] and thus add to the overall sector financial sustainability which is critical to achieving the ambitious goals.

- **Technology and Market Innovation**: The program aims to promote innovation through skills development and new business models that attract investment by encouraging the use of renewable resources (e.g. heat from geothermal steam for industrial purposes instead of heat from burning charcoal or fossil fuels, including diesel). The government is planning dedicated green clusters and industrial parks to encourage investment by industry (including SMEs) to be located close to such existing facilities. Developing the Centres close to generation hubs such as Menangai, Olkaria and Baringo-Silali will help mitigate some of the capacity constraints on the transmission grid. Investing in battery storage at such centres will allow surplus energy supplied under PPAs from generation during non-peak hours to be stored and dispatched as a firm renewable supply to meet peak demand.

- The government has put in place plans to establish energy resource parks, a production zone or production cluster reserved for industrial development, with specialised infrastructure required by the industries such as access roads, water supply, electricity and thermal heat supply connectivity and provide the investors with space to set up industries and production plants near the renewable energy supply sources, e.g. geothermal facilities. The setting up of the proposed innovative direct-use energy resource park and commercialisation of direct-use projects will attract local and foreign direct as well as

[8] Approved 4th Retail Electricity Tariff April 2023, EPRA

private sector investment. This will enhance the productive use of clean energy in the industrial sector.

- The use of green energy in the form of steam and power at such industrial resource parks is a good opportunity to ensure that women's voices and perspectives are included in the planning and decision-making processes through inclusive consultations and meetings with women-led businesses, women's organisations, and local community members to understand their needs, priorities, and suggestions for the project. The infrastructure within the industrial park will be designed with a gender-responsive approach considering women's specific needs in terms of safety, accessibility, and amenities within the park to support the participation of women workers and entrepreneurs.

- Technology-specific RE Centres of Excellence will be developed for geothermal, hydropower, wind and solar, which will promote research, training and host demonstration hubs. They will also address the challenge of inadequate skilled manpower in energy-related areas that impact on Kenya's ability to tap into its abundant renewable energy resources as captured in the LCPDP. The development of the Centres will serve as a catalyst for knowledge, skills, and technology transfer, positioning Kenya to develop a gender-inclusive workforce. Experience from the Centres and other parts of the program will be disseminated and will provide input into the program implementation. The Centres will be the repositories for Industry data and will facilitate research to enhance knowledge and will also host knowledge-sharing forums and benchmarking, especially South-South exchange. This initiative will not only provide comprehensive training and development opportunities for a diverse group of professionals and experts, youth, women and men, within the energy sector but also equip them to effectively address the challenges associated with the integration of VRE into Kenya's grid.

- The Centres will provide equal opportunities for both women and men to access training, development programs and then job opportunities. This program is expected to promote gender balance among the professionals and resource persons who undergo training, creating a gender-responsive and diverse pool of skilled manpower in the renewable energy sector. Gender will also be integrated upstream when designing the curriculum of the training offered by the Centres to address gender bias by creating an inclusive and supportive learning environment exempt from stereotypes and that takes into consideration the specific needs, interests and roles of women and men in the energy field. Gender mainstreaming will be embodied through a gender-balanced team of trainers who will foster an atmosphere that promotes women's empowerment and values the contributions of both women and men in the renewable energy sector. The RE Centres of excellence will seek to encourage and support women's leadership roles in order to actively contribute to decision-making processes within the Energy Sector. Gender-disaggregated data collection and analysis will enable monitoring of the progress and impacts of the capacity-building programs, identify any gender disparities, and inform future improvements in the training initiatives. Lastly, engagement of gender-responsive communication and outreach strategies will be undertaken to promote the Renewable Energy Centres of Excellence by using diverse and inclusive messaging that appeals to both women and men, showcasing the opportunities and benefits of participating in the program.

- Power demand growth in Kenya has largely been driven by GDP growth, population growth, urbanisation, electrification, and the implementation of government priority projects. The program will focus on stimulating increased demand for clean electricity from new drivers, notably e-mobility[9] and e-cooking, which will enhance the growth in demand for clean electricity and improve Kenya's economic development, while helping reduce GHG emissions from the fast-growing transport and cooking sectors.[10] It will also guide the private sector to develop e-mobility and e-cooking business models. which also provides other key development co-benefits. For example, the program will kick-off and demonstrate support for infrastructure development that will ultimately lead to a higher uptake of e-mobility options, including mass rapid transport, and investments such as pilot public fast charging infrastructure and battery swapping stations across the country. Electric vehicles can also power homes and inject energy into the grid during peak demand. Similarly, increased uptake of e-cooking will reduce reliance on inefficient and unsustainable biomass by households, reduce pressure from deforestation, and lower cooking costs and time spent on gathering firewood and cooking where women and girls often bear the disproportionate burden of such tasks.

- This program will facilitate access to finance and investment opportunities for women-led businesses interested in developing E-mobility and E-cooking business models. This will be achieved by creating a supportive ecosystem (including business incubators and accelerators, where appropriate) that encourages and enables women entrepreneurs to invest and innovate in these sectors. Then, designing of E-Mobility including mass rapid transport systems and E-cooking infrastructure with a gender-responsive approach will ensure a better and faster return on investment. Considering women's specific needs in terms of accessibility and safety will also encourage the smooth operation and usage of these technologies by women consumers. Women will therefore be engaged in E-Mobility and E-Cooking Initiatives as users and consumers. The program therefore will target women entrepreneurs and workers to empower them with the skills and knowledge required to participate in the development and operation of infrastructure, such as fast charging and battery swapping stations.

- **Facilitate Open Access for Renewables:** The program will attempt to address the challenge of inadequate support for inclusive energy framework and infrastructure. The program also aims to put in place gender-responsive policy and regulatory frameworks to provide for non-discriminatory open access to the transmission/distribution system; Sustainable exploitation of RE resources and promote the use of renewable energy technologies by providing prosumers with energy banking solutions to the grid.

[9] Road Map to E-mobility in Kenya
[10] Kenya Cooking Sector Study undertaken by MoEP and CCAK, 2019

To further promote the utilisation of Renewable Energy, a number of regulations that are currently under development will further catalyse the development and uptake of VREs. These regulations include but are not limited to Renewable energy resources regulations, Electricity market and open access regulations, and Net Metering and system operations regulations to operationalise the Energy Act 2019.

- Gender Mainstreaming in the Energy Sector is envisaged to ensure that women's perspectives and voices are actively included in the planning and decision-making processes of the program via women's representation in project management and advisory committees to provide diverse insights and ideas. Related training and capacity-building programs that focus on RE technologies will be provided through an inclusive process at all stages from program conception, through delivery and communication in a gender-responsive manner.

2. COUNTRY CONTEXT

2.1. Introduction

Kenya's economy has shown signs of resilience in the face of recent multiple challenges, including the COVID-19 crisis. The Republic of Kenya with a population of approximately 50.6 million people had a Gross Domestic Product (GDP) of approximately KES. 13 trillion,[11] (USD 113.42 Billion) as of 2022, which reflected an expansion of 4.8% over the previous year. Although GDP growth decelerated in 2022 following its strong post-COVID-19 rebound, it still remains broadly aligned with the average for the pre-pandemic decade. The recent worst drought in four decades that the greater Horn of Africa region experienced led to a contraction of Kenya's agriculture sector by 1.6% year-on-year in 2022 and increased food prices, subjecting millions of people to severe food insecurity and loss of livelihoods.[12] Growth in real Gross Domestic Product (GDP) is expected to be 5.0% in 2023 despite political tensions and uncertainties in the global outlook. Disruption in supply chains due to the Russia - Ukraine war and higher commodity prices including fuel, fertiliser, and food, made Kenya's inflation rise to over 9% by September 2022. To mitigate the impact of the rising inflation, the government responded by tightening monetary policy and introducing subsidies on fuel, electricity, and maize flour. From September 2022, the government withdrew maize flour and petrol price subsidies but retained subsidies on diesel and kerosene and fertilisers. Inflation finally started to decline from April 2023 and stands at 6.7% currently (August 2023).[13]

Looking ahead, Kenya Vision 2030 aims to transform Kenya into "a newly industrialising, middle-income country providing a high quality of life to all its citizens by 2030, in a clean and secure environment."[14] Addressing its infrastructure deficit has been at the core of Kenya's development strategy, and it has invested heavily in improving roads, rails, ports networks, and energy infrastructure. Clean, adequate, affordable, and reliable energy is essential to meet the goals of Vision 2030. Kenya has committed itself to 100% clean energy on the grid (electricity) by 2030 (COP 26 Global Summit). Kenya's updated Nationally Determined Contribution (NDC, 2020)[15] includes a commitment to achieve Vision 2030 through a low-carbon, climate resilient development pathway. It also has an ambitious target to reduce emissions by 32% relative to the business-as-usual scenario of 143 $MtCO_2e$ in 2030.

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[11] KNBS Economic Survey 2023

[12] Kenya Economic Update: June 2023

[13] Kenya National Bureau of Statistics

[14] https://vision2030.go.ke/

[15] Kenya's Updated NDC, December 2020. https://climate-laws.org/documents/kenya-first-ndc-updated-submission_3720?id=kenya-first-ndc-updated-submission_31ad

The Government's goal of universal access to clean, adequate, affordable, and reliable electricity is critically dependent on a robust transmission system to connect the main generation sources (geothermal, hydro and wind) in the central Rift Valley and eastern part of the country to the major load Centres and to allow for greater connectivity to regional hydropower resources. In particular, the load centres in the western and coastal regions are far from the supply sources (over 400 kms) and in the absence of adequate transmission connectivity, local generation based on high-cost fossil fuel is used to supplement grid supply in these areas. Replacement of the fossil fuel-based generation is a critical element to reducing the cost of supply in Kenya, which is high in terms of regional standards, impeding economic growth, human potential, and the competitiveness of Kenyan industries.[16]

While Kenya has very low GHG emissions, it is highly vulnerable to the impacts of climate change.[17] Kenya accounts for only 0.1% of global emissions but is ranked 143 out of 188 countries in terms of its vulnerability to climate change impact (a lower ranking means greater vulnerability).[18] According to climate projections, the increase in mean annual temperature in Kenya is projected to be between 1°C and 2°C by the 2050s and by up to 5°C by 2100. Climate and disaster risk screening indicates that Kenya has a high risk of river, urban and coastal floods, landslides and wildfires, which will add further stress to Kenya's climate vulnerability. An increase in the frequency and severity of extreme weather events would inflict a heavy toll on human lives and welfare, with a high risk of damage to the country's scarce and valuable human and natural capital. The poorest, most marginalised, and most vulnerable households and communities will be hit the hardest, as income and health shocks will drive them deeper into poverty. Infrastructure assets including electricity transmission and distribution networks can be vulnerable to both chronic and acute climate hazards. According to the World Bank's Lifelines report, the cost of disruption to the power sector due to natural shocks in Kenya was about 1.14% of GDP in 2019.[19]

2.2. Current Electricity Status in Kenya

2.2.1. Generation Capacity

Kenya is already reaping benefits from her diversified generation mix and connectivity to regional hydropower resources has enhanced security of supply in the face of the longest drought experienced in the country in four decades. Kenya's installed electricity generation

[16] Kenya's average tariff for businesses, of about USc 18 /kWh is relatively high by compared to its neighbours (Tanzania, 10.2 USc/KWh; Uganda's 17 USc/KWh Ethiopia, 3.5 USc/KWh)

[17] https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-9/

[18] World Bank Group, Climate Risk Country Profile (2021) https://climateknowledgeportal.worldbank.org/sites/default/files/2021-05/15724-WB_Kenya%20Country%20Profile-WEB.pdf

[19] In fact, fossil fuel-based generation also decreased from about 13 percent in FY2022 to a little over 11 percent in F2023 (until April 2023)

capacity of 3,246 MW comprises of hydro (839 MW), thermal (615 MW), geothermal (940 MW), wind (436 MW), Solar (210 MW), Imports (200 MW), Biogas 2 MW, Off Grid thermal 42 MW, Off Grid wind 0.55 MW and Off Grid solar 3.39 MW as depicted in Figure 1. As of September 2023, the system peak demand recorded was 2,170 MW and the highest gross energy demand in a day was 40,410 MWh. As can be noted from figure 2, Geothermal and hydro have been contributing on average about 45% and 19% of the energy respectively. Wind and Solar Energy account for approximately 17% and 3% respectively. The electricity baseload is predominantly supplied by hydroelectric power and geothermal power plants while the medium and peak load power is catered for by the VREs and thermal power plants. Despite the reduction of the national hydro generation from an average of 26% in FY 2021/22 to about 19% in FY 2022/23 (April 2023) due to a severe drought, fossil fuel-based (thermal) generation did not increase to compensate for it due to imports from Ethiopia (hydropower) from November 2022 following the commissioning of the 500 kV High Voltage Direct Current (HVDC) Ethiopia-Kenya interconnector in November 2022. Under average hydrology, around 90% of total generation has previously been from renewable energy resources, mainly geothermal (45%), hydro (26%), and wind and solar (19%). With geothermal costs at ~USc8.5/kWh, hydro at ~USc3-5/kWh (fully depreciated), and with future competitive auctions for solar and wind anticipated in the range of USc5-7/KWh (depending on size, locations etc.), and with import of hydropower from Ethiopia (at USc6.5/kWh).

Kenya is now connected to Ethiopia's vast hydropower resources, giving impetus to regional energy trade through the Eastern Africa Power Pool (EAPP). As a first of a kind in Sub-Saharan Africa, the Eastern Electricity Highway Project (EAHP) is co-financed by the African Development Bank (AfDB) and the French Development Agency (AFD). This interconnection is a flagship of power trade in the EAPP region and provides a key part of the infrastructure needed to eventually connect the EAPP to the South African Power Pool (SAPP). Electricity Imports now contribute about 5% to the main grid with a recent notable increase after the successful completion of the 1,047 km electricity highway between Kenya and Ethiopia regional Interconnector. While the interconnection has a transfer capacity of up to 2,000MW, constraints in Kenya contributed to limiting offtake to 200MW in the first phase. Urgent investments are needed to address transmission capacity and other constraints to increase uptake to 400MW by 2026 and further enable the wheeling of power down south to realise the full benefits envisaged from the interconnection.

Kenya has a unique opportunity in the near future to meet its electricity needs almost entirely from green energy sources and at affordable costs. Variable Renewable Electricity (VRE) penetration in Kenya is represented by the combined capacity of solar and wind, amounting to 646 MW or about 20% of the country's total interconnected system. The projected Variable Renewable Energy (VRE) capacity established from the Least Cost Power Development Plan 2022-2041 indicated that the deployment of 400 MW of BESS between 2024 and 2030, would further enhance the penetration of VRE to reach 454 MW for solar and 691.4 MW for wind, potentially accounting for as much as 24% of the projected installed capacity by 2030. VRE penetration could potentially reach 30% by 2030 if the proposed REI program is fully financed and implemented.[20] This substantial growth in VRE capacity is poised to have an impact on balancing electricity demand and supply, leading to lower emissions from the e-cooking and transportation sectors, which in turn will make electricity more accessible, affordable, and environmentally sustainable. The adoption of e-cooking, and e-pressure cooking in particular, will shift demand to night-time hours substantially as households plug in their appliances at night, thereby balancing electricity demand and supply and reducing curtailment while reducing the average amount of time spent on cooking, a home-based activity that predominantly affects girls and women.

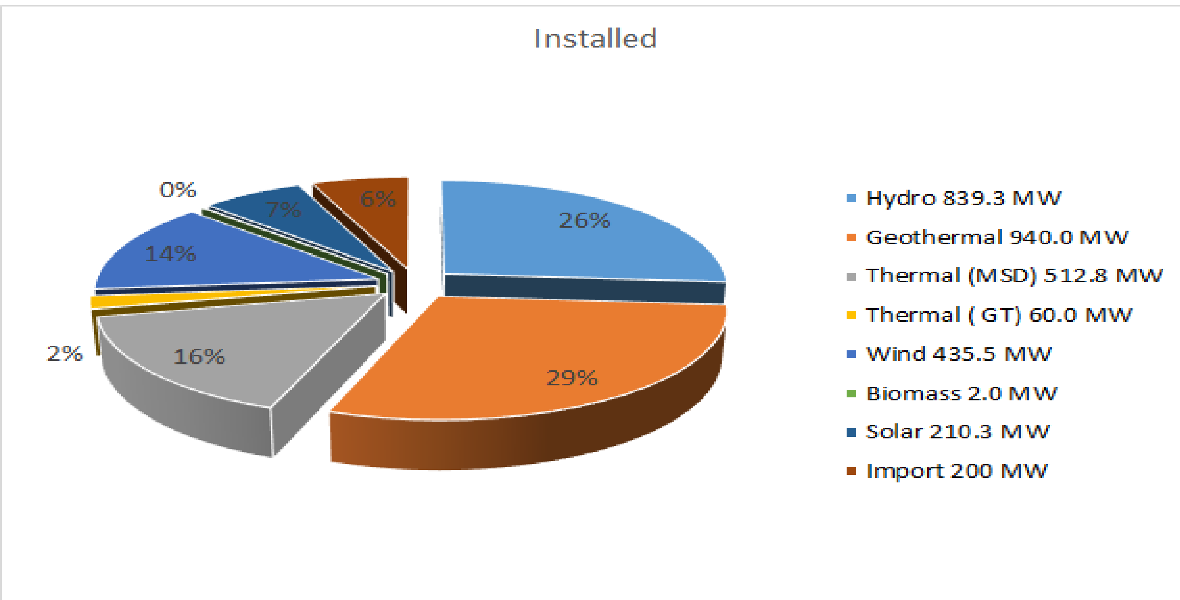

Figure 1: Installed capacity in the interconnected system June 2023. Source: Kenya Power

[20] LCPDP 2022-2041

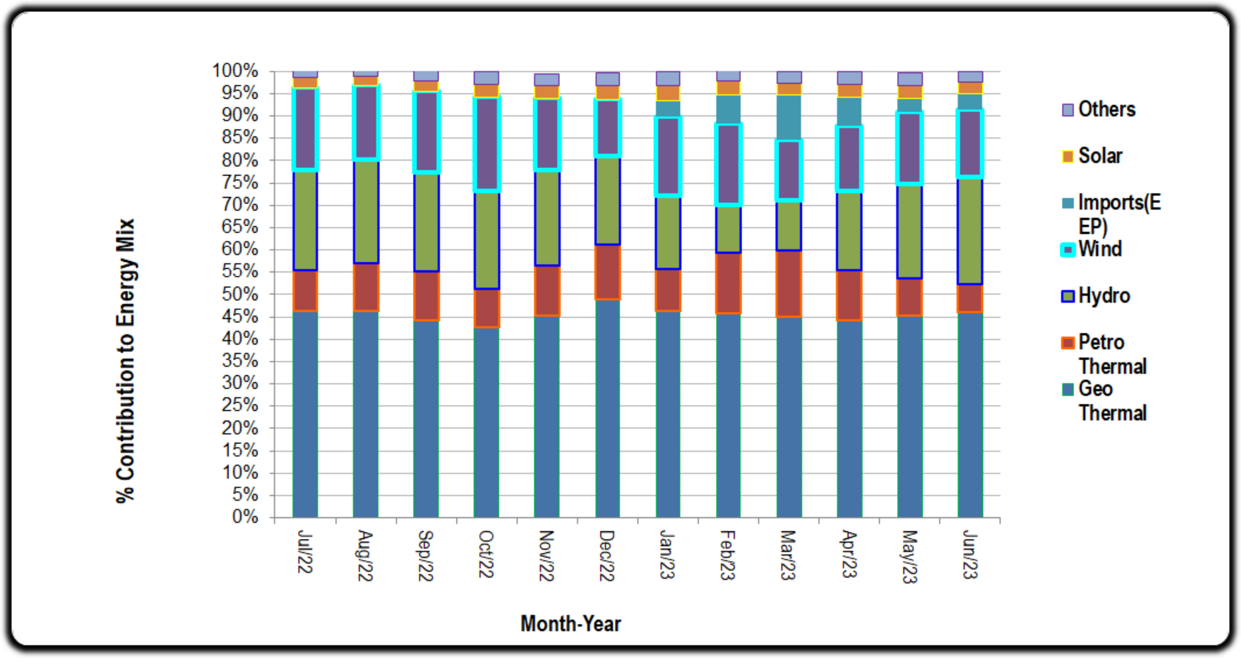

Figure 2: Contributions to the monthly generation mix by various sources: Source; EPRA

2.2.2. Transmission and Distribution Systems.

The National grid has two components, that is, transmission and distribution networks.

The power transmission network comprises 500 kV HVDC, 400 kV, 220 kV and 132 kV transmission lines and related substations, though the network is currently being operated at 220 kV and below, pending completion of additional 400 kV infrastructure. The total transmission network (500 kV, 400 kV, 220 kV, 132 kV) as of 30th June 2023 was 7,676 kilometres.

The power distribution grid has a coverage network of approximately 82,210 km for medium voltage levels (66 kV, 33 kV and 11 kV) and 200,050 km for low voltage with a cumulative number of customers connected at 9,213,047 as of June 2023. The country aims to attain universal access to electricity by 2026 by investing in among other interventions distribution grid intensification, expansion, and modernisation to improve the access, reliability and integration of more renewable energy.

Regionally, Kenya is connected to Uganda via a 132 kV line and Ethiopia via a 500 kV HVDC transmission line. Currently, the country is constructing a 400 kV Kenya - Tanzania interconnector and 400 kV Lessos - Tororo transmission line with a capacity of 1,200 MW linking Kenya to neighbouring Uganda, Rwanda, Burundi and the Eastern part of DR Congo. The implementation of the regional power interconnectors is coordinated under the Eastern Africa Power Pool (EAPP), Nile Equatorial Subsidiary Action Programme (NELSAP), Northern Corridor Integration Projects, East African Community (EAC) and Zambia - Tanzania - Kenya (ZTK) frameworks.

In addition, KETRACO plans to develop 11,131 km of transmission circuit length and 18,866 MVA substations by 2042 according to the KETRACO Transmission Master Plan 2023-42. The planned/ongoing transmission projects will provide reliability, enhance security of power supply to the existing demand hubs in the country; expand electricity transmission capacity necessary to enhance electrification initiatives and reduce technical losses.

Some of the challenges facing the Kenyan power grid are:

- **Demand and Supply imbalance**

  There is an imbalance experienced during the low demand period where energy curtailment is done due to high must-run capacity. Conversely, the system also experiences power shortages during peak hours especially when the available VRE is low. This results in suboptimal utilisation of RE and increased generation costs.

- **Inadequate Transmission Capacity**

  The existing transmission system capacity is severely constrained particularly during peak hours when system voltages in parts of Nairobi, Western and Mt. Kenya Regions drop below acceptable levels, leading to occasional load shedding despite the availability of generation capacity in other parts of the country, particularly in the Coast, Olkaria and Seven Forks. The problem is partly due to inadequate reactive power in major load Centres and also transmission constraints, particularly in the Western and Nairobi regions. The network also experiences vandalism of transmission and distribution assets which sometimes results in major outages in the absence of alternatives to the transmission path.

- **Total System Blackouts**

  Many parts of the network are not designed to the level of redundancy required to comply with the desired n-1 criteria for adequate reliability. Occasional blackouts are experienced, attributed to sudden loss of major generation sources or transmission lines. In the recent past, the high percentage of VRE without storage and adequate system spinning reserve has led to system instability and raised the risk of total blackouts. As VREs increase without storage and adequate spinning reserve, system resilience will be more compromised.

- **System Losses**

  High losses in the system are due to technical and non-technical factors which reduce the overall efficiency of the grid. As of June 2023, technical losses stood at 12.55% while commercial losses stood at 10.45% resulting in overall system losses of 23% against the allowed system losses of 19.5%[21]. This has an impact on the cost of electricity as the loss level is factored in deriving the retail tariff.

- **Inadequate Policies & Regulations**
  Long lead time and high cost of VRE due to Inadequate Policies and Regulations relating to development and competitive procurement.

- **Technical Capacity Constraints**
  Inadequate technical employees for system planning, operations and maintenance, and gender balance in the power sector. Succession planning and staff retention challenges impact negatively on knowledge management, and skills development which affects grid development and stability. As new technologies are adopted e.g. BESS there is a need for new technical expertise in these emerging fields for seamless integration to the existing grid.

2.3. Summary of National and International Climate Strategies and Plans

Kenya is highly vulnerable to climate change and has faced several extreme weather events which can be attributed to climate change, including prolonged droughts and flooding which have been recurring at an increased frequency leading to famine and loss of life and livelihoods. In response to these frequent climate related emergencies, Kenya developed a National Climate Change Response Strategy (NCCRS) in 2010, the first National Climate Change Action Plan (NCCAP) in 2013 and a National Adaptation Plan (NAP) in 2015. The strategy and plans have provided a vision for a low-carbon and climate-resilient development trajectory. To further strengthen the efforts the National Climate Change Framework policy was adopted and the Climate Change Act (2016) was enacted to facilitate an effective response to Climate Change.

Kenya, as a Party to the United Nations Framework Convention on Climate Change (UNFCCC), submitted her intended Nationally Determined Contribution (iNDC) in July 2015 as a commitment to tackling climate change by pledging to reduce its emissions by 30% from the Business as Usual (BAU) scenario of 143 $MtCO_2eq$. In 2020, Kenya enhanced her pledge through the updated NDC submitted to the UNFCCC communicating her increased ambition by pledging to reduce GHG emissions by 32% relative to the BAU scenario in line with her sustainable development agenda. The total cost of implementing the Mitigation and Adaptation actions in the updated NDC is estimated at over USD 62 Billion. Kenya intends to mobilise domestic resources to meet 13% of

[21] Allowed losses as per EPRA's Retail Electricity Tariff Review 2022/23 - 2025/26, Gazette Notice No. 3899 dated 24th March 2023.

the estimated budget while the budget balance of 87% is subject to international support. The timeframe for the implementation of this NDC is up to 2030 with milestone targets by 2025.

The National Adaptation Plan (NAP 2015-2030)[22] developed by the Government of Kenya in partnership with key stakeholders was submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2017. This was part of the government's response to the climate change challenges facing the country. The NAP was Kenya's first plan for adaptation and demonstrated its commitment to operationalise the NCCAP through the mainstreaming of adaptation measures across all sectors in the national planning, budgeting and implementation processes. This mainstreaming approach recognised that climate change is a cross-cutting sustainable development issue with economic, social and environmental impacts. The NAP established Kenya's national circumstances, focusing on current and future climate trends, and described the country's vulnerability to climate change. The NAP also elaborated on the institutional arrangements, including the roles for monitoring and evaluation processes.

Kenya's fourth Medium Term Plan (MTP IV)[23] recognises that Energy plays a key role in enhancing adaptive capacity, resilience to climate change and resource use efficiency across the different sectors. It also notes that Environmental Management in the energy sector is critical to ensuring sustainability in the energy value chain. Kenya's priority in mitigation activities include: Increasing renewables in the electricity generation mix with an emphasis on renewable sources such as geothermal, hydro, wind and solar; this creates a critical role in moving Kenya towards a green economy trajectory.

Climate change impacts have been experienced in Kenya, notably in the Energy Sector, which has faced electricity shortages and load shedding due to frequent and prolonged droughts. This in turn impacted negatively on the Country's economy, which continues to rely on expensive thermal generation. Clean and sustainable energy is therefore essential for Kenya's sustainable development and is considered one of the infrastructure enablers of the socio-economic pillar of Kenya's Vision 2030.

The actions to achieve this objective are defined by the National Climate Change Action Plan (NCCAP) 2023 – 2027, which anticipates the development of 589 MW of new renewables comprising of Geothermal (208 MW) prioritised as baseload generation that is climate resilient, Solar - 174 MW, Wind - 161 MW and two biofuel plants developed for value chain addition by the private sector by June 2028.

The NCCAP 2018-2022 projected Kenya's energy sector contribution to GHG emissions to increase sharply between 2015 and 2030. The energy sector (excluding transport and industry) accounted for 7.1% of total emissions in 2015 and was projected to rise to 29.7% of total

[22] Government of Kenya, 2023

[23] Kenya's Energy Sub Sector Fourth Medium Term Plan - 2023-2027

emissions by 2030. The NCCAP 2018-2022 therefore sought to ensure an electricity supply mix mainly composed of renewable energy that is resilient to climate change. In addition, unless addressed, GHG emissions from deforestation, agriculture, transport and industry are also projected to increase rapidly in coming years, making e-cooking solutions, e-mobility, and applying green hydrogen solutions such as green ammonia and green industry attractive areas for climate mitigation. Each of these solutions is enabled by increased production and use of clean energy.

The energy sector in Kenya is guided by the Energy Act, of 2019 and the 2018 Energy Policy. These policy documents prioritise the shift from fossil fuels and unsustainable biomass to renewable energy sources. The Government of Kenya also through the 2020 Bioenergy Strategy is committed to achieving the target of its population enjoying access to modern bioenergy services, including 100% access to clean cooking, by 2028, two years ahead of the schedule set out in the Kenya Sustainable Energy for All (SEforAll) Action Agenda. Kenya has therefore made significant strides towards realising the objective of Sustainable Development Goals 7 and 13 of ensuring access to affordable, reliable, sustainable and modern energy for all, particularly electricity access and climate action.

Kenya is therefore committed to meeting her Paris Agreement energy-sector targets as contained in the Nationally Determined Contributions (Government of Kenya, 2023) which is also important to transform several other sectors of the economy (e.g. transport, household cooking, agriculture, industry) to contribute to meeting Kenya's long-term objective of net zero by 2050, subject to accessing the requisite investment and financial resources. Enabling the financing and integrating new and emerging renewable energy technologies is the key to enabling Kenya to move towards a just, clean energy transition and to usher in a process of green transformation of its economy.

2.4. Current State of Gender and Energy in Kenya[24]

Access to clean and affordable energy is essential for sustainable development. Energy policies and programs play a critical role in meeting the energy needs of both men and women in households and for income generation. The energy sector also offers opportunities for quality paid employment. Recognising the different priorities that men and women have in accessing energy services, involving women in decision-making processes, and creating opportunities for women within the energy sector can contribute significantly to advancing gender equality. By prioritising gender-responsive approaches, the energy sector can play a key role in promoting inclusive development and empowering women.

[24] Gender and Energy brief Kenya by AfDB, CIF, Energia

2.4.1. Gender and Energy Data

Gender-disaggregated data in the energy sector is limited, hindering a comprehensive understanding of differentiated energy needs between men and women in Kenya. While some progress has been made in women's representation in leadership positions, gender imbalances persist. The current Gender Policy in Energy aims to mainstream gender in energy policies and programs, promoting inclusivity and access to clean energy solutions. However, challenges remain, including inadequate gender-disaggregated data, insufficient financial resources, and limited gender-sensitive monitoring and evaluation systems. Despite efforts to engender projects, many programs and policies remain gender-neutral, failing to address gender differences in access and impacts. Addressing these challenges is crucial to advancing gender equality in the energy sector and ensuring inclusive development.

In terms of representation, employment, and decision-making in the energy sector, women make up 35% of the total staff and hold 15% of the technical leadership positions at the Ministry of Energy's Headquarters[25].

The findings of Gender Gap Assessments (GGAs) in two energy sector companies show that the workforce participation of women is low, especially in technical fields and leadership/decision making positions. The GGA report of KPLC[26] (March 2023) shows that out of the total staff of 9,527, only 2,171 (23%) are women and 7,356 (77%) are male. Women in technical fields and leadership positions are only 9% and 16% respectively. Similarly, the Gender Gap Analysis (GGA) report for KenGen[27] (June 2023) identified that out of a total of 2,595 staff, only 649 (25%) are female and 1,946 (75%) are male. Women in technical fields are only 12 percent and while men dominate all higher levels of jobs under management, women are placed in the lowest level of employment.

The proposed Program will strategically address the identified gender equality gaps and work towards narrowing the gender gap; through holistic and sectoral gender interventions.
The implementing agencies, including MoEP, KPLC, KenGen, KETRACO and GDC are expected to have gender equality work programs. Some of the main activities will include the development of a sectoral five-year gender action plan (GAP) with specific strategic activities. MoEP will lead the revision of the gender in energy policy, establishment of sectoral gender technical working group, development of guidelines to integrate gender equality unit/department within the structure of the energy sector institute, designing feasible energy sector female talent acquisition programs to strategically attract female talent, developing tailored gender awareness capacity building programs targeting leaders and managers and conducting impact evaluation assessment on two

[25] Ministry of Energy, 2019
[26] KPLC March 2023
[27] KenGen June 2023

areas etc. The scope of KenGen GAP will be defined based on its five-year gender equality strategy. Some of the action items will be related to creating a systemic workplace-enabling environment supporting gender equality through availing a supportive institutional legal framework. Sector agencies including KPLC, KenGen, KETRACO and GDC have gender policies and respective committees established to support implementation.

2.4.2. Moving towards gender-responsive renewable energy In Kenya

In Kenya's energy sector, gender is strongly recognised, and the Ministry of Energy and Petroleum has a specific gender policy. To realise gender goals, national commitments should include full policy implementation, extending the solar access program, facilitating electricity connectivity for vulnerable groups, and collecting disaggregated data. It should also systematise gender impact assessments on projects and periodic monitoring to evaluate gender mainstreaming efforts. Assessing affordability and sustainability of electricity connections and investing in gender-responsive approaches in policies and programs, are also crucial to ensure their economic success and social relevance.

2.5. Enabling Investments for Kenya’s Energy Transition

Kenya has leveraged on her geographic advantage and clean energy abundance to attract high potential opportunities in the shift to decarbonisation, integration of renewable energy and reduction of greenhouse gas emissions. Some of the investments required to catalyse the energy transition in Kenya are detailed below:

2.5.1. Flexibility And Predictability of Renewables

Even though solar energy is available in abundance in parts of the country, local weather conditions such as cloud cover, rainfall and dust storms can cause significant and erratic variations in solar output. The power system requires the deployment of energy storage technologies, installation of Static Var Compensators, AGC and Hydromet forecasting to aid in integrating renewables into the grid. The intervention will provide an enabling environment to resolve difficulties for grid operators to plan and manage power flows effectively and avoid grid imbalances, especially in distributed generation. The operational challenges include scheduling, system control and dispatch, reactive power supply and voltage control, regulation and frequency response reserve, energy imbalance service, and operating synchronised and supplemental reserve. The country therefore requires support for the implementation of the proposed interventions to mitigate the challenges arising from the VREs.

2.5.2. Enabling Renewable Energy Policy and Regulatory Frameworks.

While Kenya's generation costs are not the highest in SSA, there is room for improvement towards establishing a fair and competitive market. Energy costs vary significantly based on specific projects and this has been a key challenge to the power distributor's ability to purchase and sell power at a globally competitive rate. This has therefore continued to limit the competitiveness of renewable energy technologies in the country.

