Ministry of Energy

MAKUENI COUNTY ENERGY PLAN

2023 - 2032

Foreword

I am privileged to introduce the Makueni County Energy Plan 2023-2032. This plan is a historic milestone for the county since energy is a key driver for innovation, sustainability, and shared prosperity.

The innovations and strategies outlined in this plan have been well aligned with global and national development aspirations to attain universal access to energy for all by the year 2030. The programs, the corresponding outcomes, outputs, and targets aim to achieve socio-economic transformation. The plan therefore identifies solutions for both domestic and productive use of energy. It will be implemented using an integrated planning and budgeting approach through a five-year County Integrated Development Plan (CIDP) and a stepwise planning process of the Annual Development Plans (ADPs).

The development of this plan was multisectoral, emphasizing our belief in and desire for strategic partnerships in our development journey. Through these strategic partnerships, innovative solutions, and a commitment to environmental stewardship, we aim to create a model for sustainable energy development within the county.

I commend the collaborative efforts of experts, stakeholders, and community members who have contributed to developing this comprehensive energy plan. Their insights, expertise, and passion have made the journey to universal access to modern energy possible. Let us embrace this plan, not merely as a document but as a shared vision for the future of Makueni. In the spirit of inclusivity, sustainability, and progress, I invite all stakeholders to be part of the vision and actively engage in its actualization. Together, we can harness the power of energy to light our t path toward a prosperous, equitable, and sustainable Makueni.

I thank you for your commitment to the betterment of our beloved county and reiterate the responsibility of my government to support and address the needs of the people of Makueni. This plan is a testament to our dedication to providing reliable and affordable energy to every household, powering businesses, and propelling our county toward economic prosperity.

Sincerely

Mutula Kilonzo Jr. CBS.
Governor

PREFACE

It is with great pleasure and a sense of responsibility that I present to you the Makueni County Energy Plan (CEP)–a blueprint for a sustainable, resilient, and energy-efficient future for our community. As the County Executive Committee Member for the Department of Infrastructure, Transport, Public works, Housing and Energy, I recognize the pivotal role that energy plays in shaping the economic, social, and environmental landscape of our county.

Makueni County is thus pleased to have attained this critical milestone of developing a comprehensive County Energy Plan. The Plan represents a collaborative effort to promote energy security and foster economic growth while addressing the challenges posed by climate change. Our development partners in developing this plan were: Strathmore University; World Resources Institute (WRI), who spearheaded the process from scratch; and the Ministry of Energy and Petroleum, who provided the guiding framework. Makueni County Department of Infrastructure, Transport, Public works, Housing and Energy played a lead role in this process.

To ensure that the CEP was aligned to the needs and priorities of the community, primary data collection was carried out in all the six sub-counties covering households, enterprises, county facilities and institutions. Key informant interviews, Focused Group Discussions (FGDs) with sectoral stakeholders, experts, and the community formed part of this extensive exercise. The plan contains a detailed roadmap outlining our goals, strategies, and action plans. It not only addresses immediate concerns but also envisions a future where our county leads in adopting innovative and sustainable energy practices. Through the integration of renewable energy sources, energy-efficient technologies, and community engagement initiatives, we aim to create a model for others to emulate.

I extend my gratitude to the residents, business community, local organizations, partners and government agencies that have contributed their insights, ideas, and offered their support in different ways throughout this process. Your commitment to a greener and more prosperous future has been inspiring. As we embark on the implementation of the County Energy Plan, I invite each of you to actively participate in this transformative journey. By working together, we can achieve our shared vision by not only meeting our energy needs but also preserving our environment for future generations.

Sincerely,

Eng. Sebastian Kyoni
CECM- Infrastructure, Transport, Public Works, Housing and Energy

FOREWORD

The Department of Infrastructure, Transport, Public Works and Energy is mandated with ensuring access to affordable, reliable, sustainable and clean energy in line with the Energy Act 2019 and SDG 7. It is for this reason that I express my personal and institutional gratitude to all actors who participated in the development of the county energy plan. Our adoption of a participatory and data-centric approach ensured insightful consultations with all stakeholders which ultimately led to the development of a consensus-driven plan. Witnessing the readiness of this plan for implementation fills me with immense pride.

First and foremost, I extend my deepest appreciation to H.E. Governor Mutula Kilonzo Junior, CBS, and the Deputy Governor, H.E. Lucy Mulili, for their unwavering support and exemplary leadership throughout the entire process. Their steadfast dedication to sustainable development and the well-being of Makueni residents played a pivotal role in bringing this plan to fruition.

Special recognition is due to the County Executive Committee Members, County Energy Planning Committee, under the guidance of the County Executive Committee Member for Infrastructure, Transport, Public Works, Housing, and Energy, Eng. Sebastian Kyoni. His steadfast guidance and leadership were instrumental in shaping the overall direction of the plan and ensuring its aligned with government shared objectives.

The drafting team deserves significant commendation for their relentless efforts. Led by team from Strathmore University, World Resources Institute (WRI), and the County Energy Plan Technical Committee, this dedicated members produced an outstanding plan. I wish to specially mention and acknowledge the contributions of the core team members: Patrick Mwanzia, Sarah Odera, Lucy Nguti, Hilarious Kifalu, Stephen Kiama, Anne Njoroge, Benson Ireri, Victor Otieno, Dimitris Mentis, Douglas Ronoh, Beryl Ajwang, Stanlus Matheka, Jacklyne Kiting'o, Benson Mutuku, Eng. Gregory Kioko, Eng. Richard Kamami, Eng. Charles Kiilu, Harrison Mwololo, and Christopher Yulu. Their commitment, passion, expertise, and collaborative spirit were invaluable assets to this plan, setting a high standard for future endeavors in Makueni County.

I recognize the vital contributions made by the County Assembly Members; led by Speaker Hon. Douglas Mbilu and particularly the Committee of Infrastructure, Transport, Public Works, Housing, and Energy for their dedication to ensuring strategic alignment of the plan with the needs of Makueni residents. The community Members and especially the Ward Energy Champions who took their time and provided valuable insights, comments, and suggestions toward this plan. You played crucial role in shaping the plan to reflect the aspirations and realities of our County.

