EMBU COUNTY ENERGY PLAN (CEP)

(2025 - 2035)

EMBU COUNTY ENERGY PLAN 2025-2035

Vision

A prosperous County with Equal Opportunities for all

Mission

To ensure effective resource mobilization and optimization for Wealth and Job Creation


Nginda Ward
Kyeni north Ward
Ruguru-Ngandori Ward
Gaturi north Ward
Kyeni south Ward
Gaturi south Ward
Evurore Ward
Kaagari South Ward
Kirimari Ward
Kithimu Ward
Mbeti north Ward
Nthawa Ward
Muminji Ward
Mbeti south Ward
Kiambere Ward
Mavuria Ward
Mwea Ward
Makima Ward

FOREWORD

It is with great pride and a deep sense of responsibility that I present the Embu County Energy Plan, a landmark blueprint that charts our course towards a secure, inclusive, and sustainable energy future.

Energy is the backbone of our county's social and economic transformation. It powers our homes, schools, health facilities, industries, and the livelihoods of our people. Yet, the challenge of ensuring reliable, affordable, and clean energy for all remains urgent. This plan represents our collective commitment to addressing that challenge with vision, innovation, and determination.

The development of the Embu County Energy Plan has been guided by the principles of inclusivity, resilience, and sustainability. It draws upon extensive consultations with communities, private sector players, development partners, and government agencies. It identifies our energy needs, opportunities, and priorities—ranging from enhancing electricity access and promoting renewable energy, to improving energy efficiency and supporting climate-smart development.

This plan aligns with Kenya's national energy policy frameworks and the global Sustainable Development Goals (SDGs), particularly SDG 7 on affordable and clean energy. It also supports our county's aspirations under the Embu County Integrated Development Plan (CIDP) and the Bottom-Up Economic Transformation Agenda.

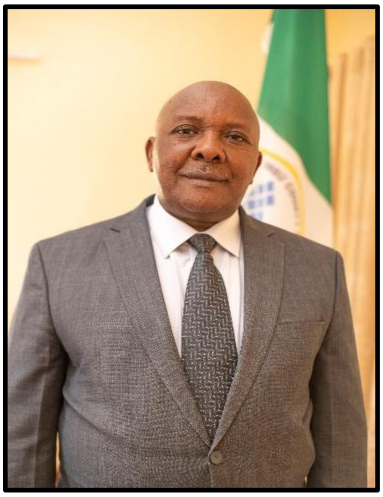
I extend my sincere appreciation to all stakeholders whose dedication, expertise, and collaboration made this plan possible. The journey ahead will require sustained partnerships, strategic investments, and bold leadership to translate these ideas into tangible results.

As we implement this plan, I call upon all residents of Embu, investors, and partners to join us in harnessing our abundant resources, innovation, and human potential to build an energy-secure and climate-resilient future for our county.

Together, we will light up Embu—powering prosperity for every household, business, and community.

H.E. Cecily Mbarire EGH Governor, Embu County

PREFACE



It is with great satisfaction that I present the Embu County Energy Plan, a framework that sets out our strategies for delivering reliable, affordable, and sustainable energy to all residents of our county.

Energy is at the heart of economic transformation. It fuels our agriculture, powers our industries, enables quality healthcare and education, and drives innovation across every sector. The preparation of this plan marks a significant milestone in our journey towards universal access to modern energy services, guided by the principles of equity, sustainability, and resilience.

The Embu County Energy Plan is the result of an extensive, collaborative process. We engaged communities, private sector actors, civil society organizations, and development partners to ensure that the priorities identified reflect both our local realities and global best practices. This plan addresses key areas including renewable energy development, grid and off-grid electrification, energy efficiency, clean cooking, and the enabling policies and investments required to achieve our goals.

In implementing this plan, we will not only enhance energy access but also unlock new opportunities for job creation, economic diversification, and climate change mitigation. This plan is aligned with the Embu County Integrated Development Plan (CIDP), Kenya's Energy Act 2019, and the Sustainable Development Goals, particularly SDG 7 on affordable and clean energy.

I wish to express my gratitude to all stakeholders who contributed their expertise and insights during the planning process. Your commitment has shaped a practical, forward-looking document that will guide our energy sector for years to come.

As the custodians of this vision, my department and I are committed to working with all partners to translate the priorities in this plan into tangible results that improve the lives of our people and strengthen the resilience of our county.

Hon. Elijah Njeru Mugo

County Executive Committee Member – Roads, Transport, Energy and Public Works

ACKNOWLEDGEMENT

The preparation of the Embu County Energy Plan (CEP) has been a collaborative exercise between the County Government of Embu, through the Department of Roads, Transport, Energy and Public Works, and its development partners.

The County Government extends its profound gratitude to Her Excellency Governor Cecily Mbarire, EGH, for her visionary leadership and unwavering support in championing sustainable energy initiatives in Embu County. We also acknowledge the guidance of Hon. Elijah Njeru Mugo, County Executive Committee Member (CECM) for Roads, Energy and Public Works, whose stewardship has been pivotal in steering this process. Special recognition is also accorded to Mr. Nicasio Mwangangi Mbiti, Director of Energy, for his dedicated coordination and technical leadership throughout the preparation of this Plan.

We gratefully acknowledge the contribution of development partners, namely GIZ Kenya under the leadership of Ms. Mariam Karanja, Practical Action (PA) under the leadership of Mr. George Theuri, and SNV, whose financial support and expert guidance were instrumental in the development of this Plan.

We further recognize the valuable input provided by directors from the various county departments who availed and consolidated critical data that formed the basis of this document. Appreciation is also extended to the numerous stakeholders, including community members, who provided information through surveys and needs assessments.

The County Government also acknowledges the support and guidance of the Ministry of Energy and Petroleum (MoEP) and the Energy and Petroleum Regulatory Authority (EPRA) in strengthening county energy planning processes. In addition, we recognize the technical advice and data provided by the Kenya Power and Lighting Company (KPLC), the Rural Electrification and Renewable Energy Corporation (REREC), and the Kenya Forest Service (KFS).

We equally appreciate the role of civil society organisations and private sector stakeholders who actively participated as members of the County Energy Planning Technical Committee.

Finally, we wish to formally acknowledge the consulting team from Cusum Energy, led by Eng. Godfrey Marambe and comprising Mr. Isaac Kerina, Mr. George Komen, Ms. Anceita Jepleting, Mr. Benson Weisiko, Mr. Brian Momanyi, and Mr. Emmanuel Kazungu, whose commitment and professionalism in facilitating workshops, guiding community participation, conducting modelling, and drafting the Plan were central to its successful completion.

EXECUTIVE SUMMARY

Energy is a key enabler of social and economic transformation in Embu County. Reliable, affordable, clean, and sustainable energy access underpins the county's ambitions in agriculture, health, education, manufacturing, and services. This Energy Plan provides a ten-year roadmap (2025–2035) for scaling up access to modern energy while ensuring environmental stewardship and resilience against climate change.

Current Status

- **Electricity Access:** Grid electricity coverage in Embu County is above 57% (rural ~32%, urban ~71%), with ongoing last-mile connections through the national electrification program. However, supply reliability and affordability remain major concerns, especially in rural areas.
- **Cooking Energy:** Over 70% of rural households rely primarily on biomass (firewood and charcoal), often using inefficient three-stone fires. Urban households are shifting toward LPG (55%) and electricity (10%), but traditional charcoal stoves remain in use. Adoption of improved and clean cooking technologies such as biogas, ethanol, and pellets is still limited.
- **Renewable Energy Resources:** Embu has untapped potential in solar, mini-hydro, and biomass (coffee husks, macadamia shells, farm residues). The county also has opportunities to pilot e-mobility and productive use of energy in agriculture, particularly for irrigation, drying, and cold storage.

Key Challenges

- **Heavy reliance on traditional biomass** (firewood and charcoal), leading to deforestation, land degradation, and indoor air pollution.
- **Affordability barriers** for modern cooking solutions (LPG, ethanol, electric cookers, pellets), especially in rural low-income households.
- **Grid reliability issues**, with frequent outages affecting businesses, institutions, and households.
- **Limited awareness and market development** for alternatives such as biogas, ethanol, and pellet stoves.
- **Weak supply chains** for clean fuels (LPG, ethanol, pellets) outside Embu town and major trading centers.

Strategic Goals (2025–2035)

1. **Universal Clean Cooking Access:** Transition households from traditional biomass toward improved firewood stoves, LPG, electricity, biogas, and emerging alternatives like pellets and ethanol. Target: at least 80% of households using clean cooking by 2035.
2. **Reliable and Affordable Electricity:** Strengthen grid reliability and expand decentralized solutions (mini-grids, solar home systems) to cover remaining unelectrified households.
3. **Renewable Energy Development:** Promote solar PV for households, institutions, and productive use; develop mini-hydro potential in riverine areas; and harness agricultural residues for biomass energy.

4. **Sustainable Biomass Management:** Support community forestry programs, promote efficient charcoal production, and regulate woodfuel harvesting to ensure sustainable supply.
5. **Institutional Energy Access:** Ensure all schools, health centers, and public facilities adopt clean, reliable cooking and electricity solutions.
6. **Climate Change Mitigation:** Align with Kenya's NDC commitments by reducing greenhouse gas emissions through clean cooking, renewable electricity, and energy efficiency.

Priority Interventions

- Scale up **LPG distribution networks** across rural wards with incentives for last-mile agents.
- Promote **improved cookstoves** (firewood ICS and charcoal ICS) as a transitional step toward cleaner options.
- Introduce **electric cooking pilots** in urban and peri-urban areas where the grid is reliable.
- Expand **biogas programs** in livestock-rich households and institutions.
- Pilot **pellet distribution chains** in Embu town and Runyenjes to test market viability.
- Support **ethanol cooking solutions** in urban centers aligned with the KOKO fuel distribution model.
- Improve **grid reliability**, and expand connectivity by working with Kenya Power and promote solar photovoltaic systems for off-grid locations.
- Leverage **agro-processing residues** (coffee husks, macadamia shells) for bioenergy in local industries.

Expected Outcomes

- **Household energy transition**: By 2035, over 80% of households will cook with clean fuels and technologies.
- **Improved health**: Reduction in household air pollution, lowering respiratory illness burden especially among women and children.
- **Environmental benefits**: Slowed deforestation and reduced greenhouse gas emissions.
- **Economic empowerment**: Lower energy costs, increased productivity in agriculture, and growth of local energy enterprises.
- **Resilient institutions**: Schools, health facilities, and government offices reliably powered with clean energy.

This Plan provides a framework for coordinated action by county government, national agencies, private investors, development partners, and communities. By pursuing the pathways outlined, Embu can achieve universal access to clean cooking and electricity, stimulate green economic growth, and contribute to Kenya's energy transition and climate goals.

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LIST OF ACRONYMS, ABBREVIATIONS & SYMBOLS

CADP	County Annual Development Plans
CBOs	Community Based Organizations
CCCAP	County Climate Change Action Plan
CECM	County Executive Committee Member
CEP	County Energy Plan
CEREB	Central Region Economic Bloc
CFA	Community Forest Association
CHP	Combined Heat and Power
CIDP	County Integrated Development Plan
COG	Council of Governors
CoK	Constitution of Kenya
CPA	Charcoal Producer Associations
DNI	Direct Normal Irradiation
ECDE	Early Childhood Development and Education
EE&C	Energy Efficiency and Conservation
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
ESCOs	Energy Service Company(ies)
FAO	Food Agriculture of the United Nations
FGDs	Focus Group Discussions
GESI	Gender Equity and Social Inclusion
GHI	Global Horizontal Irradiation
GJ	Giga Joules
GVA	National Value Added
HVAC	Heating, Ventilation, and Air Conditioning
IE ()	International Energy (Efficiency Class)

INEP	Integrated National Energy Plan
KFS	Kenya Forest Service
KFS	Kenya Forest Service (KFS)
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KNBS	Kenya National Bureau of Statistics
KTDA	Kenya Tea Development Agency
kWh	Kilo Watt-hour
LED	Light Emitting Diode
LH ()	Lower Highland ()
LPG	Liquefied Petroleum Gas
MT	Metric Tonnes
NEMA	National Environment Management Authority (NEMA)
NEMP	National Energy Master Plan
OnSSET	Open-Source Spatial Electrification Tool
OnStove	Open-Source Spatial Tool for Cooking Energy Planning.
PV	Photovoltaic
SDGs	Sustainable Development Goals
SE4All	Sustainable Energy for All
TWG	Technical Working Group
UM ()	Upper Midlands ()
VTC	Vocational Training Centres

DEFINITION OF TECHNICAL TERMS

Term	Definition
Access to Electricity	The proportion of households or institutions connected to grid or off-grid electricity systems.
Access to Clean Cooking	The proportion of households using modern cooking fuels or technologies such as LPG, biogas, electricity, ethanol, or improved biomass stoves.
Alternative Energy	Energy sources other than the conventional grid or fossil fuels, including solar, wind, hydro and biogas.
Baseline Study	Initial assessment used to determine current energy access, demand, supply, and challenges.
Bioenergy	Renewable energy produced from organic materials including biomass, biogas, and biofuels.
Biogas	A mixture of methane and carbon dioxide produced through anaerobic digestion of organic waste.
Biomass	Organic material used as fuel, such as firewood, charcoal, agricultural residues, or animal waste.
Carbon Footprint	Total greenhouse gases emitted directly or indirectly from activities, expressed in CO_2-equivalent.
Clean Energy	Energy sources with low greenhouse gas emissions, such as solar, wind, hydro, and geothermal.
Climate Change	Long-term shifts in temperature and weather patterns due to natural processes and human activities.
Climate Resilience	The ability of systems or communities to anticipate, recover from, and adapt to climate-related risks.
Demand Forecasting	Estimating future energy demand based on population, economic growth, and consumption trends.
Demand-Side Management (DSM)	Actions taken to influence electricity consumption patterns to improve efficiency and reliability.
Distributed Energy Resources (DER)	Small-scale, decentralized energy generation or storage units close to users.
Distribution Network	Infrastructure used to deliver electricity from substations to consumers.
Electrification Plan	A structured approach to achieving universal electricity access in a defined area.
Energy Access	The availability and affordability of modern energy services including cooking, lighting, and productive uses.
Energy Audit	A systematic assessment of energy use to identify opportunities for efficiency improvements.
Energy Efficiency	Using less energy to perform the same function through improved technologies and practices.
Energy Mix	The composition of different energy sources supplying a region.
Energy Poverty	Lack of access to sufficient, reliable, affordable, and clean energy services.

Term	Definition
Energy Transition	Shift from traditional fuels to clean and sustainable energy systems.
Fossil Fuels	Non-renewable fuels including coal, diesel, petrol, and natural gas.
Geospatial Planning	Use of mapping tools to guide decisions on electrification, renewable energy, and infrastructure.
Green Mini-Grid	A renewable-based mini-grid supplying electricity to households or enterprises.
Greenhouse Gases (GHGs)	Gases such as CO_2, CH_4, and N_2O that trap heat in the atmosphere.
Grid Extension	Expansion of the national electricity grid into unserved areas.
Grid Reliability	The ability of the power system to provide continuous and stable electricity supply.
Hydro Power	Electricity generated from the energy of flowing water.
Independent Power Producer (IPP)	A private entity that generates electricity for sale to the national grid or consumers.
Kilowatt (kW)	A unit of power equal to 1,000 watts.
Kilowatt-hour (kWh)	A unit of energy representing one kilowatt of power used for one hour.
Least-Cost Electrification	Approach that identifies the most economical way to provide electricity access.
Load Profile	A chart showing variation in electricity use over time.
Mini-Grid	A localised electricity network that can operate with or without the national grid.
Off-Grid System	Electricity system not connected to the national grid, such as solar home systems.
Productive Use of Energy (PUE)	Use of energy for income-generating or value-addition activities such as milling or irrigation.
Renewable Energy	Energy from natural sources that are continually replenished such as solar and wind.
Rooftop Solar PV	Photovoltaic system installed on building roofs to generate electricity.
Solar Irrigation	Use of solar-powered pumps to lift and distribute water for agriculture.
Solar Home System (SHS)	Stand-alone solar system used for lighting and small appliances.
Stand-Alone System	Independent, off-grid power system typically powered by solar PV and batteries.
Thermal Energy	Energy used for heating, cooking, or industrial processes.
Universal Energy Access	Condition where all residents have affordable, reliable, modern energy services.
Utility	A licensed entity responsible for electricity transmission or distribution (e.g., KPLC, REREC).
Vulnerable Group	Households or individuals facing barriers to energy access, such as low-income or remote communities.
Waste-to-Energy	Conversion of solid waste into usable energy through combustion, gasification, or anaerobic digestion.

1 INTRODUCTION

1.1 BACKGROUND

1.1.1 RATIONALE FOR COUNTY ENERGY PLANNING

Energy is a critical enabler of social and economic development. In Kenya, access to reliable, affordable, and sustainable energy underpins progress in key sectors such as health, education, manufacturing, agriculture, and trade. Recognizing the central role of energy in achieving national development goals, the Constitution of Kenya (2010) and the Energy Act (2019) assign counties an important mandate in energy planning and development.

County energy planning provides a framework for identifying local energy needs, resources, and opportunities while aligning them with national policies, including the Kenya National Energy Policy, the Kenya Vision 2030, and the National Energy Master Plan. This ensures that energy interventions are context-specific, demand-driven, and supportive of county development priorities as outlined in the County Integrated Development Plan (CIDP).

Kenya's counties face diverse energy challenges and opportunities, from disparities in electricity access and reliance on traditional biomass to untapped potential in renewable energy sources such as solar, wind, hydro, and biomass. Without a structured plan, these opportunities may remain underutilized, and energy deficits could continue to hinder social and economic transformation.

The county energy planning process also fosters inclusivity by engaging communities, the private sector, and other stakeholders in identifying solutions that reflect local realities. This participatory approach not only enhances the relevance of the plan but also builds local ownership, increasing the likelihood of successful implementation.

Furthermore, county energy plans are critical for attracting investment. By presenting clear priorities, data-backed analysis, and actionable strategies, they provide a roadmap that development partners, financers, and private investors can use to align their interventions.

Ultimately, county energy planning is essential for advancing the objectives of Kenya's Sustainable Energy for All (SE4All) Action Agenda, accelerating progress toward universal energy access, increasing the share of renewable energy, and improving energy efficiency, thereby driving inclusive growth and environmental sustainability.

1.1.2 HISTORY OF ENERGY PLANNING

County energy planning in Kenya is a relatively recent but important development in the country's governance and energy management framework. Its evolution is closely tied to the constitutional and legislative reforms that introduced devolution and redefined the roles of national and county governments.

The **Constitution of Kenya (2010)** established a two-tier system of government, devolving certain functions to the counties to promote equitable development and improve service delivery. Among the functions devolved to counties was county-level energy planning, with specific responsibilities for implementation, regulation, and promotion of renewable and alternative energy systems, as outlined in **Part 2 of the Fourth Schedule**.

The need for structured county energy planning became more pronounced with the enactment of the **Energy Act (2019)**. This law formally requires each county to prepare a **County Energy Plan (CEP)**, providing a comprehensive framework for assessing local energy demand and supply, identifying resource potential, and guiding investment in the sector. The Act also linked county energy planning to the **National Energy Master Plan (NEMP)**, ensuring consistency and alignment with national priorities.

In 2019, the Ministry of Energy, in collaboration with the **Council of Governors (CoG)**, development partners, and technical institutions, initiated the development of guidelines and a standardized methodology for county energy planning.

The first wave of county energy plans began emerging between 2020 and 2023, with several counties piloting the process under support from development agencies such as the World Bank, GIZ, SNV, Practical Action, and UNDP. These early plans provided valuable lessons in data collection, stakeholder engagement, and integration of renewable energy opportunities.

Today, county energy planning is increasingly recognized as a critical instrument for achieving Kenya's **Sustainable Energy for All (SE4All)** goals, fostering investment, and delivering context-specific energy solutions. It is also central to climate action, as counties integrate energy access planning with clean energy transitions, resilient buildings, and environmental sustainability.

1.1.3 OPPORTUNITIES IN COUNTY ENERGY PLANNING

County energy planning presents a strategic opportunity to transform the energy landscape in Kenya by enabling counties to leverage their unique resources, address local needs, and align with broader national and global development goals. The key opportunities include:

1. **Tailored, Context-Specific Solutions:** County energy planning allows for the design of energy interventions that reflect the county's specific socio-economic realities, resource endowment, and development priorities. This ensures that investments are targeted, efficient, and impactful.
2. **Promotion of Renewable Energy Development:** Many counties have abundant renewable energy potential—such as solar, wind, small hydro, geothermal, and biomass—that remains untapped. County energy plans provide the framework to identify, prioritize, and promote these resources for both on-grid and off-grid solutions.
3. **Improved Energy Access and Equity:** By mapping underserved areas and identifying the most cost-effective access pathways, counties can expand energy services to marginalized areas, reducing inequalities and supporting inclusive development.
4. **Catalyst for Investment and Partnerships:** County energy plans serve as investment roadmaps for development partners, financiers, and private sector actors, creating a conducive environment for funding and innovation in energy projects.
5. **Integration with Climate Action and Resilience Building:** County energy planning offers a platform to align energy development with climate change mitigation and

adaptation measures, supporting Kenya's commitments under the Paris Agreement and enhancing local resilience.

6. **Job Creation and Economic Growth:** Expanding renewable energy infrastructure and services creates opportunities for local employment, enterprise development, and value addition, particularly for youth and women entrepreneurs in the energy sector.
7. **Strengthening Governance and Policy Implementation:** The process of developing and implementing a county energy plan strengthens institutional capacity, fosters interdepartmental coordination, and promotes evidence-based decision-making in the energy sector.
8. **Alignment with National and Global Goals:** County energy planning contributes directly to the achievement of Kenya's Vision 2030, the National Energy Policy, SE4All Action Agenda, and the Sustainable Development Goals (SDGs), particularly SDG 7 on affordable and clean energy.

Harnessing these opportunities requires sustained political will, inclusive stakeholder engagement, and effective resource mobilization. By seizing them, counties can position themselves as leaders in driving Kenya's energy transition and sustainable development agenda.

1.2 PROCESS OF DEVELOPING COUNTY ENERGY PLANNING (CEP)

1.2.1 COMMITTEE CONSTITUTION

The development of the Embu County Energy Plan commenced with the formal establishment of the County Energy Planning Committee, in line with the provisions of the Integrated National Energy Planning (INEP) Framework of 2021. Its establishment marked the foundational step in operationalizing structured and inclusive energy planning at the county level.

The County Government of Embu developed this CEP, with technical assistance from Cusum Energy Limited. A Technical Working Group (TWG) was established to carry out specific roles as stipulated in the INEP Regulations. This sub-committee, chaired by the County Director responsible for energy, was tasked with facilitating the formulation of the energy plan through coordination, stakeholder engagement, and technical analysis. The formation of these institutional structures underscore Embu County's commitment to evidence-based, participatory, and sustainable energy planning in alignment with national guidelines. The detailed composition of both the CEP and the TWG is provided in Annex 10.1 of this report (Table 10-1).

1.2.2 INCEPTION MEETING AND CAPACITY BUILDING

As part of the initiation process for developing the Embu CEP, an inception meeting was held on 1st and 2nd April 2025 at Nokras Silver Oak Hotel in Embu. This two-day workshop served as the official launch of the energy planning process and brought together key stakeholders including representatives from Cusum Energy Limited, various county departments, and the Technical Working Group. The primary objective of the inception meeting was to formally introduce all stakeholders to the goals, structure, and expectations of the county energy planning process. During the workshop, the Cusum Energy team, serving as the technical assistance partner, presented an overview of their role and clarified the kind of support they would be providing throughout the development of the plan.

In addition to setting the stage for collaboration, the meeting also served as an important capacity-building session. Stakeholders were trained on a range of topics to ensure a shared understanding of energy planning principles and tools. Key areas of focus included:

- Understanding fundamental concepts in the energy sector, such as renewable energy and energy efficiency
- Overview of Kenya's energy ecosystem, including national policy frameworks and key institutions
- Promoting inter-departmental collaboration, enabling coordinated energy planning across county ministries
- Introduction to planning tools and methodologies to be used in the development of Embu County energy plan

- Climate change and renewable energy, with a specific focus on technologies like solar home systems and improved cookstoves
- Communication strategies for community-level advocacy on energy transition
- Understanding carbon credits and their potential application in supporting energy transition efforts within Embu County.

The inception meeting played a critical role in aligning the diverse group of stakeholders, setting a common understanding of the vision and process, and building the technical foundation necessary for the development of a robust and inclusive CEP.

Figure 1-1Embu CEP Inception Workshop

1.2.3 STAKEHOLDER MAPPING

Stakeholder mapping was conducted during the inception workshop to identify key actors from within and outside the county government whose data, expertise, or participation would be critical to the planning process. Relevant stakeholders were systematically identified across sectors such as energy, environment, finance, agriculture, health, and education, as well as from private sector, civil society, and development partners.

In addition to informing data collection and analysis, the stakeholder mapping exercise aimed to foster stronger collaboration between departments within the County Government of Embu and with external stakeholders. This collaborative approach enhanced coordination, promoted data sharing, and built sustained support for future county energy planning initiatives.

1.2.4 DATA COLLECTION AND STAKEHOLDER ENGAGEMENT

Data collection for the Embu CEP began with an extensive literature review of key county and national documents. These included, but were not limited to, the CIDPs, County Annual Development Plans, the County Statistical Abstract, reports from the Kenya National Bureau of Statistics (KNBS), relevant national and county Acts, policies, regulations, and prior studies and research reports. This secondary data review helped establish a contextual baseline and identify existing information gaps.

1.2.5 BASELINE SURVEY

To complement the desk review, primary data was collected through 913 surveys targeting key population segments. These included households (350), schools (157), businesses (189), agricultural farms (152), and healthcare facilities (65). The surveys were based on representative samples to ensure comprehensive coverage across the county.

Table 1-1: Baseline Survey Population Segment

Population Segment	No.
Households	350
Businesses	189
Schools	157
Agricultural Farms	152
Healthcare Facilities	65
Total	913

In addition to surveys, 13 focus group discussions (FGDs) were held with diverse stakeholder groups including women in energy, matatu and bodaboda operators, small business owners, youth groups, community-based organizations (CBOs), farmers, health workers, and teachers. These discussions were strategically distributed across all six sub-counties to promote inclusivity and representation, and to capture the community's perspectives and aspirations regarding energy access and use. As part of the productive use assessment, key informant interviews were conducted with Chief Officers and Directors from various county departments to gain deeper insights into institutional energy needs and priorities. This was further supported by site visits to major local industries including Kenya Tea Development Agency (KTDA) and Macadamia factories, dairy cooperatives, and coffee milling facilities, allowing for direct observation and evaluation of current energy use and potential areas for intervention.

1.2.6 DATA VALIDATION

A data validation workshop was held on 10th July 2025 with the technical team and relevant stakeholders to review and verify the data collected during the primary data collection phase. The objective of the workshop was to interrogate the completeness, accuracy, and relevance of the data to ensure its reliability before proceeding to the analysis stage.

1.2.7 LEAST COST ELECTRIFICATION & CLEAN COOKING MODELLING

Building on the findings from the data collection phase, energy demand and supply scenarios for Embu County were developed using the Open-Source Spatial Electrification Tool (OnSSET) and Open-Source Spatial Tool for Cooking Energy Planning (OnStove). This cost-optimization tool was used to model various electrification pathways, helping to identify the most cost-effective technological solutions for expanding electricity access, especially in currently underserved areas. In parallel, clean cooking scenarios were also analysed using OnStove, considering fuel options such as firewood, charcoal, biogas, and LPG. The modelling exercise provided a data-driven foundation for identifying sustainable and locally appropriate energy transition strategies for the county.

1.2.8 PRIORITIZING ENERGY INTERVENTIONS

Following the activities undertaken, key energy access challenges were identified and prioritised based on sectoral needs and the guiding principles of the INEP Framework. The resulting priority areas include clean cooking, electricity access, waste-to-energy initiatives, and energy efficiency and conservation. To address the identified gaps, constraints, and opportunities, a suite of targeted interventions was formulated. These have been structured into programmatic, policy, and regulatory measures, aligned with the county's development agenda and aimed at fostering sustainable and inclusive energy access.

1.2.9 GENDER EQUITY AND SOCIAL INCLUSION (GESI)

GESI considerations were mainstreamed throughout the development of the Embu County Energy Plan to ensure the process was inclusive and responsive to the needs of all population groups. During data collection, disaggregated data by gender, age, and socio-economic status was gathered to better understand the distinct energy access challenges faced by women, youth, persons with disabilities, and other marginalized groups.

In addition, focus group discussions were specifically held with women groups, youth organizations, and informal sector representatives to capture diverse perspectives and lived experiences. The planning team also ensured that both men and women were represented in stakeholder engagements, technical working groups, and validation meetings. These efforts helped shape interventions that are equitable, inclusive, and sensitive to the social dynamics that influence energy access and use in the county.

1.2.10 CEP DRAFTING

The CEP was drafted in alignment with the structure and guidelines provided by the INEP Regulations 2025, ensuring consistency with national energy planning standards and best practices.

1.2.11 DRAFT CEP VALIDATION

On 1st September 2025, a stakeholder validation meeting was held at IFAD Hall in Embu County to present and validate the results and proposed solutions contained in the draft County Energy Plan (CEP). This engagement brought together members of the County Energy Planning Committee, county government officials, community representatives who had participated in the data collection process, and development partners involved in county energy planning.

The workshop provided a platform for collaborative dialogue, where participants offered valuable feedback that informed the refinement of the CEP and supported the production of its first complete draft.

1.3 INTEGRATION OF CEP INTO CIDP

The development of the Embu CEP was closely aligned with the county's broader planning agenda, particularly the CIDPs for 2018–2022 and 2023–2027. Several initiatives proposed in 2018-2022 CIDP, including hybrid/solar-powered boreholes, power generators using renewable sources, biogas digesters, and mini hydro stations, remained unimplemented. Despite the progress of streetlight and floodlight installation in various markets, the project was shortfall. Only 60 out of the proposed 250 streetlights and floodlights were installed, and none were solar powered as it was proposed in 2018-2022 CIDP. Factors contributing to these shortfalls as highlighted in 2023-2027 Embu CIDP include: late and inadequate disbursements of funds, limited funding, pending bills, local revenue collection, human resource challenges, inadequate physical resources, emerging issues, shortfall in local revenue.

This CEP seeks to address these gaps by offering a more structured, data-driven, and actionable roadmap for achieving energy access goals. It reinforces existing CIDP commitments while introducing clearer programmatic and regulatory pathways, more robust stakeholder coordination mechanisms, and alignment with national frameworks like Kenya Vision 2030 and the Sustainable Development Goals (SDGs). As such, the CEP not only complements the CIDP but also enhances its feasibility by identifying priority interventions, potential financing models including public-private partnerships (PPPs) and more realistic implementation timelines to support sustainable energy development in Embu County.

1.4 COUNTY OVERVIEW & ENERGY PROFILE

1.4.1. LOCATION AND SIZE

Embu County is situated between latitude 0^0 10' and 0^0 55' South and longitude 37^0 15' and 37^0 55' East. It borders Kirinyaga County to the west, Kitui County to the east, Machakos County to the south, Muranga County to the southwest, Tharaka Nithi County to the north, and Meru to the northwest[1]. The County covers a total area of 2,818 km^2. Its location is as shown below.

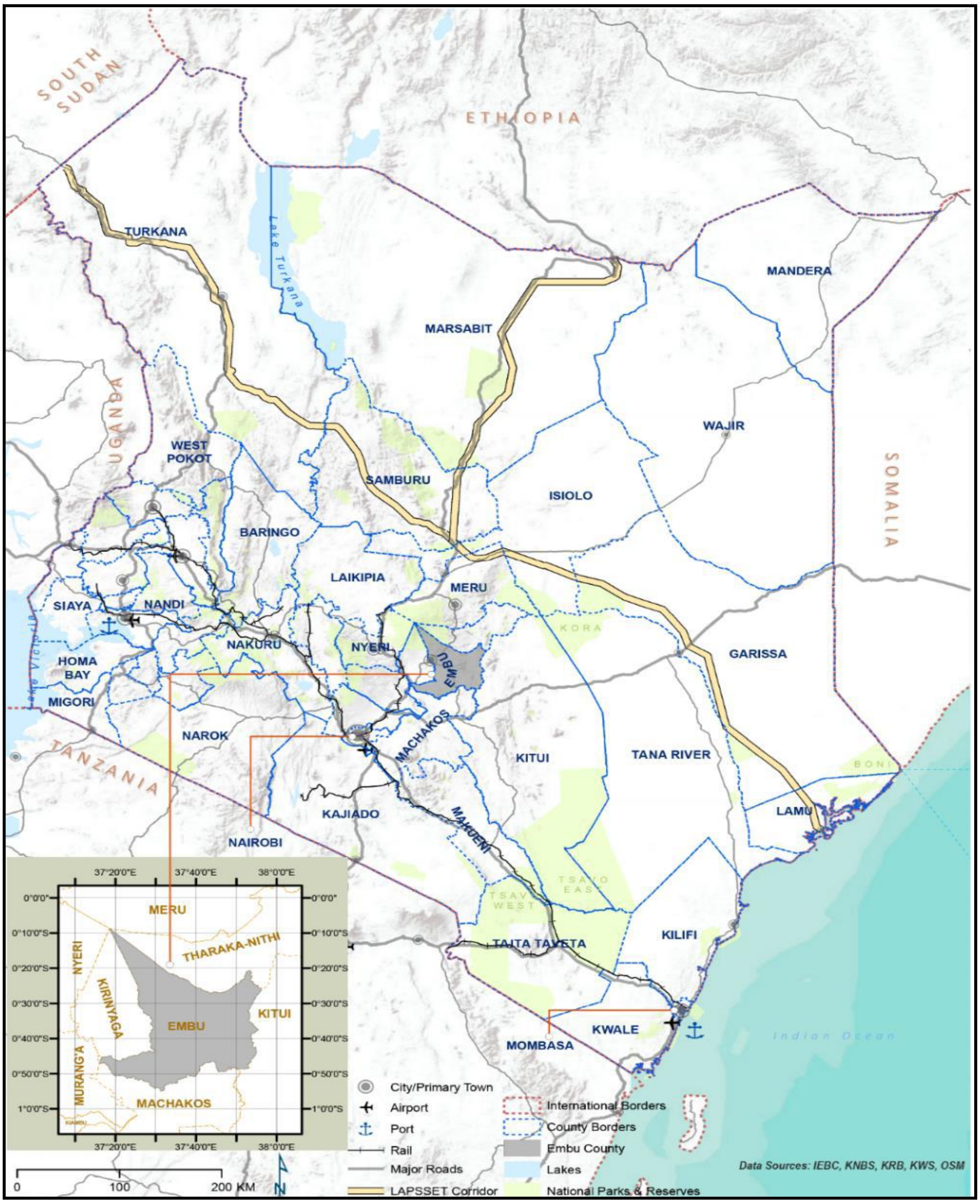

Figure 1-2: Location of Embu County in Kenya

[1] County Integrated Development Plan 2023- 2027.

1.4.2. DEMOGRAPHIC FEATURES

According to 2019 census, Embu County had a total population of 608,599 with a population density of 245 people/km[2]. These figures are projected to have risen to approximately 661,667 and 252 people/km[2] in 2025, as per the CIDP 2023-2027[1]. Also, the 2019 Census reported that the County's gender diversity was 50% male and 50% female. The County had 182,743 households with an average household size of 3.3 people[2]. About 87.5% of the County's population live in rural areas, with the remainder living in urban areas such as Embu Town, Runyenjes, Manyatta, Kiritiri and Siakago[2]. The County population is projected to rise by 11% from 608,599 in 2019 to 673,843 by 2027[1]. Population density is highest in Embu West (875/km²) and lowest in Mwea (131/km²), informing both grid and off-grid energy planning.

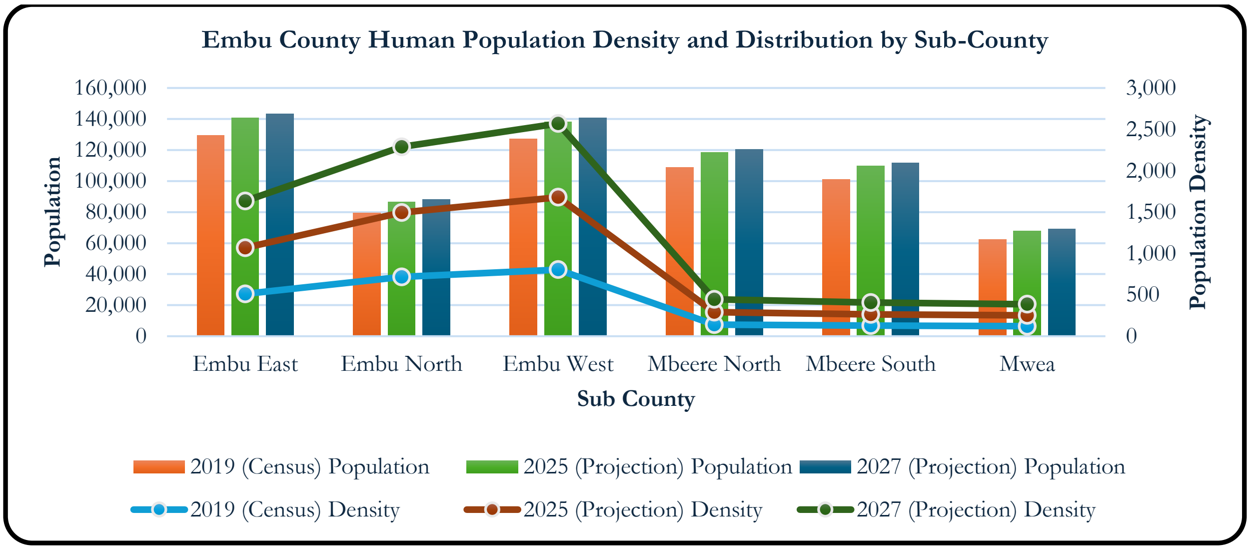

Figure 1-3: Population density and distribution by Sub-County

Source: CIDP 2023-2027

The Human Development Index (HDI) measures development through health, education, and income, making it a useful tool for guiding equitable energy planning. ***Table 1-2*** shows HDI values for the county and national levels to support targeted interventions.

Table 1-2: Human Development Indicators in Embu County

Indicator	County Values	National Values	
		Male	Female
Human Development Index	0.661	0.592	0.557
Life Expectancy at birth	66.5	58.9	64.1
Expected years of schooling	11.0	11.1	10.3
Mean years of schooling	6.5	7.3	6.1
Estimated gross income per capita	4,234	5,084	3,873

Source: CIDP 2023-2027

[2] Green-finance-assessment-of-Embu-County.pdf.

1.4.3. COUNTY ECONOMY

Embu County is part of the Central Region Economic Bloc (CEREB), which includes ten counties: Embu, Kiambu, Kirinyaga, Laikipia, Meru, Murang'a, Nakuru, Nyandarua, Nyeri, and Tharaka-Nithi[3]. The County contributes on average 1.6% of the National Gross Value Added (GVA) with an average GVA of KES113,2488 million[4]. The GVA per capita for is Ksh. 186,088 with an average population growth rate of 1.4% and overall poverty rate of 28.7%[5]. The average GVA growth rate was 2.57% from 2013-2022, with the highest rate of 10.65 per cent in 2016 and the lowest in 2014, as shown in the figure below.

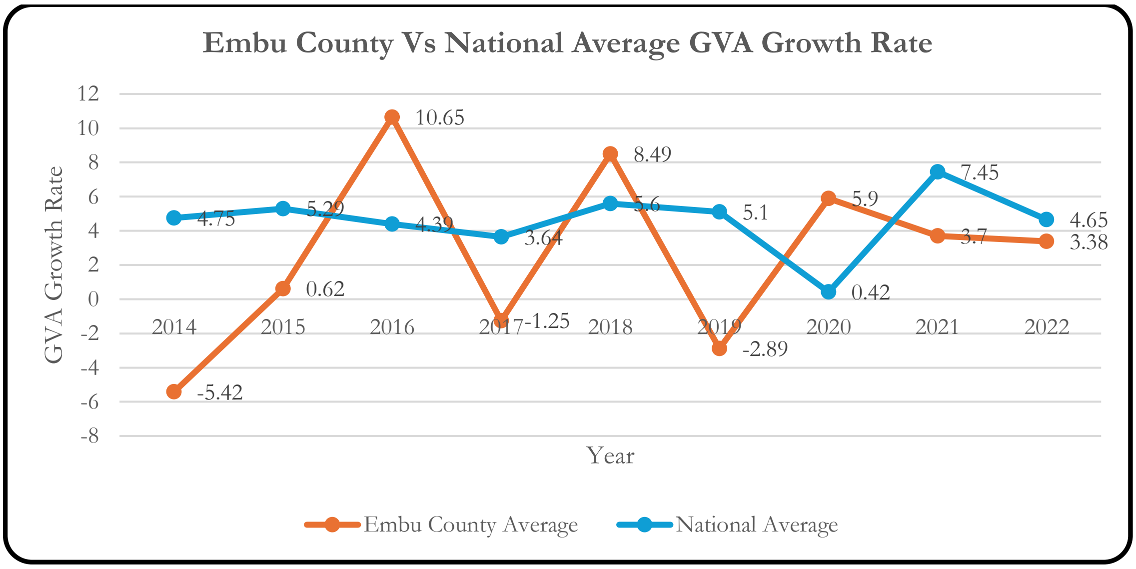

Figure 1-4: Embu GVA growth rate (Source: KNBS 2023- Gross County Product)

The Service sector is dominant with an average contribution to GVA of 48.29%. The industry sector is second, contributing an average of 26.72% to the GVA while the agriculture sector is third contributing 25.21%[4] as shown in ***Figure 1-5*** . The services sector is primarily driven by transport and storage services, which form the dominant activities within this category. The industry sector in the region is largely dominated by electricity supply, primarily due to the presence of the Seven Forks Dam, which contributes a significant share of the country's hydropower generation[3].

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[3] PROPOSED ANNUAL DEVELOPMENT PLAN 2025-2026 | County Assembly of Embu." Accessed: Apr. 09, 2025. Available: https://embuassembly.go.ke/mdocs-posts/proposed-annual-development-plan-2025-2026/

[4] C. Naeku and E. Irungu, "Assessing Labour Productivity for Embu County," no. 37.

[5] KNBS 2024-Gross-County-Product.pdf. Accessed: Apr. 09, 2025. [Online]. Available: https://www.knbs.or.ke/wp-content/uploads/2025/01/2024-Gross-County-Product.pdf

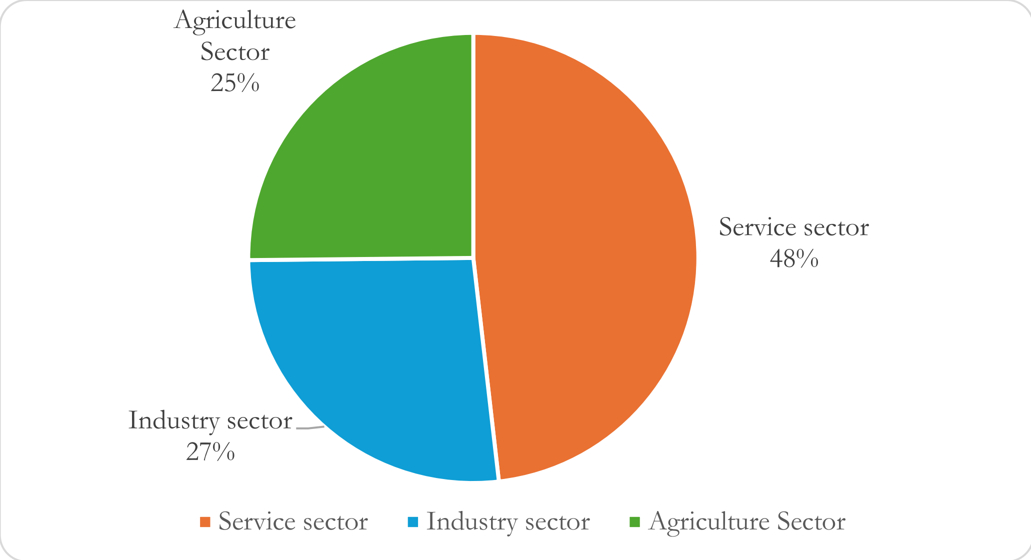


Figure 1-5: Economic Sectors' Contribution to Embu GVA

The county's inhabitants primarily rely on agriculture for their livelihood, with around 70% of the population generating income from crop production and livestock rearing[1]. Agriculture sector is the highest employer at 71.61% followed by the services sector at 21.90%, while the industry sector employs only 6.49% of the working population. Livestock production in Embu County is on a smaller scale compared to crop production. The most common types of livestock in the county are beef cattle and meat goats, while poultry production is predominantly composed of indigenous chicken. The main commercial crops are coffee, tea, macadamia, khat (miraa) and cotton, while the main food crop is maize[4].

Embu County is experiencing a high rate of literacy, with 86.1% of the population having gone to school[4]. According to 2019 report[6], the County has 606 ECDE centres, 519 primary schools, 212 secondary schools and 26 Vocational Training Centres (VTCs). The county also has 218 health facilities spread across the 4 constituencies. Manyatta constituency has 84 health facilities, Mbeere North has 33, Mbeere South has 62, and Runyenjes has 18[7].

As per the KNBS Poverty Report of 2022[8], the average national food and non-food expenditure per month per adult equivalent was KSh. 8,030 up from KSh. 7,393 in year 2021. Food share in total consumption accounted for 59.1%. Monthly food expenditure per adult in Embu County was KSh.4,038, which was slightly higher than the average national value of 3,936. Table 1-3 shows the socio-economic indicators that affect the quality of labour in Embu County.

[6] Embu-County-Kenya-County-Fact-Sheets-3rd-Edition-by-CRA.pdf
[7] "Health Facilities in Embu County. – Labflow Kenya." Accessed: Apr. 14, 2025. [Online]. Available: https://labflow.org/health-facilities-in-embu-county/
[8] The-Kenya-Poverty-Report-2022.pdf. Accessed: Apr. 09, 2025. [Online]. Available: https://knbs.or.ke/wp-content/uploads/2024/10/The-Kenya-Poverty-Report-2022.pdf

Table 1-3: Human Capital indicators in Embu County

Human Capital Indicators	Embu County	National
	86.10	78.41
Pre-primary net enrolment rate (2019)	77.56	67.51
Primary school net enrolment rate (2020)	87.10	77.72
Secondary School net enrolment rate (2020)	75.90	54.18
Average years of schooling	8.5	7.78
Percentage of children 12-23 months fully vaccinated (2022)	85.50	74.97
Percentage of stunted children (2022)	19.90	19.75
Percentage of teenage pregnancy (2022)	14.40	15.79
Primary to secondary transition rates	90.00	86.13
Pupil teacher ratio (primary school)	23.00	28.28
Food poverty head count (%)	22.50	33.63
Child poverty head count (%)	28.60	42.67

Sources: KNBS -Kenya Poverty Report 2022[9]; KIPPRA Policy Briefs

1.4.4. CLIMATIC AND ECOLOGICAL PROFILE

The rainfall pattern is bimodal, with two distinct seasons: long rains from March to June and short rains from October to December. Rainfall amounts vary by altitude, ranging from 640 mm per annum in central and southern areas to 1,495 mm per annum towards Mount Kenya. The county experiences temperatures ranging from 12^0C in July to 30^0C in March, with a mean average of 21^0C, influenced by its extensive altitudinal range. July is the coldest month with an average monthly temperature of 15^0C, while September is the warmest month with an average monthly temperature of 27.1^0C. The daily incident shortwave solar energy in Embu ranges from 6.6 kWh to 7.5 kWh, with an average variation of 0.9 kWh[1].

Embu County heavily relies on the agricultural sector. Most farmers mainly produce maize, dairy cattle, banana, and beans, with maize accounting for 61-100%, dairy cattle at 41-60%, and banana and beans at 21-40%[4]. Embu County is divided into eight agro-ecological zones, each with distinct agricultural activities. The Lower Highland (LH1) zone, including Runyenjes and Manyatta, is cold and wet, with tea, dairy cows, and dairy goat farming, along with horticulture in the upper parts. The Upper Midlands (UM1), UM2, UM3, and UM4 zones are warm and humid, with maize, beans, bananas, and coffee being common crops in areas like Kyeni North, Kagaari, and Runyenjes Central. The Lower Midlands (LM3), LM4, and LM5 zones are hot and dry, with semi-arid conditions supporting livestock farming and drought-resistant crops such as sorghum, millet, and green grams in areas like Mavuria, Mwea, Kiambere, and Makima[1].

[9] The-Kenya-Poverty-Report-2022.pdf. Accessed: Apr. 09, 2025. [Online]. Available: https://knbs.or.ke/wp-content/uploads/2024/10/The-Kenya-Poverty-Report-2022.pdf

1.5 STAKEHOLDERS

Successful development of Embu CEP required active involvement of a wide range of stakeholders from various sectors. These actors played critical roles in ensuring that energy interventions are aligned with local needs, development objectives, and sustainability goals. Figure 1-6 below is an overview of the key stakeholders engaged.

These stakeholders played different key roles in this assignment as detailed in Table 1-4.

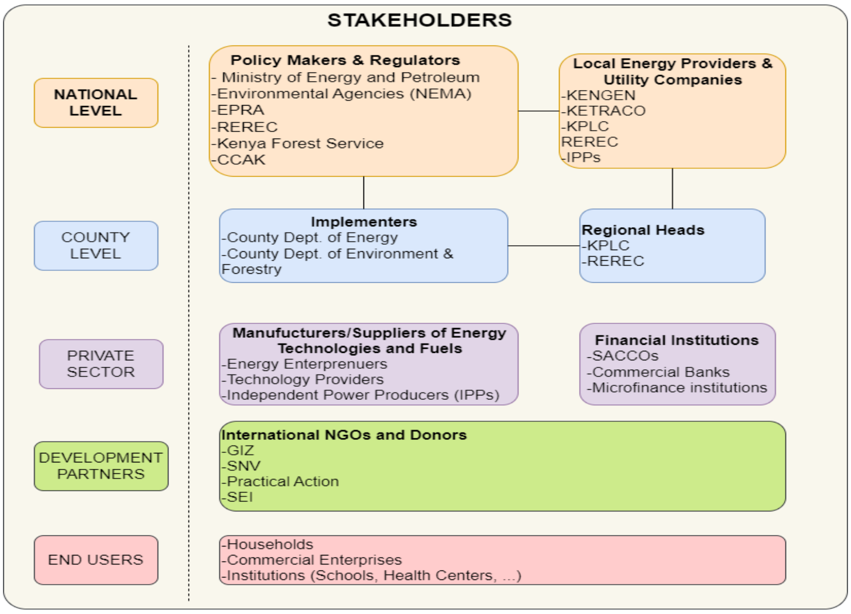


Figure 1-6: Stakeholder Mapping Framework

Table 1-4: Stakeholder Roles

Stakeholder Group	Specific Stakeholders	Role in CEP Development and Implementation
Government Institutions	County Government of Embu	- Lead CEP formulation, adoption, and implementation. - Align plans with County Integrated Development Plans (CIDPs). - Oversee stakeholder engagement and budgeting. - Monitor and evaluate energy interventions.
	Ministry of Energy and Petroleum (MoEP)	- Provide national policy oversight and technical guidance. - Align county CEPs with national energy goals. - Facilitate capacity building and national-county coordination.
	Environmental Agencies (NEMA, KWS)	- Ensure environmental compliance for energy projects. - Conduct environmental impact assessments and mitigation planning.
	Local Energy Providers and Utility Companies (KPLC, IPPs)	- Supply electricity and develop infrastructure. - Identify grid and off-grid electrification opportunities. - Provide technical expertise on power distribution.
Development Partners & Donors	GIZ (German Corporation for International Cooperation)	- Provide financial and technical support. - Promote renewable energy solutions and clean cooking. - Facilitate access to international funding.
	World Bank, USAID, UNDP, SNV, Practical Action and other donors	- Fund energy projects via grants, loans, and technical assistance. - Provide global expertise on sustainable energy. - Support financing models like Results-Based Financing (RBF).
Private Sector & Industry Players	Energy Entrepreneurs, Technology Providers, Contractors	- Deploy renewable energy technologies (solar, wind, biomass). - Implement energy efficiency solutions. - Provide financing models (pay-as-you-go, microloans).
	Independent Power Producers (IPPs), Private Energy Investors	- Invest in renewable energy infrastructure. - Operate and manage mini-grids and power generation. - Ensure long-term sustainability of energy projects.
Community & Civil Society	Local Communities (including Vulnerable Groups: Women, Youth, PWDs)	- Primary beneficiaries of the CEPs. - Provide feedback through consultations. - Participate in training and awareness programs.
	Non-Governmental Organizations (NGOs) & Civil Society Organizations (CSOs)	- Mobilize communities and advocate for energy justice. - Conduct awareness campaigns on clean energy. - Monitor and evaluate energy projects for social impact.
Research & Academia	Academic and Research Institutions	- Conduct feasibility studies and provide data on energy trends. - Support energy modelling, demand forecasting, and impact assessments. - Offer technical expertise and innovation in energy solutions.
The End Users	Residents of Embu	- Indirectly impacted by energy policies and projects. - Participate in public awareness campaigns. - Adopt and support clean energy solutions for homes, businesses and institutions.

1.6 POLICY & REGULATORY FRAMEWORK

1.6.1 NATIONAL ENERGY POLICIES AND REGULATIONS

Embu County is governed by; the Constitution of Kenya 2010, Acts of Parliament, National Policies and Regulations, as well as policies and regulations established by the county government. *Table 1-5* highlights briefly the national policies and regulations entrancing the energy sector in Embu County.

Table 1-5: National Policies and Regulations relevant to Embu's Energy Regulatory Framework

	Legislation	Year	Provision
1.	Constitution of Kenya	2010	Development of County Energy Plans (CEP) are guided by the Constitution of Kenya 2010, which outlines the roles and responsibilities of national and county governments in energy exploitation and development. Article 186, Fourth Schedule, specifies that the functions and responsibility of the national, which is responsible for energy policy including electricity and gas reticulation. The county governments are responsible for handling county planning and development of electricity and gas reticulation within the county.
2.	County Governments Act	2012	The Act outlines the implementation of the CoK 2010 framework regarding the powers, functions, and responsibilities of county governments. It mandates the county governments to develop plans and establish structured framework for county planning, including goals and principles of the plans. Additionally, under Part XI, the Act underscores the importance of aligning county plans with national development plans.
3.	Energy Act	2019	Article 5(2) require each county government to develop and submit to the Cabinet Secretary a county energy plan outlining its energy requirements
4.	Kenya Vision 2030	2008	Kenya Vision 2030 is the country's long-term development blueprint aimed at transforming the country into an industrialized-based economic providing a high quality of life to all its citizens by 2030. It has three key pillars: economic; social; and political. In all the three pillars, energy sector is a key enabler.
5.	Least Cost Power Development Plan (LCPDP) 2021 - 2041	2021	Least Cost Power Development Plan (LCPDP) 2021 – 2041 is a strategic national planning document aimed at guiding electricity generation, transmission, and distribution investments over a 20-year period.
6.	Environmental Management and Coordination Act (EMCA)	1999 *Revised 2022	It provides a legal framework for environmental governance, with direct implications for county Energy Plans. Key provisions include requirement for counties to develop County Environment Action Plans (CEAPs), which must address local environmental concerns, including energy related issues.
7.	Climate Change Act	2016 *Revised 2023	The Kenya Climate Act provides key provisions for integrating climate change into County Energy Plans, Counties are required to mainstream climate change actions into their energy planning and budgeting processes, ensuring alignment with national climate goals.
8.	Kenya National Energy Policy *Draft National Energy Policy 2025 – 2034	2018 *Revised 2023 2025	The National Energy Policy 2025 – 2034 provides a strategic roadmap for the country's energy sector over the next 10 years. Its principled on advancing affordable, reliable, and sustainable towards national development, economic growth, and climate resilience envisioned in government development goals and Sustainable Development Goals (particularly SDG 7: Affordable and Clean Energy).
9.	Kenya National Climate Change Action Plan (NCCAP)	2023 - 2027	NCCAP is a five-year plan that integrates climate action across all economic sectors at both levels governments (National and County levels). The plan supports the implementation of the Nationally Determined Contribution (NDC) and National Adaption Plan (NAP), focusing primarily on adaptation measures such as sectoral policies and strategies, coordination frameworks, and targeted investments and financing.
10.	Nationally Determined Contribution	2020	NDC outline the priority areas that the country needs to focus on toward reduction of emission by 32% by 2030 relative to the BAU scenario of 143 MtCO2eq. Its goal is to drive towards a low carbon climate resilient society to be achieved through mainstreaming climate change actions in Medium Term Plans (MTPs) and County Integrated Development Plans (CIDPs).
11.	2023 – 2027 Strategic Plan	2024	The plan aims to increase the installed capacity to 3976.8MW; construct 2930km of high voltage power transmission lines, 36 high voltage substations, 31 distribution substations, 1,183 km associated high – and medium- voltage lines, connecting 2.3 million additional consumers and 30,000 public facilities, and installing 75,000 lanterns under public lighting project.
12.	Kenya National Cooking Transition Strategy (KNCTS)	2024	The Kenya National Cooking Transition Strategy (KNCTS) (2024) is a critical framework for guiding energy planning. It outlines a clear pathway for achieving universal access to clean cooking by 2028, supporting counties in designing context-specific interventions.
13.	Kenya national Energy Efficiency and Conservation Strategy (KNEECS)	2020	The Kenya National Energy Efficiency and Conservation Strategy launched in 2020, provides a structured national roadmap to improve energy efficiency across sectors of the economy by 2025. The strategy outlines sector specific targets aimed at reducing energy demand, lowering emissions and promoting sustainable energy use.
14.	Bioenergy Strategy	2020-2027	The strategy outlines a national framework for sustainable development and formalization of the bioenergy sector. Recognizing that biomass accounts for approximately 68% of the country's total energy supply, the strategy emphasizes a shift toward cleaner, more efficient bioenergy solutions to address health, environmental and energy access challenges.
15.	Energy Gender Policy	2019	This policy aims to promote gender equality and women's empowerment in the energy sector. It focuses on ensuring that energy policies and projects are inclusive, addressing the needs of all genders while increasing women participation in energy planning and decision making.

1.6.2 COUNTY ENERGY POLICIES AND REGULATIONS

The development of this CEP reviewed county legislation and plans touching on energy planning as detailed in Table 1-6 below.

Table 1-6County Legislation

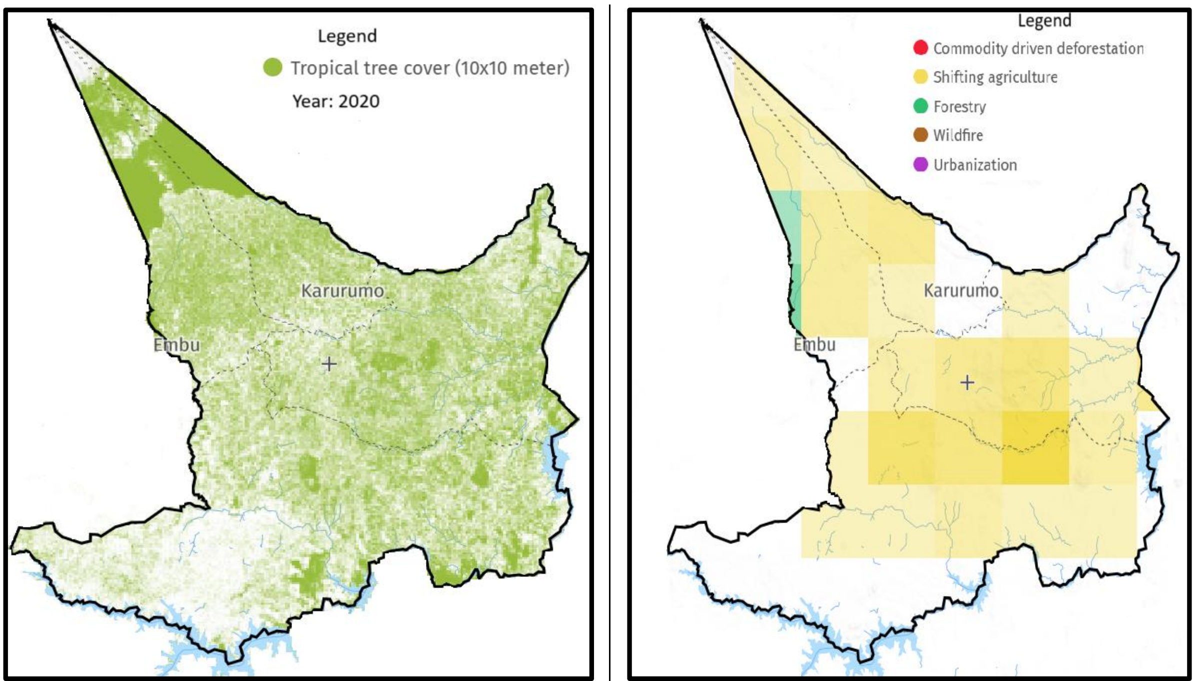
S/N	Legislation	Year	Provision
1.	Embu Climate Change Action Plan (ECCCAP)	2023 - 2027	The Embu County Climate Change Action Plan articulates the need for climate resilient projects in exploration and development of natural resources. By adopting environmentally sustainable practices, it does not only ensure compliance with the environmental legislation but also promotes green energy, sustainable natural resources management and conservation, and creating awareness of values of such resources as forest. Additionally, the plan emphasis aligning the ability of the community and county to address challenges related to changing climate particularly in priority areas that include Agriculture for Food and Nutrition security, Forestry and Agroforestry, Water and Sanitation, Disaster and Risk Management, Energy and Transport
2.	The Embu County Environment Management Act	2015	The Embu County Environment Management Act provides a legal framework for environmental protection, focusing on the control of air and noise pollution, waste management, and the reduction of public nuisances to promote a clean and healthy environment. This Act is directly relevant to County Energy Plan (CEP) development as it supports sustainable energy initiatives, particularly those involving renewable energy technologies like biogas. Its emphasis on proper waste segregation, recovery, and disposal aligns with the requirements for biogas feedstock sourcing, especially in hybrid energy systems that rely on organic waste. Additionally, by mandating public participation, environmental compliance, and institutional coordination, the Act reinforces the integration of clean energy solutions within the broader county development agenda of ensuring that CEP implementation is environmentally sound, community-driven, and legally anchored.

2 COUNTY ENERGY RESOURCES ASSESSMENT

2.1 WOOD FUEL

2.1.1 FORESTS AND NATURAL VEGETATION

Forest cover in Embu County occupies a land area of about 26,242 ha county land area[10] which is which is 11.38% of the total county land area[11]. Tropical forest cover in Embu shown in Map 2-1Map 2-1(a) shows the trees[12] cover in urban areas, agricultural lands, and in open canopy and dry forest ecosystems as of 2020[13]. The county has witnessed substantial tree cover loss particularly because of shifting agriculture[14] and marginally due to forestry[15,16] as shown in Map 2-1(b)



a) Tropical Forest Cover

b) Tree cover loss by dominant driver - 2001-2023

Map 2-1: Embu County Tropical Forest Cover and Tree Loss by Dominant Drivers[17]

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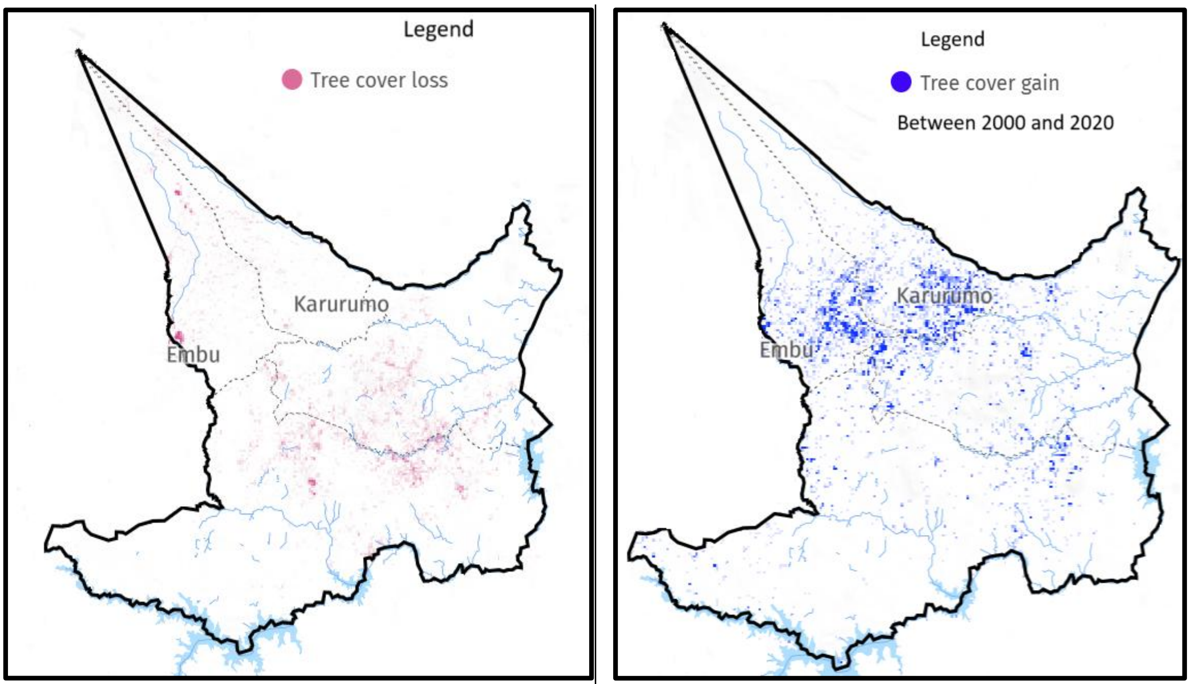
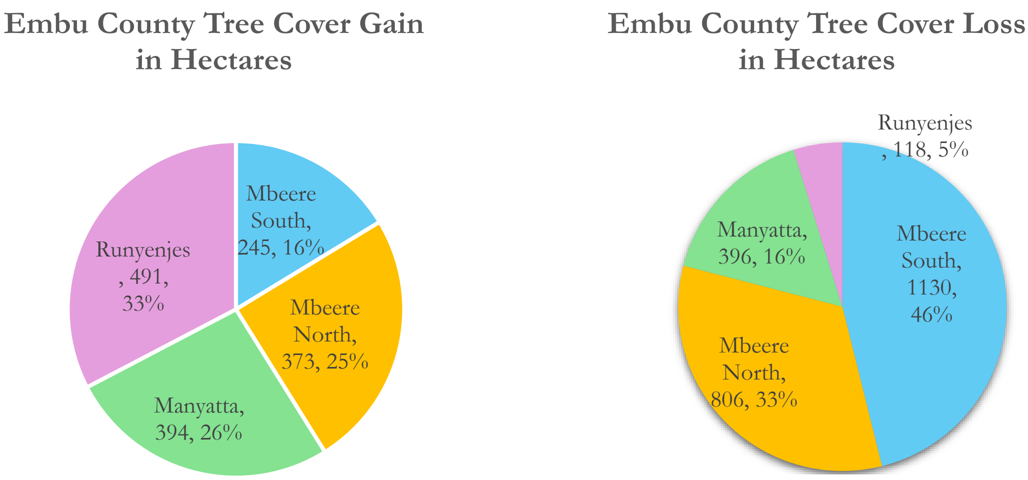
[10] KNBS: Compendium of Environment Statistics 2023 Report
[11] Embu County Government CIDP, 2023-2027
[12] Trees considered are Woody vegetation higher than 5 meters regardless of crown diameter, or between 3 and 5 meters with a minimum crown diameter of 5 meters.
[13] Brandt, Brandt, J., Ertel, J., Spore, J., & Stolle, F. (2023): Wall-to-wall mapping of tree extent in the tropics with sentinel-1 and sentinel-2. Remote Sensing of Environment, 292, 113574. https://doi.org/10.1016/j.rse.2023.11357
[14] The temporary loss or permanent deforestation due to small- and medium-scale agriculture
[15] Temporary tree cover loss from plantation and natural forest harvesting, with some deforestation of primary forests
[16] Curtis, P.G., C.M. Slay, N.L. Harris, A. Tyukavina, and M.C. Hansen. 2018. "Classifying Drivers of Global Forest Loss." Science. Accessed through Global Forest Watch on 04/04/2025. www.globalforestwatch.org.
[17] Source: 03/04/2025, accessed through Global Forest Watch on 03/04/2025. www.globalforestwatch.org.