As published in the Kenya Gazette notice of 23rd November 2021,[28] the indicative generation tariffs vary by technology and capacities. Regulations are however currently under development in electricity generation, renewable energy development, energy access, power market operations, net metering and system operations to operationalise the Energy Act 2019. Most of these regulations are at the Regulatory Impact Assessment (RIA) stage while some have been submitted to the Cabinet Secretary for approval and gazettement. This is expected to catalyse investments in renewable energy projects.

2.5.3. Technical Capacity in Kenya's Energy Sector

The technical capacity of the Energy sector is a catalyst to fully exploit, develop and deploy renewable energy technologies. The energy sector experiences inadequate research and development facilities and a lack of facilities to undertake testing of prototypes on renewable technologies and Centres to harness energy sector knowledge, institutional memory and skills and RE technology transfer to enhance Renewable Energy Integration. Delivering practical skills and know-how required by the energy sector labour markets and manufacturers is a key enabler in enhancing Renewable Energy Integration; hence the need for the RE Centre of Excellence, Lab and incubation hubs with a focus on Energy Technology.

2.5.4. Demand-Supply Balance

Low productive use of energy in Kenya cannot adequately balance energy demand and energy supply. Kenya's per capita power consumption is less than 200 kWh which means Kenya's productive use of electricity is low compared to her peers. Considering that Kenya's electricity generation is predominantly renewable sources, there is a need to catalyse increased productive use of electricity, which may also attract users seeking to decarbonise their operations such as industries, e-mobility, e-cooking, steel, aluminium, hydrogen producers and data Centres. Increased utilisation of the available generation capacity has the potential to reduce the overall costs of generation which would be beneficial to customers.

[28] Kenya Gazette Notices of 23 November 2021 No. 12819 (Benchmark Tariffs for the reverse RE auctions) and 12818 (Indicative Feed-in-Tariffs)

2.5.5. Grid Strengthening and Modernisation

The National grid falls short of ensuring n-1 reliability due to its limited reach, inadequate redundancy and capacity. To address this, real-time condition O&M systems are essential for timely upkeep and restorations. Automation of these processes and availability of sufficient strategic transmission spares will enhance grid availability, thus facilitating greater integration of renewable energy sources. Smart grids, powered by real-time data analytics, can effectively manage connected devices, optimise supply, and minimise losses.

Furthermore, the incorporation of distribution automation and smart metering can significantly improve the evacuation of intermittently generated energy, particularly in applications like water heating and water pumping which can utilise time of use tariff to enhance renewable energy uptake during low demand periods and minimise operations during peak hours which would help minimise thermal generation. Upgrades such as tap changers, capacitor switches, line regulators, and battery storage are necessary to manage bi-directional power flows and mitigate voltage fluctuations, ensuring a more resilient and efficient grid.

3. RENEWABLE ENERGY INTEGRATION CONTEXT

3.1. Overview of the Power Sector

Kenya had a unified power market up to 1997. The Electric Power Act was repealed in 1997 where generation was unbundled from transmission and distribution. This move led to a single-buyer market that allowed independent power producers (IPPs) to compete for new generation capacity. Further reforms were made with Sessional Paper no. 4 of 2004 and Energy Act of 2006, aiming to liberalise the energy sector, reshape the power system and create an energy regulator. The Energy Act of 2019 introduced an Independent System Operator (ISO) that operates independently from electricity supply and demand.

3.1.1. Market Structure

Currently, Kenya's grid-connected system is a single off-taker/buyer power market structure with central dispatch regimes organised by the system operator with a gate closure about 5 to 15 minutes ahead of delivery. The day-ahead market electricity price is determined through a merit order mechanism. Actual retail tariff determination is determined by the cost of power generation through a power purchase agreement, pass-through charges, system losses, taxes and levies. The power market utilises Time of Use (ToU) tariffs targeting commercial and industrial consumers. The country envisages open access which will help strengthen Kenya's power sector by enabling industrial and commercial consumers to choose electricity suppliers from an open market.

3.1.2. Regional Integration

Kenya is a member of the Eastern Africa Power Pool (EAPP) which coordinates cross-border power trade and regional grid interconnection among the members. Currently, EAPP is undertaking a power sector transition study towards a market-based structure through requisite interconnectors investments and the development of regional power markets to foster competition and lower costs of supply.

The Eastern Africa region, with support from development partners, identified transmission interconnectors for priority development to promote regional power trade and the development of a power market. The regional interconnectors, once completed, will strengthen the grid and therefore enhance its capacity to integrate more variable renewable energy. The regional interconnectors with Kenya are: -

a) The Kenya - Ethiopia 500 kV HVDC bipolar line (capacity of the line is 2,000 MW), which was commissioned recently (2022) has enabled Kenya to import up to 200 MW of clean power. The import capacity is expected to increase to 400 MW by 2026;
b) The Kenya - Tanzania 400 kV interconnector line is expected to be commissioned by the end of 2023, and;

c) The Kenya - Uganda 132 kV existing line and 400 kV Interconnector line currently under implementation.

Initially, power imports will only be available from Ethiopia. However, surplus power exchange and trans-border wheeling within the region are envisaged hence regional interconnections with Uganda and Tanzania are vital for actualising the EAPP power market. In addition, 200 MW will be exported from Ethiopia to Tanzania through Kenya from the year 2025. The aim of regional integration is to initially facilitate bilateral power trading and in the long run, facilitate establishment of regional power markets in Eastern Africa and trade with the Southern Africa Power Pool. Interconnections will also enhance power grid stability and support penetration of intermittent renewable technologies.

As regards other Eastern African countries, interconnector synchronous investment has been undertaken. The energisation of the Egypt – Sudan interconnector has been implemented following the installation of static var compensation on the Sudanese side of the network, leading to a capacity increase to 300 MW.

The Rwanda – Uganda interconnector is energised. In readiness for the regional power market, the design of the EAPP has been done through, the drafting of rules, and developing and delivering the trading platform, software, hardware, systems and operating procedures. In line with the market rules, capacity building for shadow trading has been undertaken.

3.2. In-depth analysis of Country's Renewable Generation Portfolio

Kenya is endowed with abundant Renewable Energy resources which are discussed below.

3.2.1. Geothermal Energy

Kenya's geothermal resource potential is estimated to be between 8,000 to 12,000 MW spread over 14 sites mainly located within the Rift Valley region. At present, geothermal power is being harnessed in the Olkaria, Menengai and Eburru fields. In the medium and long term, new geothermal reservoirs are being explored in Baringo-Silali, Chepchuk, Suswa and Longonot. Other potential geothermal sites within the Kenya Rift that have not been studied in great depth include Emuruangogolak, Arus, Badlands, Namarunu, Magadi and Barrier.

As of June 2023, geothermal provided nearly 50% of total power generation with an installed capacity of **940 MW**. Due to the low variable operational costs, geothermal power plants generally run as base load units. KenGen plants with a total of **755 MW** utilise the single flash steam technology while the plants owned by Independent Power Producers (IPP) use binary steam cycle technology. A 35 MW plant in Menengai utilising binary steam cycle technology was commissioned in August 2023.

The single flash technology[29], which is mainly utilised in Kenya today, is however restrictive in terms of providing flexible power due to technical reasons, as opposed to binary systems[30] which have a certain level of flexibility. In future, geothermal expansion will be considering other power system needs such as load following and regulation control. The possibility of implementing a binary bottoming unit in a single flash plant is recommended.

Geothermal power is expected to continue playing an essential role in the Kenyan power system. Deep knowledge and expertise in geothermal exploration, drilling, power plant implementation and operation are already present in the country today and will assist in harnessing Geothermal Power going forward. However, drilling risks, high upfront costs and long implementation period have to be taken into account in the planning. In the medium term, 243 MW of new geothermal power is expected from the new projects under implementation and for plants being rehabilitated or uprated.

3.2.2. Hydro Power

The country has a considerable hydropower potential estimated at 3,000 - 6,000 MW. Approximately 840 MW is already exploited, mainly in large installations owned by KenGen. The undeveloped hydroelectric power potential of economic significance is estimated at 1,484 MW, out of which 1,249 MW is expected from projects with a potential of 30 MW and above. This hydropower potential lies in five geographical regions, mainly in Kenya's major drainage basins. These include Lake Victoria basin (329 MW), Rift Valley basin (305 MW), Athi River basin (60MW) and Tana River basin (790 MW).

The climate in Kenya varies from humid tropical at the coastline to humid and sub-humid in the Highlands and western regions to arid in the northern and north-eastern areas, influenced by the complex topography, the proximity to the Indian Ocean and other large water bodies such as Lake Victoria, as well as the oscillating movement of the Intertropical Convergence Zone. There are seasonal variations in rainfall with most places in Kenya experiencing a bimodal rainfall pattern. The "long rains" start in March and run through May and the "short rains" occur from September to November. The most intense monsoon period is recorded in May.

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[29] Flash steam geothermal technology - technology that is used where water-dominated reservoirs have temperatures above 180°C. In these high-temperature reservoirs, the liquid water component boils, or "flashes", as pressure drops. Separated steam is piped to a turbine to generate electricity and the remaining hot water may be flashed again twice (double flash plant) or three times (triple flash) at progressively lower pressures and temperatures, to obtain more steam. Flash steam geothermal plants are categorised as open cycle technology.

[30] Binary geothermal technology - technology that utilises an organic Rankine cycle (ORC) or a Kalina cycle and typically operates with temperatures varying from as low as 73°C to 180°C. In these plants, heat is recovered from the geothermal fluid using heat exchangers to vaporise an organic fluid with a low boiling point (e.g. butane or pentane in the ORC cycle and an ammonia-water mixture in the Kalina cycle) and drive a turbine. Binary geothermal plants are categorised as closed cycle technology.

Due to the wet Congo air mass, the Western parts of the country also receive considerable rainfall from June to September while the remaining regions in Kenya experience a dry period during these months. The average annual rainfall in Kenya is estimated at 710 mm (based on measurements of 36 synoptic stations at various places in Kenya from 1979 to 2010). However, the rainfall strongly varies over the country from 0 to 265 mm in the arid and semi-arid regions (east and northeast of the country) to 2,005 mm in the wettest areas (western parts of the country). The two main hydropower reservoirs, Masinga in Eastern Kenya and Turkwel in the North-Western part of the country are carefully regulated to provide energy and capacity across the varying seasons with complementary roles where possible to enhance supply reliability.

In the 1990s, the Kenyan power generation system was dominated by hydropower with a share of 70% of the total installed generation capacity and 80% of the total electricity generation. Due to increased frequency of droughts in the past decade, the hydropower plants could, at times, not reliably provide sufficient electricity. This resulted in an intensified construction of thermal power plants that operate independently of the fluctuations in hydrology. Only two large hydropower plants, namely Sondu Miriu (60 MW) and Sang'oro (21 MW) and some 14 MW of small hydropower capacity have been commissioned in recent years. Thus, the share of hydropower in the total installed system capacity has been decreasing, and the total effective capacity of hydropower plants is 810 MW.

Hydropower currently contributes about 26% of national annual electricity generation. Eight (8) power stations have reservoirs and a capacity of more than 10 MW. At least half of the overall potential originates from smaller rivers that are key for small-hydro resources. With the introduction of the feed-in-tariff policy in 2008, small-scale candidate sites are already being developed across the country with the majority being implemented by Kenya Tea Development Authority (KTDA). The average annual hydropower generation in the last seven financial years was 3,611 GWh. In most years, the hydropower output was close to an average capacity factor of 47%.

A preliminary study carried out by KenGen indicates that Kenya has suitable sites for pumped storage hydropower projects. The potential sites identified in the study include Lake Turkana West, Samburu, Kapenguria, Kipcherere, Lomut, Sondu and Homa Bay South.[31] The current surplus energy due to the excess baseload capacity developed in the country enhances the potential for pumped hydro as the excess energy can be used to pump water back to the upper reservoir during off-peak. A full feasibility study is required to confirm viability, firm up potential sites and develop technical designs and procurement documents to develop pumped hydro as a viable option in the long-term.

[31] Opportunity and Pre-Feasibility Study on the Optimisation of Existing Hydropower Plants and the Development of Pumped Storage Hydropower in Kenya, 2019.

3.2.3. Solar Energy

Kenya is endowed with very high solar resources, among the highest of Sub-Saharan African countries. Kenya has high insolation rates, with an average of 5-7 peak sunshine hours and an average daily insolation of 4-6 kWh/m^2 due to its strategic location near the equator. 10-14% of this energy can be converted into electricity due to the dispersion and conversion efficiency of PV modules. Solar power is largely seen as an option for rural electrification and decentralised applications.

Currently, solar power plants connected to the grid are: The Rural Electrification and Renewable Energy Corporation (REREC) 50 MW Garissa Solar PV, Selenkei, Cedate, Alten (in Eldoret) and Malindi Solar each with a contracted capacity of 40 MW. It is estimated that 200,000 photovoltaic solar home systems, most of which are rated between 10We and 20We estimated at a cost of KShs 1,000/We, are currently in use in Kenya and generate 9 GWh of electricity annually, primarily for lighting and powering television sets for about 1.2% of households in Kenya. It is estimated that the rate of market penetration will increase considerably.

3.2.4. Wind Energy

A considerable potential for wind power exists in Kenya with several wind power projects proposed or planned for development. The Best wind sites in Kenya are found in Marsabit, Samburu, Laikipia, Meru, Nyeri, Nyandarua and Kajiado counties. Other areas of interest are Lamu, offshore Malindi, Loitokitok at the foot of Kilimanjaro and Narok plateau. On average, the country has an area of close to 90,000 square kilometres with excellent wind speeds of 6m/s and above.

A high-level and remote Solar and Wind Energy Resource Assessment (SWERA) mapping exercise for Kenya was completed and published in 2008. This provides general information on the areas with the highest wind potential. Moreover, a wind energy data analysis and development programme conducted in 2013 by WindForce Management Services Pvt. Ltd indicates a total technical potential of 4,600 MW.

The Wind Energy Power Plants in Kenya include; KenGen's 25.5 MW farm in Ngong and Lake Turkana Wind Power (LTWP)'s 310 MW farm in Loiyangalani, Marsabit County and the 100 MW Kipeto wind power plant in Kajiado County. The combined wind capacity from the plants constitutes about 13% of the effective generation capacity on the grid providing over 15% of annual energy purchased.

3.2.5. Bioenergy

Agricultural and agro-industrial residues and wastes have the potential to generate heat and/or power. The best example in several countries is power generation from bagasse. Presently, its use for power generation in the national electricity grid is being explored. Besides the sugar bagasse, there could be some potential in the tea industry as well, which could co-generate about 1 MW in the 100 factories using their own wood plantations for drying. The future of successfully implemented biomass projects in Kenya will strongly depend on the development of the agricultural sector. This will add to the existing cogeneration capacity of 130 MW in sugar factories and the grid-connected 2 MW Biojoule capacity.

Municipal Solid Waste (MSW) constitutes a potential source of material and energy as well. Power generation from municipal solid waste is also expected to play a role in the future. Whereas biomass energy potential appears modest at present, it could increase significantly with the agro-industrial development, mainly through revamping of the sugar mills and future concentration of other agro-industries. A specific survey of agro-residues in the medium and long term, combined with the load centre and planned network could suggest lower investments in the power sector than conventional power supply and transmission.

On a micro scale, biogas production is widely practised in Kenya, boasting a network of more than 8,000 biogas facilities that harness diverse raw materials such as agricultural residues, slaughterhouse byproducts, and municipal waste. Nonetheless, the sector is marked by inadequate centralised data on biogas output, rendering it challenging to ascertain the country's total biogas production capacity.

3.3. National Low or Zero Carbon Energy Strategies

Kenya recognises the interconnectedness between Energy, Climate Change and People, and the critical role of achieving the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change. The country has made significant strides in realising the objective of Sustainable Development Goal 7 of ensuring access to affordable, reliable, sustainable, and modern energy for all, particularly electricity access. Kenya is a global leader in the promotion and adoption of Renewable Energy and a trailblazer in climate change action in the pursuit of a carbon-neutral development pathway. The country is determined and on course to achieve full transition to clean power generation by 2030 and 100% access to clean cooking by 2028.

Kenya has made considerable efforts towards climate change mitigation and adaptation in the energy sector leveraging her competitive advantages in renewables to accelerate the shift to a low-carbon economy demonstrating that it is possible to achieve ambitious development goals while remaining green.

Electricity Generation: 80% of the installed capacity is renewable sources (mainly geothermal, hydro, wind and solar) contributing over 90% of the dispatched energy. The country has one of the cleanest electricity grids in the world. and is in pursuit of 100% clean power generation by 2030.

Electricity Access: Kenya has made good progress in electricity access; raising connectivity from less than 30% in 2013 to approximately 78%[32]. Significant results have been achieved through

[32] Kenya’s Energy Sub-Sector, Fourth Medium Term Plan - 2023-2027 (MTP IV).

concerted efforts by KPLC, REREC and the private sector through various initiatives e.g. the Last Mile Connectivity Project (LMCP) with the aim of universal access by 2026.

Bioenergy: Kenya launched the bioenergy strategy in 2020[33], to promote sustainable production and use of bioenergy resources and to accelerate transition to clean cooking fuels and technologies. The goal of the Bioenergy Strategy is "Sustainable bioenergy for all by 2028".

Clean Cooking: Kenya is currently implementing the Green Climate Fund-supported "Climate Friendly Cooking Project"[34] for professionalising the improved cookstoves sector coordinated by GIZ and implemented in collaboration with various partners. The project which is implemented in Kenya and Senegal aims to limit consumption of non-renewable biomass in the cooking sector leading to GHG emission reduction of 6.47 $MtCO_2eq$ during the project period and an additional 24.77 $MtCO_2eq$ until 2030. The project is also expected to directly benefit 11.23 million people and will enable the two countries to reach their stated NDC targets for GHG emissions in energy cooking sectors. Further, the development of a Kenya National e-Cooking Strategy (KNeCS) aims to promote improved health, and environmental protection and as a measure to stimulate demand for electricity at the household level has also been initiated.

- The Kenya Off-grid Solar Access Project (KOSAP) funded by the World Bank to increase access to electricity (solar-powered mini-grids and solar home systems) as well as distribute 150,000 clean cookstoves in 14 underserved Counties is also in progress.
- Clean Energy Transitions: Kenya's clean energy transition should focus on ending energy poverty, creating universal energy access, including clean cooking; accelerating renewable energy deployment; deeply mainstreaming gender: powering key industries and sectors for socio-economic transformation, and maximising energy efficiency. This entails promoting multiple kinds of renewable energy technologies to support energy access and industrial development to position the country as a green manufacturing hub.
- Climate-friendly investments could create more jobs in clean energy, and nature-based solutions compared to alternatives. According to IRENA[35], the Renewable Energy sector now employs more than 11 million people worldwide, with more countries manufacturing, trading and installing renewable energy technologies every year. Notably, 32% of those jobs are held by women. Kenya will endeavour to improve job quality in green sectors including wages, work security, and accessibility for excluded groups.
- Kenya has therefore firmed up her path towards carbon neutrality by 2050. Kenya's climate change policies enhance the commitment to reduce her carbon footprint by investing in clean and/or low-carbon renewable sources of energy.

[33] Bioenergy Strategy 2020-2027, GoK
[34] https://www.greenclimate.fund/project/fp103
[35] IRENA Website: https://www.irena.org/About/Employment

3.4. Institutional Framework and Capacity

3.4.1. Institutional Framework

The Energy sector in Kenya operates under a comprehensive regulatory framework established by the Energy Act 2019, building upon the foundations laid by the Energy Act 2006. This framework involves following key institutions each with distinct roles and responsibilities.

a. **The Ministry of Energy and Petroleum (MoEP)** is tasked with policy formulation and coordination of energy planning. It sets the strategic direction for the energy sector and oversees policy implementation.

b. **The Energy and Petroleum Regulatory Authority (EPRA)** serves as the technical and economic regulator for energy and petroleum services. It develops and enforces regulations, playing a crucial role in implementing the Energy Act 2019.

c. **The Energy & Petroleum Tribunal** is responsible for settling disputes and appeals in accordance with the Constitution of Kenya 2010, the Energy Act 2019 and any other relevant law.

d. **Kenya Electricity Generating Company (KenGen)** is the leading electricity generation company in the country with an installed generation capacity market share of more than 60%. The company's primary business is to provide safe, reliable and competitively priced electric energy for the country in an environmentally friendly and sustainable manner while creating value for its stakeholders. It is also a repository of significant technical expertise in hydro and geothermal technology development.

e. **Kenya Power and Lighting Company (KPLC)** is the main off-taker in the power market buying bulk power from all power generators based on negotiated Power Purchase Agreements (PPAs) for onward supply to consumers. It is the sole power off-taker in the country, and the current system operator and owns and operates the sub-transmission network below 132 kV, while it co-owns the transmission network of 220kV and 132kV with KETRACO. KPLC has been assigned the role of coordinating the preparation of the LCPDP, based on recommendations of the Presidential Task Force on PPAs.

f. **Kenya Electricity Transmission Company (KETRACO)** is mandated to plan, design, construct, own, operate and maintain high voltage (132 kV and above) electricity transmission lines. In addition, KETRACO has been designated the national power system operator as per provisions of the Energy Act, 2019.

g. **Rural Electrification and Renewable Energy Corporation (REREC)** is mandated in the development of renewable energy resources (excluding geothermal and large hydropower) and implements rural electrification projects. It owns a 50 MW Solar plant in Garissa, operated by KenGen. In addition, REREC owns off-grid stations which are managed and operated by Kenya Power.

h. **Geothermal Development Company (GDC)** is a wholly Government-owned Company undertaking surface exploration of geothermal fields, exploratory, appraisal and production drilling, managing proven steam fields and promoting direct uses of geothermal energy.

i. **Nuclear Power and Energy Agency (NuPEA)** is mandated to promote the development of nuclear electricity generation in Kenya and carry out research, development and dissemination activities of energy-related research findings. Nuclear power is being considered for potential base load supply in Kenya's energy mix, with the Kenya Nuclear Energy Development Programme overseen by NuPEA.

j. **Independent Power Producers (IPPs)** are private investors in the power sector involved in power generation.

k. **Electricity Imports and Exports** : Kenya is involved in cross-border electricity trade with her neighbours namely Uganda, Tanzania and Ethiopia. This contributes to enhancing energy security and promoting economic integration within the Eastern African region.

l. **Private Mini-grids Operators** - off-grid generation, storage and distribution networks that supply electricity to localised groups of customers not covered by the interconnected national power grid as approved by EPRA.

m. **Captive Energy** - Captive energy generators that are producing for their own consumption which is currently generating 402 MW[36] and are supported by various legal instruments. Some of these instruments include the Energy Act 2019, the Captive Power policy, the Mini Grids Regulations and the Geothermal Regulations all of which are either under review or already under implementation.

n. **Private Electricity Distribution Service Companies (DISCOs):** Kenya has several private electricity distribution companies that operate in various parts of the country. These companies play a significant role in supplementing the efforts of the state-owned utility, Kenya Power and Lighting Company (KPLC), in distributing electricity to consumers.

o. **Solar Home Systems Companies** - Suppliers of solar home systems for households mainly those located far from the grid. These will play a significant role towards the attainment of universal access to electricity Laws, Regulations and Policies.

[36] Electricity Sector Association of Kenya (ESAK) Report

p. **Electricity Consumers** - As of June 2023, there were a total of 9,213,047 customers grouped in seven (7) tariff categories[37]. Some of the customers self-generate (captive) to meet part of their load but are still connected to the grid which offers them support and security of supply.

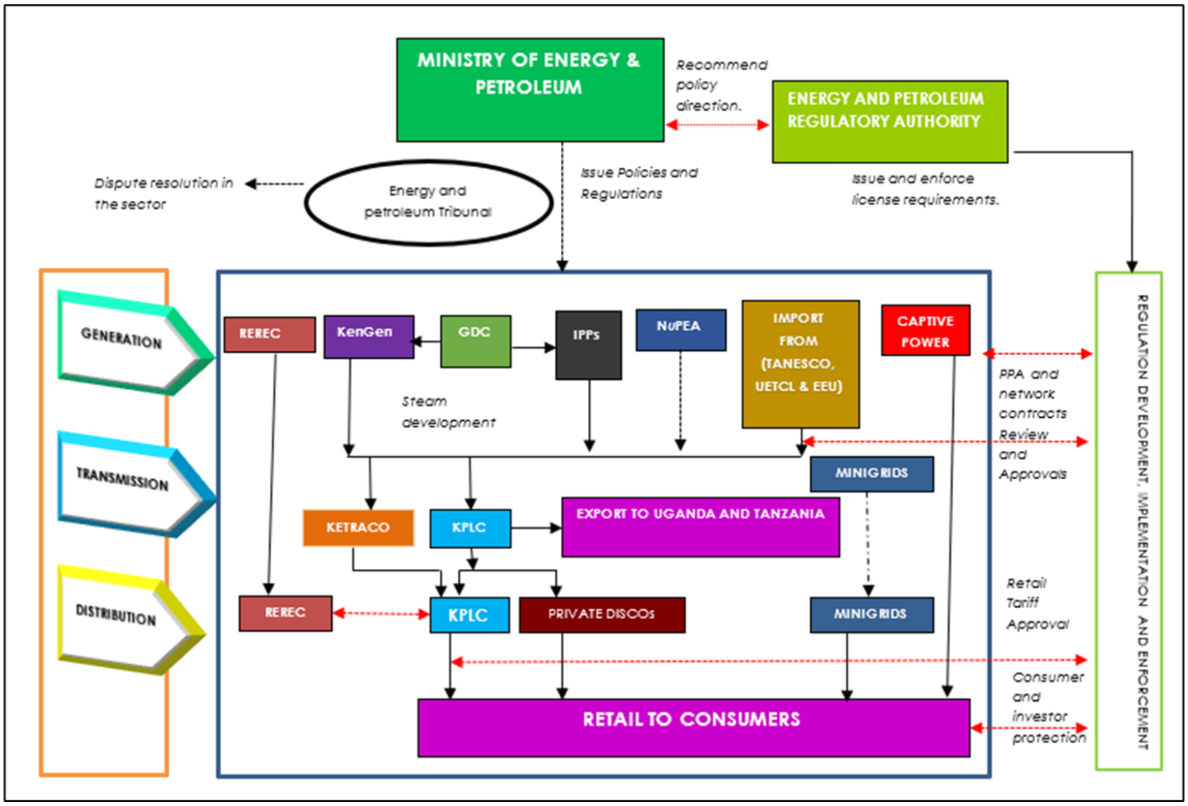

Figure 3: Kenya's Energy Sector Institutional Framework

3.4.2. Technical Capacity in Kenya's Energy Sector

Kenya has over the years built its technical capacity to support the development and management of the energy sector and has also leveraged on technical support availed under different arrangements with development partners. To this end, there exist institutions domiciled in various utilities for specialised skills development. These include the Institute of Energy Studies and Research (IESR), formerly Kenya Power Training Institute, and the KenGen Geothermal Training Centre, in addition to internal capacity-building arrangements where applicable. The bulk of skills development in the country however remains programme-specific with significant support from development partners. An example is the East African Skills for Transformation and regional integration project supported by the World Bank. There are other initiatives that are project-specific with a specific focus on skills transfer for most externally supported projects.

With respect to specialised equipment and facilities, the country, while having a reasonable stock of specialised equipment in power management, still lacks in certain areas. Among the required

[37] Domestic, Small Commercial and CI1, CI2, CI3, CI4, CI5, CI6 and Street lighting.

capacities include smart grid equipment, Automatic Generation Control (AGC) equipment as well as a comprehensive SCADA system for monitoring the operation of the power system in the country. Some of the equipment needed is important for the full integration of variable renewable energy technologies that will soon characterise the Kenyan power system. These include Hydromet equipment that is suggested in this proposal. In addition, as the country readies itself for the introduction of a power market and an open access framework, there are still capacity gaps that need to be addressed including the finalisation of the second National Control system, training of specialised controllers and training of operators of the equipment envisaged under the draft system operation regulations.

3.4.3. The Energy Act 2019 and the Energy Policy

The sector in Kenya is guided by the provisions of the Energy Act 2019 which provides for the establishment of relevant institutions and sets guidelines for management of the sector overall. Arising out of this, the sector has embarked on the development of applicable regulations.

The Act empowers the Cabinet Secretary to establish the Consolidated Energy Fund to inter alia cater for the promotion of renewable energy initiatives. Other funds like the Rural Electrification Programme Fund and National and County Energy Conservation Fund are also provided for in the Act. Regulations to operationalise the funds are in progress.

The Energy sector is also guided by the provisions of the Energy Policy that set out the strategic direction the sector is expected to take in the short, medium and long term. The Energy policy as articulated in Sessional Paper No. 1 of 2004 has been applicable in the Sector, however, the Energy policy was reviewed in 2018 and is expected to guide the sector once it's approved.

Kenya has also put in place programs to promote gender mainstreaming in Energy Planning, implementation and monitoring. The Gender Policy in Energy was launched in 2019 and the Ministry of Energy & Petroleum and its Semi-Autonomous Government Agencies (SAGAs) are already implementing the policy.

3.4.4. Regulations Development

Regulations are currently under development in electricity generation, renewable energy development, energy access, power market operations, net metering, and system operations to operationalise the Energy Act 2019. Most of these regulations are at the Regulatory Impact Assessment (RIA) stage while some have been submitted to the Cabinet Secretary for approval and gazettement. Relevant regulations with respect to renewable energy and climate change mitigation include draft Energy (Electricity Market, Bulk Supply and Open Access) Regulations, 2022; The draft Energy (Renewable Energy Resources) Regulations, 2022; draft Energy (Feed-in Tariff) Regulations 2022; The draft Energy (System Operation) Regulations, 2023 which has incorporated the updated Grid Code (KNTGC and KNDC); the draft Energy (Mini-Grids) regulations 2021; and the draft Energy (Reliability, Quality of Supply and Service) Regulations, 2022.

3.4.5. Market Operation Reforms

KETRACO has been designated as the System Operator under Section 138 of the Energy Act, 2019. This is in readiness for the transformation of the current power market system to an open-access market. The process of implementation of the open access framework is contained in the power market study and the draft Energy (electricity market, bulk supply and open access) regulations 2022. There are also proposed reforms to the existing Power Purchase Agreements (PPAs) to improve power procurement that include renegotiation of existing PPAs, reforms at KPLC to refit it into a proper commercial entity, and standardisation of government support instruments to manage both contingent liability and obligations under power purchase contracts.

3.4.6. Emerging Consumption Patterns and Policy Interventions

In recent times, the efforts to transform the country's long-term GHG emissions trajectory have led to the recognition of the role that clean electricity can play across multiple sectors, including transport, cooking, industry and agriculture. The country's efforts to transition the country to cleaner technologies across multiple sectors have largely driven changes in the consumption patterns in the power sector. Efforts towards this objective include measures to support the following initiatives:

a) Electric vehicles (EVs) Adoption and Utilisation

Kenya's energy mix has the potential to support e-mobility at scale with about 90% of our energy coming from renewables. As of 2022, it was estimated that there were about 1,350 electric vehicles (EVs) out of 3.5 million registered vehicles in Kenya. In support of the move towards EVs, a special tariff has been approved by the regulator. Kenya's Bottom-Up Economic Transformation Plan 2022-2027 (also known as the Bottom-Up Economic Transformation Agenda (BETA), envisages that the Government will construct (in partnership with private players) 1,000 electric vehicle charging stations. It is envisaged that there will be 700 in urban areas and 300 along highways. In addition to the target of achieving 5% electric vehicle registration by 2025, other notable support provided so far include: a reduction in excise duty from 20% to 10% for fully electric vehicles and a special e-mobility tariff meant to spur the uptake of electric vehicles in Kenya. EPRA recently (September 2023) published Electric Vehicle (EV) Charging and Battery Swapping Infrastructure Guidelines meant to make electric vehicle charging infrastructure accessible to all users, create uniformity and certainty towards accelerated adoption of EVs in the Country and promote affordable tariffs chargeable from Electric Vehicle (EV) owners and Charging Station Operators/Owners among other objectives.

b) Green Hydrogen Initiatives

Kenya is fully focused on leveraging on its abundant renewable energy resources and in particular the huge geothermal resources in the Rift Valley and Nyanza regions to develop green hydrogen (GH_2). GH_2 offers a wide range of opportunities including fertiliser production; import substitution for ammonia and methanol; and for optimisation of power use in the country especially in geothermal fields.

Kenya aims to harness its green hydrogen's potential as a pivotal component of its energy transition and has begun the journey towards a green hydrogen future. Through the MoEP led Green Hydrogen Working Group, the Ministry, with support from GiZ undertook a Baseline Study on the Potential for Power-to-X/Green Hydrogen in Kenya which looked at the potential uses for GH_2, a commodity for processes and energy sources, considering the use-specific opportunities and challenges within Kenya. A Green Hydrogen Strategy and Roadmap for Kenya, sponsored by the EU-Global Technical Assistance Facility (GTAF), aims to establish a robust hydrogen industry, as it provides a clear vision, direction, and framework for the development of the hydrogen sector. This will create a new economic sector which keeps larger portions of the value creation chain in the country, leading to the generation of domestic jobs and economic growth.

The AfDB also undertook a study on the Potential Role of Green Hydrogen in Kenya which identified Ammonia (NH_3) as a potential final product. There are various other studies by different players, including KenGen and the Private Sector, seeking to explore and exploit Kenya's vast RE resource and potential for the production of GH_2 and its derivatives.

c) Electric Cooking

The Ministry of Energy and Petroleum and its partners are promoting the clean cooking agenda for its environment, gender equity and health benefits. Modern energy-efficient appliances can make cooking with electricity an attractive option due to its efficiency and cost-effectiveness.

The Energy Sector Management Assistance Program from its report[38] indicates that e-Cooking with grid electricity is already cheaper than cooking with charcoal in some of the urban centres studied, where charcoal costs more than $0.40/kg and electricity tariffs are below $0.35/kWh and it's projected that by 2025, the expected increases in charcoal prices and the falling costs of battery-supported solutions suggest that the cost of e-Cooking will likely be comparable to the cost of cooking with charcoal in weak-grid and off-grid contexts ($8–39/month vs. $5–41/month respectively.

3.4.7. Market Rules

Kenya has been in the process of restructuring its power market environment largely to accommodate the desire to liberalise the distribution and retailing functions of the electricity value chain. It is noteworthy that the power market structure in Kenya is characterised by a single-buyer model with multiple bulk sellers supplying power through long-term Power Purchase Agreements. After the Energy Act 2019, there has been a significant rise in captive power generation largely as

[38] Energy Sector Management Assistance Program (ESMAP). 2020. Cooking with Electricity: A Cost Perspective. Washington, DC: World Bank

a response to perceived high grid-connected tariffs and to mitigate low quality of supply from the grid.