It would be impossible to thank everyone personally in this plan. Once more, I express my gratitude to everyone who contributed to this significant accomplishment. Let us sustain the same collaborative efforts during the implementation phase of the Makueni County Energy Plan, as well as other future initiatives aimed at achieving a transformative and sustainable development for our beloved county.

Sincerely,

Eng. Naomi Nthambi Mwanza
Chief Officer – Energy and Housing

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AD	Aerobic Digestion
ADP	Annual Development Plan
BAU	Business As Usual
CBOs	Community Based Organizations
CEP	County Energy Plan
CIDP	County Integrated Development Plan
CEPC	County Energy Planning Committee
COD	Chemical Oxygen Demand
EAE	Energy Access Explorer
EPRA	Energy and Petroleum Regulatory Authority
FGDs	Focus Group Discussions
GCP	Gross County Product
GDC	Geothermal Development Company
GDP	Gross Domestic Product
GESI	Gender Equity and Social Inclusion
GHI	Global Horizontal Indication
GIS	Geographic Information Systems
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HCF	Health Care Facility
HHs	Households
ICS	Improved Cook Stove
IEA	International Energy Agency
INEP	Integrated National Energy Planning Framework
KenGen	Kenya Electricity Generating Company
KES	Kenya Shillings
KG	Kilogram
KFS	Kenya Forestry Service
LCPDP	Least Cost Power Development Plan
KNBS	Kenya National Bureau of Statistics
KOSAP	Kenya Off Grid Solar Access Project
KPLC	Kenya Power and Lighting Company
KW	Kilowatt
kWh	Kilowatt-hours
LEAP	Low Emissions Analysis Platform
LED	Light Emitting Diode
LPG	Liquified Petroleum Gas
MEPS	Modern Energy Performance Standards
M&E	Monitoring and Evaluation
MG	Mini-grid
MSMEs	Micro Small Medium Enterprises
MW	Megawatt
NGO	Non-Governmental Organization
NSAs	Non-State Actors
OnSSET	Open-Source Spatial Electrification Tool
PLWD	Persons Living With Disabilities
PUE	Productive Use of Energy
SA	Stand Alone Solar PV
SE4ALL	Sustainable Energy for All
SDGs	Sustainable Development Goals
SERC	Strathmore Energy Research Center
SFWC	Specific Freshwater Consumption
SHS	Solar Home Systems
SMEs	Small and Medium Sized Enterprises
TWG	Technical Working Group
UK PACT	UK Partnering for Accelerated Climate Transitions
UNEP	United Nations Environment Programme
UNDP	United Nations Development Program
USD	United States Dollars
WRI	World Resources Institute
WtE	Waste-to-Energy
WHO	World Health Organization
WWTP	Wastewater Treatment Plants

EXECUTIVE SUMMARY

Introduction

The development of Makueni County's Energy Plan aligns with Kenya's Energy Act 2019, which requires energy planning at the county level to be integrated into a national framework. The overarching goal is to achieve universal energy access by 2030. This plan focuses on providing clean, sustainable, reliable, and affordable energy, driven by objectives such as advancing energy solutions, ensuring compliance with national laws, and addressing local energy challenges. The planning process utilized extensive data collection, including surveys from households, businesses, healthcare facilities, and educational institutions, alongside qualitative insights from focus groups and key informant interviews. This comprehensive approach informed the analysis of energy consumption patterns and the identification of efficient solutions for electricity and clean cooking. The plan thus caters for both local needs and broader regulatory requirements, aiming to enhance socio-economic development in Makueni County through improved energy access.

Energy Access and Energy Efficiency in Makueni County

In 2022, electricity access in Makueni County stood at 75.1%, with 29.2% from the grid and 5.7% from mini-grids and the rest coming from solar home systems and solar lanterns. Educational institutions and MSMEs showed higher connectivity rates of 85.8% and 80.3%, respectively. Clean fuel usage for cooking was low, with only 7.6% of households and 1.4% of educational facilities using LPG, while a significant majority relied on firewood. Healthcare facilities led in this area with clean fuel usage at 32.1%. Challenges included affordability, unreliable electricity supply, impacting domestic and business users. Energy efficiency varied, with LED bulbs widely adopted, but low efficiency in cooking technologies and water distribution systems was noted.

Implementation of the County Energy Plan

The execution of the county energy plan is projected to require approximately KES 74.9 billion. To realize the vision of the CEP, the Government of Makueni County aims to leverage not just its internal funds but also seek financial support from development partners, the private sector, and the National Government.

The key recommendations for Makueni County's CEP include:

- Enhancing the energy department by recruiting additional skilled personnel,
- Creating a clean energy fund to speed up clean energy adoption, in collaboration with existing financial institutions,
- Setting up energy centres for community education on new energy solutions,
- Promoting improved and clean cooking energy solutions,
- Optimizing the existing grid network through densification and intensification to improve reliability and meet increasing demand, with Kenya Power tasked to fortify grid infrastructure,
- Focusing on energy's productive use in agriculture to support irrigation, mango drying, cold storage, dairy processing, and mango processing,
- Retrofitting public buildings and streetlights with energy-efficient LEDs and automatic controls, Installing solar PV systems in county hospitals— starting with Tier 4 and 5 hospitals in Makindu and Wote—to cut energy costs, and Transitioning county motorbikes to electric models for sustainability.

1 INTRODUCTION

This chapter outlines the Makueni County Energy Plan, including its goals, objectives, preparation activities, background on energy, demographics, climate, stakeholders, and integration with existing plans and regulations.

1.1 Objectives

The overarching goal of this CEP is to ensure the provision of clean, sustainable, reliable, and affordable energy for socio-economic development and enhanced livelihood in Makueni County. This goal is supported by the following CEP objectives:

i. To provide a medium-term planning framework for advancing clean, sustainable, reliable and affordable energy within the county.
ii. To ensure proactive compliance with the provisions outlined in the Constitution of Kenya (2010) and the Energy Act (2019)[1] regarding energy planning and administration; and
iii. To address the challenges hindering universal energy access and capitalize on opportunities for productive use of energy at the county level.