Between 2000 and 2020, Embu County gained about 1,503 ha tree cover but lost about 2,450 ha of tree cover between 2001 and 2023[17]. The geospatial distribution of these gains and losses are shown in Map 2-2. The tree cover gain during this period was highest in Runyenjes and Manyatta sub-counties and the least in Mbeere South and Mbeere North as shown in Figure 2-1(a). The sub-counties with the highest tree cover gain also experienced the lowest tree cover loss as shown in as shown in Figure 2-1(b)[18].



a) Embu County Tree Cover Loss b) Embu County Tree Cover Gain

Map 2-2 Embu County Tree Cover Loss Vs Gain



a) Tree Cover Gain b) Tree Cover Loss

Figure 2-1 Embu Tree Cover Gain and Loss Per Sub- County

[18] Embu, Kenya Deforestation Rates & Statistics | GFW

About 16,275 ha of the current forest cover is occupied by gazetted national forests[19] distributed as shown in Figure 2-2 (a). Irangi forest station accounts for largest proportion (about 95%) while Kirimiri accounts for the least coverage (0.6%) of the gazetted forest. Devolved/non-gazetted forest stations, on the other hand, cover about 4,755.40 ha of land area[20] and is distributed as shown in Figure 2-2 (b). King'ombe Hill Forest Station accounts for the highest proportion of non-gazetted forests within the county, about 44.2% of non-gazetted forest cover while Kiambeere Hill Forest Station accounts for the lowest proportion, about 13.5%. The geographical locations of these gazetted and non-gazetted forests is shown in Map 2-3.

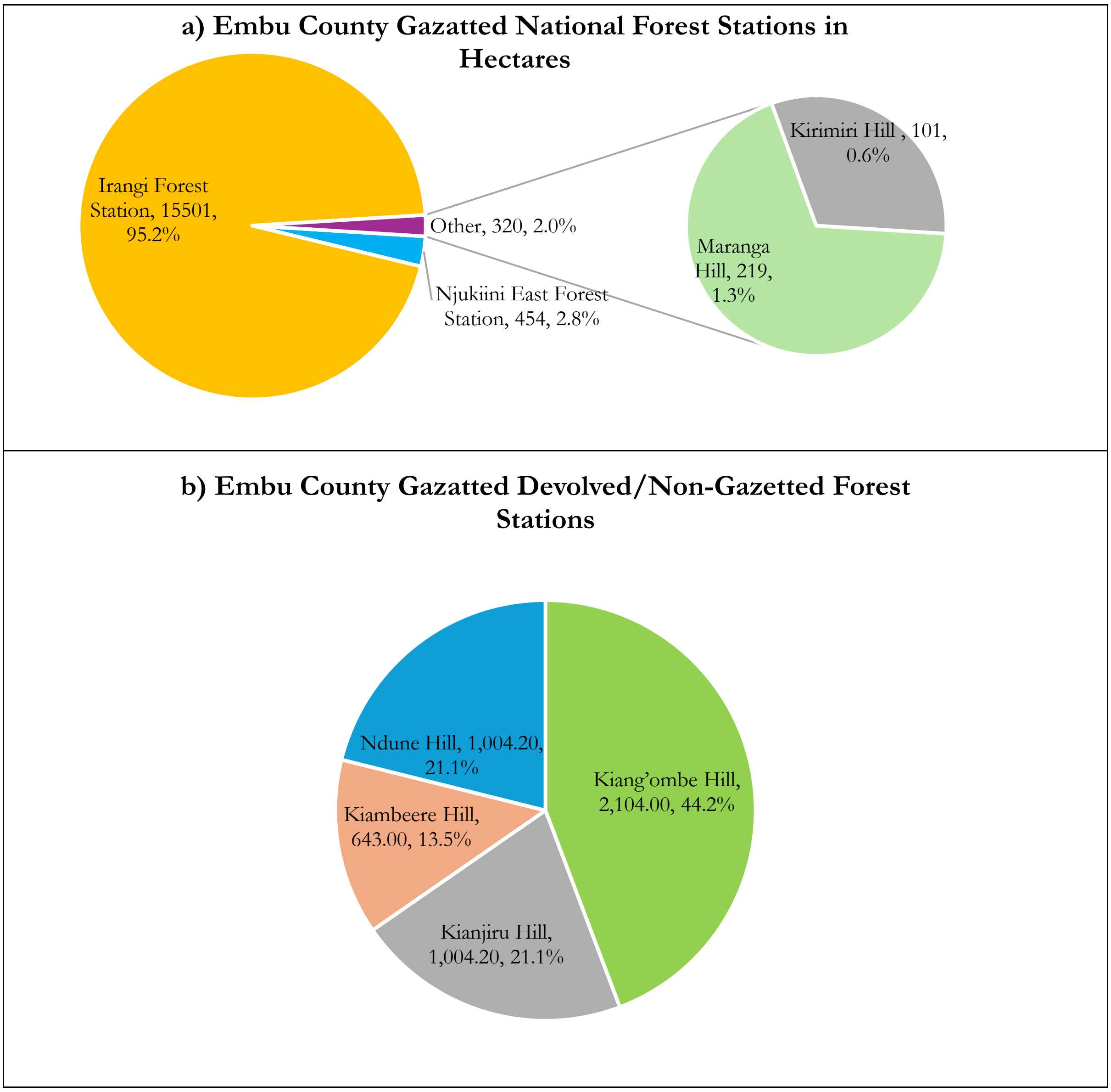
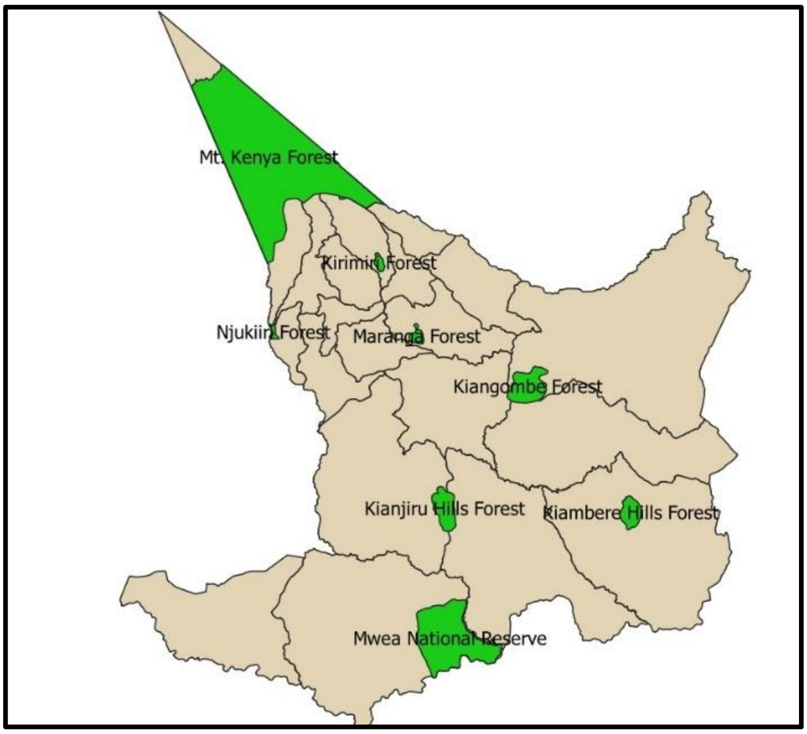


Figure 2-2: Embu County Gazetted and Non-Gazetted Forest Cover Distribution

[19] Source: Kenya Forest Service data, 2025
[20] Embu County Government CIDP (2018-2022)



Map 2-3: Geographical Location of Gazetted and Devolved Forests

Other than gazetted and devolved (non-gazetted) forest stations, Embu County also has private commercial forests and agro forests. In 2018, private commercial forests and agro forests were estimated to be 468 ha and 47,900 ha respectively with the agro forest distributed as shown in Figure 2-3. Agro forest cover is estimated to occupy over 37% land cover in Runyenjes and Manyatta constituencies and about 10% in Mbeere North and Mbeere South constituencies.

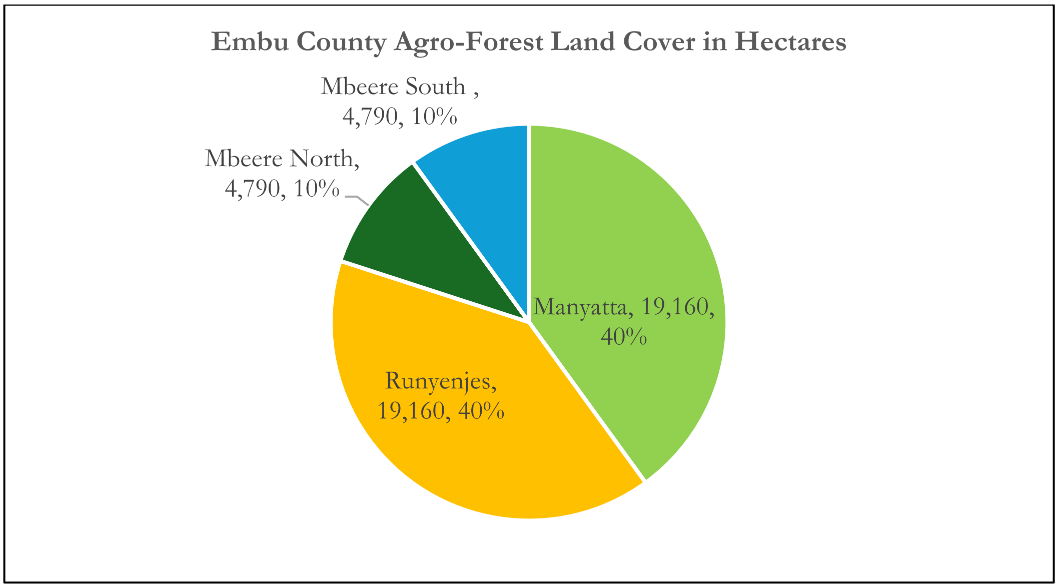


Figure 2-3: Estimated Embu Country Agro-forest Land Cover

Source: Embu County Government CIDP, 2018-2022

2.2 AGRICULTURAL RESIDUES

Embu is a rich agricultural county producing both food crops and cash crops. Amongst the crops whose residue can be utilized as bioenergy resource include coffee husks, mango kernels, millet straws, sorghum straws and stalks and Macadamia shells and husks. The production of these crops and their bio residue production potential is highlighted in the ensuing subsections.

2.2.1 MAIZE

Maize production in Embu County varies from year to year both in used land area and production quantity. Figure 2-4 shows the production trend between 2019 and 2024. The average annual production is about 26,774 MT. Maize production produces bio residue in form of maize stover and cob. The Food and Agriculture Organization of the United Nations (FAO) Agricultural Residue Tool[21] estimates that on average, crop to residue ratio for maize to stovers and cobs is 1.96 and 0.33 respectively. This implies that during the period under consideration, Embu County produced about 52,476 MT and 8,835 MT of stover and maize cobs yearly.

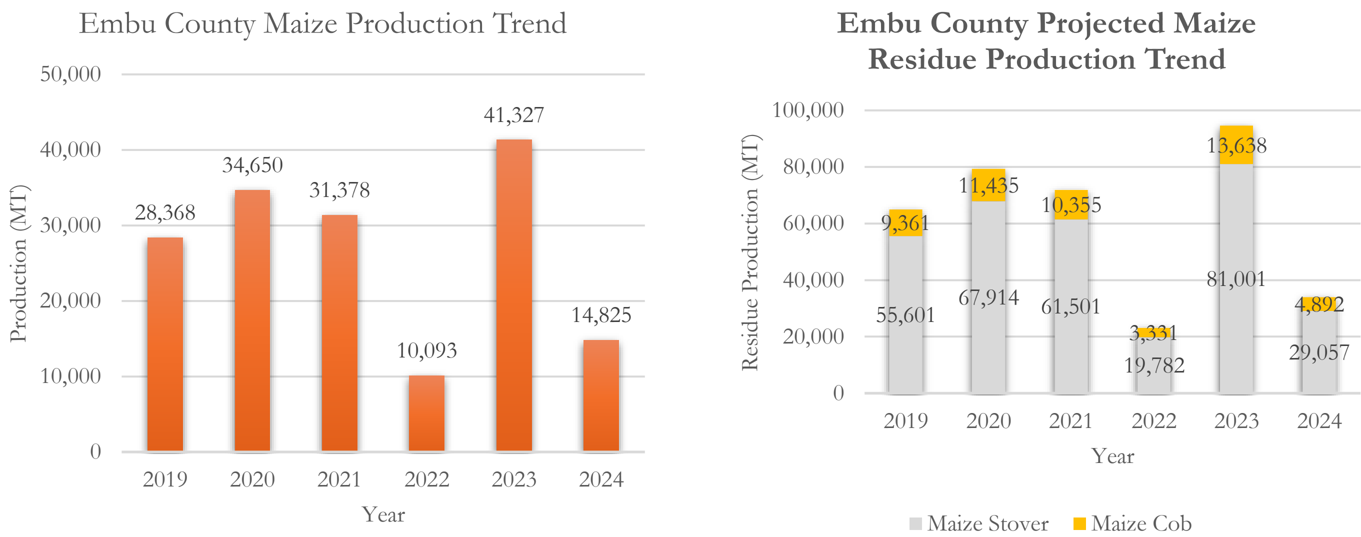


Figure 2-4: Embu County Maize and Residue Production Trend

Source: KNBS - National Agriculture Production Report, 2024 and Embu County Department of Agriculture, 2025

[21] https://www.fao.org/fileadmin/user_upload/energy/befs/natural_resources/external/Agricultural_Residues__tool_2.0.xlsm

2.2.2 MILLET

Embu County is a top 20 millet producer. The millet production varies from year to year both in used land area and production quantity. Figure 2-5 shows the production trend between 2019 and 2022. The average annual production is about 2,122 MT. Millet production produces bio residue in form of straws. The Agricultural Residue Tool[21] estimates that on average, crop to residue ratio for millet to straw is 2.54. This implies that during the period under consideration, Embu County produced about 5,389 MT of straws yearly.

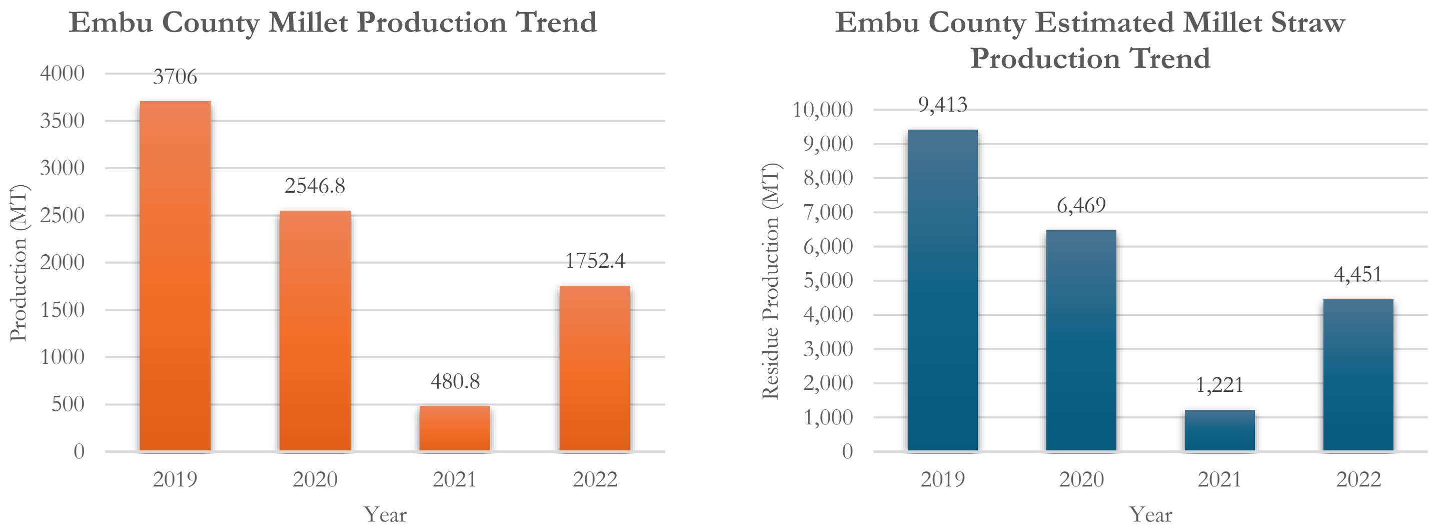


Figure 2-5: Embu County Millet and Residue Production Trend

Source: KNBS - National Agriculture Production Report, 2024 and Embu County Department of Agriculture, 2025

2.2.3 SORGHUM

Embu County is a substantial sorghum producer producing about 4,248 MT annually. The sorghum production varies from year to year both in used land area and production quantity as shown in Figure 2-6 shows the production trend between 2019 and 2023. Sorghum production produces bio residue in form of straws and stalks. The Agricultural Residue Tool[21] estimates that on average, crop to residue ratio for sorghum to straw and stalks is 2.44. This implies that during the period under consideration, Embu County produced about 10,366 MT of straws and stalks annually.

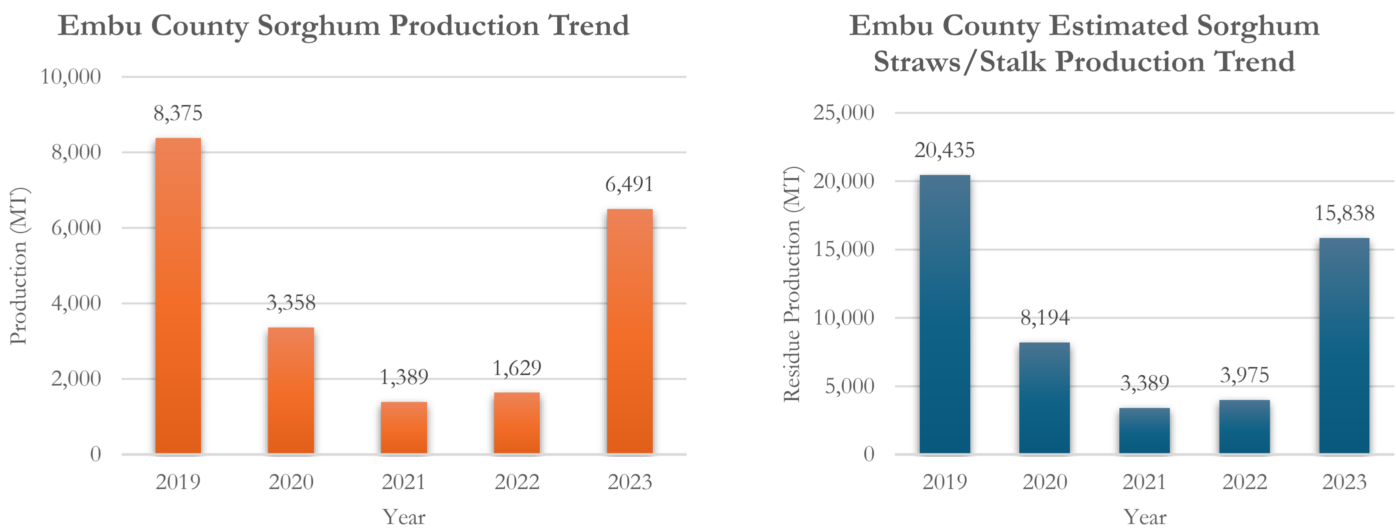


Figure 2-6: Embu County Sorghum and Residue Production Trend

Source: KNBS - National Agriculture Production Report, 2024 and Embu County Department of Agriculture, 2025

2.2.4 COFFEE

Embu County produces about 2,135 MT of clean coffee annually. Coffee production varies from year to year as shown in Figure 2-6 shows the production trend between 2019 and 2023. Coffee production produces bio residue in form of husks. The Agricultural Residue Tool[21] estimates that on average, crop to residue ratio for coffee beans to husks is 1.32. This implies that during the period under consideration, Embu County produced about 2,819 MT of husks and straws yearly.

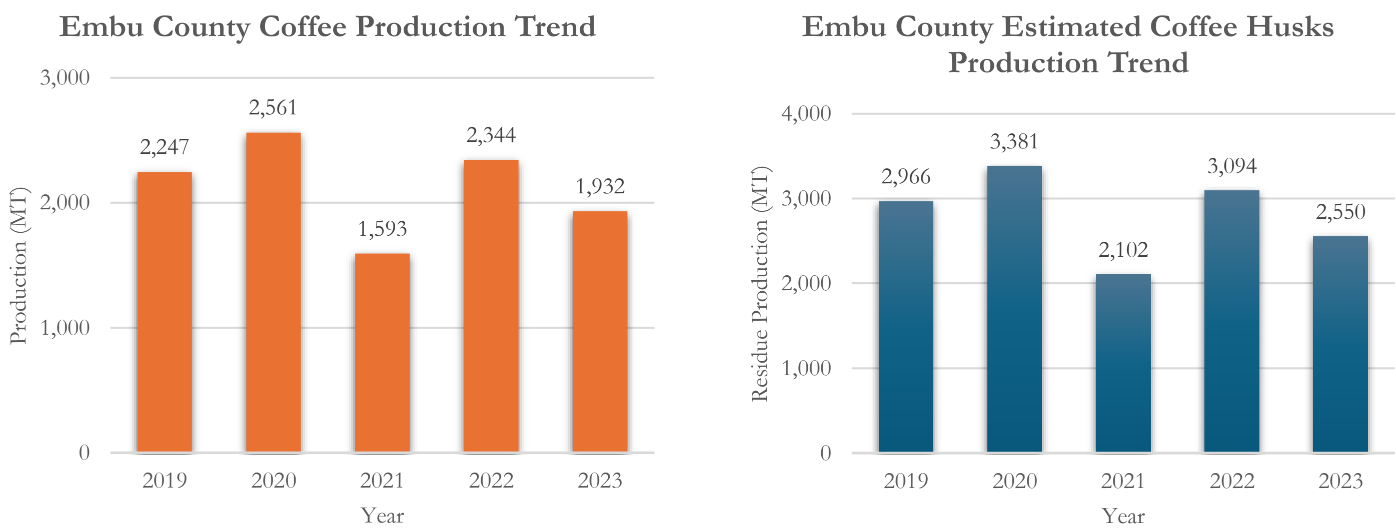


Figure 2-7: Embu County Coffee and Husk Production Trend

Source: KNBS - National Agriculture Production Report, 2024 and Embu County Department of Agriculture, 2025

2.2.5 MACADAMIA NUTS

Embu is also one of the leading producers of Macadamia in Kenya. The county produces about 5,512 MT of Macadamia nuts annually. The production varies from year to year as shown in Figure 2-8 between 2019 and 2024. Macadamia production produces bio residue in form of husks and shells. *A. Wechsler et al. (2013)*[22] estimates that on average, crop to residue ratio for macadamia nuts to husks and shells is 2.33. This implies that during the period under consideration, Embu County produced about 12,844 MT of macadamia husks and shells yearly.

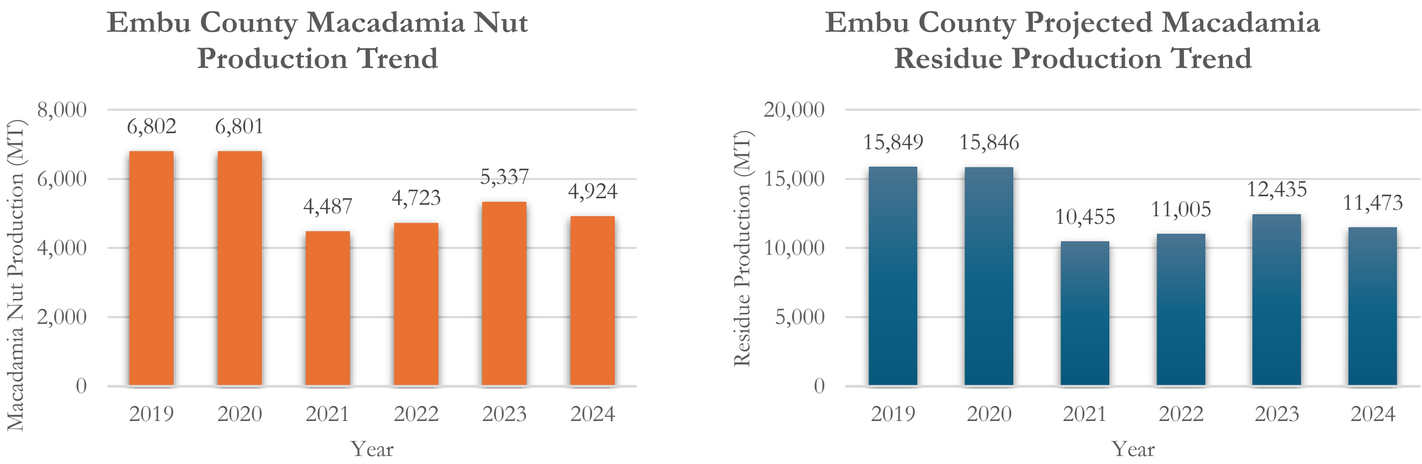


Figure 2-8: Embu County Macadamia Nuts and Bio Residues Production Trend

Source: KNBS - National Agriculture Production Report, 2024 and Embu County Department of Agriculture, 2025

[22] A. Wechsler et al., "Macadamia (Macadamia integrifolia) shell and castor (Rícinos communis) oil based sustainable particleboard: A comparison of its properties with conventional wood-based particleboard," Mater Des, vol. 50, pp. 117–123, Sep. 2013, doi: 10.1016/j.matdes.2013.03.008.

2.3 ANIMAL WASTE

2.3.1 LIVESTOCK POPULATION

Embu County has a substantial population of livestock. In 2019, Kenya National Bureau of Statistics (KNBS) reported that the county had about 40,843, 9,167 and 88,405 dairy exotic cattle, beef exotic cattle and indigenous cattle respectively. The county had also other livestock types whose excreta could be utilized in the production of biogas as shown in Figure 2-9 and Figure 2-10.

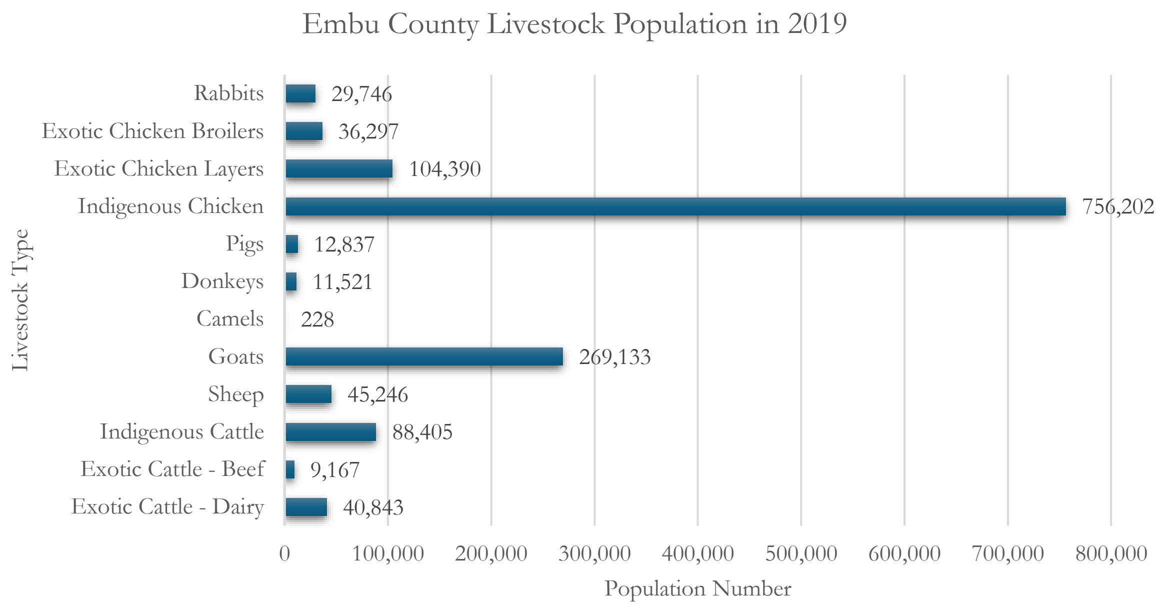


Figure 2-9: Embu County Livestock Population in 2019 by Type

Source: Kenya National Bureau of Statistics (KNBS)

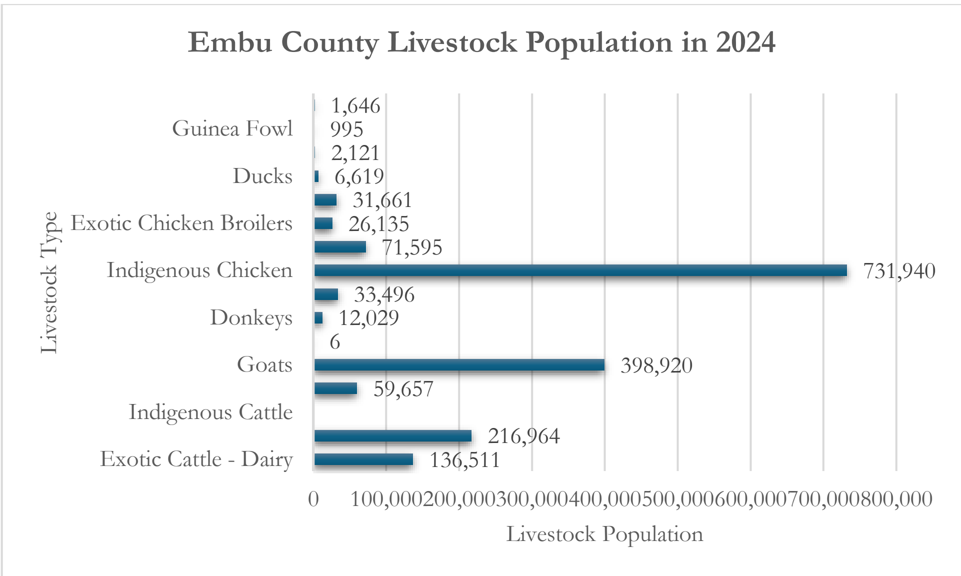
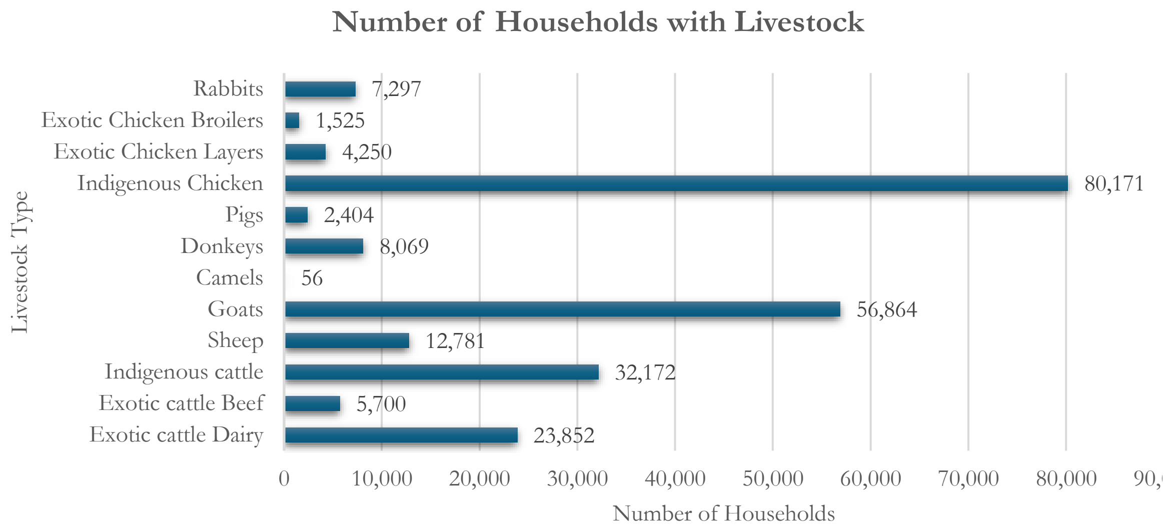


Figure 2-10: Embu County Livestock Population in 2024 by Type

Source: Embu County Department of Agriculture, 2025

Data on the current distribution of livestock per household is not available, however, according to the KNBS data of 2019, a significant number of households had livestock. The number and proportion of households with livestock within the county is shown in Figure 2-11. The distribution of each type of livestock per sub-county is shown in Figure 2-12.



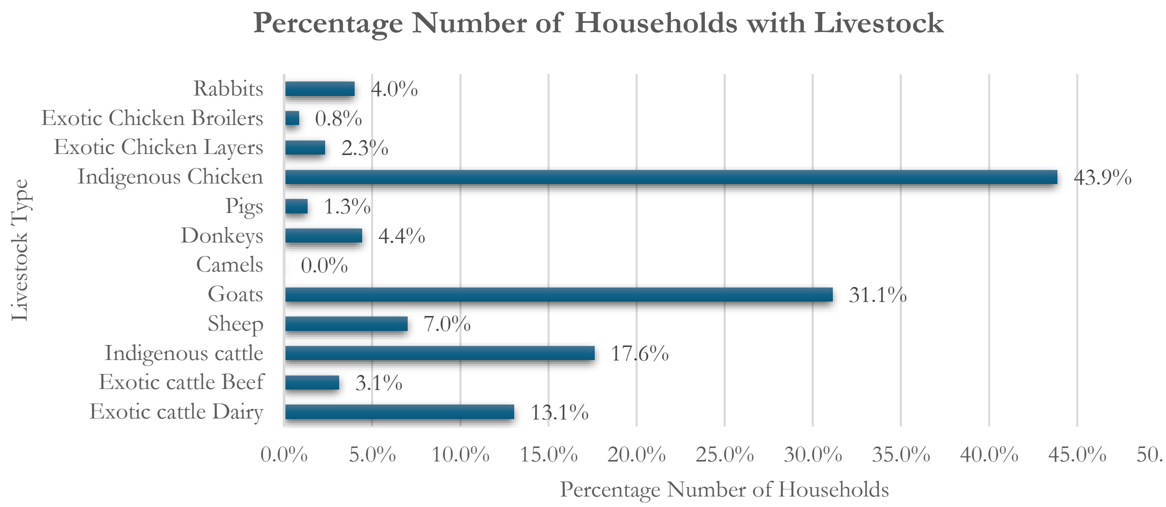


Figure 2-11: Number and Proportion of Households with Livestock

Source: Kenya National Bureau of Statistics (2019): Kenya Population and Housing Census - Distribution of Population by Socio-Economic Characteristics.

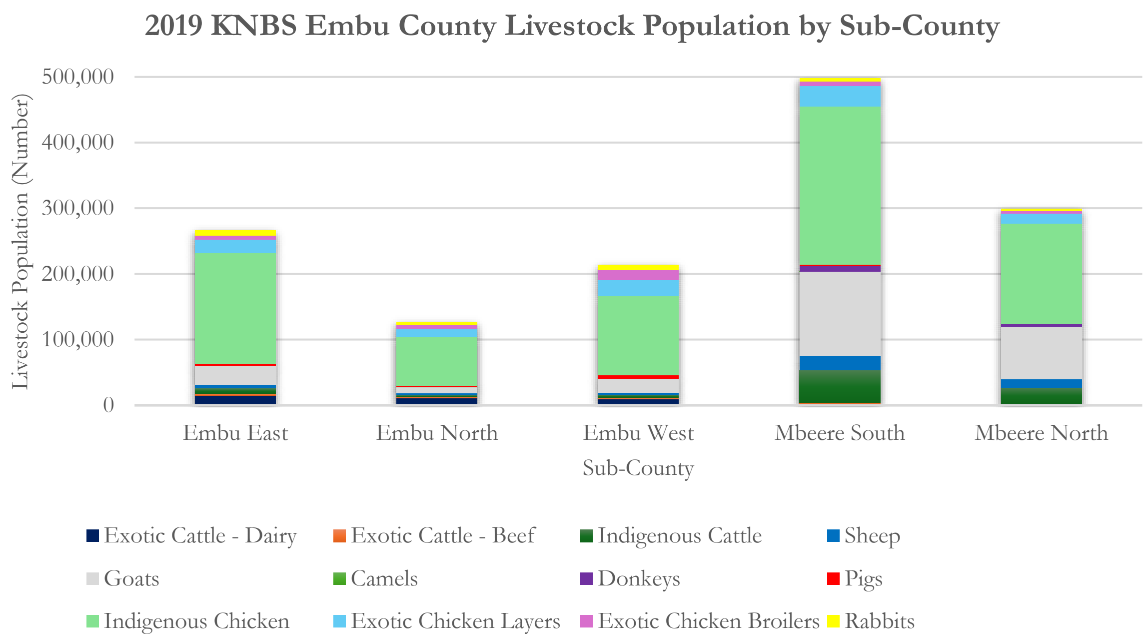


Figure 2-12: Embu County Livestock Population in 2019 by Sub County

Source: Kenya National Bureau of Statistics (2019): Kenya Population and Housing Census - Distribution of Population by Socio-Economic Characteristics.

2.4 MUNICIPAL SOLID WASTE

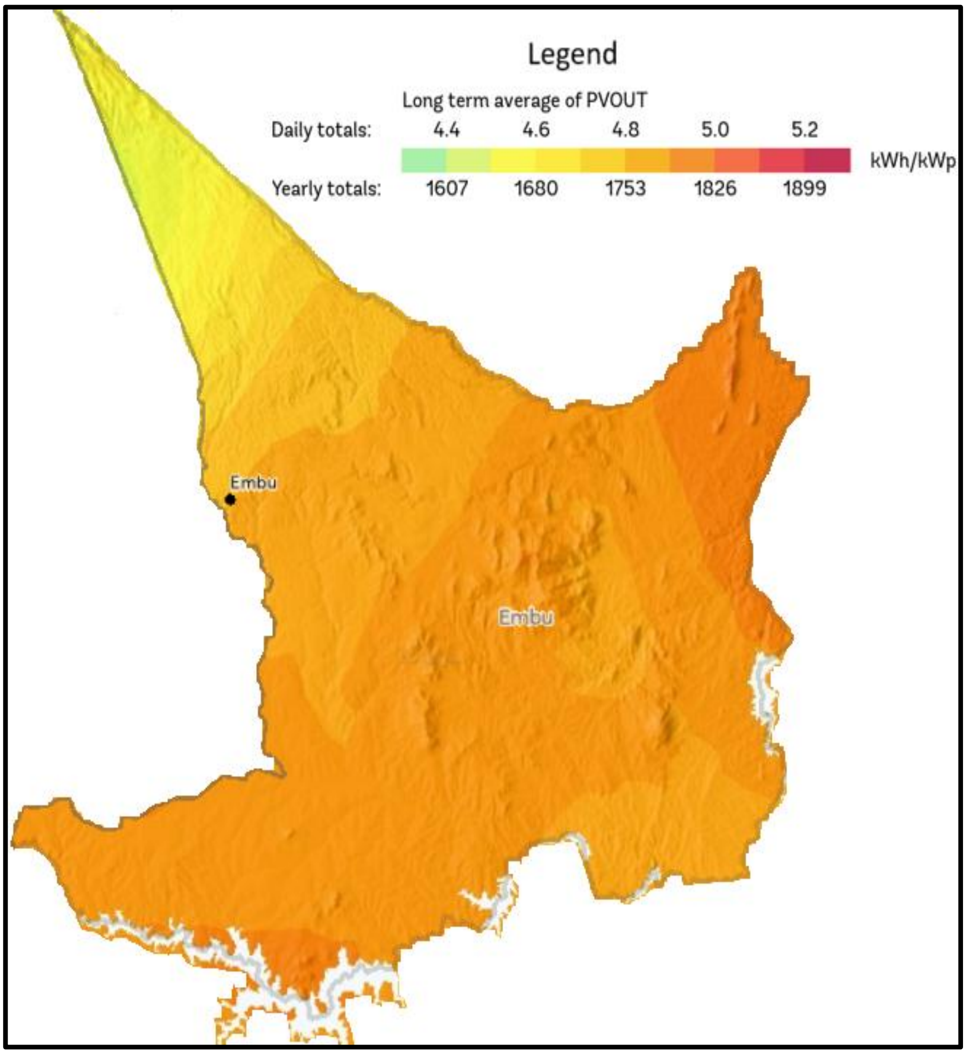
Embu County has an existing dumpsite near Embu Town. However, the County government intends to relocate the dumpsite to the Kamwimbi landfill shown in *Figure 2-13*, which spans about 33 acres of land. The landfill, which was expected to be functioning from 2022, is not yet operational and only perimeter fencing has been completed. Furthermore, the County plans to establish a material recovery facility and a waste-to-energy plant at the Kamwimbi site anchored on the improved municipal waste collection mechanism in the County. Previously, Embu County had unsuccessfully engaged private investors for the establishment of a 10-megawatt plant at the Kamwimbi landfill. Going forward, the County is keen to develop an appropriate waste collection and management ecosystem to cater for the end-to-end management of waste. Furthermore, the size of the waste currently generated in Embu County (estimated at 0.57kg/person/day) is insufficient for the proposed waste-to-energy facility. The municipal waste can however be used for the production of syngas which can be packaged and supplied as a clean cooking energy solution within the county. Additionally, with segregation of municipal waste into organic and inorganic waste, the organic waste can be utilized to produce biogas which then be used for power generation or packaged and distributed institutions such as schools and health facilities for cooking.

Figure 2-13: Kamwimbi Landfill Perimeter Wall

Source: Green Finance assessment of Embu County 2024

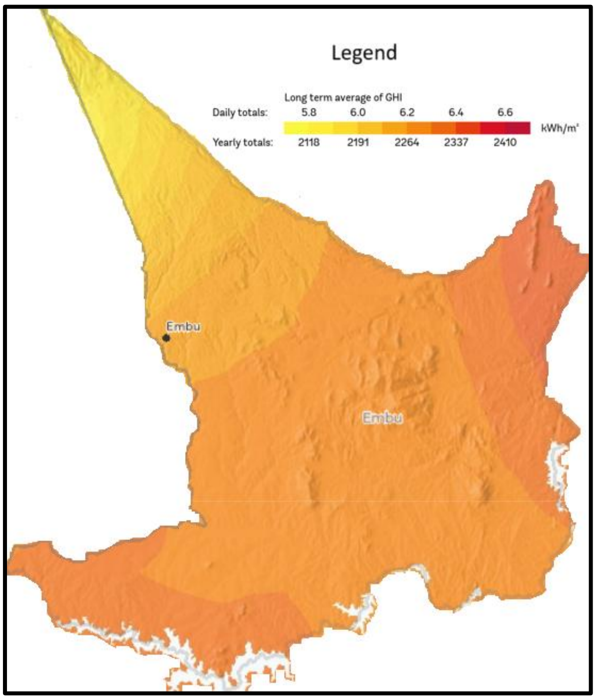
2.5 SOLAR ENERGY

Embu county has a significant solar energy resource potential, particularly in the southern part of the county (Mbeere North and Mbeere South) as shown in Map 2-4 and Map 2-5(a). According to Global Solar Atlas, the county's daily Global Horizontal Irradiation (GHI)[23], specific photovoltaic power output (PVOUT) and Direct Normal Irradiation (DNI)[24] ranges are 4.19 — 5.93 kWh/m^2, 3.48 — 4.63 kWh/kWp and 3.00 — 4.81 kWh/m^2 respectively. The DNI received by the county is not ideal for deployment of Concentrating Solar Power technologies as the maximum DNI within the county is estimated to be around 4.81 kWh/m^2 which is below the minimum requirement of 5 kWh/m^2 per day[25].

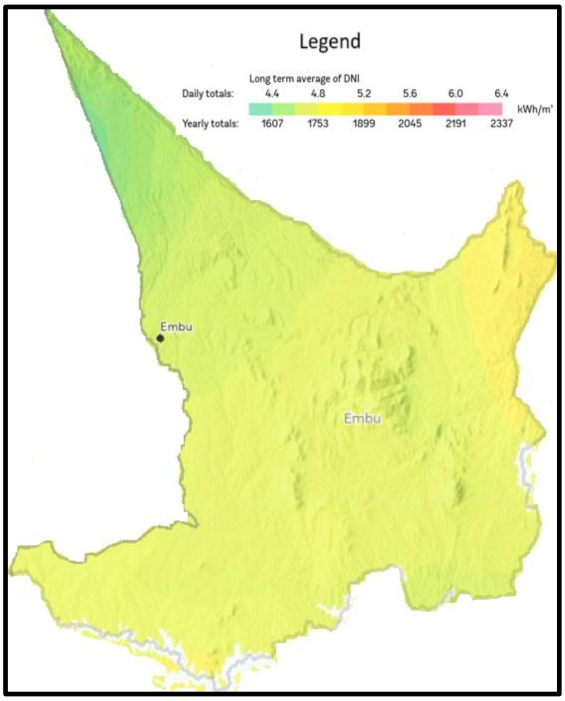


Map 2-4: Embu County Long-term Daily and Yearly PVOUT Average in kWh/kWp

[23] GHI is used to estimate energy yield for rooftop or ground-mounted PV panels that are installed at a fixed angle. It helps in predicting performance for non-tracking systems.
[24] DNI is critical for technologies that concentrate or specifically rely on direct sunlight (e.g., CSP, CPV, and solar thermal applications).
[25] K. Liaqat and J. C. Ordonez, "Design and optimization of CSP power plants for Pakistan: A comparative study," *Clean Energy*, vol. 7, no. 3, pp. 690–704, Jun. 2023, doi: 10.1093/ce/zkad018.



a) Global Horizontal Irradiation

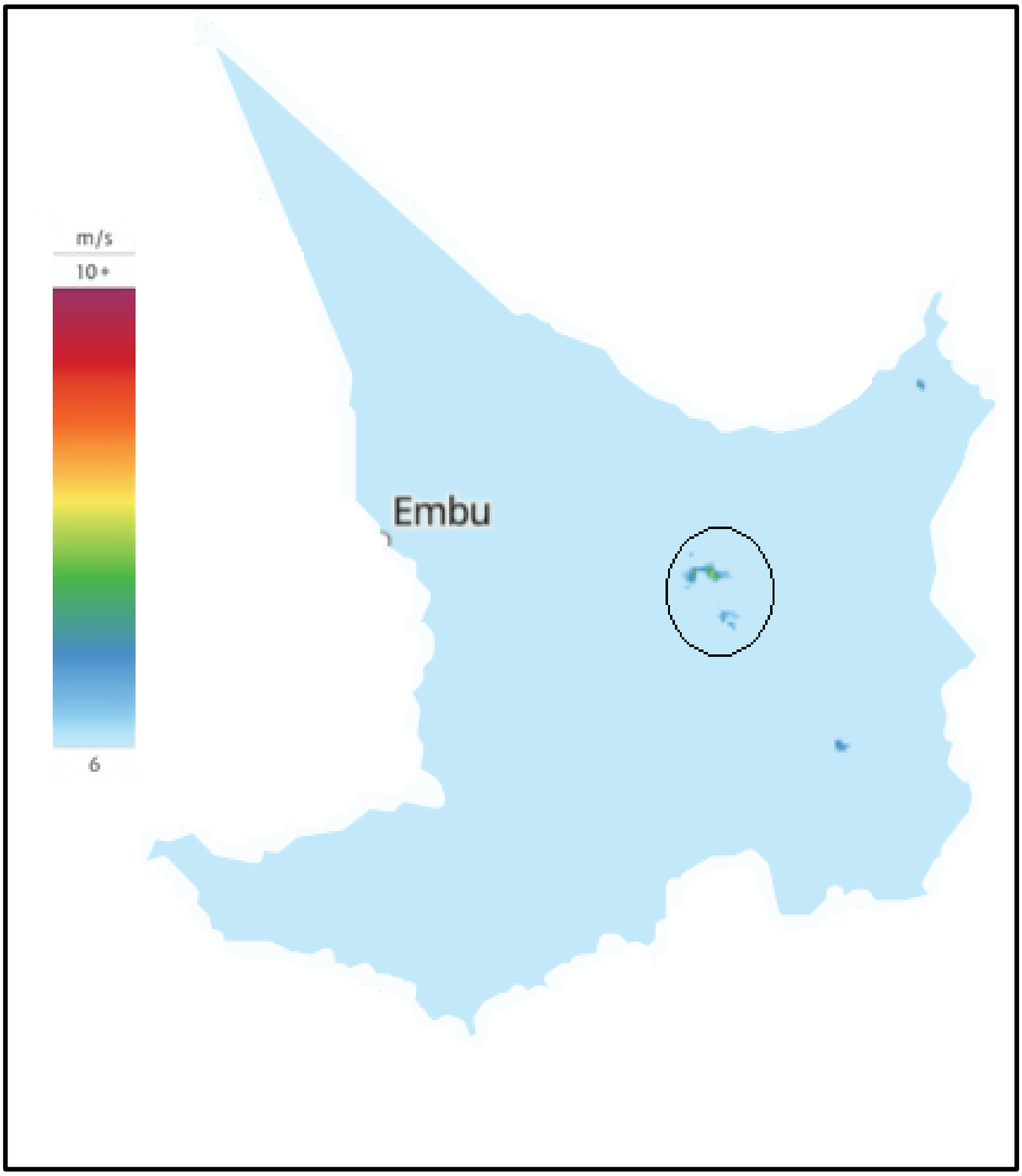


b) Direct Normal Irradiation

Map 2-5: Embu County Long-term Daily and Yearly GHI and DNI Average in kWh/m²

2.6 WIND ENERGY

Embu County has low wind speeds, lower than the minimum recommended speeds of 6.5 m/s required for utility size power generation[26] from wind energy according to the Wind Atlas. The region in Mbeere North enclosed by Ngonuomo, Kandare, Kevoe and Gangara (encircled in Map 2-6) has the highest average wind speeds of about 7.5 m/s at a height of 100 m. The area covers a surface area of about *4.17 km²* which is not viable for development of utility size wind power plant. This is however sufficient for installation of small-scale wind farms.



Map 2-6: Embu County Average Wind Speeds

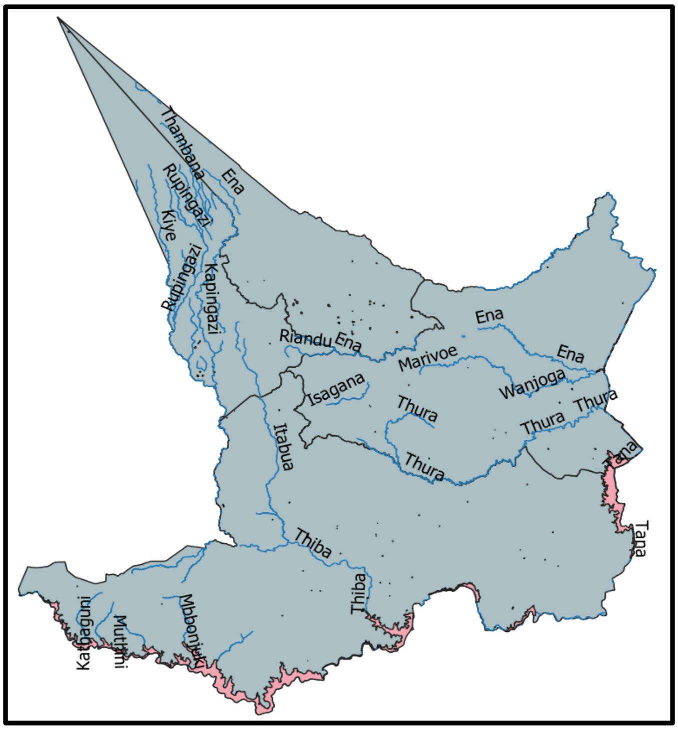
Source: Global Wind Atlas

[26] Wind Power Class 3 (Wind mean speed of above 6.5 m/s and a minimum mean power density of 320 W/m² and above) according to the National Renewable Energy Laboratory (NREL) Wind Resource Assessment Handbook

2.7 HYDRO POWER

Embu County is best-known as the hydropower giant of Kenya. It hosts the nationally germane seven forks hydroelectric dam project, which is a series of five major dams constructed along its southern border with Machakos County, along River Tana. The seven forks project collectively contribute 599.2 MW to the national grid. The hydro power stations along river Tana include Masinga Power Station, Kamburu Power Station, Gitaru Power Station, Kindaruma Power Station, and Kiambere Power Station that generate 40 MW, 94.20 MW, 225.25 MW, 72 MW and 168 MW respectively[27].

Other than river Tana, Embu County has smaller rivers suitable for the development of small and mini hydro power plants as shown in Map 2-7. The development of small hydro along river Rupingazi by Kleen Energy Venture[28] generating 6–6.8 MW demonstrates the potential to develop small to pico hydros within Embu County. The Thuci Dam project in Runyenjes sub-county is being developed for water storage/irrigation and explicitly includes hydropower generation in project disclosures[29]. Nthenge Njeru waterfall has also been identified for development of a hydropower plant[30], another sign of embedded hydropower opportunity. Embu County government should carry out a feasibility study to establish the potential sites with potential capacity for installation of small, mini and pico hydros within the county.



Map 2-72-14: Embu County Rivers

[27] Source: Kenya Electricity Generating Company (KenGen)
[28] https://repp.energy/wp-content/uploads/2020/02/Rupingazi.pdf
[29] Disclosure on Development of The Thuci Dam Project PPP Project in Embu County, Republic Of Kenya.
[30] FDS Kenya (2024):Green Finance Assessment of Embu County

The resource assessment activity framework focuses on five key dimensions: availability and economic potential, adequacy, sustainability, ease of access and cost of use.

The Rupingazi Hydropower Plant, with an installed capacity of approximately 6 MW, represents one of Embu County's key renewable energy resources, harnessing the flow of the Rupingazi River to generate clean electricity for the national grid. Located within the Njukiri Forest area, the project underscores the county's significant potential for small- to medium-scale hydropower development, contributing to Kenya's broader renewable energy mix. Beyond supplying reliable power, the plant enhances local infrastructure, creates employment opportunities during construction and operation, and demonstrates the role of county-level renewable energy investments in promoting sustainable development and climate resilience.

3 ENERGY ACCESS

3.1 ENERGY ACCESS FOR HOUSEHOLDS

3.1.1 ELECTRICITY ACCESS FOR HOUSEHOLDS

3.1.1.1 LIGHTING ENERGY FOR HOUSEHOLDS

Lighting energy in Embu County reflects a significant shift toward clean and sustainable energy sources, aligning closely with national trends, though with some regional differences. Recent data from the Kenya National Bureau of Statistics (KNBS) reveals that, nationally, 95.4% of households now rely on clean energy sources for lighting. A deeper breakdown shows that clean lighting usage is slightly higher in urban areas at 97.5%, compared to 94.0% in rural areas. These figures provide a benchmark for analyzing lighting energy patterns in Embu County.

In Embu County, 90% of households use clean energy sources for lighting, while 10% still depend on unclean sources such as kerosene, wood, and candles. Although this clean energy adoption rate is slightly below the national average, it is still relatively high, particularly given the county's predominantly rural population.

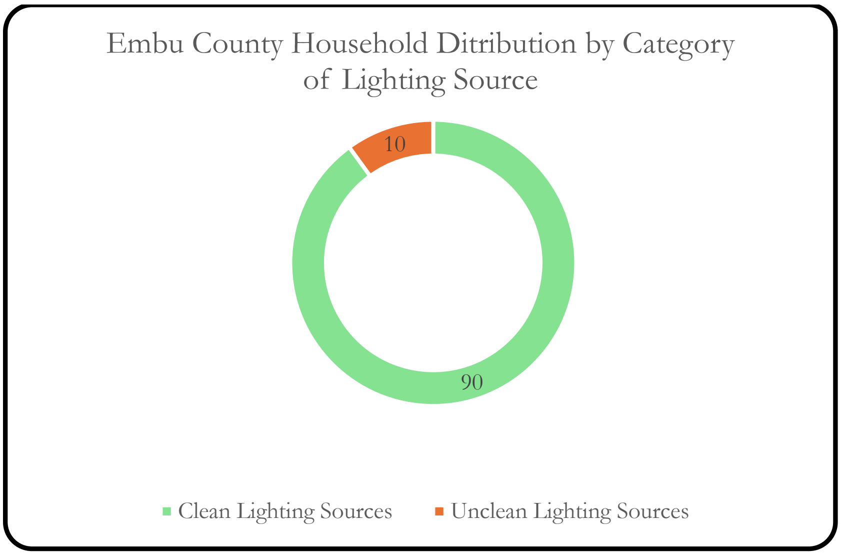


Figure 3-1 : Distribution of households in Embu by category of lighting source

Source: KNBS - 2023/24 Kenya Housing Survey – Basic Report

The national grid is the leading source of lighting in Embu, used by 53.4% of households as their primary lighting source. This is a strong indication of the penetration of grid electricity across the county and reflects successful rural electrification programs. The availability of electricity is particularly significant in the sub-counties of Manyatta, and Runyenjes, which lead in electricity adoption. These areas likely benefit from better infrastructure and proximity to urban centers.

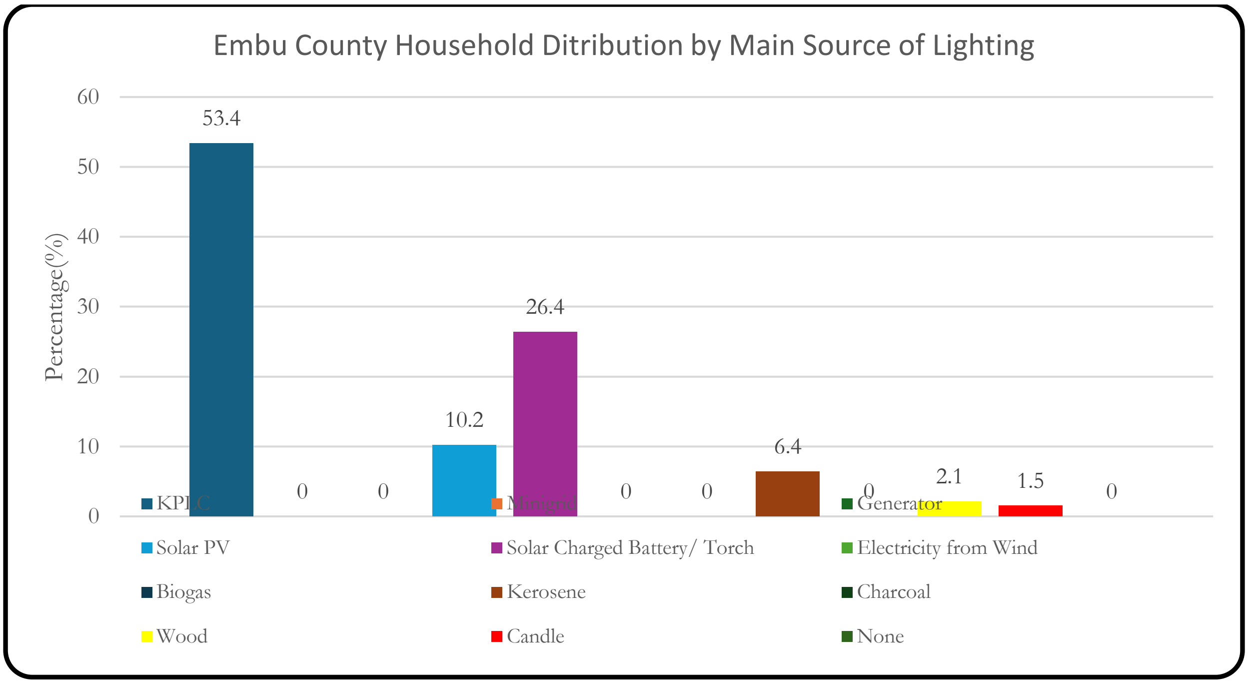


Figure 3-2: Distribution of Households in Embu by main source of lighting

Source: KNBS - 2023/24 Kenya Housing Survey – Basic Report

Solar energy plays a crucial role in supplementing lighting needs, especially in off-grid or rural areas. A combined 36.6% of households rely on solar-powered lighting: 26.4% use solar-charged batteries or torches, while 10.2% use fixed solar photovoltaic (PV) systems as their main source of lighting. The popularity of solar lighting is driven by its affordability, ease of installation, and minimal running costs, making it an ideal solution in areas where electricity access is limited or unreliable.

Despite the growing shift to clean lighting sources, a small portion of Embu's population continues to use traditional and unclean sources. Kerosene is used by 6.4% of households, mostly through tin lamps or lanterns. Wood, which is traditionally used for cooking, still serves as a lighting source for 2.1% of households, often in settings where other options are unavailable or unaffordable. Additionally, 1.5% of households use candles for lighting, which pose both fire risks and health hazards due to poor air quality in enclosed spaces.

The use of clean lighting sources in Embu is relatively uniform across the county, with electricity being particularly dominant in the more developed sub-counties. However, in remote or less electrified areas, households continue to depend on solar, kerosene, and torches powered by dry cells or rechargeable batteries. These alternatives play an important transitional role as efforts to expand grid coverage and promote renewable energy continue. The details of lighting energy sources in Embu sub counties are highlighted in the figure below.

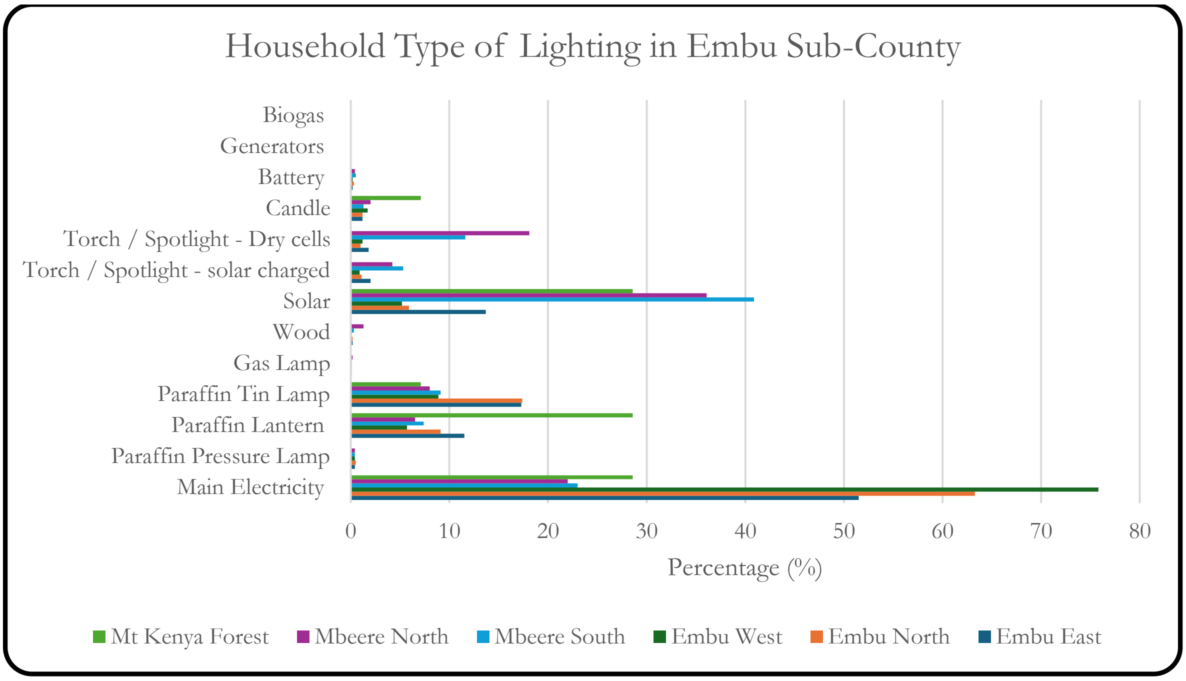


Figure 3-3: Type of Lighting in Embu Sub-Counties

Source: KNBS - 2023/24 Kenya Housing Survey – Basic Report

The use of electricity as main source of lighting was significant across all Sub-Counties. Manyatta, Runyenjes, and Mbeere South are leading sub-counties in adoption of electricity as primary source for lighting. Other sources that play a major role include solar, paraffin (tin lamp and lantern), and torch (dry cells and charged). From *Figure 3-4*, the people using solar PV for lighting was significantly high than those relying on the grid electricity.