3.4.8. Power Market and Open Access

In order to implement the aspirations of the Energy Act 2019, EPRA developed the Framework for Open Access Market Rules in the electricity market in Kenya in 2019. In addition, the Authority with support from the Ministry of Energy and Petroleum, undertook a Power Market and open access study in Kenya. The Study addressed recent developments in the power industry including but not limited to the separation of distribution and transmission assets, the establishment of an open access system, the establishment of an independent System Operator, and the associated requisite transfer of risks across all parties to ensure that services in the power sector in Kenya are provided efficiently and at least marginal cost to the consumer. Under this arrangement, the country will transition to a full power market through 4 distinct stages:

1. **In stage 1**, the concept of long-term PPAs will change and in its place, market players will participate through Bilateral Contracts for generation companies (GENCOs) and also from eligible customers. The market will be characterised by real-time balance, based on instructions to generators from the System Operator. Tariffs will be determined through ex-post hourly calculations.
2. **Stage 2** will be characterised by a day-ahead market and will involve 24-hour schedules based on offers and bids. Existing generators will be dispatched based on merit order and paid the variable cost of their generation while other generators will be paid at Short Run Marginal Price.
3. **Stage 3** will be characterised by a real-time market for upward and downward regulation with Auctions for secondary and tertiary frequency regulation and other ancillary services.
4. **The final stage** will involve the agreement of the market participants to create and fund a power exchange market including a capacity market. It will also include approval of rules for transmission rights auctions.

There are no technical obstacles to a fast implementation of this proposed market structure given that the proposed phase 1 can be mostly run with the existing technical resources. It is also possible to train the staff for the initial operation of the Kenya Electricity market in a short period of time.

A key challenge currently is that there is a need to ensure that KPLC is protected from power purchase risk and can recover all its fixed costs related to energy purchases. Priority will also be on training the initial staff of the System Operator to undertake the market functions effectively.

At the transmission level, efforts are ongoing to consolidate ownership of the transmission network under KETRACO; this will allow for better open access.

The Draft Energy (Electricity Market, Bulk Supply and Open Access) Regulations, 2022 broadly cover the market rules envisaged under the Kenya power market and provide among others:

- The market structure/design which shall be informed by the first electricity market review undertaken by the Authority in consultation with the Cabinet Secretary within the first three years in accordance with the Energy Act 2019.
- The need for a transmission or distribution licensee to provide non-discriminatory open access to its transmission or distribution system as the case may be for use by any licensee or eligible consumer upon payment of wheeling or use of system charges.
- System operations on market balancing and dispatch shall be conducted in accordance with the Energy (System Operations) Regulations 2021.
- To facilitate effective day-to-day operation and encourage capital investments, EPRA in consultation with the Cabinet Secretary shall, six months after the gazettement of the electricity market report, issue guidelines on the market governance structure.

3.4.9. Technical Standards

Renewable Energy Resource Advisory Committee (RERAC) an inter-ministerial committee established by the Energy Act 2019) advises on matters concerning the allocation of renewable energy resources, management of water catchment areas and development of multi-purpose projects such as dams and reservoirs. National Environment Management Authority (NEMA) in conjunction with EPRA however, regulates, monitors, and assesses energy activities for the purpose of environmental management.

The Kenya Electricity Grid Code has been developed as the primary technical document and is a consolidation of existing standards and practices in the Kenyan electricity sub-sector aimed at providing a transparent regulatory framework, in line with the principle of non-discriminatory access to the transmission and distribution systems. It provides the technical specifications and procedures for supporting the Energy Act. However, the Kenya Bureau of Standards (KEBS) takes the overall lead in the development of the National standards.

3.5. Role of Private Sector, Innovation and Leverage of Resources

The private sector plays a vital role in the integration of renewable energy in Kenya's energy mix. The Independent Power Producers (IPPs) account for approximately 35% of the country's installed capacity. Out of this share of IPP generation, at least 65% is from renewable energy technologies.

With the enactment of the revised Public Private Partnership Act 2021, the country is likely to benefit from private sector financing, innovation, and technical expertise both in the generation and transmission of power. Private firms are also often at the forefront of the development of new technologies such as smart grids, green hydrogen, and energy storage systems.

Policy intervention and innovations can create incentives for renewable energy development, such as tax credits, feed-in tariffs, and renewable portfolio standards. This can increase the amount of renewable energy that is deployed and improve the economics of renewable energy production. Innovation therefore plays an important role in the integration of renewable energy into the energy mix.

Leveraging on financing, innovation, and technical expertise by the Government is particularly important in developing climate-resilient energy projects. These were the basic considerations when the FIT policy was first introduced in the country in 2008 and remain a core driver for future projects even within the proposed Energy Auctions process. It is noteworthy that renewable energy investments intended to meet the country's 2030 target of reducing emissions by 32% and being carbon neutral by 2050 requires leveraging on the huge private sector potential with respect to financing, experience and expertise. The Government on its part will need to continue providing an enabling environment for the participation of all partners to meet this objective.

It is widely acknowledged that the project cost gap between RE + storage and thermal generation remains significant. As a result, the need for concessional resources is pronounced and meaningful concessionality is needed to level the playing field.

In 2019, prices for fully installed four-hour utility-scale BESS ranged from $300 to $446/kWh, meaning that a 20 MW/80 MWh storage system would cost between USD 24 and 36 million.[39] Grid scale battery storage systems' costs have been declining over the years making them more competitive options. An ongoing BESS study in Kenya shows that the recommended 100MW one hour battery size would require about USD 41.4 million capex. Fixed costs for this BESS system would range between 74.3-87.0 US$/MW-year and the variable cost inclusive of charging and discharging cost is estimated at 35.6 US$/MWh. Battery storage prices are expected to continue declining over time due to several factors, including technology improvements, manufacturing and supply chain economies of scale, competition between manufacturers, greater product integration ahead of installation, and more overall industry expertise.

Demonstrating the performance of energy storage technologies and systems in frontier markets without significant cost is a key barrier for grid-level BESS deployment at scale. Catalysing activity involving novel technology and a new operating environment entails higher risk that must be shared between the public, power sector actors, and/or developers. Sustained market engagement can be sensitive to poor early performance, though learning from early experience can help to recalibrate market expectations. Inadequate demonstration of performance in frontier markets – including Kenya – increases risks for safety, functionality, and profitability of BESS deployments and could hobble market development.

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[39] BNEF (2019). Energy Storage System Costs Survey 2019. https://about.bnef.com/blog/2h-2023-energy-storage-market-outlook/#:~:text=Global%20energy%20storage's%20record%20additions,times%20expected%202023%20gigawatt%20installations

3.6. Complementary Activities Coordinated with other Development Partners

Development partners have been very instrumental in the development of the energy sector in Kenya especially in the renewable energy field. This has been implemented through partnerships in the development of policies and regulatory frameworks, power planning and investments in renewable energy projects both in the public and private sectors.

Some of the development partners that are working or have plans to support the integration of renewable energy include the following:

Table 2: Complementary Activities by other Development Partners

Development Partner	Overview of ongoing/planned support	Objective
African Development Bank (AfDB)	▪ The Quantum Power Menengai Geothermal Project, ▪ The Kopere Solar PV Power Project	The renewable energy projects are to increase the capacity of renewable energy in the national grid.
	▪ The Ethiopia – Kenya Electricity Highway project, which is jointly financed with the AFD and the World Bank. ▪ Kenya – Tanzania Power Interconnection Project	The transmission project to assist trading for electricity between the countries and establishment of the electricity market in the EAPP
	▪ The 400 kV Mariakani substation and the 132 kV underground cable for Nanyuki – Rumuruti line. ▪ 111 km double circuit 132 kV line from Kabarnet – Rumuruti. ▪ 88 km of 132 kV double circuit transmission line from Narok to Bomet	The various substations and transmission lines will address reduction in distribution system performance arising from the very rapid increase in rural connectivity and strengthen the Kenya Grid system with increased share of renewable energy.

Development Partner	Overview of ongoing/planned support	Objective
	▪ 22 km of 220 kV single circuit line from Weru to Malindi, 51 km of 220 kV double circuit line from Weru to Kilifi.	
	Public Private Partnership in Transmission Lines	This is to assist KETRACO in developing bankable projects in relation to Public Private Partnership (PPP) in transmission lines
	Super Energy Service Company (Super ESCO)	This is to support the establishment of a KPLC run Energy Efficiency Unit operating under the Super ESCO concept.
World Bank Group (WBG)	Eastern Electricity Highway Project (EEHP)	The transmission project assists in trading for electricity between the countries and establishment of the electricity market in the EAPP.
	Kenya Electricity Modernisation Project (KEMP)	To increase access to electricity and improve reliability of electricity service
	Green and Resilient Expansion of Energy (GREEN) Program	To improve financial viability of KPLC and increase access to electricity
	Kenya Off-grid Solar Access Project (KOSAP)	The Kenya Off-grid Solar Access Project (KOSAP) funded by the World Bank aims to increase access to electricity (Solar powered mini-grids and solar home systems) as well as distribute 150,000 clean cookstoves in 14 underserved Counties.
	Upgrading of KenGen Geothermal Training Centre to a Regional Centre of Excellence.	The project supports the Eastern Africa Skills for Transformation and Regional Integration Project (EASTRIP). The Centre of Excellence would serve the full range of Energy Technology training and would act as the Regional Flagship Technical and Vocational Education and Training (TVET) Institute for the Energy sector.

Development Partner	Overview of ongoing/planned support	Objective
FCDO	Integrated National and County Energy Planning	Establish a Modern Energy Planning Process. Provision of technical assistance to build capacity within Kenya's energy planning. that is comprehensive, needs-based and leads to more cost-effective investment.
	Off grid Solar Electrification Strategy:	Project objectives are to prepare an implementation plan for standalone solar systems, supporting Kenya National Electrification Strategy; identify methodology and funding approach to implement a national programme
	▪ 52 MW Malindi Solar. ▪ 35 MW Menengai Geothermal project ▪ High Grand Falls Dam under PPP	This assists Kenya's transition to 100% clean energy in the national grid.
KfW	Grid strengthening project via KETRACO	The objective is to strengthen the national grid to uptake more variable renewable Energy and transition to 100% clean energy by 2030.
	▪ Gogo Mini hydro rehabilitation. Upgrade output from 1.8MW to 8MW ▪ Floating solar PV at Kamburu dam. ▪ Baringo - Silali Phase I - GDC ▪ Olkaria I + IV Upgrade targeting 40 MW	The renewable energy projects are to increase the capacity of renewable energy in the national grid.

Development Partner	Overview of ongoing/planned support	Objective
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	Power System Readiness for Integration of Variable Renewable Energies (VRE) Project	The objective of the project is to improve the cost-efficient integration of variable renewable energies in the electricity grid. This includes support of the LCPDP team in energy planning and modelling of economic benefits of VRE integration. The support also covers support for energy regulations (e.g. grid code, INEP regulations, study on ancillary services) and capacity development for grid operation.
	Development of Green Hydrogen Programme in Kenya	Assist Kenya in the development of green hydrogen and power to x industry.
	Advancing Transport Climate Strategies	Supports the Kenyan Government in new and innovative technology solutions, e.g. promoting electric mobility solutions and thus reducing emissions in the transport sector.
Kingdom of Denmark	Cooperation on energy planning and integration of renewable energy	Provide valuable technical assistance and sharing of experiences in the area of renewable energy integration into the power system while ensuring the security of supply and optimal power system operation by optimising power system operations including forecasting, dispatch, grid code review and technical assistance on control room performance.
European Investment Bank (EIB)	▪ Olkaria I & IV Geothermal Extension ▪ Olkaria I additional unit 6 of 83 MW ▪ The Lake Turkana Wind Power ▪ Radiant and Eldosol Solar Power of 40 MW each	The renewable energy projects are to increase the capacity of renewable energy in the national grid.

Development Partner	Overview of ongoing/planned support	Objective
	European Guarantees for Renewable Energy Technical Assistance Programme (EGRE)	The programme will provide the Ministry of Energy with capacity building in financial, legal and technical upstream support and Transaction Advisory Services. This will provide open, transparent and competitive frameworks for tendering, assistance in tender preparation; launch, award, negotiation and implementation of bankable renewable energy IPP projects.
	Demand side management, Social Infrastructures and Renewable Energy Expansion (DESIREE)	The aim is to create an EU flagship programme and brand which can deliver meaningful impact (higher electrification rates, reduction of emissions, diversification of the energy mix, equal access and efficient use of energy) in the regions and showcase innovative and scalable.
	TA support to KETRACO for Renewable Energy integration and climate change adaptation and mitigation with potential funding for a transmission line	To support grid resilience to climate change with the integration of renewable energy.
European Union (EU)	▪ Lake Turkana Wind Project ▪ Geothermal Risk Mitigation Facility (GRMF) for EA ▪ Studies for the Redevelopment of Gogo Hydropower Plant.	The renewable energy projects are to increase the capacity of renewable energy in the national grid.
	Reinforcement for the Electricity Transmission Network (RETNet) - Capacity building	The objective is to assist KETRACO to build capacity in the system operations as they transition to the system operator role.
	▪ Olkaria Additional Geothermal Projects	The renewable energy projects are to increase the capacity of renewable energy in the national grid.

Development Partner	Overview of ongoing/planned support	Objective
Japan International Cooperation Agency (JICA)	▪ Steam supply management for GDC	
	Capacity building for KETRACO	JICA is assisting KETRACO, through a partnership between the Government of Kenya and the Government of Japan with an overall goal of making sure the electric power system in Kenya is stabilised and has additional capacity to absorb variable renewable energy (VRE) and ensuring that KETRACO improves its capacity for transmission network planning, and system operation and control in preparation for future VRE grid integration.

3.7. Experiences and Lessons Learned

The design of the program has taken into account the experiences and lessons learned from previous programs and projects. These experiences have included support from the CIF's Scaling-Up Renewable Energy Program (SREP) and subsequently through the CTF's Clean Technology Fund Dedicated Private Sector Program (DPSP) to build technical and financial capacity at the newly formed Geothermal Development Company (GDC) and to offer targeted guarantees to de-risk geothermal development in Kenya.[40] AfDB and additional partners supported Phase I of GDC's high-risk geothermal resource development phase at Menengai from exploration to production drilling and steam field development, including through the deployment of an SREP resource confirmation guarantee. Subsequently, AfDB also included a CTF DPSP payment security guarantee project to attract private investors who perceived a credit risk of entering into PPAs with non-creditworthy governmental entities. A key lesson learned was how well-designed risk mitigation and guarantee structures can help support a large-scale investment through public-private cooperation.

Support from development partners was crucial in enabling the country's public sector to play its role of attracting private involvement by de-risking the process. This experience demonstrates that risk mitigation instruments can be helpful in managing specific risks that impede successful projects and partnerships in Kenya.

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[40] https://www.cif.org/sites/cif_enc/files/knowledge-documents/srep_evaluation_report.pdf

4. PROGRAM DESCRIPTION

4.1. Component 1: Enhancing Grid Flexibility

This component aims at increasing power system flexibility and security in a cost-effective manner by managing the variability and uncertainty to increase the uptake and penetration of renewable energies while minimising curtailment of renewable energy generation. The intervention entails the implementation of Automatic Generation Control (AGC), Hydromet Forecasting, Battery Energy Storage System (BESS) and Reactive Power Compensation devices projects.

4.1.1. Automatic Generation Control (AGC) and Hydromet Forecasting

Automatic Generation Control

The increased penetration of intermittent energy to the Kenyan power grid has created unprecedented system operation challenges. The intermittent nature of wind and solar energy has led to frequency stability and system control challenges which are aggravated by limitations associated with the accuracy and reliability of resource forecasting. The increase in variable generation in the system has caused an increase in frequency deviation incidences, leading to an increased frequency of phone calls to generation plants to carry out secondary frequency control causing strain on the grid system. Currently, secondary regulation is achieved manually by the National Control Centre (NCC) calling on generation plants to adjust the generation output. There is an urgent need to implement the AGC system to track generation as well as to ensure system stability as recommended by the Regulatory Impact Assessment Study on System Operation Regulation, EPRA 2023[41]. Implementation of AGC would eliminate this need to frequently make phone calls and enable faster and more effective system response to frequency deviations. AGC is also a requirement for a control area in the regional initiatives driven under the Eastern Africa Power Pool (EAPP). AGC will require an indicative figure of USD 14,412,248.63 that will be financed by CIF in order to install AGC Generator End for every generation station selected and communication/outstation works. The intervention will be implemented by KPLC, KETRACO, KenGen and IPPs.

Hydromet Forecasting

Kenya's power system is dominated by renewable energy which amounted to 89.5% as of June 2023 KPLC Dispatch Data 2022/23[42] and therefore heavily reliant on hydrological and meteorological forecasts and modelling for sustainable electricity generation. The forecasts are key for demand-supply management. Currently, the forecasts and modelling by KenGen for hydros

[41] Regulatory Impact Assessment Study on System Operation Regulation, EPRA 2023 Operational security
[42] Kenya Power Dispatch Data, June 2023

are done manually from first principles as enshrined in KenGen ISO Procedures on Work Instruction for Hydro Energy Projections[43]. In addition, the system dispatcher relies on data from KenGen and forecasts by the Independent Power Producers (IPPs) supplying renewable energy to the grid as part of PPA's requirement. Weather forecasts obtained from the Kenya Meteorological Department (KMD) are used as input for the hydrological model (Excel-based water balance model) for the hydropower projections while no centralised projections exist for variable renewable energy (VRE) technologies.

The existing forecasting tools for VRE technologies belong to IPPs and are therefore inadequate for centralised planning for efficient system planning and operation. The existing weather forecasts cannot accurately guide the energy dispatch planning and management as the temporal scale is always in the order of days. The VREs are fast increasing and therefore a need for reliable energy generation projections for system planning and management purposes as recommended by Advance Forecasting of Variable Renewable Power Generation Brief, IRENA 2020[44] and Assessment of Wind and Solar Power Forecasting Techniques in SAARC Countries Report[45].

The financing plan will involve procurement of hardware and software applications, installation and configurations, capacity building and project management amounting to USD 2,600,000. Implementation will require collaboration between KenGen, IPPs, KETRACO and the Kenya Meteorological Department.

Gender mainstreaming in the implementation of the AGC and Hydromet Forecasting can be ensured by: i) having women participating in technical trainings; ii) integrating women in engineering and technology roles, in research and innovation, as well as at the decision-making level and as entrepreneurs; iii) mainstreaming gender in policy and regulation; iv) raising awareness among women about the potential career opportunities in the renewable energy and technology sectors, e.g. by encouraging young women to pursue careers in STEM fields relevant to energy systems.

4.1.2. Battery Energy Storage Systems (BESS) and Reactive Power Compensation Devices

Kenya runs a single buyer business model, with the off-taker signing Power Purchase Agreements (PPA) with KenGen and IPPs. The off-taker is currently undertaking system operations which include power plant dispatch. The increased proportion of VREs in the Kenyan grid system coupled

[43] KenGen ISO Procedure Work Instruction for Hydro Energy Projections
[44] Advance Forecasting of Variable Renewable Power Generation Brief, IRENA 2020
[45] Assessment of Wind and Solar Power Forecasting Techniques in SAARC Countries Report

with a considerable level of geothermal baseload capacity has often resulted in energy curtailment during off-peak hours.

In addition, the high proportion of VREs in the power system requires enhanced ancillary services to maintain power system stability. On the other hand, the system often experiences firm capacity deficiencies at system peak due to planned and unplanned plant outages, and low wind availability resulting in some load shedding. During such periods the grid relies heavily on expensive thermal generation. Currently, a detailed technical Kenya BESS Options Study is ongoing with analysis of impacts to transient stability of the system.

Battery energy storage systems (BESS) will improve the Kenya grid system by reducing operational costs through peak power and energy arbitrage, spinning reserves synchronisation to the grid, enhanced frequency response, reducing network congestion, and renewable energy integration into the grid with reduction of geothermal steam venting as planned in Least Cost Power Development Plan 2022-2041.[46] The LCPDP projects 250 MW of BESS by 2025 out of which the World Bank is currently financing KenGen to develop a 100 MW/1 hour battery system.

Reactive power compensation devices on the other hand are targeted to resolve the voltage variability. Due to their fast-acting nature, the equipment will enhance evacuation and promote greater utilisation of renewable energy resources. In 2022,[47] KETRACO completed a Technical Study on the Requirement of Reactive Power Compensation Devices and Voltage Support for Kenya's Grid. The study recommended the installation of fast-acting reactive power and voltage control devices at strategic locations across the network. This will eventually lead to the discontinuation or reduced reliance on local small diesel generators currently installed in the affected areas.

The financial plan will require approximately USD 211,000,000 financed by CIF at USD 17,215,000, World Bank & AFDB at USD 103,785,000, IFC at USD 25,000,000 and the private sector at USD 65,000,000 to meet coverage in the major sites. These two projects will require implementation from KenGen, IPPs, KETRACO, KPLC and Private Sector.

Proposed intervention

The intervention aims at improving grid stability, power quality and reliability, enabling projections for real-time and day-ahead power trade envisaged by the Eastern Africa region as well as providing ancillary services to the power system. Installation of AGC systems will improve system frequency

[46] Least Cost Power Development Plan 2022-2041

[47] Technical Study on the requirement of reactive power compensation devices and voltage support for Kenya's grid, 2022

control in the Kenyan power grid and therefore enable integration of variable renewable energy. Hydromet forecasting systems will improve the accuracy of forecasting outputs from renewable energy developers. Installation of Battery storage will assist in energy arbitrage and provide ancillary services as well as reduce geothermal steam venting.

To foster gender integration, the following actions could be taken: i) encourage women to pursue careers in engineering and technology, especially in fields related to grid stability, power quality, and renewable energy integration; ii) support women entrepreneurs and developers to invest in battery energy storage systems and other renewable energy technologies that can enhance grid stability and reduce reliance on expensive thermal generation; iii) advocate for increased representation of women in data analysis and forecasting roles; iv) ensure that women's perspectives and expertise are considered in the decision-making process related to grid stability and renewable energy integration; v) support women entrepreneurs in the energy storage sector; and vi) provide capacity-building programs and workshops specifically targeted at women interested in grid stability, power quality, and renewable energy integration.

Expected Outcome: Component 1

Improved power system security, efficiency, reliability and flexibility of the grid through optimised dispatch of renewables, optimal frequency management, balanced energy supply and demand, reduction of geothermal steam venting and curtailment of VREs during low demand periods.

4.2. Component 2: Enhancing Grid Reliability and Resilience

The Development of enabling infrastructure is aimed at ensuring an adequate and reliable power grid necessary to support the evacuation and utilisation of generated renewable energy. Any interruption of the network particularly in sections lacking n-1 redundancy affects evacuation of power and may lead to curtailment of generation from renewable energy sources with a high probability of reverting to conventional thermal power generation. Enhancing network capacity and reliability will require the construction of additional transmission lines to facilitate the evacuation of renewable energy, network reinforcement to facilitate compliance with n-1 reliability criteria, restocking of emergency restoration towers, and acquisition of mobile and additional transformers.

Smart grid development and acquisition of mobile substations will enhance power quality, supply reliability and grid security as planned in the Fourth Medium Term Plan 2023-27[48]. It will facilitate the development of distributed renewable energy generation, enhance grid flexibility through demand response and increase penetration of VREs while maintaining grid stability and resilience.

[48] The fourth Medium Term Plan 2023 -2027

In addition, harnessing more renewable energy in the country's energy mix is expected to reduce the cost of energy in the long run, leveraging on the reduced cost of clean energy technologies. This is in line with the country's goal to attain a 100% clean energy transition by 2030.

Automation of conditional monitoring of power systems will provide real-time monitoring of critical substation equipment, reduce operation and maintenance costs of substation and ease planning for equipment retirement and decommissioning by leveraging on the health indices determined from Enterprise Asset Management (EAM) data analytics. With the extensive network, maintenance is becoming a critical component towards ensuring security in evacuation and supply of electric energy generated from renewable energy sources.

4.2.1. Smart Grid to Control and Dispatch Distributed Renewables

By June 2023, the installed VRE generation in the grid amounted to 646 MW comprising 436 MW and 210 MW of wind and solar power respectively. This is equivalent to 20% of the installed capacity. Least Cost Power Development Plan 2022-2041[49] indicates wind generation comprises mainly of two large power plants; the 310 MW Lake Turkana Wind Power (LTWP) in Northern Kenya, and the 100 MW Kipeto wind power located in the Nairobi Region. Solar generation comprises medium-sized power plants (40 - 50 MW) distributed around the country, with 60% of them located in the North Rift Region. These plants are monitored by the SCADA system and are therefore controllable. However, the grid has distributed small hydro and biomass generation across the country amounting to 25 MW and about 365 MW captive generation that is not monitored or controlled centrally on the SCADA system.

Due to the relatively high penetration of VREs, inadequate primary reserves and lack of Automatic Generation Control system, the grid frequently experiences frequency instability. In addition, with embedded unmonitored generation the grid experiences voltage control and protection issues as discussed in the Regulatory Impact Assessment Study on System Operation Regulation, EPRA 2023[50]

Whereas the country has plans for further deployment of VREs to facilitate clean energy transition, the grid stability issue limits further uptake of VREs. Some of the initiatives being considered to facilitate integration of more VREs include increasing grid flexibility, deployment of Large Hydropower plants, enhancement of grid ancillary services (primary reserves and regulating reserves), adoption of battery energy storage systems and development of smart grid solutions as detailed in Least Cost Power Development Plan 2022-2041. The alternative provided in the LCPDP to Hydro Pumped Storage and Battery Storage is the use of Gas turbines.

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[49] Least Cost Power Development Plan 2022-2041

[50] Regulatory Impact Assessment Study on System Operation Regulation, EPRA 2023. Operational Security

The proposed smart grid extension project will comprise financing of expansion of the digital technology and communication systems and deployment of control equipment to distributed generators at USD 9,049,500, and deployment of smart meters to identify interruptible loads to facilitate demand response at USD 5,400,000 and implementation of time of use electricity tariffs accordance with the Sixth Cost of Service Study in the Electric Power Sub-Sector[51]. KPLC will implement the project as an extension of its ongoing smart grid development. It is also proposed that the KPLC single-phase meter testing capacity be enhanced from 160 meters per day to 500 per day at a cost of USD 501,000 in preparation for more participation of the private sector in the distribution of energy meters, with KPLC undertaking large-scale quality assurance tests. The estimated cost includes enhancing staffing by an additional 3 members for each of the 3 new testing benches proposed. This would help address the associated procurement bottlenecks and expedite new customer connections and reduce energy losses. The total financial support required will be financed by CIF at USD 4,166,750 and World Bank & AFDB at USD 10,783,750.

4.2.2. Transmission Lines and Substations Equipment Strategic Spares

(Mobile Transformers, Additional Transformers and Emergency Restoration Towers).

The country's demand for electricity has grown at an annual rate of about 4.5% over the past few years, largely driven by the actualisation of the Third MTP 2018-2023[52] of the Vision 2030. The loading on several transformers in Kenya's power grid substantially increased. Simulations indicate that the impending overload situations could lead to equipment overload and subsequently, failure of transformer units in these substations hence affecting effective evacuation and utilisation of power especially for renewable sources. This has a negative impact on power utilisation and delays in addressing the situations due to various constraints invariably lead to increased system losses due to loading, loss of revenue due to load management, susceptibility to breakdowns due to equipment loading beyond or to full capacity and limits the efforts towards promoting 100% electricity access to the nation's population.

With respect to Operation and Maintenance, network power transformers and installed reactive power compensation devices have suffered failure due to various reasons. In the last 5 years, about 10 incidents on power transformers were reported, two were critical and required immediate replacement of the transformer units resulting in discontinued supply in the areas affected, causing demand curtailment and, hence a loss of revenue opportunities. As reported in the KPLC Annual Report 2021/22, the unserved energy in the 2021/22 financial year amounts to 207.8 GWh with an estimated total loss of KSh. 2,767.14 million to KPLC, due to a breakdown in infrastructure from various causes including vandalism and adverse weather/climatic conditions. The resultant

[51] The Sixth Cost of Service Study in the Electric Power Sub-Sector

[52] The Third Medium Term Plan 2018 -2022

economic loss was estimated at $ 311.7 Million to the entire economy based on a rate of $1.5 per kWh in accordance with Power Generation and Transmission Master Plan 2015-2035[53]

O&M TL and SS equipment Strategic Spares will entail four (4) truck mounted/mobile transformers, four (4) Truck Mount/Mobile Reactive Power Compensation Devices, twenty (20) Sets of Emergency Restoration Tower, five (5) Power Transformer Units 132/33 kV 23 MVA (Additional And Spares Units), three (3) Power Transformer Units 132/66kV 60 MVA (Additional And Spares Units), three (3) Power Transformer Units 220/33kv 23 MVA (Additional And Spares Units) and two (2) Power Transformer Units 220/132kV 90 MVA (Additional And Spares Units).

The financial support required for mobile transformers and special/equipment amounts to USD 24,249,500 out of which USD 9,649,500 is proposed for financing under CIF and USD 14,600,000 by the World Bank & AFDB. The implementing institutions would be MoEP in conjunction with KPLC and KETRACO.

Technical assistance and capacity building of the O&M teams is also critical to the efficient operation of the power system. Capacity building will increase the participation of women in O&M activities by ensuring i) women participating in technical training; and ii) integrating women in engineering and technology roles, in research and innovation, as well as at the decision-making level.

4.2.3. Automation of Condition Monitoring of Power System

Kenya's power transmission network has grown phenomenally over the years thus increasing the complexity of operation and maintenance of the power system. Automation of conditional monitoring of the power system is expected to maintain a healthy national grid with a well-structured and streamlined operation and maintenance regime. Attention to elements in the system on a need basis will also reduce overhead costs and downtimes in the network. The automation will also put in place a versatile asset management system for improved service delivery.

Automation of conditional monitoring of the power system will entail inter alia, supply and installation of remote sensing devices on Two (2) 220 kV and Two (2) 400 kV Power transformers, Four (4) Reactors, Ten (10) 220 kV and Ten (10) 400 kV Circuit breakers in selected substations. In addition, the supply and installation of data acquisition servers at the station level will be useful.

[53] Power Generation and Transmission Master Plan 2015-2035

The financing needed from CIF for the supply and installation of remote devices for substations and rolling for the entire system to be implemented by KETRACO will be approximately USD 2,500,000.

Proposed intervention

a. Smart Grid

The Smart grid development entails the implementation of a generation resource forecasting system, expansion of communication infrastructure, digital technology and control equipment to all generation plants including embedded generators and net-metered institutions/ customers and implementation of smart metering for all prosumers on net metering and contracted interruptible loads (irrigation, water heating, EV charging, street lighting, air conditioning etc.)[54]

Smart grid development will facilitate deployment of transmission and distribution energy management systems for the effective operation of the grid with high penetration of VREs. This is through the provision of real-time resource forecasting data and automated response to restore demand-supply balance by either curtailing or storing excess VRE generation during high generation periods or demand response to restore the power balance during periods of low VRE generation. This will complement the flexibility/ regulation response provided by conventional generators and therefore support the integration of more VREs. Smart grid solutions will also facilitate more effective voltage control by appropriately scheduling Distributed generation sources to solve voltage problems and optimise system performance with enhanced distributed generation.

b. Mobile Substations and Strategic Spares

These include power transformers and emergency restoration towers. It will reduce the downtime for power supply and improve restoration times in the event of network breakdown attributed to failures in power transformers and mechanical failures in transmission line structures. Mobile transformers will be deployed to critical areas where power transformers are overloaded to avert load shedding hence ensuring continuity of service in the system and maximising utilisation of renewable energy resources.

Under this second component, gender mainstreaming will be achieved by i) paying special attention to gender diversity in teams responsible for the implementation of smart grid solutions and generation resource forecasting systems; ii) reaching out to women entrepreneurs and developers for them to invest in renewable energy projects, including distributed generation

[54] The Sixth Cost of Service Study in the Electric Power Sub-Sector, 2018

sources like solar and wind power; iii) support increased representation of women in data analysis and automation roles; iv) provide capacity-building programs and workshops specifically targeted at women interested in smart grid development and energy management systems; and v) support women-led advocacy groups and organisations that promote renewable energy adoption and sustainable energy solutions as these groups can play a crucial role in raising awareness about the benefits of renewable energy and smart grid development.

Expected Outcome

Reduced levelised cost of electricity (LCOE) by reducing system and revenue losses, restoration times, operation and maintenance costs of the system, and load shedding/outages arising from supply capacity constraints.

4.3. Component 3: Technology and Market Innovation.

4.3.1. Renewable Energy Centre of Excellence

(Including RE Technology Transfer/ Incubation Hub)

Inadequate skilled manpower in energy-related areas impacts on Kenya's ability to tap into the abundant Renewable Energy Resources. The development of the Renewable Energy Centre of Excellence will enable Kenya to build capacity by offering training and development of a critical mass of professionals and resource persons in the energy sector within the country. With the increased variable renewable energy to Kenya's grid, there is a need for capacity building to address the challenges of intermittent power as part of the Renewable Energy Integration Program in the country.

The Renewable Energy Centres of Excellence will be an innovative hub that encompasses technology-specific energy labs including geothermal, solar, wind and hydro for RE technology transfers and incubations. The Centre will be operated by the MoEP through designated institutions within the energy sector in partnership with the private sector and academia, to provide all the required expertise and encourage research and innovation in the industry. It will involve demonstration centres to showcase ideas that can be replicated further on a larger scale in order to advance the use of clean energy technologies in the marketplace.

The RE Centres of Excellence will also provide capacity building to enhance the role of energy in meeting the practical needs and well-being. The availability of clean, sustainable and affordable energy resources requires the participation of both men and women in the social economic growth of the country while protecting the environment. The RE centres of excellence is therefore envisaged to contribute and complement Kenya's ongoing efforts towards the achievement of 100% Clean Energy by 2030 in line with SDG No. 7 while also achieving the climate change targets as established by the NDC and in fulfilment of SDG 13.

The Renewable Energy Centres of Excellence will play a vital role in building the capacity of women professionals and resource persons in the renewable energy sector. Specific training and mentoring programs can be designed to encourage more women to enter and thrive in various renewable energy fields, such as geothermal, solar, wind, and hydro. This can help address the gender gap in skilled manpower and empower women to actively contribute to the sector's growth.

The Energy Centre for Excellence, renewable energy laboratory construction and equipping of the geo-scientific laboratories will amount to USD 25,495,500 with financing from the CIF and World Bank. Additional grant funding of USD 1,938,586.24 for technical assistance in terms of capacity development in climate action will be required.

4.3.2. Direct Use of Geothermal Steam

Kenya has significant geothermal resources which have been developed in Olkaria, Menengai and Baringo - Silali. Direct use of geothermal energy is the utilisation of the thermal energy in geothermal fluids for uses other than electricity generation. Studies have shown that hot geothermal fluids, even when not suitable for electricity generation, have substantial amounts of thermal energy which can be harnessed economically for productive uses.