1.2 Development of the County Energy Plan

The development of the CEP involved: the constitution of committees, capacity building, stakeholder engagement, data collection, development of models, development of a GIS toolkit, consideration of Gender Equity and Social Inclusion (GESI), drafting, validation and dissemination of the plan.

1.3 County Overview

1.3.1 Location and size

Makueni County is located in the southeast region of Kenya, and borders Machakos, Kitui, Taita Taveta, and Kajiado Counties. It covers 8,176.7 km2 with its capital in Wote. It's divided into six sub-counties/constituencies: Makueni, Mbooni, Kibwezi East, Kibwezi West, Kaiti, and Kilome, comprising 30 electoral wards[2].

1.3.2 Demographic features

The 2019 census reported Makueni County's population at 987,653, with a projected increase to 1,042,300 by 2023, 1,053,891 by 2025, and 1,098,921 by 2028, indicating a growth rate of 1.1%[3]. The gender breakdown includes 489,691 males, 497,942 females, and 20 intersex, with an average density of 121 persons/km^2.

1.3.3 Socio-economic Activities

In 2020, Makueni County's Gross County Product was KES 111 billion, with contributions from agriculture (30%), industry (17%), and services (53%). The service sector included transport and storage, wholesale and retail trade, as well as education and health services. Agriculture featured crop cultivation and livestock rearing, producing significant amounts of grains, legumes, fruits, vegetables, and milk in 2022. The industrial sector is comprised of manufacturing (5%), construction (5%), mining and quarrying (1%), real estate activities (5%), and water supply (1%).

1.3.4 Ecological Profile

Makueni County features three agro-ecological zones: Upper Middle that has coffee, avocado, and grains; Lower High that cultivates mangoes, citrus, and tubers; and Lower Middle, which covers areas such as Kibwezi West and East, specializing in cowpeas, pigeon peas, and sorghum. Each zone supports distinct agricultural practices and crops.

1.4 National Policy and Regulatory Framework for the Energy Sector

The following are national policies and regulations that have a bearing on the energy sector in Makueni.

- Kenya Constitution 2010
- Kenya Vision 2030

1 Ministry of Energy (2019). Energy Act, Kenya
2 County Government of Makueni (2023).
3 National Bureau of Statistics. (2019). 2019 population and housing census: Population distribution by administrative units. Nairobi, Kenya.

- Energy Act 2019
- Gender energy policy
- Kenya National Electrification Strategy (KNES) 2018
- Bioenergy Strategy
- Kenya National Energy Efficiency and Conservation Strategy
- Least Cost Power Development Plan (LCPDP) 2021 -2041

1.5 County Policy and Regulatory Framework

- Makueni County Vision 2025
- Makueni County Spatial Plan (CSP) 2025
- Makueni County CIDP (2023 - 2027)
- Makueni Draft County Electrification, Gas Reticulation and Energy Regulation Policy 2023
- Makueni County Water Act 2020

2 ENERGY RESOURCE ASSESSMENT

This chapter discusses primary energy sources in Makueni County, including biomass, wind, solar, and hydro-power.

2.1 Biomass energy resources

Kenya utilizes woody biomass, crop residues, and animal dung for cooking, heating, drying, and electricity generation. The primary sources of bioenergy are forests and agricultural residues.

2.1.1 Estimation of woody biomass coverage

Makueni County's woody biomass resources encompass public forests, bushland, and on-farm trees, with forests and bushlands constituting 17% and 48% of land cover, respectively. It hosts five gazetted forests, 28 community forests, and three non-gazetted forests, managed across protected and non-protected areas, including lands under the Kenya Forest Service as shown in Table 2-1 below[4].

Table 2-1: Number and Size of Gazetted & Non-Gazetted Forests, 2020/2021.

Source: Kenya Forest Service

Size (Ha) of the gazetted and non-gazetted Forests, 2020-2021								
Year	Sub-county	Mbooni	Kilome	Kaiti	Makueni	Kibwezi West	Kibwezi East	Total
2020/2021	Gazetted forests (Ha)	4,354	615	2,878	967	341	5,850	15,005
2020/2021	Non-Gazetted forests (Ha)	49	1	8	504	6,914	125	7,601

Figure 2-1 shows the distribution of woody biomass by sub-county. Figure 2-2 visualizes forestlands for bioenergy, excluding protected areas. It details the total land area under forests, woodlands, and shrub lands, with extractive use based on sustainable yield principles.