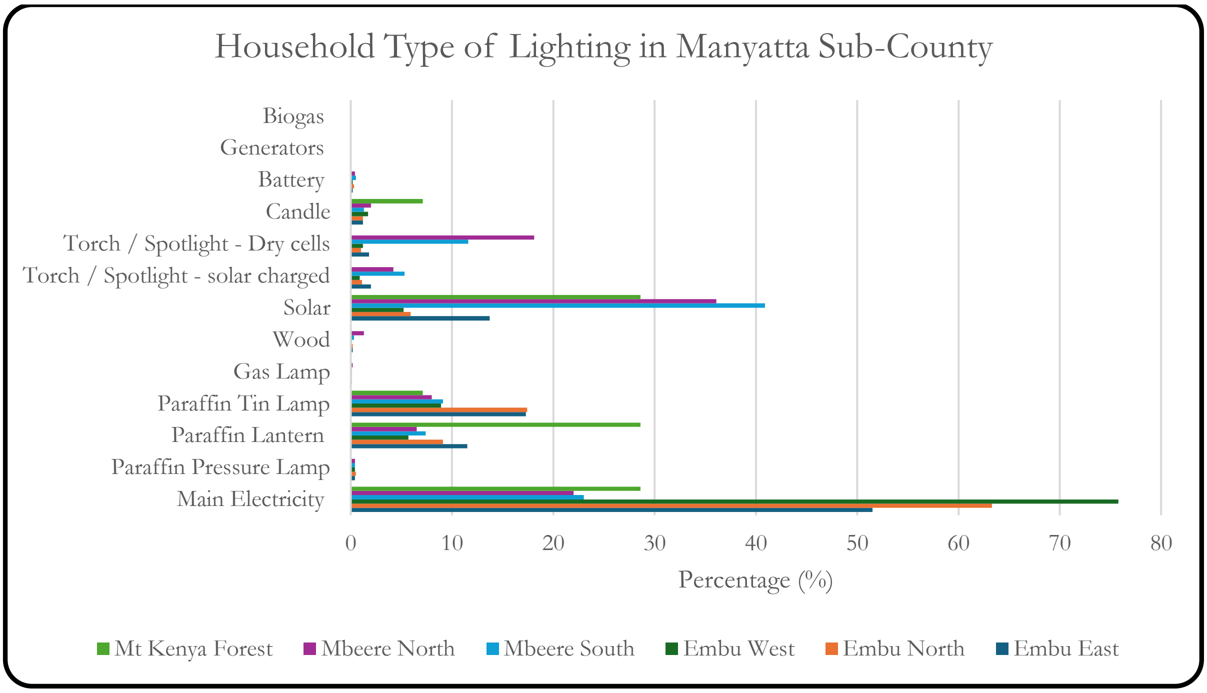


Figure 3-4: Household type of lighting in Manyatta Sub-County

3.1.1.2 ELECTRICITY ACCESS FOR HOUSEHOLDS

Embu county is home to five of the seven major hydroelectric power stations in the Seven Forks cascade: Masinga (40MW), Kamburu (94.2MW), Gitaru (225MW), Kindaruma (44MW), and Kiambere (144MW). Combined, these facilities contribute 543.2 megawatts, which is about 80.2% of the national installed hydroelectric capacity. This electricity is primarily evacuated to the national grid, with limited local benefit to surrounding communities[31]. At the sub-county level, Runyenjes and Manyatta sub-counties, only 21.2% of households are electrified (KNBS, 2019). This low rate restricts access to basic services like lighting, healthcare, education, and digital communication, and stifles local economic potential.

Figure 3-5 show the substations and distribution network within the county. The 2024 distribution grid network map for Embu County features three substations located in Embu East, Kyeni, and Runyenjes. The grid network, shown in light green lines, is denser in the Manyatta and Runyenjes sub-counties, reflecting higher electrification coverage, while the Mbeere North and South exhibit sparser distribution.

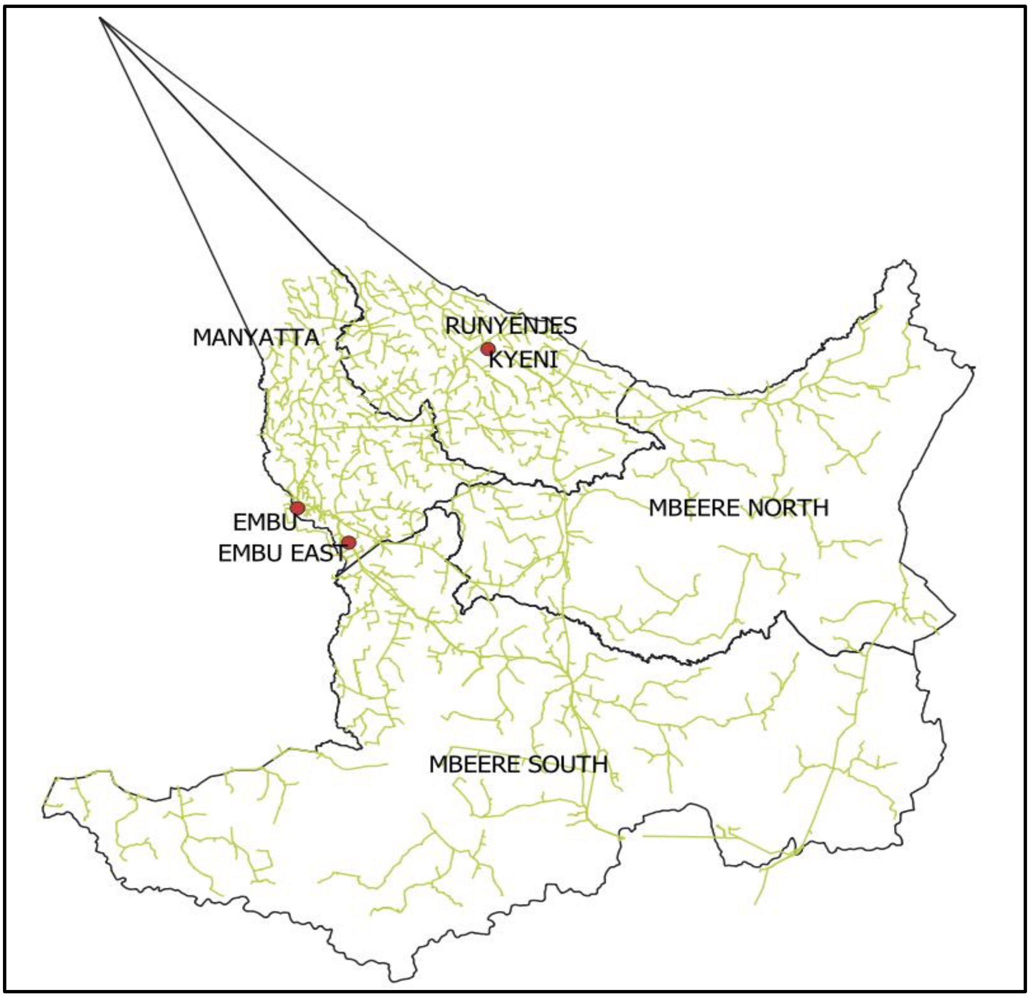


Figure 3-5: National Grid Distribution Network & Substation

[31] KNBS - 2023/24 Kenya Housing Survey – Basic Report

Findings from baseline survey indicate electricity access stands at **57.43%**, with 259 households connected to power, while **42.57%** (194 households) still lack access. This shows that although most households benefit from electricity, a significant portion, nearly two out of every five, remains unserved. The disparity highlights underlying challenges such as rural distribution gaps, affordability, and infrastructure limitations. Expanding access would not only improve household welfare through better lighting, communication, and reduced reliance on traditional fuels but also stimulate economic activities, education, and healthcare services. Bridging this gap is therefore crucial for aligning Embu with Kenya's broader national goals and global commitments under SDG 7 for universal energy access.

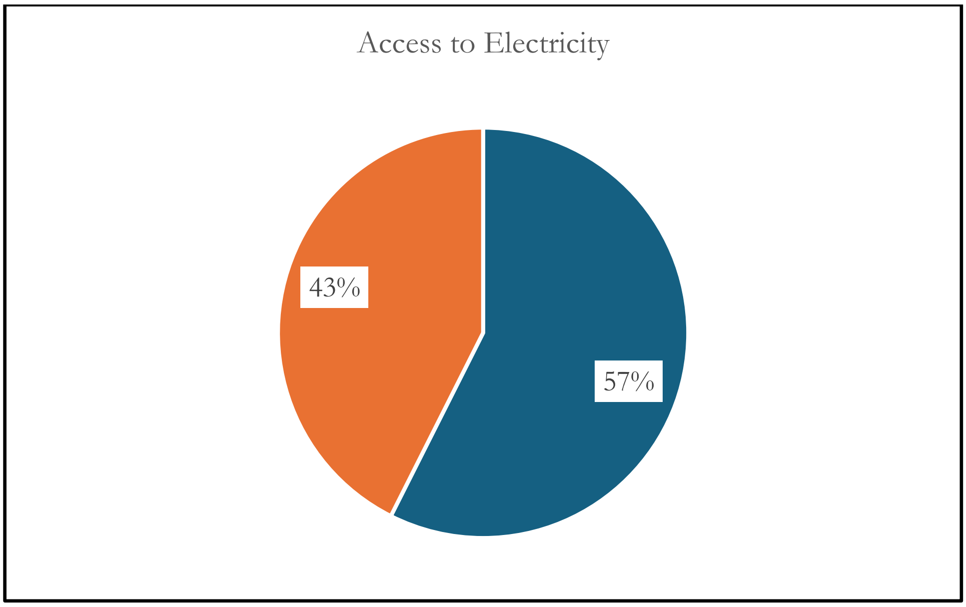


Figure 3-6: Baseline Survey on Grid Electricity Access

3.1.1.3 BARRIERS TO ELECTRIFICATION INTERVENTIONS

Figure 3-7 presents reasons why households are not connected to electricity from the main grid. Most households (47%) reported that the absence of electricity connections in their area is the reason they are not connected to the main grid[32]. This indicates a significant gap in the infrastructure and distribution of the main grid electricity network. Approximately one-third of the households cited financial constraints as the main barrier to obtaining a connection, suggesting that the initial costs associated with setting up a connection are prohibitively high for many households. Addressing such challenges requires a nexus approach bringing in improved methods and innovative technologies as well as supporting policies, financing, and socio-cultural integration.

[32] Kenya National Cooking Transition Strategy 2024 – 2028

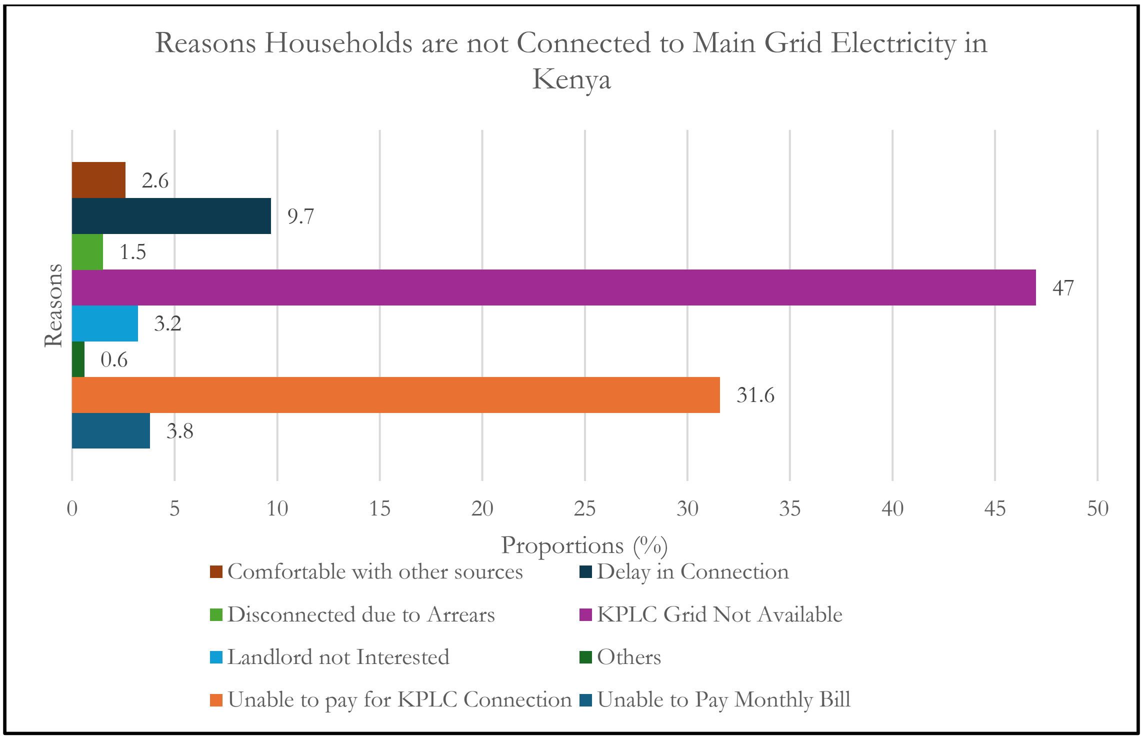


Figure 3-7: Barriers to National Grid Electricity

Findings from survey indicate majority (approximately 30%) of the household NOT CONNECTED to national grid pointed to grid being too far (or not available) to their households as the main reason. Additionally, other reasons given during the survey to not being connected to national grid include high cost of connection (19.14%), high cost of electricity (14.89%), complexity in administrative procedures (12.76%), and unreliability in the utility service (6.38%).

Findings from baseline survey indicate solar energy as both a necessity and an opportunity, particularly in areas underserved by the national grid. Communities view solar as a practical solution for lighting and small appliances, but adoption is constrained by **high upfront costs, expensive pay-as-you-go models, and recurring challenges with battery lifespan and product quality**. Residents and entrepreneurs alike noted that ***unreliable suppliers, weak after-sales support, and limited technical expertise*** further undermine consumer confidence. Despite these barriers, solar remains highly valued, with strong calls for *county–private sector partnerships to reduce costs through subsidies, flexible financing models* such as chamas, and *stricter regulation to ensure quality products*. Expanding Technical and Vocational Education and Training (TVET) programs to train local youth and women as technicians was consistently emphasized as both a service need and a job creation opportunity.

1. There are multiple actors including KenGen, KPLC, REREC, MPs, county government & MCAs, contractors, and local technicians who are undertaking electrification activities **without a coordinated county energy plan**. This has resulted in duplication, gaps, inequitable access and an avenue for illegal activities due to lack of proper identification.
2. KenGen's generation mandate creates community expectation for local electrification which they are not mandated to provide, producing perceived unfairness.

3. KPLC's commercial constraints and procedural bottlenecks such as long delays for final drops/metering, perceived requirement for title deeds, slow mapping and issuing of quotations discourage timely connections.
4. The period between REREC handing over a distribution line to KPLCs and the final connection and metering to the household is long. The application fee for final drop and metering is also out of reach for households leaving many households unconnected despite being within 600m of the transformer.
5. Complex land tenure issues such communal land, succession and the requirement for title deeds or land number cause connection delays and informal/illegal solutions.
6. Illegal connections, meter theft, and impersonation of technicians are recurring, causing safety risks, revenue loss and repeated dismantling of work.
7. Absence of a common digital/physical mapping and plan leads to transformer overloading or under-utilization, double mapping, and haphazard grid extension.
8. Lack of local KPLC presence and limited local capacity for minor repairs increases outages and reliance on unlicensed technicians.
9. Where grid is not feasible, small-scale solar systems supplied through PAYGO model exist but lack local service centers, spare-parts stock and consumer protections against high interests.
10. Safety, awareness and firefighting capacity at sub-county level are insufficient where new electrification occurs.

These barriers lead to inequitable access, safety hazards, loss of trust, system inefficiency, revenue loss, and poor use of energy for socio-economic development. There is need to address these barriers through a series of targeted interventions to streamline the electrification process.

3.1.1.4 OnSSET MODELLING FOR HOUSEHOLD LEAST COST ELECTRIFICATION

The electrification modelling for Embu County was undertaken using the OnSSET framework, incorporating demographic, technical, and economic parameters. The model applied a prioritization value of 6, enforcing grid connections within buffer zones while allowing least-cost options beyond. An auto-intensification distance of 6 km was used to account for automatic grid densification. The discount rate was set at 10%. Population was projected to grow from 661,690 in the base year to 719,716 in the end year, with the urban population ratio decreasing from 0.1137 to 0.1099. Average household sizes were assumed at 3.2 persons (urban) and 3.4 persons (rural) by the end year.

Electrification rates in the base year were set at 53% overall, comprising 71% urban and 32% rural. The grid generation cost was estimated at 0.33 USD/kWh, with power plant capital costs of 1,700 USD/kW, grid losses of 23.65%, and a base-to-peak demand ratio of 0.8. Grid infrastructure assumptions included MV line costs of 7,000 USD/km, LV line costs of 4,250 USD/km, HV line costs of 53,000 USD/km, and a HV/MV transformer cost of 25,000 USD/unit. Capacities were set at 33 kW/line (MV) and 0.24 kW/line (LV), with maximum line lengths of 50 km (MV) and 0.5 km (LV). The maximum grid extension distance was limited to 50 km, with an MV cost increase rate of 10%. Grid expansion constraints included a limit of 12,000–15,000 new connections annually and grid capacity additions capped at 100 MW (intermediate) and unrestricted in the end year. The following sub-section outlines modelled approaches for achieving universal electrification by 2035 in the county.

3.1.1.4.1 Household Electrification Technologies 2025- 2030

Figure 3-8 illustrates the recommended electrification technologies for achieving universal electricity access by 2030, based on a least-cost planning approach. Wards marked in light blue (Grid2030) represent areas where grid extension or densification is the most viable option, primarily concentrated in majorly in Manyatta and Runyenjes Sub-counties, and Evurore ward. In contrast, wards shaded in darker blue (SA_PV2030) indicate areas where stand-alone photovoltaic systems, such as solar home kits, are more suitable, covering much of Mbeere North and Mbeere South sub-counties. The distribution highlights a strategic balance between grid expansion in more accessible areas and off-grid solar deployment in lower-density or remote regions, consistent with Kenya's Vision 2030 electrification strategy.

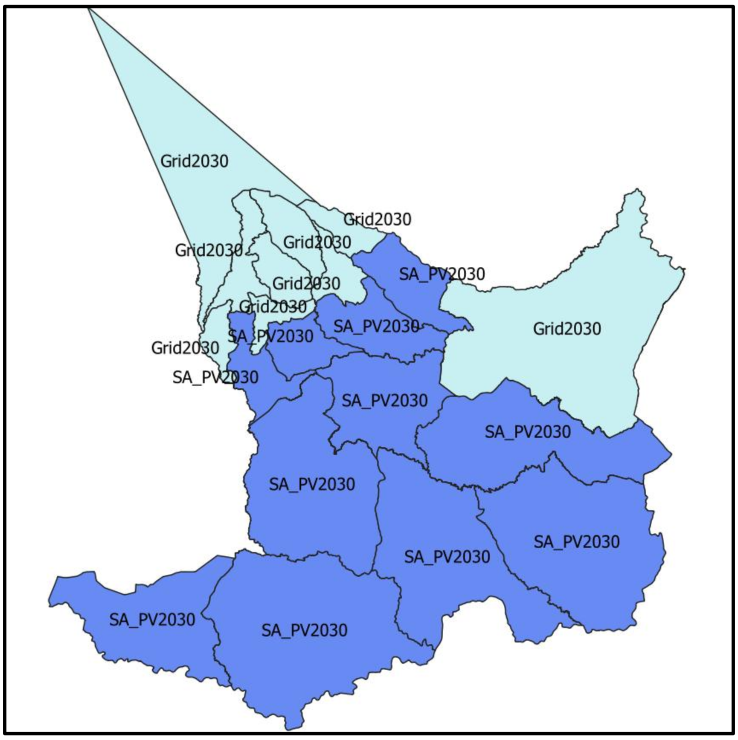


Figure 3-8: Electricity Source for Universal Electrification by 2030

Legend	
	Solar PV
	Grid Connection

3.1.1.4.2 New Household Grid Connections

Figure 3-9 and Figure 3-10 illustrates ward-level estimates of new grid connections required to achieve universal electrification by 2030, with a color gradient from light to dark blue representing increasing demand. High-demand wards that Evurore, Nginda, Mbeti North, Mbeti South, Mavuria, Nthawa, Mwea, and Makima wards have the highest number of new connections. Wards such as Kirimari and Mbeti North ward will require highest number of new connections by 2030 with 20,470 and 25,467 connections, while the Evurore ward records the highest requirement at 36,810. In contrast, wards that include Gaturi South and Kiambere wards need the lowest number of new connections with 9,368 and 10,400 connections. This distribution underscores the diverse electrification needs across the county and emphasizes a strategic focus on grid expansion, reflecting population density, infrastructure gaps, and geographic factors in line with Kenya's Vision 2030 electrification agenda.

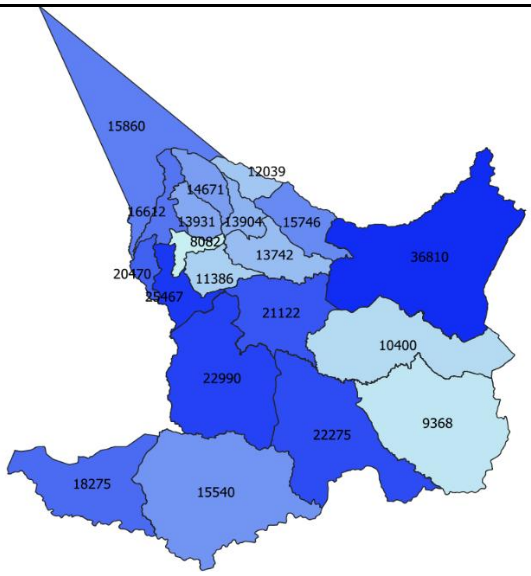


Figure 3-9: New Electricity Connection 2025 - 2030 per ward

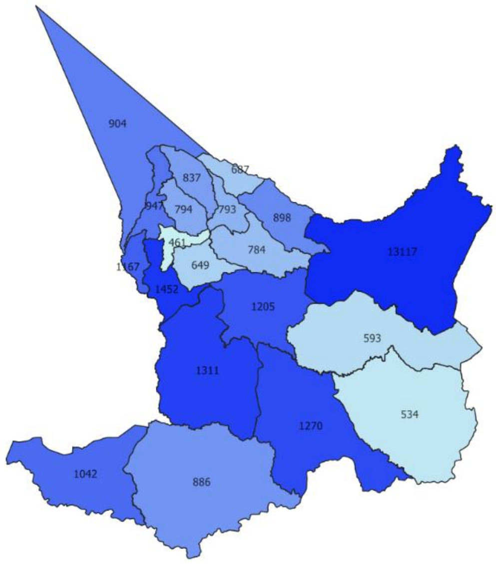


Figure 3-10: New Electricity Connection 2030 – 2035 per ward

3.1.1.4.3 New Household Solar PV Systems

Figure 3-11 and Figure 3-12 illustrate ward-level solar-based electrification needs indicated in varying levels of stand-alone PV deployment required to achieve universal access by 2030. Darker shades indicate higher demand, with the wards that include Evurore, Nginda, Ruguru-Ngandori, Kaagari North, Gaturi, and Kyeni North showing the greatest need for solar installations. In contrast, wards that include Mwea, Makima, Mavuria, and Muminji require lower number of solar PV due lower population densities. Overall, the distribution emphasizes a strategic focus on deploying solar technologies in the specific wards complementing grid expansion efforts and supporting Kenya's Vision 2030 electrification agenda.

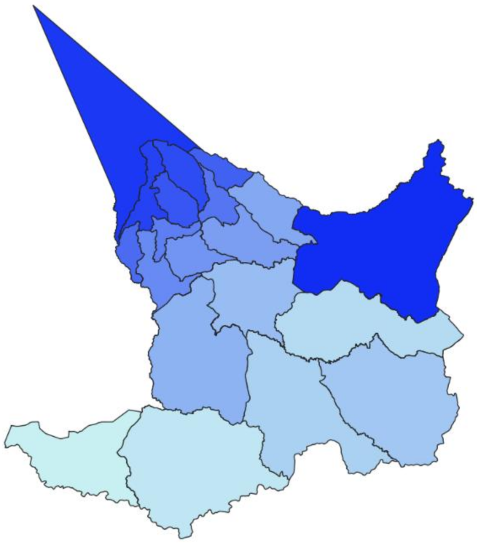


Figure 3-11: Solar PV 2030

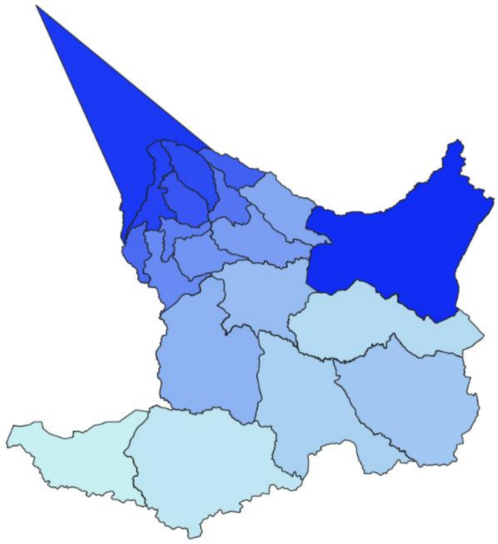


Figure 3-12: Solar PV 2035

3.1.1.4.4 Electricity Access Investments

Figure 3-13 illustrates ward-level investment needs towards electrification by 2030, with wards shaded in varying intensities of blue to represent differing requirements. Darker shades correspond to higher values, majorly in wards that include Evurore, Nginda, Ruguru-Ngandori, Kaagari North, Gaturi, and Kyeni North, where grid densification and intensification are required. Although the wards in Mbeere North and South have lower electrification rates, the investment determining factor is largely driven by number of connections and population density, which are higher in the Manyatta and Runyenjes sub-counties. From the model, total required investment by 2030 is USD 22.25 million. Evurore ward requires the highest investment of USD11,178,880 by 2030. This spatial distribution highlights priority areas for targeted interventions and aligns with Kenya's Vision 2030 strategy of combining grid expansion with renewable off-grid solutions to achieve universal access.

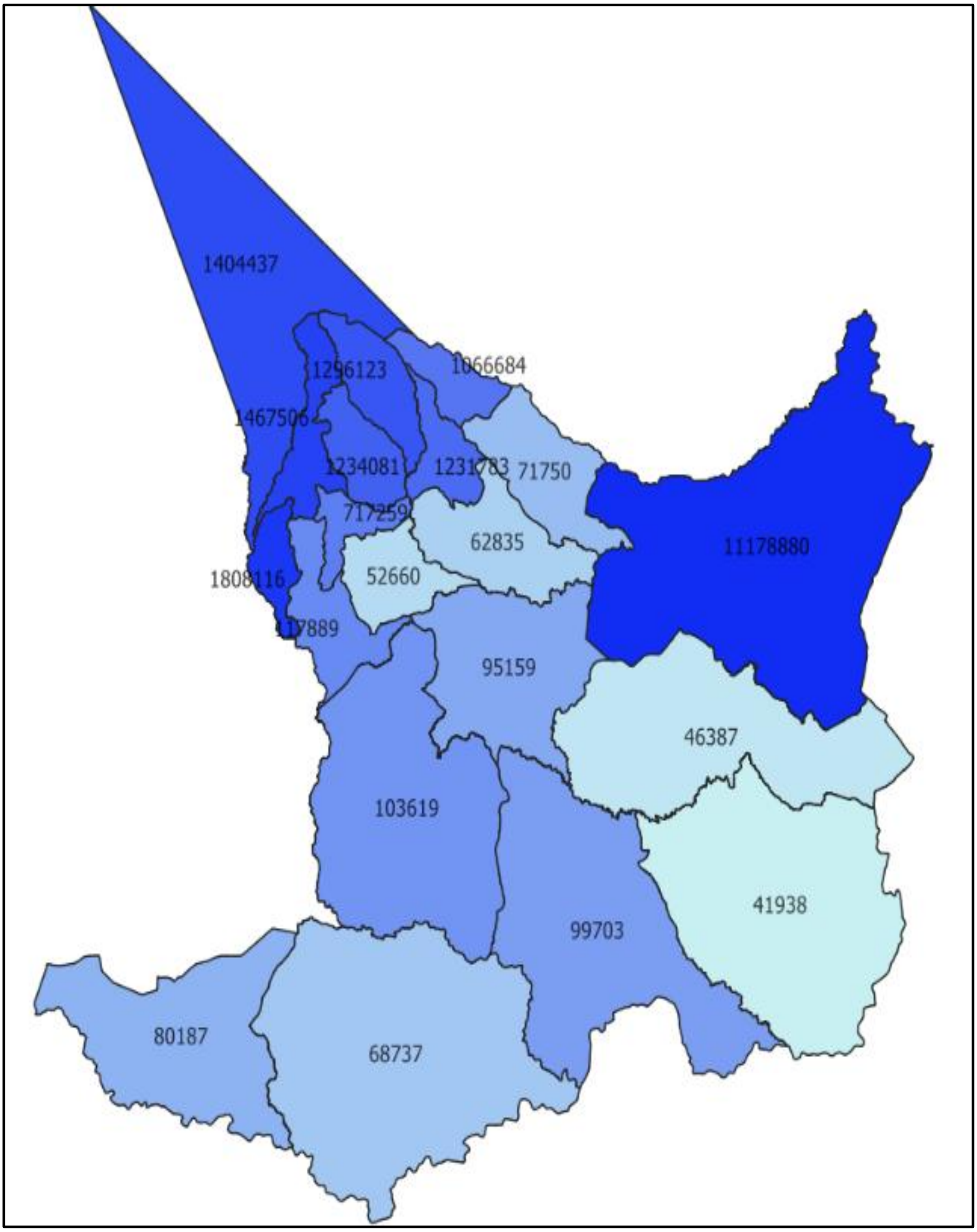


Figure 3-13: Investment Required by 2030 per Ward (USD)

3.1.1.4.5 Summary of Least Cost Electrification

The projections indicate that by 2030, Embu County will require approximately **338,688 new electricity connections** to serve a population of about 689,384, with a total additional capacity of 5 MW and an investment of USD 22.25 million. Most of these connections will come from **grid expansion (152,377 connections, 4 MW, USD 21.4 million)** and stand-alone solar PV systems (**186,310 connections, USD 0.84 million**). By 2035, the county's population is expected to rise to 719,716, with an additional **30,331 new connections needed**, requiring only 1 MW of extra capacity and **USD 2.68 million in investment**, largely from grid (16,599 connections) and solar PV (13,732 connections). Other technologies such as diesel, mini-grids, wind, and hydro show no projected contribution within this period.

Table 3-1: Least Cost Electrification

	Population2030	NewConnections2030	Capacity2030 (MW)	Investment2030 (million USD)	Population2035	NewConnections2035	Capacity2035 (MW)	Investment2035 (million USD)
Grid	304637	152377	4	21.4	208703	16599	1	2.66
SA_Diesel	0	0	0	0	0	0	0	0
SA_PV	384746	186310	0	0.84	511012	13732	0	0.02
MG_Diesel	0	0	0	0	0	0	0	0
MG_PV	0	0	0	0	0	0	0	0
MG_Wind	0	0	0	0	0	0	0	0
MG_Hydro	0	0	0	0	0	0	0	0
Total	689384	338688	5	22.25	719716	30331	1	2.68

3.1.1.5 PROPOSED ELECTRIFICATION SOLUTIONS FOR HOUSEHOLDS

A. Governance & Planning

a) County Distribution & Electrification Masterplan

- This plan proposes the creation of a consolidated GIS based County Distribution and Electrification Masterplan (CDEM) owned by KPLC & REREC and informed by the least cost electrification modelling done in this CEP.
- This CDEM should contain mapping of areas without electricity, demand projection, priorities for grid optimization and grid extension, transformer load studies, and formal update procedures.
- The anticipated outcome is a single source of truth for all electrification work regardless of the stakeholder undertaking the work.

b) Ward-level Project Management Committees (PMC)

- This project proposes the establishment of a ward level community led Project Management (PMC) hosted at the Ward Administrators office. This committee should have at least one vetted local technician.
- The PMC technician will be responsible for maintaining a list of all licensed technicians in the ward, recommending them to the community for wiring services, permitting them to carry out low level maintenance works on KPLC lines in consultation with KPLC office, accompany contractors to carry out work with the ward, maintain local ledger of new connections and meter serial numbers.

c) Permit & ID system

- This plan proposes that all works on lines require written permit from the Ward Administrators office. Technicians carrying out these works should also have a visible ID badge bearing their name, photo and organization.
- This plan also proposes that the PMC technician validates that the person has carried out the work permitted to the required standards, and no other illegal work or substandard work is done.
- It is also proposed that the Ward Administrator's office maintains a record of installed meters and installations done to prevent circulation of stolen meters.

d) Stakeholder coordination forum

- This plan proposes quarterly coordination between County Energy Dept, KPLC, REREC, MP representative, MCA representatives, contractors on the ground and PMC technicians to review progress of electrification projects. This coordination is meant to ensure the projects being implemented are following the CDEM.

B. Grid Optimization Before Extension

a) Transformer optimization programme

- This plan proposes that the CDEM should contain an audit of utilization; redistribution of loads and propose an upgrade or new installation of additional transformers where overloading is experienced.
- The CDEM should also propose optimization of under-utilized transformers especially those within schools to serve nearby households.

b) ***Standards & local workmanship quality control***
   - It is proposed that PMC Technician inspects contractor work such as pole spacing, pole depth, height, and fittings. Contractor work must meet KPLC technical specifications.

C. Transparent, Affordable Connection Process

a) ***Streamlined connection requirements***
   - This plan reaffirms the legal requirements of **land reference number, Identity card and KRA Pin** as being sufficient for connection to the national grid.
   - The plan proposes that KPLC to publish simplified connection processes, service charge charts at their offices, website and in marketplaces at the subcounty level to increase awareness against extortionists that have infiltrated the sector.

b) ***Fast-track final drop & meter installation program***
   - KPLC to set target turnaround times for final drops and metering after REREC handover. To speed up this process, KPLC should work with local technicians under the supervision of PMC Technician to speed this process.

c) ***Subsidy scheme***
   - County Government to work with REREC through the matching fund scheme to subsidize connection cost for vulnerable households, reduce variability of quotations and prioritize connections within 600m radius first.

d) ***Joint application / community pooling support***
   - County government to facilitate joint applications by offering administrative help (Ward office to collect forms, hold meetings) and flexible pooling models to reduce social friction.

D. Local Capacity, Jobs & Safety

a) ***Community Technician Registration & Training***
   - This plan proposes that the PMC technician maintains a register of all local electricians in the ward office. The county Government should use this register to sponsor training within the VTCs to enhance the capacity of wards which do not have sufficient technicians.
   - These trained technicians should be equipped to become first responders for low risk works such as fuse replacement, tree trimming, digging of holes and pulling of cables under KPLC oversight.

b) ***Local KPLC service points***
   - This plan proposes that KPLC should organize for monthly help desk services at the subcounty offices to address client complaints such as, payments, token top-ups, and collection of new applications.

c) ***Contractor local labor policy***
   - It is proposed that contractors hire local casual labour for tasks such as pole digging and pulling wires and prioritise registered local technicians for this work. These technicians should be availed to the contractors when they report at the ward administrator's office to get their permit for the work they intend to carry out.

E. Anti-Fraud, Meters & Consumer Protection

a) ***Meter registry & tagging***
   - This plan proposes that all billing meters installed by any stakeholder must be registered at Ward office and recorded in KPLC database with meter ID/serial number, customer name, geo location and outstanding loan balance (if any).

b) ***Procurement & handling control for meters***
   - It is proposed that KPLC strengthens chain of custody for meters & rapid reporting/forensic tracing for stolen meters. All meters reported stollen should be discontinued from service remotely.

c) ***PAYGO consumer protection***
   - The County should advocate for national cap on PAYGO interest and require transparent loan balances to be readable on meters or via SMS.

F. Off-Grid Alternatives Where Grid Is Uneconomic

a) ***Solar PV service network***
   - This plan requires service providers operating in Embu to have subcounty service points or registered agents, and to stock spare batteries for temporary swaps.

b) ***Backup battery & spare-parts program***
   - This plan encourages service providers to stock common spare parts (batteries, inverters) at subcounty depots.

G. Awareness, Safety and Emergency Response

1. ***Community electricity safety & productive use roadshows***
   - County department of energy and the department of education to run roadshows and training on electrical safety, safe wiring, and productive uses (agro-processing, cold storage). Include firefighting training for electrical fires.
2. ***Subcounty firefighting capability***
   - The county government should ensure county fire department has equipment and personnel in each subcounty.

Table 3-2: Summary of Proposed Electrification Solutions for Households

Project / Program	Description	Stakeholders Responsible	Expected Outcomes	Prioritization & Phasing	Performance Indicators
County Distribution & Electrification Masterplan (GIS mapping + model)	Develop a comprehensive GIS-based electrification masterplan to guide distribution, planning, and modeling for countywide access.	County Energy Dept, KPLC, REREC, Donors/consultants, Ward PMCs, KenGen.	Clear roadmap for electrification; optimized grid expansion; reduced duplication of efforts.	**Short-term (Years 1–2)** – foundational activity to guide all other programs.	Masterplan completed; % of wards mapped; GIS database operational.
Ward Project Management Committee rollout	Establish and operationalize Ward-level PMCs to coordinate energy projects and monitor implementation.	County Administration, County Energy Dept.	Improved project oversight; stronger community participation; accountability in implementation.	**Short-term (Years 1–3)** with ongoing strengthening.	% of wards with active PMCs; frequency of project monitoring reports.
Permit & ID system (digital and paper logbooks)	Create a digital and paper-based permit/ID system for technicians and contractors.	Ward Administrators, County ICT, PMC Technician.	Better regulation of field technicians; reduced fraud; enhanced transparency.	**Short-term (Years 1–3)**.	# of permits issued; % of technicians registered; system uptime/usage rates.
Transformer audit & upgrade programme	Conduct audits on existing transformers and implement necessary upgrades.	KPLC, County funding partners.	Reliable electricity supply; reduced outages; capacity for future demand growth.	**Short to Medium-term (Years 1–5)**, phased by subcounty priority.	% of transformers audited; # of transformers upgraded; reduction in outages.
Local KPLC/REREC subcounty service desks	Establish service desks at subcounty level.	KPLC, REREC, County Government.	Improved customer service; faster response; stronger local presence.	**Short-term (Years 1–3)**.	# of service desks established; average complaint resolution time.
Fast-track meter/drop program	Accelerate meter installations and service drops with SLA targets.	KPLC, PMC oversight.	Increased connections; shorter waiting times; enhanced customer satisfaction.	**Short to Medium-term (Years 1–4)**.	Average time to meter connection; # of new connections/year.
Last-Mile subsidy fund & prioritisation mechanism	Develop a subsidy fund and transparent framework to extend last-mile connectivity.	County Govt (Energy, Agriculture, Finance), REREC, donors.	Increased rural access; equitable distribution; inclusive electrification.	**Medium-term (Years 3–6)**, after initial planning frameworks are in place.	% of households benefiting; subsidy disbursed; increase in access rates.
Community Technician registration, training & VTC scholarships	Register and train technicians; provide scholarships via VTCs.	County Education Dept, County Energy Dept, VTCs.	Skilled local workforce; youth employment; sustained technical support.	**Short to Medium-term (Years 1–5)**, continuous thereafter.	# of technicians registered/trained; # of scholarships awarded; graduate employment rates.
Solar PV service centre network & PAYGO regulation advocacy	Establish PV service centres; advocate for PAYGO regulation.	County Energy Dept, private service providers, national regulators.	Reliable solar service; affordable PAYGO; consumer protection.	**Medium to Long-term (Years 4–8)**.	# of service centres established; # of PAYGO customers; adoption of regulation.
Meter Registry & chain-of-custody strengthening	Improve registry and accountability in meter handling.	KPLC, Ward Admin, County ICT.	Reduced meter losses; transparent allocation; improved asset management.	**Short-term (Years 1–3)**.	% of meters tracked in system; discrepancy reduction rate.
Public awareness & safety roadshows; firefighting capacity	Roadshows on safety; improve firefighting readiness.	County Energy Dept, Fire Service, Education Dept.	Increased safety awareness; reduced accidents; stronger emergency response.	**Continuous (start in Years 1–2, ongoing annually).**	# of roadshows held; % of population reached; response time of fire units; # of incidents reduced.

3.1.1.6 RISKS AND MITIGATION MEASURES

1. **Political interference in prioritization**: This can be mitigated by involving the political representatives in developing the County Distribution and Electrification Masterplan (CDEM), publish decision criteria and requiring that all public funded electrification works to align with this masterplan.
2. **Resistance from informal technicians**: This can be mitigated by registering informal and unlicensed technicians for training and offering job opportunities equivalent to their skill during project execution.
3. **Funding shortfalls**: This can be mitigated through a phased implementation plan, leveraging on annual funding allocations from REREC, KPLC, County government and donor schemes, subsidy schemes and NG-CDF all tied to the CDEM.
4. **Data divergence / double mapping**: This can be mitigated by through the CDEM that is periodically updated to reflect new projects and changes in demand.

3.1.2 CLEAN COOKING FOR HOUSEHOLDS

3.1.2.1 BASELINE COOKING ASSESSMENT IN EMBU COUNTY

3.1.2.1.1 Rural- Urban Distribution of Households

Embu County presents a dynamic yet challenging landscape in terms of household cooking energy demand, energy sources, and the appliances used. According to recent statistics from the Kenya National Bureau of Statistics (KNBS), the county has a total of 199,046 households. Of these, 15% (about 30,653 households) reside in urban areas, while a significant 85% (168,393 households) are in rural parts of the county as shown in Figure 3-14. This urban-rural distribution plays a major role in shaping cooking energy consumption patterns.

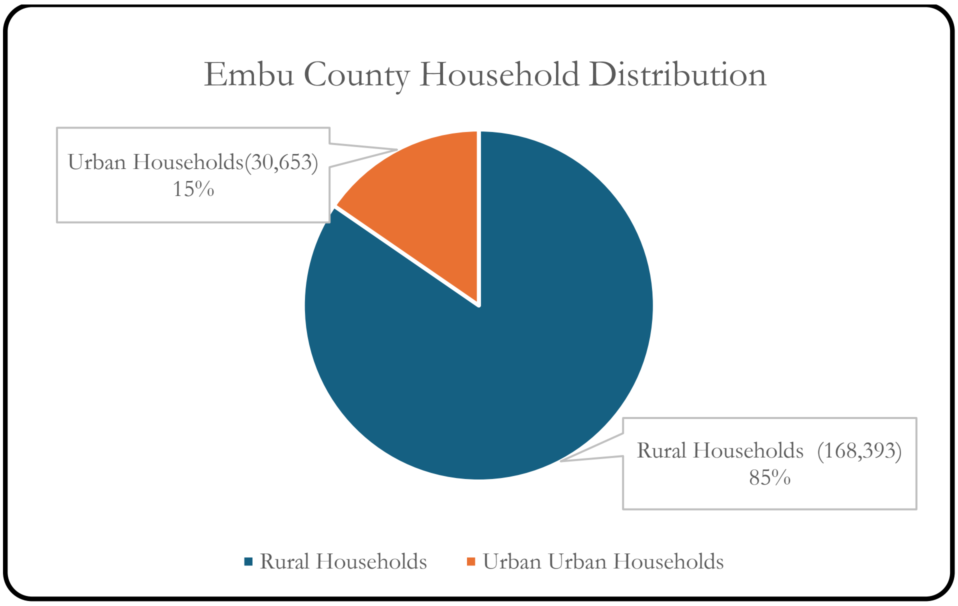


Figure 3-14: Embu Household Distribution (Source: KNBS - 2023/24 Kenya Housing Survey – Basic Report)

3.1.2.1.2 Distribution of Households by Primary Cooking Fuel

Most households in Embu continue to rely heavily on traditional and unclean sources of cooking energy. Firewood is the predominant source, used by approximately 71.6% of households. This is particularly prevalent in rural areas where firewood is often readily available and culturally embedded as the main cooking fuel. Charcoal is used by 3.7% of households, while only a small proportion, 0.7% use electricity from the national grid (KPLC) for cooking. Liquefied Petroleum Gas (LPG), a cleaner alternative, is used by 22.2% of households as shown in Figure 3-15.

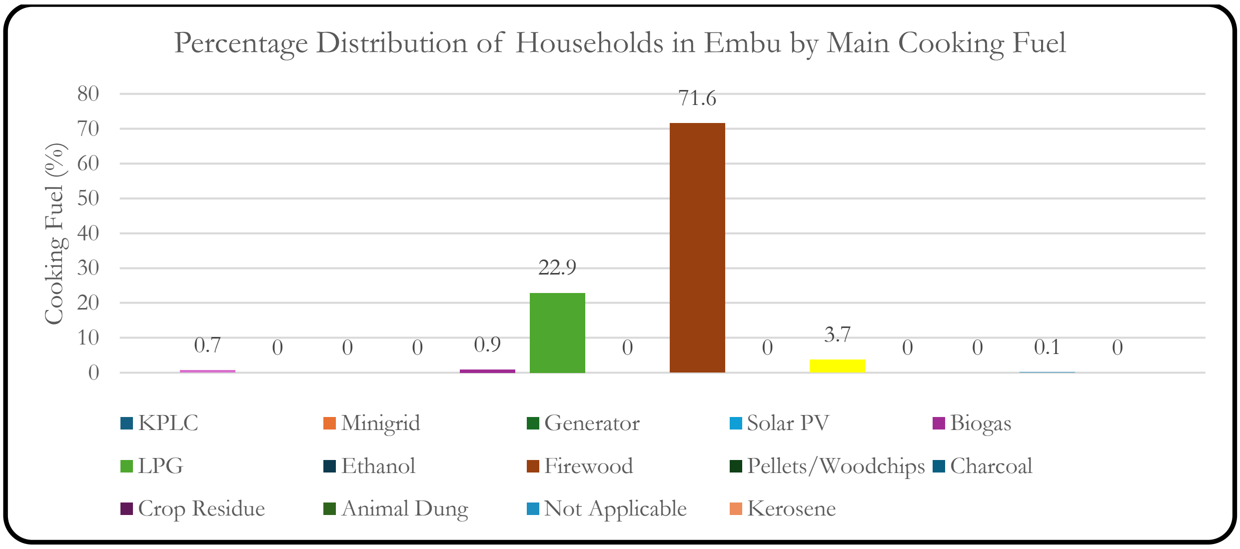


Figure 3-15:Distribution of Households in Embu by Main Cooking Fuel (Source: KNBS - 2023/24 Kenya Housing Survey – Basic Report)

In total, only 24.6% of households in Embu use clean energy sources for cooking, while a staggering 75.4% depend on unclean fuels as shown in Figure 3-16. These statistics from Embu County can be compared with the national statistics in Kenya where approximately one-third of households (33.3%) cook using appliances that run on clean fuels. Most of these households use LPG, which accounts for 31.6%, while a smaller portion, 1.7% use ethanol stoves. On the other hand, nearly half of all households in Kenya (49.7%) still rely on the traditional three-stone stove or open fire, both of which are considered unclean cooking methods.

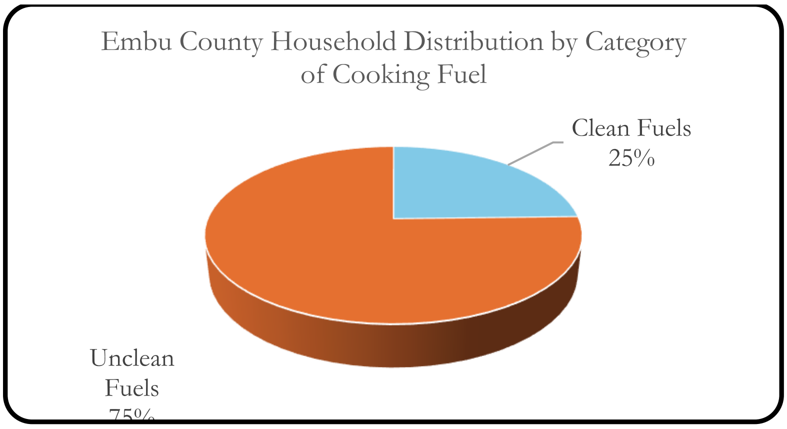


Figure 3-16:Distribution of Households in Embu by Category of Cooking Fuel

Source: KNBS - 2023/24 Kenya Housing Survey – Basic Report

Further analysis on energy usage in Embu Sub-Counties indicates that a significant majority of the population use firewood as their primary energy source for cooking. The trend was prominent across all the sub-counties. Although Embu West indicated a low firewood usage compared to other regions, charcoal is heavily used as primary energy source as indicated in Figure 3-17.

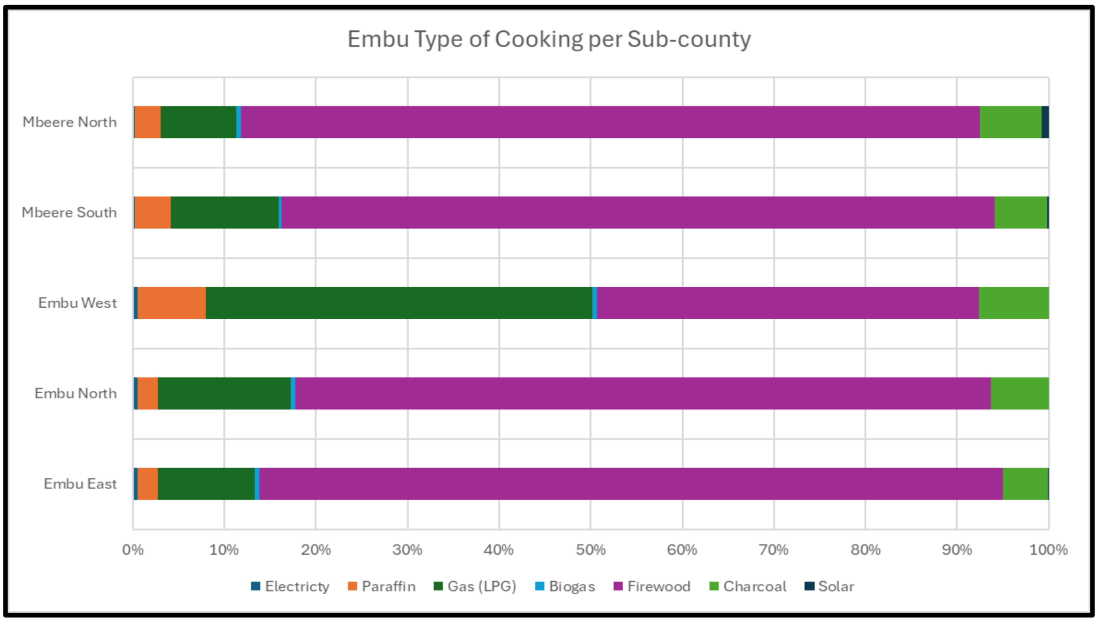


Figure 3-17: Distribution of Households in Embu region by type of cooking fuel

The implications of this reliance on traditional fuels are profound. Burning firewood and charcoal contributes significantly to indoor air pollution, exposing household members especially women and children to respiratory infections, eye irritation, and long-term health complications. Environmentally, the demand for firewood and charcoal exacerbates deforestation, soil degradation, and carbon emissions, contributing to the broader challenges of climate change and environmental sustainability.

Addressing these issues requires a multifaceted approach. There is a need to scale up public awareness campaigns highlighting the health and environmental dangers of unclean fuels. Subsidies and financial incentives could encourage households to invest in cleaner alternatives such as LPG, biogas, or improved cookstoves. Furthermore, there is a big disparity in prices between clean and unclean energy sources and fuels as indicated in Figure 3-17. Therefore, improving infrastructure to ensure the availability and affordability of clean cooking fuels in both urban and rural areas is critical.

3.1.2.1.3 Distribution of Households by Primary Cooking Technology

Cooking Technologies in Embu County

The appliances used for cooking further illustrate the dominance of traditional methods. The three-stone stove, an age-old cooking apparatus that uses firewood, remains the most used cooking appliance, with 64.3% of households relying on it. Despite efforts to promote cleaner and more efficient technologies, only 24.9% of households use electric, biogas, or LPG cookers. Improved charcoal jikos, designed to be more energy-efficient than traditional stoves, are used by 6.8% of households, while 3.4% use kerosene stoves. A mere 0.6% of households continue to use ordinary charcoal stoves as shown in Figure 3-18.

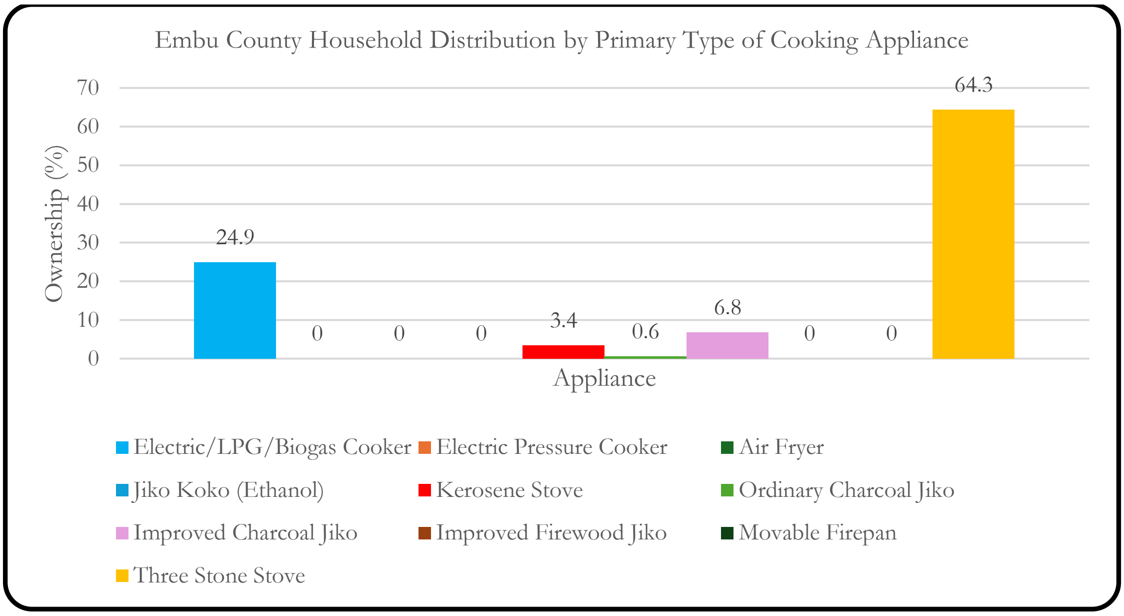


Figure 3-18: Distribution of Households in Embu by Primary Type of Cooking Appliance Source: KNBS - 2023/24 Kenya Housing Survey – Basic Report

Several factors contribute to this energy profile. Economic constraints are a major barrier to the adoption of clean energy technologies. Many households in rural Embu cannot afford the upfront cost of LPG cylinders, biogas systems, or electric cookers, even if they recognize the health and efficiency benefits. Limited education and awareness about the dangers of indoor air pollution and the advantages of clean cooking also hinder the transition. Additionally, accessibility issues particularly in remote areas make it difficult to obtain LPG refills or maintain consistent biogas supply.

Cooking Technology Market Share in Embu County

Table 3-3: Cooking technology market share (Baseline survey, 2025)

Technology	Rural Share (%)	Urban Share (%)
Biogas digester + biogas stove	2	1
Biomass forced-draft stove (wood)	3	2
Charcoal Improved Cookstove (ICS)	5	8
Improved Firewood Stove (masonry)	10	3
Traditional 3-stone firewood stove	55	5
4-burner electric cooker	1	10
KOKO ethanol stove	0	3
Kerosene stove	2	6
LPG cylinder + burner	12	55
Pellet forced-draft stove	0	2
Traditional charcoal stove	10	5
TOTAL	100	100

Average Prices of Cooking Technologies in Embu County

Table 3-4: Average Prices of Various Cooking Solutions in Kenya (Source - Kenya National cooking transition strategy 2024-2028)

Fuel used	Stove	Cost
Electricity	Electric Pressure Cookers	**KES 7,995 - 20,995 (US$55-145)**
	Electric Hotplates	**KES 1,000 - 8,495 (US$7-59)**
	Gas burner with hotplate	**KES 10,995 - 11,995 (US$76-83)**
	Induction cooker	**KES 8,750 (USD$61)**
	Microwaves	**KES 9,495 - 23,600 (US$65-163)**
	Air fryers	**KES 8,995 - 23,000 (US$62-159)**
	Rice cookers	**KES 4,400 - 12,495 (US$30-86)**
	Kettles	**KES 1,742 - 4,395 (US$12-30)**
	Toaster ovens	**KES 7,995 - 27,300 (US$55-188)**
	Sandwich makers	**KES 1,904 - 6,795 (US$13-47)**
LPG	3-kg LPG grill (with burner, grill, and LPG)	**KES 3,000 – 4,000 (US$21-28)**
	6-kg LPG grill (with burner, grill, and LPG)	**KES 4,000 – 5,000 (US$28-34)**
	13-kg LPG cylinder (with a double burner/ tabletop cooker and 4-burner (stand-alone).	**KES 8,000 – 50,000 (US$57-357)**
	M-gas 13-Kg LPG cooker	**No upfront cost**
Ethanol	Koko ethanol cooker	**KES 1,550 (US$11)**
Charcoal	Kenya Ceramic Jiko	**KES 250 – 500 (US$2-4)**
Biogas	Biodigester	**> KES 50,000 (US$345)**
Firewood	Portable firewood stove	**KES 400 – 500 (US$3-4)**
	Improved firewood stove	**KES 2,800 – 3,600 (US$20-25)**

In rural Embu, cooking practices are still dominated by traditional biomass, with over half of households (55%) relying on three-stone firewood stoves. This is supplemented by limited use of masonry improved stoves (10%) and traditional charcoal stoves (10%), while uptake of modern fuels remains low, with LPG penetration at only 12% and biogas or forced-draft technologies remaining niche. In contrast, urban Embu covering centers such as Embu town, Runyenjes, Siakago, and Kiritiri show a more diverse and modern cooking fuel mix. Most urban households (55%) use LPG, alongside notable adoption of electric cookers (10%), charcoal improved cookstoves (8%), kerosene (6%), ethanol (3%), and small shares of pellet use. Traditional three-stone wood stoves are rare in towns, accounting for just 5% of households. Overall, modern fuels including LPG, electricity, ethanol, and pellets are concentrated in urban areas where supply infrastructure and distribution networks are more developed, while rural households remain heavily dependent on biomass for daily cooking needs.

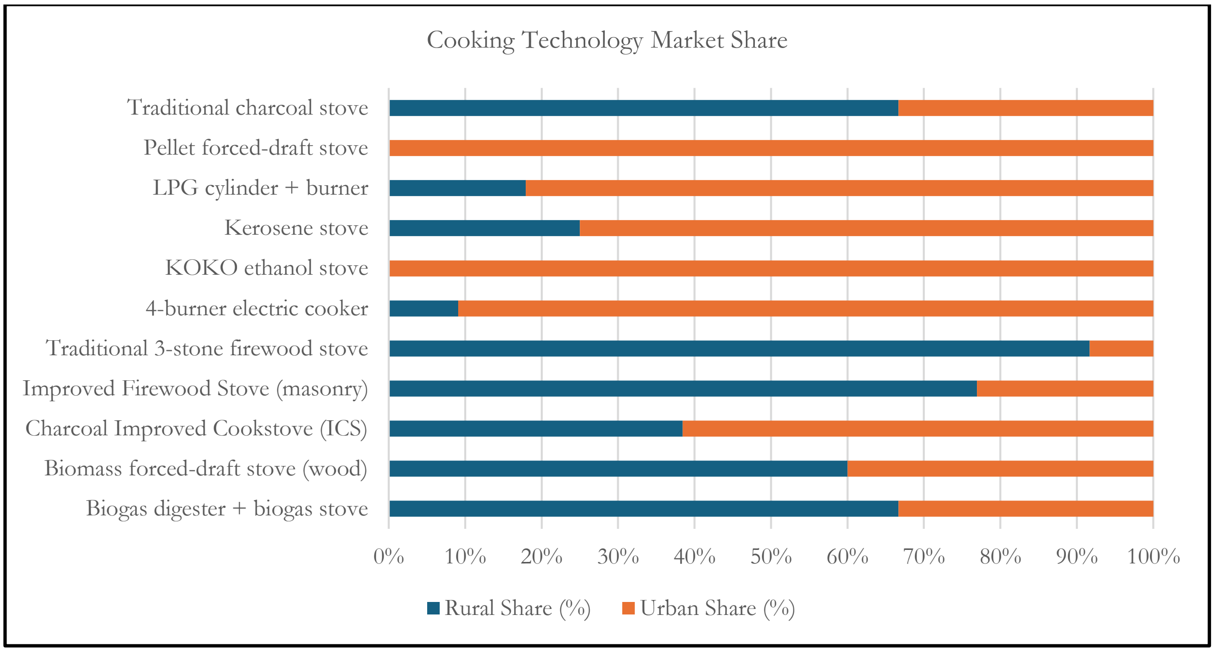


Figure 3-19: Cooking technology market share (Baseline survey, 2025)

Additionally, findings from community engagement indicate that across the county, cooking remains dominated by traditional biomass fuels, with firewood used by nearly all households and charcoal serving as a common alternative. These fuels persist due to affordability, cultural preferences, and widespread availability, but they contribute to deforestation, indoor air pollution, and health risks. LPG, briquettes, and improved cookstoves are gradually emerging as alternatives, though adoption is slowed by high upfront costs, limited rural distribution, and weak consumer awareness. Residents reported issues of corruption in LPG distribution, with half-filled cylinders discouraging uptake, while briquettes, though cleaner and more efficient, remain costly and undersupplied. Communities and entrepreneurs emphasized the potential of improved institutional and household jikos, as well as briquette production, to bridge the gap between affordability and sustainability. Aligning with the national strategy's goal of universal access to modern cooking solutions by 2028, participants called for county-led subsidies, awareness campaigns, and youth training in clean cooking enterprises to scale up local production and create jobs. By investing in these interventions, Embu can accelerate the transition to cleaner cooking, reduce environmental degradation, and improve public health outcomes.

3.1.2.2 OnSTOVE MODELLING FOR HOUSEHOLD ACCESS TO CLEAN COOKING

3.1.2.2.1 Objectives of Modelling

The goal and strategies under this section were modelled using OnStove to project future direction needed to be taken to promote clean cooking. Modelling was done with the aim of assessing clean cooking access in Embu County.

i. To establish baseline cooking technologies (three-stone fire stove and kerosene stove) for comparison.
ii. To calculate the net benefits of adopting clean cooking technologies by weighing total benefits against costs
iii. To quantify socio-economic benefits that include reduced morbidity and mortality from indoor air pollution–related diseases (COPD, IHD, lung cancer, LRI, stroke); reduced greenhouse gas and pollutant emissions; time savings from more efficient cooking methods.

3.1.2.2.2 Data Sources for Modelling

GIS and socio-economic data were gathered from resources such as: Energydata.info, Global Electrification platform, GlobalSolarAtlas.info, WorldPop, Global Human Settlement Layer, Malaria Atlas, Global Administrative Boundaries, Food and Agriculture Organization (FAO), and GridFinder.

The socio and techno-economic data was sourced from, the Kenya National Bureau of Statistics (KNBS), the Embu County Literature Review and baseline survey, the World Health Organization's BAR-HAP Tool, IRENA, IEA publications, and peer-reviewed journals.

3.1.2.2.3 Modelling Scenarios and Interpretations

OnStove produces scenarios that depict the "true" cost of clean cooking. The benefits and costs generated by the tool are interpreted as what could be expected if a *clean cooking transition were to happen immediately*. Therefore, the results from OnStove should be interpreted as an upper bound of net benefits following a switch to cleaner stoves. The tool helps to determine which combinations of interventions would be most beneficial in their respective settings.

The scenarios were:

Business-As-Usual (Reference scenario)

The BAU Scenario is based on existing information regarding GIS, socio-economic, and techno-economic data. This scenario considers the maximum net benefits from *health, time, and cost savings*. *Grid capacity installation and expansion costs were excluded from the net benefit computation*. A high discount rate was considered for this scenario, as it is often more in line with how private individuals value investments.

Social Scenario

The Social Scenario was designed to assess which technologies would offer the maximum net benefits from a social perspective. This perspective assumes that universal clean cooking access would provide the greatest benefits to households and the environment, with no emissions or spillovers. This scenario considers maximum net benefits from health, time, cost savings, environment, and spillover benefits. This scenario also included grid capacity installation and expansion costs in the computation of net benefits, and a lower discount rate value was used. Policy interventions of taxes were also considered.

Technologies Considered

For all scenarios, the following cooking technologies were considered for modeling clean cooking access in Embu County: three-stone open fire stoves, kerosene stoves, improved cookstoves (charcoal and firewood), pellet stoves, LPG, bioethanol, electricity, and biogas. These technologies represent the primary modes of cooking across all sectors of the county.