GDC has set up Direct Use demonstration projects in the Menengai geothermal project including aquaculture, milk pasteurisation, green house and grain drying and now plans to commercialise these projects at a centralised location adjacent to the Menengai Geothermal Project. Studies undertaken by the United States Agency for International Development (USAID) and Iceland International Development Agency (ICEIDA) in Menengai show the commercial viability of direct-use projects. The resource park will utilise the heat from the geothermal fluids to power the industry therefore displacing the use of fossil fuels. This will create more demand for the uptake of variable RE into the grid.

GDC has identified about 2,000 acres of land in Menengai, Nakuru County, where it will establish a geothermal resource park. Earmarked wells with brine and steam will supply the heat parks as part of the energy supply infrastructure to distribute the geothermal fluid to different end-users, along with a system of heat exchangers, pumps, valves, and controls that regulate the temperature and flow of the fluid. This infrastructure will attract private sector investors from the manufacturing, agricultural, mining, tourism and health industries. The partnership would see the industries set up in Menengai benefit from the clean and renewable thermal energy from geothermal resources. The parks will also bring economic and social benefits to the local community adjacent to the geothermal project areas and make a positive impact to those communities including those of women and girls.

The Financing required from CIF is USD 2,793,315.04 towards technical Support (Feasibility Study for Geothermal Resource Parks), and the establishment of energy supply infrastructure required to attract private sector investments from the cement manufacturing, paper processing, and aquaculture firms. The project will benefit from the development of the Renewable Energy Centres of Excellence and laboratories through joint collaborations on research on renewable energy innovations.

4.3.3. New Markets for Scaling-up RE Technologies in Other Sectors

Power demand in Kenya has largely been driven by GDP growth, population growth, urbanisation, and the implementation of government flagship projects. However, the country is on the cusp of scaling up emerging technologies through E-Mobility, E-cooking and irrigation. These technologies not only expand markets for RE in Kenya but also have the potential to reduce GHG emissions from fast-growing sectors, including agriculture, transportation and industry.

E-mobility - The transportation sector in Kenya currently contributes 12% of total national GHG emissions, which are projected to rise to 17% by 2030 in the business-as-usual case. Current annual power demand from EVs is estimated at 2,634 MWh (largely from private sources) and is projected to rise to 4,242 MWh by 2027,[55] and growing exponentially thereafter once the grid is stabilised and a business model for charging infrastructure is tested using public resources and modalities explored and established for their scale-up using private resources. The Government of Kenya targets to increase the share of total electric/hybrid vehicles in the country by 5% by 2025 annually by developing regulations and financial mechanisms to increase the ownership of electric vehicles in the country, including electric buses and fleets. Some of the initiatives currently in place to support uptake of EVs in Kenya include Electric Vehicle (EV) Charging and Battery Swapping Infrastructure Guidelines, 2023, the development of electric vehicle (EV) standards, reduction of excise tax on EVs from 20% to 10%; and partnering with development partners to finance piloting of public charging stations and infrastructure, as well as implementing promotion of E mobility in rural and urban Centres.

As demand for E-Vehicles grows, it becomes critical to expand the number of charging stations and associated infrastructure beyond the small number of charging stations for private fleets. For instance, currently the E-Vehicle charging stations in the country are notably low with e-mobility private players in place[56], which consequently slows down growth of EVs. An expansion of the

[55] Medium Term Plan of Least Cost Power Development Plan 2023 -2027
[56] Road Map to E-mobility in Kenya

charging infrastructure network in the country will largely increase the acceptability of EVs among consumers due to the increased convenience and accessibility to charging services. Additional investment in this infrastructure will positively affect growth in power demand in the country. Kenya is proposing CIF to support the country in the provision of technical support Technical Support towards the Development of EV and E-Mobility Standards, and Policy and Regulatory Framework for The Uptake of E-Mobility.

E-cooking – Transitioning to electric cooking is an essential step for the country to adopt cleaner cooking solutions, which have multiple health, climate, economic, and environmental benefits. Annual power demand from E-cooking in 2022 was estimated at 5.7 MW and is projected to increase to 6.97 MW by 2027 (MTP of Least Cost 2023-27). According to the Kenya Cooking Sector Study undertaken by MoEP and CCAK in 2019, e-cooking options only accounted for 0.3% of the cooking options currently used. In addition, 55.1% of households in Kenya still use wood as their primary fuel for cooking.[57] According to the 2019 survey, approximately 3% of the households use electric cooking appliances (mixed LPG-electricity stove, electric coil and microwave). The government has targeted to achieve universal access to clean cooking by 2028, which includes both e-cooking and clean cookstoves.

Notable ongoing projects on clean cooking include the Green Climate Fund "Climate Friendly Cooking Project"[58] for professionalising the improved cookstoves sector coordinated by GIZ and implemented in collaboration with various partners. The project which is implemented in Kenya and Senegal aims to limit consumption of non-renewable biomass in the cooking sector leading to GHG emission reduction of 6.47 $MtCO_2eq$. during the project period and an additional 24.77 $MtCO_2eq$. until 2030. The project is also expected to directly benefit 11.23 million people and will enable the two countries to reach their stated NDC targets for GHG emissions in energy cooking sectors. Secondly, the Kenya Off-grid Solar Access Project funded by the World Bank seeks to increase access to decentralised electricity generation (green mini-grids and solar home systems) as well as distribute 150,000 clean cookstoves in 14 underserved Counties.

Despite government efforts to support the adoption of e-vehicles, e-cooking and support irrigation, the inadequacy of necessary supporting energy framework and infrastructure remains to be a huge hindrance towards growth in electricity demand and hence a constraint on Kenya's economic development. There is also no policy and regulatory framework to guide the private sector to develop EVs and e-cooking business models. The government therefore banks on CIF support in the development of policy and regulatory framework and awareness to promote the uptake of e-cooking and large-scale irrigation programs. Resources, including grant finance will be

[57] Kenya Cooking Sector Study undertaken by MoEP and CCAK, 2019
[58] https://www.greenclimate.fund/project/fp103

required from CIF, amounting USD 750,000 in form of technical support to develop enabling standards, policy and regulatory framework in support of electrification of other sectors. In addition, this will enhance development of infrastructure such as fast charging stations and battery swapping stations across major towns in the country will lead to a higher uptake of Electric Vehicles, including mass rapid transport systems catalysing World Bank financing of USD 10,306,000

Component 3 can contribute to promoting gender equality and women's empowerment within the renewable energy market in Kenya, creating a more inclusive and sustainable energy transition. Gender integration can be reinforced by supporting demand stimulation for emerging technologies like electric vehicles (E-Vehicles) and e-cooking, and gender-responsive policies can be implemented to encourage the uptake of these technologies by women. For instance, awareness campaigns and financial incentives can target women to promote the ownership of E-Vehicles and the adoption of clean cooking solutions. Additionally, efforts can be made to involve women entrepreneurs and businesses in the development of EV charging infrastructure and distribution of clean cooking appliances.[59]

When planning the expansion of charging infrastructure for electric vehicles and battery swapping stations, special attention should be given to ensure that these facilities are accessible and safe for women. This may include locating charging stations in well-lit and secure areas and considering women's safety concerns during the design and implementation phase.

Component 3 will contribute to the achievement of gender equality and women's empowerment in the renewable energy sector, by fostering a more inclusive and sustainable energy transition in Kenya by:

i) Prioritising gender-responsive training and capacity-building programs in the Energy Renewable Centre of Excellence (see gender-related inputs section 1.4);
ii) Promoting women's leadership and representation in decision-making roles at the Centres of Excellence, e.g. at the Menengai Direct Use Industrial Park;
iii) Conducting gender-responsive research and innovation projects within the Energy Centres of Excellence;
iv) Enhancing gender-inclusive business opportunities: the Menengai Direct Use Industrial Park should actively promote and support women-led businesses and entrepreneurs interested in utilising geothermal energy for industrial purposes. Special consideration can be given to women-owned businesses in sectors like aquaculture, cement manufacturing, and geothermal spas to ensure their inclusion and participation in the direct use projects; and
v) Valuing women's empowerment and economic benefits.

[59] Bioenergy Strategy, 2020

Expected Outcome - Component 3

Enhanced renewable energy research, technology transfers and innovation hubs by improving human resource capacity in renewable energy technologies to accelerate deployment of E-Cooking and E-mobility, increasing demand for direct-use projects.

Gender mainstreaming in the energy sector, for gender inclusion, participation and parity human resource development and deployment including providing practical exposure to trainees through attachment, internship and mentorship programs for girls and boys, the youth, women and men.

4.4. Component 4: Facilitating Open Access for Renewables

This component aims at addressing the single buyer model that characterises Kenya's power market, providing for a competitive environment to enhance efficiency and reliability, and improving the quality of service within the electricity sector among others as detailed below.

4.4.1. Finalisation of Regulations

(In Support of Renewable Energy Integration and Climate Change Resilience in Kenya)

An enabling regulatory framework is key to facilitating an open power market environment and is vital for renewable energy integration of any power system. Kenya is in the process of implementing her commitments to the climate change conventions and has set specific targets for meeting this objective. Accordingly, efforts are underway to develop and implement key enabling regulations, restructuring its power market and putting in place mechanisms for open access. These will be necessary prerequisites for renewable energy integration in the country.

Proposed Interventions

The Energy Act 2019[60] requires the development and review of a wide range of regulations. Thirty-two (32) such regulations are at various stages of development and approval. To specifically address issues related to renewable energy integration and climate change resilience, four (4) key regulations are under development namely: the Energy (Renewable Energy Resources) Regulations, 2021, the Energy (Feed-in Tariff) Regulations 2021, the Energy (Mini-grids) regulations 2021 and the Energy (Net- metering) Regulations, 2021.

Additionally, the country's electricity market structure is largely a single-buyer model with a sole off-taker. There are, however, many generators who enter into long-term Power Purchase

[60] The Energy Act 2019

Agreements (PPAs) with the off-taker. These players together with eligible consumers require an enabling environment to operate. Accordingly, the country is in the process of restructuring its power market to allow for competition at all levels of the value chain. To support this objective, the Energy and Petroleum Regulatory Authority (EPRA) designated KETRACO to carry out System Operation (SO) functions. Among other things, the SO is expected to allow for open access to the power system. The process of transmission consolidation is also ongoing. Regulations are under development for the purpose of opening and improving the power market. The main ones include the draft Energy (System Operation) Regulations, 2023 incorporating the updated Grid Code, the draft Energy (Reliability, Quality of Supply and Service) Regulations, 2021 and the draft Energy (Electricity Market, Bulk Supply and Open Access) Regulations, 2021.There is a need to put in place these support instruments hence the need for necessary resources for finalisation.

Financial support required from CIF for the development of regulations on renewable energy resources, electricity market, bulk supply & open access amount to USD 116,297.56 in form of grant. The implementing agencies responsible are EPRA and MoEP.

It is recommended to take into account gender-responsive considerations as provided in the Gender Policy in Energy[61]. When finalising regulations in support of renewable energy integration and climate change resilience, gender considerations should be integrated into the design and implementation. This includes analysing the potential differential impacts of these regulations on men and women and taking measures to address any gender disparities. For example, in the development of policies related to electric vehicles and e-cooking, specific measures can be put in place to promote women's participation in the supply chain and distribution networks of these technologies.

4.4.2. Technical and Financial Impact of Distributed and Captive Energy on the Power Grid

There has been an upsurge among Kenyans to generate electricity for their own consumption as a supplement to the national grid supply. With plummeting prices of renewable energy technologies, small and large consumers have been installing on-site electricity plants to complement supply from the national grid. In Kenya, most prosumers have adopted solar photovoltaic technology with 154.9 MW installed at the end of June 2023[62].

With approximately 4,136 No commercial and industrial power consumers in Kenya as of 2023.[63] There is immense potential for solar PV captive power systems among these entities. The electricity

[61] Gender Policy in Energy
[62] EPRA Biannual Energy and Petroleum Statistics Report: Financial Year 2022/2023
[63] Kenya Power Annual Report and Financial Statements

generated from this technology varies through the day depending on the available insolation. Similarly, the consumer load varies depending on the connected appliances at a particular time. Thus, it is difficult to precisely match the generation with demand due to the fluctuations, creating a risk of reduced revenue. These challenges place a strain on the grid, reduce its robustness and reliability, violate its operating limits and could harm the grid equipment as a result of too much feed-in onto the grid.

Proposed Intervention

To undertake a study investigating the technological impacts on the grid including voltage variation and unbalance, current and voltage harmonics, grid islanding protection, stress on distribution transformers and the effect of different penetration levels on the net system load.

In addition, the study should investigate the financial impacts such as cost deficit to the utility, business models available to the utility involving value proposition, customer interface, infrastructure and revenue model and net metering and feed-in tariffs on the grid.

A gender lens should be applied to the Study on the Technical and Financial Impact of Distributed and Captive Energy on Kenya's Power Grid. The study should collect gender-disaggregated data to understand how men and women are participating in adopting renewable energy technologies, such as solar photovoltaic systems for captive power. The research should also explore the gendered impacts of fluctuating power generation and consumption on men and women, especially in households and businesses that rely on renewable energy.

Throughout the implementation of interventions under Component 4, gender-disaggregated data should be collected to track the participation and impact of women in various aspects of the renewable energy market design and system operations improvements.[64] This data will enable policymakers and stakeholders to identify and address gender disparities and develop more targeted interventions to enhance gender equality in the energy sector. The amount of grant financing required from the program to carry out the study by the implementing agencies; MoEP, EPRA and KPLC will amount to USD 158,302.46.

Expected outcome

Accelerated development and completion of RE policies and regulations to promote the integration of RE through innovative competitive means such as frameworks for open electricity access, and GHG emissions reduction initiatives.

[64] Gender Policy in Energy

5. POTENTIAL FOR GHG EMISSIONS REDUCTION

Kenya submitted her intended Nationally Determined Contribution (iNDC) in July 2015 as a commitment to tackling climate change by pledging to reduce its emissions by 30% from the Business as Usual (BAU) scenario of 143 $MtCO_2eq$. In 2020, Kenya enhanced her pledge through the updated NDC submitted to the UNFCCC communicating her increased ambition by pledging to reduce GHG emissions by 32% relative to the BAU scenario in line with her sustainable development agenda. This Program will therefore contribute to achieving the objectives of CIF RE Integration while at the same time reducing emissions through the following program impacts:

1) **Increased share of renewable energy in the energy mix**

   80% of Kenya's installed capacity is renewable sources (mainly geothermal, hydro, wind and solar) contributing about 90% of the dispatched energy. The country has one of the cleanest electricity grids in the world and is in pursuit of 100% clean power generation by 2030. This program seeks to contribute to the ambitious goal by providing an enabling environment to enhance renewable energy integration in the grid while greening the generation mix.

2) **Increased flexibility, reliability, and climate resilience of power networks**

   Improve power system security, efficiency, reliability and flexibility of the grid through optimised dispatch of renewables, optimal frequency management, balancing energy supply and demand, reduction of geothermal steam venting and curtailment of VREs during low demand periods. A more reliable and affordable electricity supply will make electricity an attractive option for cooking and mobility.

3) **Increased access to affordable, reliable, and modern energy service**

   The program will contribute to accelerated development and completion of RE policies and regulations to promote integration of RE through innovative competitive means such as frameworks for open electricity access, and GHG emissions reduction initiatives. The transition in cooking and transportation, which are dominated by unsustainable biomass and fossil fuels respectively to modern energy services, will be transformative. A switch to e-cooking and e-mobility will avoid deforestation, air pollution and GHG emissions.

4) **Contribution to Kenya's NDC Targets**

   The IP is expected to contribute to the achievement of Kenya's NDC targets enabling the overall emission reduction of 32% compared to the Business as Usual (BAU) scenario of 143 $MtCO_2eq$ by 2030. With implementation of the mitigation actions prioritised between 2023-

2027 through the National Climate Change Action Plan (NCCAP 2023 -2027)[65]. The electricity generation sector is expected to reduce 30.46 MtCO_2eq GHG emissions through Kenya's continued investment in renewable energy sources. The Renewable Energy Integration program as proposed by this IP will therefore contribute to achievement of this target. The clean electricity will help decarbonise other sectors of the economy including the residential sector, transport, industry and agriculture while providing options to reduce deforestation hence conserving biodiversity.

5) Contribution to technology development, deployment, diffusion, and transfer of low-emissions technologies in sectors that make major contributions to GHG emissions.

The program seeks to enhance renewable energy research, technology transfers and innovation hubs by improving human resource capacity in renewable energy technologies through the proposed energy Centres of excellence. The implementation of the program will further lead to an acceleration of deployment of e-cooking, e-mobility, and increased demand for direct-use projects.

E-mobility- The current annual power demand from EVs estimated at 2,634 MWh is projected to rise to 4,242 MWh by 2027[66]. The transportation sector in Kenya contributes 12% of total national emissions. These emissions are projected to rise to 17% by 2030 in the business-as-usual case. The Government of Kenya targets to increase the share of total electric/hybrid vehicles in the country by 5% by 2025 annually by developing regulations and financial mechanisms to increase the ownership of electric vehicles in the country.

E-cooking – Annual power demand from E-cooking in 2022 was estimated at 5.7 MW and is projected to increase to 6.97 MW by 2027 (MTP of Least Cost 2023-27). According to the Kenya Cooking Sector Study undertaken by MoEP and CCAK in 2019, e-cooking options only accounted for 0.3% of the cooking options. In addition, 55.1% of households in Kenya still use wood as their primary fuel for cooking.[67] The government targets to achieve universal access to clean cooking by 2028. According to a national survey conducted by the Ministry of Energy in 2019, approximately 3% of the households use electric cooking appliances (mixed LPG-electricity stove, electric coil and microwave. Transitioning to electric cooking is an essential step for the country to adopt cleaner cooking solutions, which have multiple health, climate, economic, gender and environmental benefits.

[65] Kenya's National Climate Change Action Plan (NCCAP 2023 -2027)
[66] Medium Term Plan of Least Cost Power Development Plan 2023 -2027
[67] Kenya Cooking Sector Study undertaken by MoEP and CCAK, 2019

6. FINANCING PLAN AND INSTRUMENTS

The estimated total resource requirement to finance the four proposed components under Kenya's Renewable Energy Integration Investment Plan is USD 312.97 Million. It is anticipated that the CIF will finance a total of USD 69.99 million plus grant of USD 5 Million for technical assistance while the remaining USD 242.97 Million will be funded by World Bank, IFC, AfDB, Private Sector and other development partners.

The structure of the financing shall be agreed upon during the negotiations with CIF, WB, AfDB, IFC and other Development Partners. The financing will primarily be a blend of concessional loans, guarantees and grants, although IFC, WB and AfDB Private Sector may also consider equity and mezzanine financing. These funds will be received by the Ministry of Energy and Petroleum, through the Government of Kenya (The National Treasury & Planning) and will be disbursed to the implementing agencies which include the MoEP, KETRACO, GDC, KenGen and Kenya Power. [A guarantee instrument to pilot and demonstrate mitigation of variable risks is also proposed to be explored.]

This Investment Plan has a schedule of proposed interventions under each main category, with the estimated cost of each proposed intervention provided. Table 3 highlights a summary of the estimated budget, categorised under each component for both Public and Private sector and from CIF funding.

Table 3: Summary of Cost Estimates for Proposed Interventions

No.	Component	Investment Component	Implementing Agency	Cost (USD)	CIF Funding (USD)	WB & AFDB (Public Sector)	IFC (Private Sector)	Private Sector Development	Total Estimated Cost By Category (USD)
1	**Enhancing Grid Flexibility**	Automatic Generation Control (AGC) including SCADA and hydromet forecasting & dispatch planning unit	KenGen, KETRACO, IPPs	17,012,248.63	17,012,248.63		-		228,012,248.63
		Battery Energy Storage Systems (BESS)	KenGen, IPPs, KETRACO, KPLC, Private Sector	100,000,000.00	10,000,000.00 (IFC)		25,000,000.00	65,000,000.00	
		Reactive Power Compensation Devices	KETRACO, KPLC	111,000,000.00	7,215,000.00	103,785,000.00			
2	**Enhancing grid reliability**	Implementation of smart grid for control and dispatch of decentralised renewables	KPLC, KETRACO	14,950,500.00	4,166,750.00	10,783,750.00			41,700,000.00

		O&M TL and SS equipment strategic spares (mobile transformers, additional transformers and emergency restoration towers)	KPLC, KETRACO	24,249,500.00	9,649,500.00	14,600,000.00			
		Automation of condition monitoring of power system O&M	KETRACO	2,500,000.00	2,500,000.00				
3	**Technology and Market Innovation**	Establish energy Centers of excellence and labs to enhance operational capacity, Capacity Building for the National CIF Committee, enhance gender inclusivity, support R&D, and demonstrate new business models to utilise renewables, e.g. new enterprise creation around Olkaria.	MOEP, KETRACO, KENGEN, GDC, REREC,KPLC	9,335,586.24	4,938,586.24	4,397,000.00	-	-	42,983,401.28
			GDC	10,900,000.00	5,750,000.00	5,150,000.00	-	-	
			KenGen	7,198,500.00	3,250,000.00	3,948,500.00	-	-	
		Commercialization of geothermal steam for use in adjacent economic and industrial activities (Menengai)	GDC	2,793,315.04	2,793,315.04	-	-	-	
		Stimulating renewable energy demand through country-wide pilot investments using emerging technologies e.g. charging stations for e-mobility, e-cooking, irrigation	MoEP	12,756,000.00	2,450,000.00	10,306,000.00	-		
4	**Facilitating Open Access for Renewables**	Policies and regulations on renewable energy generation, electricity market, bulk supply & open access	EPRA, MoEP	116,297.56	116,297.56		-		274,600.02

		Study on technical and financial impact of distributed & captive energy to Kenya's power grid	MoEP, EPRA, KPLC	158,302.46	158,302.46		-		
	Grand Total				*69,999,999.93	152,970,250.00	25,000,000.00	65,000,000.00	312,970,249.93

7. ADDITIONAL DEVELOPMENT ACTIVITIES

The Kenyan energy sector is working closely with other development partners on a wide range of renewable energy activities. Table 2 in Section 3.6 above lists a more comprehensive set of such additional activities supported by development partners.

The following initiatives illustrate relevant other parallel activities in the sector that are additional to those proposed in the Investment Plan: -

1. **Capacity Building as part of Enabling Actions from the NCCAP 2023-2027[68] by the Energy Sector Agencies - These Activities support the Energy Centre of Excellence Activities.**

Transformation of Kenya's Energy sector requires enhancing of STEM education and internship training to expand women's employment in energy utilities, including managerial roles as part of actualising SDG 5 on ensuring gender equality.

A number of Initiatives detailed below are currently being implemented by the Energy Sector Agencies and other partners as part of Capacity Building and enhancing the skills to facilitate the integration of Renewable Energy Technologies.

- Geothermal Development Capacity Building - Training of 60 participants per year (Coordinated by KenGen & GDC)
- Training 1,000 participants annually on renewable energy technologies (Coordinated by REREC)
- Training of 100 students per year by Kenya Power (Institute of Energy Studies and Research) on renewable energy technologies; and
- Training of 500 industry representatives annually on climate change, circular economy, carbon footprint and emerging climate change themes (Coordinated by Kenya Association of Manufacturers)

2. **Capacity building activities on decentralised Mini Grid renewable energy solutions to foster energy access in East Africa by Kenya Power Institute of Energy Studies and Research (IESR) and RES4Africa in partnership with Enel Foundation, Strathmore University, AVSI and St. Kizito Vocational Training Institute.**

The purpose of the Microgrid Academy is to foster knowledge transfer at the highest level, providing lectures and on-site training while bringing together local and international experts and students for a true knowledge exchange in a holistic micro-grid training programme. The trainers

[68] NCCAP 2023 - 2027

are drawn from IESR, Strathmore University, GIZ, St. Kizito VTI, UN-Habitat, Massachusetts Institute of Technology (MIT), Columbia University, State University of New York, Sapienza University of Rome and RES4Africa. The major transformational objective is to accelerate the uptake of decentralised renewable energy and rural electrification in East Africa.

3. **Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)'s Advancing Transport Climate Strategies (TraCS) project, together with a host of partners, in shaping a greener and more sustainable transportation landscape in Kenya.**

Key areas of focus included policy and regulatory development, training and networking to build institutional capacities, support for piloting activities, and the implementation of the BRT E-Bus component. In addition, the support entails a six-month funding programme set up by the Transformative Urban Mobility Initiative (TUMI), which is a global implementation initiative on sustainable mobility for young entrepreneurs by uniting the private sector and fostering collaboration. This is aimed to address Kenya's capital city of Nairobi challenges in the transport sector which include traffic jams, polluted air and unreliable public transport with an agenda to a green and sustainable transport system

8. IMPLEMENTATION POTENTIAL WITH RISK ASSESSMENT

8.1. Absorptive capacity for REI Program

8.1.1. Summary

Kenya has a huge potential for renewable energy and the Government has prioritised the development of geothermal, hydro, wind, solar, biomass and bioenergy to achieve 100% clean energy on the grid by 2030. Expanding the grid's capacity to integrate variable renewable energy (VRE) will not only help fulfil a major climate change goal by Kenya but can also help reduce foreign exchange requirements for oil imports for thermal generation.

An expanded, resilient and reliable electric grid powered by affordable clean energy generation will enable the transformation of other growing sectors of Kenya's economy, including agriculture (the use of green ammonia as fertiliser), transport (e-mobility and EVs), and industry (green hydrogen). Expansion of e-cooking will not only pollute less and provide health benefits, but it will also reduce deforestation by reducing the need for biomass but will also reduce the time women and girls spend to collect firewood and provide them the time and choice to pursue education and broader economic opportunities.

Kenya has previously implemented projects supported by SREP and by CTF DPSP and co-financed by the MDBs. Accordingly, the Country has the capacity to absorb concessional CIF resources and is Implementation-ready for the REI investment plan in the country to increase the pace, scale and penetration of renewable energy projects towards achieving a green economy. The implementation readiness is supported by strong government support, effective regulatory and policy frameworks and targeted incentives including extension of VAT exemption for renewable energy products, tax exemptions to encourage e-mobility and other initiatives to promote green hydrogen.

8.1.2. Macro-Economic Context

Kenya is a lower middle-income country and Real GDP growth remained robust at 4.8% in 2022 despite a contraction in agriculture as the country experienced the worst drought in decades. The growth in Real Gross Domestic Product (GDP) is expected to be 5.0% in 2023 despite the uncertainties in the global outlook. Disruption in supply chains due to the Russian invasion of Ukraine and higher commodity prices including fuel, fertilizer, and food, further fueled Kenya's inflation to rise over 9% by September 2022. To mitigate the impact of rising inflation, the government responded by tightening monetary policy and introducing subsidies on fuel, electricity, and maize flour. Inflation finally started to decline from April 2023 and stands at 6.7% currently (August 2023). From September 2022, the government withdrew maize flour and petrol price subsidies but retained subsidies on diesel and kerosene prices, as well as on fertilisers.

8.1.3. Debt Sustainability

Overall public debt remains sustainable; however, risks persist. With about half being external debt (estimated at 32.2% of GDP in FY 2022/23), exposure to foreign currency risk remains high. The government's measures to contain expenditure and raise revenue resulted in a lower fiscal deficit and a slowdown in debt accumulation.[69] Following the supplementary budget of January 2023, the revised fiscal deficit for FY 2022/23 is estimated at 5.7% of GDP, lower than the 6.2% budgeted earlier. A narrowing fiscal deficit has reduced financing needs, helped reduce the primary deficit, and slowed debt accumulation; with the stock of public debt increasing by 11.8% percent in the first nine months of FY 2022/23, compared to a 14.5% expansion in the same period in FY 2021/22. However, the exchange rate depreciation has contributed to debt accumulation in the last three years. Total debt is estimated to reduce by 2.6 percentage points to 64.8% of GDP by June 2023. The decline in commercial loans (suppliers' credit, commercial banks, Eurobonds) in the recent five years – from 35.2% of total external debt in March 2019 to 27.1% in March 2023 – has contributed to the accumulation of relatively less costly and long maturity concessional debt. However, the upcoming bullet payment of previous commercial loans (Eurobond repayment due in 2024) has created a surge in refinancing risks as the cost of borrowing in the external financial market rises.

8.1.4. Favourable Medium-Term Economic Outlook

Despite significant economic challenges that remain against the backdrop of slow global economic growth and tight financial conditions, the IMF's recent reviews of Kenya's economic program recognise the importance of ongoing policy actions, including reform of state-owned enterprises such as KPLC. According to the IMF, GoK has responded to shortfalls in revenue collection and challenging financing conditions and that the policy actions underway in these areas will take some time to bear fruit but will support what remains a favourable medium-term outlook for the Kenyan economy."[70]

Gok budget targets for FY 2023/24 will require careful control of commitments. Further actions to bring back liquidity to the interbank market for foreign exchange and support exchange rate flexibility are instrumental to securing effective market functioning and backstopping the external position. "On the fiscal side, government spending execution has been prudent this fiscal year, consistent with available resources. Moreover, the draft FY2023/24 budget submitted to Parliament proposes to further reduce the deficit from 5.7 - 4.1% of GDP, with significant new revenue measures consistent with the objective of reducing the ratio of debt to GDP. Monetary

[69] Much of the discussion in this paragraph is drawn from Securing Growth: Opportunities for Kenya in a Decarbonising World, Kenya Economic Update, World Bank Group, June 2023.

[70] https://www.imf.org/en/News/Articles/2023/05/23/pr23171-kenya-imf-reaches-sla-5th-rev-eff-arr-rsf

policy has also been tightened, with the central bank policy rate having been increased by 250 basis points over the past year."[71]

8.1.5. Catalysing Climate Finance

The IMF Board approved in July 2023, a new arrangement in the amount of SDR 407.1 million (about USD 551.4 million) under the Resilience & Sustainability Facility (RSF) intended to enhance "Kenya's capacity to address challenges posed by climate change and help bolster long-term structural climate resiliency and adaptation, while also strengthening macroeconomic stability as the economy transitions toward renewable energy." Building on Kenya's commitments under the Paris Agreement, reforms under the proposed program include "integrating climate-related considerations into budget preparation and public investment frameworks, embedding management of climate risks, including in the financial sector, and enhancing early warning systems."[72]These reforms are expected to "catalyse further private climate financing."[73] It should be noted that in order to be eligible under the RSF, a country requesting access needs both "high quality policy reforms addressing the long-term structural challenges of climate change" as well as "sustainable debt and ability to repay."[74]

8.1.6. Institutional Structure, Capacity & Reform of Energy Sector

Kenya is a dynamic and entrepreneurial economy with the largest off-grid solar market in Sub-Saharan Africa.[75] Kenya received a Regulatory Indicators for Sustainable Energy (RISE) overall score of 73 compared to a global average of 48[76] and a Sub-Saharan Africa score of 39 in 2021,[77] where Kenya's score was second highest behind only Rwanda at 78.[78]

8.1.7. Institutional Structure

The Kenyan energy sector through the enactment of the Energy Act 2019 has achieved significant reforms with key institutions established with specific mandates and responsibilities to enhance efficiency in electricity generation, transmission, distribution, and access. The Act revised and redefined the mandates of key sector institutions to align them with emerging sector needs and Kenya's 2010 Constitution. Further reforms and recommendations to enhance the sustainability

[71] https://www.imf.org/en/News/Articles/2023/05/23/pr23171-kenya-imf-reaches-sla-5th-rev-eff-arr-rsf
[72] Ibid.
[73]https://www.imf.org/en/News/Articles/2023/07/17/pr23265-kenya-imf-executive-board-completed-fifth-reviews-eff-ecf-approves-rsf
[74] of change

[75] https://www.global-climatescope.org/markets/ke/
[76] https://rise.esmap.org/country/kenya
[77] https://rise.esmap.org/reports
[78] https://rise.esmap.org/country/rwanda

of the sector are presented in the report of the Presidential Task Force on the Review of PPAs, 2022.[79]

Key sector players in the sector include inter alia, the Ministry of Energy & Petroleum, an independent Energy & Petroleum Regulatory Authority (EPRA) and semi-autonomous government agencies including KenGen, KPLC, KETRACO, and Rural Electrification & Renewable Energy Corporation (REREC) as well as government owned GDC. All of these agencies have significant experience in implementing projects in the sector, including with the MDBs, and many have previous experience implementing SREP and CTF DPSP projects with MDB co-financing.

8.1.8. Coordination and Implementation Capacity

The Ministry of Energy and Petroleum has a fully-fledged Renewable Energy Directorate responsible for the promotion and coordination of activities aimed at renewable energy development. In addition, the REI programme is supported by the revised draft Feed in Tariffs Policy and Renewable Energy Auction Policy, both at final stages of approval.

The GoK has constituted a multi-agency CIF Committee consisting of members from key electricity sub-sector institutions, as well as a consultative group from a wide range of stakeholders in the renewable energy space. The Ministry of Energy and Petroleum is the focal point and coordinates all activities for the preparation and implementation of the REI Plan, as well as the implementation of the plan. It is foreseen that the CIF Committee will continue to play an overall coordination role during the project implementation. The organisational set-up for the REI investment plan and implementation is as follows:

- Overall Responsible Agency: MoEP
- Focal Point Person: Secretary Renewable Energy, MoEP
- CIF Committee: MoEP, KPLC, KETRACO, GDC, KenGen & EPRA

Development partners are playing a key role in supporting renewable energy in geothermal, wind, solar, rural electrification, electrification of transport sectors, mini-hydros, and clean cooking stoves and have shown interest in supporting the REI Plan. The REI Plan will leverage on the support from implementing agencies, policymakers and investors. Investors' appetite for renewable energy investments continues to be strong, provided that the country can develop the supporting network infrastructure needed to integrate increasing levels of variable renewable energy in the system.

[79] https://kplc.co.ke/img/full/28102021_210-The-Report-of-the-Presidential-Taskforce-on-PPAs.pdf

8.1.9. Sector Reform

Depreciation of the value of the Kenyan Shilling against the US Dollar in the past year (from 1 USD:121 KSh to KSh 148)[80] has added financial stress to major players in the sector. KPLC has recorded unrealised losses on foreign debt and system loss reduction has not kept pace with the approved tariff. Improving revenue collection, optimising the use of electricity contracted through long-standing PPAs and reducing curtailment as proposed in the REA program is integral to KPLC's ongoing reform process and return to financial sustainability. See Section 3.4 for more information on the sector's institutional framework.

8.2. Country/ Regional Risks - Institutional, Technology, Environmental, Social, and Financial

Implementation of the REI programme faces financial, technological, regulatory, environmental, social, and political risks. The overall implementation risk assessment for the REI activities is moderate. The key risks envisaged under REI activities are listed below:

8.2.1. Technological Risks

The energy sector is facing a rapidly changing technological environment in regard to the power generation, transmission, distribution, and access. While the technology to be adopted for AGC, Reactive power compensation devices and smart grid are proven and less complex to handle, technology related to the BESS, hydrometer, e-mobility and e-cooking continue to witness rapid technological changes and cost reduction and will require significant investment in technical expertise. This risk will be partly mitigated by the capacity building component to be supported under REI preparation activities, including technical assistance/capacity building and advisory services and also by other development partners.