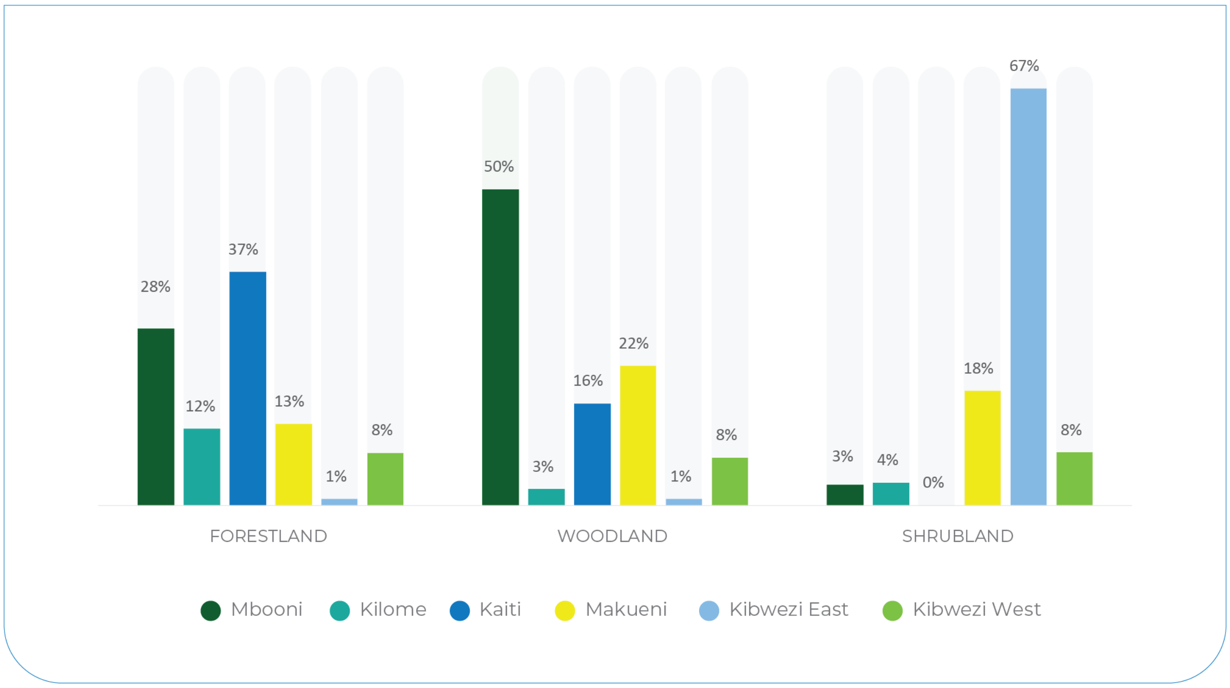


Figure 2-1: Distribution of Woody Biomass in Makueni

4 County Government of Makueni. (2019). Makueni County Statistical Abstract. Kenya National Bureau of Statistics. Retrieved June 20, 2024, from https://www.knbs.or.ke/makueni-county-statistical-abstract/

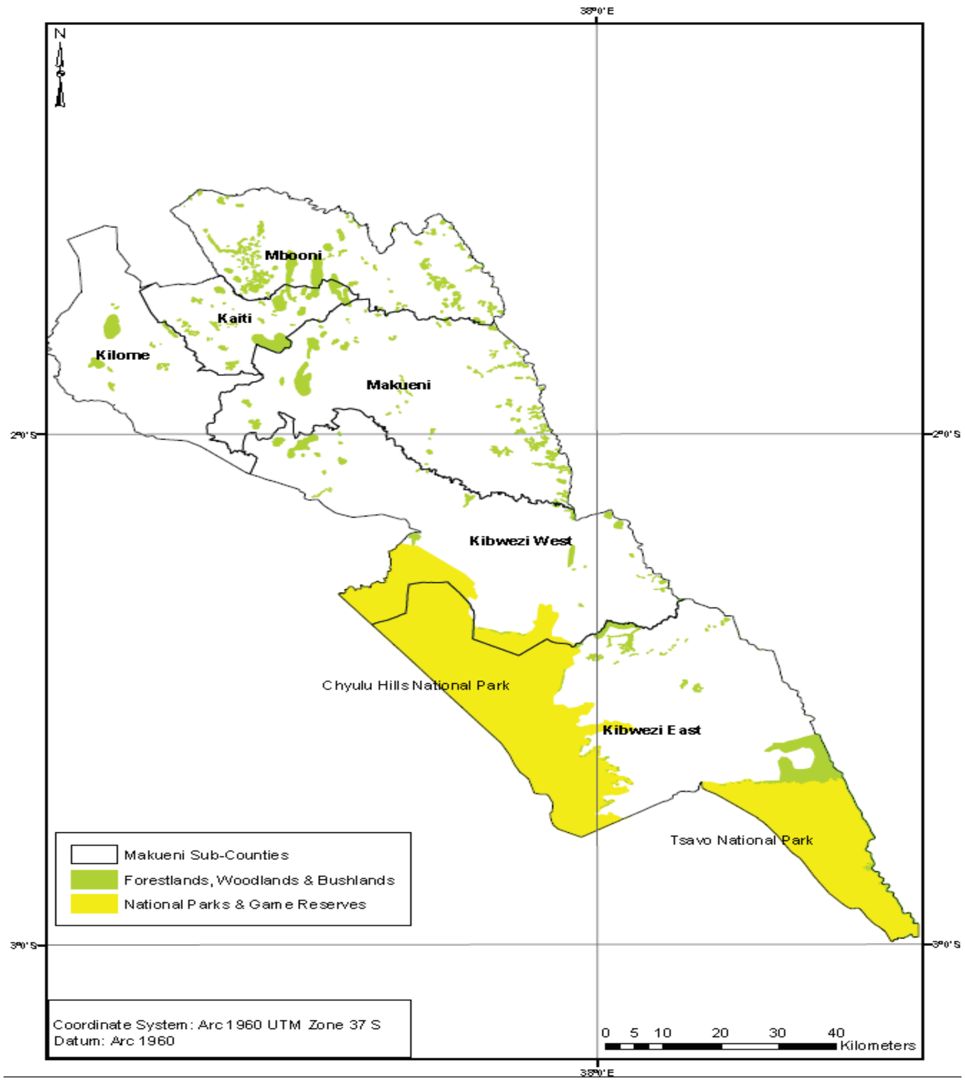


Figure 2-2: Distribution of Woody Biomass in Makueni

Between 2001 and 2021, Makueni County lost 2,092 ha of tree cover, or 1.5% of its total forest area, impacting both protected and non-protected lands managed by various governmental and private entities[5]. Table 2-2 shows the forest loss by sub-counties in Makueni.

Table 2-2: Forest Loss in Makueni

Sub-county	Land lost (Ha)	Land lost (%)
Kibwezi West	473	23
Makueni	468	22
Mbooni	446	21
Kaiti	321	15
Kilome	246	12
Kibwezi East	138	7
Total	**2,092**	**100**

2.1.2 Estimation of baseline sustainable supply from woody biomass cover

To sustainably produce biomass for energy, it's assumed that 50% of harvested wood can be used, accounting for the maintenance of stocks and other uses such as timber. Exact sustainable productivity rates need further study, given the lack of data on firewood versus charcoal use, particularly because charcoal trading is illegal

5 Global forest watch (2024). Makueni, Kenya Deforestation Rates & Statistics. Global Forest Watch. Retrieved March 20, 2023, from https://www.globalforestwatch.org/dashboards/country/KEN/23/?category=forest-change.

in Makueni County. An average wood density of 562.5 kg/m^3 was used to estimate the net annual woody biomass productivity at 19,409 tonnes for 2023 as shown in Figure 2-3 disaggregated by sub-county. The following equation was used. Further details regarding projections can be obtained from the Master Technical Report.

$$SS = AAP * H$$

Where:

AAP (average annual productivity) is dependent on the wood cover type. In farmlands, the annual net productivity (AAP) of woody biomass is assumed to be 1.44 m^3/ha/year. Outside farmlands, AAP was assumed to be 0.79 m3/ha/year, representing the average productivity of closed forests/tree cover, woodlands or vegetation in flooded areas, and bushlands[6]

H is the land area (Ha) for each land cover type, and

SS is the Sustainable Supply (SS).