3.1.2.2.4 Selection of Clean Cooking Interventions

Business-As-Usual (BAU) Scenario

The map in Figure 3-20 shows who should cook with what and where to invest to achieve universal access to clean cooking transition in Embu by 2028 for maximum net benefits. More than one clean cooking technology is selected for maximum net benefits in a single region, because resources may not be sufficient for one technology. Figure 3-21 shows the number and percentage of people that would accrue maximum net-benefits in terms of health, time and costs if by potentially transitioning to cooking technologies such as improved cookstove (ICS), Liquified Petroleum Gas (LPG) and biogas. The distribution is dependent on the available resources, such as biomass in an area for charcoal, availability of manure for biogas production, and possibility of transporting LPG to households in consideration of motorized friction and travel time in the county.

BAU Scenario

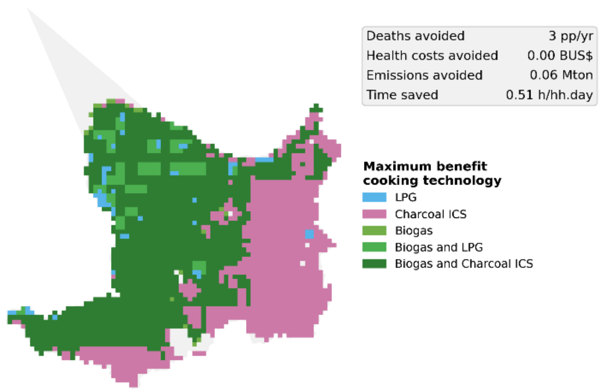


Figure 3-20: Clean cooking technology share for universal clean cooking transition in Embu County – BAU Scenario

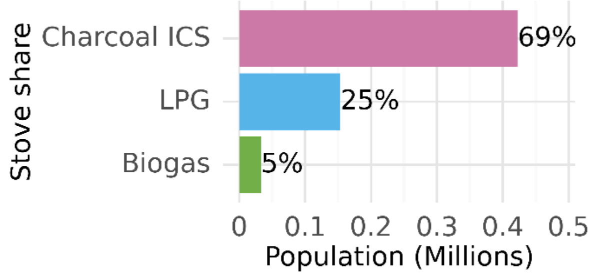


Figure 3-21: Stove share technology among households in Embu County – BAU scenario

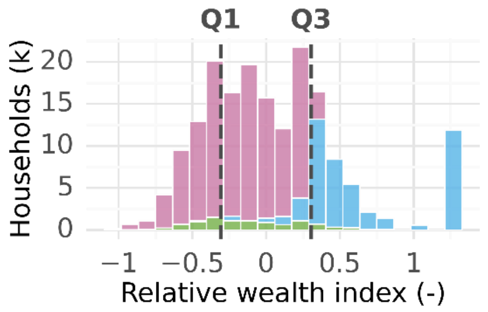


Figure 3-22: Suitable stoves for populations under different wealth index – BAU Scenario

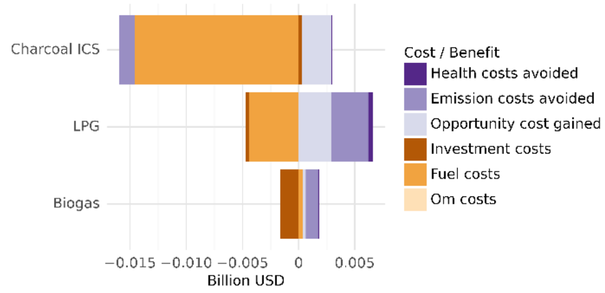


Figure 3-23: Net benefits vs Costs of transition in Embu County – BAU scenario

Figure 3-22 shows the cooking stove that could be adopted by different categories of households in terms of their wealth index. This figure shows that LPG would be ideal cooking solution with maximum net benefits in areas where populations with a high relative wealth live. Improved charcoal stove and Biogas are good clean cooking populations for households with low relative wealth index, however, affordability for these technologies could be an issue. Improved charcoal stove and biogas are suitable clean cooking transitions in rural areas. Adoption of Improved charcoal stove and biogas could however be a challenge in rural areas due to affordability constraints.

Table 3-5 shows that Embu County needs an investment cost of about 6.2882 million USD to transition using these cooking technologies. On the other hand, we would avoid 3 deaths per 100,000 cases of indoor air pollution related diseases yearly, health costs would be reduced by 0.5998 MUSD & 0.0.0595 million ton of CO2 equivalence would be reduced per year, and the average household would save around 0.51 hours per day.

Table 3-5: Summary of the maximum net benefits of transition at county level – BAU scenario

	Max. Benefit Tech.	Pop. (Millions)	Households (Millions)	Total Net Benefit (MUSD)	Deaths Avoided (pp/yr)	Health Costs Avoided (MUSD)	Hours /hh.day	Opportunity Cost Avoided (MUSD)	Reduced Emissions (Mton CO2eq)	Emission Costs Avoided (MUSD)	Investment Costs (MUSD)	Fuel Costs (MUSD)	O&M Costs (MUSD)	Salvage Value (MUSD)
0	Biogas	0.03301	0.009708759	-0.8515	0.5213	0.1277	0.4500	0.2479	0.0212	1.0857	5.9222	-0.3889	0.0273	4.3461
1	ICS	0.422242	0.124188784	-11.6285	0.3427	0.0666	0.3874	2.6372	-0.0264	-1.3474	-0.2791	14.6012	-0.0042	-0.0078
2	LPG	0.153347	0.046444653	-1.4853	1.6486	0.4053	0.8614	2.8933	0.0645	3.2939	0.6451	4.38317	-0.0031	0.2819
	Total	0.608599	0.180342196	-13.9654	2.5127	0.5997	0.5128	5.7785	0.0594	3.0321	6.2882	18.5954	0.0199	4.6202

Recommendations

This analysis, based on geospatial modeling using OnStove, has yielded several key insights and actionable recommendations for the universal clean cooking transition in Embu County.

1. A single clean cooking solution cannot fit all. The mapped areas in Figure 1 and Figure 5 show which areas are better suited for specific clean cooking solutions. Based on these findings, Embu County can develop tailored transition strategies, including awareness creation, behavioral change campaigns, training, and capacity building to promote these technologies.
2. Financing schemes, e.g., results-based financing, that aim to subsidize biogas would enhance the adoption of these technologies by making them affordable for populations with a low relative wealth index.
3. Incentivize e-cooking by educating and demonstrating its benefits and costs to potential consumers having access to electricity.
4. Removal of 16% VAT from electric cooking appliances and import duty on LPG cylinders would see more households adopt these technologies through demand creation.
5. Lobby and support for e-cooking tariffs and tax incentives for imported technologies and fuels like electric cooking and ethanol stoves from the national government.
6. The county can partner with organizations and programs that support household and institutional cooking programs, such as the Energizing Development, GIZ, Modern Energy Cooking Services, Practical Action, Energy for Impact (E4I), Sustainable Energy for All (SE4ALL), World Food Program, and UNDP, to promote clean cooking in institutions, households, and to explore access to carbon markets for entrepreneurs in the county.
7. Explore and implement ways to strengthen the distribution network for LPG and ethanol. Additionally, map local manufacturing and distribution networks, build capacity for the local manufacturing and distribution of bioethanol fuel.
8. Allocate funding for clean cooking and create innovative, bankable financing models to help unlock private investment in the clean cooking sector in the county.
9. Improve the affordability of clean cooking technologies by partnering with institutions that provide results-based financing. Create an environment suitable for the private sector to provide subsidies and low-cost appliances such as electric cooking appliances, biogas and ethanol stoves.
10. Partner with KPLC and REREC to increase electricity access from the current 57% to universal access by 2028 via grid expansion, and mini grids. This could lead to more households taking advantage of e-cooking technologies and accruing the maximum benefits of the clean cooking transition.
11. Develop a local technical and business training program for clean cooking, focusing on men, women, youth, and PLWDs (people living with disabilities). The goal is to create employment opportunities and establish clean cooking champions & promoters in the county.
12. According to the available resources in the county, it is possible for the population to transition to clean cooking technologies like improved charcoal stoves, e-cooking, biogas, and LPG. Awareness creation on the importance of the clean cooking transition at the household level can play a key role in increasing the adoption of these technologies.

3.1.2.2.5 Barriers, Risks & Mitigation Measures

In clean cooking sector, heavy dependence on biomass, particularly firewood and charcoal, has had significant impact on the environment and health. However, transitioning to alternatives has been hindered by high cost of such technologies as LPG, improved stoves, and electric cooking for most low-income households. Remoteness and inaccessibility have contributed to supply chain inefficiencies compounded by import dependence and inconsistent policies have constrained adoption of clean technologies. Cultural beliefs have also had significant influence on uptake of technological innovation in the sector. Studies have shown that some people belief that cooking using traditional methods (charcoal and firewood) make food taste distinctly.

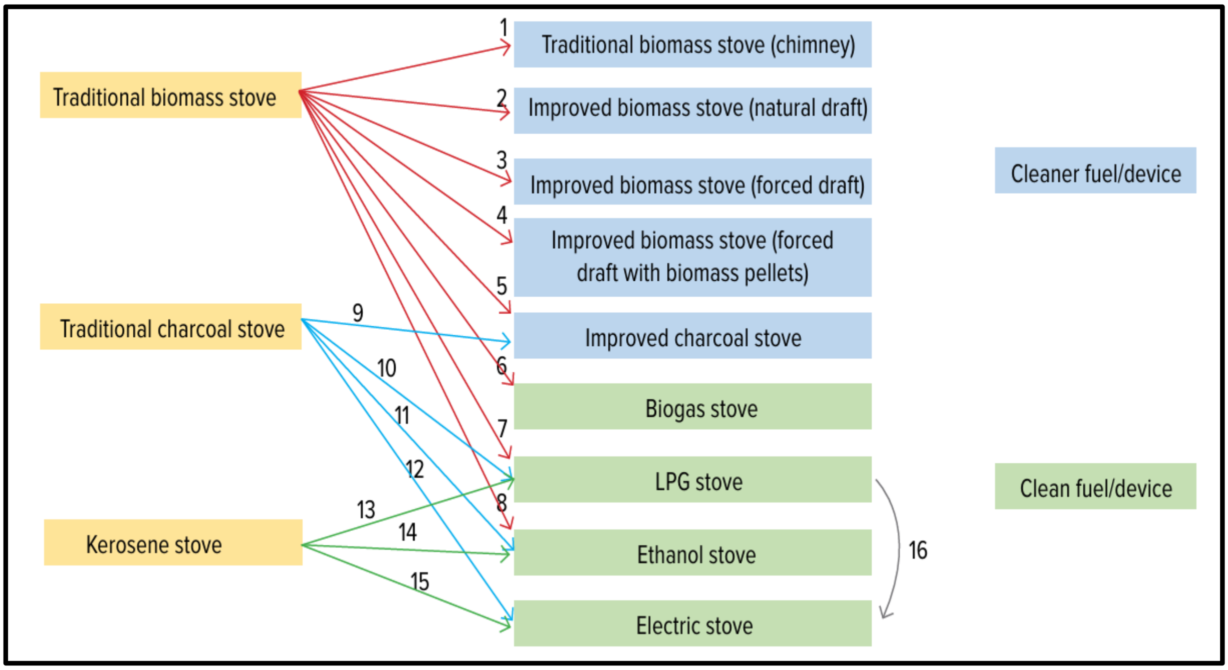


Figure 3-24: Illustration of cooking technology and fuel (OnSTOVE)

The National Cooking Transition Strategy (2024-2028) categorized barriers to uptake and use of clean cooking technologies into three: overarching; supply-side; and demand side barriers. Under overarching barriers, these are components that include insufficient government funding, weak inter-ministerial coordination, and poor enforcement of regulations such the laws and regulations touching on LPG and charcoal. Additionally, the lack of long-term planning, inconsistent fiscal policies, and slow policy adaptation hinder the transition to clean sustainable cooking strategies. The cooking sector also suffers from inadequate data tracking, minimal integration into broader energy strategies, and narrow perception of cooking energy as merely a household issue rather than a key factor affecting economy, health, and environment[33].

On supply side, such variables as high production and import costs and limited financing options, as well as international determinants restricting market growth. Geopolitical instability affects fuel prices, while distribution challenges particularly to remote and rural areas increase costs.

[33] Kenya National Cooking Transition Strategy 2024 – 2028

Furthermore, the market is undermined by counterfeit products, local materials, and infrastructural challenges such as centralized LPG system. These barriers collectively result in high prices.

Demand-side barriers that include high upfront and recurring costs of clean cooking solutions. The challenges result in consumers going back to cheaper and access alternatives such as firewood and charcoal. Additionally, limited financing options for consumers and poor last-mile connectivity play a significant role. Pertinent issues such as cultural preferences such as beliefs of food tasting better when cooked with firewood, fear around clean fuels (LPG), and misinformation have had significant impact on the adoption of clean cooking techniques[34]. As such, without systematic transformation in policy, financing, infrastructure, and public awareness, the shift away from traditional unclean cooking techniques will remain slow and uneven.

[34] Kenya National Cooking Transition Strategy 2024 – 2028

3.2 ENERGY ACCESS FOR EDUCATION INSTITUTIONS

3.2.1 ELECTRICITY ACCESS FOR EDUCATION INSTITUTIONS

3.2.1.1 ELECTRICITY ACCESS FOR PRIMARY SCHOOLS

From baseline survey, only 1 primary school is not electrified (Mugwanjuki Primary and JS) while the rest 389 have electricity access.

Table 3-6: Electricity Access for Primary Schools

Grid Connection	Solar PV	No Electricity	Total
389	0	1	390

However, the issue of productive use of energy and reliability were observed. As part of the recommendation, before connecting to the grid or through solar PV, there is need for wiring the classrooms. For schools without electricity access, REREC should prioritize wiring at least 3 classes before connecting a school to electricity. This is informed by previous incidents where a distribution line or solar PV system was constructed at a school only to remain idle since there is no wiring. However, priority is given to lower grade classrooms where pupils use digital learning devices.

3.2.1.2 ELECTRICITY ACCESS FOR SECONDARY SCHOOLS, VTCs AND TVETs

From baseline survey, all secondary schools, VTCs, and TVETs have electricity access connected to the central grid (KPLC supply). However, the issues associated with reliability and quality of power supply were raised and observed. The increase push for back-up system such as that include thermal diesel generators and solar PV were noted to come from need to reliable and affordable power supply.

3.2.2 CLEAN COOKING FOR EDUCATION INSTITUTIONS

Cooking is one of the key energy end-use categories in the education sector. Figure 3-25 shows that the Traditional Three Stone Open Fire is the dominant technology, at **82.69%.** Fixed masonry Cookstoves are also widely used at **9.62%** across educational institutions.

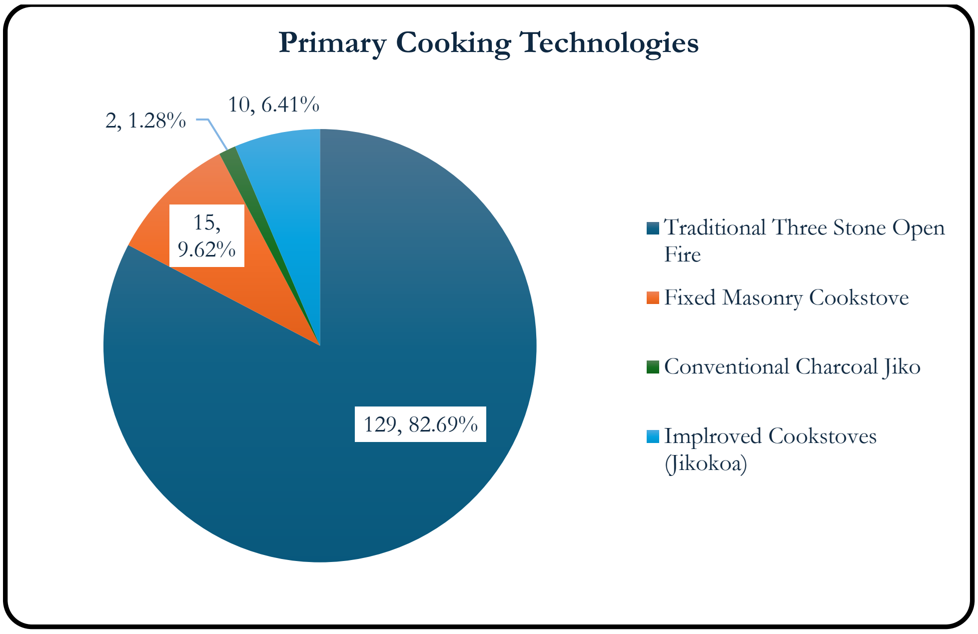


Figure 3-25: Primary Cooking Technologies in Education Facilities

Firewood is the main source of cooking energy, with monthly average cost of up to more than **KES 30,000 a month**. The median cost of this technology is between **KES 500 to KES 5,000 Monthly.** Figure 3-26 shows the monthly average costs of firewood as a source of energy in educational institutions.

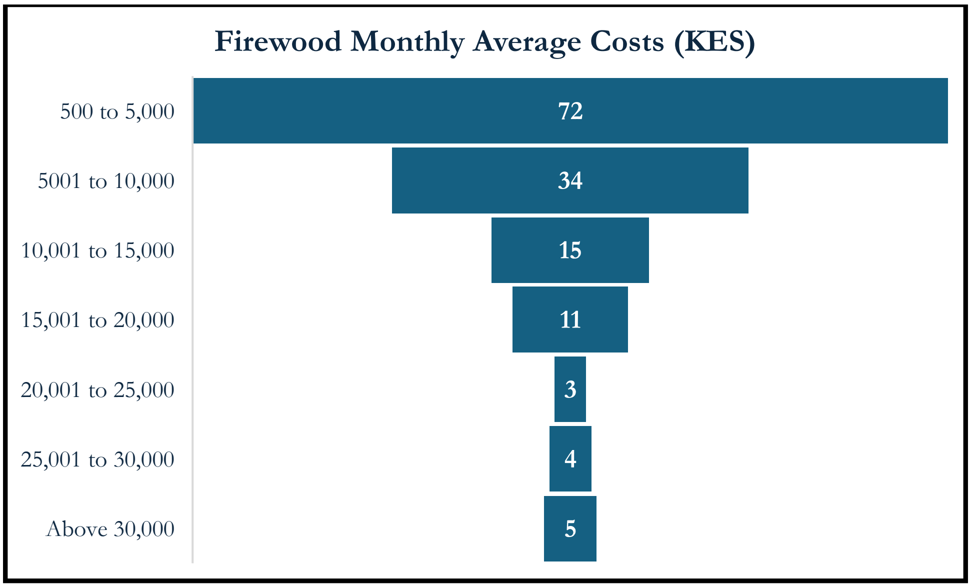


Figure 3-26: Firewood Monthly Average Costs

3.3 ENERGY ACCESS AT THE UNIVERSITY OF EMBU

3.3.1 ELECTRICITY AT THE UNIVERSITY OF EMBU

1.1.3.1 BASELINE ASSESSMENT

The University of Embu (UoEm) is a key institutional energy consumer within Embu County, hosting over **15,000 students**, approximately **800 of whom reside on campus**. Electricity supports lighting, ICT, research, laboratories, and water pumping.

The university currently sources power from **KPLC**, complemented by a **118 kWp solar PV system** installed on rooftops. This solar system offsets part of the electricity bill—saving **KES 375,150 monthly** under full operation and **KES 137,970** during low-peak periods.

The average power bill stands at **KES 1,263,360** monthly during peak academic activity and **KES 797,160** during off-peak months. Unreliable grid supply often causes power interruptions, forcing the institution to use **diesel generators**, which cost approximately **KES 791,998 per year** in fuel.

A comprehensive assessment has identified critical interventions needed to enhance power reliability, reduce costs, and transition the university to renewable and sustainable energy systems.

1.1.3.2 KEY CHALLENGES

1. **High monthly electricity bills** result from grid dependence.
2. **Frequent power outages** that disrupt learning and research.
3. **Limited renewable energy integration** — current PV system capacity is insufficient for total load.
4. **Inefficient grid connection** — current line requires relocation to more stable connection point.
5. **Partial solar street lighting coverage**, with many dark zones on campus.
6. **Limited technical capacity** for renewable system management and maintenance.

1.1.3.3 PROPOSED SOLUTIONS AND PATHWAYS

1. **Relocate electricity transmission lines** to a reliable connectivity point, reducing outages.
2. **Expand rooftop solar PV capacity** from 118 kWp to **at least 500 kWp** to meet daytime and partial nighttime loads.
3. **Upgrade and expand solar street lighting** throughout the university for improved safety and reduced electricity bills.
4. **Establish an Energy Research and Training Centre** at the University to train solar, biogas, and clean energy technicians and support applied research.
5. **Implement capacity building** on renewable electricity systems management.

Table 3-7: Summary of Works and Costs for Moving Power Transmission Lines

Item	Description of Works	Estimated Cost (KES)
Materials and Equipment	Procurement of necessary materials	500,000
Structural Components	Foundations and supports	1,000,000
Conductors and Cables	Supply and installation of new conductors and cables	6,000,000
Insulators	Supply and fixing	400,000
Hardware and Fittings	Brackets, bolts, nuts, etc.	100,000
Grounding and Protection	Safety earthing systems	300,000
Civil Works	Trenching, foundations, and route clearance	200,000
Assembly and Erection	Pole and tower erection	100,000
Conductor Stringing & Tensioning	Laying and tensioning works	400,000
Cable Laying	Cable route excavation and installation	150,000
Total		**8,650,000**

Table 3-8: Summary of Solar Street Lighting Requirements

Area/Route Covered	Approx. No. of Lights	Average Rating (W)	Estimated Cost (KES)
Internal roads and hostels vicinity	45	80–100	700,000
Sports fields, library area, and ABH grounds	70	200	3,000,000
Gate A, B, and C roads and parking	25	80–100	600,000
University farm and dams	60	200	2,500,000
TVET blocks, workshops, and fisheries area	20	80–200	583,000
Total	**~220 lights**	**80–200 W**	**7,383,000**

Table 3-9: Summary of Proposed Electricity Projects and Programs

Project / Program	Description	Stakeholders Responsible	Expected Outcomes	Prioritization & Phasing	Performance Indicators	Cost (KES)
Grid Reliability Enhancement	Relocate transmission line	UoEm, KPLC, County Gov't	Reliable power supply	2025–2026	Reduction in generator fuel use	8,650,000
Solar PV Expansion	Add 382 kWp rooftop solar	UoEm, County Gov't, Partners	60% solar energy share	2026–2028	PV capacity installed (kWp)	45,000,000
Solar Street Lighting	Install ~220 solar lights	UoEm, County Gov't	Lower lighting costs	2025–2026	No. of operational solar lights	7,383,000
Energy Research & Training Centre	Establish energy training hub	UoEm, County Gov't, MoE	Skilled workforce, innovation	2026–2029	Centre operationalized	20,000,000
Energy Efficiency Program	Replace inefficient lighting, audit energy	UoEm	Reduced energy intensity	2026–2030	% reduction in power use	5,000,000

3.3.2 CLEAN COOKING AT THE UNIVERSITY OF EMBU

1.1.3.4 BASELINE ASSESSMENT

Cooking in the University of Embu is primarily powered by **charcoal and LPG**, with annual usage of **360 bags of charcoal** and **3,000 kg of LPG**. Cooking takes place mainly at:

- The **students' mess** (100-person capacity per sitting)
- The **ABH staff cafeteria** (50-person capacity per sitting)

The University also operates an extensive **septic system** collecting human waste from hostels and staff facilities, and a **farm with 35 grade cows**, producing organic waste suitable for **biogas generation**.

The institution plans to integrate clean cooking solutions, solar water heating, and waste-to-energy systems for sustainability and reduced carbon footprint.

1.1.3.5 KEY CHALLENGES

1. High cost of LPG and charcoal.
2. Environmental degradation from charcoal use.
3. Untapped potential for biogas production.
4. Mixed waste streams (detergents and greywater contamination).
5. Lack of infrastructure for gas distribution from a central biodigester.
6. Limited technical expertise in biogas and solar thermal systems.

1.1.3.6 PROPOSED SOLUTIONS AND PATHWAYS

1. **Biogas System Establishment:** Remodel the septic tank into a biodigester, separate wastewater, and connect cow dung feedstock. Install gas pipelines in the student mess and cafeteria.
2. **Solar Water Heating Systems:** Install stand-alone solar water heating units in 8 hostels, students' mess, and ABH cafeteria.
3. **Clean Cooking Transition:** Replace charcoal and LPG with biogas and solar-assisted thermal systems.
4. **Training and Capacity Building:** Train technicians and catering staff on biogas and solar thermal technologies.
5. **Research Collaboration:** Undertake research on **industrial briquette development for tea factories**, ensuring locally adaptable biofuel options.

Table 3-10: Biogas Works and Costs

Description of Works	Details	Estimated Cost (KES)
Design, consultation and supervision	Preliminary designs, structural drawings, supervision	300,000
Renovation works	Rebuilding septic tank, formwork, plastering, finishing	10,000,000
System plumbing and interior works	Installation of piping, restrainers, downpipes	5,000,000
Bioreactor restrainers	Supply and installation	1,500,000
Total Estimated Cost		**16,800,000**

Table 3-11: Hostel Solar Water Heating Requirements

Hostel/Facility	No. of Students / Capacity	Hot Water Requirement (Litres/day)	Estimated Cost (KES)
Mt Elgon	148	7,400	4,995,000
Mt Kenya	109	5,450	3,678,750
Aberdares	112	5,600	3,780,000
Taita Hills	32	1,600	1,080,000
Ngong Hills	40	2,000	1,350,000
Menengai	40	2,000	1,350,000
Kilima Mbogo	60	3,000	2,025,000
Shimoni	10	500	337,500
Students Mess	100 persons per sitting	50,000	33,750,000
ABH Staff Cafeteria	50 persons per sitting	30,000	20,250,000
Total			**72,596,250**

Table 3-12: Summary of Proposed Clean Cooking Projects and Programs

Project / Program	Description	Stakeholders Responsible	Expected Outcomes	Prioritization & Phasing	Performance Indicators	Estimated Cost (KES)
Biogas Energy System	Remodel septic tank into biodigester	UoEm, County Gov't	Reduced LPG/charcoal use	2025–2026	% reduction in fossil cooking fuel	16,800,000
Solar Water Heating Systems	Solar heaters in hostels, mess, cafeteria	UoEm, County Gov't	Hot water, reduced electricity/charcoal	2025–2027	Systems installed	72,596,250
Clean Cooking Transition Program	Introduce biogas, electric, and solar cookstoves	UoEm, MoE, County Gov't	Full clean cooking adoption	2026–2028	No. of clean cookstoves adopted	5,000,000
Briquette Research Initiative	Develop industrial briquettes for tea factories	UoEm, Tea Factories, County Gov't	Firewood replacement fuel	2027–2029	Viable briquette prototype	10,000,000
Capacity Building Program	Train biogas and solar thermal technicians	UoEm, County Gov't, TVETs	Skilled local workforce	Continuous	No. of technicians trained	1,500,000

3.4 ENERGY ACCESS FOR HEALTH FACILITIES

3.4.1 ELECTRICITY ACCESS FOR HEALTH FACILITIES

Embu County has a total of 113 public health facilities, which include three Level 5 hospitals, six Level 4 hospitals, 14 Level 3, and 90 Level 2 hospitals. These are spread across the sub-counties, with Mbeere South and Runyenjes each hosting 25 facilities, Manyatta with 23, and Mbeere North with 17.

The Embu Level 5 Hospital is the largest and most critical health facility in the region. Established in 1924, it currently handles over 1,200 outpatient visits each month and has a physical bed capacity of 670 and an authorized bed capacity of 618. There is a new private wing under construction that will have a 66-bed capacity. This unit is planned to be opened by January 2026. With an average monthly electricity bill of KES 15 million, the hospital's operational costs are significant. Planned developments such as a modern mother and child wing, a new emergency department, a cancer treatment center, improved water access, and enhanced medical waste management systems are all expected to further increase its energy consumption[35].

In response to these growing demands, the county is embracing alternative energy solutions. The government has announced plans to solarize all health facilities to reduce the dependency on the national grid and to cut electricity costs. Some health centres already operate on solar PV systems, but to ensure reliability, especially at night or during cloudy days, there is a pressing need for proper energy storage solutions, such as battery systems.

Moreover, to support environmental goals and improve sustainability, the county aims to install additional medical waste incinerators, introduce biodigesters for biogas production, and strengthen rainwater harvesting systems. All these initiatives will have direct and indirect impacts on energy consumption, particularly in rural and underserved areas.

3.4.1.1 ELECTRICITY ACCESS IN LEVEL 2 HEALTH FACILITIES

3.4.1.1.1 Baseline Assessment of Electrification in Level 2 Health Facilities

Figure 3-27 indicates electricity access in level 2 health facilities showing that the vast majority, **72%**, are connected to the national grid through Kenya Power, demonstrating strong reliance on the main electricity supplier. A small share, 2**%**, depend primarily on generators, indicating limited backup or alternative supply capacity. However, **14% of health facilities lack any form of electricity access**, which is a critical gap as it directly affects the delivery of essential health services such as lighting, refrigeration of vaccines, and operation of medical equipment. Overall, while grid access is dominant, the presence of facilities without electricity underscores the need for targeted interventions, such as decentralized solar systems or hybrid solutions, to ensure reliable and universal power access in the health sector.

[35] Green Finance assessment of Embu County 2024

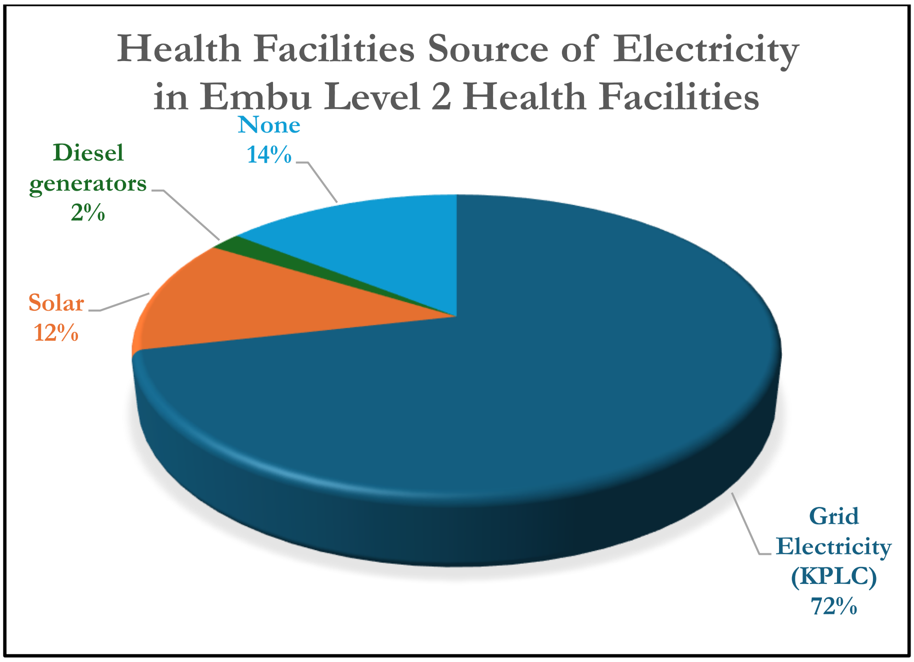


Figure 3-27: Composition of sources of electricity for Embu Level 2 Hospitals

3.4.1.1.2 Pathways for Universal Access to Electricity for Level 2 Health Facilities

The county has 90 Level 2 health facilities, of which 15 remain unelectrified as shown in the Table 3-13. The county has a total of 90 Level 2 health facilities, of which 15 remain unelectrified, as summarized in Table 3.5. While several facilities such as Mbondoni, Malikini, Riacina, Ntharawe, Kiogogo, Mulukusi, Gachabari, and Blue Valley have completed wiring and obtained KPLC quotations, others including Gatiruri, Makutano, Kirathe, Ngunyumu, Ciangera, Kirigo, and Kyenire remain pending due to incomplete wiring or lack of nearby transformers.

To accelerate electrification, the county will collaborate with KPLC to fast-track connections for facilities with completed wiring and existing quotations. For those located far from the grid or where connection costs are high, the county will explore off-grid and hybrid solar PV solutions to ensure uninterrupted electricity access. Prioritization will be guided by factors such as patient volume, service criticality, and cost-efficiency, ensuring equitable and sustainable energy access across all Level 2 health facilities.

Table 3-13: Status of electricity access for Level 2 health facilities, including wiring, KPLC application progress, and estimated costs

	Facility Name	Keph Level	Ward	Wiring	Est. Cost of Wiring	KPLC Application	GPS Coordinates	Nearest Transformer	KPLC Quote	Est. Total Cost (KPLC/Solar PV)
1	Mbondoni Dispensary	Level 2	Makima	Done	N/A	Done	-0.8390123553686776, 37.545686006118274		167,666.00	
2	Malikini Dispensary	Level 2	Mwea	Done	N/A	Done	-0.8400422872925701, 37.42579169919191		45,100.00	
3	Gatiruri Dispensary	Level 2	Evurore	Not Done		Not Done	-0.42215964044780013, 37.84059554675431			
4	Makutano Dispensary	Level 2	Mwea	Not Done		Done	-0.7604650358231574, 37.2784718715214		298,908.00	
5	Kirathe Dispensary	Level 2	Mavuria	Not Done		Done	-0.6723606473122672, 37.68630045488105		217,399.00	
6	Riacina Dispensary	Level 2	Kiambeere	Done	N/A	Done	-0.7605231980112436, 37.829998235567395		51,567.00	
7	Ntharawe Dispensary	Level 2	Kiambeere	Done	N/A	Done	-0.6697871173456302, 37.7404279727898		118,023.00	
8	Kiogogo Dispensary	Level 2	Evurore	Done	N/A	Done	-0.5766152741815371, 37.64267612453821		169,572.00	
9	Mulukusi Dispensary	Level 2	Makima	Done	N/A	Done			592,904.00	
10	Gachabari Dispensary	Level 2	kiambere	Done	N/A	Done			86,091.00	
11	Ngunyumu Dispensary	Level 2	Evurore	Not Done		Done			41,933.00	
12	Ciangera Dispensary	Level 2	Evurore	Not Done		Done			592,907.00	
13	Kirigo Dispensary	Level 2	Evurore	Done	N/A	Not Done				
14	Blue Valley Dispensary	level 2	Kirimari	Done	N/A	Done			261,000	
15	Kyenire Dispensary	Level 2	Evurore	Done	N/A	Not Done	-0.4922914963111646, 37.84189349095184			

3.4.1.2 ELECTRICITY ACCESS IN LEVEL 3 HEALTH FACILITIES

3.4.1.2.1 Baseline Assessment of Electrification in Level 3 Health Facilities

Embu County has a total of 14 Level 3 health facilities distributed across various sub-counties as illustrated in Figure 3-28. All the facilities are connected to the electricity grid, ensuring access to reliable power for routine healthcare operations. However, backup power capacity varies across the facilities as shown in Figure 3-29: seven (7) rely on diesel generators, one (1) utilizes a solar PV system, while six (6) currently lack any backup electricity source. Strengthening backup systems, particularly through clean energy solutions such as solar PV with battery storage, is essential to enhance energy reliability and reduce operational dependence on fossil fuels within Level 3 health facilities.

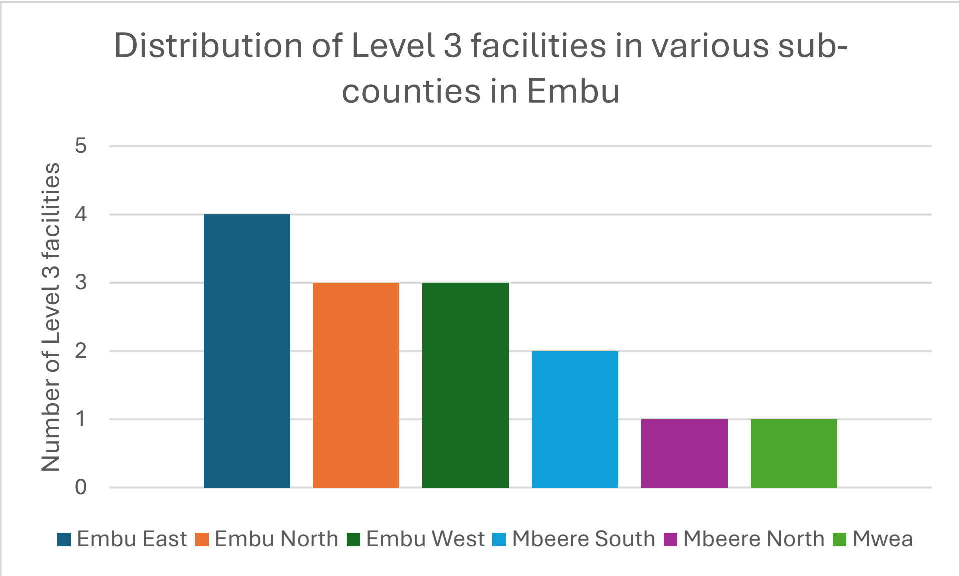


Figure 3-28: Distribution of Level 3 health facilities in various sub-counties in Embu

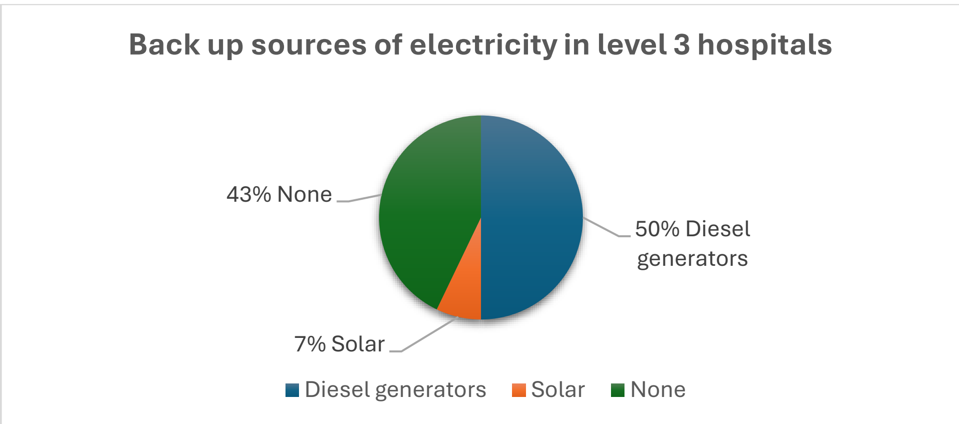


Figure 3-29: Back-up sources of electricity in Level 3 hospitals

3.4.1.3 ELECTRICITY ACCESS IN LEVEL 4 HEALTH FACILITIES

3.4.1.3.1 Baseline Assessment of Electrification in Level 4 Health Facilities

Embu County has a total of six (6) Level 4 health facilities distributed across four sub-counties as shown in Figure 3-30, all of which are connected to the national electricity grid. These facilities rely on diesel generators as backup power sources to ensure continuity of essential medical services during grid outages. While this provides a measure of energy reliability, the county recognizes the need to transition towards cleaner and more sustainable backup systems, such as solar PV with battery storage, to reduce fuel dependence and operational costs in the medium term.

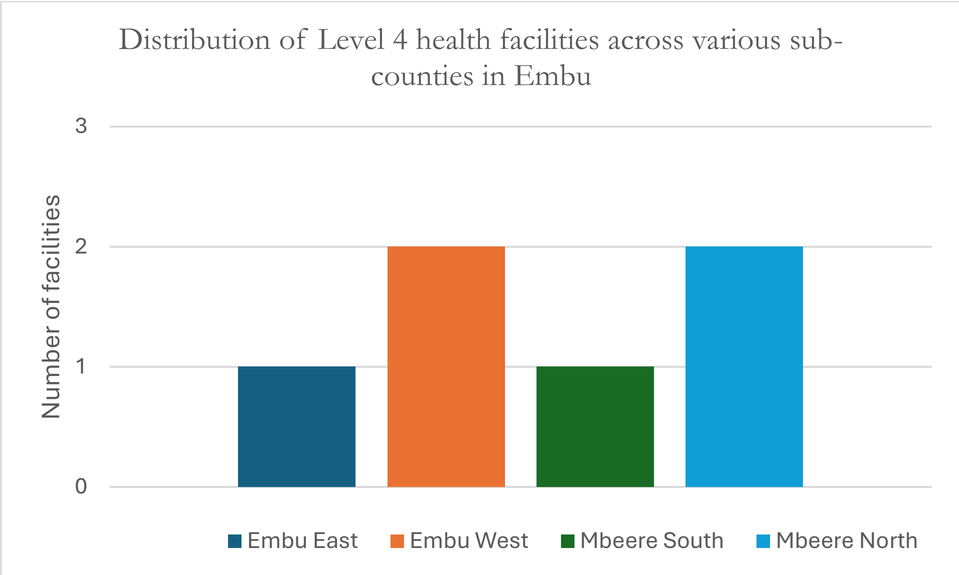


Figure 3-30: Distribution of Level 4 Health facilities across various Sub-Counties

3.4.1.4 ELECTRICITY ACCESS IN LEVEL 5 HEALTH FACILITIES

3.4.1.4.1 Baseline Assessment of Electrification in Level 5 Health Facilities

All three level 5 facilities as shown in Table 3-14 are connected to the national electricity grid (KPLC), ensuring access to reliable grid power for critical healthcare operations. Each of these hospitals is also equipped with a diesel generator as a backup power source to maintain uninterrupted service delivery during grid outages.

Table 3-14: Electrification Status of level 5 hospitals in Embu County

Name of the Hospital	Ward	Primary Source of electricity	Back up Source of electricity
Embu Level 5 Hospital	Kirimari	KPLC	Diesel generator
Embu Children Hospital-Tenri	Manyatta	KPLC	Diesel generator
Consolata Hospital Kyeni	Embu east	KPLC	Diesel generator

These facilities exhibit the highest electricity demand due to the wide range of energy-intensive medical and support equipment they operate. Key electricity-consuming equipment includes diagnostic machines (X-ray and ultrasound), laboratory analyzers, patient monitoring devices, refrigerators for medicine and vaccine storage, and water pumps. However, affordability, power quality issues such as voltage fluctuations, and unreliable supply from KPLC remain major challenges affecting the stability and efficiency of electricity use in these hospitals. The continuous operation of these systems underscores the importance of stable and redundant power infrastructure to safeguard healthcare delivery and patient outcomes.

A priority project identified by the County Department of Health is the solarization of Embu Level 5 Hospital. This intervention aims to enhance energy reliability, reduce dependence on diesel generators, and lower operational costs associated with electricity consumption. The initiative is driven by persistent electricity supply challenges, including high tariffs, voltage fluctuations, and intermittent power outages, which adversely affect service delivery and equipment performance. Through solarization, the county seeks to reduce electricity bills paid to KPLC and improve power stability using clean, renewable energy. The facility records an average monthly electricity consumption of approximately 2.3 million kWh, translating to an average monthly electricity bill of about KES 13.4 million. The department of Health has committed to availing Ksh. 9 million to start this solarization project. Details are presented in Table 3-15.

Table 3-15: Electrification status in Embu Level 5

	Facility	Keph Level	Av. Consumption (kWh)	Av. Bill (KES)	Est. Cost of Solarization	Committed Amount (KES)
1	Embu Level 5	Level 5	2300000	13.4 Million		9 Million

3.4.2 CLEAN COOKING FOR HEALTH FACILITIES

3.4.2.1 CLEAN COOKING IN LEVEL 2 HEALTH FACILITIES

Majority of level 2 facilities were found to be using LPG as their primary source of cooking. However, 22 Level 2 facilities were found not to have any form of cooking or having unreliable gas cylinders.

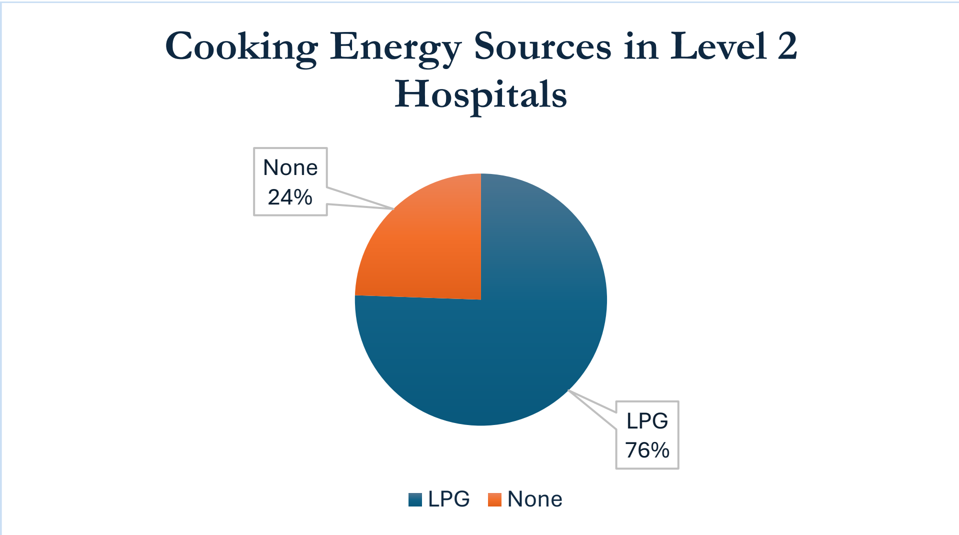


Figure 3-31: Cooking Energy Sources in Level 2 Hospitals

As a departmental priority to promote clean cooking, these facilities will be supplied with LPG gas cylinder, 3 burner steel stove, regulator and hose pipe.

	Solution	Item/Description	Qty	Unit Cost (KES)	Sub Total (KES)
1	LPG	13kg Gas cylinder	1	7,000	7000
		Regulator	1	1,000	1000
		A 3-burner steel stove	1	50,000	50,000
		Hosepipe	1	500	500
		TOTAL			**58,500**

Table 3-16: Status of Cooking Energy and Proposed Clean Cooking Transition in Low Volume Level 2 Health Facilities

	Facility Name	Keph level	Ward	Cost of Proposed Solution (KES)	Responsible Stakeholder
1	Kevote Dispensary	Level 2	Gaturi North	58,500	Department of Health, Development Partners
2	St Marks Kigari Teachers College Dispensary	Level 2	Ruguru-ngandori	58,500	
3	Muchagori Dispensary	Level 2	Gaturi North	58,500	
4	Kithunguriri Dispensary	Level 2	Ruguru-ngandori	58,500	
5	Embu Drop In Centre (DICE)	Level 2	Kirimari	58,500	
6	Karurina Dispensary	Level 2	Gaturi South	58,500	
7	University Of Embu Health Unit	Level 2	Kirimari	58,500	
8	Rukira Dispensary	Level 2	Kithimu	58,500	
9	Kangaru Dispensary	Level 2	Kirimari	58,500	
10	Itabua Police Dispensary	Level 2	Mbeti North	58,500	
11	Gk Prison Dispensary	Level 2	Mbeti North	58,500	
12	Ngunyumu Dispensary	Level 2	Evurore	58,500	
13	Ciangera Dispensary	Level 2	Evurore	58,500	
14	Kirigo Dispensary	Level 2	Evurore	58,500	
15	Kamugu Dispensary	Level 2	Nthawa	58,500	
16	Kyenire Dispensary	Level 2	Evurore	58,500	
17	Kogari Dispensary	Level 2	Evurore	58,500	
18	Ntharawe Dispensary	Level 2	Kiambeere Ward	58,500	
19	Mutuobare Dispensary	Level 2	Kiambeere Ward	58,500	
20	Makutano Dispensary	Level 2	Mwea	58,500	
21	Wachoro Dispensary	Level 2	Mwea	58,500	
22	Riakanau Dispensary	Level 2	Mwea	58,500	

3.4.2.2 CLEAN COOKING IN LEVEL 3 HEALTH FACILITIES

3.4.2.2.1 Low Volume Level 3 Health Facilities

Low-volume Level 3 health facilities in the county mainly use firewood and charcoal for cooking, with small LPG cylinders reserved primarily for staff use. To promote cleaner and more efficient energy use, the County Department of Health proposes the introduction of LPG systems with 2 burner steel stove and energy-saving jikos (201 and 101) as outlined in Table 3-17. Energy saving Jiko comes complete with sufuria and chimney system. The average monthly cooking expenditure for these facilities ranges between KES 3,800 and KES 9,000, depending on fuel type and facility size.

Table 3-17: Proposed clean cooking solutions for low volume level 3 facilities

	Solution	Item/Description	Qty	Unit Cost (KES)	Cost (KES)
1	LPG	13kg Gas cylinder	1	7,000	7,000
		Regulator	1	1,000	1,000
		A 2-burner steel stove	1	35,000	35,000
		Hosepipe	1	500	500
2	Energy Saving Jiko	A 25-litre Energy Saving Jiko	1	35,000	35,000
		A 10-litre Energy Saving Jiko	1	15,000	15,000
		TOTAL			**93,500**

Table 3-18: Status of Cooking Energy and Proposed Clean Cooking Transition in Low Volume Level 3 Health Facilities

	Facility Name	Keph level	Ward	Primary Cooking Fuel	Avg. Monthly Expenditure on Cooking(KES)	Cost of Proposed Solution (KES)	Responsible Stakeholder
1	Kigumo Health Center	Level 3	Gaturi North	Firewood	7000	93,500	Department of Health, Development Partners
2	Kithimu Health Center	Level 3	Ruguru-Ngandori	Firewood, Charcoal	9000	93,500	
3	Kibugu Health Center	Level 3	Gaturi North	Firewood, Charcoal	9000	93,500	
4	Makima Health Center	Level 3	Ruguru-Ngandori	Firewood, Charcoal		93,500	
5	Kiambere Health Center	Level 3	Kirimari	Firewood, Charcoal	3800	93,500	
6	Kairuri Health Center	Level 3	Kirimari	Firewood, Charcoal	7500	93,500	

3.4.2.2.2 High Volume Level 3 Health Facilities

As for high volume level 3 health facilities, the County Department of Health proposes the introduction of LPG systems with 3 burner steel stove and energy-saving jikos (501 and 251) as outlined in Table 3-19. Energy saving Jiko comes complete with sufuria and chimney system. The average monthly cooking expenditure for these facilities ranges between KES 3,000 and KES 16,500, depending on fuel type and facility size.

Table 3-19: Proposed clean cooking solutions for high volume level 3 facilities

	Solution	Item/Description	Qty	Unit Cost (KES)	Cost (KES)
1	LPG	13kg Gas cylinder	1	7,000	7,000
		Regulator	1	1,000	1,000
		A 3-burner steel stove	1	50,000	50,000
		Hosepipe	1	500	500
2	Energy Saving Jiko	A 25-litre Energy Saving Jiko	1	35,000	35,000
		A 50-litre Energy Saving Jiko	1	70,000	70,000
		TOTAL			**163,500**

Table 3-20: Status of Cooking Energy and Proposed Clean Cooking Transition in High Volume Level 3 Health Facilities

	Facility Name	Keph level	Ward	Primary Cooking Fuel	Avg. Monthly Expenditure on Cooking	Cost of Proposed Solution	Responsible Stakeholder
1	Kanja Health Center	Level 3	Gaturi North	Firewood, Charcoal	3000	163,500	Department of Health, Development Partners, Investors
2	Dallas Health Center	Level 3	Ruguru-Ngandori	Firewood, Charcoal	5000	163,500	
3	Karurumo Health Center	Level 3	Gaturi North	Firewood, Charcoal	16500	163,500	
4	Kianjokoma Health Center	Level 3	Ruguru-Ngandori	Firewood, Charcoal	10000	163,500	
5	Kiritiri Health Center	Level 3	Kirimari	Firewood, Charcoal	15000	163,500	
6	Gategi Health Center	Level 3	Kirimari	Firewood, Charcoal	12000	163,500	

3.4.2.3 CLEAN COOKING IN LEVEL 4 HEALTH FACILITIES

Level 4 health facilities in the county primarily rely on firewood and charcoal as their main cooking fuels, with limited LPG use mainly reserved for staff kitchens. This reliance on biomass fuels contributes to high operating costs, indoor air pollution, and unsustainable fuel consumption. To address these challenges, the County Department of Health proposes the adoption of clean cooking technologies, including LPG systems, biogas plants, and energy-saving jikos as outlined in Table 3-21 and Table 3-22. Energy saving Jiko comes complete with sufuria and chimney system. These interventions aim to enhance energy efficiency, reduce firewood and charcoal dependence, and promote compliance with the county's clean energy transition goals. The average monthly cooking expenditure for the Level 4 facilities ranges between KES 20,000 and KES 27,500, depending on the facility size.

Table 3-21: Proposed clean cooking solutions for level 4 facilities

	Solution	Item/Description	Qty	Unit Cost (KES)	Cost (KES)
1	LPG	50 kg Gas cylinder	1	25,000	25,000
		Regulator	1	1000	1,000
		A 3-burner steel stove	1	50,000	50,000
		Hosepipe	1	500	500
2	Energy Saving Jiko	A 100-litre Energy Saving Jiko	1	130,000	130,000
		A 50-litre Energy Saving Jiko	1	70,000	70,000
3	Biogas	10 m³ Biogas Plant	1	600,000	600,000
		TOTAL			**876,500**

Table 3-22: Status of Cooking Energy and Proposed Clean Cooking Transition in Level 4 Health Facilities

	Facility Name	Keph level	Ward	Primary Cooking Fuel	Avg. Monthly Expenditure on Cooking	Cost of Proposed Solution	Responsible Stakeholder
1	Runyenjes Hospital	Level 4	Gaturi North	Charcoal, Firewood	25000	876,500	Department of Health, Development Partners, Investors
2	Siakago Hospital	Level 4	Ruguru-Ngandori	Charcoal, Firewood	20000	876,500	
3	Ishiara Hospital	Level 4	Gaturi North	Charcoal, Firewood	27500	876,500	

3.4.2.4 CLEAN COOKING IN LEVEL 5 HEALTH FACILITIES

Embu Level 5 Hospital, the county's main referral facility, currently relies on firewood as its primary cooking fuel. This dependence on biomass leads to high operational costs, inefficient energy use, and environmental concerns. To transition toward cleaner and more sustainable cooking solutions, the County Department of Health proposes the installation of a 1,500-litre LPG storage system with piping works, supported by energy-saving jikos, standby LPG cylinders, and a biogas plant, as outlined in Table 3-23 and Table 3-24. These interventions aim to replace firewood with modern clean energy options, reduce fuel costs, and improve health and environmental outcomes. The average monthly expenditure on cooking at Embu Level 5 Hospital is approximately KES 45,000.

Table 3-23: Proposed clean cooking solutions for level 5 facilities

	Solution	Item/Description	Qty	Unit Cost (KES)	Cost (KES)
1	LPG	1500kg LPG Storage with piping works	1	1,500,000	1,500,000
		50 kg Standby LPG Gas cylinder	2	25,000	50,000
2	Energy Saving Jiko	A 100-litre Energy Saving Jiko	4	130,000	520,000
		A 50-litre Energy Saving Jiko	2	70,000	140,000
3	Biogas	20 m³ Biogas Plant	1	1,500,000	1,500,000
		TOTAL			**3,710,000**

Table 3-24: Status of Cooking Energy and Proposed Clean Cooking Transition in Embu Level 5 Hospital

	Facility Name	Keph level	Primary Cooking Fuel	Avg. Monthly Expenditure on Cooking	Cost of Proposed Solution	Responsible Stakeholder
1	Embu Level 5	Level 5	Firewood	45000	**3,710,000**	Department of Health, Development Partners, Investors

3.5 ENERGY ACCESS FOR CORRECTIONAL FACILITIES

3.5.1 EMBU WOMENS PRISON

3.5.1.1 ELECTRICITY ACCESS FOR EMBU WOMENS PRISON

3.5.1.1.1 Baseline Assessment

Embu Women Prison relies exclusively on electrical energy from the national grid for its lighting and administrative functions. The facility has a population of 87 inmates and 9 children under four years of age, creating a consistent energy demand for lighting, security, and office operations. The prison's **average monthly electricity consumption** is approximately **891 kWh**, translating to a **monthly bill of about KES32,000**. The facility currently has a **solar-powered floodlight** installed for security purposes, though its coverage is limited to a few areas within the compound.

With rising electricity costs and frequent power interruptions, there is an increasing need to explore renewable and reliable alternatives to supplement grid electricity.

3.5.1.1.2 Key Challenges

1. **High Electricity Costs** – The facility incurs a significant monthly expense on grid power, straining its limited operational budget.
2. **Inadequate Lighting Infrastructure** – The prison has limited lighting within wards and around the compound, compromising safety and night-time visibility.
3. **Reliance on a Single Power Source** – Total dependence on grid electricity exposes the facility to risks associated with blackouts and voltage fluctuations.
4. **Limited Use of Renewable Energy** – While a solar-powered floodlight exists, renewable energy adoption remains minimal.
5. **Lack of Energy Monitoring and Efficiency Measures** – Absence of energy management systems to monitor usage and optimize efficiency.

3.5.1.1.3 Proposed Solutions

1. **Installation of a Solar PV System**
    - Install a grid-tied solar photovoltaic (PV) system to offset electricity costs and improve supply reliability.
    - Prioritize design for administrative buildings and lighting loads.
2. **Expansion of Solar-Powered Lighting**
    - Increase the number of solar-powered floodlights inside the compound and along access roads.
    - Adopt energy-efficient LED technology for all indoor and outdoor lighting.
3. **Electrical Retrofitting and Energy Audits**
    - Conduct an energy audit to identify inefficiencies and opportunities for load reduction.

   - Replace old electrical fixtures with modern, efficient alternatives.
4. **Integration of Backup Power and Battery Storage**
   - Install small-capacity battery storage to maintain critical lighting and administrative operations during outages.
5. **Capacity Building and Maintenance Training**
   - Train prison staff in basic solar PV maintenance and energy management to ensure system sustainability.

Table 3-25: Electricity Projects and Programs for Female Correctional Facility

Project/Program	Description	Stakeholders Responsible	Expected Outcome	Prioritization & Phasing	Estimated Cost (Ksh)	Performance Indicators
Solar PV System Installation	Install hybrid solar PV system with storage to offset grid electricity consumption	State Department of Prisons, County Dept. of Energy, REA, Private Solar Firms	Reduced electricity costs; improved reliability	Short term (1–2 years)	1,200,000	% reduction in monthly electricity bills; installed solar capacity (kWp)
Expansion of Solar-Powered Floodlighting	Add solar-powered security and compound lights inside and along prison streets	County Energy Dept, KPLC, Prison Administration	Enhanced security and night-time visibility	Short term (1–2 years)	320,000	Number of functional solar streetlights installed
Electrical Efficiency Audit & Retrofitting	Conduct audit and replace inefficient fixtures	County Energy Dept, EPRA, State Department of Prisons	Reduced energy wastage	Medium term (2–4 years)	600,000	% reduction in electricity consumption
Staff Training on Energy Management	Build capacity in operation and maintenance of energy systems	Prison Admin, County Energy Dept, Technical Training Institutes	Sustainable management of energy systems	Continuous	150,000	Number of staff trained; maintenance compliance rate

3.5.1.2 CLEAN COOKING FOR EMBU WOMENS PRISON

3.5.1.2.1 Baseline Assessment

Cooking activities at Embu Women Prison are primarily powered by **biogas**, produced through a **60 m³ biodigester** that utilizes human and animal waste as feedstock. The biogas generated is used for cooking and occasionally for powering backup security lighting.
However, the biodigester's performance is currently **below optimal**, and the prison often relies on **biogas supplied from Embu Men's Prison** to meet daily cooking needs. This situation affects the consistency of meal preparation and exposes the prison to logistical challenges.
The use of biogas demonstrates commendable progress toward clean cooking and sustainable waste management. Yet, several operational and maintenance challenges hinder the full potential of the system.

3.5.1.2.2 Key Challenges

1. **Underperformance of the Existing Biodigester** – The biodigester is not fully functional, resulting in insufficient biogas production.
2. **Limited Feedstock Supply** – Inadequate animal and organic waste restricts consistent gas generation.
3. **Low Biogas Pressure** – Poor gas pressure reduces cooking efficiency and reliability.
4. **Unpleasant Odor During Biogas Use** – Occasional foul smell discourages extended use, especially in confined cooking spaces.
5. **Lack of Technical Capacity** – Staff and inmates lack training on biodigester management and improved cookstove design.
6. **Dependence on External Biogas Supply** – Reliance on Embu Men's Prison for biogas supply poses sustainability risks.

3.5.1.2.3 Proposed Solutions

1. **Optimization of the Existing Biodigester**
    - Repair and upgrade the biodigester to restore full functionality.
    - Install a **biogas storage balloon** to stabilize gas pressure and ensure steady supply.
2. **Waste Augmentation through Poultry Project**
    - Establish a **chicken rearing program** to increase organic waste supply for biodigester feedstock.
    - Integrate this with the prison's rehabilitation and skills-building programs.
3. **Biogas Odor Management and Safety Improvement**
    - Introduce purification and filtration systems to reduce odor and improve user comfort.
4. **Improved Cookstove Production and Training**
    - Launch a training program for inmates and staff on **improved cookstove design and fabrication**.
    - Integrate the activity under the **Prison Industries and Enterprises Framework** to generate income and build capacity.
5. **Capacity Building and Maintenance Training**

- Conduct periodic training on biodigester operation, maintenance, and safety procedures.

6. **Exploration of Hybrid Cooking Solutions**
   - Introduce **solar water heating** for meal preparation and sanitation use, complementing biogas energy where feasible.

Table 3-26: Clean Cooking Projects and Programs for Female Correctional Facility

Project/Program	Description	Stakeholders Responsible	Expected Outcome	Prioritization & Phasing	Estimated Cost (Ksh)	Performance Indicators
Biodigester Rehabilitation and Upgrade	Repair and install biogas balloon to enhance performance and pressure	State Dept. of Prisons, County Energy Dept., NEMA	Reliable biogas supply for cooking	Short term (1–2 years)	250,000	Volume of biogas produced (m^3/day); % reduction in firewood use
Chicken Rearing Waste Augmentation Project	Establish poultry unit to increase feedstock for biodigester	Prison Admin, Ministry of Agriculture, County Livestock Dept.	Increased waste supply; enhanced biogas output	Medium term (2–3 years)	640,000	No. of chickens reared; increase in feedstock volume
Odor Control & Filtration System	Install simple gas filters and improve piping to minimize odor	County Energy Dept., Prison Admin	Improved kitchen comfort and hygiene	Short term (1–2 years)	87,000	Reduction in odor complaints; user satisfaction levels
Improved Cookstove Production Training	Train inmates/staff in making improved cookstoves under prison industries	Prison Industries Dept., County Energy Dept., TVET Institutions	Skills development and alternative income	Medium term (2–4 years)	270,000	No. of trainees certified; no. of stoves produced
Solar Water Heating Integration	Introduce solar water heating for complementary cooking/heating needs	County Energy Dept., Private Solar Firms, State Dept. of Prisons	Reduced reliance on biogas; enhanced energy mix	Long term (4–6 years)	1,500,000	Installed solar capacity (L/day); % reduction in energy cos

3.5.2 EMBU MENS PRISON

3.5.2.1 ELECTRICITY ACCESS IN EMNU MENS PRISON

3.5.2.1.1 Baseline Assessment

Embu Men Prison accommodates approximately **1,300 inmates**, making it the largest correctional facility in the county. The facility's electricity is supplied solely by the **national grid (KPLC)** and serves diverse needs — lighting, water pumping, administrative functions, and industrial operations.

The facility incurs a **monthly electricity bill of about KES92,000** for the main prison and an additional **KES30,000** for the **22 kW water pumping station**, **KES5,000** for the **prison industry section**, and **KES5,000** for the **Level 2 dispensary**. This brings the total average monthly power expenditure to **KES132,000**.

A **7.5 kW petrol generator** exists but is currently **non-functional and non-automated**. It previously served the administrative block and wards. Additionally, there is a **borehole** capable of supplying both the men's and women's prisons, but it requires **refurbishment and solarization**, estimated at **KES900,000**.

There is a proposal to install a **large centralized solar PV system** to serve the entire facility, requiring rewiring to connect all sections under one energy management system.

3.5.2.1.2 Key Challenges

1. **High Dependence on Grid Power:** The prison relies entirely on KPLC, exposing it to high costs and supply unreliability.
2. **Aging and Dysfunctional Backup Generator:** The existing generator is out of service and lacks automation for efficient use during outages.
3. **Fragmented Power Supply System:** Multiple meters (administration, industry, dispensary, pumping station) make power management inefficient.
4. **High Energy Costs:** The facility's monthly electricity cost is among the highest in public institutions within the county.
5. **Unreliable Water Pumping Energy:** The canal-based pumping system consumes large amounts of grid electricity (22 kW pump).
6. **Underutilized Renewable Potential:** The borehole solarization opportunity remains untapped, and there is no existing solar PV system.

3.5.2.1.3 Proposed Solutions

1. **Installation of a Centralized Solar PV System:**
   - Design and install a **100–120 kWp grid-tied solar PV system** with partial battery storage to supply the prison, water pumping station, industry, and dispensary.
   - Conduct rewiring to integrate all sections under one centralized distribution and metering system.
2. **Refurbishment and Solarization of Borehole:**

   - Refurbish the borehole and install a **solar water pumping system** (estimated cost KES900,000).
   - Use solar energy for irrigation, cleaning, and sanitation water supply.
3. **Replacement of Generator with Solar-Ready Backup:**
   - Replace the old 7.5 kW generator with an automated hybrid backup system integrated with the solar PV array.
4. **Energy Efficiency Improvements:**
   - Conduct a full **energy audit**, replace existing bulbs with **LEDs**, and install **motion sensors** and **smart metering systems**.
5. **Capacity Building and Energy Management:**
   - Train staff on solar system operation, load management, and energy conservation practices.