8.2.2. Financial Risks

Kenya's electricity sector has been somewhat financially self-sustainable due to sound regulatory policies as well as to the design of the retail tariffs charged by KPLC. KPLC is vulnerable to financial stress from reduced revenues due to increased system losses and grid defection as well as uncollected revenues. While additional reforms and ongoing capacity development are required to address these issues, the recent devaluation of the Kenya shilling (see 8.2.3 below) has added stress to the finances of all sector institutions, including KPLC. There could be ways to reduce variable risks (especially risks such as currency and interest rates) through local currency financing or tailored variable risk guarantee instruments supported by CIF. New business models for the addition of Battery Energy storage systems, smart grid control, e-mobility, e-cooking, managing

[80] https://tradingeconomics.com/kenya/currency

them and making them financially sustainable would require regulatory measures, and market studies and research.

8.2.3. Foreign Exchange Rate Risks

The Kenyan shilling has a floating exchange rate and the value of our currency varies according to the forces of the international foreign exchange market. The Kenyan shilling fluctuates against the international major currencies including the United States Dollar. Kenya's electricity tariffs incorporate the Foreign Exchange Rate Fluctuation Adjustment (FERFA), a tariff adjustment made to account for variations in foreign exchange-denominated utility costs. These adjustments enable management of currency risks in electricity tariffs which are passed to customers, making electricity less affordable to customers.

Recently these currency fluctuations have been extraordinary due to global market conditions, and there is limited ability to hedge these risks since there is a relatively shallow market for Kenya Shilling. As an example, between September 2022 and September 2023, the shilling has declined by 22% against the USD.

Such high volatility hurts projects and may delay the implementation and timing of desired results. Most of the REI projects are financed through loans denominated in foreign currency, while revenues are expected in Kenya Shillings, creating a mismatch. The denomination may create extraordinary exchange rate risk for energy sector institutions and developers that may lead to demands for additional security against such risks, and drive-up costs and affordability. Partial mitigation of this risk may include local currency financing, although most procurements, including works and goods, are based on hard currency contracts. In addition, a pilot CIF Variable Risk Guarantee to mitigate extraordinary variable risks could be considered.

8.2.4. Social and Political Risks

Increasing pace, scale and penetration of renewable energy projects in the country will provide affordable electricity to citizens and improve the quality of electricity supply as well as promote greater economic growth. Public consultations through stakeholder engagement and participation are mandatory parts of renewable energy project development in Kenya enshrined in the Kenya Constitution of 2010. People’s participation is also mandatory in Environmental Impact Assessments, which would also include social impact assessments, as per the Kenya Environmental Management and Coordination Act 2015. The National Environmental Management Authority makes available all draft EIAs and provides the public with 40 days for feedback. Corrective action plans by project proponents are generally included as a condition for approval of the EIAs. Appropriate social development measures will be incorporated into the project design. Free prior and informed consent (FPIC) shall also be considered in the renewable energy projects.

8.3. Risk Analysis and Mitigation Measures

The description of risks and their ranking together with planned actions for mitigation, monitoring and reporting of the risks is summarised in Table 4.

Table 4: Kenya REI Investment Programme Risk Analysis and Mitigation Measures

Type Of Risk	Description Of the Risk	Likelihood	Impact	Mitigation Measure
Financial Risk	Foreign Exchange fluctuation risks: Unfavourable changes in the exchange rate	M	H	Arranging for revenues and payment in hard currency, implementing a long-term hedging strategy and currency reserve accounts, and Indexing part of the local project costs in local currency. A CIF Variable Risk Guarantee to mitigate risks such as exchange risk could be considered.
	Credit risk: inability to meet financial obligations	M	H	Adequate financial safeguards in the contracts
Technological Risks	Rapid technological changes in renewable energy technologies and costs	M	M	Technical assistance/capacity building and research
Implementation risk	REI Investment plan not achieving set objectives and targets	M	M	Periodic monitoring and evaluation of REI investment plan to ensure set objectives and targets are met.
	Inadequate monitoring, evaluation and corrective interventions of REI investment programme ▪ REI investment plan not achieving set objectives and targets	M	M	Mobilise adequate resources for monitoring and evaluation of the projects by: ▪ Establishing an oversight mechanism for monitoring and evaluation recommendations. ▪ Undertaking continuous Capacity building of the M&E team within the Energy sector. ▪ Periodic monitoring and evaluation of REI investment plan to ensure set objectives and targets are met. ▪ Continuous learning to inform selected Activities
Compliance risks	Non-compliance with policy and legal obligations	M	M	Periodic evaluation of compliance to policies, laws and regulations

Type Of Risk	Description Of the Risk	Likelihood	Impact	Mitigation Measure
	Litigation Challenges in integrating Variable Renewable Energies (VREs) into the grid	M	L	▪ Ensuring prudent contract drafting and management, Stakeholder management ▪ Installation of Battery and pumped storage facilities ▪ Implementation of Automatic Generation Control (AGC) and STATCOMs in the national grid
Environmental risks	Non-compliance with National and International Environmental policies and legal obligations, and non-compliance with EIA/ESMP	M	M	Incorporate appropriate environmental management measures into the project plans and designs
Social & Political risk	Changes in law affecting regulations of the Renewable Energy Technologies project, Lack of political goodwill to support the implementation of REI investment programme. Lack of Government commitment	L	L	▪ Carrying out adequate stakeholder engagement and management ▪ Adherence to regulations and guidelines ▪ Close coordination with relevant government agencies
Gender Inclusion	▪ Limited Representation and Participation of women in decision-making processes, workforce, and leadership positions within the energy sector, including in policy formulation and project implementation. ▪ Gender-Blind Policies and Programs: Without specific gender considerations, energy policies and programs might not adequately address the unique energy needs, preferences, and constraints faced by men and women, resulting in potential disparities in access to energy services and benefits.	M	M	▪ Integrate gender considerations into energy policies, regulations, and programs to ensure that they consider and address the diverse needs and interests of men and women. Promote gender mainstreaming in policy development and implementation. ▪ Provide training and capacity-building programs that specifically target women, empowering them to take on leadership roles and technical positions within the energy sector. Encourage the inclusion of women in decision-making bodies and energy project teams. ▪ Ensure the collection and analysis of gender-disaggregated data related to energy access, usage,

Type Of Risk	Description Of the Risk	Likelihood	Impact	Mitigation Measure
	▪ Unequal Access to Energy Services: Gender disparities in access to electricity and clean cooking solutions might persist, with women in rural areas and marginalised communities facing greater challenges in accessing and affording modern energy services. ▪ The lack of gender-disaggregated data might hinder the identification of gender-specific energy needs, roles, and constraints, making it challenging to design targeted interventions for women.			and decision-making to inform evidence-based policymaking and program design. ▪ Implement programs that promote women's economic empowerment through energy entrepreneurship, access to finance, and ownership of renewable energy technologies like solar home systems. ▪ Conduct gender-focused awareness campaigns and training on the benefits of renewable energy and clean cooking technologies, targeting both men and women in rural and urban areas. ▪ Develop inclusive energy access plans that target marginalised communities, ensuring that gender considerations are taken into account in designing energy solutions that meet the needs of women and men. ▪ Ensure that energy projects consider gender aspects throughout their implementation, including hiring practices, project design, and community engagement, to address potential gender disparities and promote women's involvement.
Grid sustainability	▪ Transition to alternative energy sources. ▪ supply-demand imbalance	L	M	▪ Demand initiatives in sectors of manufacturing, irrigation, e-cooking and e-mobility ▪ Development for regulation interventions to ensure sustainability ▪ Improve system reliability to retain customer base

9. MONITORING, EVALUATION AND LEARNING

The Monitoring, Evaluation and Learning approach for Kenya's IP, based on the CIF-REI´s Integrated Results Framework (IRF), aims at enabling the tracking and reporting of progress throughout the achievement of outcomes and objectives of the program including progress towards 100% Clean Energy by 2030, enhanced grid reliability and improved gender mainstreaming.

The integrated approach comprises monitoring of activities within the program in order to capture the impacts of project activities through multiple dimensions of monitoring, evaluation, learning, and other key cross-cutting approaches such as gender inclusion, transformational change, just transition and integration of Sustainable Development Goals. The objective of this approach is to enable delivery of a comprehensive assessment of the program's progression, and specific results from the various components of the program with feedback of key learnings for ongoing program implementation.

9.1. CIF Theory of Change and IRF

Applying the Theory of Change, each component taken into consideration for the Kenyan REI IP generally tries to solve particular obstacles and barriers to achieving greater integration of renewable energy in Kenya`s power system and accelerating decarbonisation. The IP makes an assumption that all the support activities meet the criteria for funding and support.

Additionally, as shown in Table 5, the Theory of Change Concept Map, expected outcomes and indicators have been created in connection with the IP's Integrated Results Framework (IRF). This will enable monitoring and evaluation of accomplishments based on conceptualised program expectations that link to overall CIF level impacts, REI program level outcomes, co-benefits and SDGs. Gender equality and social inclusion has been integrated into the program to enhance participation and increase program acceptance as part of the transformational change under the program.

Theory of Change

If Kenya's REI program can enhance grid flexibility, increase reliability, demand creation through renewable energy innovation and facilitate open access for renewables then these investments will enable the country to scale up renewable energy, create a flexible and reliable grid providing economic benefits to the country through a holistic integrated socially equal, gender equal process towards Kenya's long-term pathway to economy-wide low carbon transformation.

Impact of Kenya REI Investment Plan

Table 5: Integrated Results Framework Table

CIF-level Impacts	Indicators	Baseline	Targets
Catalyse Kenya's transformation to 100% Clean Energy by 2030	Clean Energy dispatch (%)	89%	100%
Number of beneficiaries	Annual Capacity building (No)	200	1,000
	Direct Use projects commercialised (No)	1	3
Volume of co-finance leveraged[81]	Volume of co-finance leveraged (USD)	0	CIF 70 MUSD public & Private funding **242.97 MUSD** ratios 1:3
REI Program-level Impacts	**Indicators**	**Baseline**	**Targets**
Concessional climate finance to demonstrate that investments intended to enhance system flexibility, reliability and support energy affordability can enable a transition to 100% clean energy by 2030 and place the country on a long term economy-wide low carbon transformation.	VRE Capacity on Grid (%)	20%	30%
	Reduce Levelised Cost of Electricity (USD cents)	9.24	8.68
Improved policies and regulations	Number of new gazetted or amended policies and regulations that are related to RE integration	0	4

[81] This is based on the maximum CIF funding of 70 MUSD.

REI Program Level Outcomes

Table 6: REI Program Level Outcomes (Component 1 - Enhanced grid flexibility)

Component 1: Enhanced Grid Flexibility				
	AGC	**Hydromet**	**BESS**	**Reactive power compensation devices**
Barriers	Unpredictable and rapid ramping of renewable power causing system disturbance conditions. Non-visibility of small renewable generators to the system controller for efficient operations	Inadequate/ inaccurate forecasting tools for variable/ intermittent energy technologies	High upfront costs of energy storage technologies	Inadequate grid infrastructure to manage voltage and grid frequency variability
Supported Activities	Installation of Automatic Generation Control (AGC) systems with associated communication network link between the generation units and national control/dispatch centre to enhance dispatch planning and system operation efficiency.	Deployment of a centralised forecasting System linked to RE developers, asset owners, and system operators to model engines for generating plant output forecasts.	Developing grid-connected battery storage systems (either utility type or as part of decentralised systems)	Installation of voltage control devices and fast-acting reactive power devices to stabilise the system.
Main Expected Outcome	Increased power system flexibility and reliability in a cost-effective manner by managing the variability and uncertainty to increase uptake and penetration of renewable energy without curtailment of renewable generation.	Optimised dispatch of renewables and improve the accuracy of forecasting the outputs from renewable energy developers.	Increased ratio of power available from a storage system deployed from VREs. In addition, reducing operational costs through peak power and energy arbitrage, spinning reserves synchronised to the grid	Improved grid/frequency stability and system control challenges by resolving the voltage variability enabling the integration of variable renewable energy.

Component 1: Enhanced Grid Flexibility				
	AGC	**Hydromet**	**BESS**	**Reactive power compensation devices**
Transformational Change	Increased power system flexibility and reliability geared to energy efficiency improvement.	Support the national decarbonisation agenda by reducing GHG emissions by 32% from the Business as Usual (BAU) scenario in 2030 and accelerate uptake of clean energy in the grid and the green energy transition.	Expand energy storage infrastructure and upgrade technology for supplying modern and sustainable renewable energy services to increase substantially the share of renewable energy in the country energy mix	Promote increased demand and utilisation of renewable energy from geothermal complex

Table 7: REI Program Level Outcomes (Component 2 - Enhanced grid Reliability)

Component 2: Enhanced grid reliability			
	Smart Grid	**Mobile substation & strategic spares**	**Automation of condition monitoring of Power System O & M**
Barriers	Embedded unmonitored generation causes the grid to experience voltage control and protection issues.	System constraints invariably lead to system losses and revenue due to loading, loss of revenue due to load management, susceptibility to breakdowns due to equipment loading beyond or to full capacity	High initial costs for automation of conditional monitoring to reduce operational overhead costs
Supported Activities	Deploying a generation resource forecasting system, expansion of communication infrastructure, digital technology and control equipment to all generation plants including embedded generators and net-metered institutions/ customers and implementation of smart metering for all prosumers	Support for network reinforcement to facilitate compliance with n-1 reliability criteria, restocking of emergency restoration towers and acquisition of mobile transformers to facilitate evacuation of renewable energy.	Installation of remote sensing devices on selected substations and rolling out to a pilot fully functional automated asset management system. In addition, data acquisition servers at station level.

Component 2: Enhanced grid reliability			
	Smart Grid	**Mobile substation & strategic spares**	**Automation of condition monitoring of Power System O & M**
	on net metering and contracted interruptible loads		
Main Expected Outcome	Enhanced power quality, supply reliability and grid security through development of distributed renewable energy generation, enhance grid flexibility through demand response and increase penetration of VREs while maintaining grid stability and resilience	Reduction in unserved energy due to transformation capacity due to planned and forced outages.	Reduction in breakdowns and restoration times of power transmission services due real time monitoring of critical substation equipment.
Transformational Change	Catalyse Kenya's transformation to 100% Clean Energy by 2030	Enhanced system operation efficiency with reduced risk of system outages and blackouts	

Table 8: REI Program Level Outcomes (Component 3 - Technology and market innovation)

Component 3: Technology and Market Innovation.			
	Renewable Energy Centre of Excellence	**Geothermal resource park, commercialisation of Direct Use projects**	**Support electricity demand stimulation on emerging technologies e.g., e-mobility, e-cooking, irrigation to enhance utilisation of RE**
Barriers	Limited resources and facilities for innovative research and development of capacity for experts in the energy sector	Limited research and investor awareness on the potential of Direct Uses in the geothermal field	Low nocturnal demand has led to underutilisation of RE resources (geothermal and wind) at night; this among other reasons has led to high cost of the electricity due to low plant factors. Electrification of systems and processes will also result in avoiding GHG emissions.
Supported Activities	Construction and operationalisation of the Kenya National Renewable Energy Centres of Excellence at Konza and expansion and modernisation of the institutional campuses at OlKaria, Menengai and Kamburu.	Construction of geothermal resource park, commercialisation of Direct Use projects and engagement of investors	Development of fast charging infrastructure for EVs across the country. Deployment of clean cooking options (fuels and technologies) particularly e-cooking (electric cooking
Main Expected Outcome	Laboratories and workshop for development and testing of RE technologies.	Construction of geothermal resource park, commercialisation of Direct Use projects	Increased uptake of Electric Vehicles in the country, both in the medium term and long term
Transformational Change	Enhanced local expertise across the various demographics of the Kenyan population. Enhanced collaboration in Policy, Research and Technology in Academia and Industry	Enhanced investor engagement, commercialisation of alternative uses of geothermal energy.	Reduced greenhouse gas GHG emission by 32% by 2030 and supported SDG 11 through inclusive and sustainable transport systems paying special attention to air quality in urban areas. Higher demand for electrical power in the country which will be met by higher RE plant utilisation in off peak hours. Reduced consumption of unsustainable biomass for cooking.

Table 9: REI Program Level Outcomes (Component 4 - Facilitate Open Access for Renewables)

Component 4: Facilitate open access for renewables		
	Regulations on Renewable Energy Resources; Electricity Market, Bulk Supply & Open Access; Feed-in Tariff; Net- metering	**Study on Technical and Financial impact of distributed & Captive Energy to Kenya's power grid**
Barriers	Inadequate enabling renewable energy frameworks for compensations and pending market reforms	Pending study to offer certainty to grid operator for deployment of distributed and Captive energy
Supported activities	Completion of Four (4) Energy Regulations to operationalise the Energy Act 2019 by carrying out Regulatory Impact Assessment for the underlisted regulations: - - The Draft Energy (Electricity Market, Bulk Supply and Open Access) Regulations 2022 - The Draft Energy (Renewable Energy Resources) Regulations 2022 - The Draft Energy (Feed-in Tariff) Regulations 2021 -The Energy (Net-metering) Regulations, 2021	Comprehensive study on Technical and Financial impact of distributed & Captive Energy to Kenya's power grid
Main expected outcome	Suitable regulatory environment for Renewable Energy Management and Climate Change response as well as opening up of the power market to healthy competition	Determination of; - Regulatory requirements for captive power adoption - Optimal or acceptable volumes of captive power in the system. - Technical and Technological options for captive power
Transformational change	Accelerated harnessing of renewable energy resources in Support of the national decarbonisation agenda by reducing GHG emissions by 32% from the Business as Usual (BAU) scenario in 2030	Harnessing Kenya's RE potential without compromising SO effective operations and financial sustainability.

Integrated Result Framework (IRF) in Table 5 tracks the actual progress of the program's impact level and specific project output performance through defined indicators within CIF REI under the Kenya`s IP objective context of integrating renewable energy. The program co-benefits level captures other social and economic development outcome areas beyond CIF's core climate objectives under Annex IV.

The IRF has a dual multi-dimensional design with a monitoring approach embedded with Evaluation & learning approaches. A detailed evaluation & learning approach encompasses a robust assessment and the intended transformational change with the following 5 dimensions.

Relevance: The country is in consideration to achieve transformational changes to net zero emissions and accelerated harnessing of renewable energy resources in support of the national decarbonisation agenda by reducing GHG emissions. The proposed component 1: AGC, Hydromet, BESS and Reactive Power compensation devices will increase uptake of VRE and flexibility of the system, Component 2: Smart Grid to control and dispatch distributed renewables in the IP leverages on existing renewable technologies rather than fossil fuel alternatives developed in the grid. This ensures relevance and deliberate choice to climate resilient development on carbon and greenhouse gas emission as well as provide eligible investors opportunity to get financial access.

Systemic change: Potential intervention under Component 3 and 4 identified and proposed for financing under the CIF-REIs resources analysed exhibits co-benefit of fair, just and inclusive change to the society through gender inclusivity and diversity through the Renewable energy centres of excellence including tech Transfers, innovation hubs, E-cooking and E-Mobility.[82] In principle, all the four components are geared toward achieving engendered just transition and their impact will have spillover changes to other sectors in the economy and more specifically within transport, agriculture, education, and manufacturing.

Scale: The IP supports incremental progress in achieving energy efficiency and transition to full deployment of renewable energy programs taking into consideration the sustainable growth and flexibility of the energy sector. The gains, experiences and results expected to be obtained from the interventions proposed demand creation innovation in component 3 is significant in terms of their replicability and scalability to the entire energy system and value chain. In addition, the CIF - REI funding is expected to catalyse additional financing from other development partners to scale the investments in renewable energy programs.

Speed: The pace of anticipated transformational change from proposed intervention is expected to increase renewable energy penetration and decrease fossil fuel-based utilisation in the energy sector. The change will create opportunities and increase productivity in other sectors of the economy. E- mobility is expected to spur utilisation of nocturnal demand and increased uptake of

[82] BioEnergy Strategy

Electric Vehicles in the country, both in the medium term and long term[83]. Also, the interventions will increase the speed of decarbonising the grid and enhance security of supply.

Adaptive sustainability: To enhance sustainability and continuity, operational capacity development support initiative in terms of knowledge transfer, innovation hubs and skills acquisition around new technologies including energy storage systems will be required. Proposed RE centres will promote development of local expertise across the various demographics of the Kenyan population and increase collaboration in Policy, Research and Technology in academia and industry. The proposed approaches will make it possible to combine systematised monitoring with research and evaluation designed to complement each other, taking advantage of mixed methods that, through different tools and forms of evidence, contribute to building a comprehensive and clear view on what will end up being achieved and learnt from the program´s implementation.

9.2. Whole of Energy Systems Analysis

The IP's Integrated Results Framework serves as the main instrument that defines Kenya's program with defined measurable national-level indicators and targets, and thereafter links the program's theoretical objectives with the measurable outcome-level results anticipated through the individual project components as detailed in this IP that seeks to enhance the integration and higher utilisation of Renewable Energy (RE) on the Kenyan grid, thereby enabling the country's transition to 100% clean energy by 2030. The IP has been developed by a multi-agency team within Kenya's Energy Sector with inputs from partners and key stakeholders. The process of defining project-level objectives as well as the related results developed in the Integrated results framework has established a consistent and system-wide approach to the coherence of and between interventions and on accountability between the expected outcomes and individual program results.

9.3. Anticipated Program-Level Impacts

The following are the anticipated programme-Level impacts:

1) Reduction of GHG emissions from the energy sector.
2) Increased share of renewable energy generation in grid-connected energy systems.
3) Increased National off-grid access in various parts of the country not covered by the National grid.
4) Enhanced power system security, efficiency, flexibility and grid reliability.
5) Increased number of women and men, businesses, and community services benefiting from improved access to electricity and/or other modern energy services directly or indirectly.
6) Enhanced inclusive human capacity for clean/renewable energy technologies in Kenya

[83] Least Cost Power Development Plan 2021-2042

7) Enhanced Regulatory/policy frameworks and financial mechanisms for renewable energy integration.

9.4. Tracking And Evaluation of Transformational Change and Inclusivity Aspects

Transformational change, just transition and inclusivity effects from the execution of the proposed IP shall be evidenced in job creation, quality and distribution of jobs, including in new SMEs and industry clusters, use of gender-responsive approaches, and achievement of impacts such as reduced emissions and contamination. The program will monitor and evaluate gender mainstreaming during the implementation of the proposed interventions, including but not limited to employment opportunities for women as part of gender mainstreaming and promoting local content in terms of supply of locally produced materials and local labour, including both skilled and unskilled services such as transport, security and hospitality. Reporting shall also help verify which adopted interventions/programs have mainstreamed gender in their implementation process and provide adequate safeguards during the same period.

The execution process of the IP shall be transparent, with information relating to all processes made available to all potential stakeholders, with a clear feedback mechanism development for adaptive learning and future improvement purposes.

ANNEXES

Annex I: Responsiveness to CIF Investment Criteria

Annex Table 1: Responsiveness to CIF Investment Criteria

CIF Criteria	Relevance to Kenya REI Program
1. Potential for Transformational Change	
Relevance	The country is in consideration to achieve transformational changes to net zero emissions and accelerated harnessing of renewable energy resources in support of the national decarbonisation agenda by reducing GHG emissions. The proposed component 1: AGC, Hydromet, BESS and Reactive Power compensation devices will increase uptake of VRE and flexibility of the system, Component 2: Smart Grid to control and dispatch distributed renewables in the IP leverages on existing renewable technologies rather than fossil fuel alternatives developed in the grid. This ensures relevance and deliberate choice to climate resilient development on carbon and greenhouse gas emission as well as provide eligible investors opportunity to get financial access.
Systemic Change	Potential intervention under Component 3 and 4 identified and proposed for financing under the CIF-REIs resources analysed exhibits co-benefit of fair, just and inclusive change to the society through gender inclusivity and diversity through the Renewable energy centres of excellence including tech Transfers, innovation hubs, E-cooking and E-Mobility. In principle, all the four components are geared toward achieving engendered just transition and their impact will have spillover changes to other sectors in the economy and more specifically within transport, agriculture, education, and manufacturing.
Scale	The IP supports incremental progress in achieving energy efficiency and transition to full deployment of renewable energy programs taking into consideration the sustainable growth and flexibility of the energy sector. The gains, experiences and results expected to be obtained from the interventions proposed demand creation innovation in component 3 is significant in terms of their replicability and scalability to the entire energy system and value chain. In addition, the CIF -REI funding is expected to catalyse additional financing from other development partners to scale the investments in renewable energy programs.
Speed	Battery storage technologies are key to speeding up the replacement of fossil fuels with renewable energy and will play an increasingly pivotal role between green energy supplies and responding to electricity demands, at least in the short-and medium term until pumped hydro storage systems can be developed. The IP supports incremental progress in achieving energy efficiency and transition to full deployment of renewable energy programs taking into consideration the sustainable growth and flexibility of the energy sector. The

CIF Criteria	Relevance to Kenya REI Program
	gains, experiences and results expected to be obtained from the interventions proposed demand creation innovation in component 3 is significant in terms of their replicability and scalability to the entire energy system and value chain. In addition, the CIF -REI funding is expected to catalyse additional financing from other development partners to scale the investments in renewable energy programs.
Adaptive Sustainability	To enhance sustainability and continuity, operational capacity development support initiative in terms of knowledge transfer, innovation hubs and skills acquisition around new technologies including energy storage systems will be required. Proposed RE centres will promote development of local expertise across the various demographics of the Kenyan population and increase collaboration in Policy, Research and Technology in academia and industry. The proposed approaches will make it possible to combine systematised monitoring with research and evaluation designed to complement each other, taking advantage of mixed methods that, through different tools and forms of evidence, contribute to building a comprehensive and clear view on what will end up being achieved and learnt from the program´s implementation.
2. Potential for GHG Reductions/Avoidance	
Contribution to Achieving Kenya's NDC Goals	The IP is expected to contribute to the achievement of Kenya's NDC targets enabling the overall emission reduction of 32% compared to the Business as Usual (BAU) scenario of 143 MtCO2eq by 2030. With implementation of the mitigation actions prioritised between 2023-2027 through the National Climate Change Action Plan (NCCAP 2023 -2027). The electricity generation sector is expected to reduce 30.46 MtCO2eq GHG emissions through Kenya's continued investment in renewable energy sources. The Renewable Energy Integration program as proposed by this IP will therefore contribute to achievement of this target. The clean electricity will help decarbonise other sectors of the economy including the residential sector, transport, industry and agriculture while providing options to reduce deforestation hence conserving biodiversity.
3. Financial Effectiveness	
Value for Money	Energy policy reform is moving towards greater liberalisation and more open grid access to reach 100% green energy on the grid and by promoting the sustainable involvement of the private sector in the energy sector, specifically for variable renewable energy development. Techno-economic studies to determine the relative benefits and costs of various options in the Kenyan grid have informed the optimal combination of technologies selected to improve reliability and flexibility of the grid to absorb VRE. For example, while both BESS and STATCOM technologies offer reactive power support and can increase critical fault clearance time, BESS offers certain services when implemented with various control logics, including energy

CIF Criteria	Relevance to Kenya REI Program
	arbitrage, voltage control, frequency support, replacement reserve provision and black start capability. The use of concessional CIF resources to offset the higher costs of BESS delivers a wider range of benefits to the grid. Over the next several years, the cost of BESS is expected to decline. STATCOM technologies proposed under this Program will complement those proposed under other ongoing engagements and will facilitate power trade, in particular hydro power, to help integrate VRE to the grid.
Potential for Mobilization	Public investments through the REI program to strengthen the grid will enable mobilisation of resources into the system for variable renewable energy investment, primarily through the private sector.
4. Just Transition	
Each of the four components of Kenya's REI Program is geared toward achieving gender transition and their impact will have spillover changes to other sectors in the economy and more specifically within transport, agriculture, education, and manufacturing. Component 3 will support the development of Centres of Energy Excellence which will help incubate and support SMEs including women and marginalised groups in communities near geothermal and other sites. The centres will also provide training to women for employment in technical and senior roles in renewable energy.	
5. Gender Equality & Social Inclusion	
The Centres of Excellence will also provide training to women for employment in technical and senior roles in renewable energy. Promotion of e-cooking will reduce the burden of women and girls to collect firewood for cooking and enable more time to pursue other interests, in particular education and economic activities.	
6. Development Impact Potential	
▪ Enhancing the participation of women in the energy sector and institutions (corresponding with furthering SDG 5 on Gender Equality. ▪ Reduced GHG emissions (corresponding with SDG 13 on Climate Action), including from transport (e-mobility), deforestation (e-cooking) and with Green Hydrogen, potentially in agriculture (green ammonia) and industry. ▪ With e-cooking, more time and opportunity for women to choose other economic activities ((SDG 5 on Gender Equality) + reduced deforestation and enhanced biodiversity (corresponding with SDG 15, Life on Land) ▪ Health benefits through a cleaner environment (furthering the goals of SDG 3 on Good Health and Well-Being)	

CIF Criteria	Relevance to Kenya REI Program
	▪ Expanded carbon credit market associated with credible emission reductions (corresponding with the goals of SDG 13 on Climate Action) ▪ Affordable and clean electricity due to declining costs (corresponding to goals of SDG 7, Affordable & Clean Energy. ▪ Enhanced regional competitiveness through more affordable clean energy(corresponding to goals of SDG 7, Affordable & Clean Energy. ▪ Accelerated economic growth (corresponding with goals of SDG 8 on Decent Work & Economic Growth). ▪ Optimised use of energy resources e.g. hydro when using AGC ▪ Employment creation (corresponding with goals of SDG 8 on Decent Work & Economic Growth). ▪ Conducive environment for green investments and use of renewable geothermal energy to substitute fossil fuels in industrial thermal applications (SDG 12, Responsible Consumption & Production).

Annex II: Investment Concept Briefs - Detailed Project Components

Component 1: Enhancing Grid Flexibility

Automatic Generation Control (AGC) and Hydromet Forecasting to Enhance Dispatch Planning and System Operation Efficiency

Introduction

The increased penetration of intermittent energy in the Kenyan power grid has created unprecedented system operation challenges. The intermittent nature of wind and solar energy leads to frequency stability and control issues which are aggravated by limitations associated with the accuracy and reliability of resource forecasting. With increased variable generation in the system, frequency deviation incidences have increased, leading to an increased frequency of calls to generating plants to carry out secondary frequency control, causing strain on system operators. Currently, secondary regulation is achieved manually by the National Control Centre calling generation plants to adjust the generation output. With the increased integration of variable wind and solar plants into the Kenyan grid, there is even an urgent need to implement the Automatic Generation Control (AGC) system to track generation as well as to ensure system stability. Implementation of AGC would eliminate this need to frequently make calls and also result in faster and more effective system response to frequency deviations. Automatic Generation Control is also a requirement for a control area in the regional initiatives driven under the Eastern Africa Power Pool (EAPP).

A system dominated by renewable energy like Kenya's is heavily reliant on hydrological and meteorological forecasts and modelling for sustainable electricity generation. The forecasts are also key for demand-supply management. Currently, the forecasts and modelling are done manually from the first principles. Traditionally, the grid operator depended on large hydropower plants in the system to provide primary reserves. But these are now stretched due to the level of the intermittent power in the system. Advanced weather forecasting is one of the main applications of AI in facilitating and improving VRE integration. Application of advanced weather forecasting methods that take advantage of modern digital technologies such as artificial intelligence (AI) and big data, to analyse live and historical weather data and make projections would enhance accuracy and system efficiencies. The Hydromet component of the project will support the national decarbonisation agenda by reducing GHG emissions and accelerating the uptake of clean energy in the grid and the green energy transition.

The proposed AGC and Hydromet projects would be very useful for grid stability and reliability as well as enabling projections for real-time and day-ahead power trade envisaged by the Eastern Africa region.

1. AUTOMATIC GENERATION CONTROL

Problem Statement

The increased variable generation in the system has led to more frequency deviations which compromises the grid voltage stability. Currently, secondary regulation is achieved manually by the National Control Centre calling generation plants to adjust the generation output. Further, this inhibits the national goal to enhance the penetration of renewable energy on the grid to displace conventional thermal and meet the growing power demand.

The NCC system control SCADA does not currently capture some major units such as the 106 MW Turkwel hydropower plant. A number of small renewable generators are also not visible to the controller and therefore require the installation of SCADA systems. For these units to be visible to the controller and have the large units participate in AGC, it will be necessary to provide active power measurement, online indication and control status indication to NCC. Another challenge the system operator currently faces is the lack of sufficient operating reserves, especially during low hydrology periods and also during times of low demand when hydro units are shut down.

With the increased integration of variable wind and solar plants into the Kenyan grid, there is even an urgent need to implement the Automatic Generation Control (AGC) system to track generation as well to ensure system stability. The system thus faces a higher risk of outage and reduced power supply quality.

Proposed Contributions to Initiate Transformation.

Two contributions are proposed to address the challenges posed by the increased generation from variable renewables: the introduction of a Hydromet forecasting system to improve the accuracy of forecasting the outputs from renewable energy sources; and the installation of Automatic Generation Control (AGC) systems to improve on system frequency control in the Kenyan grid and therefore enhance system stability and power quality on the Kenyan national grid. Improved accuracy of forecasting power outputs from renewables increased efficiency in dispatch planning and system operation functions. AGC systems enable fast and adequate response during unpredictable and rapid ramping of renewable power and in system disturbance conditions, by regulating the operating reserves to maintain power balance and therefore frequency as the generator's output and loads vary.

Implementation Readiness

1. Implementation of AGC requires collaboration between the current off-taker and System Operator, KPLC and KenGen, IPPs, and KETRACO which is the designated system operator. Implementation of AGC will be effective with the optimisation of the Governor and excitation system. Thus, the proposed scope includes but is not limited to the study of the implementation of AGC within generation plants and integration into the System Operator's system. Develop and validate generating units' power system simulation models.
2. Carry out dynamic performance testing on existing major generating units.

3. Provide software tools used to develop and validate dynamic models and PSS/E software licences.
4. Develop manuals and guides for carrying out dynamic model development and validation and performance testing on major KenGen units.
5. Train KenGen, KPLC and KETRACO staff on AGC, generating unit's performance testing, generating units dynamic model development and validation, carrying out power system studies and other best practices and advising on simulation tools that can be used for future studies and modelling.

Two options have been considered in implementing the AGC.

- The first case is whereby the NCC AGC system sends control signals (generator set points) directly to participating generating units.
- The second option is for NCC to send one control signal, the area control error (ACE) to KenGen for processing and control of their participating generators.

In both cases, the set points or the ACE is sent through the inter-control centre communication protocol (ICCP). This ICCP link is currently unavailable. The KPLC SCADA system is already performing ACE calculations (tests for accuracy required) and can be linked to the Kengen SCADA system through the ICCP in order to communicate to and control the generators.