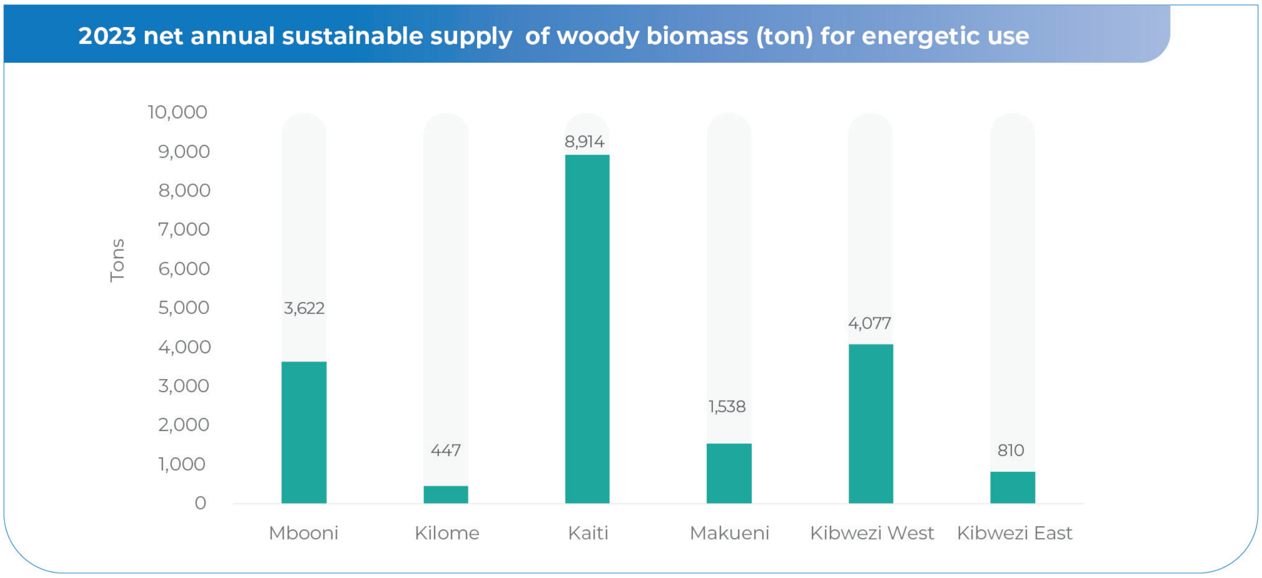


Figure 2-3: Future projections of sustainable supply of bioenergy from woody biomass

2.1.3 Alternative bioenergy resources in Makueni County

Kenya's Bioenergy Strategy identifies agricultural residues from livestock, crops, and mango processing as potential sources for energy production and bio-fertilizers, including dung for biogas and waste for briquettes, pellets, and biogas[7].

2.1.4 Potential for biogas production from livestock population

The county has a large livestock population, including beef cattle, dairy cattle, sheep, goats, and poultry. Potential biogas production was estimated for baseline year 2023 and projected up to 2032[8]. The calculations were based on the following assumptions:

- That animals spend all their nights in a shed,
- Annual dung collection is proportional to the number of days/nights the animals spend in the cowsheds or pen.
- All animal waste is available for biogas production.
- Biogas yield used the IPCC parameters (13% and 18%) methane for a kg of volatile solids for cattle and small ruminants.

The annual biogas production estimate for Makueni County in 2023 is shown in Figure 2-4. Projections up to 2032 can be obtained from the Master Technical Report.

6 Ministry of Energy (MoE) (2002). Study on Kenya's energy demand, supply and policy strategy for households, small scale industries and service establishments. Kamfor Consultants, Nairobi, Kenya