Table 3-27: Electricity Projects and Programs for Male Correctional Facility

Project/Program	Description	Stakeholders Responsible	Expected Outcome	Prioritization & Phasing	Estimated Cost (KSh)	Performance Indicators
Centralized Solar PV Installation	Install 100–120 kWp grid-tied solar PV system with rewiring for centralized power supply	State Dept. of Prisons, County Energy Dept., REA, Private Solar Firms	Reduced energy costs, stable and clean power supply	Short–Medium term (1–3 years)	15–18 million	Installed solar capacity (kWp); % reduction in monthly electricity bills
Borehole Refurbishment & Solarization	Refurbish borehole and install solar pumping system	County Energy Dept., WRA, Prison Admin, REA	Reliable and sustainable water supply for both prisons	Short term (1–2 years)	0.9–1.0 million	Operational solar water system; % reduction in water pumping costs
Hybrid Generator Backup Installation	Replace dysfunctional 7.5 kW generator with automated hybrid backup system	Prison Admin, County Energy Dept., Private Suppliers	Reliable backup power for essential services	Medium term (2–3 years)	2.0–2.5 million	Generator uptime (%); reduced power interruptions
Energy Efficiency Retrofit	Conduct audit, install LED bulbs, motion sensors, and smart meters	EPRA, County Energy Dept., Prison Admin	Lower consumption and improved monitoring	Medium term (2–4 years)	1.0–1.5 million	% reduction in kWh consumption; number of fixtures replaced
Capacity Building	Train technical staff on energy system maintenance and management	County Energy Dept., TVET Institutions	Improved operational sustainability	Continuous	0.3–0.4 million	No. of staff trained; maintenance compliance rate

3.5.2.2 CLEAN COOKING IN EMBU MENS PRISON

3.5.2.2.1 Baseline Assessment

Embu Men Prison utilizes a **hybrid cooking system** comprising **biogas and firewood** to meet the energy needs of approximately **1,300 inmates**. The **124 m³ biodigester** uses a mixture of human and animal waste as feedstock to generate biogas, which is used to cook lighter meals such as breakfast and tea. Firewood is used to prepare heavy meals due to biogas limitations.

The **average daily firewood consumption** per prisoner is **2.5 kg**, translating to approximately **70 tonnes per month**. At an average cost of **KES7,000 per tonne**, the total monthly cost of firewood is **KES604,500** — equivalent to over **KES7.2 million annually**.

The **biodigester slurry** is reused as manure for the prison farm, promoting circular waste management. However, the system faces issues with gas pressure and capacity to meet full demand. There are proposals to install a **biogas storage balloon** (cost ~KES300,000), add **more biogas stoves**, install **efficient firewood cookstoves**, and **refurbish the kitchen** to enhance efficiency and ventilation.

3.5.2.2.2 Key Challenges

1. **Insufficient Biogas Production:** Despite a large biodigester, gas output is not enough for all meals.
2. **Low Biogas Pressure:** Inadequate pressure reduces cooking efficiency.
3. **High Firewood Dependency and Costs:** Firewood remains the dominant cooking fuel, creating unsustainable costs and deforestation pressure.
4. **Outdated Cooking Infrastructure:** The current kitchen setup lacks efficient stoves and adequate chimneys.
5. **Limited Biogas Jikos:** The number of functional biogas stoves is insufficient for the scale of meal preparation.
6. **Odor and Maintenance Issues:** Inefficient gas flow and lack of skilled maintenance lead to occasional odor problems.

3.5.2.2.3 Proposed Solutions

1. **Biodigester Optimization and Balloon Installation:**
   - Install a **biogas storage balloon** (KES300,000) to increase gas pressure and ensure stable flow.
   - Conduct maintenance to enhance digestate management and gas storage.
2. **Expansion of Biogas Cooking Infrastructure:**
   - Add **10–12 biogas stoves (jikos)** to scale up biogas utilization for main meals.
3. **Introduction of Fuel-Efficient Firewood Cookstoves:**
   - Replace traditional stoves with **improved firewood cookstoves** to reduce wood use by up to 40%.
4. **Kitchen Refurbishment and Chimney Upgrades:**

    - Reconfigure kitchen layout, add efficient chimneys, improve ventilation and safety conditions.
5. **Waste Management and Feedstock Enhancement:**
    - Integrate more animal waste from prison farms to increase biodigester input.
6. **Capacity Building:**
    - Train kitchen staff and inmates in clean cooking technologies and biodigester management.

Table 3-28: Summary Table – Clean Cooking Projects and Programs for Male Correctional Facility

Project/Program	Description	Stakeholders Responsible	Expected Outcome	Prioritization & Phasing	Estimated Cost (KSh)	Performance Indicators
Biodigester Optimization & Balloon Installation	Install biogas storage balloon and repair biodigester	State Dept. of Prisons, County Energy Dept., NEMA	Stable biogas pressure and increased output	Short term (1–2 years)	0.3–0.4 million	Volume of biogas produced (m^3/day); % of meals cooked using biogas
Expansion of Biogas Cooking Jikos	Add 10–12 biogas stoves for main meal preparation	County Energy Dept., Private Contractors, Prison Admin	Reduced reliance on firewood	Short term (1–2 years)	0.8–1.0 million	No. of biogas jikos installed; % reduction in firewood use
Installation of Fuel-Efficient Firewood Jikos	Replace old stoves with improved institutional firewood jikos	Prison Admin, County Energy Dept., GIZ	Reduced firewood consumption and costs	Medium term (2–3 years)	1.2–1.5 million	% reduction in wood usage; cost savings per month
Kitchen Refurbishment and Chimneys	Redesign kitchen, improve ventilation and chimney system	State Dept. of Prisons, County Works Dept.	Improved air quality and worker safety	Medium term (2–4 years)	2.0–2.5 million	Improved indoor air quality; reduced smoke exposure
Feedstock Enhancement (Farm Waste Integration)	Integrate animal waste and crop residue for biodigester feedstock	Prison Farm Unit, County Agriculture Dept.	Higher and consistent gas production	Medium term (2–4 years)	0.6–0.8 million	Volume of waste processed; increase in gas yield
Staff & Inmate Training	Train on operation and maintenance of clean cooking systems	County Energy Dept., TVET Institutions	Improved skills and sustainability	Continuous	0.3–0.4 million	No. of trained staff/inmates; system uptime

3.6 ENERGY ACCESS FOR INDUSTRIES

3.6.1 ELECTRICITY ACCESS FOR INDUSTRIES

3.6.1.1 ELECTRICTY ACCESS FOR EMBU COUNTY AGGREGATION AND INDUSTRIAL PARK (CAIP)

The Embu County Aggregation and Industrial Park (CAIP) is a flagship infrastructure project designed to support agro-industrial development, value addition, and manufacturing within the county. The park is currently under construction, with ongoing enrolment and profiling of prospective industrial tenants. As a new industrial hub, CAIP is expected to host a variety of industries including agro-processing units, cold storage facilities, packaging industries, small-scale manufacturing workshops, and logistics services.

Given the diversity of potential industrial activities, the park's energy requirements will be a critical enabler for its successful operation. Preliminary engagement with the Kenya Power and Lighting Company (KPLC) indicates that, once fully operational, the park may require an **additional 1 MW of electricity supply capacity**. This estimate reflects the projected cumulative load from industrial equipment, refrigeration systems, lighting, water pumping, ICT infrastructure, and administrative services.

In the short term, energy demand will remain modest during the construction and early occupancy phase. However, as the number of tenants increases, electricity demand is expected to rise progressively, potentially exceeding the initial 1 MW projection depending on the scale of cold chain facilities, mechanised processing, and planned expansion phases.

To ensure reliable and adequate supply, the County, in collaboration with KPLC, will need to:

- Upgrade local distribution infrastructure to support the additional 1 MW demand.
- Assess the need for dedicated feeders or a substation to ensure reliability and minimize downtime.
- Explore integrating renewable energy options—particularly **rooftop solar PV, solar-powered cold rooms, and energy storage**—to reduce operating costs and ease pressure on the grid.
- Promote energy-efficient industrial equipment to lower overall demand and enhance sustainability.

The development of a robust energy framework for CAIP is therefore essential to attract investment, support industrial productivity, and align the park with national and county-level green growth goals.

3.6.1.2 ELECTRICTY ACCESS FOR TEA INDUSTRIES

3.6.1.2.1 Baseline Assessment

Embu County hosts **three major tea factories — Mungania, Kathangariri, and Rukuriri — all owned and managed by the Kenya Tea Development Agency (KTDA)**. These factories are among the largest energy consumers in the county due to the energy-intensive nature of tea processing.

During field visits conducted as part of this County Energy Plan, the project team visited **Mungania Tea Factory** to assess its energy profile and engage the management on challenges and opportunities for energy efficiency and renewable energy integration.

The **electricity demand** in tea factories is mainly used for:

- Driving motors in the *Cut, Tear and Curl (CTC)* process;
- Running conveyor systems and fans during withering and drying;
- Lighting and ancillary plant operations; and
- Powering office and administrative functions.

Although **electricity accounts for only about 15% of total energy use** in a typical KTDA factory, it represents **50–60% of total energy costs** due to the high cost of grid power. The dependence on grid electricity exposes factories to high operational costs and supply interruptions.

To mitigate this, KTDA has initiated a number of interventions to improve electricity efficiency and security of supply. These include:

- **Energy audits** and implementation of efficiency measures (motor replacement, fan upgrades, lighting retrofits);
- **Training of staff** on energy management;
- **Installation of variable speed drives (VSDs)** and power factor correction equipment; and
- **Investments in renewable electricity generation**, notably **small hydro power plants**.

A flagship project under this effort is the **1.8 MW Thuci River Hydro Power Project**, being implemented by KTDA Power Company (KTPC Ltd). The hydro plant will supply electricity to the three factories — Mungania, Kathangariri, and Rukuriri — significantly reducing their dependence on grid electricity.

The **estimated cost** of the Thuci hydro project is **USD 400 million**. Upon completion, the project is projected to yield **annual electricity savings of about USD 54 million**, thereby enhancing competitiveness and profitability of the factories while reducing carbon emissions.

3.6.1.2.2 Key Challenges

1. **High grid electricity tariffs**, contributing to high production costs and reduced farmer incomes.
2. **Frequent power outages** that disrupt production processes and lower product quality.
3. **Limited access to concessional finance** for investment in renewable energy and energy efficiency measures.

4. **Slow implementation of renewable energy projects** due to lengthy licensing and regulatory processes.
5. **Lack of real-time energy monitoring systems**, making it difficult to track consumption and losses.

3.6.1.2.3 Proposed Solutions

1. **Accelerate completion of the 1.8 MW Thuci River Hydro Project** to supply clean, low-cost, and reliable electricity to the three factories.
2. **Scale up energy efficiency programmes** through audits, equipment replacement, and automation of operations.
3. **Establish real-time energy monitoring and management systems** to optimize energy use.
4. **Develop county–KTDA partnerships** to facilitate approvals, support clean energy investments, and attract climate finance.
5. **Encourage adoption of solar PV systems** on factory rooftops for daytime load support.
6. **Enhance staff capacity** in energy management and data-driven decision-making.

Table 3-29: Summary of Proposed Electricity Projects and Programs for Tea Factories

Project/Program	Description	Stakeholder Responsible	Expected Outcome	Phasing & Prioritization	Estimated Cost (USD)	Performance Indicators
1.8 MW Thuci Hydro Power Project	Develop and commission a mini-hydro plant to supply the three KTDA factories	KTDA Power Co. Ltd, Embu County Govt., MoE	Reliable clean electricity, reduced grid dependence	Short term (2025–2027)	400 million	MW installed, % reduction in grid use
Factory Energy Efficiency Program	Conduct audits, replace inefficient motors/fans, install VSDs and LED lighting	KTDA, Factory Mgmt., GIZ	Reduced energy intensity and costs	Continuous	1 million	GJ/t MT, % cost savings
Smart Energy Monitoring Systems	Install sensors and digital dashboards for real-time monitoring	KTDA, County Govt.	Improved energy management	Medium term	0.3 million	Energy monitoring system operational
Rooftop Solar PV Systems	Install 200–300 kW solar PV systems for each factory	KTDA, Private Investors	Reduced electricity cost, lower emissions	Medium term (2026–2028)	0.9 million	kWh of solar power generated annually
Capacity Building on Energy Management	Train factory personnel on efficient electricity use and maintenance	KTDA, MoE, County Govt.	Sustained efficiency improvements	Short term	0.1 million	No. of staff trained, efficiency score

3.6.1.3 ELECTRICITY ACCESS FOR COFFEE INDUSTRIES

3.6.1.3.1 Baseline Assessment

In Embu County, the coffee sector is organized around a single central coffee miller (which handles dry milling, storage, and green bean export functions), and a network of farmer cooperative societies (FCSs) that carry out the wet processing (washing / pulping / fermentation / drying) steps.

Table 3-30: List of Coffee Factories and Cooperatives in Embu County

Coffee Industry/Factory/Cooperative		Sub-County
Murue Fcs	Cooperative	Manyatta
Gakundu Fcs	Cooperative	Manyatta
Kibugu Fcs	Cooperative	Manyatta
Kithungururu Fcs	Cooperative	Manyatta
Central Ngandori Fcs	Cooperative	Manyatta
Muramuki Fcs	Cooperative	Manyatta
Thambana Fcs	Cooperative	Manyatta
Rianjagi Fcs	Cooperative	Manyatta
Nembure Fcs	Cooperative	Manyatta
Kirurumwe Fcs	Cooperative	Manyatta
Gatondo Fcs	Cooperative	Manyatta
New Kapingazi Fcs	Cooperative	Manyatta
Ivinge Fcs	Cooperative	Manyatta
Kagaari South Fcs	Cooperative	Runyenjees
Kagaari North Fcs	Cooperative	Runyenjees
Kiviuvi Fcs	Cooperative	Runyenjees
Kiangagwa Fcs	Cooperative	Runyenjees
Kanjugu Fcs	Cooperative	Runyenjees
New Kyeni Fcs	Cooperative	Runyenjees
New Kirimiri Fcs	Cooperative	Runyenjees
New Runyenjes Fcs	Cooperative	Runyenjees
Kamurai Fcs	Cooperative	Runyenjees
Kirindiri Fcs	Cooperative	Runyenjees
Mikiki Fcs	Cooperative	Runyenjees
Embu County Coffee Mill Cooperative	Miller	

These FCSs receive coffee cherries from farmers, perform wet processing (sorting, pulping, fermentation, washing, and initial drying), and then deliver **parchment coffee** to the central coffee miller (or possibly to dry-milling facilities).

Because the wet processing steps are energy- and water-intensive, the FCSs represent key nodes in the electricity demand profile of the local coffee sector.

Electricity Demand and Use in the Coffee Value Chain

At the FCS / wet mill level, electricity is used in:

- **Pulping** machines (including motors, pumps)
- **Water pumping, washing and recirculation systems**
- **Mechanical sorting, grading, conveying systems**
- **Auxiliary motors, fans, ventilation**
- **Lighting, control systems, administration, monitoring**

At the central miller / dry-milling stage, electricity is used for:

- Parchment hulling / de-pulping / polishing machines
- Grading / sizing / cleaning / packing machinery
- Storage (humidity control, lighting)
- Quality control labs, sample handling, administration

Innovations are gradually being introduced. For example, **eco-pulpers** (machines that mechanically separate cherry pulp without or with minimal water) are being promoted because they reduce both water usage and electricity demand. (SCP recommendations for Kenya suggest eco-pulper adoption as a resource-efficient step).

Further, some FCSs have benefited from clean energy and waste valorization programs. For instance, the **Rainforest Alliance project** supports transforming **coffee husks** into **smokeless briquettes** through **Household Energy Centers (HECs)** in Embu, notably targeting **Kibugu FCS** as part of pilot interventions.

Nevertheless, the current electricity usage remains heavily dependent on **grid power** (where available), supplemented by **diesel backup generators** during outages. Many FCSs operate under constrained capacity, limited infrastructure, and aging machinery.

3.6.1.3.2 Key Challenges

1. Many FCSs are located in rural or semi-rural areas with **unstable grid supply** and frequent **power outages** or voltage fluctuations, which disrupt pulping and washing operations and can damage equipment.
2. High unit cost of grid electricity, particularly during peak hours, exacerbates processing costs.
3. Some FCSs rely on diesel generators as backup, which are expensive, polluting, and inefficient.
4. Limited financial capacity at the cooperative level to invest in renewable energy, battery storage, or efficiency upgrades.
5. Lack of **energy management systems**, sub-metering, or monitoring to detect energy wastage or optimize operations.
6. Older pulping / washing / pumping equipment often operates at suboptimal efficiency, with poor power factor and high losses.
7. Scale constraints: many FCSs may have relatively small throughput that makes large renewable installations less cost-effective individually.
8. Regulatory and interconnection hurdles in deploying captive generation or hybrid systems.

9. Limited technical capacity in cooperatives to plan, operate, and maintain renewable power systems or hybrid systems.
10. Mismatch between power supply (e.g. solar only during daylight) and load timing (e.g. pulping might concentrate in limited hours).

3.6.1.3.3 Proposed Solutions

1. **Solar PV installations** at FCS wet mills (e.g. 20–100 kW), sized to handle pulping, washing and auxiliary loads.
2. **Hybrid PV + battery + grid/diesel backup systems** for resilience and smoothing loads.
3. **Centralized shared solar / microgrid models** aggregating several FCSs to justify larger systems.
4. **Energy efficiency retrofits**: replace inefficient motors, pumps, fans; add Variable Speed Drives (VSDs); improve power factor correction.
5. **Energy monitoring and control systems** (sub-meters, dashboards) to guide operational adjustments and detect faults.
6. **Pilot "solar eco-pulper" units** in strategically located FCSs to showcase reduced power and water consumption.
7. **Facilitate concessional financing, grants, revolving funds** for cooperative energy investment.
8. **Capacity building / training** for cooperative technicians and management in renewable energy, O&M, energy audit.
9. **Simplify permitting & regulatory frameworks** at the county level for captive power.
10. **Incorporate renewable energy in FCS planning**, including solar in future FCS upgrades or expansions.
11. **Explore small hydropower or mini-hydro** (if streams or water sources are available near FCSs) as a distributed option.
12. **Link with biomass or biogas electricity from waste streams** (e.g. from excess mucilage or fermentation waste) to further offset grid use.

Table 3-31: Proposed Electricity Projects / Programs in Embu Coffee Sector

Project / Program	Description	Stakeholder(s) Responsible	Expected Outcome	Phasing & Priority	Estimated Cost (USD)	Performance Indicators
Solar PV for FCS Wet Mills	Install PV arrays (20–100 kW) at selected FCSs to power pulping, washing, lighting	FCSs, County Govt, NGOs, private investors	Lower grid electricity demand and cost	Medium term (2025–2027)	0.05–0.4 million per FCS	kWh solar generation, % grid offset
Hybrid PV + Battery Systems	Combine PV with battery storage and backup (grid/diesel)	FCSs, energy service providers	Reliability during outages, smoother power supply	Medium term	0.1–0.5 million	Hours of backup, load coverage
Shared Solar Microgrid among FCSs	Aggregate demand of clusters of FCSs for a shared energy infrastructure	County, FCS federation	Economies of scale and lower unit cost	Medium–long term	0.5–1.5 million	Number of FCSs served, unit cost reduction
Solar Eco-Pulper Demonstration Units	Deploy energy- and water-efficient solar-assisted pulpers	Selected FCSs, coffee associations	Reduced energy & water per kg of cherry	Short term (2025–2026)	0.05–0.1 million per unit	Electricity use per kg cherry, water consumption
Energy Efficiency Upgrades	Replace motors, install VSDs, optimize pump systems, lighting retrofit	FCSs, technical service providers	Reduced electricity consumption and peak loads	Rolling program	0.02–0.1 million per FCS	kWh saved, % electrical efficiency gain
Energy Monitoring & Controls	Install sub-meters, dashboards, load analytics	FCSs, County ICT partners	Data-driven management, fault detection	Medium term	0.01–0.05 million per FCS	% energy monitored, number of alerts
Training & Capacity Building	Training in design, O&M, energy audits	County Govt, coffee institutions, NGOs	Skilled local capacity for sustained operations	Immediate & ongoing	0.02 million	Number of technicians trained, audits conducted
Hydropower or Micro-hydro Feasibility	Assess small hydro potential in FCS catchments	County, FCSs, hydropower specialists	Additional renewable electricity potential	Short term (study)	0.05 million (study)	Potential MW identified, feasibility reports
Regulatory / Permitting Support	Streamline captive power rules, interconnection support	County Govt, national energy regulator	Faster deployment of captive systems	Short term	—	Reduced permitting time, number of systems approved

3.6.1.4 ELECTRICITY ACCESS FOR MACADAMIA INDUSTRIES

3.6.1.4.1 Baseline Assessment

Embu County is among Kenya's leading macadamia-producing regions, with production supported by its favorable agro-climatic conditions and organized farmer cooperatives. The macadamia value chain in the county involves multiple stages—ranging from seedling production to processing and export—each with distinct electricity needs.

Electricity use across the macadamia value chain varies significantly by scale and activity:

- **Input Supply and Seedling Production:** Electricity is used minimally for lighting and irrigation pumps in nurseries. Most seedlings are propagated manually in small-scale nurseries run by the Kenya Agricultural and Livestock Research Organization (KALRO) and private entrepreneurs.
- **Primary Production (Farming):** Most farms depend on manual tools with minimal mechanization. Small petrol or electric dehuskers are used by some farmers or cooperatives, while solar drying is common. Only a few large-scale farmers use electric shelling or drying machines.
- **Aggregation and Bulking:** Electricity is primarily used for weighing scales, lighting at cooperative centers, and storage facilities. Some aggregation centers also use small electric dryers or fans to maintain nut quality before transport to processors.
- **Processing and Value Addition:** This stage is the most electricity-intensive in the value chain. Activities include mechanical cracking, sorting, grading, and packaging. In Embu County, **Privamnuts EPZ Kenya Ltd** is the main macadamia processor. The factory operates both automated and semi-automated machinery powered by electricity. It has installed a **solar PV system** that supplies approximately **30% of its total electricity needs**, with the remainder drawn from the national grid (Kenya Power). Key electric loads include conveyors, nut cracking machines, graders, air compressors, lighting, and office equipment.

Table 3-32: Macadamia Factories

	Role	Subcounty	Ward
Unity Macadamia FCS	Aggregating	Manyatta	Ruguru Ngandori
Embu County Macadamia FCS	Marketing		Kirimari
Privamnuts EPZ Kenya Ltd	Processing	Manyatta	

3.6.1.4.2 Key Challenges

1. **High electricity costs** from the national grid increase the cost of processing and reduce competitiveness.
2. **Limited grid reliability**, with occasional power interruptions affecting continuous operations.
3. **Limited adoption of energy-efficient technologies** among smaller processors and cooperatives.
4. **Low awareness** among cooperatives and farmers about the benefits of renewable electricity solutions such as solar PV and hybrid systems.
5. **High upfront capital costs** of installing solar systems or energy-efficient machines.

3.6.1.4.3 Proposed Solutions

1. **Promote Solar PV and Hybrid Systems:**
   Scale up adoption of grid-connected or off-grid solar PV systems among cooperatives and processing plants.
2. **Energy Audits and Efficiency Upgrades:**
   Implement targeted energy audits in processing plants and cooperatives to identify energy-saving opportunities.
3. **Reliable Power Supply:**
   Collaborate with Kenya Power to improve voltage stability and expand three-phase power coverage in industrial and aggregation zones.
4. **Capacity Building:**
   Train cooperative managers and processors on energy management, solar technology, and financing models.
5. **Green Financing Partnerships:**
   Facilitate access to concessional financing for energy investments through commercial banks, SACCOs, and development partners.
6. **Innovation Support:**
   Support local engineering firms in developing low-cost, energy-efficient dehuskers, dryers, and cracking equipment.

Table 3-33: Summary Proposed Projects and Programs for Macadamia Sector

Project/Program	Description	Stakeholder Responsible	Expected Outcome	Phasing & Prioritization	Estimated Cost (KSh)	Performance Indicators
Solarization of macadamia factories	Install grid-tied solar PV systems at Privamnuts EPZ and cooperative processing centers	Embu County Gov't, EPRA, Privamnuts, Cooperatives	Reduced electricity costs; 30–50% renewable electricity share	Short to Medium Term	120 million	Installed solar capacity (kWp); % electricity from solar
Energy audit program for agro-processors	Conduct energy audits and implement efficiency measures	County Gov't, MoE, NITA, KAM	Improved energy efficiency in macadamia industry	Short Term	10 million	Number of audits completed; % reduction in energy intensity
Grid reliability improvement	Upgrade power infrastructure in processing zones	Kenya Power, County Gov't	Improved power stability and reduced outages	Medium Term	50 million	Outage duration (SAIDI/SAIFI)
Energy management capacity building	Train cooperative managers on energy planning	County Gov't, REA, KAM	Enhanced local capacity in energy management	Short Term	5 million	Number of participants trained
Green finance facilitation program	Create linkages with banks for renewable energy investments	County Gov't, Financial Institutions	Increased investment in clean energy	Medium Term	2 million	Amount of credit extended (KSh)

3.6.1.5 ELECTRICITY ACCESS FOR DAIRY INDUSTRIES

3.6.1.5.1 Baseline Assessment

The dairy value chain in Embu County plays a crucial role in rural livelihoods and local economic development. It consists of smallholder farmers organized into cooperatives that aggregate, cool, and transport milk to processors in Embu, Meru, and other neighboring counties.

Electricity is primarily used in the following stages:

- **Milk collection and weighing** at collection centers.
- **Cooling and storage** of milk using electric chillers.
- **Lighting** of cooperative facilities and offices.
- **Operation of small processing units** (for pasteurization, yoghurt production, etc.).
- **Water heating (in some cases via electric geysers)** for equipment cleaning.

The main electricity supply source for most cooperatives is the **national grid (KPLC)**. However, **unreliable power supply and frequent outages** disrupt milk cooling and quality preservation, leading to losses.

To mitigate outages, some cooperatives have installed **diesel generators** as backup power sources, while others (like Mburugu Dairy Cooperative) have invested in **solar PV systems**. However, financing for solar systems remains a major barrier.

Electricity consumption in cooling centers is significant. Milk coolers account for **60–70% of total electricity demand**, followed by lighting (10–15%), office operations (5%), and small processing activities (10–20%).

While none of the cooperatives currently meet the energy audit threshold under the **Energy (Energy Management) Regulations, 2012**, the growing scale of operations suggests the need to start adopting **energy management practices and audits** to improve efficiency and reduce operational costs.

Table 3-34: List of Dairy Cooperatives in Embu County

	Group Name	Ward	Cooler capacity (Ltrs)	Source of cooler	Daily collection (Ltrs)/day	Outlet(Processor)
1	Njukiri Nthambo CBO	Kirimari	1000	UTaNRMP	4000	Brookside & Embu University
2	Tumaini Dairy Cooperative	Kithimu	1000	MKEPP	2000	Brookside
3	Kibugu Dairy CBO	Nginda	5000	County Government	7000	Lantana
4	Mburugu Dairy (Kathangariri satellite cooler)	Nginda	3000	National Government	3914	Mt. Kenya Dairies
5	Gakundu Dairy Cooperative	Ruguru, Ngandori	5000	County Government	4000	Lantana
6	Mburugu Dairy	Ruguru, Ngandori	5000	National Government	14200	Brookside
7	Mburugu Dairy	Ruguru Ngandori	3000	National Government		Brookside
8	Mwendano Cooperative	Mbeti North	3000	National Government	6000	Brookside
9	Ena Multipurpose	Kagaari South	3000	National Government	2000	Meru Dairy
10	Kawanjara Cooperative	Kagaari South	3000 &2000	National Government	5200	Meru Dairy
11	Ugweri milk cooler	Kagaari South	5000	National Government	6000	Limuru
12	Kathande	Kagaari North	3000	National Government	9000	Brookside
13	Kanja Milk Cooler	Kagaari North	5000	County Government	16000	Meru Dairy
14	Kararitiri Milk Cooler	Kagaari North	3000	National Government	1100	Meru Dairy
15	Karurumo	Kyeni South	3000	National Government	0	Vandalised and items taken
16	Mkulima Mbora (Gatumbi)	Kyeni North	5000	County Government	3000	NCC (New KCC)
17	Gachoka milk cooler	Mbeti South	3000	National Government	0	
18	Kirurumwe milk cooler	Gaturi North	5000	National Government, County Government	1900	Brookside
19	Engamutundu (Kigumo)	Kyeni South	3000	National Government	1300	Meru Dairy
20	Kathanjuri milk cooler	Kyeni South	3000	National Government	3400	Brookside
21	Ciandakika	Gaturi North	3000	National Government	5400	Brookside
22	Mukuuri Wangombe	Kagaari north	3000	National Government	3500	Mt. Kenya Dairies

3.6.1.5.2 Key Challenges

1. **Unreliable Grid Power:** Frequent power interruptions cause milk spoilage and operational delays.
2. **High Electricity Costs:** Tariffs and backup generator fuel costs increase the cost per litre of milk handled.
3. **Limited Renewable Energy Adoption:** Few cooperatives have installed solar PV systems; maintenance and technical support are limited.
4. **Inadequate Financing Mechanisms:** High upfront cost of solar and efficient electrical systems hinders adoption.
5. **Limited Technical Capacity:** Cooperative managers often lack knowledge in energy management, procurement, and maintenance of renewable systems.
6. **Inefficient Equipment:** Many cooperatives use outdated chillers and lighting systems that consume excessive electricity.
7. **Weak Energy Data Management:** Cooperatives lack systems to monitor and analyze their energy consumption patterns.

3.6.1.5.3 Proposed Solutions

1. **Promote Solar PV Hybrid Systems:**
   Encourage installation of grid-tied or hybrid solar systems to power chillers, lighting, and office equipment, reducing reliance on the grid and diesel generators.
2. **Upgrade Electrical Equipment:**
   Replace conventional chillers and lighting with **energy-efficient milk coolers** and **LED lighting** to reduce consumption by up to 40%.
3. **Energy Management and Audits:**
   Train cooperative managers on energy management, encourage periodic energy audits, and support implementation of efficiency measures.
4. **Establish Cooperative Energy Financing Schemes:**
   Integrate renewable energy financing in dairy cooperative SACCOs for solar PV, efficient chillers, and cold storage upgrades.
5. **Technical Capacity Building:**
   Partner with TVET institutions, County Energy Department, and EPRA to train local technicians on solar installation, maintenance, and energy efficiency.
6. **Digital Energy Monitoring Systems:**
   Deploy smart meters and IoT-based monitoring tools for real-time tracking of energy use, enabling better management and cost control.
7. **Public–Private Partnerships:**
   Collaborate with private energy companies, financial institutions, and development partners (e.g., NARIGP, KCSAP, USAID) to scale up renewable adoption across dairy cooperatives.

Table 3-35: Summary of Proposed Programs and Projects in Dairy Industry

Project/Program	Description	Stakeholder Responsible	Expected Outcome	Phasing & Prioritization	Estimated Cost (KES)	Performance Indicators
Solar PV Electrification for Dairy Cooperatives	Installation of 10–20 kWp hybrid solar PV systems for 10 dairy cooperatives	County Government, Co-operatives, KPLC, REA	Reduced grid dependence; stable electricity supply	Short-term (1–3 years)	120 million	No. of cooperatives powered by solar
Energy-Efficient Chiller Replacement Program	Replace outdated milk coolers with energy-efficient models in 10 cooperatives	County Government, EPRA, Donors	Reduced energy costs by 30–40%	Short-term (1–3 years)	50 million	% reduction in electricity cost per litre
LED Lighting and Electrical Retrofit	Replace old lighting with LED and upgrade electrical systems	Cooperatives, County Energy Office	Improved lighting efficiency, reduced bills	Short-term (1–2 years)	10 million	No. of facilities retrofitted
Cooperative Energy Audit & Capacity Building	Conduct energy audits, train managers and technicians	County Energy Dept., EPRA, KIRDI	Enhanced energy efficiency & data management	Medium-term (3–5 years)	15 million	No. of trained personnel; audits completed
Smart Energy Monitoring System	Install digital meters and monitoring systems	County Gov't, Cooperatives	Improved energy data tracking	Medium-term (3–5 years)	5 million	No. of systems operational
Cooperative Renewable Energy Financing Facility	Establish a revolving fund within SACCOs for renewable projects	County Treasury, Development Partners	Increased financing access for solar and efficiency	Medium to Long-term (3–7 years)	30 million	No. of projects financed through SACCOs

3.6.2 THERMAL ENERGY FOR INDUSTRIES

3.6.2.1 THERMAL ENERGY FOR TEA INDUSTRIES

3.6.2.1.1 Baseline Assessment

Tea processing is **highly thermal energy-intensive**, with **85–93% of total energy consumption** dedicated to heat production for withering and drying. In Embu's KTDA factories, heat is produced in **central steam boilers** that operate at 9–10 bar and 200°C. The generated steam is distributed to withering and drying sections — **4 bar for withering** and **8 bar for drying**. Historically, KTDA factories used **fuel oil** for their boilers, but due to rising oil prices and sustainability concerns, they transitioned to **wood-fired boilers** starting in the 1980s. By 2012, KTDA had fully replaced fuel oil with **fuelwood boilers**.

To secure a sustainable fuelwood supply:

- KTDA purchased **16,820 ha of land** for plantations by 2019, and has planted over **15,500 ha** of trees;
- Factories have **on-site wood storage facilities** to dry and store wood;
- Smallholder tea farmers are encouraged to plant **1 ha of woodlots for every 4 ha of tea**.

However, challenges persist with **moisture content (MC)** and sustainability of supply. The target MC for optimal combustion is **25%**, but in practice, delivered wood averages **over 50%**, reducing boiler efficiency and increasing smoke.

To address cost and sustainability, some factories have trialed **alternative biomass fuels**, including:

- **Briquettes** from macadamia shells, rice husks, and sawdust;
- **Direct use of macadamia shells**, which have high calorific value (19.6 GJ/t dry basis);
- **Sawdust** and **factory residues** as supplementary fuels.

These alternatives have shown promising efficiency gains. For instance, using a **50:50 mix of fuelwood and briquettes** has achieved **25% fuel cost savings** in pilot projects.

3.6.2.1.2 Key Challenges

1. **High cost and scarcity of sustainable fuelwood**, driven by deforestation and land competition.
2. **High moisture content of fuelwood**, reducing combustion efficiency.
3. **Limited availability and high cost of alternative biomass fuels**, such as macadamia shells.
4. **Lack of standardization and quality control** for briquettes and biomass fuels.
5. **Seasonality of supply** for agricultural residues.
6. **Limited local capacity** for biomass drying, storage, and boiler efficiency optimization.

3.6.2.1.3 Proposed Solutions

1. **Promote fuelwood drying and moisture monitoring systems** to improve combustion efficiency.

2. **Expand sustainable woodlot development** on KTDA and farmer lands through agroforestry programs.
3. **Scale up the use of briquettes and macadamia shells**, targeting at least **20% non-wood bioenergy substitution**.
4. **Facilitate partnerships** with briquette producers for bulk supply and technology transfer.
5. **Introduce high-efficiency boilers** with automated feeding and combustion control.
6. **Train boiler operators** on efficient combustion and maintenance.
7. **Develop county-level biomass fuel quality standards and certification mechanisms.**

Table 3-36: Summary of Proposed Clean Cooking / Heating Projects and Programs for Tea Factories

Project/Program	Description	Stakeholder Responsible	Expected Outcome	Phasing & Prioritization	Estimated Cost (USD)	Performance Indicators
Fuelwood Drying & Storage Program	Construct drying sheds, introduce MC testing for delivered fuelwood	KTDA, County Govt., KEFRI	Improved combustion efficiency	Short term (2025–2026)	0.5 million	Avg. MC of firewood (%), boiler efficiency
Sustainable Fuelwood Plantation Expansion	Expand KTDA and farmer-owned plantations	KTDA, Forest Dept., County Govt.	Reliable, sustainable biomass supply	Medium term (2025–2028)	2 million	Ha planted, % of fuel from own sources
Biomass Briquette & Residue Utilization Program	Promote briquette use and integration of macadamia shells	KTDA, Private Sector	Reduced reliance on wood, cost savings	Medium term	0.8 million	% of non-wood fuel use, cost/GJ
Boiler Efficiency Upgrade	Replace or retrofit boilers with efficient models	KTDA, Donors	Reduced fuel consumption, lower emissions	Medium term	1.5 million	GJ/t MT, emission reduction
Boiler Operator Training	Train operators in combustion efficiency, safety, and maintenance	KTDA, MoE, County Govt.	Enhanced operational efficiency	Continuous	0.1 million	No. of operators trained
Biomass Quality Standards Framework	Develop county-level standards for briquettes, wood, residues	County Govt., KEBS	Improved fuel quality and market confidence	Long term	0.2 million	Standards adopted, compliance rate

3.6.2.2 THERMAL ENERGY IN COFFEE INDUSTRIES

3.6.2.2.1 Baseline Assessment

In Embu's FCSs, after pulping, fermentation and washing, the resulting **parchment coffee** must be dried to a **moisture content of ~10–12%** to become stable for storage and further milling. The prevailing method is **sun-drying**: cooperatives spread parchment coffee on **raised drying beds / tables** in open air and rake them regularly for 7–21 days (depending on weather, humidity, and solar exposure).

While sun-drying is cost-minimal, it carries significant challenges:

- **Unreliable solar conditions** (cloud cover, rain) prolong drying, degrade quality, lead to mold or rewetting.
- Large land area and infrastructure (drying tables) are needed, often stretching cooperative resources.
- Over-drying or under-drying can damage quality and weight.
- Labor-intensive management (stirring, shading, covering at night).
- During peak harvest periods, drying table **congestion** is frequent, lowering capacity and delaying cherry intake.

To address these, solar dryers are increasingly being adopted in Kenya, including by Kenyan cooperatives. A solar dryer acts like a greenhouse: trapping solar heat, controlling airflow/ventilation, and shielding beans from adverse weather. Studies show solar dryers can reduce drying time from ~7–10 days to ~4–7 days under controlled conditions.

However, adoption has been limited due to cost, maintenance, scaling, and reliability constraints.

In Embu, the county government has already invested in upgrades to cooperative infrastructure — including **solar dryers**, metallic drying beds, improved sheds, sorting sheds, and fermentation tank improvements (supported through NAVCDP funding of KES28 million across four cooperatives: Kirimiri, Rianjagi, Kanjugu, Muramuki). These enhancements suggest a foundation on which thermal innovations can be scaled.

Another thermal energy source is **coffee husks / pulp residues**. Globally, coffee husks have been used as fuel in low-grade drying or as biomass fuel in boilers. A study on combustion of coffee husks shows they have lower calorific value but are viable in certain contexts.

Also, conversion of coffee waste to **briquettes** (for cooking or small thermal heating) is underway in Kenya (Rainforest Alliance HECs). In Embu's context, such briquettes have primarily been oriented to **household cooking** rather than industrial drying.

Importantly, in wet coffee processing, **fermentation wastewater / effluent** also represents a source of methane emissions. Capturing biogas from fermentation might offer an opportunity to supply low-grade heat or power, though this is less commonly practiced in Kenyan cooperatives.

Thus, the current thermal energy regime is dominated by passive solar drying, with nascent solar dryers, and limited biomass use (mainly soldiered toward household rather than industrial thermal use).

3.6.2.2.2 Key Challenges

1. **Dependence on climatic conditions**, making drying unpredictable and slow during cloudy or rainy periods.
2. **Drying table congestion** during peak harvest due to limited capacity.
3. **High capital and maintenance cost** of solar dryers (structure, covering, ventilation, fans).
4. **Scale mismatch**: Solar dryers often too small to handle full cooperative volumes.
5. **Overheating / poor control** in solar dryers (risk of over-drying or quality loss).
6. **Lack of skilled personnel** to operate or maintain thermal systems, calibrate controls, and monitor performance.
7. **Limited access to quality biomass fuel** for backup heating (coffee husks may not always be available in sufficient quantity or with consistent moisture).
8. **Integration complexity**: blending solar + biomass + ventilation control in one system.
9. **Financing and cost recovery**: FCSs may struggle to invest in thermal infrastructure and recoup costs.
10. **Absence of standards or guidelines** for cooperative-scale solar dryers, hybrid dryers, or biomass heater integration.

3.6.2.2.3 Proposed Solutions

1. **Deploy modular solar dryers** at selected FCSs with capacities aligned to harvest volumes (e.g. 5 to 20 ton batches).
2. **Hybrid solar–biomass dryers**, using coffee husks or other biomass to support drying under low-sun conditions.
3. **Construct biomass-fired hot-air booths / backup heaters** fueled by coffee husks / briquettes to complement solar dryers.
4. **Promote cooperative-level coffee husk briquette programs**, with possible aggregation for thermal use or sale.
5. **Install control systems (temperature, humidity sensors, ventilation control)** to manage drying curves and prevent damage.
6. **Train technicians and cooperative staff** in dryer operation, maintenance, repair, and optimization.
7. **Establish centralized drying hubs or shared thermal facilities** serving several FCSs to achieve scale efficiency.
8. **Link thermal systems with biogas from fermentation / wastewater** where applicable, to provide supplemental heat.
9. **Facilitate concessional funding, grants, subsidies** for thermal infrastructure in cooperatives.
10. **Develop standards and guidelines** for cooperative solar dryers, hybrid dryers, and biomass heating systems, drawing on existing design manuals (e.g. GIZ / Fairtrade solar dryer manuals).
11. **Pilot demonstration FCSs** to showcase performance and build confidence in adoption.

Table 3-37: Proposed Thermal Projects / Programs in Embu Coffee Sector

Project / Program	Description	Stakeholder(s) Responsible	Expected Outcome	Phasing & Priority	Estimated Cost (USD)	Performance Indicators
Modular Solar Dryers at FCSs	Install solar drying units (greenhouse-type) at selected FCSs	County Govt, FCSs, NGOs, donors	Reduced drying time, improved quality	Medium term (2025–2027)	0.03–0.15 million per FCS	Days of drying reduced, % of volume processed
Hybrid Solar–Biomass Dryers	Solar dryers combined with backup biomass heater	FCSs, private firms, energy service providers	Reliable drying under varying weather	Medium term	0.1–0.25 million	Uptime, % reliance on biomass backup
Biomass Hot-Air Systems / Boilers	Install biomass-fired hot-air heaters or booths fueled by coffee husks / briquettes	FCSs, private sector, donors	Supplemental heat supply, reduce delays	Medium term	0.1–0.3 million	Thermal energy delivered, % share in drying
Coffee Husk Briquette Program	Collect coffee husks and produce briquettes for thermal use or sale	FCSs, local entrepreneurs, NGOs	Value-add, additional revenue, fuel source	Short–medium term	0.02–0.1 million	Tons briquettes produced, sales volume
Drying Control / Automation	Sensor-based control of ventilation, humidity, shading	FCSs, technical providers	Optimized drying curves, reduced defects	Medium term	0.01–0.05 million	% of time under control, defect rates
Centralized Drying Hubs	Build shared thermal drying facility serving multiple FCSs	County Govt, cooperative federation	Economies of scale, lower unit cost	Long term	0.4–1.0 million	Number of FCSs served, cost per kg dried
Biogas Thermal Pilot	Deploy anaerobic digestion of fermentation waste to produce heat for drying	Select FCSs, research institutions, donors	Renewable heat from waste, reduced fuel cost	Pilot (short–medium)	0.05–0.2 million	Biogas yield, thermal output used
Training & Capacity Building	Train cooperative staff and artisans in thermal systems	County Govt, coffee institutions, NGOs	Skilled local management and sustainability	Ongoing	0.02 million	No. of trainees, maintenance logs
Standards & Guidelines Development	Create technical manuals and guidelines for cooperative solar dryers, hybrid heaters	County, coffee bodies, design specialists	Better design, safety, performance	Short term	0.01 million	Manuals produced, adoption rate

3.6.2.3 THERMAL ENERGY FOR MACADAMIA INDUSTRIES

3.6.2.3.1 Baseline Assessment

Thermal energy plays a critical role in the macadamia value chain, particularly during drying and roasting processes. In Embu County, thermal energy sources vary by scale:

- **At farm and cooperative level:** Drying is mainly done through **solar drying** or air drying. Some cooperatives use small biomass or charcoal dryers for initial moisture reduction before aggregation.
- **At processing level:** Factories such as **Privamnuts EPZ Kenya Ltd** use significant amounts of thermal energy for drying nuts to final moisture levels (~1.5%). The factory operates a biomass boiler that uses **macadamia shells** as fuel. Approximately **15 tonnes of shells** are generated weekly; **5 tonnes** are used internally for drying, while **10 tonnes** are sold as a low-value by-product to factories in Thika. This closed-loop use of shells as fuel provides a sustainable thermal energy source, reducing dependence on fossil fuels and lowering waste.

Thermal processes in macadamia factories typically include:

- Drying of nuts-in-shell and kernels
- Steam generation for blanching and cleaning
- Roasting and pasteurization
- Space heating (minimal)

3.6.2.3.2 Key Challenges

1. **Inefficient biomass combustion technologies**, leading to heat losses.
2. **Limited utilization of waste shells** in smaller processors or cooperatives.
3. **Lack of standardized designs for efficient dryers and boilers.**
4. **Air pollution** from poorly designed biomass boilers.
5. **Limited awareness and technical skills** for maintaining efficient thermal systems.
6. **Underutilization of waste heat recovery and insulation practices.**

3.6.2.3.3 Proposed Solutions

1. **Promote modern, efficient biomass boilers** and dryers adapted to macadamia shell fuel.
2. **Encourage shell briquetting** to improve storage, transport, and combustion efficiency.
3. **Establish centralized drying hubs** powered by shared biomass or solar-hybrid dryers for small processors.
4. **Conduct thermal energy audits** in major processing plants.
5. **Support R&D on efficient macadamia dryers** through collaboration with universities and technical institutes.
6. **Promote emission control and safety standards** for industrial biomass use.
7. **Encourage by-product valorization** (e.g., shell-based activated carbon and charcoal substitutes).

Table 3-38: Summary of Proposed Projects and Programs for Macadamia Sub-Sector

Project/Program	Description	Stakeholder Responsible	Expected Outcome	Phasing & Prioritization	Estimated Cost (KSh)	Performance Indicators
Efficient biomass boiler adoption	Replace old boilers with efficient shell-fired systems	Privamnuts, County Gov't, MoE	Reduced fuel use; lower emissions	Short Term	30 million	Boiler efficiency (%)
Macadamia shell briquetting program	Support SMEs to produce briquettes from waste shells	County Gov't, KEFRI, MSMEs	Increased shell utilization; new jobs	Medium Term	15 million	Tonnes of shells briquetted
Centralized drying hubs	Establish shared biomass-solar hybrid drying facilities for cooperatives	County Gov't, Cooperatives, REA	Improved drying efficiency and quality	Medium to Long Term	60 million	No. of hubs established
Thermal energy audit and training	Conduct audits and train operators on thermal management	County Gov't, NITA, MoE	Enhanced energy efficiency	Short Term	5 million	No. of audits; % savings achieved
Emission control and safety program	Introduce emission standards and safety inspections	NEMA, County Gov't	Improved air quality	Long Term	3 million	No. of inspections conducted

3.6.2.4 THERMAL ENERGY IN DAIRY INDUSTRIES

3.6.2.4.1 Baseline Assessment

Thermal energy is vital in the dairy value chain, particularly for **heating water, pasteurization, cleaning of equipment, and potential value addition processes** such as yoghurt and cheese production. In Embu County, the main sources of thermal energy in dairy cooperatives are:

- **Firewood**: Predominantly used to heat water for cleaning milk cooling tanks and equipment. Firewood is either purchased from suppliers or sourced locally by cooperative members.
- **Electric Geysers**: Used in some cooperatives to heat and store water, though they significantly increase electricity bills.
- **Solar Water Heaters (SWHs)**: Installed in a few cooperatives (e.g., Kawanjara and Mburugu Dairy), but many are non-functional due to lack of maintenance and unavailability of local service technicians.
- **Biogas**: While the majority of farmers have dairy cows, **adoption of biogas systems at the farm level remains very low** due to limited awareness, high upfront cost, and lack of technical support.

Thermal energy demand within the dairy value chain occurs at three levels:

1. **Milk Cooling Centers** – Hot water is required daily for cleaning the chillers, cans, and pipelines. Average hot water demand ranges between 200–400 liters per day per cooperative.
2. **Processing Units (Value Addition)** – Pasteurization and fermentation processes require heating milk to specific temperatures (60–90°C), often achieved using firewood or electric heaters.
3. **Farm Level** – Farmers may require hot water for sanitation of milking equipment, though most rely on firewood or charcoal.

The heavy reliance on firewood for heating contributes to **deforestation and rising fuel costs**, while electric geysers increase dependence on grid power. There exists a strong opportunity for **biogas and solar thermal technologies** to meet these heating needs sustainably.

3.6.2.4.2 Key Challenges

1. **High Cost and Unsustainability of Firewood:** Overdependence on purchased firewood increases operational costs and contributes to forest degradation.
2. **Non-functional Solar Water Heaters:** Installed systems often fail due to lack of local technical support for maintenance and repairs.
3. **Low Adoption of Biogas:** Despite large dairy cow populations, few farmers use biogas for cooking or water heating due to lack of awareness, credit facilities, and confidence in the technology.
4. **Use of Electric Geysers:** These systems increase electricity demand and cost, negating energy efficiency gains.
5. **Limited Awareness of Efficient Thermal Technologies:** Cooperative staff lack training in the operation and maintenance of efficient stoves, boilers, and thermal insulation systems.

6. **Inadequate Policy and Coordination:** Absence of county-level frameworks promoting renewable thermal energy adoption in the dairy sector.

3.6.2.4.3 Proposed Solutions

1. **Promotion of Biogas Adoption at Farm Level**
    - Support farmers to install small-scale biogas systems using dairy cow dung.
    - Develop credit schemes through cooperatives for biogas financing.
    - Demonstrate community-level digesters for cooperative use (e.g., heating cleaning water).
2. **Solar Water Heating Systems (SWHs):**
    - Rehabilitate existing systems and install new ones to replace electric geysers.
    - Train local youth technicians on SWH maintenance.
    - Integrate SWHs into new cooperative infrastructure designs.
3. **Improved Biomass and Firewood Efficiency:**
    - Introduce **improved cookstoves or gasifier boilers** to replace open-fire systems, reducing firewood use by 40–60%.
    - Encourage use of sustainably sourced fuelwood and briquettes.
4. **Thermal Energy Efficiency Audits:**
    - Conduct audits in cooperatives to identify opportunities for energy savings and better insulation in hot water systems.
5. **Local Capacity Building and Awareness Creation:**
    - Train cooperative managers, technicians, and farmers on efficient thermal technologies, biogas utilization, and safety.
6. **Policy and Institutional Framework:**
    - Develop county-level incentives for renewable thermal technologies (tax breaks, subsidies, or low-interest loans).

Table 3-39: Summary of Proposed Programs and Projects for Dairy Sub-Sector

Project/Program	Description	Stakeholder Responsible	Expected Outcome	Phasing & Prioritization	Estimated Cost (KES)	Performance Indicators
Biogas for Dairy Farmers Program	Support installation of 500 small biogas units for households with dairy cows	County Government, Cooperatives, NARIGP, NGOs	Reduced firewood dependence; improved sanitation	Short-term (1–3 years)	75 million (150,000 per unit)	No. of biogas systems installed
Cooperative Biogas Demonstration Units	Construct 10 institutional biogas plants (e.g., at Mburugu, Kawanjara)	County Energy Dept., Cooperatives	Demonstration of biogas heating; reduced operating costs	Short-term (1–3 years)	25 million (2.5M per unit)	No. of functioning demo units
Solar Water Heating Program	Install and rehabilitate 20 SWH systems in cooperatives	County Government, EPRA, REA	Reliable hot water supply; reduced electricity use	Medium-term (3–5 years)	20 million (1M per system)	No. of operational SWHs
Improved Biomass Boilers and Stoves Initiative	Replace firewood stoves with efficient boilers and cookstoves	Cooperatives, NGOs, Private Sector	Reduced fuel use by 50%; cleaner operations	Medium-term (3–5 years)	15 million	% reduction in firewood use
Thermal Energy Efficiency Audits	Conduct audits and implement recommended measures	County Energy Dept., EPRA	Enhanced energy performance and cost savings	Medium-term (3–5 years)	5 million	No. of audits conducted
Training and Capacity Building on Thermal Technologies	Train cooperative managers, technicians, and farmers	County Energy Dept., TVETs, NGOs	Improved technical capacity; sustainable maintenance	Ongoing	10 million	No. of trainees; systems maintained
Sustainable Fuelwood and Briquette Program	Promote establishment of woodlots and briquette production	County Environment Dept., KFS, Private Sector	Reduced deforestation; sustainable biomass sourcing	Long-term (5–7 years)	12 million	Area under woodlots; tons of briquettes produced

3.7 ENERGY ACCESS FOR WATER AND IRRIGATION

3.7.1 BASELINE ASSESSMENT

Access to reliable and affordable energy remains central to water and irrigation service delivery in Embu County. The county's water infrastructure depends heavily on boreholes, river pumping stations, and water supply systems powered by both conventional and renewable energy sources.

3.7.1.1 BOREHOLES AND SOLARIZATION EFFORTS

Before devolution, Embu County had 51 boreholes, most equipped with manual hand pumps and primarily developed by NGOs and development partners. Recognizing inefficiencies and high operational costs, the Department of Energy initiated a solarization program targeting these pre-devolution boreholes. To date, **9 boreholes have been successfully solarized**, improving water access, reducing labor burden, and increasing system reliability.

Since devolution, the County Government has drilled **36 new boreholes**, of which **30 are solar-powered** and **6 are grid-connected** through Kenya Power. This deliberate shift toward solarization reflects the county's policy commitment to renewable energy integration and operational cost reduction.

3.7.1.2 ENERGY USE IN MAJOR WATER SUPPLY SYSTEMS

The county's major water treatment plants are drawn from Gitau, Masinga, and Kiambere dams.

1. **Gitaru Water Treatment Plant** operates on national grid electricity, but plans are underway to introduce a solar PV hybrid system.
2. **Masinga Water Treatment Station** has fully transitioned to solar power, marking significant progress toward sustainable water operations.
3. **Kiambere–Gitaru–Mutuobare and Gitaru–Mathigira–Kenda systems** are large-scale water schemes currently grid-powered, with hybridization plans to enhance reliability and lower recurrent costs.

3.7.1.3 COMMUNITY-BASED WATER PROJECTS

The county supports **eight community-established water projects**, several of which are solar-powered.

1. **Ngandori** has been upgraded to a fully registered Water Service Provider (WSP).
2. **Ndamvuge** is undergoing formalization as a WSP.

These projects demonstrate community ownership and sustainability in decentralized water management, particularly in rural areas.

3.7.1.4 ONGOING AND PLANNED WATER SUPPLY PROJECTS

The county and national government, through the Ministry of Water and the Tana Water Development Agency, are implementing several hybrid and solar-based projects including:

1. **Kamburu Water Supply System** (10,000 m^3/day, hybrid solar-grid, under construction)
2. **Kiambere Water Supply System** (10,000 m^3/day, fully solar-powered, planned)
3. **Masinga–Indune Water Supply System** (10,000 m^3/day, hybrid solar-grid, ongoing)
4. **18 new boreholes planned for FY 2025–2026**, to be fully solarized from inception through partnerships with NDMA, KCEP-CRAL, NAVCDP, and Kenya Red Cross.

By the end of 2024, **water coverage is projected to reach 68%**, though disparities remain in arid areas such as Evurore and Muminji wards.

3.7.2 KEY CHALLENGES

Despite commendable progress, the sector faces several challenges that hinder efficient energy access for water and irrigation services:

1. **Incomplete Solarization:** Of the 51 pre-devolution boreholes, 42 remain manual and require modernization.
2. **High Initial Investment:** Solar pumping systems and hybrid installations demand significant upfront capital.
3. **Grid Dependence:** Major treatment plants (e.g., Gitaru and Kiambere systems) remain heavily reliant on grid power, exposing operations to outages and high costs.
4. **Uneven Water Distribution:** Areas with low groundwater potential, particularly Mbeere South, face persistent water shortages despite energy interventions.
5. **Limited Technical Capacity:** Some community-managed systems lack trained personnel for solar system maintenance.
6. **Fragmented Coordination:** Weak linkages between the Department of Energy, the Department of Water, and implementing agencies slow project execution and data sharing.
7. **Environmental and Climatic Stress:** Drought and erratic rainfall affect groundwater recharge, leading to reduced water yields even in solarized boreholes.

3.7.3 PROPOSED SOLUTIONS

To enhance energy access, efficiency, and sustainability in the water and irrigation sector, the following strategic interventions are proposed:

1. Complete Solarization of Existing Boreholes

a) Solarize all remaining 42 manual boreholes with 4 kW solar pumps and 10,000-liter storage tanks.
b) Approximate cost: **KES2.5 million per borehole** including distribution infrastructure.
c) Prioritize boreholes in drought-prone and low-grid-access areas.

2. Hybridization of Grid-Powered Systems

a) Integrate solar PV into existing grid-dependent systems such as **Gitaru–Mathigira Kenda** and **Kiambere–Gitaru Mutuobare**.
b) Introduce battery storage and automated switching to improve reliability and lower power costs.

3. Expansion of Solar-Powered Irrigation

a) Support the development of large-scale irrigation projects in Makima, Mbeere, and Evurore through hybrid systems (e.g., Masinga–Indune, Kiambere, Kamburu schemes).
b) Promote adoption of solar mini-grids for smallholder irrigation cooperatives.

4. Strengthening Technical Capacity and Maintenance

a) Train local youth and WSP staff in solar water pumping maintenance and data management.
b) Establish a county solar maintenance unit under the Department of Energy.

5. Improved Coordination and Planning

a) Develop a joint planning framework between the Departments of Water, Energy, and Agriculture for integrated project design, monitoring, and data sharing.
b) Strengthen partnerships with national agencies and donors to leverage financing and technology.

6. Groundwater and Climate Resilience Measures

a) Undertake hydrogeological surveys to identify viable borehole sites.
b) Promote rainwater harvesting and storage systems to supplement solar pumping during dry seasons.

Table 3-40: Summary of Water and Irrigation Energy Projects for Water and Irrigation Sector

Project/Program	Description	Stakeholder Responsible	Expected Outcome	Prioritization & Phasing	Estimated Cost (KSh)	Performance Indicator
Solarization of 42 Pre-Devolution Boreholes	Conversion of manual boreholes to 4 kW solar-powered systems with 10,000L tanks	Dept. of Energy, Dept. of Water, Partners (NDMA, KCEP, NGOs)	Improved access to clean water; reduced manual labor	High priority (2025–2027)		Number of boreholes solarized
New Solarized Boreholes (18 Planned)	New boreholes equipped with solar pumps	Dept. of Water, NDMA, KCEP, NAVCDP	Expanded rural water access	Ongoing (2025–2026)		New solar boreholes commissioned
Gitaru–Mathigira Kenda Hybridization	Addition of solar PV to 11 kW grid system	Dept. of Water, EPRA, KPLC	Reduced electricity costs; improved reliability	Medium priority (2026–2027)		Hybrid system commissioned
Kiambere–Gitaru Mutuobare Hybridization	Integration of solar PV into grid system	Dept. of Water, Tana Water Works Dev. Agency	Reduced grid dependence	Medium priority (2026–2028)		System operating on hybrid mode
Masinga Mbondoni River Pumping Station	7.5 kW solarized system using welded angle-line mounts	Community Committee, Dept. of Water	Community-managed sustainable water supply	Completed/Ongoing		Continuous operation uptime
Masinga–Mwanyani–Kiangeni Water System	7.5 kW solar-powered large supply system	Dept. of Water, Community	Sustainable water delivery	Completed		Volume of water supplied daily
Kamburu Water Supply System	30 kW hybrid system with 10,000 m³/day capacity	Ministry of Water, Tana Water Dev. Agency	Reliable domestic & agricultural water	Under construction		System operationalized
Kiambere Water Supply System	30 kW solar intake and booster pumps (irrigation)	Ministry of Water, County Govt.	Expanded irrigation coverage	Planned (2026–2028)		Irrigation coverage increased
Masinga–Indune Water Supply System	30 kW hybrid intake + solar booster for irrigation	Tana Water Dev. Agency	Improved irrigation in Mbeere	Ongoing		Irrigated land (hectares)
Community Water Project Upgrading	Formalization and solar upgrade of community projects (Ngandori, Ndamvuge)	Dept. of Water, WSPs	Strengthened community water governance	Ongoing		No. of projects formalized

3.8 ENERGY ACCESS FOR MARKETS AND STREET LIGHTING

Street lighting significantly contributes to the overall electricity consumption in public spaces. It supports night-time economic activity, enhances road and pedestrian safety, and improves the security of neighborhoods. These benefits make it an essential service that should be prioritized in energy access programs.

According to the Kenya National Bureau of Statistics (KNBS) 2023/24 Kenya Housing Survey, only 22.6% of dwellings nationally had access roads equipped with streetlights or high mast lighting. The divide between urban and rural areas is stark: 47.6% of urban households report access to such lighting compared to just 6.8% in rural areas. Nairobi leads with 75.4% coverage, whereas Vihiga County lags at 2.4%.[36]

In comparison, Embu County has relatively low coverage, with only 12.3% of the county's 199,046 households reporting streetlights or high mast lighting on their access roads. While this is above the lowest national figures, it still indicates a considerable gap, particularly in rural zones of the county. This low coverage directly affects nighttime visibility, safety, and access to services, especially for residents in underserved areas.

As Embu County develops its energy strategy, increasing public lighting coverage should be a priority not only to reduce the disparity with more urbanized counties but also to catalyse local economic growth, improve quality of life, and enhance overall public safety. Investments in energy-efficient lighting technologies, such as solar-powered LED streetlights, can offer sustainable and cost-effective solutions tailored to the county's geographic and economic context

3.8.1 ELECTRICITY FOR STREET LIGHTING

3.8.1.1 BASELINE ASSESSMENT OF FLOODLIGHTS AND STREETLIGHTS

Floodlights and streetlights form a crucial part of Embu County's public infrastructure, improving safety, enabling night-time economic activities, and supporting social cohesion. As of 2025, the county has a total of **176 floodlights** and **93 streetlights**, distributed across all 20 wards.

3.8.1.1.1 Energy Mix and Operational Status

1. Of the **176 floodlights**, **9 are solar-powered**, while **167 rely on grid electricity**.
2. Approximately **38% (86 units)** of floodlights are functional, and **62% (138 units)** require repair or replacement.
3. For **streetlights**, **46% (43 units)** are functional, while **54% (50 units)** are non-functional.

[36] KNBS 2023/24 Kenya Housing Survey – Basic Report

4. Solar floodlights have demonstrated greater reliability and minimal maintenance needs compared to grid-connected units.

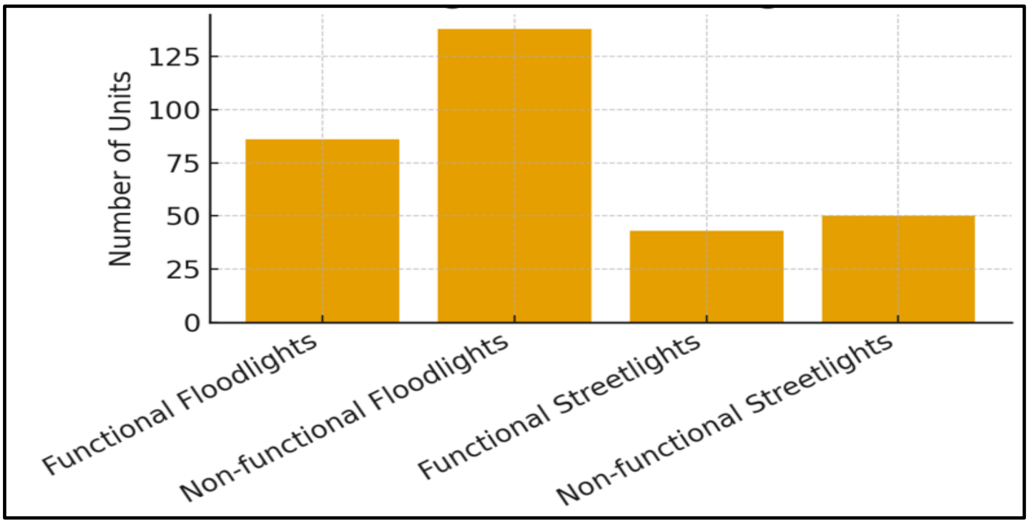


Figure 3-32: Functional Floodlights and Streetlights

3.8.1.1.2 Maintenance and Cost Analysis

1. The **average repair cost** per grid-powered floodlight is **KES50,000**, while solar units require about **KES12,000** every three years.
2. For streetlights, annual repair costs average **KES100,000** for grid-powered units.
3. The total estimated cost of restoring all non-functional floodlights is **KES6.5 million**, and **KES4.6 million** for streetlights.

3.8.1.1.3 Electricity Bills and Budget Trends

Electricity expenses are a major financial burden. As of 30th June 2024, the county had an outstanding bill of **KES54 million** owed to KPLC for public lighting. As of February 2024, the bill stood at **KES48.3 million.** Budget allocations for maintenance have declined steadily:

1. FY 2022/2023: **KES3 million**
2. FY 2023/2024: **KES2 million (including rollovers)**
3. FY 2024/2025: **KES0.5 million**

This underfunding has resulted in delays in repairs, frequent disconnections, and system deterioration.

3.8.1.1.4 Ward-Level Summary

A summarized analysis of the situation at the ward level indicates the following:

1. **Functional floodlights**: Highest coverage in Kirimari, Kyeni North, and Evurore wards.

2. **Non-functional floodlights**: Most affected wards include Mbeti South, Ruguru Ngandori, and Kagaari South due to transformer faults and vandalism.
3. **Functional streetlights**: Concentrated in Kirimari and Mbeti North.
4. **Vandalism and wiring issues** are key contributors to system downtime across several wards.