Two implementation approaches on the AGC will be considered:

- Centralised control - The AGC calculates ACE and computes the desired generation set points for all the generators under AGC in the system that will minimise the ACE. In this case, performance monitoring and reporting for each unit under AGC is performed directly from NCC.
- Hierarchical control- In this case, the calculated ACE from the NCC system is sent to Kengen. There will be a need for a slave AGC server at the Kengen end to receive the error from NCC and compute the set points for the AGC participating generators. Performance monitoring may be done at both levels.

These are provisional as the selection of units needed for AGC is yet to be carried out. More detailed options will be evaluated during the preparation of the technical specification. The proposed project would also include the operationalisation of the recently developed standard operating procedures for the integration of renewables.

Rationale for Renewable Energy Integration Financing

The Kenya National Transmission Grid Code requires that the system frequency be controlled by automatic response from synchronised generators and dispatching generating plants including AGC among other control measures. The system operator is required to operate sufficient generating units under AGC for balance system generation and interchange schedules to the system demand. For the initial implementation phase, KenGen hydro units have been identified for AGC operation by the AGC task force.

The Kenyan power grid is interconnected with two power grids: Ethiopia through a 1200 km HVDC and with Uganda grid through an old tie line. A new line is under implementation to strengthen the link with Uganda. Currently, a Kenya-Tanzania interconnection line is under implementation with the aim of enhancing regional power trade within the Eastern Africa region and the SAPP member countries beyond Tanzania. SAPP countries including South Africa and Zambia are currently experiencing severe power shortfalls.

Results indicators

The expected outcome of the AGC component include:

- Increased flexibility of the grid following the deployment of the SACDA infrastructure and AGC system, and other FACTS devices.
- Increased uptake and penetration of renewable energy
- Reduced venting of geothermal steam and curtailment of solar and wind during low-demand periods
- Enhanced system operation efficiency with reduced risk of system outages and blackouts
- Improved power quality as a result of the automated regulation provided by the AGC system.

Financing Plan

The costs summarised in Annex Table 1 include allowances for extending the existing power plant DCS to provide the necessary AGC signals and for adding a new gateway / RTU at each power plant. We have assumed that existing DC supplies for control and instrumentation (C&I) at each power plant will have sufficient spare capacity to support these minor additions to the overall C&I load. They also include costs for the provision of a GPS clock at each outstation for improving time synchronisation across all RTUs / Gateways. Whether or not AGC implemented a facility for Set Point control and RTU/signal adaptation work has been estimated.

Also included is the Communication cost: All power plants that are large enough to have provision for closed loop AGC control also have an associated transmission level substation which has an RTU connected to the SDH network. The costs shown here cover the cost of linking the new RTU / IEC Gateway provided as part of the power plant outstation works to the SDH network via the SDH node in the local transmission level substation. They also cover the cost of making the data in each transmission substation available to the new NSCC main and the Emergency Centre

Annex Table 2: AGC Financing Plan

Component: Activity	Item	Indicator	Unit	Total Estimate cost (USD)	Source of Finance			
					CIF	WB & AFDB	IFC	Private sector and Other Partners
Automatic Generation Control	National System Control centre AGC Software Acquisition and Installation		Lot	1,000,000.00	1,000,000.00			
	A Generator End for every generation station selected to be under AGC	No of Power plant under AGC	No	8,777,248.63	8,777,248.63			
	Communications/Outstations Works		Lot	4,085,000.00	4,085,000.00			
	Annual Maintenance Charge and Guaranteed availability period		Lot	550,000.00	550,000.00			
	Total			**14,412,248.63**	**14,412,248.63**			

To achieve it will take approximately two years to complete the project. Project preparation timetable for all components is on Annex Table 12.

Requests, if any, for Investment preparation funding

No support is required for investment preparation.

2. HYDROMET FORECASTING SYSTEM

Problem Statement

A system dominated by renewable energy like Kenya's is heavily reliant on hydrological and meteorological forecasts and modelling for sustainable electricity generation. The forecasts are also key for demand-supply management. Currently, the forecasts and modelling are done manually from first principles. Furthermore, there is an inadequate/inaccurate forecasting tool for variable/intermittent technologies. The weather forecasts are obtained from the Kenya Meteorological Department (KMD) as an input into the hydrological model (Excel-based water balance model) for the hydropower projections while no projections exist for variable renewable energy (VRE) technologies. The existing weather forecasts cannot accurately guide the energy dispatch planning and management as the temporal scale is always in the order of days. The VREs (wind and solar power) technologies are fast increasing and currently require reliable energy generation projections for system planning and management purposes.

Proposed Contributions to Initiate Transformation

Going forward it is critical to adopt a robust system that can respond to the real-time behaviour of the demand and supply sides of the electricity system. This may require information to enable the system to respond automatically in real-time in a matter of seconds or minutes as opposed to the current days ahead planning. A hydro-met forecasting system and tools can optimise the weather-dependent energy resources (hydro, wind and solar) and system response to the resource behaviour. Therefore, it is recommended to implement a hydrometer forecasting system with accurate forecasting tools for all weather-dependent renewable energy projects including VREs.

Accurate weather forecasting is crucial for integrating wind and solar power-generating resources into the grid, especially at high penetration levels. It is a crucial, cost-effective tool available to both renewable energy generators and system operators. For weather-dependent renewable generators, like solar and wind power plants, the most critical scheduling input comes from weather forecasting data. A power generation forecast is a combination of plant availability and weather forecasts for the location.

Advanced weather forecasting methods take advantage of advances in digital technologies, such as artificial intelligence (AI) and big data, to analyse live and historical weather data and make projections. In fact, advanced weather forecasting is one of the main applications of AI in facilitating and improving VRE integration. Driven by an increase in computing power and improvement in algorithms, power generation forecasts have become more accurate. In a similar vein, thanks to the increasing use of AI fuelled by big data, time granularity for short-term projections have increased as well. These factors can greatly contribute to the integration of renewable power into the grid.

Improving VRE generation forecasts on short-term and long-term timescales engenders a diverse set of benefits for various stakeholders in the power sector. At short timescales, accurate VRE generation forecasting can help asset owners and market players to better bid in the electricity markets, where applicable. Bids based on more accurate forecasts would reduce the risk of incurring penalties for imbalances (for not complying with the generation offered in the bid). For power system operators, accurate short-term VRE generation forecasting can improve unit commitment (operation scheduling of the generating units) and operational planning, increase dispatch efficiency, reduce reliability issues and, therefore, minimise the size of operating reserves needed in the system.

Over longer timescales (over days or seasons), improved RE generation forecasting based on accurate weather forecasting brings significant benefits to system operators, especially when planning for extreme weather events. By contributing to the allocation of appropriate balancing reserves, long-term weather forecasting assists in ensuring safe and reliable system operations. It can also help in better planning the long-term expansion of the system, both generation and network transmission capacity, needed to efficiently meet future demand.

Implementation Readiness

Implementation of the Hydromet forecasting system requires collaboration between generators (KenGen, IPPs), the System Operator , and the National climate and weather services provider (Kenya Meteorological Department. The large hydropower generator (KenGen) currently receives seasonal and monthly weather forecasts with 7-day and 5-day weather updates to assist in dispatch planning. For this to be improved to include every 5 minutes and 30 minutes ahead, the following scope is proposed.

a. Designing a Forecasting System which will be centralised (performed by the system operator) or decentralised (performed by plant operators) and feed the forecasts back to the dispatch Centre.

b. Implementing a forecasting system that converts the raw forecast data from various models into a flow of information useful to the system operator. The major components of a typical IT-based forecasting system include the following:
    i. user interface that allows users to interact with the forecasting system.
    ii. connection of components of a forecasting system.
    iii. IT integration for enabling communication within the forecasting system and with other systems.
    iv. data repository containing working data for the forecasting system.
    v. model engine for generating plant output forecasts based on the model.

c. Increasing the accuracy and completeness of the forecast with significant amounts of data on the status of plants, meteorological conditions, and O&M. It should also provide insight into the level of data required to develop an accurate power output forecast.

d. Sourcing for a commercial forecasting system that is well integrated, through a comprehensive and flexible integration layer that allows interaction with all systems.

e. Capacity building for the system operator and generators

Rationale for renewable energy integration financing

Forecasting systems use meteorological variables or historical generation data to estimate the total plant energy output at any given time horizon.

Forecasting methods can be broadly divided into physical and statistical methods. Physical methods use weather data to populate a physical model of the atmosphere. Statistical methods use historical generation data to project plant output. Statistical methods work best for intra-hourly forecasts and up to three-hour ahead forecasts. Physical methods are used primarily for forecasting output beyond three to six hours, with some exceptions in solar, such as the application of total sky imagers for short-term forecasting for cloud prediction. In general, statistical models perform better for wind energy than for solar energy over short time horizons and physical models show better results for both wind and solar over long time horizons, because statistical models do not do a good job of predicting cloud coverage. Physical models sometimes use total sky imagers and digital cameras that produce high-quality images to show the entire sky to the horizon for short-term high-resolution forecasting.

Hybrid forecasts combine results from forecasts produced by multiple methods in a single cohesive forecast, which is often more accurate than individual forecasts.
Forecasting models provide an estimate of the weather parameters at the plant site. Physical or statistical methods combine these forecasts with the power curve of a wind turbine or solar PV module either in real-world use or from the theoretical estimate from the manufacturer to convert them into accurate and useful data for system operators that reflect plant responses to meteorological forecasts.

Results indicators

The expected outcome of the Hydromet component includes:

- Improved accuracy of dispatch planning
- Optimised dispatch of renewables including hydropower based on the accuracy of prediction of energy outputs.
- Improved system operation and control
- Enhanced system reliability

Financing Plan

The financing plan will involve procurement of hardware and software applications, Installation and configurations, capacity building, and project management.

Annex Table 3: Hydromet Financing Plan

Component: Activity	**Item**	**Indicator**	**Unit**	**Total Estimate cost (USD)**	**Source of Finance**			
					CIF	**WB & AFDB**	**IFC**	**Private sector and Other Partners**
Hydromet Forecasting System	1. Hardware including supercomputers, sensors, receivers, sky imagers, and supporting accessories (purchase, installation, and training) for NWP and Satellite Data assimilation	Required hardware installed and operational	Lot	1,200,000.00	1,200,000.00			
	2. Advanced weather forecasting models and Data analytics software (software purchase, installation, configuration, and training) for hydro, wind and solar energy forecasting.	Forecasting tools in place (models)	Lot	450,000.00	450,000.00			
	3. Communications protocols (interoperable protocol co-ordination between RE developers, asset owners, system operators)	Communication protocol in place	Lot	750,000.00	750,000.00			
	4. Project Management			200,000.00	200,000.00			
	Total			**2,600,000.00**	**2,600,000.00**			-

3. BATTERY ENERGY STORAGE SYSTEMS (BESS) AND REACTIVE POWER COMPENSATION DEVICES

Problem statement
The increased proportion of VREs in the Kenyan power system coupled with a considerable level of geothermal baseload capacity has often resulted in energy curtailment during off-peak hours. In addition, the high proportion of VREs in the power system requires enhanced ancillary services to maintain power system stability. On the other hand, the system often experiences firm capacity deficiencies at system peak due to planned and unplanned plant outages, and low wind availability resulting in some load shedding. During such periods the grid relies heavily on expensive thermal generation.

The country's power system is characterised by long high-voltage lines that connect renewable energy-rich sites to the bulk supply points that in turn supply the load Centres which are categorised into four (4) main regions based on the source and location of the bulk supply point. With the variability of the intermittent sources, and the compounding factor of the long high voltage lines to these areas, the system suffers voltage variation that in many instances exceeds the safe operating limits; these load centres far from the main generation sources continue to report on the instabilities in voltage profile that limit their production and destroy their equipment (motor drives etc). The system has been relying on local generation (predominantly grid-connected diesel power generators MSDs) to stabilise voltages in such areas during both peak periods and off-peak periods, this curtails the deployment of renewable energy power watering down the efforts made towards increasing penetration of renewable energy.

Proposed Contribution to Initiating Transformation
Battery energy storage systems can be used to improve the Kenya grid system and reduce operational costs. Some of the benefits are: Peak Power and energy arbitrage, spinning reserves synchronised to the grid with a maximum response time of less than ten seconds, Frequency response, reducing network congestion, Differing the transmission and distribution infrastructure and Renewable Energy Integration into the grid is simplified when battery storage provides peaking and transmission and distribution services to deal with renewable energy variability.

Reactive power compensation devices on the other hand are targeted to resolve the voltage variability. Due to their fast-acting, the equipment, if installed in targeted locations (areas far from main generation-RE rich Centres and linked via long – over 300 km of high voltage), this will enhance evacuation and promote utilisation of RE energy in these areas, thereby discontinue or reduce reliance to local small diesel generators currently installed in the affected areas.

Implementation Readiness
The Ministry of Energy and Petroleum is currently undertaking a study on Storage Energy Systems for the grid. The objective of the study is to determine the economic viability of introducing BESS electricity storage versus other alternatives including PSP in the Kenyan power system in the medium (5 years) to long term (20 years) period.

Foreseeing the need for the battery energy system as the country targets to integrate more renewable energy into the grid, the energy regulator in their recent tariff review included a battery energy system as part of the revenue requirement for the tariff.

Kenya has a very robust electricity market with both the public and private sector playing some critical roles. The national generator, KenGen, is ready to implement a 100MW one hour battery energy storage system with support from the World Bank through Green Climate Fund (GCF). Additionally, Private sector has an opportunity to invest in further development of 150MW BESS to support the power system.

KETRACO, the transmission utility in Kenya, with support from the German Bank (KfW), completed a Technical Study (Requirement of Reactive Power and Voltage Compensation Devices for Kenya's Power Grid- June 2022). The report analysed the current and future systems and recommended the areas, including the sizes, that require devices installed to ensure voltage stability in the system. Apart from Rabai and Suswa Static Var Compensators SVCs which are currently under discussion with the World Bank, the study further recommends additional reactive power compensation devices at Lessos, Kibos and Western Kenya.

Rationale for REI Financing

The initial analysis which also informed the need for the energy systems study was undertaken by the planning team. It indicated that for the power system to integrate more renewable energy and reduce steam venting during off-peak, there is a need for energy storage systems in the grid. The Least Cost Power Development Plan 2022-2041 indicates that the first battery energy system is needed in the system by 2024. Based on the Technical Report above, KETRACO has started implementing the recommendations required at Suswa and Rabai and is expected in 2025. Other reactive power compensation devices have been scheduled for deployment in the medium and long term as depicted in this report.

Results Indicators

The following are the results indicators that are expected to be monitored.

- The number of MW of capacity installed.
- The number of MWh of energy dispatched from the battery energy system
- The amount of MW of Renewable energy from solar and wind integrated into the system.
- The amount in MWh of steam that is not vented.
- Capacity (MVAR) of reactive power compensation devices installed.

Annex Table 4: Financing Plan, Including Financial Instruments

Component: Activity	Item	Total Estimate cost (USD)	Source of Finance			
			CIF	WB & AFDB	IFC	Private sector and Other Partners
BATTERY ENERGY STORAGE SYSTEMS (BESS) AND STATIC VAR COMPENSATORS (SVC)	Battery Energy Storage Systems (150MW)	100,000,000	10,000,000		25,000,000.00	65,000,000.00
	Reactive Power Compensation Devices	111,000,000	7,215,000.00	103,785,000.00		
	Total	**211,000,000**	**17,215,000.00**	**103,785,000.00**	**25,000,000.00**	**65,000,000.00**

**This maybe leveraged form the Private Sector through PPP*

Requests, if any, for investment preparation funding

Funding will be required to carry out a feasibility study and detailed project design.

Component 2: Enhancing Grid Reliability and Reliability

4. DEVELOPMENT OF SMART GRID TO FACILITATE INTEGRATION OF VRES

Problem statement

The currently installed Variable Renewable Energy resources in the grid amount to 645.8 MW comprising 435.5 MW and 201.3 MW wind and solar power respectively. This is equivalent to 20% of the effective grid installed capacity and 30% of the peak demand. The wind generation comprises mainly of two large power plants (i) 100 MW LTWP located in Northern Kenya, about 400 km North of Nairobi and (ii) 100 MW Kipeto wind power located in Nairobi Region. Solar generation comprises medium-sized power plants (40 – 50 MW) distributed around the country but 60% are located in the North Rift Region. These projects are monitored by the SCADA system and are therefore controllable. However, the grid has distributed small hydro and biomass generation across the country amounting to 25 MW and about 270 MW captive generation that is not monitored or controlled centrally on the SCADA system. Due to the relatively high penetration of VREs, inadequate primary reserves and lack of Automatic Generation Control system, the grid frequently experiences frequency instability. Additionally, with embedded unmonitored generation the grid experiences voltage control and protection issues.

Whereas the country has plans for further deployment of VREs to facilitate clean energy transition, the grid stability issue limits further uptake of VREs. Among the envisaged solutions to facilitate the integration of more VREs include increasing grid flexibility, enhancing grid ancillary services (primary reserves and regulating reserves), energy storage and development of smart grid solutions. This concept note focuses on requirements for the development of smart grid solutions to facilitate monitoring and control of distributed generation and implement demand response.

The scope of the project includes implementing a generation resource forecasting system, expansion of communication infrastructure, digital technology and control equipment to all generation plants including embedded generators and net-metered institutions/ customers, implementing smart metering for all prosumers on net metering and contracted interruptible loads (irrigation, water heating, EV charging, street lighting, air conditioning etc.)

Contribution to Initiating Transformation

Smart grid development will facilitate deployment of transmission and distribution energy management systems for effective operation of the grid with high penetration of VREs. This is through the provision of real-time resource forecasting data and automated response to restore demand-supply balance by either curtailing or storing excess VRE generation during high generation periods or demand response to restore the power balance during periods of low VRE generation. This will complement the flexibility/ regulation response provided by conventional generators and therefore support the integration of more VESs. Smart grid solutions will also facilitate more effective voltage control by appropriately scheduling Distributed generation sources to solve voltage problems and optimize system performance with enhanced distributed generation.

Implementation Readiness

Smart grid technology has been deployed in the Kenya grid to some extent to facilitate the implementation of energy management and transmission and Distribution management systems that enable automation and control of network devices. All transmission substations and a significant proportion of distribution primary substations are automated using the SCADA system and automation of key distribution network equipment in major load centres (Nairobi and Mombasa cities) is completed and plans are underway to automate network equipment in other major cities countrywide. To facilitate energy management, smart meters have been installed at 85% of industrial and large commercial customer installations, most of the primary distribution substations and distribution feeders and the project is ongoing. Smart metering systems have also been installed for 67,000 small and medium enterprises in the country.

The proposed smart grid extension project will comprise weather/ resource forecasting systems, expansion of the digital technology and communication systems and deployment of control equipment to distributed generators, and deployment of smart meters to identify interruptible loads to facilitate demand response and implementation of time differentiated electricity tariffs. KPLC will implement the project as an extension of its ongoing smart grid development program.

Rationale For REI Financing

Development of a smart grid will enhance power quality and supply reliability Kenya targets to attain a 100% clean energy transition by 2030. To achieve this target, it is imperative that the grid be developed significantly to support increased penetration of VREs while maintaining grid stability Harnessing more renewable energy will facilitate electrification and reduction of energy cost leveraging on the reduced cost of clean energy technologies.

Results Indicators

The following shall be the results indicators for the development of Kenya's smart grid to facilitate enhanced integration of Renewable energy.

- Amount in MW of distributed/embedded generation centrally monitored and controlled.
- Number of contracted interruptible loads with smart meters to facilitate demand response.
- Number of additional customer installations with smart meter systems
- Implementation of weather / renewable energy resource forecasting system

Annex Table 5: Smart Grid Cost estimates / Financing plan

Component: Activity	Item	Number	Unit Cost (USD)	Total Estimate cost (USD)	Source of Finance			
					CIF	WB & AFDB	IFC	Private sector and Other Partners
DEVELOPMENT OF SMART GRID TO FACILITATE INTEGRATION OF VRES	Automation Infrastructure and Equipment For Embedded Generators	180	50,275	9,049,500.00	2,516,250.00	6,533,250.00		
	Interruptible Loads and Customers Advanced Metering Infrastructure And Smart Meters	900	6000	5,400,000.00	1,400,000.00	4,000,000.00		
	Single phase meter testing benches	3	167,000	501,000.00	250,500.00	250,500.00		
	Total Cost Estimates			**14,950,500.00**	**4,166,750.00**	**10,783,750.00**		-

Investment preparation funding

Funding will be required to carry out a feasibility study and detailed project design.

5. OPERATION & MAINTENANCE, TRANSMISSION LINE AND SUBSTATION EQUIPMENT STRATEGIC SPARES

(MOBILE TRANSFORMERS, ADDITIONAL TRANSFORMERS AND EMERGENCY RESTORATION TOWERS).

Problem Statement

The country's demand for electric energy has been steadily growing at a rate of about 4.5% per year driven by the realisation of the third MTP for Vision 2030 (Big 4 Agenda). The loading on several transformers in Kenya's power grid substantially increased. Simulations indicate that the impending overload situations could lead to equipment overload and subsequently failure of transformer units in these substations hence affect effective evacuation and utilisation of power. In some situations, load shedding is effected to reduce overloading stress on existing transformers. This has a negative impact on power utilisation and on the efforts towards promoting 100% electricity access to the nation's population.

Substations currently affected and those likely to be affected within the medium term include: Kegati, Meru, Malindi, Bomet, Naivasha, Konza, Narok, Nanyuki, Kiganjo, Kutus, Soilo, Lanet, Muhoroni, Lanet Eldoret and Kitale. Most of these areas notably get their supply from various renewable energy resources.

With respect to Operation and Maintenance, a number of network power transformers and installed reactive power compensation devices have suffered failure due to various reasons. In the last 5 years, from about 10 incidents on power transformers reported, two have been critical and required immediate replacement of the transformer units. This discontinued supply from the areas for close to a month and as result of the demand was curtailed and revenue opportunities lost.

Breakdown in transmission services due to mechanical failures in transmission lines infrastructure as a result of vandalism, human interference (such vandalism etc) and adverse weather/climatic condition has been reported in the past and currently four lines/corridors, although service has resumed, the system at the risks longer interruption period as the stock for Emergency restoration towers are exhausted.

Proposed Contribution to Initiating Transformation

The mobile substation and strategic spares that include power transformers emergency restoration tower will reduce the downtimes for power supply and improve restoration times from several months to several days in the event of network breakdown attributed to failures in power transformers and mechanical failures in transmission line structures. The mobile transformers will be deployed to critical areas where power transformers are overloaded to avert load shedding hence ensure continuity of service in the system and maximise utilisation of renewable energy resources.

Implementation Readiness

The Kenya Electricity Transmission Company Limited and Kenya Power are the current transmission system owners and operators. The two utilities have identified substations that are highly loaded and put measures in place to monitor the loading of the transformers. The need to upgrade several substations by adding new transformer units and/or replacing existing transformers with large capacities has been simulated and included as part of projects in the transmission master including their tentative timelines and estimated cost.

Likewise, the concept notes for mobile transformers have been prepared and with support of KfW, up to four (4) units are expected in the medium term once the process is approved. With these it is expected that relevant personnel KETRACO will be trained on concepts, installation and operation of the mobile units.

The two utilities have personnel that undergone operation and maintenance training that include erection and installation of emergency restoration towers and there is adequate capacity required to install and use the emergency restoration towers.

Rationale for Renewable Energy Integration (REI) Financing

Kenya's energy mix is dominated by power generated from renewable energy sources that include wind, solar, geothermal, hydro (both run-off the river and with reservoir) with 85-93% of Kenya's electricity demand being supplied from renewable energy sources, it is imperative that the transmission infrastructure is adequate and reliable to support the evacuation and utilisation of this renewable energy. Any interruption of transmission line will prevent evacuation of power and curtail generation from rich renewable energy sources with a high probability of reverting to isolated small diesel power generators in the absence of grid connected power.

Results Indicators

The following shall be the results indicators for implementation in revamping O&M TL and SS equipment Strategic Spares (mobile transformers, additional transformers and emergency restoration tower).

- Number of truck mount/mobile transformers
- Number of truck mount/mobile reactive power compensation devices.
- Number (Sets) of Emergency Restoration Tower (Sets).
- Number of power transformer units (additional and spares units)
- Reduction of duration of downtimes following failure episode/case on the transmission system element.

Financing Plan

Annex Table 6: O&M TL and SS Equipment Strategic Spare Proposed Financing Plan

Component: Activity	**Item**	**Quantity**	**Unit Cost (MUSD)**	**Total Estimate cost (USD)**	**Source of Finance**			
					CIF	**WB & AFDB**	**IFC**	**Private sector and Other Partners**
OPERATION & MAINTENANCE, TRANSMISSION LINE AND SUBSTATION EQUIPMENT STRATEGIC SPARES (MOBILE TRANSFORMERS, ADDITIONAL TRANSFORMERS AND EMERGENCY RESTORATION TOWERS).	Truck Mount/Mobile Transformers	4	1,500,000.0	6,000,000.0	1,500,000.0	4,500,000.0		
	Truck Mount/Mobile Reactive Power Compensation Devices.	4	1,500,000.0	6,000,000.0	1,500,000.0	4,500,000.0		
	Sets Of Emergency Restoration Tower	20	120,000.0	2,400,000.0	1,200,000.0	1,200,000.0		
	Number Of Power Transformer Units 132/33kV 23 MVA (Additional And Spares Units)	5	500,000.0	2,500,000.0	1,000,000.0	1,500,000.0		
	Number Of Power Transformer Units 132/66kV 60 MVA (Additional And Spares Units)	3	900,000.0	2,700,000.0	1,800,000.0	900,000.0		
	Number Of Power Transformer Units 220/33kv 23 MVA (Additional And Spares Units)	3	600,000.0	1,800,000.0	1,200,000.0	600,000.0		
	Number Of Power Transformer Units 220/132kV 90 MVA (Additional And Spares Units)	2	1,424,750.0	2,849,500.0	1,449,500.0	1,400,000.0		
	TOTAL			**24,249,500.0**	**9,649,500.0**	**14,600,000.0**		

Source; KETRACO:

6. AUTOMATION OF CONDITION MONITORING FOR KENYA'S POWER TRANSMISSION SYSTEM

Problem Statement

Kenya's transmission system has evolved and transformed from a radially connected network to a meshed network comprising 400kV, 220kV and 132kV lines all interconnected to form the national grid linking to neighbouring countries such as Uganda, Ethiopia and soon to Tanzania. In the last 15 years, the size of the transmission network has increased from about 3,500km to more than 7,000km in circuit length.

The number of substations has also increased drastically both in number and complexity, with over 40 new substations with a transformation capacity of more than 6,000MVA within the same period. An additional 3,400km in circuit length and 28 new substations (about 6,500MVA in transformation capacity) are expected within the next five (5) years. The current methods of condition monitoring include physically patrolling substation sites and checking the alarms in the substation Human Machine Interface for stations that are not visible on SCADA and visual checks on the equipment. With the increasing number of substations and length of transmission lines, this method is becoming counterproductive as the travel-related overheads put more stress on the funds allocated to adequately operate and maintain (repair) the system as needed. To some extent, the maintenance activities may lack a defined structure leading to delays in effecting or carrying out critical repairs leading to fast deterioration of equipment. There is thus a need to completely automate the condition monitoring of the substations (including key equipment) in order to ensure the healthy equipment meets the required security requirements.

Proposed Contribution to Initiating Transformation

With an automated condition monitoring system, it is expected the operational activities required to maintain a healthy national grid will be well structured and streamlined for cost-effectiveness ensuring attention is accorded to elements on a need basis thereby reducing t operational overheads and downtimes in the network as maintenance will be implemented on demand based. The automation will also put in place a versatile asset management system for improved service delivery.

Implementation Readiness

The transmission utility with support from development partners is implementing a new national system control Centre (NSCC) that will include an enterprise asset management system with capabilities and functionalities that include remote condition monitoring, automated data collection techniques, work order and workflow management system, asset management, reporting and analytics.

As part of the scope, there is provision for the installation of remote sensing devices on selected substations and rolling out a pilot fully functional automated asset management system. Completion of this project is expected in 2026.

Rationale for REI Financing

The transmission system is growing to accommodate the evacuation needs and supply requirements in support of increased penetration of renewable energy With the extensive network, maintenance is becoming a critical component towards ensuring security in evacuation and supply of electric energy generated from the renewable energy sources. The pilot automated condition monitoring is expected to cover a few critical stations, there are plans to roll out to other remaining substations' equipment and operationalise and maximise the use of the centralised enterprise automation system.

Results Indicators

The following are the results indicators that are expected to be monitored.

- The number of substation equipment fitted with remote condition monitoring devices.
- Remote condition monitoring enabled and operationalised.

Annex Table 7: Automation of Condition Monitoring - Financing Plan

Component: Activity	**Item**	**Quantity**	**Unit Cost (USD)**	**Total Estimate cost (USD)**	**Source of Finance**			
					CIF	**WB & AFDB**	**IFC**	**Private sector and Other Partners**
AUTOMATION OF CONDITION MONITORING FOR KENYA'S POWER TRANSMISSION SYSTEM	Supply and Installation of Remote Devices For Substations And Rolling For The Entire System	100	25,000.00	2,500,000	2,500,000			
	Total			**2,500,000**	**2,500,000**			-

Requests, if any, for investment preparation funding

Not Applicable

Component 3: Technology and Market Innovation.

7. **RENEWABLE ENERGY CENTRE OF EXCELLENCE INCLUDING RENEWABLE ENERGY TECHNOLOGY TRANSFER /INCUBATION (TECHNOLOGY & MARKET INNOVATION)**

Problem Statement

There are pervasive challenges that impede the capacity of the Energy sector to fully exploit, develop and deploy renewable energy technologies despite the existence of substantial potential in the country. The energy sector experiences inadequate research and development facilities, lack of facilities to undertake testing of prototypes on renewable technologies and centres to harness energy sector knowledge, institutional memory and skills transfer to enhance sustainability. Delivering practical skills required by the energy sector labour markets is a key enabler in enhancing development of Kenya and Africa's Renewable Energy Integration program hence the need for the Centre of Excellence with focus on Energy Technology.

In order to spur the development of clean energy technologies, the Government through the Ministry of Energy and Petroleum is seeking to set up a fit for purpose Kenya National Renewable Energy Centre of Excellence to offer capacity building to support the upscaling of renewables. The Centre of Excellence will contribute to and complement on-going efforts towards achievement of 100% clean energy by 2030 as well as SDG 7. With the increased variable renewable energy to the grid, there is a need for capacity building to address the challenges of intermittent power as part of the Renewable Energy Integration Program.

Proposed Contribution to Initiating Transformation

The Energy Sector will leverage on existing expertise within the sector in enhancing capacity building and meeting the training needs of the energy players in the region through the following initiatives.

1. Promotion of Research and Collaborations in energy technology in both academia and industry
2. Put in place mechanisms to attract multi-sectoral funding in research and human resource development.
3. To build capacity in energy development and address technological gaps.
4. Provide practical exposure to trainees through attachment and internship programs.
5. Enhance STEM education and internship training to expand women's employment in energy utilities, including managerial roles as part of realising SDG 5 on ensuring gender equity within the energy sector.

The Energy Centre of Excellence will provide capacity building to enhance the role of energy in meeting practical needs and wellbeing of women, men, the youth, boys and girls. Availability of clean, sustainable and affordable energy sources facilitates the participation of both men and women in the social economic growth of the country while improving the environment.

The program will support the renewable energy and energy conservation development and deployment and will work closely with industry, government, academia, small businesses, international organisations, and non-profit organisations to advance the use of clean energy technologies in the marketplace.

Implementation Readiness

The central physical Kenya National Renewable Energy Centre of Excellence facility will be located within the Konza Techno City as the headquarters. It is planned that specialised laboratories/centres of Excellences, including Energy Conservation lab, KenGen Geothermal Centre of Excellence, GDC geothermal laboratory and testing Centre, Bio-energy lab, Solar/wind lab, Hydro lab will be operated by various institutions within the energy sector;

KenGen Geothermal Training Centre of Excellence - KenGen is currently in the process of upgrading its Geothermal Training Centre to a Regional Centre of Excellence, which supports the Eastern Africa Skills for Transformation and Regional Integration Project (EASTRIP). The Centre of Excellence would serve the full range of Energy Technology training and would serve as Regional Flagship TVET Institute for the Energy sector; The Centre of Excellence would also serve as a Knowledge Centre and Assessment Centre for Energy Technology and would be serving the Kenyan or regional markets and beyond, creating a very large catchment area. This project will go a long way in realising the aspirations of the Africa Geothermal Centre of Excellence (AGCE) which is a continental initiative supported by the African Union Commission (AUC), Governments of member countries and the UN Environment. The main objective of the program is to train and develop a critical mass of professionals and resource persons in the geothermal sector within the continent. This will aid in accelerating efforts towards geothermal resource exploration and development across the continent.

To support and enhance a sustainable model for training and development of the critical human resource personnel in the region, there is a need to continuously develop curricula in identified gap areas in the sector.

GDC Geothermal Laboratory and Testing Centre - The lab will be managed and operated by Geothermal Development Company Ltd. The main objective of establishing the Geothermal Laboratory and Testing Centre is to accelerate the geothermal development in Kenya and the ARGeo region through sample testing, technological diagnosis, research and demonstrations. The facility will be modelled to form a Centre of excellence with a state-of-the-art laboratory with equipment for geothermal testing/research and to create the required capacity currently lacking in the region. The Centre will also provide lab testing services, workshops and consultancy services to other industry players as well as provision of equipment pool for use by other research institutions. The proposed Laboratory and Testing Centre will comprise of; Scientific Laboratories (Geology, Geochemistry, Geophysics, GIS and Environment); Engineering workshops; Materials storage yard; and demonstration Centre for geothermal applications. The Centre will be located in Kabarak, Nakuru County where GDC has a developed Menengai geothermal field for ease of practical training and demonstrations.

Wind lab - This will be managed and operated jointly by the Ministry of Energy and Petroleum, Kenya Electricity Generating Company PLC and Rural Electrification and Renewable Energy Corporation (REREC). The facility will be set up in Konza Technopolis.

Solar lab - It will be managed and operated jointly by the Ministry of Energy and Petroleum and Rural Electrification and Renewable Energy Corporation (REREC). The facility will be set up in Konza Technopolis.

Bio-energy lab - It will be located in Konza Technopolis and will be managed and operated jointly by the Ministry of Energy and Petroleum and Rural Electrification and Renewable Energy Corporation (REREC).