7 Ministry of Energy (2020). Bioenergy strategy 2020-2027, Nairobi, Kenya.

8 County Government of Makueni (2022). Makueni County Statistical Abstract. County Government of Makueni.

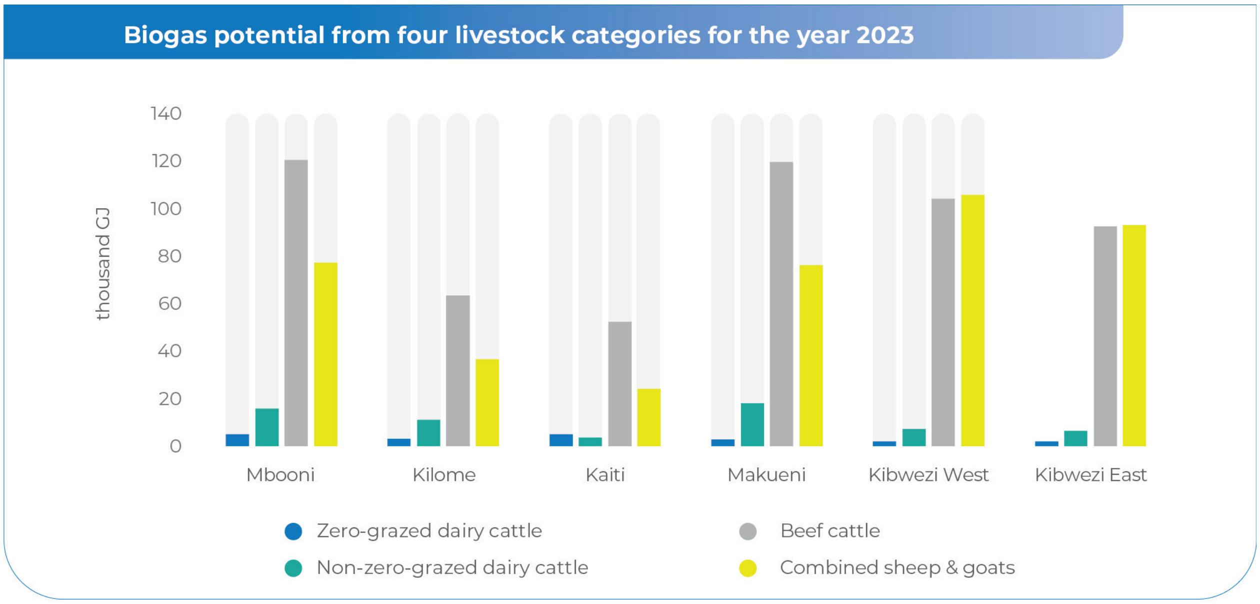


Figure 2-4: Summary of the estimated quantity of annual biogas production potential and equivalent energy from each of the four main livestock categories

2.1.5 Potential for bioenergy production from crop residues

The County Statistical Abstract 2022 highlights the potential of crop residues from food, horticultural, and industrial crops as bioenergy feedstock. Mango, coffee, and sisal processing is notable, with residue availability assessed at the sub-county level based on 2017-2021 data[9][10]. Major crops whose residues have potential for briquettes or pellet manufacturing are summarized in Table 2-3.

Table 2-3: Key crops producing residues with high potential for the manufacture of briquettes/pellets

Key residues producing crops		Residue to-product ratio[11][12][13]	Residue recovery factor[14]	Competition for residues (other than fuel)[15]**	*Moisture content as received (wt %)	HHV or LHV (MJ/kg)
Maize	Stalk	1.60	80 %	67 %		15 *LHV
	Husk	0.20	100 %	+67 %		18.02 *LHV
	Cobs	0.29	100 %	0 %		9.69 *LHV
Cow peas	Stalk	1.10	*50 %	0 %		15.0 LHV
Coffee	Husks	0.24	100 %	0 %		12.69 * LHV
Macadamia	Nutshells	0.7	60 %	0 %	10	21*HHV
Sorghum	Stalk	4.20	80 %	67 %		12.38 *LHV
Beans	Stalk	1.10	*50 %	0 %		16.0 * LHV
Pigeon peas	Stalk	1.10	*50 %	0 %		15.0 LHV
Green grams	Stalk	1.10	*50 %	0 %		15.0 LHV

** The variable on moisture content as received was only needed for quantification of bioenergy for macadamia residues as its higher heating value (HHV) was available. We assumed a 10 % moisture content on a wet basis by weight.*

9 County Government of Makueni (2022). Makueni County Statistical Abstract. County Government of Makueni.

10 NIRAS LTS International (2021). Policy Briefing Paper Bioenergy in the Sisal Processing Sector in Kenya

11 Welfle, A., Chingaira, S., Kassenov, A. (2020). Decarbonising Kenya's domestic & industry Sectors through bioenergy: An assessment of biomass resource potential & GHG performances. Biomass and Bioenergy, Volume 142, 105757, ISSN 0961-9534, https://doi.org/10.1016/j.biombioe.2020.105757.

12 NIRAS-LTS, E4tech, AIGUASOL and Aston University (2021b). Bioenergy for Sustainable Local Energy Services and Energy Access in Africa, Demand Sector Report 7: Sisal Processing, Kenya. For Carbon Trust and UK Government. London.

13 Maj, G., Szyszlak-Bargłowicz, J., Zaj, G., Słowik, T., Krzaczek, P. and Piekarski, W. (2019). Energy and Emission Characteristics of Biowaste from the Corn Grain Drying Process. Energies 2019, 12, 4383; doi:10.3390/en12224383

14 Ibid

15 Primary Data collection (2022) Baseline Survey

***Where competition for residue is 0%, all residue is available for bioenergy purposes*

+ With information from primary data collection, it was assumed that 65 % of maize husks and cobs are already put into use in Makueni County

Biogas potential from industrial processing of sisal and mangoes

The technical potential for biogas production from sisal and mango waste in Makueni County was assessed using residual biomass and energy content calculations. For 2023, mango waste could generate 62,066 Nm^3/yr of biogas (2,000 GJ), while sisal waste could produce 5,065,956 Nm^3/yr (127,000 GJ). Future projections up to 2032 can be obtained in the Master Technical Report.

2.1.6 Biogas production from slaughterhouses

The meat industry produces considerable waste, including bones, organs, and fats, alongside significant water use and wastewater generation in slaughterhouses, estimated at 360-560 litres of wastewater per animal.

Table 2-4: Potential waste from different animals slaughtered and the specific freshwater consumption used in slaughterhouses

Animal type	Weight of animal	Weight of meat		Weight of waste per unit animal		Specific freshwater consumption (SFWC)
	kg	kg	%	kg	%	l/head
Cattle	350	140	40	210	60	560
Sheep/goats	30	12	40	18	60	360

Utilizing data from the Government of Makueni County on animal slaughter figures[16], the bioenergy potential from slaughterhouse waste was estimated, revealing significant opportunities for energy generation through anaerobic digestion. Biogas projects like those in Kiserian, Dagoretti, Bungoma, and Homabay exemplify the viability of converting high-organic-content waste into biogas at a commercial scale.