3.8.1.2 KEY CHALLENGES

1. **Inadequate Budgetary Allocation:** The available budget for maintenance and electricity bills is insufficient, leading to frequent disconnections, delayed repairs, and limited expansion of public lighting systems.
2. **Lack of Specialized Maintenance Equipment:** The absence of essential tools—particularly a **man lift** and electrical testing equipment—hampers timely and safe maintenance of high-mounted streetlights and floodlights.
3. **Fragmented Responsibilities and Weak Coordination:** Floodlight installation and maintenance functions are spread across several departments, including **Trade**, **Roads**, and **Public Works**, leading to duplication of efforts, poor accountability, and weak oversight.
4. **Unclear KPLC Billing and Metering Structures:** Some installations operate without proper metering or on non-consumption-based billing systems, resulting in inaccurate or disputed bills and inefficient use of county funds.
5. **Limited Technical Personnel:** The County has an insufficient number of skilled technicians to conduct inspections, routine maintenance, and troubleshooting, resulting in long downtimes and poor service quality.
6. **High Operational Costs of Grid-Powered Systems:** The reliance on grid electricity for floodlights and streetlights has led to high operational costs that are financially unsustainable over time.

3.8.1.3 PROPOSED SOLUTIONS

To address these challenges and ensure the sustainability of Embu County's public lighting system, the following solutions are proposed:

1. **Secure Dedicated Budgetary Allocations:** Allocate specific annual budget lines for maintenance, accessories, and electricity bills to ensure continuous operation of existing public lighting infrastructure and prevent disconnections.
2. **Procurement of Maintenance Equipment:** Acquire a **man lift**, diagnostic tools, and other specialized equipment to support efficient, safe, and timely maintenance and repairs.
3. **Recruitment and Capacity Building:** Recruit additional technical personnel and provide **training in modern and solar lighting technologies** to enhance in-house maintenance capacity and reduce reliance on contractors.
4. **Transition to Solar and Energy-Efficient Lighting:** Implement a phased **conversion of grid-powered floodlights and streetlights to solar-powered systems** to reduce electricity costs and enhance sustainability. Additionally, adopt **LED lighting and automation technologies** such as timers or motion sensors to minimize unnecessary energy consumption.

5. **Centralized Management and Coordination:** Consolidate all streetlight and floodlight projects under the **Department of Roads, Public Works, Transport, Energy, and Logistics** to streamline management, improve accountability, and enhance resource allocation.
6. **Settlement of Pending Bills and Audit of Existing Accounts:** Clear outstanding electricity arrears to avoid penalties and disconnections and conduct **joint energy audits with KPLC** to validate billing accuracy and curb illegal connections.
7. **Revenue Generation for Maintenance Sustainability:** Explore **commercial use of lighting poles**—such as advertising spaces, CCTV installations, or telecommunication attachments—to generate revenue that can support maintenance and system expansion. Such initiatives should be guided by appropriate policy or cabinet-level approval.
8. **Monitoring and Evaluation Framework:** Establish a regular monitoring program for public lighting performance, including tracking uptime, response time to faults, and energy consumption trends, to guide decision-making and continuous improvement.

Table 3-41: Summary of Market and Streetlighting Projects and Programs

Project/Program	Description	Stakeholder Responsible	Expected Outcome	Prioritization & Phasing	Estimated Cost (KSh)	Performance Indicator
Restoration of Non-Functional Floodlights	Repair and rewiring of 138 units countywide	Dept. of Roads, Energy & Logistics	Improved visibility and security	High (2025–2026)	6.5M	% functional floodlights
Restoration of Non-Functional Streetlights	Repair of 50 AC-powered streetlights	Dept. of Energy, KPLC	Enhanced safety in urban centers	High (2025–2026)	4.6M	% operational streetlights
Procurement of Maintenance Equipment	Purchase of man lift and tools	Dept. of Energy	Faster and safer maintenance	Immediate (2025)	10M	Maintenance response time
Recruitment & Training	Hiring and capacity building for technicians	Public Service Board, Energy Dept.	Improved maintenance capacity	Short term (2025–2027)	0.8 M	Number of trained staff
Transition to Solar Lighting	Conversion to solar-powered LED	Dept. of Energy, Donors	Reduced costs and sustainability	Medium (2026–2030)	30M	% solarized installations
Centralized Management System	Integration of lighting under one department	Dept. of Roads & Energy	Improved coordination	Immediate (2025)	Policy measure	Unified reporting system
Settlement of KPLC Bills	Payment of outstanding KES48.3M and audits	Dept. of Finance, KPLC	Accurate billing and no disconnections	Immediate (2025)	48.3M	Bills cleared and audited
Revenue Generation Initiative	Leasing poles for ads and smart tech	Dept. of Trade & Energy	Revenue for maintenance	Medium (2026–2028)	5M setup	Annual revenue generated
Monitoring & Evaluation Framework	Regular performance tracking	Dept. of Energy, ICT Unit	Reliable data-driven planning	Continuous	0.2M annually	Uptime and fault resolution rate

3.9 ENERGY ACCESS FOR TRANSPORT

3.9.1 BASELINE ASSESSMENT OF THE COUNTY FLEET

Transport is a major energy consumer within Embu County Government operations. The Department of Transport maintains a fleet of over 260 vehicles and 200 motorbikes serving various departments including Health, Infrastructure, Water and Environment, Public Service, Agriculture, and others. The county fleet is vital for service delivery from healthcare logistics and public works to administrative mobility and field supervision.

However, the 2025 fleet audit reveals that a significant proportion of county vehicles are non-operational, aged, and fuel-inefficient, resulting in high maintenance and fuel costs. Transitioning toward electric mobility (e-mobility) offers an opportunity for the County to lower operational costs, improve service reliability, and align with Kenya's climate and energy transition goals.

Table 3-42: Departmental Summary

Department / Section	Total Fleet	Operational	Non-Operational	% Operational	Notable Vehicle Types	Key Observations
Office of the Governor	7	6	1	86%	Toyota Prado	Fleet in good condition; mostly new SUVs.
Public Service, Administration & Devolution	17	4	13	24%	Trucks, Land Rovers	Majority grounded; old fire trucks and pickups uneconomical to repair.
Gender, Culture, Children & Social Services	2	1	1	50%	Ford Kuga, Toyota Corolla	One operational sedan; other unit grounded in Nairobi.
Trade, Tourism, Investment & Industrialization	4	0	4	0%	Ford Kuga, Isuzu D-Max	Entire fleet grounded; aged vehicles.
Finance & Economic Planning	21	8	13	38%	Ford Ranger, Isuzu D-Max	High number of grounded units due to accidents and repair issues.
Education	3	0	3	0%	Ford Kuga, Isuzu D-Max	Entire fleet non-operational; one burnt vehicle.
Lands, Housing & Physical Planning	2	1	1	50%	Toyota Hilux	One vehicle stolen; minimal functional fleet.
Water & Environment	6	4	2	67%	Ford Kuga, Ashok Leyland	Modern units in use; some grounded due to accidents.
Infrastructure, Roads & Public Works	47	19	28	40%	Toyota Hilux, Graders, Land Rovers	Many grounded graders; vital area for e-mobility pilot in heavy equipment.
Health Services	58	15	43	26%	Land Cruisers, Pickups, Vans	Majority grounded; high maintenance cost; ideal for EV and e-bike pilot.
County Public Service Board	1	0	1	0%	Nissan Urvan	Burnt unit; no active vehicle.
Agriculture, Livestock & Fisheries (Motorbikes)	40	35	5	88%	Suzuki, Yamaha, Honda	Motorbikes widely functional and efficient for fieldwork.
Public Health (Motorbikes)	60	50	10	83%	Yamaha, KTM	Mostly operational; some in poor condition at health facilities.
(TVETs, IFAD, Uncollected Assets)	25	6	19	24%	Buses, Dozers, Tractors	Many grounded for learning use or disposal.

Observations

1. **Health, Infrastructure, and Administration** departments have the largest and oldest fleets — priority targets for EV replacement.
2. **Motorbike fleets** (especially in Health and Agriculture) are already energy-efficient and could easily shift to **electric motorcycles**.
3. **Heavy machinery electrification** (e.g., graders, tractors) will require long-term partnerships and pilot projects.
4. **Fleet consolidation** and **phased replacement** with electric vehicles will yield immediate fuel savings and emission reductions.

Table 3-43: County-Wide Summary of the Country Fleet

Category	Total Units	Operational Units	Non-Operational	% Operational	Common Models	Average Age (Years)
Government Vehicles (Cars, Pickups, Trucks, Graders)	260	120	140	46%	Toyota, Ford, Isuzu, Land Rover	10–20
Motorbikes (Mainly in Health and Agriculture)	200	180	20	90%	Yamaha, Suzuki, Kibo	2–10
Heavy Machinery (Graders, Bulldozers, Tractors)	30	10	20	33%	Mitsubishi, New Holland, Komatsu	15–40

Observations

1. Nearly half of the county's vehicles are grounded, mostly due to age, lack of spare parts, or uneconomical repair costs.
2. Many operational vehicles are over 10 years old and consume large volumes of diesel or petrol.
3. Motorbikes remain the most energy-efficient segment and are widely used in field operations, especially in Health and Agriculture.
4. Several graders and heavy equipment are grounded, constraining infrastructure service delivery.
5. The fuel cost analysis shows potential for major cost savings through efficiency or electrification.

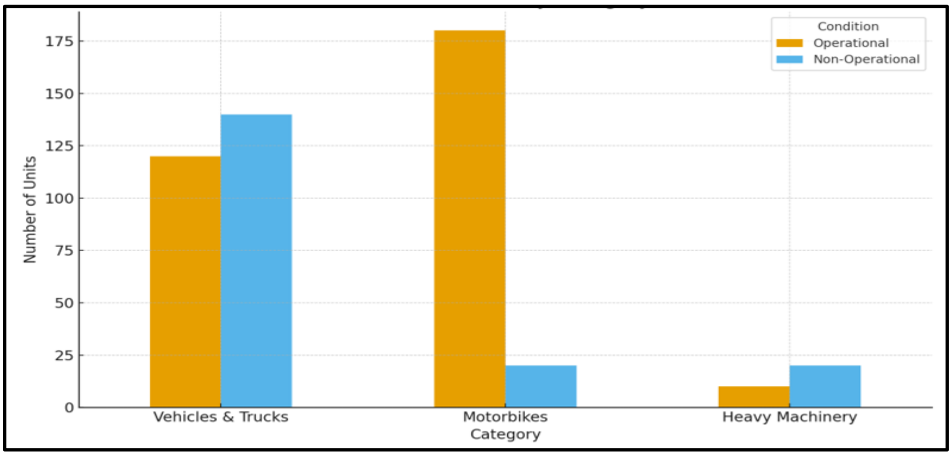


Figure 3-33: Operational and Non-operational Fleets

3.9.2 KEY CHALLENGES

1. **Aging and Inefficient Fleet:** A large portion of the fleet consists of vehicles over 10 years old, many of which are no longer economical to maintain.
2. **High Fuel and Maintenance Costs:** Fossil-fuel vehicles, especially large SUVs and trucks, consume excessive fuel and require frequent repairs.
3. **Limited Preventive Maintenance:** Lack of scheduled maintenance and poor record-keeping accelerate wear and tears.
4. **Underutilized or Grounded Assets:** Nearly half of vehicles are grounded, leading to poor resource utilization.
5. **Lack of E-Mobility Infrastructure:** There are no county-level charging stations or incentives for adopting electric vehicles (EVs).
6. **Weak Fleet Management Systems:** Absence of GPS tracking, fuel monitoring, and digital maintenance logs.
7. **Policy Gaps:** No county-level policy or framework promoting electric mobility or fuel efficiency in government operations.

3.9.3 PROPOSED SOLUTIONS AND PATHWAYS FOR E-MOBILITY

A. Short-Term (1–3 Years)

1. **Fleet Rationalization and Disposal Program:** Assess and dispose of uneconomical vehicles to reduce maintenance and storage costs.
2. **Fleet Management Digitalization:** Deploy a Fleet Management Information System (FMIS) integrating GPS tracking, fuel logs, and maintenance schedules.
3. **E-Mobility Pilot Program:** Procure a small number of electric vehicles (EVs) and e-motorbikes for pilot use in select departments (e.g., Health, Environment).
4. **EV Charging Infrastructure:** Install initial charging stations at the County Headquarters, Embu University, and Level 5 Hospital.
5. **Policy Development:** Draft and adopt the Embu County Clean Transport and E-Mobility Policy.

B. Medium-Term (4–7 Years)

1. **Fleet Modernization:** Gradual replacement of ICE vehicles with hybrid and electric models during procurement cycles.
2. **Expansion of Charging Infrastructure:** Partner with Kenya Power, EPRA, and private sector for countywide EV charging points.
3. **Capacity Building:** Train county drivers, mechanics, and administrators on EV operation and maintenance.
4. **Partnership with Embu University:** Collaborate on EV research, data collection, and student innovation projects on clean mobility.

C. Long-Term (8–10 Years)

1. **Full E-Mobility Integration:** Target at least **50% of the county fleet** to be electric by 2035.
2. **Green Procurement Framework:** Institutionalize low-emission criteria in all future vehicle procurements.
3. **Renewable-Powered Transport:** Link EV charging to solar PV systems at county facilities to ensure clean energy use.

Table 3-44: Summary of Proposed Projects and Programs

Project/Program	Description	Stakeholders Responsible	Expected Outcomes	Prioritization & Phasing	Performance Indicators
County Fleet Rationalization	Audit and disposal of uneconomical vehicles	Dept. of Transport, Finance	Reduced maintenance costs	Short-term (2025–2027)	% of grounded vehicles disposed
Digital Fleet Management System	Introduce FMIS with GPS and fuel tracking	Transport Dept, ICT, Treasury	Real-time data and efficiency	Short-term	System operational in all departments
E-Mobility Pilot Project	Introduce EVs and e-motorbikes	Energy Dept, Transport, Health	Proof of concept for e-mobility	Short-term	No. of EVs/e-bikes procured
EV Charging Infrastructure	Install charging stations at key facilities	Energy Dept, EPRA, KPLC, Embu University	Functional charging hubs	Short to Medium-term	No. of charging stations installed
Fleet Modernization & Green Procurement	Replace ICE vehicles with EVs	Transport, Procurement, Finance	Reduced fuel use	Medium-term (2027–2031)	% of new purchases electric
Capacity Building for EV Transition	Train drivers and mechanics	Transport Dept, TTI, Embu University	Skilled workforce for EV maintenance	Medium-term	No. trained
Clean Transport Policy	Develop EV and fleet efficiency policy	Energy & Transport Depts, Legal Office	Institutional support for EVs	Short-term	Policy approved
PPP on E-Mobility	Engage EV suppliers and utilities	Energy Dept, Finance, EPRA, KPLC	Sustainable EV ecosystem	Long-term (2030+)	No. of PPPs established
Renewable-Powered Charging Systems	Link EV charging to solar PV systems	Energy Dept, Environment, Donors	100% renewable EV energy	Long-term	% of chargers powered by solar

4 ENERGY EFFICIENCY AND CONSERVATION

4.1 INTRODUCTION

Energy efficiency refers to the practice of using less energy to perform the same task without impacting on the output negatively. This can be achieved through deployment of appliances or devices that use less energy relative to conventional technologies or devices. An example of an energy efficiency practices includes replacing fluorescent lighting bulbs or tubes with LED Lighting fixtures. On the other hand, energy conservation refers to the practice of adopting behaviors or habits which reduce energy consumption. An example of an energy conservation practice includes switching off lights during the daytime to utilize natural lighting.

Implementing energy efficiency and conservation (EE&C) measures yields a lot of benefits at household, industrial, commercial and institutional level. At end user point, energy efficiency and conservation measures reduce energy bills while enhancing operational efficiency and process optimization, especially in industries. Additionally, EE&C measures help in cutting carbon emissions which are in line with the global, regional and national agenda on climate change mitigation strategies. At production point, EE&C reduces the demand on the national grid and consequently the resources used in generation of electricity.

Under the Energy Act, 2019 (sections 193,194 and 195) County Governments are mandated to promote energy efficiency and conservation through various measures. With the approval of the Authority, they may amend energy conservation building codes to suit local climatic conditions and require compliance from designated consumers. Counties can also direct consumers to undertake energy audits by accredited auditors, ensure compliance with conservation building codes, and encourage the adoption of energy-efficient appliances and equipment. Furthermore, they are tasked with creating public awareness, training personnel and specialists on energy efficiency techniques, and disseminating information on efficient energy use. In addition, County Governments may require consumers to furnish periodic energy consumption data, specify matters for inspection, and take necessary steps to foster preferential treatment for energy-efficient practices. The Energy (Energy Management) Regulations 2025 also mandates institutional, industrial and commercial facilities that consume more than 180,000 kWh of energy annually to carry out an energy efficiency audit at least once in 4 years. Additionally, the Energy (Appliances' Energy Performance and Labelling) Regulations, 2016 sets out the Minimum Energy Performance (MEPs) indicators for appliances like fridges, air conditioners, bulbs and motors.

4.2 ENERGY EFFICIENCY IN HOUSEHOLDS

Promotion of energy efficiency and conservation measures at the household level may involve dissemination of information regarding energy efficient appliances, and energy conservation practices. At the household level, energy efficiency and conservation should focus on adopting practices and technologies that reduce unnecessary energy use while maintaining comfort and functionality. Households can achieve efficiency by using energy-saving appliances such as LED lighting, energy-efficient refrigerators, and solar water heaters. Conservation practices include switching off lights and appliances when not in use, proper insulation of houses to reduce heating and cooling needs and adopting natural lighting and ventilation wherever possible. Households can also be encouraged to invest in clean energy solutions such as solar PV systems and improved cookstoves, which lower dependence on grid electricity and biomass while cutting energy costs. In addition, monitoring energy bills, carrying out simple audits, and creating awareness among family members about responsible energy use are key strategies for sustaining efficiency. These measures not only lower household expenses but also contribute to environmental protection and support county and national goals on energy conservation and climate change mitigation.

4.3 ENERGY EFFICIENCY IN HEALTH FACILITIES

To assess the level of energy efficiency in health facilities within Embu County, survey questionnaires were administered across facilities categorized from level 2 to level 5. A total of 62 responses were received across with Level 2 having the highest number of responses (65%) while level 5 contributed the least responses (6%). Figure 4-1 shows share responses by hospital category

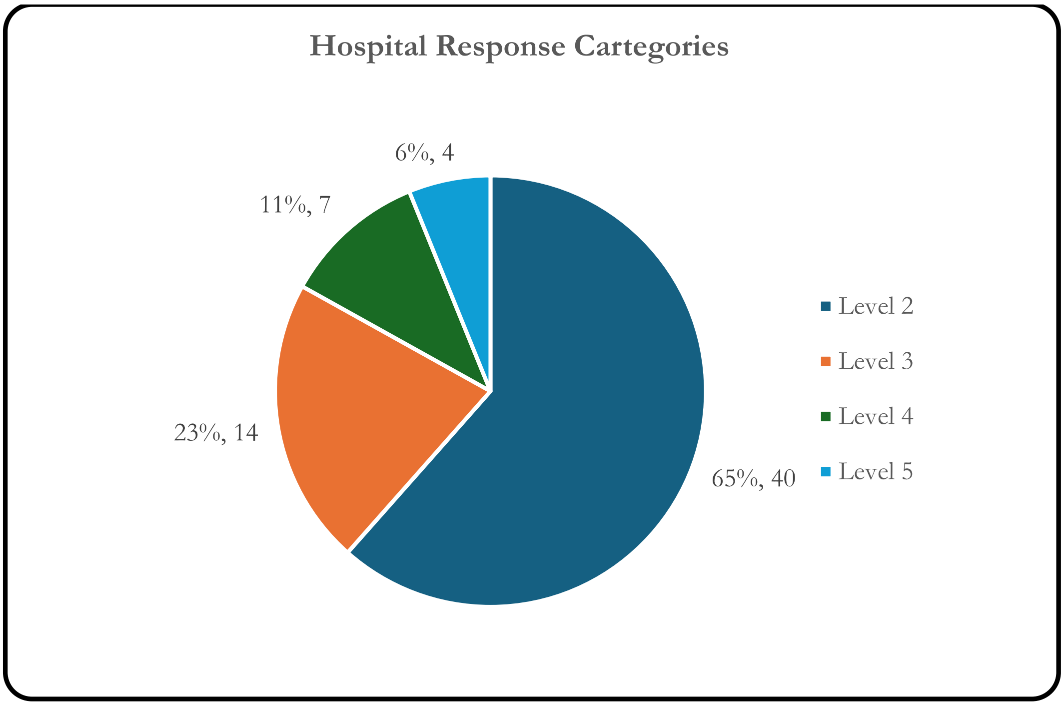


Figure 4-1: Response share by Hospital Category

4.3.1 ENERGY EFFICIENCY AUDITS

Out of the 62 facilities that were surveyed, only 4 (6%) reported having conducted energy audit while the majority, 58(94%) have not undertaken such an exercise. This indicates low level of compliance with conducting energy audit practices within Embu County Health Sector despite the critical role audits play in identifying efficiency opportunities and cost saving measures. Figure 4-2 shows hospital responses for energy efficiency audits.

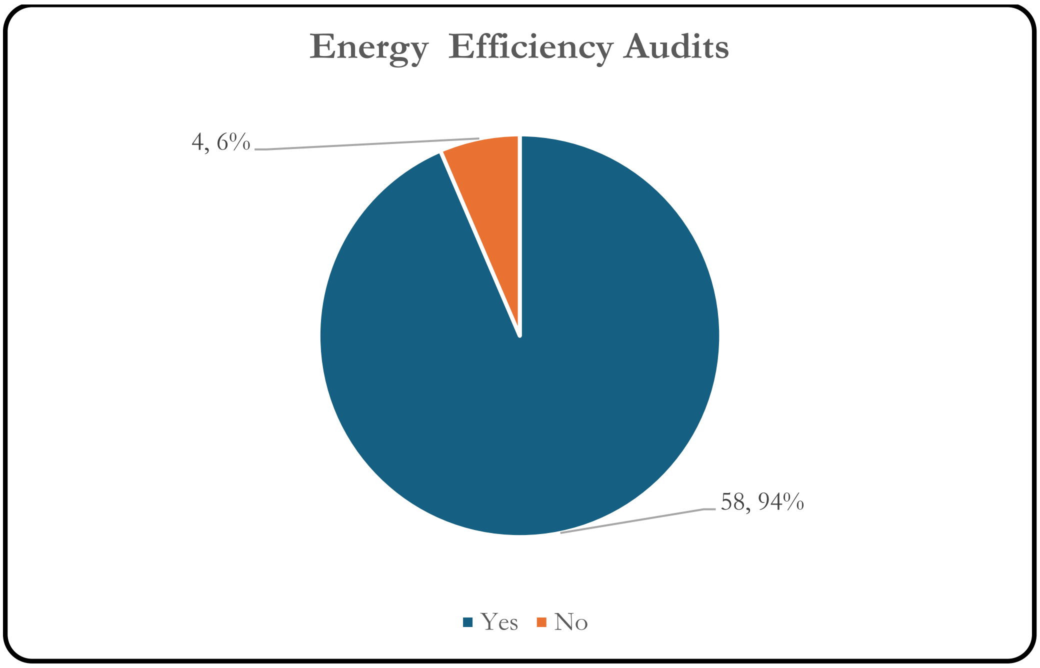


Figure 4-2: Energy Efficiency Audits

4.3.2 BUILDING ENVELOPE AND INSULATION MEASURES

Figure 4-3 the adoption of Building Envelope Insulation measures across the hospital facilities surveyed. Wide windows for natural lighting have the highest uptake at 79.03% of the facilities while sustainable building design has a low uptake 3.23%. Notably, 24.19% of the facilities reported having none of the listed measures which underscores the limited integration of building energy efficient practices in the health infrastructure.

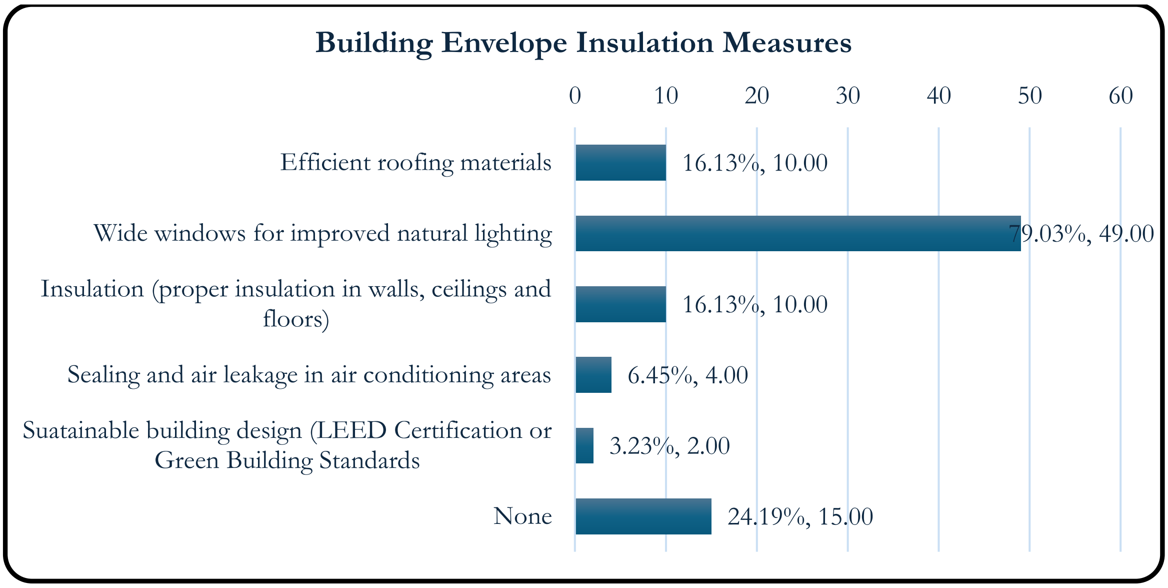


Figure 4-3: Building Envelope Insulation Measures

4.3.3 ENERGY EFFICIENT LIGHTING MEASURES

Figure 4-4 shows the adoption of efficient lighting measures across health facilities. LED lighting has the highest uptake at 82.26% reflecting a strong shift towards efficient lighting. However, it is also important to note that a significant portion of facilities (22.58%) have no efficient lighting measures in place. This gap highlights the importance of targeted awareness to ensure efficient lighting solutions which can significantly reduce energy consumption and operational costs in health facilities.

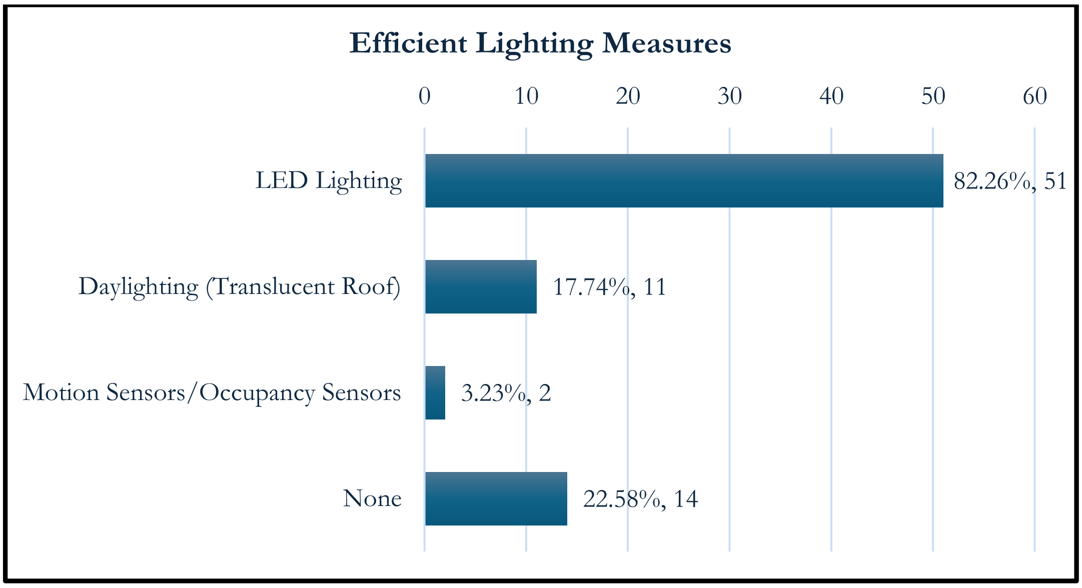


Figure 4-4: Efficient Lighting measures

4.3.4 WATER HEATING CONSERVATION MEASURES

Figure 4-5shows the adoption of Water Heating Conservation Measures across health facilities. Overall, the adoption rate is very low with most of the response (70.97%) having no efficient Water Heating Conservation Measures in place. Only a small fraction has adopted measures such as water conservation (25.81%), high efficiency water heaters (6.45%), use of solar water heaters (6.45%) and recirculating hot water systems (1.61%).

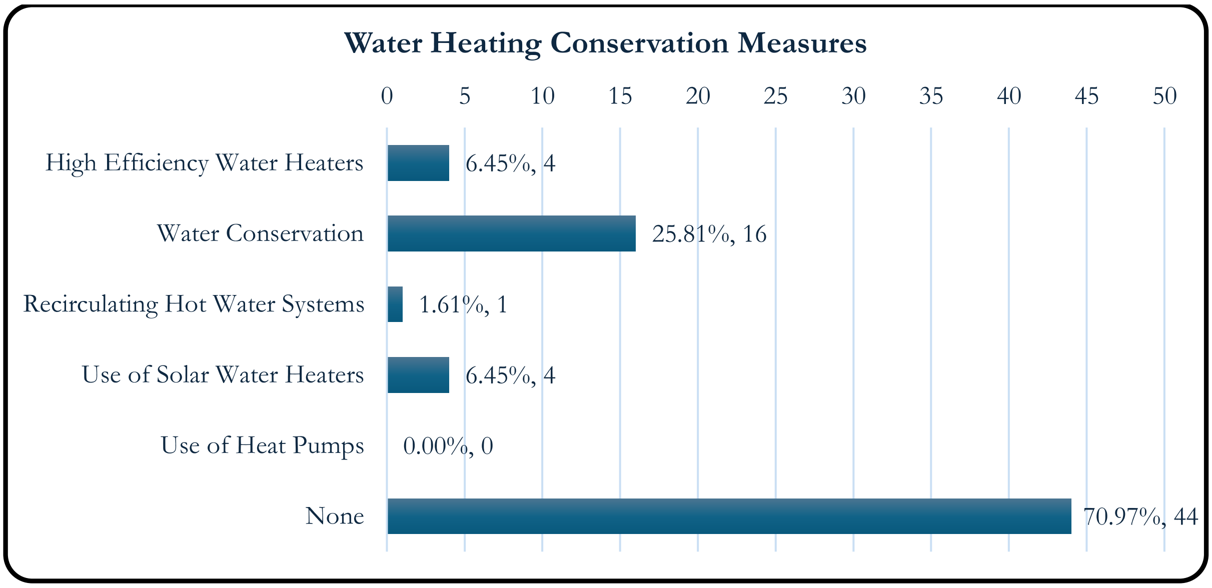


Figure 4-5: Water Heating Conservation Measures

4.3.5 ENERGY MANAGEMENT SYSTEM

Figure 4-6 shows the adoption of Energy Management Systems across health facilities. Overall, the adoption is very low with most of the response (85.48%) having no efficient energy management system measures. Only a small fraction has adopted measures such as monitoring and controlling the energy use in facilities (14.52%) and installing submetering track energy consumption in specific areas (8.06%).

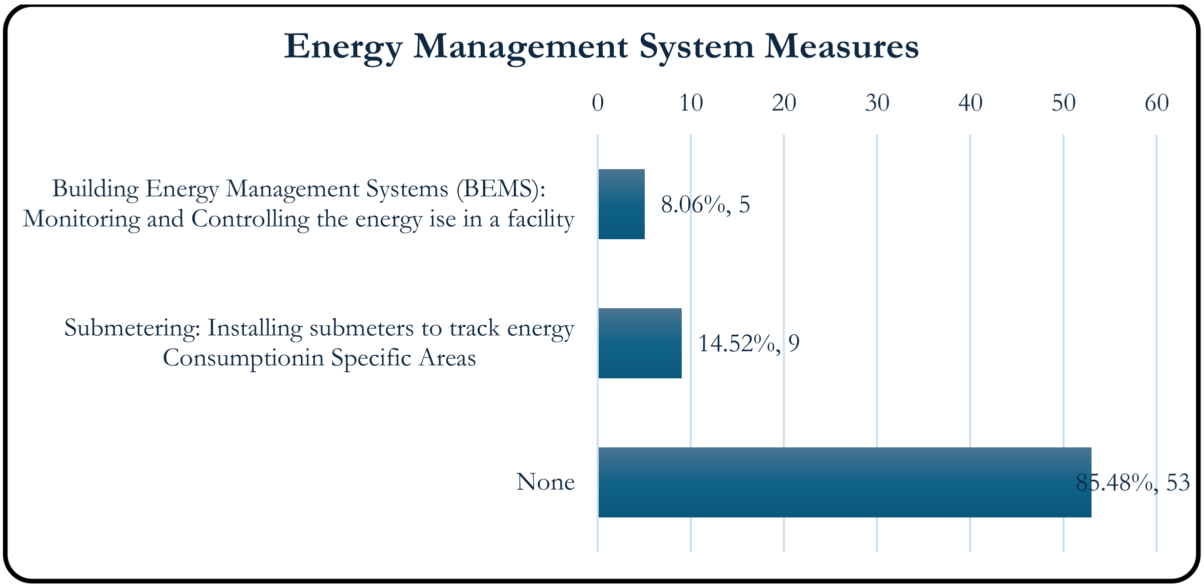


Figure 4-6: Energy Management System Measures

4.3.6 EFFICIENT OPERATION AND MAINTENANCE PRACTICES

Chart 4-1 shows the adoption of efficient operations and maintenance practices across health facilities. Overall, the adoption is very low with the majority of the response (67.74%) having no efficient operations and maintenance practices. Only a small fraction has adopted (33.87%) while (3.23%) reported to have staff training and awareness.

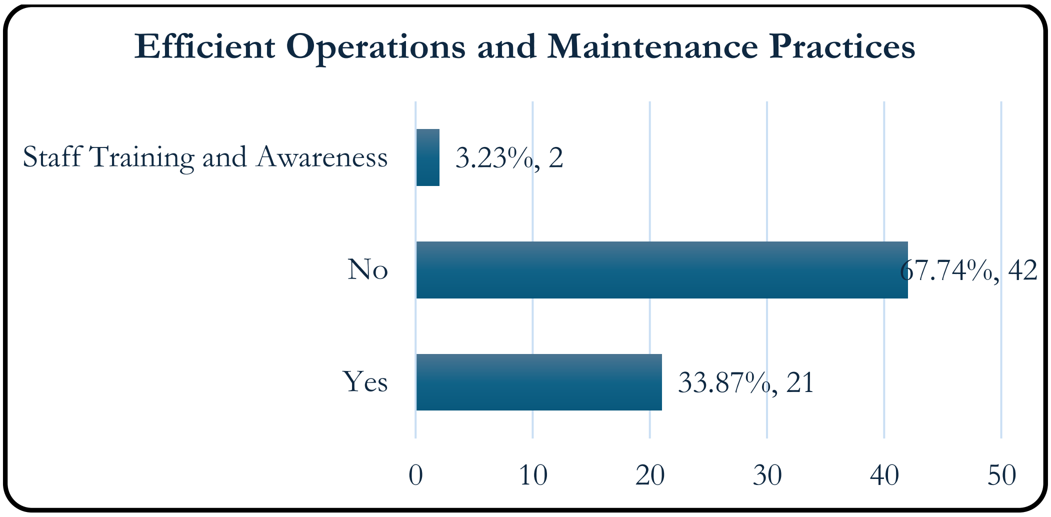


Chart 4-1: Efficient Operations and Maintenance Practices

4.3.7 WAY FORWARD

Table 4-1: Health Institutions Recommendations Matrix

Area of Focus	Survey Finding (Gap)	Recommendation	Expected Benefit	Implementation Timeline	Responsible Stakeholders
Energy Efficiency Audits	Only 6% of facilities have conducted audits.	• Conduct mandatory energy audits every 4 years • Roll out county-led sensitization campaigns on energy audits	• Identification of cost saving opportunities • Improved Operational efficiency	Short-term (0–2 yrs)	EPRA, County Government, Facility Managers
Building Envelope & Insulation	24.19% have not adopted efficient measures.	• Enforce building codes requiring natural ventilation, daylighting, and insulation for new facilities.	• Reduced reliance on artificial lighting • Improved indoor Comfort • Lower energy Costs	Medium-term (2–5 yrs)	County Government, Ministry of Public Works, Facility Engineers
Lighting systems	22.58% of facilities rely on inefficient lighting.	• Replace all incandescent/fluorescent lights with LEDs. • Install motion and occupancy sensors in corridors, wards, and offices. • Promote daylight harvesting in new facility designs.	• Reduction in lighting cost of electricity	Short-term (0–2 yrs)	County Government, Facility Managers, Development Partners
Water Heating & Conservation	70.97% have not implemented efficient water heating.	• Install solar water heaters in wards, kitchens, and staff houses.	• Reduced Electricity Bills • Improved sustainability	Medium-term (2–5 yrs)	County Health Dept., Facility Managers, Energy Service Companies (ESCOs)

		• Explore heat pump technology for larger facilities.			
Energy Management Systems (EMS)	85.48% have no EMS in place.	• Train facility managers on EMS • Introduce submetering & energy tracking systems in large hospitals (level 4 & level 5)	• Accountability in Energy Use • Continuous monitoring of efficiency	Long-term (5+ yrs)	EPRA, County Government, Facility Managers
Efficient Operations & Maintenance	67.74% lack structured O&M practices.	• Develop county level training programs for staff. • Institutionalize routine maintenance schedules.	• Behavioral change leading to energy savings • Prolonged lifespan of equipment	Short-term (0–2 yrs)	County Government, Facility Administrators, Development Partners

4.4 ENERGY EFFICIENCY IN EDUCATION INSTITUTIONS

To assess the level of energy efficiency in educational facilities across Embu County, survey questionnaires were deployed. A total of 156 responses across ECD institutions, Lower Primary Schools, Secondary Schools, TVETs, Colleges and Universities were recorded using google form questionnaire. Figure 4-7 shows responses share by sub-county.

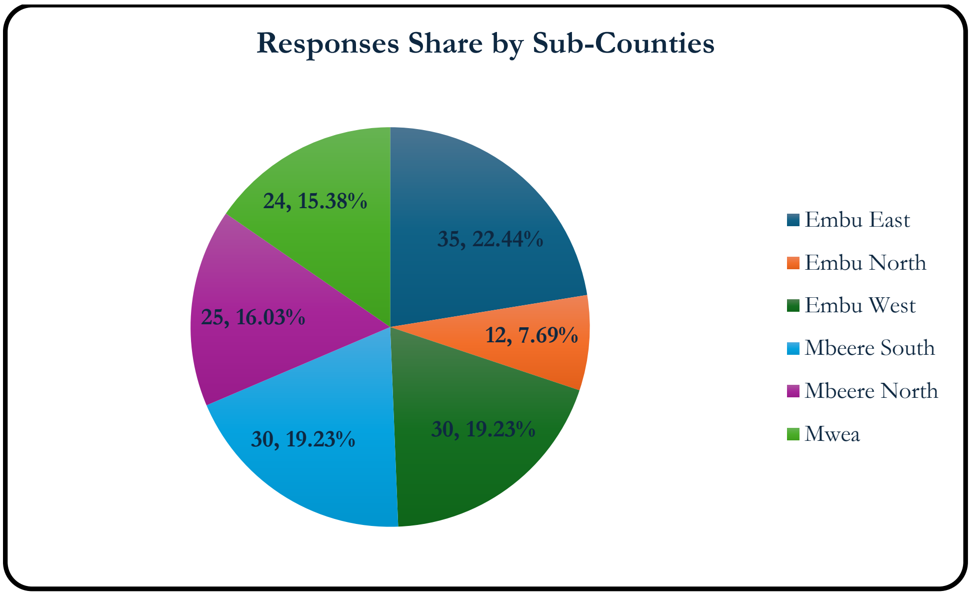


Figure 4-7: Responses Share by Sub-Counties

The aspects of energy efficiency audits, building envelopes, energy efficient lighting measures, water heating and conservation measures, energy management systems and efficient operation and maintenance practices were investigated through the questionnaire.

4.4.1 ENERGY EFFICIENCY AUDITS

Figure 4-8 shows the level of energy efficiency audit compliance across the educational institutions in the county. Out of 156 institutions surveyed, only **4 institutions**, representing **2.56%,** have conducted an energy efficient audit at least. This number is still very low, and awareness creation is key to having education institutions save on energy costs and gain operational efficiency through energy audit conducting.

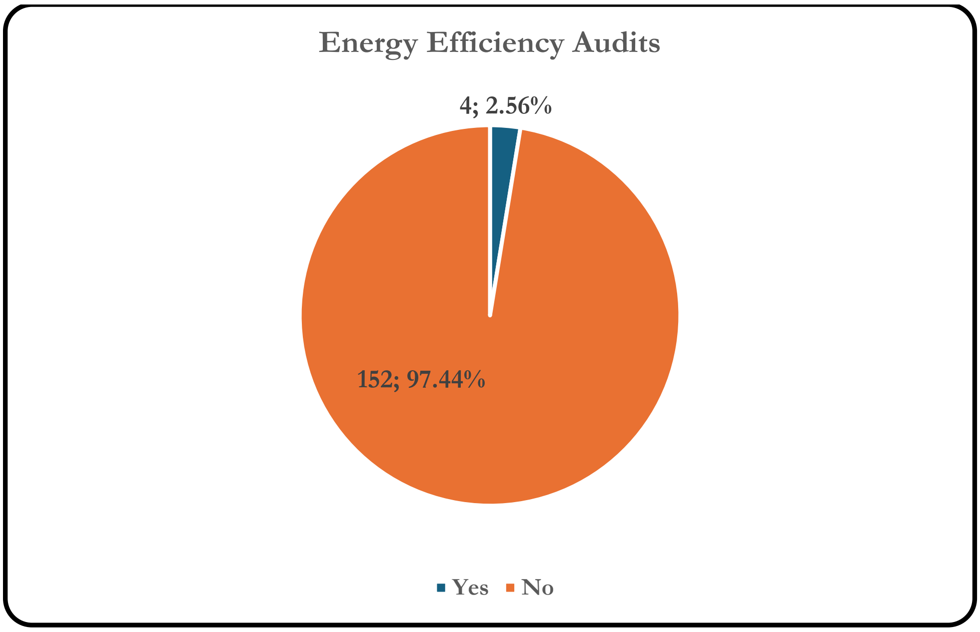


Figure 4-8: Energy Efficiency Audit

4.4.2 BUILDING ENVELOPE AND INSULATION MEASURES

Efficient building practices are some of the measures aimed and increasing building efficiency by cutting on energy consumption, water consumption and even cut down carbon emissions. Measures like energy efficient roofing materials, wide windows for natural lighting, and building insulation are some of the energy efficient measures. The survey established that across the county, **45.51% (71 Educational Institutions)** of the educational institutions have not integrated any building envelope measures aimed at enhancing energy efficiency as shown in Figure 4-9.

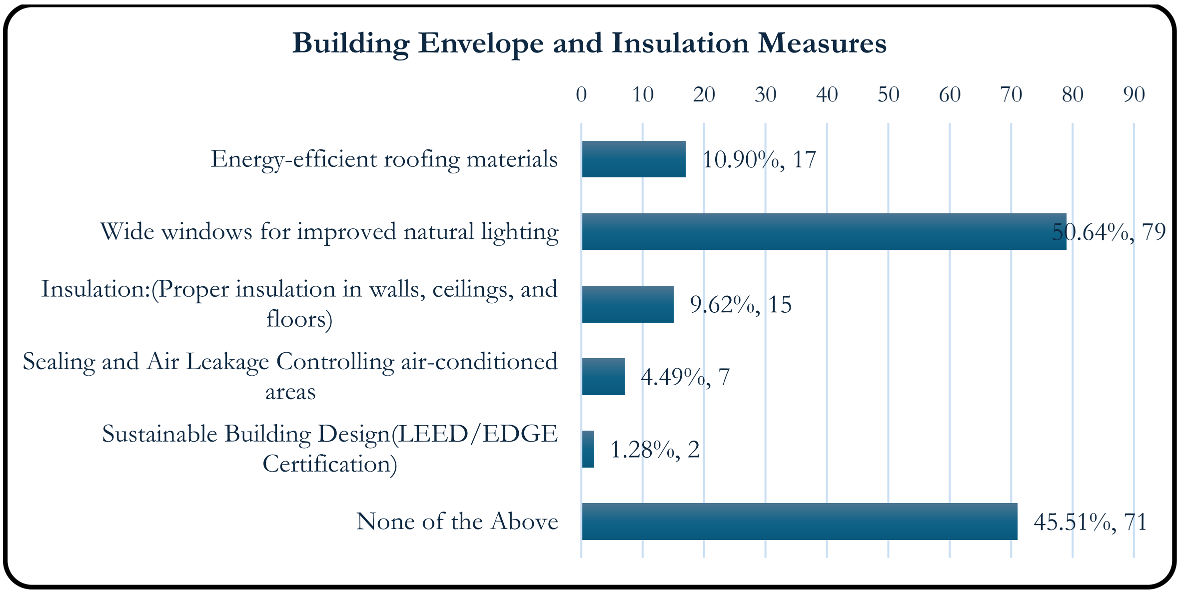


Figure 4-9: Building Envelope & Insulation Measures

4.4.3 ENERGY EFFICIENT LIGHTING MEASURES

Lighting systems are one of the major consumers of energy in educational facilities. Conventional lighting systems like mercury vapor, incandescent bulbs and fluorescent tubes consume **more than 2 times** of energy in comparison to an equivalent lighting system like the LED tubes and bulbs. In addition to efficient lighting fixtures, automated lighting controls like occupancy and motion sensors optimise lighting systems by having them on only when necessary. The survey questionnaire, as shown in Figure 4-10 indicates that across the county, many educational institutions are still using conventional lighting technologies, which rise their energy demand and consequently their electricity bills. Out of the 156 Institutions surveyed, **100 institutions**, translating to **64.10%** have not implemented any efficient lighting measures like LED lighting, daylighting and lighting optimisation through installation of motion and occupancy sensors.

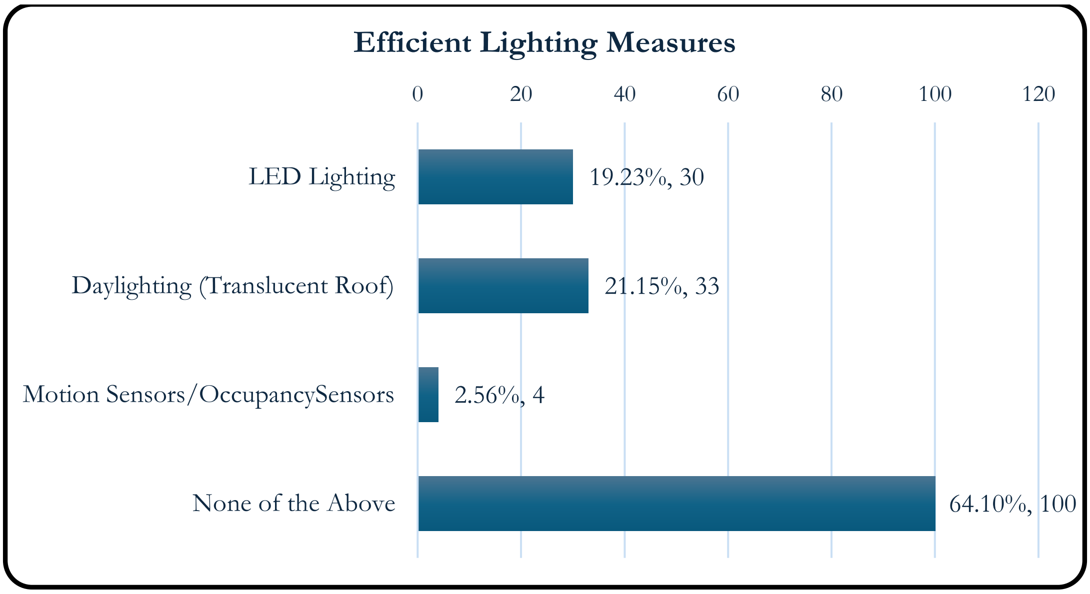


Figure 4-10: Efficient Lighting Measures

4.4.4 WATER HEATING AND CONSERVATION MEASURES

Water heating practices are one of the energy consumers in educational facilities especially in students' hostels and instructors' premises. With the rising cost of electricity, efficient water heating practices like solar water heaters, use heat pumps, recirculation of hot water can significantly bring down the energy demand in educational facilities. As shown in Figure 4-11, only **22.44%** of the educational facilities across the county have implemented some of the efficient water heating systems. **123** institutions, translating to **78.85%** of the facilities surveyed, have not implemented any efficient water heating technology or practice.

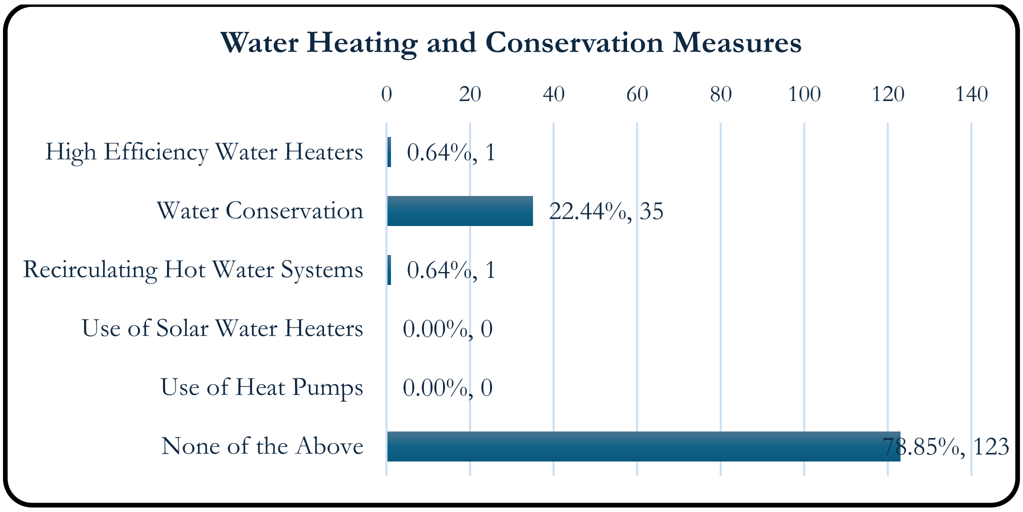


Figure 4-11: Water Heating & Conservation Measures

4.4.5 ENERGY MANAGEMENT SYSTEMS (EMS)

Building Energy Management Systems, and Submetering coupled with reporting is a key step toward energy efficiency. The survey questionnaire aimed to gain insights into the energy management systems utilised by educational institutions across Embu County. As shown in Figure 4-12, only **14.74%** of the education facilities have least adopted one of the energy management systems highlighted. A total of **133** institutions, translating to **85.26%** of the surveyed facilities have not put in place any of the highlighted energy management systems.

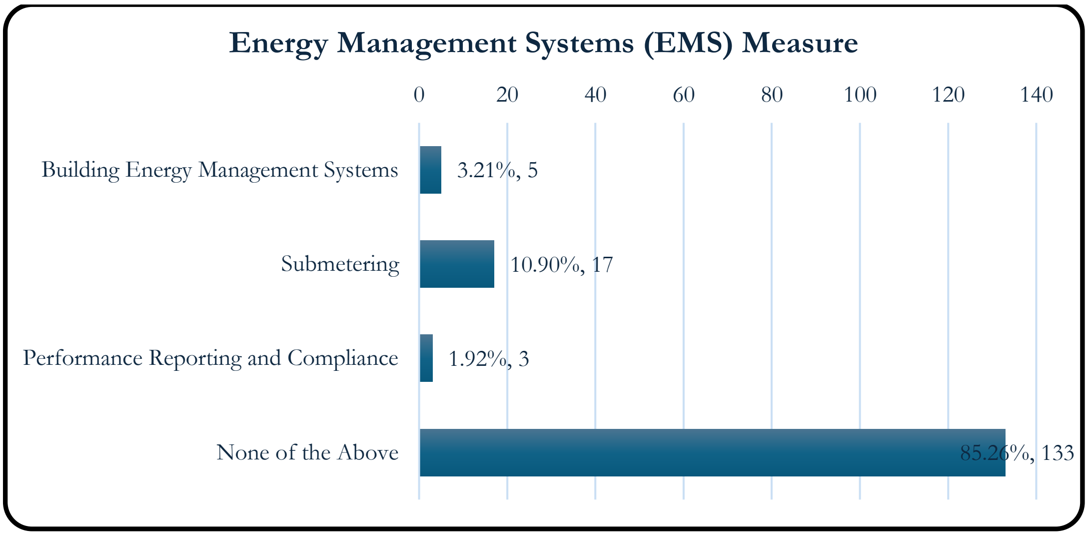


Figure 4-12: Energy Management Systems (EMS)

4.4.6 EFFICIENT OPERATIONS AND MAINTENANCE PRACTICES

Routine Maintenance Practices, Staff and students Training and awareness on energy efficiency are some of the operational and maintenance practices that can significantly enhance energy efficiency in educational facilities. As shown in Figure 4-13, only **17.95%** of the education facilities have adopted routine maintenance of equipment while 10.26% have staff training and awareness programs. A total of **122** institutions, translating to **78.21%** of the surveyed facilities have not put in place any of the highlighted practices.

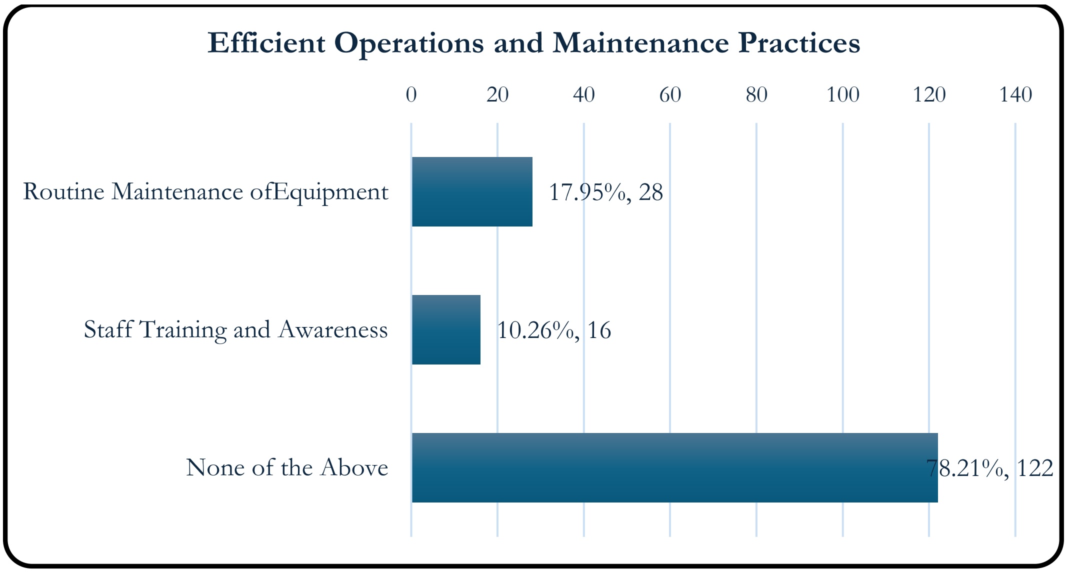


Figure 4-13: Operation & Maintenance Practices

4.4.7 WAY FORWARD

Table 4-2: Educational Institutions Recommendations Matrix

Area of Focus	Survey Finding (Gap)	Recommendation	Expected Benefit	Implementation Timeline	Responsible Stakeholders
Energy Efficiency Audits	Only **2.56%** of institutions have conducted audits	• Roll out county-led sensitization campaigns on energy audits • Partner with EPRA & licensed energy auditors to offer subsidized or cluster-based audits for schools	• Identification of cost-saving opportunities • Improved operational efficiency	Short-term (0–2 yrs)	County Energy Office, EPRA, School Boards, Private Auditors
Building Envelope & Insulation	**45.51%** have no envelope efficiency measures	• Introduce guidelines for energy-efficient school designs (daylighting, ventilation, insulation) • Retrofit existing schools with reflective roofing and natural lighting solutions	• Reduced reliance on artificial lighting • Improved indoor comfort	Medium-term (2–5 yrs)	County Public Works Dept., Ministry of Education, Contractors
Lighting Systems	**64.10%** still use conventional lighting	• County-wide program for **LED retrofits** in schools • Integrate motion/occupancy sensors in dormitories, classrooms, and offices	• Reduction in lighting electricity costs	Short-term (0–2 yrs)	County Energy Office, School Boards, Donors/Development Partners
Water Heating & Conservation	**78.85%** lack efficient systems	• Deploy **solar water heaters** in boarding schools & staff quarters- Pilot heat pump technology in colleges/universities- Promote water-saving fixtures	• Reduced electricity bills • Improved sustainability	Medium-term (2–5 yrs)	School Boards, County Energy Office, Renewable Energy Companies
Energy Management Systems (EMS)	Only **14.74%** adopted EMS	• Introduce **submetering & energy tracking systems** in large institutions (universities, TVETs) • Seek Services of energy managers for schools	• Data-driven management • Accountability in energy use • Continuous monitoring of efficiency	Long-term (5+ yrs)	EPRA, Universities/TVETs, ICT Providers
Operations & Maintenance Practices	**78.21%** lack structured practices	• Conduct regular training for staff & students on energy-saving culture • Establish "Energy Champions" in each institution • Develop simple maintenance checklists	• Behavioural change leading to energy savings • Prolonged lifespan of equipment	Short-term (0–2 yrs)	County Education Office, School Heads, NGOs

4.5 ENERGY EFFICIENCY IN INDUSTRIES

Embu County Industrial sector serves as a backbone in local economic development, fostering innovation and providing employment. Key industries include agriculture and agro-processing industries such as coffee, macadamia and tea processing factories. These industries are significant to the county's economy but often face very high energy costs due to inefficient equipment, lighting and process operations. The role of energy efficiency becomes significant in fostering economic growth as well as mitigating climate change. By optimizing processes and leveraging energy efficient technologies, industries can reduce their energy consumption resulting in cost savings, improving competitiveness and minimizing environmental impact.

Implementing energy efficiency measures such as use of energy-efficient motors (Class IE3 & IE4), optimized refrigeration and HVAC systems, LED Lighting, solar PV for captive power, and proper process optimization can reduce operational costs, increase productivity, and lower greenhouse gas emissions. Conducting energy audits, at least once in 4 years in line with the Energy (Energy Management) Regulations 2025, capacity building, and targeted incentives for adopting energy-efficient technologies are recommended to improve sustainability.

Given the county's agricultural processing focus, investments in energy efficient equipment for tea and coffee factories, macadamia processing plants, and cotton ginneries offer high potential for cost savings and enhanced competitiveness. Furthermore, renewable energy integration can help industries manage peak energy demands, reduce dependence on the grid, and enhance energy security.

4.6 BARRIERS, RISKS AND MITIGATION MEASURES

Despite various efforts to support energy efficiency, the uptake of these technologies and practices remains low. One of the major challenges is the upfront cost of investing in energy efficient technologies which discourages many businesses, particularly small and medium sized enterprises, from making such investments. Limited technical expertise as industries lacks skilled managers and auditors who can identify energy efficient opportunities and guide implementation. There is also lack of awareness as many facility owners and limited access to affordable financing mechanisms making it difficult for industries to upgrade to modern energy efficient systems.

The risks of failing to embrace and adopt energy efficiency are significant such as rising energy costs especially in facilities that heavily rely on grid electricity. Additionally, facilities are bound to face operational disruptions when outdated and inefficient equipment breaks down. Failure to comply with the EPRA energy management regulations 2025 which require conducting mandatory energy audits for designated facilities consuming 180,000 units per year will attract penalties. Also, inefficient energy use also contributes to higher carbon emissions which undermines sustainability goals.

There exist opportunities to mitigate. Capacity building for facility management can help to bridge skills gap and equip them with practical skills in energy management and efficiency improvement. Conducting regular energy audits as provided in the energy management regulations will help identify areas of energy and cost savings and enable industries to adopt best practices. Financing challenges can be addressed through approaches such as energy service companies (ESCOs), Concessional Green Loans and tax incentives that ease the burden of capital investment.

5 BIO-ENERGY RESOURCES

5.1 STAKEHOLDERS IN BIOENERGY SECTOR

Biomass (firewood, charcoal, agricultural residues, briquettes, biogas and potentially biomass CHP) is a major energy source for Embu County's households, institutions, agro-processing, and small industry. This stakeholder mapping will help align regulation, standards, extension services, finance, and market development across the value chain from feedstock, conversion technologies, distribution and uptake.

5.1.1 NATIONAL PUBLIC STAKEHOLDERS

Table 5-1: National Stakeholders in Bioenergy Sector

Stakeholder	Mandate in Bioenergy	Key Resources & capacities	Relevance for Embu
Ministry of Energy & Petroleum (MoEP) – State Department for Energy	Policy leadership for renewable energy incl. bioenergy; national strategies; oversight of EPRA & REREC; coordination of clean cooking agenda.	Policy/strategic planning units; access to national programs and donor platforms; inter-ministerial convening power.	Aligns Embu plans with national policy; channels national programs (e.g., clean cooking, institutional biogas, efficient biomass use) into county pipelines.
Energy & Petroleum Regulatory Authority (EPRA)	Regulates energy sector; sets/approves standards, licensing and compliance for fuels and energy systems; market surveillance for appliances (e.g., stoves, boilers, ethanol).	Technical standards teams; inspection/enforcement officers; testing collaborations with KEBS; data/market intelligence.	Supports quality assurance for stoves, briquettes and ethanol; safety oversight for institutional/industrial biomass systems; data to guide county targeting.
Ministry of Environment, Climate Change & Forestry (MECC&F)	Forestry and climate policy; sustainable forest management; climate action coordination incl. MRV for emissions reductions.	Climate Change Directorate; national climate funds access; interlink with KFS, NEMA, KEFRI.	Ensures bioenergy feeds into NDC actions; links Embu projects to climate finance/MRV; integrates tree-growing and woodlot programs.
Kenya Forest Service (KFS)	Management of state forests; licensing and policing of forest produce; promotion of on-farm forestry/woodlots.	Forest rangers; county forest conservancies; nurseries; extension collaboration with counties & CFAs.	Sustainable woodfuel supply plans; support for farm woodlots; permits for charcoal transport; restoration offsets for bioenergy demand.
Kenya Forestry Research Institute (KEFRI)	R&D on tree species, woodfuel supply, charcoal/briquette technologies, kiln efficiency, agroforestry models.	Research stations; laboratories; extension publications; trials/demonstrations.	Technical guidance on high-yield woodlots; residue-to-fuel characterization; kiln/retort designs for local producers.
National Environment Management	Environmental safeguards: EIA/ESIA, licensing and compliance	Environmental inspectors; licensing systems; compliance monitoring.	Streamlines approvals; enforces pollution/air-quality rules; guides waste feedstock

Authority (NEMA)	for facilities (charcoal production, briquette plants, biogas, biomass boilers); waste-to-energy oversight.		use (abattoirs, markets, agro-residues).
Kenya Bureau of Standards (KEBS)	National standards for biomass fuels (briquettes, pellets, charcoal), stoves, biogas digesters, ethanol fuel; conformity assessment.	Standards committees; labs; product certification (KEBS marks).	Quality seals that build market trust; reduces substandard devices/fuels in Embu markets.
Rural Electrification & Renewable Energy Corporation (REREC)	Implements renewable energy projects in public institutions and off-grid areas; supports productive-use energy; demonstration pilots (incl. biogas/biomass where relevant).	Project implementation units; procurement frameworks; technical teams.	Institutional biogas for schools/health facilities; biomass-powered productive-use pilots; community demonstrations.
Kenya Power (KPLC)	Off-take for grid-connected biomass CHP; interconnection, metering and safety; demand-side management for efficient cooking in institutions.	Network planners; interconnection engineers; DSM programs.	Advises any prospective agro-residue CHP (tea/coffee/horticulture) and supports efficient institutional kitchens.
Kenya Electricity Transmission Company (KETRACO)	Transmission for large plants (rare at county scale).	Transmission planning & wayleave teams.	Advisory if any future large biomass projects emerge.
Water Resources Authority (WRA)	Water abstraction/discharge permits; relevant for wet waste handling and biogas effluent.	Catchment officers; permitting system.	Ensures compliant effluent management for biogas digestate and agro-processing.
National Treasury / Public Finance Management	Fiscal policy, incentives (VAT/excise), public investment and climate finance access.	Incentive design; donor coordination.	Can support tax/VAT treatment for clean cooking and bioenergy equipment; unlocks concessional lines.
Kenya Industrial Research & Development Institute (KIRDI) & Kenya National Cleaner Production Centre (KNCPC)	Industrial R&D; resource-efficiency; cleaner production for SMEs (e.g., boiler efficiency, fuel switching, briquetting lines).	Pilot plants; engineering support; SME training.	Technical backstopping for local briquette SMEs and institutional kitchens/boilers.