Energy Efficiency and Conservation lab - It will be located in Konza Technopolis and will be managed and operated by the Ministry of Energy and Petroleum

Hydro Centre of Excellence - The facility will be operated and managed by Kenya Electricity Generating Company PLC at the Eastern Regional Offices in Kamburu in order to benefit from the expertise of the Hydro Plants operations in the region. The Hydro Centre of Excellence hosts labs, mini-training workshops, prototypes and demo halls to enhance practical skills in the research, design, development and operation of Hydro Power Plants.

Rationale for REI financing

Development of renewable energy sources in the African continent is limited by various challenges including inadequate skilled manpower in the areas of Geothermal Science and Technology. Amongst the initiatives to address the challenges include the establishment of Africa Geothermal Centre of Excellence (AGCE), headquartered in Kenya. African countries have come up with energy development strategies aimed at fast tracking renewable energy projects including geothermal resources for power generation and direct use applications and Kenya is well placed to offer its technical skills based on its successful experience in development of Renewable Energy Resources.

The Energy Centre of Excellence will therefore provide all the necessary skills and knowledge needed in the energy sector especially in clean energy sources by ensuring that the trainees are exposed to state of art techniques/ technologies in the sector. This will be done by offering a range of practical and technical training in exploration, utilisation and sustainability of renewable energy resources, care and maintenance of production equipment and other specialised courses related to renewable energy development. In addition human resources are needed to transfer knowledge in the energy sector and ensure that knowledge transfer and exposure to state of art techniques/ technologies in the industry.

The Energy Centre of Excellence will also focus on establishing partnerships with institutions from other Countries and the region in order to leverage existing expertise and promote sharing in knowledge, technology, research and innovation.

Results Indicators

- No of programs offered by the Centre of Excellence
- No of trainees enrolled for various programmes
- No. of new programmes developed (Curriculum development)
- No of laboratories and Centres of Excellence set up
- No of research programs completed
- No of consultancies offered
- No of innovative programs implemented within the sector

Financing plan, including financial instruments

Annex Table 8: Energy Centres of Excellence Proposed Financing Plan

Component: Activity	Item	Quantity	Unit Cost (USD)	Total Estimate cost (USD)	Source of Finance			
					CIF	WB & AFDB	IFC	Private sector and Other Partners
RENEWABLE ENERGY CENTRE Of EXCELLENCE INCLUDING RENEWABLE ENERGY TECHNOLOGY TRANSFER /INCUBATION (TECHNOLOGY AND MARKET INNOVATION)	Energy Centre Konza hub (MOE&P): Solar Lab, Wind Lab, Bio- Energy lab, Energy Efficiency and conservation Lab	● Laboratory infrastructure and facilities ● Capacity building for technical experts	7,397,000	7,397,000	3,000,000	4,397,000		
	Geothermal Laboratory and Testing Centre (GDC)	● Laboratory infrastructure and facilities ● Acquisition of the laboratory equipment, fittings, tools, and consumables ● Capacity building for technical experts	10,900,000	10,900,000	5,750,000	5,150,000		
	KenGen Geothermal Centre of Excellence & Hydro Centre of Excellence	● Curriculum development for new programmes for Geothermal Centre of Excellence ● Capacity building for	7,198,500	7,198,500	3,250,000	3,948,500		

		experts including women to ensure inclusivity						
		● Laboratories						
		● Centre management personnel						
		● Demonstration and simulation centres						
		● Lecture rooms						
		● Exhibition halls						
	Capacity Building for the National CIF Committee (TA)		1,938,586.24	1,938,586.24	1,938,586.2	-		
	TOTAL		**27,434,086**	**27,434,086**	**13,938,586**	**13,495,500**		-

8. MENENGAI GEOTHERMAL RESOURCE PARK PROJECT (TECHNOLOGY & MARKET INNOVATION)

Problem Statement

Geothermal is a clean and renewable energy source and has less carbon effect hence its increased use will lead to reduced use of fossil fuels. Geothermal fluids, unsuitable for electricity generation due to its thermodynamic characteristics, is, however, useful for direct uses. Other geothermal by-products such as water, minerals and gases can also be economically harnessed. As the development of geothermal energy progresses, the availability of steam and separated geothermal brine increases. Direct use of geothermal energy is the utilisation of the thermal energy in geothermal fluids for other uses other than electricity generation. Studies have shown that hot geothermal fluids, not usually suitable for electricity generation, have substantial amounts of thermal energy which can be harnessed economically. The thermal energy harnessed from the steam and brine will be utilised for Direct Use. The increasing demand for industrial development requires affordable energy as well as a proper check on emissions to the environment. This project will therefore displace the use of fossil fuels for industrial production and create demand for more renewable energy into the grid. Geothermal Direct-Use offers a solution as it provides clean energy.

Direct-Uses of geothermal energy has not been fully exploited and there exists an opportunity for private and public partnerships to spur the industry for more investor engagement. GDC seeks to develop geothermal resource parks at the Menengai Geothermal project. This project will assist in the commercialisation of the Direct Use projects in Menengai that GDC is currently doing.

Proposed Contribution to Initiating Transformation

The development of the industrial park will establish an economic zone through development of the Geothermal Resource-Parks and supply thermal energy to industries adjacent to the geothermal project areas. The industrial park will stimulate additional electrical and energy demand for the country and absorption of renewable geothermal energy from the Menengai Geothermal project. The project will displace the use of fossil fuel and spur both the local and national economy and create jobs for both men and women. The project will also benefit from the battery energy storage project where excess power can be stored for use during peak demand.

IMPLEMENTATION READINESS

The project will be undertaken by Geothermal Development Company (GDC) at the Menengai Geothermal Project. GDC has the mandate to promote alternative uses of geothermal energy, commonly referred to as Direct-Uses. Since its inception, GDC has been researching Direct-Use technology and has set up demonstration projects to showcase and market the technology. Over the years, GDC has reached many people and institutions i.e. government, non-government and academic institutions, local and international investors, financiers, organised groups most of which have been interested in investing in the technology. GDC's current focus is on commercialisation of the Direct-Use technology by partnering with investors to realise it. GDC has also carried out pre-feasibility studies of the Direct Use projects with the help of development partners including USAID and ICEIDA.

Rationale For REI Financing

Direct Use is an innovative way of using geothermal energy for purposes other than electricity generation. The commercialisation of Direct Use projects will create a demand for the exploitation of geothermal resources and displace the use of fossil fuels. It will also create opportunities for new and innovative technologies for industries to produce their products using clean energy. This will subsequently lead to industries that are conscious of environmental conservation.

Results Indicators

The following are the expected results indicators for the Menengai Direct Use industrial park

1. No of geothermal resource parks established
2. Enhanced energy supply infrastructure
3. No of Direct Use projects commercialised
4. No of private investors engaged
5. No of jobs created
6. Amount of additional thermal energy consumed.

Financing Plan, Including Financial Instruments

Below is the estimated project cost of the geothermal resource park.

Annex Table 9: Menengai Geothermal Resource Park Project Proposed Financing Plan

Component: Activity	**Item**	**Total Estimate cost (USD)**	**Source of Finance**			
MENENGAI GEOTHERMAL RESOURCE PARK PROJECT (TECHNOLOGY AND MARKET INNOVATION)			**CIF**	**WB &AFDB**	**IFC**	**Private sector and Other Partners**
	Technical Support (Feasibility Study for Geothermal Resource Parks)	336,813.74	336,813.74			
	Establishment of Energy supply infrastructure for cement manufacturing, paper processing and aquaculture	2,456,501.30	2,456,501.30			
Subtotal	**TOTAL**	**2,793,315.04**	**2,793,315.04**			

Note: The proposed budget above will go towards the technical support for a feasibility study for the geothermal resource park and the establishment of energy supply infrastructure required for the commercialisation of Direct Use projects including cement manufacturing, paper processing, and aquaculture firms thus attracting private sector investments.

9. SUPPORTING DEMAND STIMULATION ON EMERGING TECHNOLOGIES IN KENYA

Problem Statement

Power demand in Kenya has largely been driven by GDP growth, population growth, urbanisation, and the implementation of government flagship projects over the past decade. However, lately, the country has seen an introduction of other demand drivers, notably from E-cooking and E-Mobility. In addition, with the government prioritising irrigation to ensure food security in the country, it is projected that irrigation infrastructure will immensely increase electricity demand both in the short term and long term.

It is estimated that there are 512 electric vehicles (EVs) registered in Kenya as of 2022. Power demand from EVs in 2022 is estimated at 3.28MW, while that from E-cooking is approximately 5.7MW. Demand for EV and E-cooking is projected to increase to 5.28MW and 6.97MW respectively by 2027 (MTP of Least Cost 2023-27).[84] The Kenya National Energy Efficiency and Conservation Strategy sets a roadmap towards setting and achieving energy efficiency goals within a five-year timeline up to 2025. The Government of Kenya's medium-term target for scaling up and adoption of E-mobility is to increase the share of total electric/hybrid vehicles imported into the country by 5% by 2025 annually by developing regulations and financial

[84] Medium Term Plan of Least Cost Power Development Plan 2023-27

mechanisms to increase the ownership of electric vehicles in the country[85]. Also, 55.1 percent of households in Kenya still use wood as their primary fuel for cooking. The government has set the target for universal access to clean cooking to 2028 ahead of the global goal of 2030.

Despite government efforts to support adoption of E-Vehicles and E-cooking, inadequacy of necessary supporting energy framework and infrastructure remains to be a huge hindrance towards growth in electricity demand and hence a constraint on Kenya's economic development. There is also no policy and regulatory framework to guide the private sector to develop EVs and E-cooking business models. As the demand for E-Vehicle grows the charging station becomes critical. For instance, the coverage of E-Vehicle charging stations in the country is notably low, which consequently slows down growth of EVs. In order to achieve significant reduction of GHG emission in the transport sector it is crucial to speed up transition to electrification of mass public transport. The government considers involvement of development partners essential to the success of the E-Vehicles and E-cooking programs given the size and scale-up envisioned in the long term. Additional investment in this infrastructure will positively affect growth in power demand in the country.

Although Kenya's electrification rate as of 2018 was 75%, the use of electricity for cooking is still low. According to a national survey conducted by the Ministry of Energy in 2019, approximately 3% of the households use electric cooking appliances (mixed LPG-electricity stove, electric coil and microwave.

The low uptake of cooking with electricity has been attributed to complex mix of demand-side and supply-side barriers such as the high up-front cost of electric stoves compared to other improved stoves, lack of awareness of efficient cooking electric appliances, diverse electric appliance options, limited distribution points of electric appliances and the high cost and low-quality electricity supply of electricity in the country. Cooking using traditional forms of biomass, especially fuelwood and charcoal, is the leading source of greenhouse gas emissions in Kenya and is associated with widespread negative environmental and health impacts.

The society is now witnessing a rapid evolution in electric cooking technologies, including new designs of electric pressure stoves, air fryers, rice cookers and electromagnetic induction stoves in the Kenyan market. This evolution is complemented by increased access to electricity and innovative business models, such as pay-as-you-go solutions that resolve the affordability challenge. Transitioning to electric cooking is an essential step for the country to adopt cleaner cooking solutions, which have multiple health, climate, economic, and environmental benefits.
Kenya has recognized clean cooking as a high-impact initiative and has set a target under SDG-7 to accelerate access and achieve universal access to clean energy cooking services in the country by 2028.

[85] Kenya National Energy Efficiency and Conservation Strategy

The government the Government is pursuing strategies to increase the update of clean cooking solutions with support from GIZ, EU, Dutch Government amongst others. The additional support entails:

i. Consumer Educational awareness - there is a need to conduct strategic consumer education that demonstrates how to use electric cooking appliances and discusses the benefits of transitioning to cooking entirely with electricity.
ii. Research and development – the biggest barrier to cooking entirely with electricity is associated with the limited availability, cost and cooking compatibility of electric cooking appliances. More research on improving these aspects of these electric cooking appliances is required for the household to entirely transition to cooking with electricity.
iii. Regulatory and legal framework – the Energy Act of 2019, the Energy Policy and the associated Regulations guide the development of the e-cooking solutions in the country. However, there has been no specific tariff for electric cooking. The government therefore requires support in undertaking studies on the tariff guidelines for transitioning of rural and urban dwellers from biomass to electric cooking solutions.

Proposed Contribution to Initiating Transformation

The Government's strategy of scaling up and adopting E-mobility and E-cooking in the country can be promoted to increase the market uptake and availability, and also enable the displacement of fossil fuel powered motor vehicles, and fossil fuel cooking, which contribute to high CO2 emissions. It is expected these programmes and support initiatives would significantly reduce GHG emissions and create employment opportunities for Kenyans. Development of infrastructure such as fast charging stations and battery swapping stations across major towns in the country will lead to a higher uptake of Electric Vehicles, including mass rapid transport systems.

In addition, development of necessary policies and regulatory framework in support of uptake of e-mobility and adoption of electric battery technology in the motor industry can also motivate the shift towards EVs, increasing power demand in the country. There is a need to create awareness on the benefits of transiting to e- mobility and e-cooking, which is a component of clean cooking, as this is one of the primary challenges affecting their user acceptability.

Implementation Readiness

The Kenyan government is currently in progress putting in place electricity demand creation measures to optimise utilisation of the existing and committed generation capacity. For instance, in the national budget 2019/20, the excise duty for electric vehicles carrying more than 10 persons was lowered from 20% to 10%. The Kenya Bureau of Standards has developed and adopted standards that apply to electric vehicles imported into the country. Up until now, a total of 24 standards have been developed and adopted, covering specifications and testing procedures for safety aspects as well as performance and power consumption elements. In support of the Government initiatives towards EVs, KPLC has proposed a special tariff for this category of consumers who will be charged at an off-peak rate for consumers connected at CI1-CI5. The intention is to increase off-peak utilisation of the power system but to also decarbonise the energy sector. Efforts are underway to expand charging ports across major highways and to increase consumer awareness among public transports, namely motor cyclists, bus owners and even private motorists. The Ministry of Energy and Petroleum, among other partners, is also promoting the e-cooking agenda.

Rationale for Renewable Energy Integration (REI) Financing

Kenya's energy mix is very favourable to support e-mobility and e-cooking, with nearly 85% of its energy coming from renewables. Financing development of charging infrastructure across the country can help stimulate power demand, in addition to improved air quality, reduction of greenhouse gas emissions, and positive economic impacts of the technology through the creation of new local value chains.

CIF funds would complement the ongoing Government funded green projects including e-mobility and clean cooking projects in the country. The participation of the private sector will be key in the setting up of the E-mobility and E-cooking projects to complement government measures. The availability of EVs, e-mobility and e-cooking infrastructure in rural areas in particular would reduce reliance on biomass which is the primary fuel in the rural domestic households.

Results Indicators

The following shall be the results indicators for implementation of support for demand stimulation on emerging technologies in Kenya.

- Regulatory Frameworks/policies and financial mechanisms developed to increase the ownership of electric vehicles in the country.
- Revised Building Code incorporating charging stations in public buildings and new estates,
- Awareness-raising initiatives on electric vehicles, e-mobility, e-cooking
- Share of electric/ hybrid vehicles in total vehicles imported into Kenya
- Tariff guidelines for e-cooking
- Number of Charging stations in the country.
- Number of Electric Vehicles in the country.
- Share of electric cooking among households in the country.
- Quantity of CO_2 emissions reductions
- Energy sector Technical Demand Committee Capacity building sessions
- Number of jobs created directly from the establishment of charging stations.

Financing Plan

Annex Table 10: Demand Stimulation on Emerging Technologies Proposed Financing Plan

Component: Activity	Item	Quantity	Unit Cost (USD)	Total Estimate cost (MUSD)	Source of Finance			
					CIF	WB &AFDB	IFC	Private sector and Other Partners
SUPPORTING DEMAND STIMULATION ON EMERGING TECHNOLOGIES IN KENYA	EV Charging Station.	100	58,060	5,806,000	-	5,806,000		
	Battery Swapping Stations	10	450,000	4,500,000	-	4,500,000		
	Technical Support (Capacity Building) In Battery Technology	1	750,000	750,000	750,000			
	Technical Support (Development of EV and E-Mobility Standards)	1	200,000	200,000	200,000			
	Policy and Regulatory Framework for The Uptake of E-Mobility	1	750,000	750,000	750,000			
	Technical Support (Capacity Building, Consumer Educational Awareness, Research and Development, And Tariff Guidelines) In E-Cooking	1	750,000	750,000	750,000			
	Total Cost (USD)			**12,756,000**	**2,450,000**	**10,306,000**		

Source; GIZ study on Electric Mobility in Kenya: Charging Infrastructure

Component 4: Facilitating Open Access for Renewables

10. REGULATIONS FINALISATION IN SUPPORT OF RENEWABLE ENERGY INTEGRATION AND CLIMATE CHANGE RESILIENCE IN KENYA

Problem Statement

Kenya is in the process of aligning its regulatory framework to the Energy Act 2019. The need to review existing regulations and develop new ones to address emerging issues in the energy sector space has led to the development or review of not less than 32 regulations. These regulations cover various aspects of energy management as outlined in the Act. To specifically address issues related to renewable Energy Management and climate change resilience, EPRA is in the process of finalising the following key regulations:

1. The draft Energy (System Operation) Regulations, 2023 that have incorporated the updated Grid Code (KNTGC and KNDC).
2. The draft Energy (Reliability, Quality of Supply and Service) Regulations, 2022.
3. The draft Energy (Integrated National Energy Plan) Regulations, 2022.

These draft regulations are currently in the later stages of finalisation. On the other hand, the following three (3) regulations, currently in draft form require finalisation and implementation but have no financial allocations for these processes:

1. The draft Energy (Electricity Market, Bulk Supply and Open Access) Regulations, 2022
2. The draft Energy (Renewable Energy Resources) Regulations, 2022
3. The draft Energy (Feed-in Tariff) Regulations 2021

The remaining activities towards their finalisation include:

- contracting (an) expert(s) to finalise (a) regulatory Impact Assessment(s) (RIA) and (a) Regulatory Impact Statement(s) (RIS)
- Supporting the process of the mandatory stakeholder consultations and validation

Gazettement And Implementation of The Regulations

The objectives of the draft Energy (Electricity Market, Bulk Supply and Open Access) Regulations, 2022 include the provision of guidance on the review of the electricity market, the governance structure for the operations and management of the proposed electricity market, open access and bulk supply. They will give effect to sections 131, 136(1)(c), 138, 140(d) & (e), 163 and 167(j), (k), (l) & (n) of the Energy Act 2019. They will also provide for a competitive environment in the power market intended to enhance efficiency, and reliability and improve the quality of service within the electricity market. Further, they provide for non-discriminatory open access to the transmission and/or distribution system. The overall objective of the regulations is to address the current single buyer model that characterises the Kenyan power market and achieve greater accountability and transparency in the operations of the electricity market.

The draft Energy (Renewable Energy Resources) Regulations, 2022 are intended to regulate persons engaged in the renewable energy industry undertaking exploration, development, manufacturing, importation, transportation, generation, operation, distribution, retailing, consumption, storage and exportation of renewable energy resources and related equipment with the exception of geothermal resources. The regulations give effect to sections 73-76; 44(1) (f, i, j & m) and 93(2) (r) of the Energy Act 2019. They are aimed at regulating the Planning, Sustainable exploitation, Licensing for exploitation, data management, and mapping of RE resources. The regulations are also intended to promote the development and use of RE including the establishment of Energy Centres and management of Carbon Credits.

Finally, the draft Energy (Feed-in Tariff) Regulations 2021 seek to implement sections 91, 92 and 93 of the Energy Act, 2019 with regard to the renewable energy Feed-in-Tariff system. They apply to the generation of power from small-hydros, biogas, biomass, biofuel, cogeneration, municipal waste and tidal wave for generation not exceeding 10,000 kilowatts. The regulations set out the guidelines and timelines for application and approval procedures to enter into a FiT-system and the function of the regulator on the same.

Proposed Contribution To Initiating Transformation

Support for finalisation of these three draft regulations is critical for renewable energy resources development in the country as this would lead to accelerated investment in renewable energy technologies for the power sector and attract necessary private sector participation in the sector. The level of intermittent wind and solar energy is expected to rise rapidly in the Kenyan system in the medium to long term. This is in line with the country's renewed vigour of accelerating the development and use of renewable energy technologies partly to meet its international obligations on climate change and also to fulfil the provisions of the Energy Act 2019, section 75 (2).

The country has finalised two studies namely a *power market study* and *system operation and dispatch guidelines*. In addition, it is in the process of reviewing the FIT policy 2012 as well as the proposed Energy auctions for technologies not covered under the revised FIT policy. An implementation and enforcement framework from the three draft regulations will not only assist in meeting the country's NDC target of reducing emissions by 32% in 2032 and net zero targets by 2050 but would also transform the Kenyan power market into a competitive, cost-reflective and sustainable system with multiple players.

Implementation Readiness

The draft regulations have been subjected to the initial stakeholder consultations and are therefore ready for the remaining processes. The country is also in the process of approving necessary policy support documents that will be implemented through these regulations including the FIT revised policy and the Energy auctions policy. Accordingly, the finalisation of these draft regulations only requires necessary financial support for completion. Given that the draft regulations are fairly refined, only minimal budgetary support is required to complete the task in the shortest time possible

Rationale For REI Financing

Though internal finances from the Ministry of Energy and Petroleum and EPRA were used in the drafting of the regulations, finalisation is however not guaranteed due to competing priorities and resource constraints. The expected cost for the completion process for the three (3) regulations is tabulated below.

Results Indicators

1. Number of Regulatory Impact Assessment reports finalised.
2. Number of Stakeholder forums held, comments consolidated and incorporated into the final regulations.
3. Number of regulations reviewed, finalised and implemented.

• Financing plan, including financial instruments

Annex Table 11: Provisional Budget for Implementation of a Set of Draft Energy Regulations

Component: Activity	**Item**	**Total Estimate cost (MUSD)**	**Source of Finance**			
			CIF	**WB &AFDB**	**IFC**	**Private sector and Other Partners**
	Review of Draft Regulations	14,243.00	14,243.00			
REGULATIONS FINALISATION IN SUPPORT OF RENEWABLE ENERGY INTEGRATION AND CLIMATE CHANGE RESILIENCE IN KENYA	Regulatory Impact Assessment (Consultancy)	67,362.75	67,362.75			
	Gazettement Of First Draft And RIA For Public Comments, And Undertake Stakeholder Engagements.	33,681.37	33,681.37			
	Gazettement Of Final Regulations	1,010.44	1,010.44			
	Total	**116,297.56**	**116,297.56**			-

Requests, if any, for investment preparation funding

There will be no resources required for project preparation funding as the draft regulations are already in place.

11. STUDY ON THE TECHNICAL AND FINANCIAL IMPACT OF DISTRIBUTED AND CAPTIVE ENERGY TO KENYA'S POWER GRID

Problem Statement

There has been a sharp increase in Kenyans generating electricity for their own consumption to complement supply from the national grid. This captive generation is largely driven by the decline in the cost of renewable energy technologies. Several domestic, commercial, industrial and institutional facilities in Kenya have installed on-site electricity plants and have integrated the plants to the national grid and become prosumers. The captive generation is mostly based on renewable energy technologies (RETs) such as solar photovoltaic (PV), hydropower, and biomass. In Kenya, most prosumers have adopted solar photovoltaic technology with over 144MW estimated to be installed. The electricity generated from this technology varies through the day depending on the available solar insolation. Similarly, demand varies depending on the consumer's needs at any given time. It is therefore challenging to precisely match generation with demand. Prosumers require the grid to meet generation shortfalls and also to dump any excess energy from their captive plants.

With roughly 4,136 commercial and industrial power consumers in Kenya as of June 2023, there is immense potential for the development of captive solar PV systems among these customers. This creates operational and financial risks for the distribution licensee or off-taker and the power sector in general. There is a need to review the pertinent policies and operation frameworks to address the emerging challenges which include the strain on the grid, reduced system robustness and reliability, and violation of operating limits due to the unregulated energy feed-in to the grid.

Proposed Contribution To Initiating Transformation

A study on the technical and financial impact of the distributed and captive energy in the grid is required to increase the uptake of renewables, reduce the cost of electricity, ensure the reduction of greenhouse gases, constant and uninterrupted supply of electricity to the consumer and provide grid parity. Further benefits from the data received would be in terms of the economic impacts such as job creation among the women, the youth, and people with disabilities (PWDs) in the renewable energy space, business opportunities through importation and sale of equipment, reduced operational maintenance costs, reduced technical losses and increased revenue through tax collection.

The study will investigate the technological impacts on the grid such as:

- Voltage variation and imbalance
- Current and voltage harmonics
- Grid islanding protection
- Stress on distribution transformers
- Effect of different penetration levels on the net system load

The study will also investigate the financial impacts such as:

- Cost deficit to the utility

- Business models available to the utility involving value proposition, customer interface, infrastructure and revenue model.
- Net metering and feed-in tariffs on the grid.

Implementation Readiness

Kenya has one of Africa's highest installed capacity or decentralised off-grid solar PV systems, illustrating the viability of off-grid renewable generation in the country at present. The Energy Act, of 2019, allows electricity end users to develop captive generation not exceeding 1 MW without the need for a licence from the Energy and Petroleum Regulatory Authority (EPRA). According to the 2019 baseline study on Captive Power Generation (CPG), Kenya has an estimated over 400MW of captive energy with an estimated 75% of the installed capacity being renewable mainly from solar, bio-energy, hydro and geothermal. The captive power industry has been necessitated by the electricity supply reliability, attractive tariffs, the existence of a legal framework, as well as the need to go green.

Uptake of distributed and captive energy has been predominantly utilised by Commercial and Industrial customers, however, domestic households have increased the installed capacity of captive power in the region. This has increased the use of alternative renewable sources and moving away from diesel which catered for 15% of their consumption. The influx of small-scale embedded generation units in Commercial, Industrial and domestic establishments showcases the country's maturing power sector and sets the foundation for further studies in the CPG industry. This step has assisted in the reduction of greenhouse gases and helped in meeting the NDC target of 32%.

Rationale For REI Financing

The size of distributed and captive energy in the country is significant enough to warrant recognition. The spike in the use of PV grid-tied solar systems, distributed and captive energy and its exponential growth has created the need for a study to look at the impact it has on the grid. Financing of this project will enable the government and utility to gain insight and data that will assist in the development of policy formulation and frameworks on captive energy and net metering. It will also support the uptake of renewables as the utility and consumers will have knowledge of how the distribution lines and transformers are loaded and increase reliability on the grid due to voltage and frequency control. This data will assist the utility operators in electricity planning, to better handle system disturbances and inherently create capacity building in the space of renewables. This study is instrumental in the achievement of grid parity and a just transition in the space of renewables in the country.

Results Indicators

The result indicators for the study on the technical and financial impact of distributed and captive energy to Kenya's power grid are:

- Draft report finalised
- Capacity building on the software and methodology used

- Stakeholder forums held, comments consolidated and incorporated into the final report
- Report reviewed, finalised and implemented.
- Financing plan, including financial instruments

Annex Table 12: Provisional Cost Impact of Distributed and Captive Energy Study

Component: Activity	**Item**	**Total Estimate cost (MUSD)**	**Source of Finance**			
			CIF	**WB &AFDB**	**IFC**	**Private sector and Other Partners**
STUDY ON THE TECHNICAL AND FINANCIAL IMPACT OF DISTRIBUTED AND CAPTIVE ENERGY TO KENYA'S POWER GRID	Draft Study Report (Consultancy)	101,044.12	101,044.12			
	Capacity Building Workshops	26,945.10	26,945.10			
	Stakeholder Forums	16,840.69	16,840.69			
	Final Study Report	13,472.55	13,472.55			
	Total	**158,302.46**	**158,302.46**			-

Annex Table 13: Implementation Plan for all components

	Proposed Initiative	**Sub Items**	**Proposed activity**	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**2028/2 9**
Component 1	Automatic Generation Control and Hydromet		IP Endorsement & Approval						
			Project preparation & documentation AGC & Hydromet						
			Disbursement						
			Execution: Installation Engineering & Configuration AGC & Hydromet						
			Testing and Commissioning						
	Battery Energy Storage Systems (BESS)		*IP Endorsement & Approval*						
			Project Preparation and Agreement						
			Disbursement						

			Execution																								
			Monitoring and Evaluation																								
	Static VAR Compensators (SVC)		*IP Endorsement & Approval*																								
			Project Preparation, Agreement and Disbursement																								
			Execution																								
			Monitoring and Evaluation																								
Component 2	Development of Smart Grid to Facilitate Integration of VREs		*IP Endorsement & Approval*																								
			Project Preparation: Feasibility study and documentation																								
			Disbursement																								
			Execution																								
			Monitoring and evaluation																								

	O&M TL and SS equipment strategic spares (mobile transformers, additional transformers and emergency restoration towers)	Mobile/Truck Mounted Transformers and Reactive Power Compensation devices	IP Endorsement & Approval
			Disbursement
			Execution
			Monitoring & Evaluation
		Power Transformers Spare/Additional Units	IP Endorsement & Approval
			Disbursement
			Implementation:
			Monitoring & Evaluation
		Emergency Restoration Towers	IP Endorsement & Approval
			Disbursement
			Execution
			Monitoring & Evaluation
	Automatic of Condition		IP Endorsement & Approval

	monitoring for Kenya`s Power Transmission System		*Project Preparation, Agreement and Disbursement*																								
			Execution																								
			Monitoring and Evaluation																								
Componen t 3	*Renewable Energy Centre Of Excellence Including Renewable Energy Technology Transfer /Incubation (Technology & Market Innovation), Menengai Geothermal Resource Park Project (Technology & Market Innovation), Supporting*		Approval																								
			Disbursement																								
			Implementation																								

	Demand Stimulation On Emerging Technologies In Kenya.		Monitoring & Evaluation																								
Component 4	*Regulations Finalisation In Support of Renewable Energy Integration And Climate Change Resilience In Kenya and Study on the Technical and Financial Impact of Distributed and Captive Energy Preparation Timelines*		Approval																								
			Disbursement																								
			Implementation																								

Annex III: MDBs Investment Concept Briefs

1. Enhancing Grid Reliability and Resilience – World Bank, AfDB and Private Sector

Problem Statement

Kenya is one the countries that has the potential to achieve universal access to electricity much ahead of 2030 as is targeted under the UN Sustainable Development Goal (SDG7) and 100 percent renewable energy by 2030 in line with the country's COP26 commitment. Kenya is already at the forefront in the use of renewable energy with around 90 percent of energy being generated from clean sources, thanks to its indigenous geothermal, hydro, wind and solar as well as import from Ethiopia. Kenya has more than quadrupled its geothermal capacity in the last 10 years from 198 MW in 2010 to 950 MW currently, placing the country 7th globally in terms of power generation from this renewable firm energy resource. The goal of 100 percent clean energy is possible through further development of indigenous geothermal resources, competitive auctions for intermittent renewable (solar and wind) resources, and energy trading through regional interconnections.

Kenya is now tapping into the cheaper and renewable hydropower resources of Ethiopia through the recently commissioned Ethiopia-Kenya Interconnector. This flagship interconnector supported by the World Bank (WB), African Development Bank (AfDB) and French Development Agency (AFD) has a transfer capacity of up to 2,000MW and will be a critical link for the Eastern Africa Power Pool (EAPP). However, the Kenya system will need to be strengthened significantly if the national and regional renewable energy including variable renewable energy resources are to be utilised properly to provide reliable, affordable and clean energy in Kenya and broadly in the EAPP countries. In addition to strengthening the grid, investments are needed in automation of network operations and maintenance (O&M) including strategic inventory of network materials for enhancing grid reliability and resilience. There is also a need to catalyse the transition to a fully green grid through setting of the appropriate policy and regulatory frameworks.

The need for grid reliability and flexibility arises from variable renewable energy that makes system operations challenging. The operational challenges include scheduling, system control and dispatch, reactive power supply and voltage control, regulation and frequency response reserve, energy imbalance service, and operating synchronised and supplemental reserve. The lack of a reliable national grid due to its limited reach, inadequate redundancy and capacity compounds this further. These challenges can be addressed with the installation of smart grids, reactive power compensation devices, mobile substations and emergency restoration towers.

At this point of its renewable energy development, Kenya needs to develop a Centre of Excellence and an incubation hub to further harness knowledge on renewable energy technologies. Such a centre will help in renewable energy knowledge transfer helping the region transitioning to clean energy technologies. Research and development work is also needed on productive use of electricity in areas such as e-mobility, e-cooking, and irrigation etc.

In recognition of the need to facilitate renewable energy integration, the energy sector in Kenya has identified several key enabling regulations that need to be developed. The required regulations are in the areas of system operations, tariffs and markets, net metering and quality of services.

Proposed Intervention

- Interventions aimed at increasing power system flexibility and security in a cost-effective manner by managing the variability and uncertainty to increase uptake and penetration of renewable energies. The intervention entails implementation of Automatic Generation Control (AGC), Hydromet Forecasting and Reactive Power Compensation devices.
- Battery Energy Storage System (BESS) through private sector financing will improve the Kenya grid system by reducing operational costs through peak power and energy arbitrage, spinning reserves synchronised to the grid, frequency response, reducing network congestion reduction, and renewable energy integration into the grid with reduction of geothermal steam venting.
- Development of enabling infrastructure is aimed at ensuring an adequate and reliable power grid necessary to support the evacuation and utilisation of generated renewable energy. This includes the development of smart grids, acquisition of mobile substations and automation of conditional monitoring of power systems.
- Technology and Market Innovation through development of centres of Excellence for renewable energy, productive use of geothermal steam and electrification of other sectors such as E-mobility, E-cooking, and irrigation programs.
- Facilitating Open Access for Renewables through the finalisation of draft Regulations in Support of Renewable Energy Integration and Climate Change Resilience in Kenya such as regulations on renewable energy resources, electricity market, bulk supply & open access, energy auction, updating feed-in-Tariffs for small hydro and biomass, and net metering, among others.

Implementation Readiness

A number of sector agencies will be involved in implementing various components. The Ministry of Energy and Petroleum (MOEP) and the Energy and Petroleum Regulatory Authority (EPRA) will be involved in implementing the sector technical assistance for development of the enabling regulations. Sector agencies- Kenya Electricity Transmission Company (KETRACO), Kenya Power (KPLC), Kenya Electricity Generation Company (KenGen) and Geothermal Development Company (GDC) will be implementing various investment components. Exact roles and responsibilities of the sector agencies will be discussed and agreed during project preparation. All these entities have extensive experience in implementing projects supported by various development partners including the World Bank. Appropriate implementation arrangements will be discussed and agreed during project preparation.

Rationale for REI Financing

The projects to be financed by Kenya's CIF-REI program will strengthen the grid system to allow for integration of variable renewable energy (VRE). Proposed interventions will be enhancing grid flexibility for integration of VRE, improved forecasting of VRE to allow for system readiness for greater integration of VRE, as well as research and development activities and studies for greater integration of VRE.