2.1.7 Biogas production from municipal wastes

Makueni County's urban waste management challenges offer a biogas generation opportunity from waste and sludge. The lack of centralized sewer systems and data on sludge volumes underscores the need for anaerobic digestion, supporting resource recovery and energy generation strategies. Using data from the County Statistical Abstract, biogas potential from municipal solid waste (MSW) in Makueni County was estimated, with projections showing the largest daily volumes in Kibwezi East, Kibwezi West, and Makueni sub-counties. An assumed 20% collectible MSW proportion guided the calculations. The following equation was used to estimate[17]:

$$Q_{biogasmsw} = FM_{collected} * Availability * DM_{content} * VS_{content} * Biogas_{potentialmsw} * Methane_{cont}$$

Where:

- **FM** $_{collected}$ is the amount of residue (tonnes per year)
- **Availability** is the seasonal availability of the residue (for biogas production, a residue should be available throughout the year or should be storable)
- **DM** $_{content}$ is the dry matter (DM) content of the residue (% fresh matter, FM)
- **VS** $_{content}$ is the volatile solids (VS) content (% DM)
- **Biogas** $_{potential-msw}$ is the biogas potential for the substrate (m3/t VS); and methane content in the biogas (%)
- **Methane** $_{content}$ is the percentage of methane content in the biogas

Considering Makueni County's waste-to-energy potential requires addressing waste composition, financing, and plant placement. Despite costs and risks, Public-Private Partnerships could leverage private innovation and investment in waste management and energy conversion, as highlighted by Mutz et al[18].

16 County Government of Makueni (2022). Makueni County Statistical Abstract. County Government of Makueni.

17 GIZ (2010). Assessment on potential for agro-industrial biogas in Kenya: Potentials, Estimates for Tariffs, Policy and Business Recommendations. German Biomass Research Centre

18 Mutz, D., Hengevoss, D., Hugi, C. and Gross, T. (2017). Waste-to-Energy Options in Municipal Solid Waste Management - A Guide for Decision Makers in Developing and Emerging Countries. Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH

Table 2-5: Average daily quantity of solid waste collected in urban areas, 2019-2021.

(Source: County Government of Makueni, 2022)

Sub-county	Tonnes		
	2019	2020	2021
Mbooni	18.40	18.60	18.80
Kilome	11.20	11.30	11.40
Kaiti	12.50	12.60	12.70
Makueni	17.90	18.10	18.30
Kibwezi West	19.00	19.20	19.40
Kibwezi East	23.20	23.50	23.80
Total	**102.20**	**103.30**	**104.40**

2.1.8 Bioenergy crops

The establishment of an Agri-hub in Wote, Makueni County, revitalizes bioenergy crop production like castor and jatropha by offering market opportunities through oil seed processing for biofuel, aimed for export to Italy. This initiative encourages local cultivation and MSME participation in briquette production from processing waste, suggesting potential for sustainable bioenergy development through government partnership and further research. Figure 2-5 below shows the potential of bioenergy production through oil pressing in Makueni

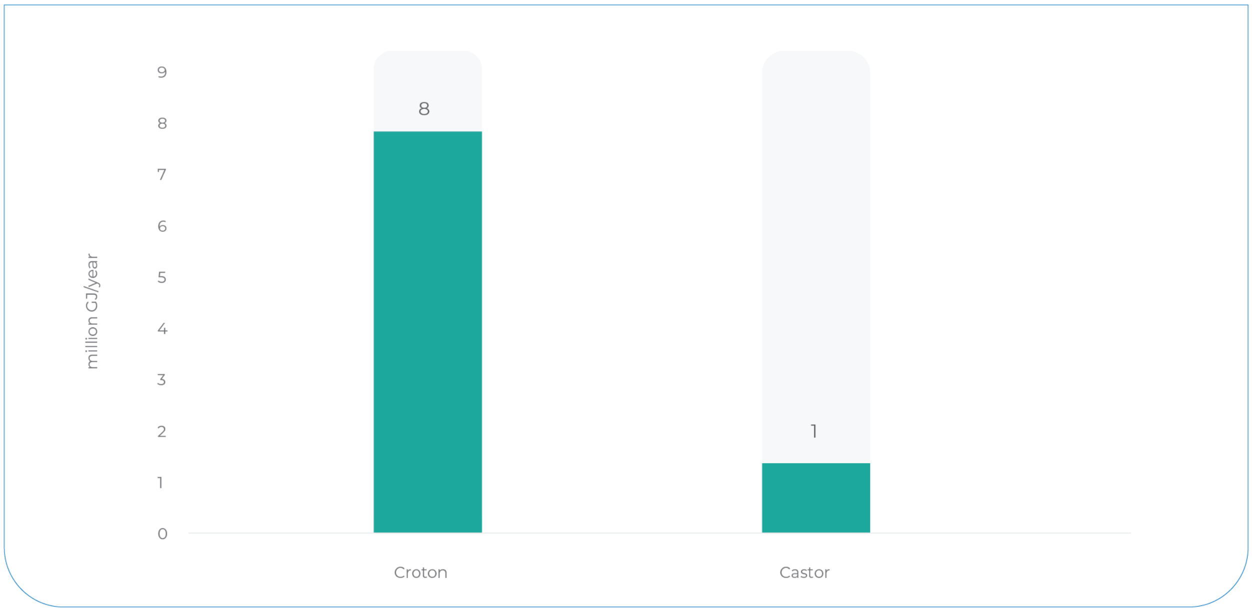
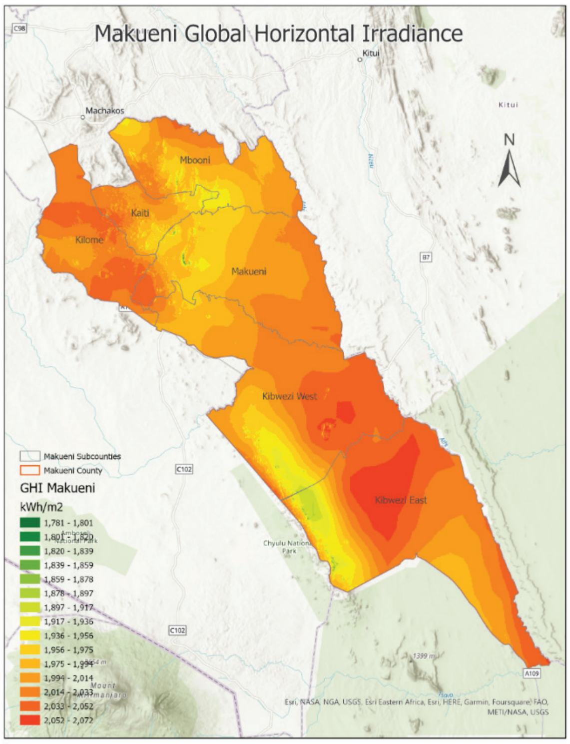


Figure 2-5: Potential bioenergy (million GJ) that can be produced by using wastes or residues generated through oil pressing of croton and castor seeds by the Agri-hub in Makueni County

2.2 Solar Power

Makueni County's solar energy potential is particularly strong in southern and north-western areas. It has an average yearly Global Horizontal Irradiation (GHI) of 2,008 kWh/m^2, showing significant solar resource availability. The County has high solar energy potential, with an average PV output of 4.35 kWh/kWp/day, ideal for off-grid areas and residential systems.