5.1.2 COUNTY GOVERNMENT STAKEHOLDERS

Table 5-2: County Government Stakeholders in Bioenergy Sector

County entity	Core mandate in bioenergy	Resources & capacities	Practical relevance
Department of Energy	County-level clean cooking & bioenergy planning; program design for institutions/communities; coordination with national actors and development partners; M&E.	Policy/planning staff; county budgeting; convening wards and stakeholders.	Leads county portfolio (efficient stoves, institutional kitchens, briquettes market development, biogas adoption, awareness).
Department of Environment, Water & Natural Resources	Woodlots on public land; tree-growing; environmental compliance support; climate actions.	Extension officers; nurseries; ward-level teams.	Scales sustainable feedstock (farm forestry, woodlots) and links to climate programs.
Department of Agriculture, Livestock & Fisheries	Extension to farmers/co-ops; residue management (coffee husks, macadamia shells, maize cobs, banana waste, dairy waste for biogas).	AEZ-based extension officers; farmer field schools; co-op linkages.	Aggregates residues for briquettes/pellets; promotes household and farm biogas; integrates energy into value-chain upgrading.
Department of Trade, MSME & Industrialization	MSME development; Jua Kali clusters; markets and industrial parks; business formalization.	Business centres; market infrastructure; SME registries.	Organizes briquette producers; allocates workspace; facilitates BDS (branding, bookkeeping, licensing).
Department of Health	Public health compliance (kitchen ventilation, indoor air quality); institutional energy for facilities (biogas, efficient cookstoves).	Public health officers; facility managers.	Guides safe kitchens; prioritizes facilities for biogas/ICS; tracks IAP health benefits.
Department of Education	School feeding kitchens energy planning; institutional stove/biogas roll-outs; behavior change with pupils.	School infrastructure budgets; head-teacher networks.	Aggregates demand for standardized institutional stove/biogas solutions.
County Treasury & Planning Unit	Budgeting; PBB integration; performance tracking; climate tagging.	PFM systems; M&E units.	Secures budget lines; blends with climate/development partner funds.
County Assembly (Energy/Environment Committees)	Oversight and enabling legislation/by-laws (e.g., charcoal trading by-laws, market space for briquette SMEs).	Legislative process; public participation.	Legal backbone for sustainable biomass trade and quality control.
County Environment Committee / EMCA structures	Coordinates environmental management with NEMA/KFS at county level.	Multistakeholder forum.	Accelerates licensing and compliance resolution.

5.1.3 RESEARCH, ACADEMIA & TVET

Table 5-3: Research, Academia & TVET stakeholders in Bioenergy

Stakeholder	Role	Capacity
University of Embu; Dedan Kimathi University; JKUAT; TVETs	Applied R&D (stove design, briquette binders, digester optimization), testing and student projects; entrepreneur incubation.	Labs, workshops, students; potential for joint pilots and M&E studies.
KEFRI field stations	Species trials, biomass yields, kiln/retort demonstrations.	Research plots, extension materials.

5.1.4 PRIVATE SECTOR STAKEHOLDERS

Table 5-4: Private Sector Stakeholders in Bioenergy Sector

Stakeholder	Role in value chain	Capacity/notes
Farmer cooperatives (coffee, tea, dairy, horticulture, macadamia)	Aggregate residues (husks, shells, prunings, manure); host institutional kitchens/biogas; potential anchors for briquette demand.	Strong member networks; storage space; governance structures.
Sawmills & carpentry workshops	Provide sawdust/wood offcuts for briquetting; potential for efficient kilns.	Continuous feedstock streams near urban centres/markets.
Briquette & pellet SMEs	Convert residues into standardized fuels; supply institutions/households.	Growing but fragmented; need quality certification, finance and BDS.
Institutional energy service companies (ESCOs)	Design/finance/maintain institutional kitchens, boilers, biogas plants under service models.	Engineering + O&M capacity; potential PPPs with the County.
Hospitality, schools, health facilities, prisons	Large, predictable thermal loads; anchor customers for clean biomass fuels and high-efficiency stoves.	Can sign offtake/service contracts that de-risk suppliers.
Hardware/retail distributors	Channels for stoves, biogas kits, briquettes, ethanol.	County-wide reach; consumer financing linkages.

5.1.5 CIVIL SOCIETY, ASSOCIATIONS & PROGRAMS

Table 5-5: Civil Society and Development Partners in Bioenergy Sector

Stakeholder	Role	Capacity/notes
Clean cooking associations & producer groups	Self-regulation, training, advocacy; market data; quality awareness.	Industry networks; standards literacy.
Community Forest Associations (CFAs)	Co-management of forest resources; woodlot establishment; sustainable charcoal frameworks.	Grassroots legitimacy; can enforce local rules.
Women and youth groups/Co-ops	Production and last-mile distribution of stoves/briquettes; savings groups for uptake.	Strong in Embu's wards; social enterprises.
NGOs & development partners (e.g., GIZ/EnDev, SNV, Practical Action, World Bank programs)	TA, results-based finance, market development, M&E.	Grant/TA facilities; proven toolkits for county-level scaling.

5.1.6 FINANCIAL SECTOR STAKEHOLDERS

Table 5-6: Financial Sector Stakeholders in Bioenergy

Stakeholder	Role	Capacity/notes
Commercial banks & MFIs/SACCOs	Working capital for briquette SMEs; asset finance for institutional kitchens/biogas; PAYGo for stoves.	Branch networks; climate/SME credit lines.
Kenya Industrial Estates (KIE) & Business Incubators	Machinery finance (presses, dryers, retorts); sheds and industrial clusters.	Concessional loans; entrepreneur support.
Climate finance facilities (national & international)	Results-based finance, carbon revenue for clean cooking/biogas.	MRV frameworks; can blend with county budgets.

5.1.7 CONSTITUTIONAL AND NATIONAL LEGAL FRAMEWORK

a) The Constitution of Kenya (2010)
- *Article 42*: Guarantees every person the right to a clean and healthy environment.
- *Article 69(1)*: Obligates the State to ensure sustainable exploitation, utilization, and conservation of the environment and natural resources.
- *Fourth Schedule*: Assigns functions between national and county governments. Forestry, environmental conservation, and energy regulation fall under concurrent functions, with counties mandated to implement specific aspects.

b) Forest Conservation and Management Act, 2016
- *Section 44*: Requires a license from the Kenya Forest Service (KFS) for felling, cutting, or removing forest produce from public or county forests.
- *Section 49*: Requires permits for transportation of timber, fuelwood, and charcoal.
- *Section 58*: Provides for Community Forest Associations (CFAs) to manage forest resources through participatory agreements.

c) The Energy Act, 2019
- *Section 191*: Recognizes biomass as part of renewable energy sources and mandates promotion of efficient biomass technologies.
- *Section 192(2)(d)*: Requires the Energy and Petroleum Regulatory Authority (EPRA) to develop standards for biomass stoves and systems.
- *Section 224*: Empowers County governments to promote renewable energy, including biomass, at the local level.

d) Environmental Management and Coordination Act (EMCA), 1999 (Revised 2015)
- *Section 58*: Requires Environmental Impact Assessment (EIA) licenses for large-scale biomass energy projects.
- *Section 68*: Mandates environmental audits and monitoring of ongoing biomass and forestry projects.
- Subsidiary legislation such as the Environmental (Impact Assessment and Audit) Regulations, 2003 guide compliance.

e) The Land Act, 2012 and Land Registration Act, 2012
- *Section 5*: Categorizes land as public, community, or private, determining access to biomass resources.

- *Section 15*: Provides for land use planning, which affects woodlots, agroforestry, and bioenergy projects.

f) Community Land Act, 2016

- *Section 6*: Vests ownership of community land in communities, who hold rights to exploit forest and biomass resources.
- *Section 21*: Provides for community by-laws on natural resource use, including woodfuel harvesting.

g) The Charcoal Rules, 2009 (Legal Notice No. 106 of 2009 under the Forest Act, 2005)

- *Rule 3*: Requires formation of Charcoal Producer Associations (CPAs), registered with KFS.
- *Rule 7*: Prohibits production or transportation of charcoal without a license and permit.
- *Rule 8*: Requires CPAs to prepare sustainable charcoal production plans, including establishment of woodlots.

h) National Energy Policy, 2018

- Recognizes biomass as the dominant household energy source and calls for promotion of efficient biomass technologies, sustainable woodlots, and regulation of woodfuel trade.

i) National Climate Change Act, 2016

- *Section 18*: Mandates mainstreaming of climate change into sectoral plans, including sustainable bioenergy strategies to reduce deforestation and emissions.

5.2 LAWS AND REGULATIONS IN BIO-ENERGY SECTOR

Biomass energy production and use in Embu County is guided by a combination of constitutional provisions, national legislation, subsidiary regulations, and county-level mandates. These legal frameworks are designed to promote sustainable use of biomass resources while safeguarding livelihoods and ecosystems.

5.2.1 COUNTY-LEVEL LEGAL AND POLICY FRAMEWORK

a) County Governments Act, 2012 (Section 30)

Empowers counties enact by-laws regulating biomass trade and transport at local level. In practice, Embu County issues trading licenses for charcoal and firewood vendors through the County Revenue Department.

b) Embu County Forest Conservation and Management By-laws (2019)

Operationalizes sustainable forest management at the county level, providing guidance on harvesting, charcoal production, and reforestation obligations.

c) Embu County Climate Change Act (2022)

Requires the mainstreaming of climate-smart practices, including promotion of alternative fuels and sustainable biomass use, into county plans.

5.2.2 LICENSING REQUIREMENTS

a) Production
- *Forest Conservation and Management Act, 2016 (Section 44)*: Felling or collecting wood fuel from public and county forests requires a license from KFS or County Government.
- *Charcoal Rules, 2009 (Rule 3 & 7)*: Charcoal producers must belong to a registered CPA and obtain a production license.

b) Trade
- *Charcoal Rules, 2009 (Rule 7)*: Charcoal traders must be licensed by KFS through their CPA.
- County Government by-laws require a trade license for selling firewood or charcoal in markets.

c) Transport
- *Forest Conservation and Management Act, 2016 (Section 49)*: Movement of forest produce, including charcoal and firewood, requires a transport permit (Movement Permit) from KFS.
- *Charcoal Rules, 2009 (Rule 7(3))*: Vehicles transporting charcoal must carry waybills from licensed CPAs.

5.2.3 ENFORCEMENT EFFECTIVENESS

The enforcement of biomass energy regulations in Embu County reflects the wider challenges seen nationally, where existing legal frameworks are in place, but implementation is weak.

a) Weak Enforcement of Legal Frameworks

The Charcoal Rules (2009) and the Forest Conservation and Management Act (2016) provide a strong legal basis for sustainable biomass production and trade. However, enforcement in Embu is undermined by inadequate staffing and funding for both the Kenya Forest Service (KFS) and the county government. Patrols, inspections, and monitoring of production areas are limited, allowing unsustainable harvesting to persist.

b) Dominance of Informal Trade

A large share of the charcoal and firewood trade in Embu remains informal and unregulated. Many small-scale traders operate without licenses, while licensed producers are often undercut by informal suppliers. This informal dominance not only deprives the county of revenue but also fuels unsustainable extraction of biomass resources.

c) Corruption in Transport

Along transport routes, illegal payments at roadblocks remain a significant barrier to enforcement. Transporters often bypass legal compliance by bribing enforcement officers, making it difficult for authorities to track the true origin and sustainability of woodfuel entering Embu markets.

d) Weak Community Self-Regulation

While Charcoal Producer Associations (CPAs) are mandated to promote sustainable practices and self-regulation, in Embu many remain inactive, poorly organized, or underfunded. The lack of technical and financial capacity reduces their ability to ensure members adhere to sustainable harvesting and reforestation requirements.

e) County-Level Gaps

County enforcement is often limited to issuing trade licenses to biomass dealers, with little follow-up on the sustainability of sourcing practices. This gap perpetuates illegal harvesting in forests and farmlands, as traders can operate legally on paper but continue to source wood unsustainably.

5.2.4 MONITORING SUSTAINABLE HARVESTING

Despite a robust legal and policy framework, monitoring of sustainable biomass harvesting in Embu County remains weak.

a) Legal Provisions for Sustainability

The Charcoal Rules (2009, Rule 8) require Charcoal Producer Associations (CPAs) to establish dedicated woodlots and implement harvesting plans to ensure long-term sustainability. Similarly, the Forest Conservation and Management Act (2016, Section 58) empowers Community Forest Associations (CFAs) to participate in co-managing forests, including monitoring wood extraction and replanting activities. Additionally, the Environmental Management and Coordination Act

(EMCA, 1999, revised 2015) obligates large-scale biomass operators to carry out continuous environmental audits to track sustainability impacts.

b) Weak Implementation

In practice, monitoring remains inadequate in Embu due to a lack of up-to-date biomass inventories, limited technical capacity, and insufficient resources for county or KFS officers to conduct regular inspections. Without clear data on standing biomass and harvesting rates, it is difficult to track whether extraction is exceeding regeneration capacity.

c) County-Level Monitoring Systems

The county government has yet to establish fully operational monitoring mechanisms for firewood and charcoal supply chains. Licensing processes often focus on trade authorization rather than tracking sustainability along the supply chain—from harvesting to transportation and sales. This gap makes it easy for unsustainably sourced firewood and charcoal to dominate the local market.

Key challenges hindering monitoring sustainable harvesting of biomass energy in Embu County include:

a) Overlaps in Institutional Mandates

The roles of the Kenya Forest Service (KFS), county governments, and the National Environment Management Authority (NEMA) often overlap, creating confusion and inefficiencies. For example, licensing, monitoring, and environmental compliance are split across agencies, leading to duplication of efforts and gaps in enforcement.

b) Widespread Informality

Much of the firewood and charcoal trade in Embu operates outside the formal licensing system. This informality undermines compliance with the Charcoal Rules (2009), reduces revenue collection, and facilitates unsustainable harvesting.

c) Weak Enforcement of Reforestation Obligations

Although CPAs are legally required to establish woodlots and reforest harvested areas, enforcement is minimal. Many CPAs lack resources or capacity, and oversight agencies do not systematically track compliance, leading to continued forest depletion.

d) Limited Monitoring Capacity

Both KFS and the County Forest Department face resource and staffing constraints, limiting their ability to conduct regular field inspections, biomass inventories, or sustainability assessments. This allows illegal and unsustainable practices to persist undetected.

e) Land Tenure Insecurity

In many parts of Embu, uncertain land ownership and tenure disputes discourage households and producers from investing in long-term biomass sustainability measures such as tree planting or managed woodlots. Without secure land rights, reforestation and sustainable woodfuel production remain low priorities.

5.3 BASELINE SUPPLY OF BIO-ENERGY

Biomass remains the single most important source of primary energy in Embu County, especially for cooking, heating, and small-scale industrial processing. The county's energy system relies on a diverse set of bio-resources that include farm-grown trees, residues from agriculture, municipal and agro-industrial waste streams, and products from forests and rangelands. Understanding the baseline supply of these resources is essential to quantify current potential, identify sustainable harvesting limits, and guide future investment in efficient biomass and alternative fuels.

5.3.1 MACADAMIA SHELLS AND HUSKS

Macadamia is grown in Embu for commercial purposes, with their shells and seed husks providing high-calorific residues suitable for energy use. Macadamia shells are an excellent boiler fuel and briquetting feedstock, given their density and energy content of about 18–20 MJ/kg. Currently, some factories within Embu County use them in boilers for primary energy provision, but much of the resource remains untapped and could be aggregated for county-level energy initiatives. Macadamia nut shells and other waste components (e.g., husks) constitute almost 85% of the total nut by weight[37]. Between 2019 and 2024, macadamia shells and husks have the potential of providing about 81,415 GJ of primary energy annually. Figure 5-1 highlights the primary energy potential trend during the period under consideration.

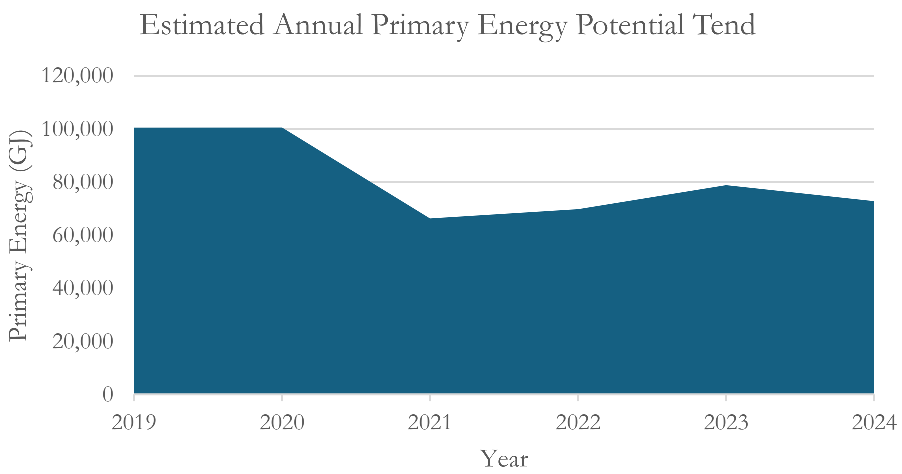


Figure 5-1: Embu County Estimated Annual Primary Energy Potential from Macadamia Bio Residues

5.3.2 COFFEE HUSKS

Coffee husks, which have a relatively low moisture content, are already used in some areas for briquette production or as boiler fuel with Embu County. Most coffee husks are underutilized and often burned or dumped, indicating high potential availability[38]. Coffees husks have a 100% recovery ratio[39]. For practicality, a recovery ratio of 80% was used for this estimation. Figure 5-2

37

Agrifutures Australia (2018), "Macadamia Industry Overview")
38 Wintgens (2004), Coffee: Growing, Processing, Sustainable Production
39 Silva et al. (2018), Renewable Energy 123: 757–769

shows coffee husks potential primary energy provision trend between 2019 and 2023. It is estimated that Embu County can provide about 36,077 GJ of primary energy from coffee husks annually.

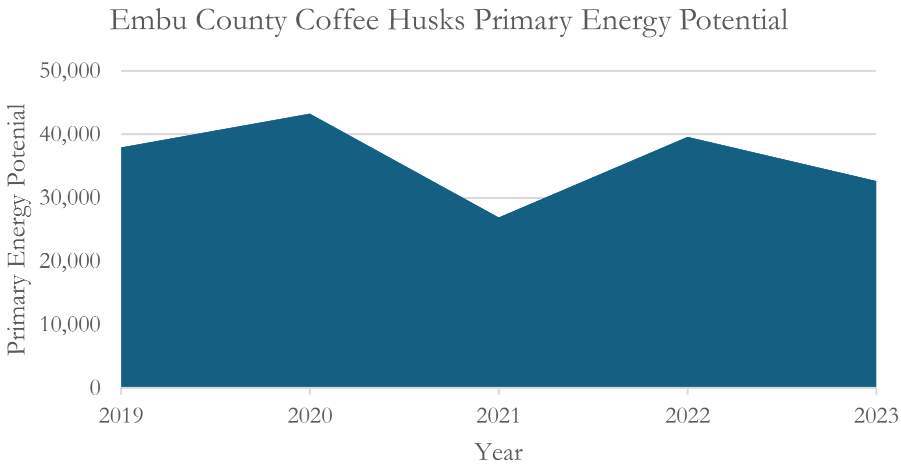


Figure 5-2: Embu County Estimated Annual Primary Energy Potential from Coffee Husks

5.3.3 MAIZE COBS & STOVER

Residues from maize, including cobs and stalks, are abundant in the midland and lowland areas of Mbeere. While part of these residues must be left on fields to preserve soil health and moisture, the surplus can be collected for energy use. Maize cobs, in particular, are valuable for small-scale briquetting enterprises. Maize stover is typically left on the farm for soil improvement. Cobs on the other hand, are typically removed from the farm. For provision of energy, only a part of the stover should be used. A maximum stover recovery ratio of 40% is recommended[40] while 100% of maize cobs can be recovered as lacks soil fertility roles compared to stover. For purposes of primary energy potential estimation, maize cob recovery ratio will be set at 70%. Figure 5-3 shows maize residue potential primary energy provision trend between 2019 and 2024. It is estimated that Embu County can provide about 475,564 GJ of primary energy from maize stover and cobs annually.

[40] Nunes, M. R., De, M., McDaniel, M. D., Kovar, J. L., Birrell, S., & Karlen, D. L. (2021). Science-based maize stover removal can be sustainable. Agronomy Journal, 113(4), 3178–3192. https://doi.org/10.1002/agj2.20724

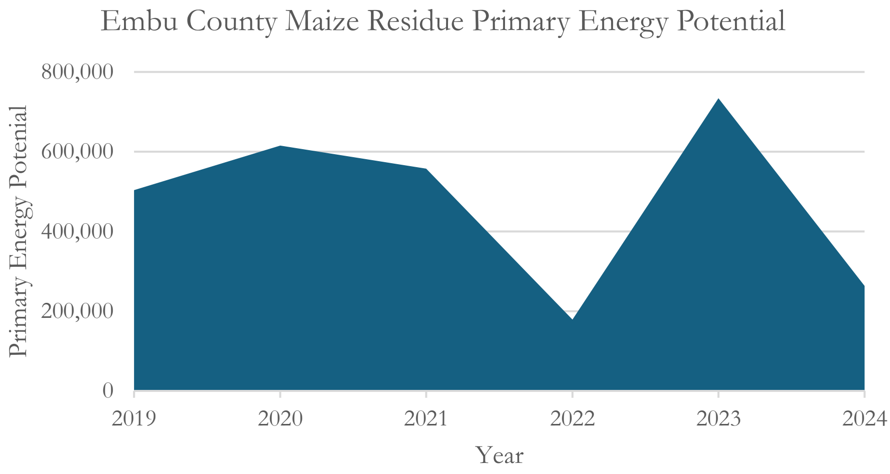


Figure 5-3: Embu County Estimated Annual Primary Energy Potential from Maize Residue

5.3.3.1 SORGHUM AND MILLET STRAWS

Embu county is a key producer of sorghum and millet and associated straw (bio residue). The straws are normally left of the farm for soil conditioning. Part of the straws can be used for energy provision. A maximum straw recovery ratio of 40% is recommended[41] for purposes of energy production with the others left for other uses such as soil conditioning amongst others. Figure 5-4 shows sorghum and millet straws potential primary energy provision trend between 2019 and 2022. It is estimated that Embu County can provide about 71,337 GJ of primary energy from sorghum and millet straws annually.

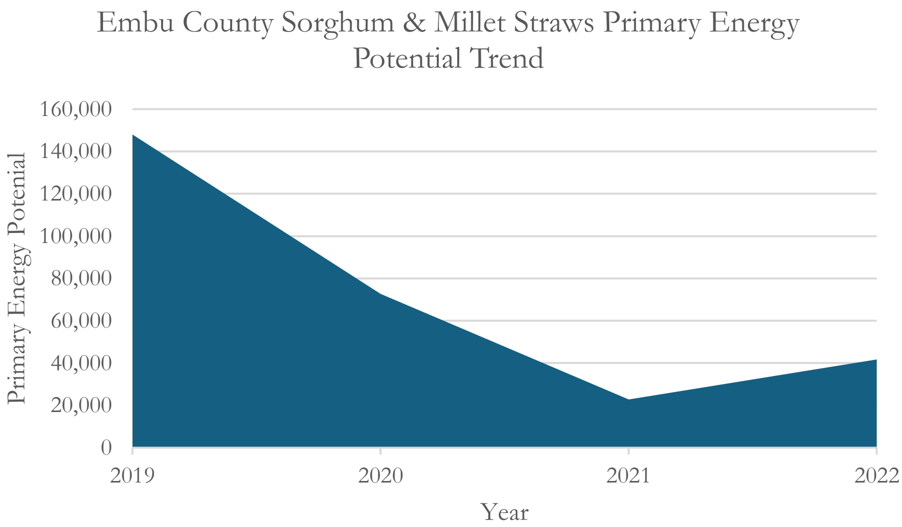


Figure 5-4: Embu County Estimated Annual Primary Energy Potential from Sorghum and Millet Straws

[41] Nunes, M. R., De, M., McDaniel, M. D., Kovar, J. L., Birrell, S., & Karlen, D. L. (2021). Science-based maize stover removal can be sustainable. Agronomy Journal, 113(4), 3178–3192. https://doi.org/10.1002/agj2.20724

5.3.4 FARM WOODLOTS – AGRO-FORESTRY

Across Embu County, farmers have established small-scale woodlots and boundary plantings of fast-growing species such as eucalyptus and grevillea. These trees are primarily cultivated for construction poles, timber, and income generation, but their off cuts, thinning, and small roundwood are important sources of fuelwood. In some areas, eucalyptus is managed on rotations of 6–10 years, with an average growth rate of 10–20 cubic metres per hectare per year. When harvested sustainably and replanted, these woodlots provide a reliable stream of household firewood and raw material for small industries.

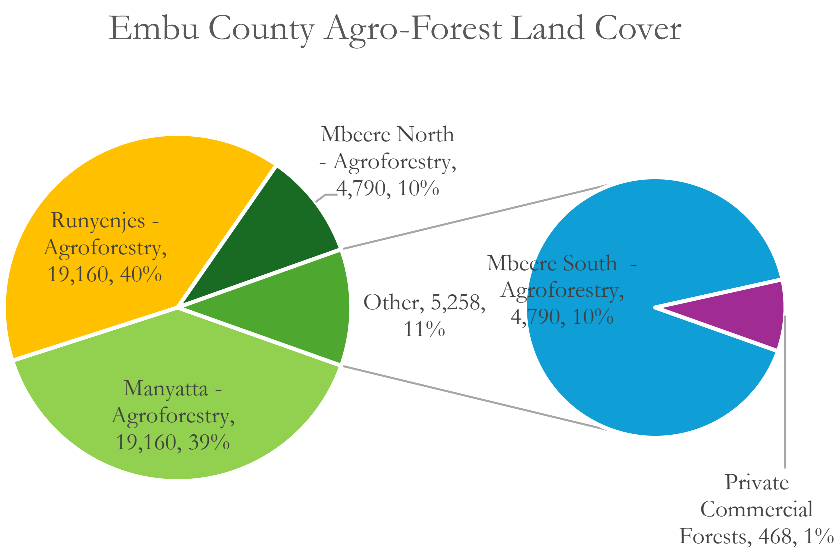


Figure 5-5: Agro-Forestry and Private Land Coverage

Source: Embu County CIDP, 2018-2022

Grevillea robusta on farms can reach 15 $m^3/ha/yr$[42]. Since 80% of trees grown central Kenya is Grevillea[42], this baseline assessment shall assume that agro forests are mainly made up of Grevillea. Using the following assumptions:

- Grevillea robusta wood density: 0.5–0.7 t/m^3 reported[43]
- Air-dry wood (10–20% moisture) net calorific value: 13–16 MJ/kg[44]

The estimated agro forests can provide primary energy of between 3,113,500 and 8,047,200 GJ annually within Embu County.

5.3.5 LIVESTOCK MANURE (BIOGAS)

Embu County households keep different types of livestock with potential for biogas production. The livestock range from zero grazed dairy cattle to poultry. Zero-grazing units are concentrated in the highlands, and such systems provide a steady supply of cattle manure. Southern areas of the

[42] Carsan S. et al (n.a): Timber business environment and its value chains - Timber business environment and its value chains
[43] Wamboi, J (2003): Abundance and Potential Use of Grevillea Robusta in The Wood Carving Industry. A Case of Embu District, Kenya.
[44] Food and Agriculture Organization of the United Nations. ((2015)):Wood fuels handbook.

county are dominated by indigenous cattle and other livestock such as goats. According to the reported livestock population by the County Department of Agriculture for 2024, the county could have potentially 1,083,492 GJ of primary energy from biogas derived from livestock manure (waste) as highlighted in Table 5-7.

Table 5-7: Estimated Potential Biogas Production from Livestock Manure

Livestock Type	Headcount	Biogas m^3/day	Annual biogas (m^3/yr)	Energy (GJ/yr)
Cattle	353,475	63,044	23,011,201	828,403
Sheep	59,657	1,853	676,369	24,349
Poultry	829,670	1,496	546,183	19,663
Pigs	33,496	2,433	888,161	31,974
Goats	398,920	13,630	4,975,088	179,103
Total		82,458	30,097,002	1,083,492

5.4 CHALLENGES AFFECTING BIO-ENERGY SECTOR MARKET

Despite the growing recognition of bioenergy as a reliable and sustainable energy option, the development of a robust bioenergy market in Embu County faces significant challenges. These challenges cut across the supply chain, policy environment, technology adoption, and consumer behavior.

1. Policy, Legal and Institutional Challenges

a) **Fragmented policy and regulatory framework**: Bioenergy regulation is scattered across forestry, agriculture, energy, and environmental agencies without clear coordination. For example, the *Energy Act (2019)*, *Forest Conservation and Management Act (2016)*, and *Environmental Management and Coordination Act (1999)* overlap, leading to duplication of roles and weak enforcement.

b) **Limited enforcement of sustainability regulations**: Although wood fuel production requires permits under the *Forest (Charcoal) Rules, 2009*, informal and illegal charcoal production persists in Mbeere, undermining sustainable supply.

c) **Absence of county-specific bioenergy policy/by-laws**: Embu lacks a harmonized county bioenergy policy or by-law to regulate and guide the sector's growth.

2. Technical and Technological Challenges

a) **Low adoption of modern bioenergy technologies**: Uptake of biogas, briquettes, and bioethanol stoves remains minimal due to high upfront costs and lack of awareness.

b) **Inadequate technical capacity**: Limited expertise in design, installation, and maintenance of biogas digesters, briquette machines, and ethanol stoves constrains reliability and user confidence.

c) **Quality and standardization issues**: Informal production of briquettes and cookstoves often results in sub-standard products, which discourages sustained adoption.
d) **Weak research and data**: There is no county-level biomass resource inventory or monitoring system, making it difficult to plan supply-demand balances effectively.

3. Financial and Market Barriers

a) **High initial investment costs**: Bioenergy systems such as institutional biogas plants or efficient biomass boilers require significant capital, which many households and institutions cannot afford without subsidies or credit.
b) **Limited financing options**: Commercial banks and microfinance institutions perceive bioenergy ventures as high-risk due to lack of collateral and limited success stories.
c) **Weak value chains**: Most bioenergy supply chains (briquettes, ethanol, sustainable charcoal) remain underdeveloped, informal, and poorly integrated with markets, leading to inefficiencies.
d) **Low willingness to pay**: Households and small businesses often prefer "free" firewood collection or low-cost charcoal despite inefficiency and environmental costs.

4. Supply-Side Challenges

a) **Resource depletion and sustainability issues**: Overharvesting of wood fuel in dryland areas of Mbeere North and Mbeere South is leading to scarcity and higher costs.
b) **Seasonality of feedstock**: Agricultural residues such as maize cobs and coffee husks are seasonal, limiting year-round supply for briquette production.
c) **Competition for feedstock**: Crop residues are often used as livestock fodder or organic fertilizer, creating competition between energy and agriculture uses.
d) **Transport and logistics**: High cost of transporting bulky biomass residues from farms to processing centers reduces profitability.

5. Social and Cultural Barriers

a) **Cultural preferences for traditional fuels**: Many households prefer charcoal and firewood for taste and cooking speed, limiting transition to briquettes or ethanol.
b) **Low awareness and information gaps**: Consumers and institutions are not well-informed about the benefits, efficiency, and long-term cost savings of modern bioenergy technologies.
c) **Gendered burden of biomass energy**: Women and children spend significant time collecting firewood, yet their voices are underrepresented in energy planning and decision-making.

6. Infrastructure and Institutional Demand Challenges

a) **Households**: Limited adoption of modern bioenergy appliances due to affordability barriers.
b) **Education institutions**: High firewood demand but limited transition to biogas or briquettes due to upfront costs.
c) **Health institutions**: Energy needs remain unmet, with very limited uptake of bioenergy solutions despite suitability of biogas and ethanol for sterilization and cooking.

d) **Industries**: Agro-processing industries in Embu (coffee, tea, rice) often rely on direct biomass combustion, but lack incentives to adopt efficient biomass boilers or cogeneration systems.

7. Environmental and Climate-Related Challenges

a) **Deforestation and land degradation**: Unsustainable charcoal and firewood harvesting is contributing to forest loss in Mt. Kenya and community forests.
b) **Climate change impacts**: Erratic rainfall reduces availability of biomass crops and residues, particularly in the semi-arid Mbeere areas.
c) **Air pollution and health risks**: Continued use of traditional biomass stoves exposes households to indoor air pollution, with women and children most at risk.

8. Governance and Coordination Challenges

a) **Weak inter-agency coordination**: Limited collaboration between the County Department of Energy, Kenya Forest Service (KFS), NEMA, and REREC undermines enforcement of bioenergy regulations.
b) **Poor data management**: Lack of centralized data on biomass demand and supply hinders effective planning.
c) **Limited stakeholder involvement**: Private sector, women's groups, and community cooperatives are rarely integrated into decision-making structures for bioenergy markets.

5.5 CROSS CUTTING ISSUES IN BIO-ENERGY

5.5.1 GENDER ISSUES

Gender plays a critical role in shaping access to, use of, and participation in the bioenergy sector. In Embu County, women and men experience the bioenergy market differently due to their distinct roles in households, communities, and economic activities. While bioenergy provides opportunities for improved livelihoods, health, and environmental sustainability, gender inequalities often limit women's participation and benefits.

5.5.2 DIVISION OF ROLES AND RESPONSIBILITIES

Household energy management: Women and girls bear the primary responsibility for sourcing, collecting, and using traditional biomass fuels such as firewood and charcoal. In rural Mbeere, this can take 2–5 hours daily, reducing time available for education, income-generating activities, or rest.

Cooking and household health: Women and children are disproportionately exposed to indoor air pollution from traditional stoves, leading to respiratory illnesses, eye problems, and burns.

Men's involvement: Men are more active in commercial aspects of biomass energy (charcoal production, trading, and transport), while women's participation is mostly at the household consumption level.

5.5.3 ACCESS TO RESOURCES AND OPPORTUNITIES

Land and feedstock access: Women have limited land ownership and tenure rights, which restricts their ability to grow bioenergy crops, plant woodlots, or invest in biomass feedstock production.

Capital and credit: Limited access to financial resources prevents women from investing in modern bioenergy technologies (e.g., biogas digesters, improved cookstoves, briquette machines).

Information and training gaps: Women often lack access to technical training, extension services, and market information due to cultural and institutional barriers.

Leadership roles: Women are underrepresented in decision-making structures within cooperatives, community forest associations, and energy policy processes at county level.

5.5.4 IMPACTS OF BIOENERGY ON GENDER EQUALITY

Health benefits: Transition to clean bioenergy (biogas, ethanol, briquettes) can reduce women's and children's exposure to smoke-related diseases.

Time savings: Adoption of efficient stoves and fuels reduces the burden of firewood collection, allowing women to engage in education, care, and entrepreneurship.

Economic empowerment: Women's groups in Embu have begun venturing into small-scale briquette production and biogas use in dairy farming, creating opportunities for income generation. However, they face scaling challenges due to lack of equipment and market access.

Education outcomes: Girls in rural areas often sacrifice schooling to assist with firewood collection, perpetuating gender disparities in education.

5.5.5 STRUCTURAL AND CULTURAL BARRIERS

Traditional norms: Patriarchal structures in many communities assign energy decision-making to men, even though women are the main users of bioenergy.

Technology acceptance: New technologies such as ethanol stoves or household biogas may face cultural resistance due to cooking traditions, taste of food, or lack of trust in modern fuels.

Workload inequality: Even with modern bioenergy adoption, women remain primary household cooks and managers, and technology adoption may not automatically reduce gendered labor divisions.

5.5.6 INSTITUTIONAL AND POLICY GAPS

Limited gender mainstreaming in energy policy: Although Kenya's *Energy Act (2019)* and *Kenya National Energy Policy (2018)* recognize gender inclusion, implementation at the county level is weak.

Absence of county-specific gender-energy strategy: Embu County lacks a structured framework to integrate women and marginalized groups into bioenergy programs.

Weak representation: Women's associations and community-based organizations have little influence in shaping bioenergy policies and programs despite being key users.

5.5.7 OPPORTUNITIES FOR GENDER MAINSTREAMING IN BIOENERGY

Women-led enterprises: Support to women's groups in briquette making, biogas units, and efficient stove businesses can enhance livelihoods and strengthen supply chains.

Capacity building and training: Tailored training programs can equip women and youth with technical and entrepreneurial skills in bioenergy technologies.

Access to finance: County governments, SACCOs, and microfinance institutions can develop credit lines targeting women entrepreneurs in bioenergy.

Community participation: Integrating women into Community Forest Associations (CFAs) and farmer cooperatives can ensure inclusive management of bioenergy feedstocks.

Awareness and education: Public sensitization campaigns can address cultural biases and promote shared household responsibilities in energy management.

5.5.8 ENVIRONMENT AND CLIMATE CHANGE

5.5.8.1 Deforestation and Land Degradation

Fuelwood and charcoal production remain the dominant sources of bioenergy in Embu, supplying over 75% of household energy. The unsustainable harvesting of natural forests and communal woodlands has led to:

a) Deforestation in Mount Kenya Forest Reserve, Kianjokoma, and communal hills.
b) Encroachment into riparian and catchment areas.
c) Land degradation through soil erosion, reduced soil fertility, and declining water retention capacity.

The quantified demand–supply balance shows a **31% annual biomass deficit**, driving illegal harvesting and forest degradation that undermine ecosystem services.

5.5.8.2 Greenhouse Gas Emissions

Incomplete combustion of biomass fuels in traditional stoves and open fires contributes significantly to GHG emissions.

- Firewood and charcoal combustion produce CO_2, methane (CH_4), and black carbon, which have high global warming potential.
- With 78% of households reliant on wood fuel, Embu's bioenergy use contributes substantially to county-level emissions.
- Charcoal production, largely through traditional earth kilns, results in conversion inefficiencies - losing up to 80% of wood energy and emitting large volumes of greenhouse gases.

5.5.8.3 Indoor and Outdoor Air Pollution

Indoor air pollution from firewood and charcoal is a leading environmental health issue in Embu County. Women and children, who spend the most time near household hearths, are disproportionately exposed. Impacts include:

- Respiratory infections, eye problems, and increased risk of chronic diseases.
- Schools and hospitals using smoky kitchens exacerbate exposure in institutional settings.

5.5.8.4 Water and Ecosystem Impacts

Deforestation linked to biomass harvesting threatens the upper Tana watershed, which feeds the Seven Forks Hydropower cascade and Nairobi's water supply. Loss of vegetative cover affects river flows (Thiba, Rupingazi, Kii, Nguu) and reduces hydrological stability. Biodiversity loss is evident in areas where forests have been degraded for charcoal production.

5.5.8.5 Climate Change Vulnerability

Climate change is already affecting the biomass supply chain in Embu:

- **Erratic rainfall patterns** reduce agricultural residue availability and compromise the productivity of woodlots and bioenergy crops.
- **Extended droughts** increase reliance on forests for survival, accelerating unsustainable harvesting.
- **Increased wildfires** in Mount Kenya and community forests threaten remaining carbon sinks.

5.5.8.6 Opportunities for Climate Mitigation and Adaptation

Bioenergy offers both risks and opportunities for addressing climate change if managed sustainably. Key interventions include:

- **Sustainable Woodlots:** Establishment of fast-growing tree plantations (eucalyptus, grevillea, bamboo) to reduce forest pressure.
- **Residue Utilization:** Turning coffee husks, rice husks, sugarcane bagasse, and maize cobs into briquettes to replace wood fuel.
- **Clean Cooking Technologies:** Scaling up biogas, bioethanol, and improved cookstoves to reduce emissions and deforestation.
- **Carbon Finance:** Leveraging carbon credits through improved cookstove and reforestation projects under voluntary carbon markets.
- **County Climate Change Fund (CCCF):** Mainstreaming bioenergy sustainability in climate adaptation projects under the Embu County Climate Change Act (2020).

5.5.8.7 Risk and Disaster Management

The bioenergy sector in Embu County is vulnerable to a wide range of risks and disasters that threaten both energy security and community resilience. These risks arise from over-reliance on unsustainable biomass resources, weak regulation, and growing climate variability. Proactive disaster risk management is therefore essential to safeguard livelihoods, ensure sustainable energy access, and protect the environment.

5.5.9 PROPOSED COMMUNICATION FRAMEWORK FOR BIOENERGY

a) Multi-Stakeholder Engagement
- Establish a County Bioenergy Communication Platform bringing together county government, KFS, NEMA, KEFRI, private sector actors, and CBOs.
- Regular joint communication campaigns to harmonize messages on sustainability, licensing, and clean technologies.

b) Community-Centered Communication
- Leverage chief's barazas, ward-level energy committees, and extension officers as frontline communicators.
- Translate technical information into local languages (Kĩembu, Kiswahili) for greater accessibility.

c) Digital and Mass Media Platforms
- Use county social media pages, community radio, SMS alerts, and WhatsApp groups to disseminate information on subsidies, regulations, and clean cooking campaigns.
- Partner with local FM stations (e.g., Runyenjes FM, Wimwaro FM) to run regular energy awareness programs.

d) Education and Awareness Campaigns
- Integrate bioenergy information into school environmental clubs and adult literacy programs.
- Demonstration centers in agricultural shows, markets, and institutions to showcase technologies such as biogas, briquettes, and improved stoves.

e) Feedback and Grievance Redress Mechanisms
- Establish county hotlines and suggestion boxes for communities to report illegal logging, charcoal trading, or poor service delivery.
- Regular participatory reviews with communities to assess the effectiveness of bioenergy interventions.

5.5.10 ROLE OF THE COUNTY DEPARTMENT OF EDUCATION

The **County Department of Education** is responsible for institutionalizing bioenergy innovation and training through:

- **Curriculum Integration** – embedding bioenergy skills (stoves, briquettes, biogas, waste-to-energy) into vocational training programs.
- **Training Infrastructure** – equipping centres with demonstration units and fabrication workshops.
- **Youth and Women Empowerment** – linking graduates to incubation and financing opportunities.
- **Coordination** – aligning vocational training with development partner projects to ensure sustainability beyond donor timelines.
- **Knowledge Transfer** – using vocational centres as regional hubs for bioenergy innovation and skills dissemination.

5.5.11 ROLE OF DEVELOPMENT PARTNERS

Development partners have been instrumental in:

- Training and Capacity Building – delivering hands-on training for women and youth in cookstove construction and briquette production.
- Enterprise Support – enabling community groups to start micro-enterprises in biomass energy.
- Awareness and Outreach – organizing bioenergy roadshows in partnership with the County Department of Energy. However, low community turnout highlights the need for more inclusive, localized communication models.
- Technical Assistance – introducing new technologies and providing start-up kits for community-based bioenergy ventures.
- Partnership Building – linking local actors with national programs and global climate initiatives.

5.6 SELECTION OF INTERVENTIONS

This subsection sets out the interventions to advance the bioenergy goals of Embu County, prioritizing those with the greatest socio-economic and environmental benefits, high feasibility, and alignment with national strategies. It also outlines governance and implementation structure

List and Prioritize Potential Intervention Options

Based on the demand-supply analysis, stakeholder consultations, and national energy policy alignment, the following potential interventions were identified and prioritized:

a) Promotion of **Improved Cookstoves (ICS)** for households and institutions.
b) Scale-up of briquette production and distribution enterprises using agricultural residues.
c) Expansion of **biogas systems** (household and institutional).
d) Sustainable woodlot establishment and agroforestry programs to secure biomass supply.
e) Promotion of **liquid biofuels (ethanol, biodiesel)** for transport and industry.
f) Capacity building for women and youth in clean energy entrepreneurship.
g) Strengthening research, innovation, and local manufacturing capacity for bioenergy technologies.
h) Establishment of **county bioenergy supply chain governance and regulation** (traceability, licensing, standards).

Priority was given to interventions addressing household energy poverty, institutional demand, and industrial competitiveness, while ensuring gender equity and environmental sustainability.

Selected Interventions

The following interventions were selected for implementation under the Embu County Energy Plan:

a) Households

- Mass roll-out of ICS and briquette adoption (target: 70% household clean cooking by 2035).
- Biogas expansion for rural households with livestock.

b) Institutions
- Transition schools and health facilities to ICS, biogas, and briquettes (target: 80% adoption by 2035).
- Establish a County Revolving Fund to support affordable technology access.

c) Industrial and Agro-processing
- Develop bioenergy clusters for coffee, tea, and macadamia processing using residues for heat and power.
- Pilot liquid biofuel substitution in agro-industrial boilers.

d) Supply-Side Interventions
- Promote community-based woodlots and agroforestry programs.
- Support SMEs in briquette manufacturing and distribution chains.

e) Crosscutting
- Training and incubation programs for women and youth in bioenergy enterprises.
- Strengthen R&D and technology innovation through University of Embu and KEFRI.
- Develop county-level bioenergy regulations, certification, and supply chain monitoring.

Governance Structure for Implementation

A **County Bioenergy Coordination Platform (CBCP)** will be established under the Department of Energy to steer implementation.

- **Lead Agency**: Embu County Department of Energy.
- **Technical Partners**: University of Embu, KEFRI, Kenya Forestry Service (KFS), EPRA.
- **Development Partners**: UNDP, SNV, Practical Action, GIZ, World Bank, among others (support financing, training, roadshows).
- **Private Sector**: Local SMEs, cooperatives, stove and briquette manufacturers.
- **Community Structures**: Producer cooperatives, women and youth associations.
- **Monitoring and Evaluation (M&E)**: Jointly managed by County Dept. of Energy and National Ministry of Energy with annual progress reviews.

Implementation Matrix

Table 5-8: Implementation Matrix

Intervention Area	Specific Action	Lead Actor	Partners/Supporters	Timeline	Expected Outcome
Household clean cooking	Roll-out of 100,000 ICS units; expand household biogas	County Dept. of Energy	NGOs, SMEs, Dev Partners, Community groups	2025–2035	70% household clean cooking adoption
Institutional adoption	Transition 80% of schools & health facilities to ICS, biogas, briquettes	Dept. of Education & Dept. of Health	County Energy, NGOs, CDF, Dev Partners	2025–2030	80% institutional clean cooking adoption

Industrial/agro-processing	Establish bioenergy clusters; pilot biofuels in boilers	Dept. of Trade & Industry	Private sector, KEPSA, REREC, KFS	2026–2035	40% fossil fuel displacement in industry
Biomass supply security	Promote 5,000 ha of woodlots & agroforestry	KFS, Dept. of Agriculture	Communities, NGOs, Research Institutions	2025–2035	Sustainable supply of biomass feedstock
Briquette value chain	Support 50 SMEs in briquette production & marketing	County Dept. of Trade & Energy	NGOs, Youth/Women groups, Private sector	2025–2030	30% market penetration of briquettes
Gender & youth empowerment	Entrepreneurship training; incubation for 200 women & youth-led bioenergy SMEs	Dept. of Youth, Gender & Energy	Dev Partners, Vocational Centres	2025–2030	≥40% youth/women participation in bioenergy enterprises
Research & innovation	Establish county bioenergy R&D hub at University of Embu	Univ. of Embu, KEFRI	Dev Partners, County Energy, KIRDI	2025–2035	New technologies piloted & scaled
Governance & regulation	Establish county bioenergy standards, certification, and supply chain registry	County Dept. of Energy, EPRA	NEMA, KFS, Ministry		

5.7 BARRIERS, RISKS & MITIGATION MEASURES

This section identifies the key barriers and risks affecting the bioenergy sub-sector in Embu County, with corresponding mitigation measures to ensure sustainable growth.

5.7.1 BARRIERS

a) High Upfront Costs of Bioenergy Technologies
- Improved cookstoves, biogas digesters, and briquette machines remain unaffordable for many households and institutions.
- Limited access to credit facilities worsens adoption.

b) Weak Supply Chains
- Distribution of stoves, briquettes, and biogas accessories is fragmented.
- Inconsistent quality standards discourage trust and repeat purchases.

c) Low Awareness and Behavioral Resistance
- Many households and institutions remain accustomed to traditional three-stone cooking.
- Roadshows and awareness campaigns have had limited reach and attendance.

d) Limited Biomass Resource Management
- Overharvesting of fuelwood and limited woodlot establishment leads to unsustainable supply.
- Weak enforcement of sustainable harvesting practices.

e) Institutional and Governance Gaps
- Lack of coordination among county departments, NGOs, and private sector actors.
- Limited monitoring and certification systems for bioenergy products.

f) Gender and Social Inequities

- Women, who bear the burden of household cooking, often lack decision-making power and financing access.
- Youth involvement in innovation and enterprises is still minimal.

5.7.2 RISKS

Table 5-9: Risk

Risk Category	Description	Potential Impact
Economic/Financial	High technology costs; limited financing for SMEs and households	Slow adoption, underdeveloped private sector
Environmental	Unsustainable fuelwood harvesting; climate variability affecting biomass	Deforestation, soil erosion, reduced resilience of bioenergy supply
Technical	Poor quality or counterfeit stoves and briquettes	Low user confidence, health hazards, wasted investments
Social & Gender	Exclusion of women and youth in project design and benefits	Gender inequality, missed opportunity for empowerment
Institutional/Policy	Weak regulatory enforcement; fragmented governance	Duplication of efforts, inefficiencies, and unsustained outcomes
Market/Adoption	Resistance to behavior change; weak consumer trust	Limited uptake of modern bioenergy solutions
Disaster & Safety	Risks of biogas accidents, fire hazards in briquette storage	Threats to safety, potential loss of confidence in technologies

5.7.3 MITIGATION MEASURES

a) Financial and Economic Measures

- Establish a County Bioenergy Revolving Fund to provide micro-credit and subsidies for households, schools, and SMEs.
- Promote public-private partnerships to reduce technology costs through local assembly and bulk procurement.

b) Strengthening Supply Chains

- Support bioenergy SMEs and cooperatives with training, equipment, and marketing.
- Develop county-level quality assurance and certification standards for stoves, briquettes, and biogas systems.

c) Awareness and Behavior Change

- Intensify outreach through schools, churches, and health facilities where attendance is higher than roadshows.
- Deploy community energy champions to promote adoption and demonstrate technologies.

d) Resource Sustainability

- Promote agroforestry and woodlot development to secure biomass supply.
- Enforce sustainable harvesting guidelines through local forest management committees.

e) Governance and Institutional Strengthening

- Operationalize the County Bioenergy Coordination Platform (CBCP) for multi-sectoral planning.

- Build capacity within the Department of Energy for bioenergy monitoring, licensing, and enforcement.

f) Gender and Social Inclusion
- Mainstream gender by ensuring 40% of county energy grants and training slots go to women and youth.
- Support women-led cooperatives in stove distribution and briquette production.

g) Risk and Disaster Management
- Establish safety training modules for biogas construction and use.
- Develop fire safety standards and protocols for briquette storage and transport.
  - Include bioenergy safety in county disaster preparedness plans

5.7.4 RISK MANAGEMENT FRAMEWORK MATRIX

Table 5-10: Risk Management Framework Matrix

Risk/Barrier	Proposed Mitigation Measure	Responsible Actors	Timeline
High upfront costs of bioenergy technologies	Establish County Bioenergy Revolving Fund; promote PPPs for bulk procurement and local assembly	County Government (Energy, Finance), SACCOs, Private sector, Development partners	Short–Medium term
Weak supply chains	Support bioenergy SMEs/cooperatives with training, equipment, and marketing; introduce quality assurance standards	Dept. of Energy, Trade & Industry, KEBS, NGOs, Development partners	Medium term
Low awareness & behavioral resistance	Use schools, churches, and health facilities for outreach; deploy community energy champions	Dept. of Energy, Dept. of Education, NGOs, CBOs, Religious institutions	Continuous
Unsustainable biomass harvesting	Promote agroforestry, woodlots, and community forest management; enforce harvesting guidelines	Dept. of Environment & Natural Resources, Kenya Forest Service, Community Forest Associations	Medium–Long term
Institutional & governance gaps	Establish County Bioenergy Coordination Platform (CBCP); strengthen monitoring/licensing capacity	Dept. of Energy, County Executive Committee (CEC), National Ministries, Development partners	Short term
Gender and social inequities	Reserve 40% of training and financing for women and youth; support women-led cooperatives	Dept. of Gender, Dept. of Energy, NGOs, Women & Youth groups, Development partners	Continuous
Poor quality/counterfeit technologies	Develop certification and testing centers for stoves, briquettes, and biogas systems	KEBS, County Dept. of Energy, Private Sector, Universities/TVETs	Medium term
Market resistance/adoption risk	Introduce incentive schemes (tax waivers, subsidies); pilot projects in households, schools, and hospitals	National Treasury, County Govt., Development partners, NGOs	Short–Medium term
Environmental & climate risks	Integrate bioenergy into county climate change adaptation plans; promote drought-resilient bioenergy crops	County Climate Change Unit, Dept. of Agriculture, NGOs, Research Institutions	Long term
Disaster & safety risks (fires, biogas accidents)	Provide safety training for users/constructors; develop storage and fire safety standards	Dept. of Energy, County Disaster Management Unit, NEMA, Development partners	Short–Medium term
Financial sustainability of interventions	Mainstream bioenergy in County Integrated Development Plan (CIDP) to secure budget allocations	County Treasury, Dept. of Energy, County Assembly, Development partners	

6 ENERGY PROGRAMMES & PROJECTS

6.1 INTRODUCTION

This chapter provides a structured framework to guide the implementation of the proposed projects and programs outlined in this County Energy Plan. It translates the County's vision of achieving universal household access to affordable, reliable, and sustainable energy into a clear and actionable roadmap for the period 2025–2035.

The chapter builds upon the findings from Chapter 3, which analysed the current state of energy access across different sectors within the County. It outlines strategic interventions aimed at expanding electricity and clean cooking access, promoting renewable energy adoption, improving energy efficiency, and strengthening institutional capacity for effective energy governance.

The proposed projects and programs have been developed in alignment with the **Embu County Integrated Development Plan (CIDP) 2023–2027**, the **Annual Development Plan (ADP)**, and the **County Budgetary Allocations for the Financial Year June 2025–June 2026**. This ensures that the implementation of energy initiatives is well-integrated within the County's broader development framework and fiscal planning cycles to enhancing the feasibility and sustainability of the proposed actions.

Each project or program is presented with a clear description, expected outcomes, responsible stakeholders, indicative investment requirements, and implementation status (new or ongoing). A detailed roadmap spanning 2025–2035 provides yearly activities and milestones, categorized into **short-term (2025–2027)**, **medium-term (2028–2031)**, and **long-term (2032–2035)** interventions. This structured sequencing is intended to facilitate effective planning, budgeting, coordination, and monitoring of progress toward the County's energy access targets.

Ultimately, this chapter serves as a **practical guide** for stakeholders to implement prioritized energy projects. It provides a basis for resource mobilization, partnership building, and performance tracking as towards **100% household electrification and universal access to clean cooking solutions.**

6.2 ELECTRIFICATION PROJECTS AND PROGRAMS

6.2.1 HOUSEHOLD ELECTRIFICATION PROJECTS AND PROGRAMS

Summary of Project/Program and Timing

- **Short-Term (2025–2027):** Projects 1–6, 10, 12, 13 (Foundational phase)
- **Medium-Term (2028–2031):** Projects 7, 8 (continuing), 9 (start), 15 (start)
- **Long-Term (2032–2035):** Projects 9 (sustain), 14, 11 (continuous)

Total Estimated Cost: ≈ **KES 1.18 billion** over the 10-year horizon (excluding private and donor leverage).

Table 6-1: Summary of Proposed Household Electrification Projects and Programs

	Project / Program	Description	Expected Outcomes	Implementing Agency	Est. Cost (KES million)	Phase	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	County Distribution & Electrification Masterplan (GIS Mapping + Modelling)	Develop a GIS-based masterplan to guide distribution, prioritization, and least-cost planning for countywide electrification.	Clear electrification roadmap; optimized grid and solar expansion; data-driven planning.	County Energy Dept, KPLC, REREC, Donors	50	**Short-term (2025–2026)**	Develop ToR, hire consultant	Mapping, modelling, validation	Finalize plan, adoption								
2	Ward Project Management Committees (PMCs) Rollout	Establish and operationalize Ward-level PMCs to oversee energy project implementation.	Strengthened local participation, accountability, and monitoring.	County Admin, County Energy Dept	10	**Short-term (2025–2027)**	Policy frame-work, training	PMC formation & training	Full rollout across wards								
3	Permit & ID System for Technicians	Create digital and paper-based registry for technicians and contractors.	Enhanced transparency, regulation, and professionalism in field works.	County ICT, Energy Dept, Ward Admin	8	**Short-term (2025–2027)**	System design	Registration rollout	Continuous updating								
4	Transformer Audit & Upgrade Programme	Conduct technical audit and upgrade/replace transformers by priority.	Improved grid reliability and reduced outages.	KPLC, County Govt, REREC	120	**Short–Medium (2025–2030)** **ADP 2025-2026**	Audit, procurement	Upgrade 10 units (ADP)	Phase 2 upgrades	Phase 3 upgrades	Monitoring & Evaluation						
5	Local KPLC/REREC Subcounty Service Desks	Establish subcounty-level energy service offices.	Improved response time and customer service.	KPLC, REREC, County Govt	15	**Short-term (2025–2027)**	Identify sites, pilot	Equip & operationalize	Review effectiveness								
6	Fast-track Meter & Service Drop Program	Accelerate meter installations and service drops with SLA targets.	Increased access, reduced connection delays, higher customer satisfaction.	KPLC, PMCs	200	**Short–Medium (2025–2030)**	Pilot in key wards	Scale-up to 2 subcounties	Countywide rollout	Expansion	Review performance	Maintenance					
7	Last-Mile Subsidy Fund & Prioritization Mechanism	Create a transparent subsidy framework for connecting poor households.	Promote equity and accelerate last-mile connectivity.	County Energy Dept, REREC, Finance Dept, Donors	400	**Medium-term (2028–2031)**			Develop policy & framework	Fund mobilization	Pilot phase	Full rollout	Review & adjust				
8	Community Technician Training & VTC Scholarships	Register, train and certify technicians; offer scholarships to youth via VTCs.	Build local technical capacity and create employment.	County Education Dept, VTCs, Energy Dept	60	**Short–Medium (2025–2030)**	Curriculum review	Training launch	Scholarship awards	Continuous training	Graduate absorption	Evaluation					
9	Solar PV Service Centre Network &	Establish solar service centres and advocate for	Reliable solar services; expanded off-	County Energy Dept, Private	100	**Medium–Long (2028–2033)**				Site identification	Pilot 2 centres	Expand to all	PAYGO regulation roll-out	Maintenance			

	PAYGO Regulation	consumer-friendly PAYGO regulation.	grid access; consumer protection.	Sector, EPRA								sub-counties				
10	Meter Registry & Chain-of-Custody Strengthening	Enhance accountability in meter handling through registry and tracking system.	Reduced losses, transparency, improved asset management.	KPLC, ICT Dept, Ward Admin	15	**Short-term (2025–2027)**	Design registry	Deploy system	Monitor performance							
11	Public Awareness & Safety Roadshows & Firefighting Capacity	Conduct public awareness and safety campaigns and strengthen fire response units.	Reduced electrical accidents; improved safety culture.	County Energy Dept, Fire Service, Education Dept	20	**Continuous (2025–2035)**	Launch campaign	Expand to all wards	Annual roadshows							
12	Household Solar Lamp Distribution	Provide solar lamps to rural households through climate change funding.	Enhanced access to lighting and reduced kerosene use.	Climate Change Unit, Energy Dept	8	**Short-term (2025–2026) ADP 2025-2026**	Procurement & distribution	Monitoring & reporting								
13	Electrification of 10 Rural Areas (Grid Extension)	Connect 10 rural areas to grid as per ADP 2025/26.	Increased rural electrification and social inclusion.	REREC, KPLC, County Govt	25	**Short-term (2025–2027) ADP 2025-2026**	Design & site surveys	Construction & connection	Commissioning							
14	Productive Use & Demand Growth Program (PU4E)	Promote productive uses of electricity (agro-processing, cold storage, ICT hubs).	Stimulate rural enterprise, enhance energy-use sustainability.	County Energy Dept, Trade Dept, Donors	150	**Long-term (2030–2035)**					Develop PU4E strategy	Pilot projects	Scale-up	Expansion	Evaluation	Sustainability
15	Electrification Monitoring & Evaluation System (CEIS integration)	Develop an M&E dashboard integrated with County Energy Information System.	Real-time tracking of electrification progress and performance.	County Energy Dept, ICT, National Data Centre	10	**Medium-term (2028–2032)**				Develop dashboard	Integrate data systems	Operatio nalize	Continuous updates			

6.2.2 ELECTRIFICATION PROJECTS AND PROGRAMS IN EDUCATION INSTITUTIONS

Summary of Project/Program and Timing

Short-Term (2025–2026):	1, 2, 4	Foundational access and reliability phase
Medium-Term (2026–2030):	3, 5, 6, 7	Expansion, renewable integration, and efficiency programs
Long-Term (2029–2035):	8, 9, 10	Sustainability, monitoring, and behavioural transformation

Total Estimated Cost: ≈ KES 263 million (excluding leveraged partner contribution

Table 6-2: Summary of Proposed Electrification Projects and Programs in Education Institutions

	Project / Program	Description	Expected Outcomes	Stakeholders Responsible	Est. Cost (KES million)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	Electrification of Mugwanjuki Primary and Junior Secondary School	Connect the only unelectrified school to the KPLC grid through REREC support.	Achieve 100% electricity access in all education institutions.	REREC, KPLC, County Education Dept	2.5	**Short-term (2025)**	Connection design, procurement, and installation										
2	Grid Reliability Enhancement – University of Embu	Relocate vulnerable transmission line supplying the University to minimize outages.	Stable and reliable electricity supply; reduced generator fuel use.	UoEm, KPLC, County Govt	8.65	**Short-term (2025–2026)**	Site survey and engineering design	Line relocation and commissioning									
3	Solar PV Expansion – University of Embu	Install 382 kWp rooftop solar system to supplement grid supply and increase renewable share.	Reduce grid dependence; achieve 60% solar energy share; lower carbon emissions.	UoEm, County Govt, Development Partners	45.0	**Medium-term (2026–2028)**	Feasibility study, design	Procurement and installation	Commissioning and performance review								
4	Solar Street Lighting – University of Embu	Install ~220 solar-powered streetlights within the campus and access roads.	Enhance safety, reduce lighting costs, and improve nighttime security.	UoEm, County Govt	7.38	**Short-term (2025–2026)**	Procurement and installation of 100 lights	Completion of remaining 120 lights and commissioning									
5	Energy Research & Training Centre – University of Embu	Establish a Centre for applied energy research, innovation, and capacity building in renewable and efficiency technologies.	Promote research, training, and innovation; develop skilled local workforce.	UoEm, County Govt, Ministry of Energy, MoE	20.0	**Medium-term (2026–2029)**	Feasibility and design	Infrastructure construction	Equipping and staffing	Launch operations							
6	Energy Efficiency Program – University of Embu	Conduct energy audits, replace inefficient	Reduce energy intensity by 20%; improve energy	UoEm	5.0	**Medium–Long-term (2026–2030)**	Baseline audit	Lighting and equipment replacement	Staff/student awareness campaign	Monitoring and verification	Final performance report						

		lighting and appliances, and promote behavioral energy management.	management and savings.														
7	School Power Quality and Reliability Enhancement Program (Countywide)	Undertake transformer audits, install stabilizers, and upgrade wiring in select schools with unstable power.	Improved reliability and reduced learning disruption due to outages.	County Energy Dept, KPLC, REREC	60.0	**Medium-term (2026–2030)**	Identify schools and audit power supply	Pilot upgrades in 10 schools	Rollout phase II	Rollout phase III	Evaluation						
8	Solar PV Retrofit Program for TVETs and VTCs	Install rooftop PV and hybrid systems (10–50 kWp) in vocational institutions for practical training and backup power.	Enhance renewable energy training and ensure reliable power for workshops.	County Energy Dept, TVET Authority, VTCs	90.0	**Medium–Long-term (2027–2032)**	Feasibility and design	Pilot installations (2 VTCs)	Expansion to 5 VTCs	Countywide rollout	Monitoring	Review & maintenance					
9	Green School Program – Energy Awareness & Clubs	Introduce school energy clubs to promote energy conservation, tree planting, and safety awareness.	Foster energy culture, youth engagement, and environmental responsibility.	County Education Dept, Energy Dept, UoEm	10.0	**Continuous (2025–2035)**	Launch program in 20 schools	Scale to 50 schools	Annual awareness drives	Annual competitions	Expand partnerships	Continue activities	Continuous reviews				
10	Energy Data and Monitoring System for Schools	Develop a countywide digital dashboard to track energy use and costs in learning institutions.	Improved data management and informed decision-making on energy efficiency.	County ICT, Energy Dept, Education Dept	15.0	**Long-term (2029–2033)**				Develop software prototype	Pilot data system	Countywide rollout	Integration with CEIS				

6.2.3 ELECTRIFICATION PROJECTS AND PROGRAMS FOR HEALTH FACILITIES

Short-Term 2025–2027 **Projects 1, 2, 3, 8** Foundational Access and Reliability Phase

Medium-Term 2026–2031 **Projects 4, 5, 6** Expansion and Efficiency Phase

Long-Term 2030–2035 **Project 7** Sustainability and Monitoring Phase

Continuous 2025–2035 **Project 8** Capacity Strengthening and Institutionalization Phase

Table 6-3: Summary of Proposed Electrification Projects and Programs in Health Facilities

	Project / Program	Description	Expected Outcomes	Stakeholders Responsible	Est. Cost (KES million)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	Solarisation of Level 2 facilities	Install 5 - 10 kWp with 16 kWh battery storage	Achieve 100% electrification of level 2 health facilities, and reduce cost	County Energy Dept, County Health Dept, Development partners	0.5	**Short-term (202526)** **(Budgeted 2025/26)**	Site survey, wiring, and solar PV sizing	Installations, testing, and commissioning									
2	Electrification of Unelectrified Dispensaries (15 sites)	Connect 15 Level 2 facilities via KPLC or standalone solar PV systems.	Achieve 100% electrification of primary healthcare facilities.	County Energy Dept, REREC, KPLC, Health Dept	4.5	**Short-term (2025–2027)**	Site surveys, wiring, and KPLC applications	Installations and testing	Commissioning and monitoring								
3	Solarization of Embu Level 5 Hospital	Install 500–600 kWp solar PV with hybrid storage to supplement grid supply.	Reduce electricity costs, ensure reliability for critical services.	Dept. of Health, KPLC, Energy Dept, Partners	120	**Short–Medium (2025–2028)** **(KES 9M committed in 2025 Budget)**	Feasibility & design	Procurement & installation (Phase 1)	Commissioning	Performance review							
4	Electrical Works at Ishiara Level 4 Hospital	Installation of power, transformer, and electrical upgrades.	Reliable and stable power supply for hospital operations.	Dept. of Health, KPLC	6.5	**Short-term (2025–2026)** **(Budgeted 2025/26)**	Design and procurement	Implementation and commissioning									
5	Health Facility Power Reliability & Backup Program	Install hybrid inverters, batteries, and stabilizers in selected Level 3–5 hospitals.	Minimize power interruptions and equipment failure.	KPLC, County Energy Dept, Health Dept	80	**Medium-term (2026–2031)**	Identify critical facilities	Procure backup systems	Install systems (Phase 1)	Install systems (Phase 2)	Monitoring & review						
6	Health Facility Energy Efficiency Program	Conduct energy audits, replace inefficient lighting, and install solar water heaters.	Reduce electricity consumption and operational costs.	Dept. of Health, Energy Dept	25	**Medium–Long (2026–2032)**	Audit planning	Lighting and appliance replacement	Solar water heater installation	Expansion to all Level 4–5 facilities	Review & reporting	Monitoring					
7	Solarization of Level 4 Hospitals (Ishiara, Runyenjes, Siakago)	Install rooftop solar PV (100–200 kWp) in Level 4 hospitals.	Improve reliability and cut costs for medium-size hospitals.	Dept. of Health, Partners	60	**Medium-term (2027–2030)**	Feasibility studies	Procurement	Installations	Commissioning	Review						
8	County Health Energy Monitoring & Data System	Develop dashboard integrated with County Energy Information System (CEIS).	Track energy performance and cost savings across health facilities.	County ICT, Energy Dept, Health Dept	10	**Long-term (2030–2035)**				Develop system	Pilot testing	Rollout	Expansion	Continuous updates			
9	Capacity Building & Maintenance Training	Train health facility maintenance teams on energy management, PV systems, and safety.	Improved sustainability and reduced downtime.	Energy Dept, VTCs, MoE	12	**Continuous (2025–2035)**	Develop training curriculum	Conduct 1st training	Annual refreshers								

6.2.4 ELECTRIFICATION PROJECTS AND PROGRAMS FOR CORRECTIONAL FACILITIES

Summary of Project Categories and Timing

Short-Term	2025–2026	**Projects 1, 2, 6**	Access and Safety Phase — focuses on immediate improvements in power access, solar installations, and enhanced security lighting for both prisons.
Short–Medium Term	2025–2028	**Project 5**	Renewable Integration Phase — installation of a centralized solar PV system to stabilize power supply and reduce operational costs at Embu Men's Prison.
Medium-Term	2026–2029	**Projects 3, 7, 8**	Reliability and Efficiency Phase — prioritizes hybrid backup installation, energy audits, and retrofits to improve performance and reduce consumption.
Continuous	2025–2035	**Projects 4, 9**	Capacity Building and Sustainability Phase — ensures ongoing training and institutional strengthening for energy system maintenance and management.