Annex Table 14: Results Indicators

Proposed Components	**Indicators**
Enhancing Grid Flexibility	Clean Energy dispatched (%) MW of reduction of geothermal steam venting
Enhancing Grid Reliability	VRE dispatched (%)
Technology and Market Innovation	Capacity building (Number) Direct Use projects commercialised (Number) Private sector funding mobilised (Amount)
Facilitating Open Access for Renewables by finalising Regulations	Number of new or amended policies and regulations that are related to RE integration
Gender	Percentage of Women Employed

Annex Table 15: Financing Plan

Components	CIF Funding (USD)	WB & AFDB	IFC	Private Sector	Total Estimated Cost (USD)
Enhancing Grid Flexibility	24,227,248	103,785,000			128,012,248
BESS	10,000,000		25,000,000	65,000,000	100,000,000
Enhancing grid reliability	16,316,250	25,383,750			41,700,000
Technology and market innovation	19,181,901	23,801,500			42,983,401
Facilitating Open Access for Renewables	274,600	0			274,600
Grand Total	**69,999,999**	**152,970,250**	**25,000,000**	**65,000,000**	**312,970,249**

Annex Table 16: Project Preparation and Estimated Implementation/ Disbursement timeframe

Item	2023	2024				2025				2026				2027			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

IP endorsement																		
WB project preparation																		
Official agreement																		
1st Disbursement																		
Execution																		

2. **Battery Energy Storage System – Solution to Integrating Renewable Energy Sources – IFC and Private Sector**

Problem Statement

Energy storage is a crucial tool for enabling the effective integration of RE and unlocking the benefits of local generation and a clean, resilient, dispatchable energy supply that can directly compete with fossil fuel-based generation. Storage solutions are needed most in developing countries, where power grids cannot take full advantage of intermittent solar and wind resources and a rapid increase in energy demand, especially during peak hours, needs to be urgently met. Energy storage such as battery solutions are capital intensive, and costs have risen recently due to increased demand and supply chain constraints, especially for equipment that follow best sourcing practices. As a result, deployment remains concentrated mainly in developed countries that benefit from the higher purchasing power of end-consumers and government subsidies.

Renewable energy coupled with energy storage has the potential to decarbonize power systems while providing reliable, dispatchable electricity. Energy storage, amongst other components of power system flexibility, is essential to achieving a high penetration of variable renewable energy such as solar PV and wind and displacing fossil-fuel generation. RE systems with energy storage can also replace expensive diesel generators in small-to-medium sized grids and industrial applications.

Battery storage technology has become an emerging asset class with a multitude of uses. Batteries are already critical for consumer electronics, such as mobile phones. As a performance track record is established and technology costs fall, batteries can also pave the way for the electrical vehicle market. This versatility makes them attractive. Affordable battery storage is the missing link between generating intermittent RE – for example, in a solar mini-grid – and delivering it to end-users when they need it. Battery energy storage systems (BESS) serve as generators when they release stored energy and can perform transmission/distribution functions and provide ancillary services. BESS is the most scalable type of grid-scale storage, and the market has seen strong growth in recent years.

Proposed Contribution to Initiating Transformation

The proposed project will focus on identifying opportunities for private sector participation and financing for options promoting clean energy innovation and advancing the adoption of BESS to demonstrate the viability and/or large-scale application of battery storage solutions. The successful execution and operation of the project will help BESS technology become cost-competitive, achieved in part by growing economies of scale in the manufacturing of energy storage units, technology improvements that reduce material needs, and cost decreases across the manufacturing value chain.

By utilising innovative de-risking structures that use blended concessional finance, REI funds will support private sector RE generation projects with storage configurations, which will be structured to address and overcome the barriers that inhibit market transformation. Additionally, the intervention is expected to increase attractiveness of project structures that involve RE + storage and generate positive demonstration effects across the East Africa region and Sub-Saharan Africa. This will help to incentivize private sector developers, increase competition, and help drive down the tariffs to levels competitive with those of thermal generation, enabling the global transition to sustainable energy and net zero emissions economies.

Implementation Readiness

Kenya's Least Cost Power Development Plan 2021-2030 (LCPDP) includes BESS in its demand forecast, which includes 250MW of BESS in the generation mix by 2026.[86] Private sector companies are currently considering Kenya as a market for BESS technology and are engaging MoE and Kenya Power, the national offtaker, to advance discussions.[87] IFC's engagement can support this developing pipeline in Kenya, with a view to finance projects that can establish a track record to help accelerate the deployment of energy storage technologies to decarbonize existing power systems.

Rationale for REI Financing

The significant upfront investment required for BESS is difficult to overcome without government support (including appropriate regulatory frameworks and competitive procurement) and/or low-cost financing. Concessional finance through the range of financial instruments available under REI can support the deployment of BESS in Kenya. It is widely acknowledged that the project cost gap between RE + storage and thermal generation remains significant. As a result, the need for concessional resources is pronounced and meaningful concessionality is needed to level the playing field.

In 2019, prices for fully installed four-hour utility-scale BESS ranged from $300 to $446/kWh, meaning that a 20 MW/80 MWh storage system would cost between USD 24 and 36 million.[88] Grid scale battery storage systems' costs have been declining over the years making them more competitive options. An ongoing BESS study in Kenya shows that the recommended 100MW one hour battery size would require about USD 41.4 million capex. Fixed costs for this BESS system would range between 74.3-87.0 US$/MW-year and the variable cost inclusive of charging and discharging cost is estimated at 35.6 US$/MWh. Battery storage prices are expected to continue declining over time due to several factors, including technology improvements, manufacturing and supply chain economies of scale, competition between manufacturers, greater product integration ahead of installation, and more overall industry expertise as illustrated in figure 4.

[86] US Department of Commerce (2021). Market Intelligence: Kenya Energy Storage System. https://www.trade.gov/market-intelligence/kenya-energy-storage-system

[87] Ibid.

[88] BNEF (2019). Energy Storage System Costs Survey 2019. https://about.bnef.com/blog/2h-2023-energy-storage-market-outlook/#:~:text=Global%20energy%20storage's%20record%20additions,times%20expected%202023%20gigawatt%20installations

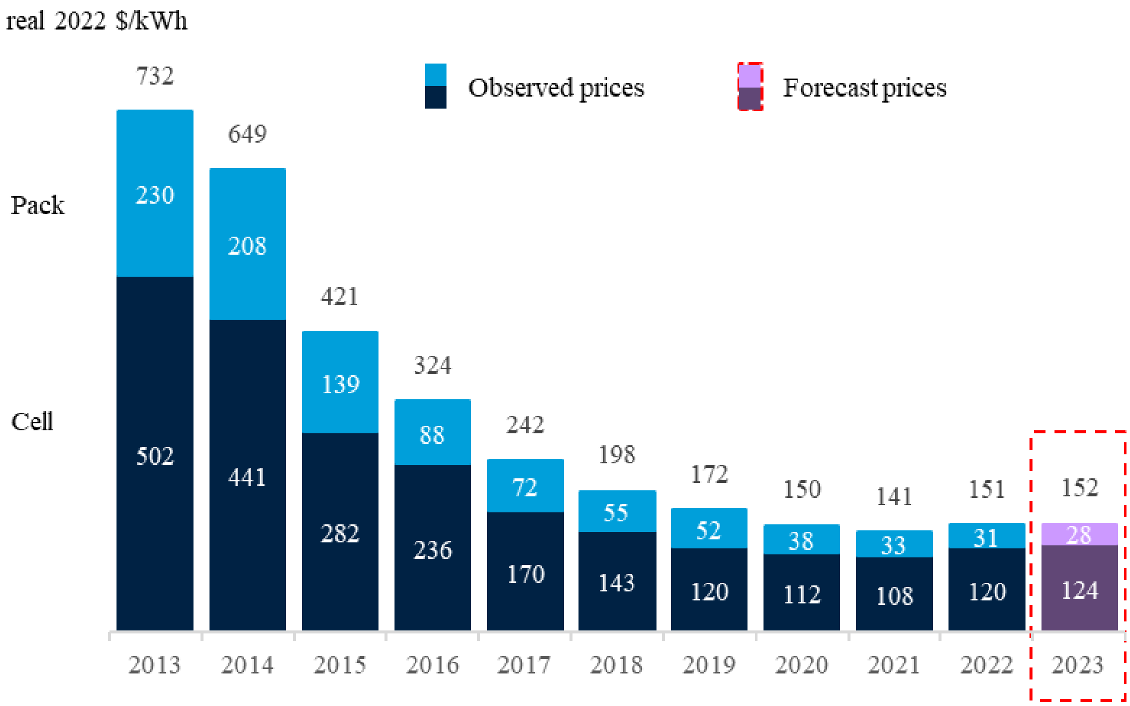

Figure 4: Near-term lithium-ion battery cell and pack price forecast

Source: BloombergNEF

Demonstrating the performance of energy storage technologies and systems in frontier markets without significant cost is a key barrier for grid-level BESS deployment at scale. Catalysing activity involving novel technology and a new operating environment entails higher risk that must be shared between the public, power sector actors, and/or developers. Sustained market engagement can be sensitive to poor early performance, though learning from early experience can help to recalibrate market expectations. Inadequate demonstration of performance in frontier markets – including Kenya – increases risks for safety, functionality, and profitability of BESS deployments and could hobble market development.

Results Indicators

The performance indicators outlined below will be tracked at least annually and will include:

Annex Table 17: Result Indicators

CIF-level Impacts	Indicators	Baseline	Targets
Catalyse Kenya's transformation to 100% Clean Energy by 2030	Clean Energy dispatch (%)	89%	100%
Number of beneficiaries	Annual Capacity building (No)	200	1,000
	Direct Use projects commercialised (No)	1	3
Incremental financing leveraged, USD million[89]	Volume of co-finance leveraged (USD)	0	CIF 70 MUSD public & Private funding 246.9 MUSD (ratios 1:3)

Financing Plan Estimate

Component	Financing Source (USD million)			
	REI	IFC	Private Sector	Total
Battery storage system	10	25	65	100

Project preparation timeline

The project is expected to be implemented over 36 months, including an initial 12-month period for project scoping and a 24-month period for PPP preparation and tendering. These are indicative timelines that will be refined as the project concept matures.

Annex Table 19: Project Preparation Timelines

Phase	2023		2024				2024				2027				2028			
	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
IP Endorsement		X																
Project Scoping			X	X	X	X												
Project Preparation							X	X	X	X	X	X	X	X				
1st Disbursement															X			

[89] This is based on the maximum CIF funding of 70 MUSD.

Phase	2023		2024				2024				2027				2028			
	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
Execution															X	X	X	X

Annex IV: Development Co-Benefits

The implementation of the IP will contribute to additional co-benefits to communities from the development of projects. The following co-benefits have been identified to be attributed to implementation of the program:

a) Future Skills and Job Creation through Renewable Energy Program

Access to clean and affordable energy is essential for sustainable development. Energy policies and programs play a critical role in meeting the energy needs of both men and women in households and for income generation through creation of employment. It is therefore expected that implementation of the components of this program including enhancing grid flexibility, reliability, demand creation and capacity building. The E-mobility program is expected to create new jobs including the EV charging infrastructure which will support local jobs.

b) Just Transition: Social Inclusion and Distributional Impacts

Capacity Building shall be key activities to be performed and provided in order to achieve this co-benefit from specific projects to be implemented. MoEP launched the Gender in Energy Policy in 2019 to promote gender considerations in energy planning, implementation and monitoring. The Ministry and Semi-Autonomous Government Agencies are already implementing the policy.

c) Reduction of Air Pollution and improved environmental quality.

Clean energy transitions focus on ending energy poverty, creating universal (decentralised) energy access, including clean cooking; accelerating renewable energy deployment; powering key industries and sectors for Africa's socio-economic transformation, and maximising energy efficiency.

d) Energy Access

Kenya has made good progress in electricity access; we have raised connectivity from below 30 % in 2013 to over 70% in 2021. In addition, Kenya has demonstrated that it is possible to achieve ambitious development goals while still remaining green. This program will therefore enhance affordable energy access (corresponding with the goals of SDG 7 on Affordable and Clean Energy), and enable economic development.

e) Additional Development Benefits

- Enhancing the participation of women in the energy sector and institutions (corresponding with furthering SDG 5 on Gender Equality.
- Reduced GHG emissions (corresponding with SDG 13 on Climate Action), including from transport (e-mobility), deforestation (e-cooking) and with Green Hydrogen, potentially in agriculture (green ammonia) and industry.
- With e-cooking, more time and opportunity for women to choose other economic activities (SDG 5 on Gender Equality) + reduced deforestation and enhanced biodiversity (corresponding with SDG 15, Life on Land)
- Health benefits through a cleaner environment (furthering the goals of SDG 3 on Good Health and Well-Being)
- Expanded carbon credit market associated with credible emission reductions (corresponding with the goals of SDG 13 on Climate Action)
- Affordable and clean electricity due to declining costs (corresponding to goals of SDG 7, Affordable & Clean Energy.
- Enhanced regional competitiveness through more affordable clean energy (corresponding to goals of SDG 7, Affordable & Clean Energy.
- Accelerated economic growth (corresponding with goals of SDG 8 on Decent Work & Economic Growth).
- Optimised use of energy resources e.g. hydro when using AGC.
- Employment creation (corresponding with goals of SDG 8 on Decent Work & Economic Growth).
- Conducive environment for green investments and use of renewable geothermal energy to substitute fossil fuels in industrial thermal applications (SDG 12, Responsible Consumption & Production).

Annex V: Stakeholder Consultations

Kenya´s CIF-REI Investment Plan was developed through a transparent, consultative, and participatory process under leadership of the Ministry of Energy and Petroleum to identify and prioritise interventions in which financing support mechanisms are required to accelerate the integration of RE. In addition to the two major public consultation meetings held in February 2023 and October 2023, the draft IP was also publicly disclosed for stakeholder information and comments on the websites of the MoEP and its key agencies for a period of two weeks between October 11th to 25th, 2023.

The first consultation took place during the MDB Joint Scoping Mission undertaken in February 2023, during which the MDBs presented the key features of the REI Program to all stakeholders. The program aimed to enhance the flexibility of energy systems for the smooth integration of higher-shares of VREs generation into the grid. The main areas of support included in this IP were identified and discussed based on these discussions. Participants of these discussions are listed in Annexe Table 20 and 22.

Annex Table 20: Participants First stakeholder Consultation

List of Mission Team Members		
	Name	**Organisation**
1.	Humphrey Ndwiga Richard	AFDB
2.	Leandro Azevedo	
3.	Kidanua Abera Gizaw	
4.	Neelam Patel	IFC
5.	Tendai Madenyika	
6.	Zanele Hlatshwayo	
7.	Rahim Virani	
8.	Zubair Sadeque	World Bank
9.	Laurencia Njagi	
10.	Juliet Pumpuni	
11.	Aalok Pandey	

12.	Grace Njeru	
13.	Beatrice Okiro	
Public Sector		
14.	Dennis Olila	**National Treasury**
15.	Eng Isaac Kiva	**MoEP**
16.	Eng. Mungai Kihara	
17.	Carl Otwack	
18.	James Metto	KENGEN
19.	Dr. Willis Ochieng	
20.	Edwin Gwaro Ototo	KETRACO
21.	Eng. Jared Othieno	GDC
22.	Eng. Paul Ngugi	
23.	Jackylyne Wakhungu	
24.	Caroline Tele	
25.	Daniel Kiptoo	EPRA
26.	Dr. John Mutua	
27.	Waweru Karanja	
Private Sector		
28.	Ajay Shah	Geothermal Exploration Limited
29.	Mugwe Manga	Olsuswa Energy
30.	Dr. Stephen Onacha	Akiira Geothermal Limited
31.	Guo Dong	SNG International

32.	VenuGopal Varanasi	Sosian Energy
33.	Tony Wanyama	Capital Power
34.	Charles Munywoki	Savannah Power
35.	Michael Karanja	Geothermal Association of Kenya
36.	Shama Sambili	Arus Energy
37.	John Omenge	SNG International
38.	Bruce Lyn	Energy China
39.	George Aluru	Electricity Sector Association of Kenya
40.	Khilna Dodhia	Kenergy
41.	Samuel Mwangi	Virunga Power
42.	Eugene Obiero	Serengeti
Development Partners		
43.	Mugwe Kiragu	EIB
44.	Anne Angwenyi	British High Commission
45.	Julie Trognon	French Embassy
46.	Jackson Mutonga	GIZ
47.	Daniel Ngundi	UNIDO
48.	Evanson Njenga	JICA
49.	Willian Madara	USAID
50.	Matthew Ecoffer	French Embassy
51.	Bernadette Medefo Tabeko	IFC
52.	Rahim Virani	IFC

53.	Jeff Murage	KfW

The second stakeholder consultation forum took place on 3rd October 2023 where the draft-final version of the IP was presented to the stakeholders, a record of the participants is detailed in Table22.

The stakeholders engagement was presided over by the Principal Secretary, State Department of Energy, Ministry of Energy and Petroleum and representatives from Development Partners including the World Bank, AfDB, IFC, EIB among other key stakeholders in the Energy Sector.

The summary of stakeholders' comments and feedback received during the engagement session is tabulated in the matrix below:

Annex Table 21: Summary of Stakeholders' Comments and Feedback

No	Focus Area	Comment/Concerns/Suggestions	Response
1	Battery storage and pumped hydro storage	Consideration of Pumped hydro and green hydrogen apart from the Battery Storage.	Battery storage studies are ongoing, and development is largely private led. However, one of our interventions include development of 150MW (1 hour) battery storage. In addition, WB is currently supporting KenGen for development of a 100MW (1 hour) battery. Pumped Storage is also being considered in the long term, while studies are ongoing for Green Hydrogen.
2	Open access	The process needs to be comprehensive so that the whole sector grows and should not affect predictability e.g. the existing PPAs.	Regulatory Impact Assessment for electricity market, bulk supply and open access regulations, renewable energy resources regulations, Feed-in Tariff for biomass and small hydro regulations and net- metering regulations is required to be done in order to create an enabling environment for renewables in the whole sector.
3	Enhancing grid flexibility	Objectively prioritise the transmission lines and hasten the process of completion of ongoing lines e.g. Narok -Bomet for increased reliability	Prioritising completion of transmission lines and specific substations is very important for purposes of grid strengthening and reliability. Completion of these infrastructure projects are key in facilitating flexibility.

No	Focus Area	Comment/Concerns/Suggestions	Response
6	Geothermal steam supply	There is need to integrate the benefits to the local communities around the resource area	The IP will highlight and reflect the benefits brought by the implementation of the components. It will also highlight social benefits such as youth and women empowerment through training and job creation.
7	Human resource capacity	There is need to map out the capacity skills requirement in the sector	With the increased VREs into the grid, the sector will continually map out new skills that will be necessary to keep up with the energy standards and ensure human and technical capacities are at par with best practices for implementation of the projects.
8	LCPDP	What is the status of the LCPDP and how is it linked to the IP.	The IP is only complementary and is not a replacement to the activities planned in the LCPDP. The investment plan will focus on the integration of variable renewable energy in the grid by enhancing grid stability and flexibility.
9	Initiatives to support the private sector investment	There is a need for lead times for regulations and policies to be reduced for faster implementation of projects.	There are regulations that are currently being developed that will facilitate private sector participation and there is a need to fast track the finalisation of the regulations.
10	Micro-scale Bioenergy Consideration in the IP	There is a need for consideration of the micro-scale business opportunities in bioenergy and promotion of their growth.	Section 3.2.5 was enhanced to include opportunities for investment in the micro-scale bioenergy initiatives based on Kenya's Bioenergy Strategy.
11	Enhancing Grid Flexibility	Proposal to incorporate Ancillary Services market in Kenya, Implementation of the Time of Use tariff (TOUT), establishment of several Energy Storage Systems such as BESS (Battery Energy Storage Systems), PSP (Pumped Storage Plants), Green Hydrogen and consideration of emerging Power-to-X-Technologies such as EVs (Electric Vehicles), Green	The comments have been addressed in the IP including in section 4.4 on facilitating open access for renewables, section 4.1.2 on BESS, Section 4.2.1 on Smart Grid which enables implementation of Time of Use Tariff and section 4.3 on Technology and Market Innovation.

No	Focus Area	Comment/Concerns/Suggestions	Response
		Hydrogen, Green Ammonia, Hydrogen Vehicles.	

Annex Table 22: List of Participants to the Stakeholders Engagement

List of Participants to the Stakeholders Engagement Held at Sarova Panafric Hotel, Nairobi on Tuesday 3rd October 2023		
S/No	NAME	ORGANIZATION
1.	Alex K. Wachira	MOEP - State Department for Energy (SDE)
2.	Eng. Thomas Karungu	MOEP - SDE
3.	Bernard Osawa	Frontier Energy/ESAK
4.	Girma Mekuria	AfDB
5.	Neelam Patel	IFC
6.	Zubair Sadeque	World Bank
7.	Humphrey Ndwiga Richard	AfDB
8.	Nicholas Kiminda	KPLC
9.	Adrian Mwai	Hewani Energy
10.	Kiragu Mugwe	EIB
11.	John Mutua	EPRA
12.	Lasse Toft	Danish Embassy
13.	Janice Angengo	MOEP - SDE
14.	Gloria N. Wekesa	MOEP - SDE
15.	Peter Kirena	MOEP - SDE
16.	Doris Moturi	MOEP - SDE
17.	Jilloh Hezekiah Jita	MOEP - SDE

List of Participants to the Stakeholders Engagement Held at Sarova Panafric Hotel, Nairobi on Tuesday 3rd October 2023		
18.	Mwangi Charles	MOEP - SDE
19.	Eng. Okere O. Makokha	Engineers Board of Kenya
20.	Julie Trognon	French Embassy
21.	Naibei Lawrence	MOEP - SDE
22.	Joseph Kitilit	GDC
23.	Shammah Kiptanui	GDC
24.	Linet Luvai	UNIDO
25.	Willy Kiptoo	MoEP - SDE
26.	Erastus Kiruja	KPLC
27.	Kajuju Kageenu	Ofgen
28.	Kevin Kagwe	MOEP - SDE
29.	Wahu Kigano	MOEP - SDE
30.	Scholastic Nafula	MOEP - SDE
31.	William Kaigwara	MOEP - SDE
32.	Davide Danielle	EU Delegation
33.	Aalok Pandey	World Bank
34.	Laurencia Njagi	World Bank
35.	Karan Capoor	Climate Finance Adviser
36.	Jane Willen Lohre	EIB
37.	Grace Njeru	World Bank
38.	Jukka Stroud	World Bank
39.	Anderson Ngowa	World Resources Institute
40.	David Oloo	EIB
41.	Mary Githinji	World Resources Institute
42.	Benson Ireri	World Resources Institute

List of Participants to the Stakeholders Engagement Held at Sarova Panafric Hotel, Nairobi on Tuesday 3rd October 2023		
43.	Richard Charagu	Yok Consulting Co.
44.	Trognon Julie	French Embassy
45.	James Metto	KenGen
46.	Kevin Kasyoka	KETRACO
47.	Lucy Musau	MOEP - SDE
48.	Yukabeth Ndege	MOEP - SDE
49.	James Kiteme	MOEP - SDE
50.	Caroline Tele	GDC
51.	Fredrick Ochieng	USAID
52.	Willy Kiptoo	MOEP - SDE
53.	Miriam Ochola	MOEP - SDE
54.	Dorothy Murithi	GDC
55.	Dr. Willis Ochieng	KenGen
56.	Sam Karanja	KenGen
57.	Edwin Gwaro Ototo	KETRACO
58.	Peter Maneno	MOEP - SDE
59.	Jackline Kimeli	MOEP - SDE
60.	Phyllis Gathoni Mathenge	GDC
61.	Ann Wanjau	MOEP - SDE
62.	Matthew Arrumm	Bowmans
63.	Eng. Ephantus Kamweru	REREC
64.	Eng. Jonathan Rono	EPRA
65.	Eng. Fred Ishugah	REREC
66.	Carl Otwack	MOEP - SDE
67.	Richard Mavisi	MOEP – SDE

List of Participants to the Stakeholders Engagement Held at Sarova Panafric Hotel, Nairobi on Tuesday 3rd October 2023		
68.	Charles Njoroge	KETRACO
69	Jack Nduri	KETRACO

Annex VI: Review of the Investment Plan

1. Title of the investment plan: **Renewable Energy Integration Program for Kenya**

2. Program under the GCAP: **CIF Renewable Energy Integration Program**

3. Name of the reviewer: **Stratos Tavoulareas**

4. Date of submission: **November 14, 2023**

Overall Assessment: The proposed program supports both the short-term and long-term climate goals of Kenya by increasing the capacity and resilience of the power grid; hence, increasing the potential integration of more renewables, which is the focus of the CIF/REI program. Kenya's goal to achieve net-zero GHG emissions from the power sector by 2030 and net zero economy-wide by 2050 are in line with international goals and the country's commitments under the Paris Agreement.

The IP complies with the general and REI-specific criteria and the proposed activities are consistent with the decarbonization of Kenya's power sector. A number of recommendations are made and questions raised to improve the clarity of the IP, as well as the design and implementation of the program.

	Questions/Comments	Answers/Comments
General criteria	The IP complies with the general criteria of CIF and the principles, objectives, and criteria of REI Program. The capacity of the country and the implementing agencies are adequate to implement the proposed programs; the World Bank, African Development Bank (AfDB) and IFC are all very active in Kenya and the key power sector organizations have worked with them to implement projects and programs of similar size and complexity. Most of the proposed components of the program have been developed based on engineering studies and specific policies and initiatives of the country. Successful implementation of the IP is transformative because it is going to enhance the capacity of the grid to increase the renewable generation and achieve the net zero strategy of the country. On the hardware side, batteries, advanced electronics, smart grid and grid-	

	strengthening will improve the capacity of the power grid to accommodate more renewables. On the soft side, policy support, training and technical assistance will strengthen the capacity of the country to achieve its climate goals. The proposed program includes components of high priority; certainly, the grid strengthening scope is urgent and will have immediate positive results on the reliability and quality of power supply. Adequate stakeholder consultation has been done, even though it would have been desirable to see at least some effort to reach out to public organizations (e.g., relevant communities, industry associations and non-governmental organizations). The IP investments reflect additional funding requirements on top of on-going and planned funding from MDBs. Adequate justification is provided in the IP regarding their additionality. Institutional arrangements and coordination are appropriate, as the implementing agencies are already recipients of loans from the MDBs and have relevant experience. The MDBs are very active in Kenya and have established working relations with the key Ministries, the State-owned Enterprises and the Government in general. There is no information on cost-effectiveness of the proposed investment, but the investments are part of the country's power development plan, which should be considered as the "least cost" scenario. Furthermore, batteries and reactive power compensators are deemed essential for the reliable and safe operation of the power grid. Similarly, grid enhancements under Component 2 are very important. MDB procurement requirements ensure that the installed assets will be selected through competitive bidding which should result in the lowest cost.	Several industry associations and NGOs were invited to the consultations, and some attended the final consultation meeting. Additional consultations will be conducted during project preparation by the respective MDBs. Kenya's REI will support the establishment of a competitive process to procure BESS and/or hybrid investments, with full specification of requirements, including choice of technology, supply of battery along with electro-mechanical and civil works contractor(s), warranties, and long-

		term service agreements. Public procurement will apply whether the projects are developed by the private sector or through KenGen which will tender for EPC. All CIF-financed procurements will be supervised according to MDB guidelines as agreed in the respective project agreements.
Compliance with the investment criteria or business model of the REI	The proposed IP involves the addition of energy storage (batteries), reactive power compensators, smart grid components, etc., which strengthen the power grid and increase its capacity to absorb more renewables. The country is clearly committed to the Paris Agreement, as reflected in the Nationally Determined Contributions (Government of Kenya, 2023) aiming to reduce GHG emissions through the deployment of renewables and transformation of several sectors of the economy (e.g. transport, household cooking, agriculture, industry). The specific goals are reflected in official documents, policies and strategies including: • Decarbonization of the power sector by 2030. • Greenhouse Gas (GHG) Emission reduction by 32% by 2030 relative to the Business as Usual (BAU) scenario of 143 MtCO2eq, as reflected in Kenya's updated Nationally Determined Contribution (NDC, 2020) • 100% access to clean cooking by 2028 • Goal of Net Zero by 2050. • Kenya's Least Cost Power Development Plan (LCPDP) 2022-2041 • The National Adaptation Plan (NAP 2015-2030 • The National Climate Change Action Plan (NCCAP) 2023 – 2027	

	The proposed IP focuses clearly on renewable integration; the addition of energy storage, reactive power compensators and smart grid components increase the flexibility of the power grid and will ensure that more renewables can be integrated. The IP mobilizes $243 million from World Bank, AfDB, IFC and private investors, compared to $70 million requested from CIF-REI, a 3.5 to 1 leverage. Furthermore, the improved flexibility and resilience of the power grid, should enable more investments on renewables (especially from the private sector), which will improve the leverage ratio further. While the country seems to be clearly committed to decarbonization and increased deployment of renewables, the proposed plan includes further support for policies and institutions (Components 3 and 4). The implementing agencies have well-proven capacity to implement the proposed project. This capacity is demonstrated by the history of prior and on-going projects with MDBs. Gender aspects have been considered adequately. The proposed program is ready for implementation as supported by studies which have been completed already. For example: There is clear need for the batteries. Also, KETRACO completed a Technical Study on the Requirement of Reactive Power Compensation Devices and Voltage Support for Kenya's Grid (2022).	
Recommendations	While the overall assessment of the IP is positive, a number of recommendations are made to strengthen further the program and increase the likelihood for success: • In addition to the proposed activities, a **comprehensive assessment is recommended which will evaluate all the options for using the excess geothermal and wind energy during periods of low demand**. In addition to the options mentioned in the proposed IP, **thermal storage should be evaluated too**.	Agree. A battery storage technical assessment (pre-feasibility study) is currently on- going with Bank support. The preliminary results of the study have established that the primary use of the first set of battery storage will be for load-shifting (charging batteries with excess energy during off-peak to discharge during peak period) thus

	Also, **pumped storage (PSP)** should be evaluated for the whole power system of Kenya; it is a key option and may prove to be the most cost-effective. It is acknowledged that a study is going on led by the Ministry of Energy and Petroleum. It is likely that both battery storage and PSP would be needed, and PSP may be a lower cost option. But batteries would be needed for fast response. • Furthermore, it is not clear whether **imports from Ethiopia** can increase considering that the transmission interconnection already exists and its underutilized.	replacing thermal generation to meet peak demand. Subsequent comprehensive assessments will be carried out by the Kenya energy sector on other new technological options such as thermal storage. A feasibility study by KenGen on PSP is on-going. Given that current hydro capacity is already fully utilized, additional hydro capacity will need to be developed with the PSP option, PSPs may ultimately be a lower cost option, but have a long lead time of up to a decade or more to be prepared and constructed. In this context, batteries would be needed for fast response. In the long-term, both PSP and battery storage will be needed in the Kenya system. The Kenya – Ethiopia interconnector has a capacity for 2,000 MW. Kenya has a PPA for up to 400 MW which may be amended on need taking into consideration the demand from power trading in the EAPP Power market. The additional capacity is to allow for trans-border wheeling of power within the region. The Ethiopia-Kenya interconnector has sufficient capacity, but the constraints in the Kenya system do not allow

		additional import from Ethiopia beyond the current ~160MW.
	• Finally, it would be wise to have and present a clear strategy regarding the percentage of the demand which will be covered by the **power grid** and what is more practical and cost-effective to be covered by **off-grid/mini-grid** applications.	A National Electrification Strategy was developed in 2018 and supported by the WB. It identified the least cost options for electrification that included grid, mini-grid, and stand-alone solar systems. An update of the strategy is currently being planned. Off grid capacity is currently at 1.4% of the total installed capacity. Off-grid areas are addressed through other initiatives like World Bank-financed KOSAP project and supported in the Kenya National Electrification Strategy
Additional comments and questions	• Integrated Results Framework Table (page 5); also, Table 5 in page 88: change the "public & Private funding" from 241.9 MUSD to 242.97 MUSD • Page 7: The assessment of direct use applications for geothermal energy is a good idea. But it is not clear if these applications will be supported only by "low enthalpy" steam or by geothermal power wells which may have excess steam at times of low electricity demand. This should be clarified. Also, special attention should be paid to the energy demand patterns of industrial and commercial users, as these need to be matched with the capacity to produce the required geothermal energy.	Thank you. This has been updated in the IP. Page 7 has been amended to reflect that the direct use is limited to low enthalpy steam. Direct use applications for geothermal energy under consideration implies the use of "low enthalpy" geothermal fluids and possible uses of residual or waste heat from

	• In the same page the following is mentioned: "Since the costs of producing steam are normally passed through to the off-taker via provisions for capacity charges in geothermal gas supply agreements and Power Purchase Agreements (PPAs)". Fully agree, but the off-taker will generate no revenue and would need to deal with this.	geothermal power plants. Industrial customers have the opportunity to utilise time-of-use tariff to ramp up the load at off-peak. The increase in geothermal capacity is based on projected demand growth under the LCPDP. When steam is vented, the overall unit cost for geothermal goes up. The off-taker loses since capacity charges are on a take-or pay basis. Thus, avoiding venting is useful for the off-taker and also to consumers, since tariffs are set based on revenue requirements. The off-taker has provisions for revenue generation through the tariff review and approval process.
	• In page 10, distributed generation is mentioned, but it is not clear whether this is part of the proposed scope or not. Please clarify.	Distributed generation is not proposed to be supported directly, but system enhancements (smart metering etc) will be supported to facilitate distributed generation.
	• Table 4/page 114: Please clarify the unit cost of the batteries ($/kW or $/KWh), as well as the storage duration (4 hrs storage?). Also, how is the private investor going to be compensated? Through a PPA? Is it a fixed payment ($/month) or variable?	Battery storage technical assessment study assumed a cost of $395/kWh for 1 hr storage. The mode of compensation for the battery services will be informed by the ongoing studies

	• Table 9/page 130: The first item is a feasibility study. What about the following four items (Energy supply infrastructure; Cement manufacturing; Paper processing; and Aquaculture)? Are these studies too or investments in hardware?	such as the BESS Options study and Ancillary Services study. WB support through Kenya GREEN MPA (Phase 2) which is currently under preparation will support the first set of battery storage investments upto 200MWh, with the exact capacity dependent on the study findings. This support will also include developing appropriate regulatory frameworks, Including compensation for ancillary services that will allow for battery storage to be implemented by the private sector. The proposed budget will go towards the technical support for a feasibility study for the geothermal resource park and the establishment of energy supply infrastructure required for the commercialisation of Direct Use projects including - cement manufacturing, paper processing, and aquaculture firms – with the goal of attracting additional private sector investments.

The Climate Investment Funds

The Climate Investment Funds (CIF) were established in 2008 to mobilize resources and trigger investments for low carbon, climate resilient development in select middle and low income countries. To date, 14 contributor countries have pledged funds to CIF that have been channeled for mitigation and adaptation interventions at an unprecedented scale in 72 recipient countries. The CIF is the largest active climate finance mechanism in the world.

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