Total Estimated Investment (2025–2035): ≈ KES 23.5 million

Table 6-4: Summary of Proposed Electrification Projects for Correctional Facilities

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholders Responsible	Est. Cost (KES million)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	**Hybrid Solar PV System – Women's Prison**	Install hybrid solar PV system with battery storage to supplement grid supply and improve reliability.	Reduce grid dependence, improve reliability, and lower energy costs.	State Dept. of Prisons, County Energy Dept., REA, Private Solar Firms	1.2	**Short-term (2025–2026)**	Feasibility & design	Installation and commissioning									
2	**Solar-Powered Floodlighting – Women's Prison**	Install solar-powered security and compound lights within and around the prison.	Enhance safety, visibility, and security at night.	County Energy Dept., KPLC, Prison Administration	0.32	**Short-term (2025–2026)**	Procurement & site works	Installation & commissioning									
3	**Electrical Efficiency Audit & Retrofitting – Women's Prison**	Conduct energy audit and replace inefficient lighting and wiring systems.	Reduce electricity consumption and optimize system performance.	County Energy Dept., EPRA, Prisons Dept.	0.6	**Medium-term (2026–2028)**	Conduct audit	Retrofit inefficient systems	Performance monitoring								
4	**Staff Training on Energy Management – Women's Prison**	Train staff on operation, maintenance, and energy efficiency management.	Build capacity for sustainable energy system management.	Prison Admin, County Energy Dept., TVETs	0.15	**Continuous (2025–2035)**	Training curriculum development	First cohort training	Annual refresher courses								
5	**Centralized Solar PV System – Men's Prison**	Install 100–120 kWp grid-tied solar PV system with internal rewiring to centralize power.	Stable, clean, and cost-effective electricity supply.	State Dept. of Prisons, County Energy Dept., REA, Private Solar Firms	16.5	**Short–Medium (2025–2028)**	Feasibility study	Procurement & installation (Phase 1)	Commissioning & testing	Performance monitoring							
6	**Borehole Refurbishment & Solarization – Men's & Women's Prisons**	Refurbish borehole and install solar-powered pumping system for water supply.	Reliable and sustainable water pumping; reduced energy costs.	County Energy Dept., WRA, REA, Prison Admin	1.0	**Short-term (2025–2026)**	Borehole refurbishment	Solar pumping installation									
7	**Hybrid Generator Backup Installation – Men's Prison**	Replace old 7.5 kW generator with automated hybrid (diesel + solar) backup.	Reliable backup power for critical loads and reduced downtime.	Prisons Admin, County Energy Dept., Private Contractors	2.3	**Medium-term (2026–2028)**	Design and procurement	Installation and commissioning	Performance review								
8	**Energy Efficiency Retrofit – Men's Prison**	Conduct audit, replace lights with LEDs, install motion sensors and smart meters.	Lower energy consumption and improve energy monitoring.	EPRA, County Energy Dept., Prison Admin	1.3	**Medium-term (2026–2029)**	Conduct audit	Retrofit installations	Expansion phase	Review & reporting							
9	**Capacity Building on Energy Systems – Men's Prison**	Train prison technical staff in maintenance and energy management.	Sustained energy efficiency and system upkeep.	County Energy Dept., TVET Institutions	0.35	**Continuous (2025–2035)**	Develop training program	Conduct initial training	Annual refreshers	Annual refreshers							

6.2.5 ELECTRIFICATION PROJECTS AND PROGRAMS FOR INDUSTRIES

6.2.5.1 ELECTRIFICATION PROJECTS AND PROGRAMS FOR TEA INDUSTRIES

Summary of Project Categories and Timing

Short-Term	2025–2027	**Projects 1, 5**	Renewable Integration and Capacity Phase — focuses on establishing clean energy supply through the Thuci mini-hydro plant and building local technical capacity for efficient energy use.
Medium-Term	2026–2029	**Projects 3, 4**	Digital and Solar Expansion Phase — emphasizes digitalization of energy management systems and installation of rooftop solar PV systems in all KTDA factories.
Continuous	2025–2035	**Project 2**	Efficiency and Optimization Phase — ensures ongoing energy audits, retrofits, and continuous performance improvements in all tea factories.

Estimated Total Investment (2025–2035): ≈ KES 705 million

Table 6-5: Summary of Proposed Electrification Projects and Programs for Tea Industries

In	Project / Program	Description	Objectives / Expected Outcomes	Stakeholders Responsible	Est. Cost (KES million)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	1.8 MW Thuci Mini-Hydro Power Project	Develop and commission a mini-hydro plant to supply three KTDA tea factories (Runyenjes, Kathangariri, and Mungania).	Provide reliable, clean, and low-cost electricity for processing operations; reduce dependency on the national grid.	KTDA Power Co. Ltd, Embu County Govt., Ministry of Energy	400	Short-Term (2025–2027)	Feasibility study and EIA	Construction and civil works	Installation and commissioning								
2	Factory Energy Efficiency Program	Conduct comprehensive energy audits, retrofit inefficient motors and fans, install Variable Speed Drives (VSDs) and LED lighting.	Reduce energy intensity per kg of processed tea; improve factory competitiveness.	KTDA, Factory Management, GIZ, County Energy Dept.	130	Continuous (2025–2035)	Energy audits	Retrofits and VSD installation	Monitoring and verification	Energy Audits every 4 Years	Upgrades & training	Continued optimization & Annual reviews					
3	Smart Energy Monitoring Systems	Deploy real-time digital dashboards and energy sensors for factory energy tracking and analysis.	Enhance energy management, early fault detection, and data-driven decision-making.	KTDA, County Govt., ICT Dept.	40	Medium-Term (2026–2029)	System design & pilot	Installation in 1 factory	Expansion to remaining factories	Performance review	Full integration						
4	Rooftop Solar PV Systems (200–300 kW per factory)	Install solar PV systems on rooftops of KTDA factories to supplement grid and hydro sources.	Diversify energy mix; lower operational costs; reduce emissions.	KTDA, Private Investors, County Govt.	120	Medium-Term (2026–2028)	Feasibility and design	Installation phase I (2 factories)	Installation phase II (1 factory)	Performance monitoring							
5	Capacity Building on Energy Management	Train factory engineers, technicians, and management on best energy use and maintenance practices.	Improve internal technical capacity and sustain energy efficiency improvements.	KTDA, MoE, County Govt., EPRA	15	Short-Term (2025–2026)	Training curriculum & baseline audit	Training sessions for all factory personnel									

6.2.5.2 ELECTRIFICATION PROJECTS AND PROGRAMS FOR COFFEE INDUSTRIES

Summary of Project Categories and Timing

Category	Period	Projects	Description of Category
Short-Term	**2025–2026**	Projects **4, 7, 8, 9**	**Foundational Renewable and Capacity Phase** — focuses on early adoption of clean energy technologies, pilot eco-pulpers, feasibility studies, and regulatory framework strengthening.
Medium-Term	**2025–2029**	Projects **1, 2, 6**	**Renewable Expansion and Reliability Phase** — targets the installation of solar PV and hybrid systems across coffee factories, backed by digital monitoring for improved efficiency.
Medium–Long-Term	**2027–2032**	Project **3**	**Clustered Electrification and Scale-Up Phase** — implements shared solar microgrids among cooperatives for cost reduction and energy resilience.
Continuous	**2025–2035**	Project **5**	**Sustained Efficiency and Optimization Phase** — ensures ongoing audits, retrofits, and performance improvements to maintain low energy intensity.

Estimated Total Investment (2025–2035): ≈ KES 350–500 million (≈ USD 2.5–3.5 million)

Table 6-6: Summary of Proposed Electrification Projects and Programs for Coffee Industries

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholders Responsible	Est. Cost (KES million)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	**Solar PV Systems for FCS Wet Mills**	Install 20–100 kW solar PV arrays at selected coffee factories to power pulping, washing, and lighting.	Lower electricity bills, reduce grid dependence, and promote renewable energy adoption.	FCSs, County Govt, NGOs, Private Investors	8–65 per FCS	**Medium-Term (2025–2027)**	Feasibility & site surveys	Installation phase 1 (pilot 5 FCSs)	Expansion to additional 10 FCSs								
2	**Hybrid PV + Battery Backup Systems**	Integrate PV systems with battery storage and backup to ensure uninterrupted operations.	Reliable and continuous power supply during outages; improved quality of processing.	FCSs, Energy Service Providers, County Energy Dept.	13–65	**Medium-Term (2026–2029)**	Feasibilit y and design	Procurement and installation (Phase 1)	Rollout to more FCSs	Expansion & evaluation							
3	**Shared Solar Microgrids among FCSs**	Develop shared solar microgrids serving multiple factories within proximity to reduce cost per unit.	Economies of scale, reduced energy cost, and increased reliability.	County Govt, FCS Federations, Private Investors	80–200	**Medium–Long-Term (2027–2032)**	Feasibility & design	Partnership structuring	Construction phase 1	Commissioning (cluster 1–2)	Expansion to other clusters	Performance monitoring					
4	**Solar Eco-Pulper Demonstration Units**	Install solar-assisted, energy- and water-efficient eco-pulpers in selected FCSs.	Demonstrate efficiency in coffee processing and promote technology adoption.	Selected FCSs, Coffee Associations, NGOs	7–15	**Short-Term (2025–2026)**	Procurement and installation	Commissioning and demonstrations									
5	**Energy Efficiency Upgrade Program**	Replace outdated motors, introduce VSDs, optimize pump systems, retrofit lighting.	Reduce energy consumption and enhance overall plant performance.	FCSs, Technical Service Providers, County Energy Dept.	3–10 per FCS	**Continuous (2025–2035)**	Baseline audits	Retrofits (batch 1)	Retrofits (batch 2)	Audits every 4 year, optimization & upgrades							
6	**Energy Monitoring & Control Systems**	Install digital sub-meters, sensors, and energy dashboards at cooperative factories.	Data-driven management and operational efficiency through real-time tracking.	FCSs, County ICT Dept., Donor Partners	2–7 per FCS	**Medium-Term (2026–2029)**	System design	Pilot in 3 FCSs	Installation phase 2	Expansion to all FCSs	Monitoring & review						
7	**Training & Capacity Building on Energy Management**	Conduct training on solar design, maintenance, energy auditing, and safety for factory personnel.	Improved technical skills, safe operations, and sustainable management of systems.	County Govt, Coffee Directorate, NGOs, TVETs	3	**Short-Term (2025–2026)**	Curriculum design & partnerships	Training of trainers (ToT) & first cohort									
8	**Hydropower / Micro-Hydro Feasibility Studies**	Assess small hydro potential in coffee zones for captive energy use.	Identify renewable hydro opportunities for future factory power supply.	County Energy Dept., FCSs, Hydropower Consultants	8	**Short-Term (2025–2026)**	Feasibility studies & mapping	Report validation & investor outreach									
9	**Regulatory & Permitting Support Program**	Streamline energy permitting, interconnection, and licensing for FCS captive systems.	Reduce delays, enhance private sector participation in energy solutions.	County Govt, EPRA, MoE	—	**Short-Term (2025–2026)**	Develop guidelines	Stakeholder sensitization									

6.2.5.3 ELECTRIFICATION PROJECTS AND PROGRAMS FOR MACADAMIA INDUSTRIES

Summary of Implementation Phasing

Short Term (2025–2028): **Projects 2** – Energy Audit Program for Agro-Processors; 4 – Energy Management Capacity Building.

Medium Term (2025–2030): **Projects 1** – Solarization of Macadamia Factories; 3 – Grid Reliability Improvement; 5 – Green Finance Facilitation Program.

Long Term (Beyond 2030): Continuation of monitoring, maintenance, and scaling up of renewable systems initiated under Projects 1 and 3.

Table 6-7: Summary of Proposed Electrification Projects and Programs for Macadamia Industries

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholder Responsible	Estd. Project Cost (KES)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	Solarization of Macadamia Factories	Install grid-tied solar PV systems at Privamnuts EPZ and cooperative processing centers.	Reduce electricity costs; achieve 30–50% renewable energy share.	Embu County Gov't, EPRA, Privamnuts, Cooperatives	120 million	Short–Medium Term (2025–2029)	Feasibility, financing setup	Procurement, installation (Privamnuts EPZ)	Installation (cooperative centers)	Commissioning & optimization	Monitoring & evaluation						
2	Energy Audit Program for Agro-Processors	Conduct energy audits and implement efficiency measures.	Improve energy efficiency and reduce energy intensity in macadamia industry.	County Gov't, MoE, NITA, KAM	10 million	Short Term (2025–2028)	Design & training	Conduct audits (Phase I)	Implement audit recommendations	Follow-up & verification							
3	Grid Reliability Improvement	Upgrade power infrastructure in processing zones (transformers, substations, and lines).	Improve power stability, reduce outages (SAIDI/SAIFI).	Kenya Power, County Gov't	50 million	Medium Term (2025–2030)	Feasibility & design	Procurement	Implementation Phase I	Implementation Phase II	Commissioning	Evaluation & maintenance					
4	Energy Management Capacity Building	Train cooperative managers and technical staff on energy planning, monitoring, and maintenance.	Enhance local capacity for energy management and sustainability.	County Gov't, REA, KAM	5 million	Short Term (2025–2028)	Develop curriculum	Conduct training workshops	Follow-up mentoring	Evaluation							
5	Green Finance Facilitation Program	Create linkages with banks and financial institutions for renewable energy investments and energy efficiency loans.	Increase access to clean energy financing for macadamia industries.	County Gov't, Financial Institutions	2 million	Medium Term (2025–2030)	Stakeholder engagement	Develop financing mechanisms	Launch pilot credit schemes	Monitor uptake & impact	Scale-up (County-wide)						

6.2.5.4 ELECTRIFICATION PROJECTS AND PROGRAMS FOR DAIRY INDUSTRIES

Summary of Implementation Phasing

Short Term (2025–2028): **Projects 1** – Solar PV Electrification for Dairy Cooperatives; 2 – Energy-Efficient Chiller Replacement Program; 3 – LED Lighting and Electrical Retrofit.

Medium Term (2025–2029): **Projects 4** – Cooperative Energy Audit & Capacity Building; 5 – Smart Energy Monitoring System.

Medium–Long Term (2025–2031): **Project 6** – Cooperative Renewable Energy Financing Facility.

Table 6-8: Summary of Proposed Electrification Projects and Programs for Dairy Industries

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholder Responsible	Est. Project Cost (KES)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	Solar PV Electrification for Dairy Cooperatives	Installation of 10–20 kWp hybrid solar PV systems for 10 dairy cooperatives.	Reduce grid dependence; provide stable and reliable electricity for milk cooling and processing.	County Gov't, Co-operatives, KPLC, REA	120 million	Short Term (2025–2028)	Feasibility, site surveys, design	Procurement, installation (Phase I: 5 coops)	Installation (Phase II: 5 coops)	Commissioning, performance monitoring							
2	Energy-Efficient Chiller Replacement Program	Replace outdated milk coolers with energy-efficient models in 10 cooperatives.	Reduce energy costs by 30–40%; improve milk cooling efficiency.	County Gov't, EPRA, Donors	50 million	Short Term (2025–2028)	Equipment assessment and procurement	Installation (Phase I: 5 coops)	Installation (Phase II: 5 coops)	Performance review & training							
3	LED Lighting and Electrical Retrofit	Replace old lighting with LED and upgrade electrical systems in dairy cooperatives.	Improve lighting efficiency, reduce power bills, enhance safety.	Cooperatives, County Energy Office	10 million	Short Term (2025–2027)	Assessment & procurement	Retrofit implementation	Completion & verification								
4	Cooperative Energy Audit & Capacity Building	Conduct energy audits and train cooperative managers and technicians.	Enhance energy efficiency, data management, and informed energy decisions.	County Energy Dept., EPRA, KIRDI	15 million	Medium Term (2025–2029)	Develop training modules	Conduct audits (Phase I)	Conduct audits (Phase II), training workshops	Follow-up audits & evaluations							
5	Smart Energy Monitoring System	Install digital meters and monitoring systems in dairy cooperative facilities.	Improve energy data tracking and decision-making.	County Gov't, Cooperatives	5 million	Medium Term (2025–2029)	Design specifications	Procurement	Installation & commissioning	Monitoring & evaluation							
6	Cooperative Renewable Energy Financing Facility	Establish revolving fund through SACCOs to finance renewable and energy efficiency projects.	Increase financing access for cooperatives to adopt renewable energy solutions.	County Treasury, Development Partners	30 million	Medium–Long Term (2025–2031)	Framework development	Fund capitalization & pilot financing	Implementation & monitoring	Scale-up (County-wide)	Review & expansion						

6.2.6 ELECTRIFICATION PROJECTS AND PROGRAMS FOR WATER AND IRRIGATION

Summary of Implementation and Phasing

Short-Term	**2025–2027**	1, 2, 5, 6, 9	**Foundational Access & Solar Rollout Phase** — focuses on solarizing all pre-devolution boreholes, constructing new solar boreholes, and completing community solar water systems.
Medium-Term	**2026–2029**	3, 4, 7, 8, 10	**Hybridization & System Upgrade Phase** — expands hybrid grid-solar systems for large water supply schemes and formalizes community water projects.
Medium–Long-Term	**2027–2031**	11	**Efficiency & Optimization Phase** — introduces energy-efficient pumping, VSDs, and smart metering across water systems.
Long-Term	**2030–2035**	12	**Digitalization Phase** — integrates SCADA and digital monitoring for countywide water system management.
Continuous	**2025–2035**	13	**Capacity Strengthening Phase** — continuous training for WSPs, technicians, and community committees.

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholders Responsible	Est. Cost (KES million)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	**Solarization of 42 Pre-Devolution Boreholes**	Convert manual boreholes to 4 kW solar pump systems + 10,000 L elevated tanks	Increased rural water access; reduced manual pumping; lower O&M costs	County Water Dept, County Energy Dept, NDMA, KCEP, NGOs	210	**Short-Term (2025–2027)**	Site assessment & design	Solar installation (batch 1)	Solar installation (batch 2)								
2	**Solarization of 18 New Boreholes**	Install new boreholes with solar pumping systems	Expanded rural water access and resilience	Dept. of Water, NDMA, NAVCDP, KCEP	90	**Short-Term (2025–2026)**	Drilling & equipping (batch 1)	Solar installation & commissioning									
3	**Gitaru–Mathigira Kenda Hybridization**	Add solar PV to an existing 11 kW grid-powered water system	Reduced electricity costs and improved reliability	Dept. of Water, EPRA, KPLC	12	**Medium-Term (2026–2027)**	Feasibility & design	Installation & commissioning									
4	**Kiambere–Gitaru Mutuobare Hybridization**	Integrate solar PV into grid supply for improved efficiency	Reduced grid dependency; better O&M	Dept. of Water, Tana Water Works Dev. Agency	20	**Medium-Term (2026–2028)**	Design & approvals	Installation phase 1	Installation phase 2								
5	**Masinga Mbondoni Pumping Station Upgrade**	Solarize 7.5 kW river pumping system using steel angle-line mounts	Sustainable, community-managed water supply	Community Water Committee, Dept. of Water	4	**Short-Term (2025)**	Final commissioning										
6	**Masinga–Mwanyani–Kiangeni Solar Water Supply System**	7.5 kW solar-powered system serving multiple villages	Increased volume & reliability of water	Dept. of Water, Community	6	**Short-Term (2025)**	Monitoring										
7	**Kamburu Water Supply System (Hybrid)**	30 kW hybrid solar-grid system for 10,000 m³/day capacity	Reliable domestic & agricultural water supply	Ministry of Water, Tana Water Works Dev. Agency	60	**Medium-Term (2026–2028)**	Construction works	Installation & commissioning	Stabilization & monitoring								
8	**Kiambere Water Supply Solar Intake & Booster**	Install 30 kW solar intake pump + booster pumps for irrigation	Expanded irrigation coverage in Kiambere area	Ministry of Water, County Government	35	**Medium-Term (2026–2028)**	Feasibility	Installation (phase 1)	Installation (phase 2)								
9	**Masinga–Indune Solar Water Supply System**	30 kW hybrid solar solution with irrigation booster	Increased irrigation area in Mbeere	Tana Water Dev. Agency	25	**Medium-Term (2025–2027)**	System upgrade	Solar installation	Commissioning								
10	**Community Water Project Upgrading & Solarization**	Formalize community schemes (Ngandori, Ndamvuge) + install solar pumping	Improved governance; sustainable systems	County Water Dept, WSPs	18	**Medium-Term (2025–2029)**	Needs assessment	Formalization	Solar upgrade (batch 1)	Solar upgrade (batch 2)	Review & monitoring						
11	**Water Sector Energy Efficiency Program**	Introduce VSDs, efficient pumps, smart meters for large water schemes	Reduced energy costs in water pumping	Dept. of Water, County Energy Dept	15	**Medium–Long-Term (2027–2031)**	Audits & baseline	Install VSDs	Smart metering	Expansion	Review						
12	**Water Sector Digital Monitoring & SCADA Integration**	Install digital dashboards, sensors & remote monitoring for big schemes	Better control, early fault detection, improved uptime	County ICT, Water Dept, Tana Water Agency	30	**Long-Term (2030–2035)**				Prototype & design	Pilot 1 system	Scale-up to 3 schemes	Integration countywide	Monitoring & Updates			
13	**Capacity Building for WSPs, Water Committees & Technicians**	Annual training on O&M, energy management, solar pump maintenance	Sustained system performance; reduced downtime	County Water Dept, VTCs, NGOs	3 annually	**Continuous (2025–2035)**	Training	Training	Training	Training							

6.2.7 ELECTRIFICATION PROJECTS AND PROGRAMS FOR FLOODLIGHTS AND STREETLIGHTS

Summary of Implementation and Phasing

Short-Term	**2025–2026**	Projects **1, 2, 3, 4, 6, 7**	**Restoration & Capacity Phase** — focuses on repairing existing units, establishing management structures, settling power bills, and building technical capacity.
Medium-Term	**2026–2030**	Projects **5, 8**	**Solar Transition & Revenue Phase** — emphasizes replacing AC units with solar-powered systems and creating revenue streams to sustain public lighting.
Continuous	**2025–2035**	Project **9**	**Monitoring & Optimization Phase** — ensures ongoing tracking, reporting, and performance improvement over the decade.

Estimated Total Investment (2025–2035):

≈ KES 105–110 million
(Excluding annual M&E costs)

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholders Responsible	Est. Cost (KES Million)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	**Restoration of 138 Non-Functional Floodlights**	Repair, rewiring, pole strengthening and lamp replacement for countywide floodlights	Improve visibility, enhance security, and support night markets	Dept. of Roads, Energy & Logistics	6.5	**Short-Term (2025–2026)**	Full assessment & repairs	Completion of remaining repairs									
2	**Restoration of 50 Non-Functional AC Streetlights**	Repair of AC-powered streetlights and replacement of faulty control gear	Increased urban safety, reduced accidents, improved business environment	Dept. of Energy, KPLC	4.6	**Short-Term (2025–2026)**	Repairs & testing	Completion & audit									
3	**Procurement of Maintenance Equipment (Man-lift & Tools)**	Acquire man-lift, safety gear, and specialized tools for lighting maintenance	Reduced downtime, faster fault resolution	Dept. of Energy	10	**Short-Term (2025)**	Procurement & deployment										
4	**Recruitment & Training of Energy Technicians**	Hire and train streetlighting and floodlighting technicians	Enhanced internal capacity, improved O&M	Public Service Board, Energy Dept.	0.8	**Short-Term (2025–2027)**	Recruitment	Training cycle 1	Training cycle 2								
5	**Transition to Solar Streetlights and Floodlights (Countywide)**	Replace AC lamps with solar-powered LED units; install new solar masts in dark spots	Lower energy bills, improved reliability, climate action	Dept. of Energy, Donors, PPP	30	**Medium-Term (2026–2030)**	Feasibility & design	Phase 1 installation	Phase 2 installation	Phase 3 installation	Final installations						
6	**Development of a Centralized Lighting Management System**	Unify management of all floodlights/streetlights under one department; establish digital registry	Better coordination, single reporting system	Roads & Energy Dept., ICT Unit	Policy-based	**Short-Term (2025)**	Policy development										
7	**Settlement of KPLC Outstanding Bills & Audit (KES 48.3M)**	Pay outstanding electricity bills and audit all streetlighting meters	Prevent disconnections; ensure accurate billing	Dept. of Finance, KPLC	48.3	**Short-Term (2025)**	Payment & audit										
8	**Revenue Generation Initiative (Pole Leasing & Smart Poles)**	Lease poles for advertising, Wi-Fi hotspots, CCTV, IoT sensors	New revenue stream to finance maintenance	Dept. of Trade & Energy	5 (setup)	**Medium-Term (2026–2028)**	Policy & design	Rollout phase 1	Rollout phase 2								
9	**Monitoring & Evaluation Framework for Public Lighting**	Develop M&E metrics, digital tracking, reporting system	Data-driven planning, improved responsiveness	Energy Dept., ICT Unit	0.2 annually	**Continuous (2025–2035)**	M&E setup	Annual M&E									

6.3 CLEAN COOKING PROJECTS AND PROGRAMS

6.3.1 CLEAN COOKING PROJECTS AND PROGRAMS FOR EDUCATION INSTITUTIONS

6.3.1.1 CLEAN COOKING PROJECTS AND PROGRAMS FOR UNIVERSITY OF EMBU

Implementation Phasing Summary

Short Term (2025–2027)

- Project 1 – Biogas Energy System
- Project 2 – Solar Water Heating Systems (Phase I & II)
- Project 3 – Clean Cooking Transition (start in 2026)

Medium Term (2026–2029)

- Project 3 – Clean Cooking Transition Program (completion)
- Project 4 – Briquette Research Initiative

Long Term (2025–2035)

- Project 5 – Capacity Building Program (continuous technical training)

Summary

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholders Responsible	Estimated Cost (KES)	Project Status	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	**Biogas Energy System**	Remodel existing septic tank into a biodigester to produce biogas for cooking.	Reduce LPG/charcoal consumption; generate renewable cooking fuel; lower emissions.	UoEm, County Gov't	**16,800,000**	**Short Term (2025–2026)**	Feasibility study; design; approvals	Construction & commissioning	Monitoring & optimization								
2	**Solar Water Heating Systems**	Install solar thermal heaters in hostels, mess areas, and cafeteria for hot-water supply.	Reduce electricity/charcoal use for water heating; improve hot-water reliability.	UoEm, County Gov't	**72,596,250**	**Short–Medium Term (2025–2027)**	Technical design; procurement	Installation Phase I	Installation Phase II & commissioning	Monitoring & refinement							
3	**Clean Cooking Transition Program**	Introduce biogas, electric and solar cookstoves across campus kitchens.	Achieve full clean-cooking adoption at UoEm; remove charcoal/LPG reliance.	UoEm, MoE, County Gov't	**5,000,000**	**Short–Medium Term (2026–2028)**	Planning; procurement	Deployment Phase I	Deployment Phase II	Performance monitoring; user training							
4	**Briquette Research Initiative**	Research, design and test industrial-grade biomass briquettes for tea factory use.	Develop commercially viable briquettes; reduce use of firewood in factories.	UoEm, Tea Factories, County Gov't	**10,000,000**	**Medium Term (2027–2029)**	Research design	R&D Phase I	R&D Phase II; prototype testing	Field pilots with factories							
5	**Capacity Building Program**	Train solar thermal and biogas technicians; support clean-cooking technology adoption.	Build skilled workforce; support sustainable system maintenance.	UoEm, County Gov't, TVETs	**1,500,000**	**Long Term (2025–2035)**	Training cycle										

6.3.2 CLEAN COOKING PROJECTS AND PROGRAMS FOR HEALTH FACILITIES

Summary of Categories and Timing

Short-Term	**2025–2027**	Projects **1, 2, 3**	**Foundational Clean Cooking Rollout Phase** — provides LPG systems and energy-saving jikos to all Level 2 and Level 3 facilities.
Medium-Term	**2026–2029**	Projects **4, 5**	**Clean Cooking Infrastructure Phase** — installation of hybrid LPG–biogas systems in Level 4 and Level 5 hospitals.
Continuous	**2025–2035**	Project **6**	**Capacity-Building & Safety Phase** — continuous training to ensure proper usage and maintenance of all installations.

Total Estimated Cost (All Clean Cooking Projects) ≈ KES 9.37 Million + annual training

Breakdown:

- Level 2 facilities → 1.287M
- Low-volume Level 3 → 0.561M
- High-volume Level 3 → 0.981M
- Level 4 → 2.6295M
- Level 5 → 3.710M
- Annual training (0.20M × 10 years) → 2.0M

Grand total including training (2025–2035): ≈ KES 11.37 Million

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholders Responsible	Est. Cost (KES Million)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	**Clean Cooking Package for 22 Level 2 Facilities**	Supply LPG cylinder (13 kg), 3-burner stove, regulator, hosepipe to all 22 Level 2 facilities	Eliminate firewood/charcoal use; reduce indoor air pollution; improve staff and patient welfare	County Health Dept., Energy Dept., Suppliers	**1.287** (22 × 58,500)	**Short-Term (2025–2026)**	Procurement & distribution	Follow-up monitoring									
2	**Clean Cooking Package for 6 Low-Volume Level 3 Facilities**	Supply LPG set (2-burner), energy-saving jikos (25L & 10L), regulator, hosepipe	Reduce biomass use; improve efficiency; lower costs	Health Dept., EPRA, Suppliers	**0.561** (6 × 93,500)	**Short-Term (2025–2026)**	Procurement & installation	Monitoring									
3	**Clean Cooking Package for 6 High-Volume Level 3 Facilities**	Provide LPG system (3-burner), energy-saving jikos (50L & 25L), regulator, hosepipe	Support high-volume kitchens; reduce biomass dependence	County Health Dept., Development Partners	**0.981** (6 × 163,500)	**Short-Term (2025–2027)**	Procurement	Installation & training	Monitoring								
4	**Clean Cooking Upgrade for 3 Level 4 Hospitals**	Install LPG system (50kg), energy-saving jikos (100L & 50L), biogas plant (10 m³)	Reduce charcoal/firewood costs; provide hybrid clean cooking	Health Dept., EPRA, Contractors	**2.6295** (3 × 876,500)	**Medium-Term (2026–2029)**	Feasibility assessments	Procurement	Installation phase 1	Installation phase 2	Monitoring						
5	**Clean Cooking Upgrade for Level 5 Hospital**	Install 1500kg LPG storage + piping, standby cylinders, 6 energy-saving jikos, 20 m³ biogas plant	Replace firewood completely; modernize hospital kitchen; reduce O&M costs	Health Dept., County Govt., EPC Contractors	**3.71**	**Medium-Term (2026–2028)**	Design & approvals	Procurement & civil works	Installation & commissioning	Monitoring							
6	**Capacity Building & Safety Training for All Health Facilities**	Training on LPG safety, biogas maintenance, jiko operation, fuel management	Improved safety; sustained functionality; reduced risk	Health Dept., County Energy Dept., Training Institutions	**0.20 annually**	**Continuous (2025–2035)**	Training cohort 1	Training cohort 2	Annual refreshers								

6.3.3 CLEAN COOKING PROJECTS AND PROGRAMS FOR CORRECTIONAL FACILITIES

Summary of categories & implementation timing

Short-Term (2025–2026)	1, 3, 6, 7	**Foundational Clean Cooking Phase** – Rapid rehabilitation of biodigesters, odor control, installation of biogas jikos, and stabilization of clean cooking systems.
Medium-Term (2026–2029)	2, 4, 8, 9, 10	**System Expansion & Efficiency Improvement Phase** – Expanding feedstock supply, improved institutional stoves, chimney upgrades, cookstove training, and kitchen modernization.
Long-Term (2028–2032)	5	**Thermal Energy Sustainability Phase** – Integration of solar water heating to diversify energy mix and reduce long-term operating costs.
Continuous (2025–2035)	11	**Capacity Strengthening & Institutionalization Phase** – Ongoing staff and inmate training to ensure system reliability, safety, and sustainability.

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholders Responsible	Estimated Cost (KSh)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	**Women's Prison – Biodigester Rehabilitation & Upgrade**	Repair existing biodigester, install new gas balloon, improve piping	Stable biogas production, reduced firewood use	State Dept. of Prisons, County Energy Dept., NEMA	**250,000**	**Short-Term**	Repairs & balloon install	Testing & optimization									
2	**Women's Prison – Poultry Waste Augmentation Project**	Establish chicken unit to boost biodigester feedstock	Increased biogas yields, sustainable waste supply	Prison Admin, MoA, County Livestock Dept.	**640,000**	**Medium-Term**	Setup of poultry unit	Scale-up flock	Stabilization								
3	**Women's Prison – Odor Control & Filtration System**	Install simple filters, improve piping to reduce odors	Improved kitchen comfort & hygiene	County Energy Dept., Prison Admin	**87,000**	**Short-Term**	Installation	Monitoring									
4	**Women's Prison – Improved Cookstove Production Training**	Train inmates and staff to make improved stoves	Skills development & income generation	Prison Industries, TVETs, County Energy Dept.	**270,000**	**Medium-Term**	Training curriculum	Hands-on training	Production rollout								
5	**Women's Prison – Solar Water Heating Integration**	Install solar hot water for kitchen & laundry	Reduced biogas & firewood use	County Energy Dept., Solar Firms, State Dept. of Prisons	**1,500,000**	**Long-Term**	Feasibility	Procurement	Installation	Commissioning							
6	**Men's Prison – Biodigester Optimization & Balloon Installation**	Repair biodigester & install gas storage balloon	Improved gas pressure & reliability	State Dept. of Prisons, County Energy Dept.	**300,000–400,000**	**Short-Term**	Repairs & balloon install	Testing & optimization									
7	**Men's Prison – Expansion of Biogas Cooking Jikos**	Add 10–12 biogas stoves for meal preparation	Reduced firewood consumption	County Energy Dept., Contractors, Prison Admin	**800,000–1,000,000**	**Short-Term**	Procurement	Installation									
8	**Men's Prison – Fuel-Efficient Institutional Firewood Jikos**	Replace old jikos with efficient models	Reduced fuelwood use & costs	Prison Admin, County Energy Dept., GIZ	**1.2–1.5M**	**Medium-Term**	Procurement	Installation	Monitoring								
9	**Men's Prison – Kitchen Refurbishment & Chimney Upgrade**	Ventilation upgrade, chimney redesign	Improved indoor air quality & safety	State Dept. of Prisons, County Works Dept.	**2.0–2.5M**	**Medium-Term**	Design	Installation	Commissioning								
10	**Men's Prison – Feedstock Enhancement (Farm Waste Integration)**	Integrate farm waste—manure, crop residue	Consistent biodigester feedstock	Prison Farm Unit, County Agriculture Dept.	**0.6–0.8M**	**Medium-Term**	Waste stream mapping	Integration works	Stabilization								
11	**Correctional System – Staff & Inmate Training on Clean Cooking Systems**	Training on biodigester operation, stove maintenance, energy safety	Sustainability & reduced downtime	County Energy Dept., TVETs	**300–400k**	**Continuous**	Training										

6.3.4 THERMAL ENERGY PROJECTS AND PROGRAMS FOR INDUSTRIES

Summary of Categories & Timing

Short-Term (2025–2026)	1, 9, 10, 14	**Foundational Thermal Efficiency Phase** – rapid adoption of fuel-efficient boilers, biogas pilots, drying sheds, and briquette programs.
Medium-Term (2026–2029)	2, 3, 4, 7, 8, 11, 15, 16, 17	**Industrial Renewable Heat Expansion Phase** – solar dryers, hybrid dryers, SWH, efficient boilers, thermal audits, briquetting scale-up.
Medium–Long (2027–2032)	12	**Scaling & Shared Infrastructure Phase** – establishment of centralized hybrid drying hubs.
Long-Term (2030–2035)	6, 19	**Standards & Sustainability Phase** – biomass quality standards, long-term sustainable fuelwood/briquette production.
Continuous (2025–2035)	5, 18	**Capacity Building & Skills Sustainability Phase** – ongoing training and boiler operator capacity support.

Total estimated investment (2025–2035)

Because costs were provided in **USD for tea/coffee** and **KES for macadamia/dairy**, total estimates are grouped:

- **Tea & Coffee (USD): ~USD 5.2–6.0 million**
- **Macadamia & Dairy (KES): ~KES 227 million**

Summary

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholders Responsible	Est. Cost	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	**Fuelwood Drying & Storage Program (Tea Factories)**	Construct wood drying sheds; introduce moisture content testing	Improved combustion efficiency; reduced wood use	KTDA, County Govt., KEFRI	**USD 0.5M**	**Short-Term**	Design & procurement	Construction & rollout	Monitoring								
2	**Sustainable Fuelwood Plantation Expansion (Tea)**	Establish woodlots for factories & outgrowers	Sustainable biomass supply	KTDA, KFS, County Govt.	**USD 2M**	**Medium-Term**	Site identification	Seedling production	Planting phase 1	Planting phase 2	Monitoring						
3	**Biomass Briquette & Residue Utilization (Tea)**	Promote briquettes and macadamia shell use	Reduce reliance on firewood	KTDA, private sector	**USD 0.8M**	**Medium-Term**	Market setup	Pilot adoption	Scale-up	Monitoring							
4	**Boiler Efficiency Upgrade (Tea)**	Retrofit boilers or replace with efficient models	Lower fuel use, reduced emissions	KTDA, Donors	**USD 1.5M**	**Medium-Term**	Audits & procurement	Installation	Commissioning								
5	**Boiler Operator Training (Tea)**	Train operators in combustion efficiency & safety	Improved boiler performance	KTDA, MoE, County Govt.	**USD 0.1M**	**Continuous**	Annual training										
6	**Biomass Quality Standards Framework**	Develop briquette & firewood quality standards	Improved fuel quality and compliance	County Govt., KEBS	**USD 0.2M**	**Long-Term**	Technical drafting	Validation	Rollout	Monitoring							
7	**Modular Solar Dryers for Coffee Factories**	Install solar greenhouse dryers	Reduce drying time & defects	County Govt., FCSs	**USD 0.03–0.15M/FCS**	**Medium-Term**	Procurement	Installation	Monitoring								
8	**Hybrid Solar–Biomass Dryers (Coffee)**	Solar dryers + biomass heater	Reliable drying during bad weather	FCSs, private sector	**USD 0.1–0.25M**	**Medium-Term**	Feasibility	Installation	Commissioning								
9	**Coffee Husk Briquette Program**	Produce briquettes from husks	Fuel substitution; income	FCSs, SMEs	**USD 0.02–0.1M**	**Short–Medium Term**	Pilots	Equipment installation	Expansion	Monitoring							
10	**Efficient Biomass Boilers (Macadamia)**	Replace old boilers with efficient shell-fired boilers	Reduced emissions; fuel savings	Privamnuts, MoE	**KES 30M**	**Short-Term**	Procurement	Installation	Commissioning								
11	**Macadamia Shell Briquetting Program**	Utilize macadamia shells for briquettes	Waste reduction; new jobs	County Govt., KEFRI, MSMEs	**KES 15M**	**Medium-Term**	Capacity building	Production rollout	Cooperatives integration								
12	**Centralized Drying Hubs (Macadamia & Coffee)**	Shared biomass-solar hybrid drying hubs	Economies of scale	County Govt., Cooperatives	**KES 60M**	**Medium–Long**	Feasibility	Design	Construction phase 1	Construction phase 2	Commissioning						
13	**Industrial Biogas Pilots (Coffee & Dairy)**	Install biogas units for heat use	Renewable thermal energy	FCSs, Dairy Coops, NGOs	**USD 0.05–0.2M**	**Short–Medium**	Feasibility	Construction	Commissioning								
14	**Biogas for 500 Dairy Farmers**	Household biogas units	Clean thermal energy, sanitation	Co-ops, NGOs	**KES 75M**	**Short-Term**	Procurement	Installation	Monitoring								
15	**Solar Water Heating for Dairy Factories**	Install/rehabilitate 20 SWH systems	Reduce electricity & biomass use	EPRA, County Energy Dept	**KES 20M**	**Medium-Term**	Audits	Installation	Expansion	Monitoring							
16	**Improved Biomass Boilers for Dairy**	Efficient boilers & stoves	50% reduction in fuel	Cooperatives, NGOs	**KES 15M**	**Medium-Term**	Procurement	Installation	Monitoring								
17	**Thermal Energy Audits (All Industries)**	Audits for factories	Energy savings; cleaner production	EPRA, County Energy Dept	**KES 5M**	**Medium-Term**	Audits	Implementation	Follow-up								
18	**Training & Capacity Building (All Sectors)**	Training for thermal tech	Skilled operators; safer operation	Energy Dept, TVETs	**KES 10M**	**Continuous**	Annual Training										
19	**Sustainable Fuelwood & Briquette Program (Dairy)**	Promote woodlots & briquettes	Reduced deforestation	Env. Dept., KFS	**KES 12M**	**Long-Term**	Baseline	Seedlings	Rollout phase 1	Rollout phase 2	Monitoring						

6.4 PROJECTS AND PROGRAMS IN TRANSPORT AND E-MOBILITY

Summary of Implementation and Phasing

Short-Term	**2025–2026**	Projects **1, 2, 3, 7**	**Foundational Modernization Phase** — audit fleet, introduce EV pilots, deploy FMIS, and develop county clean transport policy.
Short–Medium Term	**2025–2029**	Project **4**	**Charging Infrastructure Development Phase** — installation of countywide EV charging hubs.
Medium-Term	**2027–2031**	Projects **5, 6, 10**	**Fleet Modernization & Skills Phase** — procurement of EV fleet replacements, technical training, and NMT electrification support.
Long-Term	**2030–2035**	Projects **8, 9**	**Green Mobility Expansion Phase** — PPPs, renewable-powered charging hubs, and countywide scale-up of EV infrastructure.

Estimated Total Investment (2025–2035):

≈ KES 530–600 million

Summary

	Project / Program	Description	Objectives / Expected Outcomes	Stakeholders Responsible	Est. Cost (KES Million)	Category	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	**County Fleet Rationalization Program**	Audit all county vehicles, identify grounded/uneconomical units, and dispose/reallocate	Reduced maintenance costs; efficient fleet size	Dept. of Transport, Finance	5	**Short-Term (2025–2027)**	Fleet audit	Disposal & reallocation	Completion & reporting								
2	**Digital Fleet Management System (FMIS)**	GPS tracking, fuel monitoring, driver behavior analytics across all county vehicles	Improved efficiency, reduced fuel loss, real-time fleet visibility	Transport Dept, ICT, Treasury	15	**Short-Term (2025–2026)**	Procurement & installation	Full deployment in all departments									
3	**E-Mobility Pilot – County EVs & E-Motorbikes**	Procure electric motorbikes, EVs for Health, Environment, and Inspectorate	Demonstrate viability of EVs; reduce fuel costs	Energy Dept, Transport, Health	40	**Short-Term (2025–2026)**	Procurement & deployment	Performance evaluation									
4	**EV Charging Infrastructure Deployment**	Install public and government charging hubs at county HQ, Embu University, hospitals, markets	Enable adoption of EVs countywide	Energy Dept, EPRA, KPLC, Embu University	50	**Short–Medium (2025–2029)**	Site identification, permitting	Installation phase 1	Installation phase 2	Expansion to sub-counties	Completion						
5	**Fleet Modernization & Green Procurement Program**	Replace aging ICE fleet with EVs through phased purchasing	Reduced fuel use, lower emissions	Transport Dept, Procurement, Finance	300+	**Medium-Term (2027–2031)**	Preparatory work	Procurement phase 1	Procurement phase 2	Procurement phase 3	Procurement phase 4	Completion					
6	**Capacity Building for Drivers & Mechanics (EV Skills)**	Train county drivers, mechanics, and TTI students on EV maintenance and safety	Skilled workforce for EV transition	Transport Dept, TTIs, Embu University	8	**Medium-Term (2026–2028)**	Curriculum development	Training cohort 1	Training cohort 2								
7	**County Clean Transport Policy Development**	Develop an EV, fleet efficiency & clean mobility policy	Institutional framework for green mobility	Energy & Transport Depts, Legal Office	2	**Short-Term (2025)**	Policy drafting & approval										
8	**E-Mobility PPP Program**	Engage private EV suppliers, financiers, and utilities for charging/EV leasing models	Sustainable EV ecosystem, reduced county capex	Energy Dept, Finance, EPRA, KPLC	3	**Long-Term (2030–2035)**			PPP framework	Pilot PPP	Countywide PPP rollout	Review	Expansion				
9	**Renewable-Powered Charging Systems**	Integrate solar PV into county charging hubs, especially in sites with high load	100% renewable EV charging; reduced grid costs	Energy Dept, Environment Dept, Donors	60	**Long-Term (2030–2035)**				Feasibility & design	Solarization phase 1	Solarization phase 2	Solarization phase 3	Completion			
10	**Non-Motorized Transport (NMT) Electrification Support**	Solar-powered street furniture, e-bike docking, integrated pedestrian/EV corridors	Safer, greener urban mobility	Dept. of Transport, Urban Planning, Energy	25	**Medium-Term (2027–2030)**	Design & stakeholder engagement	Pilot corridor	Expansion (3 towns)	Completion							

7 IMPLEMENTATION, COORDINATION, MONITORING & EVALUATION

7.1 CLEAN COOKING PROJECTS AND PROGRAMS

The successful delivery of proposed clean cooking projects and programs requires a coordinated and well-structured implementation and monitoring framework. This chapter outlines the institutional arrangements, coordination mechanisms, and monitoring & evaluation processes that will guide implementation from 2030 to 2035. It also provides a results-based time schedule to ensure accountability and tracking of progress.

7.1.1 Implementation Framework

7.1.2 Institutional Roles

- **County Government (Department of Energy):** Lead implementation, budget allocation, and oversight of county-level clean cooking initiatives.
- **National Government Agencies (MoE, MoH, KEBS, NEMA):** Provide enabling policies, standards, and technical guidance.
- **Development Partners (e.g., SNV, GIZ, Practical Action):** Support through funding, capacity building, and technical expertise.
- **Private Sector (cookstove manufacturers, LPG distributors, biogas installers):** Drive technology deployment, innovation, and market development.
- **Civil Society & Community-Based Organizations:** Facilitate community mobilization, awareness, and behavioral change.
- **Academic & Research Institutions (University of Embu, Kenya Forestry Research Institute):** Provide research, monitoring, and impact evaluation.

7.1.3 Implementation Approach

1. **Phased Rollout:**
   - **Phase I (2025–2030):** Scale-up LPG and improved cookstoves; pilot institutional biogas programs.
   - **Phase II (2030–2035):** Mainstream adoption of clean cooking technologies, expansion of biogas, and integration of e-cooking.
2. **Geographic Targeting:** Focus first on underserved areas (Mbeere North & South), then scale countywide.
3. **Financing Mechanisms:** Leverage county budgets, donor funds, climate finance (carbon credits), and public-private partnerships.
4. **Capacity Development:** Train local artisans, entrepreneurs, and women's groups in manufacturing, distribution, and maintenance of clean cooking technologies.
5. **Awareness Creation:** County-wide campaigns to educate households on health, environmental, and economic benefits of clean cooking.

7.1.4 Coordination Mechanisms

- **County Energy Technical Committee (CETC):** Multi-stakeholder platform coordinating energy projects across sectors.
- **Inter-Agency Taskforce:** Linking the County Energy Department, Public Health, Agriculture, and Trade for integrated planning.
- **Public–Private Partnerships Forum:** Facilitate dialogue and alignment between county government, private sector, and development partners.
- **Community Energy Committees:** Local-level monitoring, feedback, and adoption tracking.

7.1.5 Monitoring & Evaluation Framework

7.1.6 Guiding Principles

- **Results-Based Monitoring:** Tracking outcomes against clear indicators.
- **Evidence-Driven:** Using household surveys, facility audits, and partner reports.
- **Participatory:** Involving communities and stakeholders in evaluation.
- **Adaptive:** Allowing mid-course corrections where targets lag.

7.1.7 Key M&E Activities

1. **Baseline Studies (2025):** Establish baseline on fuel use, health impacts, and household adoption.
2. **Midterm Review (2032):** Assess progress, refine strategies.
3. **End-term Evaluation (2035):** Measure outcomes, document lessons, and provide sustainability pathways.
4. **Data Collection Sources:** Kenya National Bureau of Statistics (KNBS), County Integrated Monitoring System (CIMS), partner reports, household energy surveys, health records.
5. **Reporting:** Annual progress reports shared with County Executive Committee, County Assembly, and development partners.

Table 7-1: Summary for Clean Cooking Projects and Programs

Program/Project	Outcome/Indicators	Baseline Year	Baseline Value	Midterm Target (2032)	End-Term Target (2035)	Source of Data	Frequency	Responsibility
LPG Expansion Program	% of households using LPG	2025	32% (KNBS 2023 est.)	55%	70%	KNBS, Household Surveys	Annual	County Energy Dept., MoE, LPG Companies
Improved Cookstove Program	No. of households adopting improved biomass stoves	2025	18,000 households	45,000 households	80,000 households	County Energy Dept., SNV Reports	Annual	County Energy Dept., NGOs, Private Sector
Institutional Biogas Program	No. of schools/health facilities with functional biogas systems	2025	10 institutions	50 institutions	120 institutions	County Energy Dept., MoE, Partner Reports	Bi-Annual	County Energy Dept., GIZ, Practical Action
E-Cooking Program	% of urban households adopting electric cooking	2025	2%	10%	25%	KNBS, Kenya Power Data	Annual	County Energy Dept., KPLC, Private Sector
Awareness & Training Campaigns	No. of households sensitized on clean cooking benefits	2025	<5,000	100,000 households	200,000 households	County Reports, NGOs	Bi-Annual	County Energy Dept., Civil Society
Standards & Regulation Enforcement	% of clean cooking technologies certified by KEBS	2025	40%	80%	100%	KEBS Reports, County Inspections	Annual	KEBS, NEMA, County Energy Dept.
Financing Mechanisms for Adoption	No. of households accessing credit/financing for clean cooking	2025	2,000	15,000	30,000	SACCO/Bank Records, NGO Reports	Annual	County Trade Dept., MFIs, Development Partners

7.2 ELECTRICITY ACCESS PROJECTS AND PROGRAMS

Expanding electricity access through the proposed projects and programs requires effective coordination, implementation, monitoring and evaluation framework. This chapter outlines how electricity access programs will be delivered, who is responsible for each stage, and how progress will be tracked. It builds on the targets and investment needs identified and focuses on institutional arrangements, coordination mechanisms, and performance measurement tools to ensure that results are achieved between the planning period of 2025 and 2035.

7.2.1 Implementation Framework

7.2.2 Institutional Roles

- **County Government (Department of Energy):** Lead agency for planning, implementation oversight, and stakeholder coordination.
- **National Government (Ministry of Energy, KPLC, REA):** Grid extension, network upgrades, and policy support.
- **Private Sector (Mini-grid developers, solar companies, financers):** Investment, innovation, and last-mile distribution of stand-alone systems.
- **Development Partners (World Bank, AfDB, GIZ, SNV, Practical Action):** Provide financing, technical assistance, and knowledge transfer.
- **Financial Institutions & SACCOs:** Extend credit for electricity connections and productive use equipment.
- **Academic & Research Institutions (University of Embu, KETRACO, KEBS):** Research, data generation, and standard-setting.
- **Community Groups:** Mobilization, feedback, and local participation in energy projects.

7.2.3 Implementation Approach

1. **Phased Rollout:**
    - **2025–2030:** Focus on mass household electrification (grid + solar), with priority to underserved rural wards.
    - **2030–2035:** Consolidation through targeted connections, productive use support, and integration of renewable mini-grids.
2. **Technology Mix:** Grid expansion in peri-urban/urban areas and large rural centers; stand-alone PV and mini-grids in sparsely populated or off-grid areas.
3. **Productive Use Integration:** Electricity to power irrigation, cold storage, agro-processing, and businesses to stimulate job creation.
4. **Financing Mechanisms:** PPP models, concessional loans, county budgetary allocation, and donor support.
5. **Capacity Building:** Train local technicians on solar PV, grid extension works, and maintenance.

7.2.4 Coordination Mechanisms

- **County Energy Technical Committee (CETC):** Align County electrification targets national grid expansion.
- **Joint Planning with KPLC and REA:** To ensure harmonization of county electrification projects with national master plans.
- **Public–Private Dialogue Platforms:** To align private solar companies and mini-grid operators with county programs.
- **Multi-Sectoral Task Force:** Integrating education, health, agriculture, and trade departments to electrify social and productive facilities.
- **Community Committees:** Monitor household adoption and provide feedback on quality of service.

7.2.5 Monitoring & Evaluation Framework

7.2.6 Guiding Principles

- **Results-Oriented:** Indicators linked to household, institutional, and productive connections.
- **Evidence-Based:** Using KNBS, KPLC, REA, and solar company reports.
- **Participatory:** County, national agencies, private sector, and communities all feed into reporting.
- **Adaptive:** Annual reviews to adjust targets based on progress and demand shifts.

7.2.7 Key M&E Activities

1. **Baseline Establishment (2025):** Current electrification rate (approx. 68% for Embu County households).
2. **Annual Progress Reports:** From county and partner institutions.

3. **Midterm Review (2032):** Adjustments based on uptake and investment flows.
4. **End-Term Evaluation (2035):** Outcomes, lessons, and sustainability strategies.
5. **Data Sources:** KPLC, REA, KNBS, County Monitoring System, solar company sales data, facility audits.

7.2.8 Summary Time Schedule for Electricity Access Projects and Programs

Program/Project	Outcome/Indicators	Baseline Year	Baseline Value	Midterm Target (2032)	End-Term Target (2035)	Source of Data	Frequency	Responsibility
Grid Connection Expansion	No. of new household connections (grid)	2025	152,377 required	300,000 households	316,599 households	KPLC, REA, KNBS	Annual	KPLC, REA, County Energy Dept.
Stand-alone Solar PV Rollout	No. of households with stand-alone solar systems	2025	186,310 required	350,000 households	363,732 households	Solar Company Sales Data, County Reports	Annual	Private Solar Companies, NGOs, County Energy Dept.
Mini-grid Development	No. of functional mini-grids in rural areas	2025	5 mini-grids	25 mini-grids	40 mini-grids	REA, Solar Developers	Annual	REA, Private Sector, Development Partners
Electrification of Schools	% of schools connected to electricity	2025	70% connected	90%	100%	MoE, County Education Dept., KPLC	Annual	County Education Dept., KPLC
Electrification of Health Facilities	% of health facilities connected	2025	75% connected	95%	100%	MoH, County Health Dept.	Annual	County Health Dept., MoH, REA
Electrification of Agro-Processing Facilities	No. of agro-processing units electrified	2025	20 units	60 units	100 units	County Trade & Agriculture Dept., Surveys	Bi-Annual	County Trade & Agriculture Dept., KPLC, Private Sector
Productive Use of Energy (PUE) Program	No. of SMEs and farms using electricity for productive purposes	2025	2,000 SMEs/farms	10,000	20,000	County Surveys, SACCO/Bank Records	Annual	County Trade Dept., SACCOs, Private Sector
Institutional Electrification (Prisons & Public Facilities)	No. of public institutions electrified	2025	Embu Main Prison un-electrified	Embu Prison + 10 other facilities	100% public institutions electrified	County Energy Dept., MoE	Annual	County Energy Dept., KPLC, REA
Renewable Energy Capacity Additions	Additional installed capacity (MW)	2025	0 MW	4 MW (by 2030)	+1 MW (by 2035)	MoE, County Energy Dept., IPPs	Annual	County Energy Dept., MoE, IPPs

8 CONCLUSIONS

The Embu County Energy Plan (2025–2035) has provided a comprehensive roadmap for achieving sustainable, inclusive, and reliable energy access for all residents of the County. The Plan recognizes energy as both a **basic human need** and a **catalyst for socio-economic transformation**, underpinning health, education, enterprise, agriculture, and environmental stewardship.

Summary of Key Insights

1. **Energy Access Gaps:** Despite significant progress, over 30% of households in Embu County remain without modern energy access. Our modeling (ONSSET, 2025) projects that by 2030, an additional **338,688 households** will require new electricity connections, while demand for clean cooking will remain a priority for over 70% of households.
2. **Electricity Access Pathways:** The analysis demonstrates a balanced approach between the **national grid** (152,377 new connections by 2030, with an investment of USD 21.4 million) and **stand-alone solar PV systems** (186,310 connections at USD 0.84 million). Between 2025–2030, Embu will need to mobilize at least **4 MW of new capacity**, followed by 1 MW between 2030–2035.
3. **Clean Cooking Transition:** The County acknowledges that traditional biomass use poses major health, gender, and environmental challenges. Clean cooking solutions—such as improved biomass stoves, LPG, biogas, and emerging technologies like electric pressure cookers—have been prioritized. Partnerships with national agencies (EPRA, MoE), county departments, private sector actors, and development partners (GIZ, SNV, Practical Action, etc.) will be critical in scaling adoption.
4. **Public Lighting and Safety:** Floodlights and streetlights remain essential for security, commerce, and social cohesion. The Plan emphasizes transitioning from grid-dependent to **solar-powered systems** to reduce runaway electricity bills (noted at Kshs. 54 million in FY 2023/2024), strengthen sustainability, and enhance financial predictability.
5. **Cross-cutting Priorities:** The County has identified **capacity building**, **budgetary allocation**, **procurement of modern equipment**, and **interdepartmental coordination** as core enablers of success across all energy sectors. Gender inclusion, youth employment, and private sector participation are embedded within each program.

Strategic Vision to 2035

The Plan envisions **"Universal, Affordable, and Sustainable Energy Access for All in Embu County by 2035."** To achieve this, the County Government commits to:

- Expand clean cooking adoption to reach at least **90% of households** by 2035.
- Achieve near-universal electricity access through a combination of grid expansion, mini-grids, and stand-alone solar systems.
- Transition public infrastructure (schools, health facilities, security lighting) to **renewable and energy-efficient systems**.

- Strengthen partnerships with the private sector and development partners to attract investment, technical expertise, and innovation.
- Institute a robust **Monitoring, Evaluation, and Learning (MEL) framework** to track progress, ensure accountability, and adapt strategies where necessary.

The success of this Plan will depend on **sustained political commitment, adequate financing, inter-agency coordination, and community participation**. Energy planning is not a one-off exercise but an evolving process that must adapt to emerging technologies, demographic growth, and climate imperatives.

Through coordinated implementation, Embu County has the opportunity to not only close its energy access gaps but also to establish itself as a **regional leader in sustainable energy transition**. The County Government therefore calls upon all stakeholders—national government agencies, development partners, the private sector, civil society, and communities—to rally around this shared vision

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10 ANNEXES

10.1 COUNTY ENERGY PLANNING COMMITTEE COMPOSITION

Table 10-1: County Energy Planning Committee Team Composition

	Name	Organization	Position
1	Elijah Mugo Njeru	County Executive Committee Member (CECM) - Energy	Chairperson
2	Daniel Mbogo	County Chief Officer- Energy	Alternate Chairperson
3	Nicassio Mwangangi	Director - Energy	Secretary
4	John Micira Njeru	Director- Finance and Economic Planning	Member
5	Patrick Njeru	Director- Agriculture	Member
6	Stephen Musyoka	Director - Livestock	
7	Eng. Gatuta	Director- Water, Irrigation, Environment, Climate Change and Natural Resources	Member
8	Dr. Eliza Kathure	Director - Health	Member
9	Pascal Njoka	Biomedical Engineer - Health	
10	Anthony Sawaya	Director -Trade, Tourism & Industry Development	Member
11	Jeremiah Ireri	Director -Education	Member
12	Jacob Gititi	Director – Lands, Housing and Urban Planning	Member
13	Michael Karanja	KPLC	Member
Co-opted Members			
14	George Theuri	Practical Action	Member
15	Godfrey Marambe	Cusum Energy Ltd- Lead Consultant	Member
16	Mirium Kamau	Kenya Forest Service - CFC	Member
17	Eunice Wambui	REREC	Member

10.2 BIOENERGY ASSUMPTIONS

Agroforestry Primary Energy Supply Potential

- Grevillea robusta on farms can reach 15 m^3/ha/yr under good management[45]
- Grevillea robusta: 0.5–0.7 t/m^3 reported[46]
- Air-dry wood (10–20% moisture): 13–16 MJ/kg[47]
- Primary energy (GJ/yr) = (dry tonnes/yr) × (NCV, MJ/kg) ÷ 1000

Agricultural Residues Primary Energy Supply Potential

Macadamia Fruit Residue

- Macadamia shells LHV is 19.64 MJ/kg and macadamia husks LHV is 16.5 MJ/kg[48]
- Composition of residues by mass: Husk 25–30%, shell 60%, kernel 10–15% depending on variety[49].
- Shells have a 100% recovery, since they have no agronomic need in the field. Practical availability: 80% (allowing for some alternative uses).
- Husks are technically recoverable, but some are returned to orchards as mulch/soil conditioner. Practical recovery has been taken as 40%, for sustainability provision of energy and used for soil conditioning[50].

Coffee Husks

- Coffee husks LHV: 16 MJ/kg
- Coffee Husks recovery ratio: 100%[51]

Maize Residue

- Average the net calorific value of maize whose plants is around 17.5 MJ/kg[52]
- Maize residue recovery ratio: 40%[50].

Sorghum and Millet Straws

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- Average the LHV of sorghum and millet straws is 12.40 MJ/kg[53] and 12.39 MJ/kg respectively[54].
-

Livestock Biogas Production Potential[55]

Livestock	Amount of manure[a] (kg/head/day)	Recoverability fraction[b]
Cattle	12	0.2
Sheep	1.2	0.2
Poultry	0.07	0.3
Pigs	2.5	0.5
Goats	2	0.2

[a] (Kemausuor et al., 2014)Odoi-Yorke et al., 2022)

[b] (Odoi-Yorke et al., 2022)

Theoretical methane potential of animal waste

Livestock type	Volatile solids (kg head^{-1} day^{-1})	Methane potential, (m^3/kg VS)
Cow	2.67	0.2
Goat	0.33	0.31
Sheep	0.30	0.31
Chicken	0.02	0.18
Pig[56]	0.3	0.29

Source: (Shane et al., 2015)

Mass of manure per day produced by livestock is computed using equation 10.1;

$$P_{manure} = X_{live} \times Y_{man} \times Z_{rec} \qquad 10.1$$

Where; P_{manure} = technical potential of animal manure $\left(\frac{kg}{day}\right)$

X_{live} = livestock population

Y_{man} = manure produced per head per day $\left(\frac{kg}{head.\,day}\right)$

Z_{rec} = recoverability fraction

Equation 10.2[57] is used to determine animal waste's potential for producing biogas.

$$BP_{animal} = \sum_{i=1}^{n} N_i \times VS_i \times 365 \times B_{Oi} \times 1.67 \qquad 10.2$$

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Where; BP_{animal} = Annual biogas potential of animal waste $\left(\frac{m^3}{year}\right)$

N_i = Population of each animal category

VS_i = Volatile solids $\left(\frac{kg}{head.\ day}\right)$

Boi = Bio − methane potential $\left(\frac{m^3}{kg\ of\ VS}\right)$

1.67 = a conversion factor for obtaining volume of biogas from methane fraction of 0.6