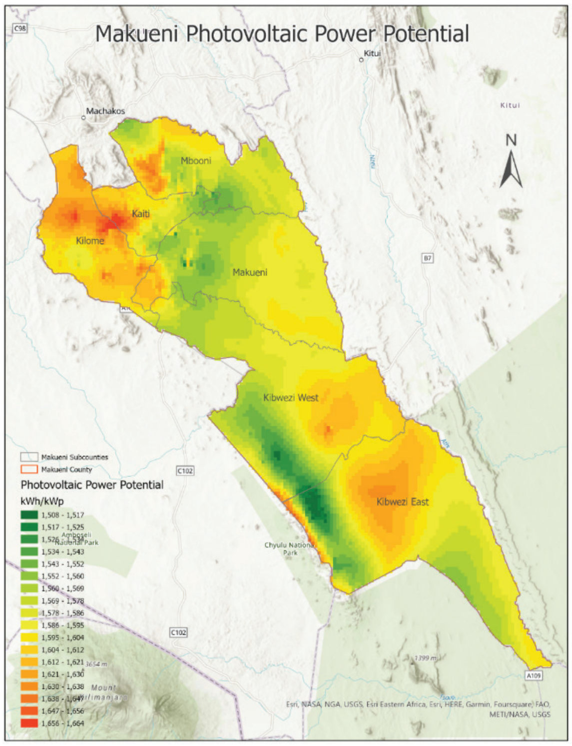
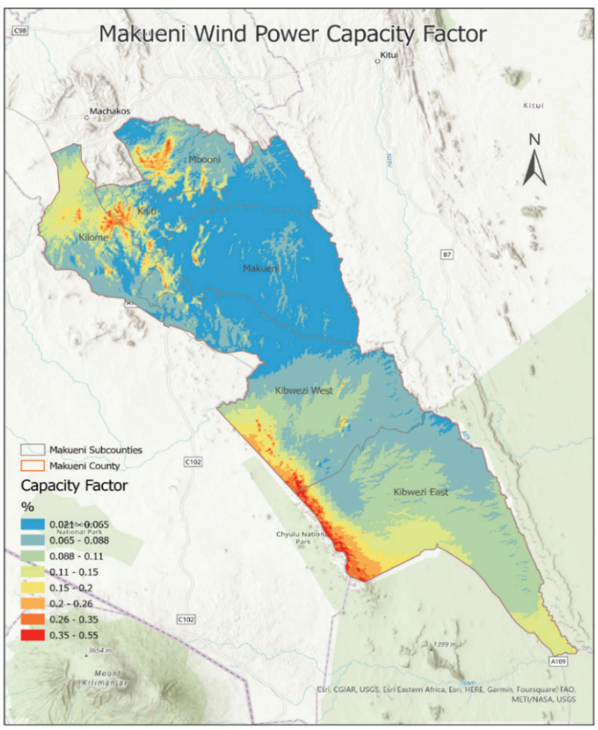


Figure 2-6: Long-term yearly average of potential photovoltaic electricity production in kWh/kW-peak in Makueni County

Figure 2-7: Long-term yearly average of global horizontal irradiation (GHI) in kWh/m2 in Makueni County

2.3 Wind Power

The Global Wind Atlas data indicates Makueni County's mean annual wind speed and capacity factor, essential for evaluating wind power generation potential.



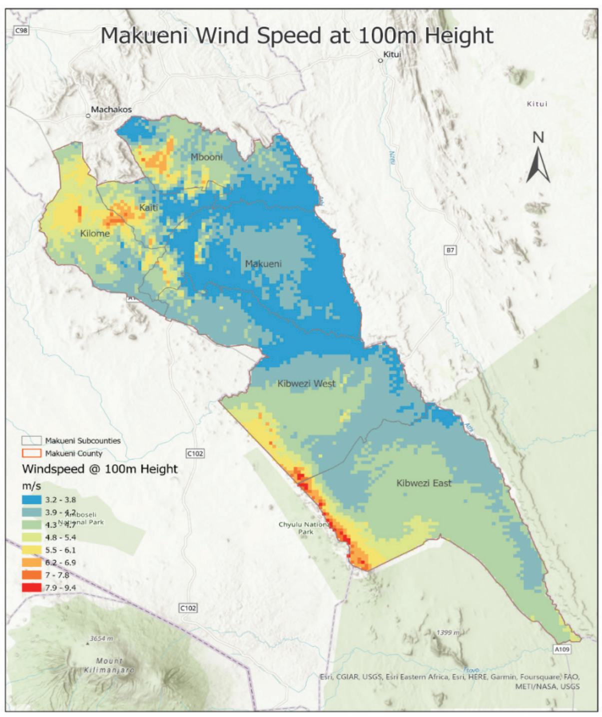


Figure 2-8 Wind power capacity factor for Makueni County

Figure 2-9: Mean annual wind speed at 100 meters heights for Makueni County

Figures 2-8 and 2-9 reveal higher wind speeds and capacity factors in Makueni's northern and south-western regions, particularly in Kilome and Kibwezi East, indicating suitability for wind Power installations.

2.4 Hydropower

A KTH study pinpointed a site in Makueni County suitable for a 0.16MW mini-hydropower plant[19], as shown in Figure 2-10. The existence of another site with a 0.4 MW hydropower potential near Makueni's border in Kajiado County underscores the need for inter-county collaboration.

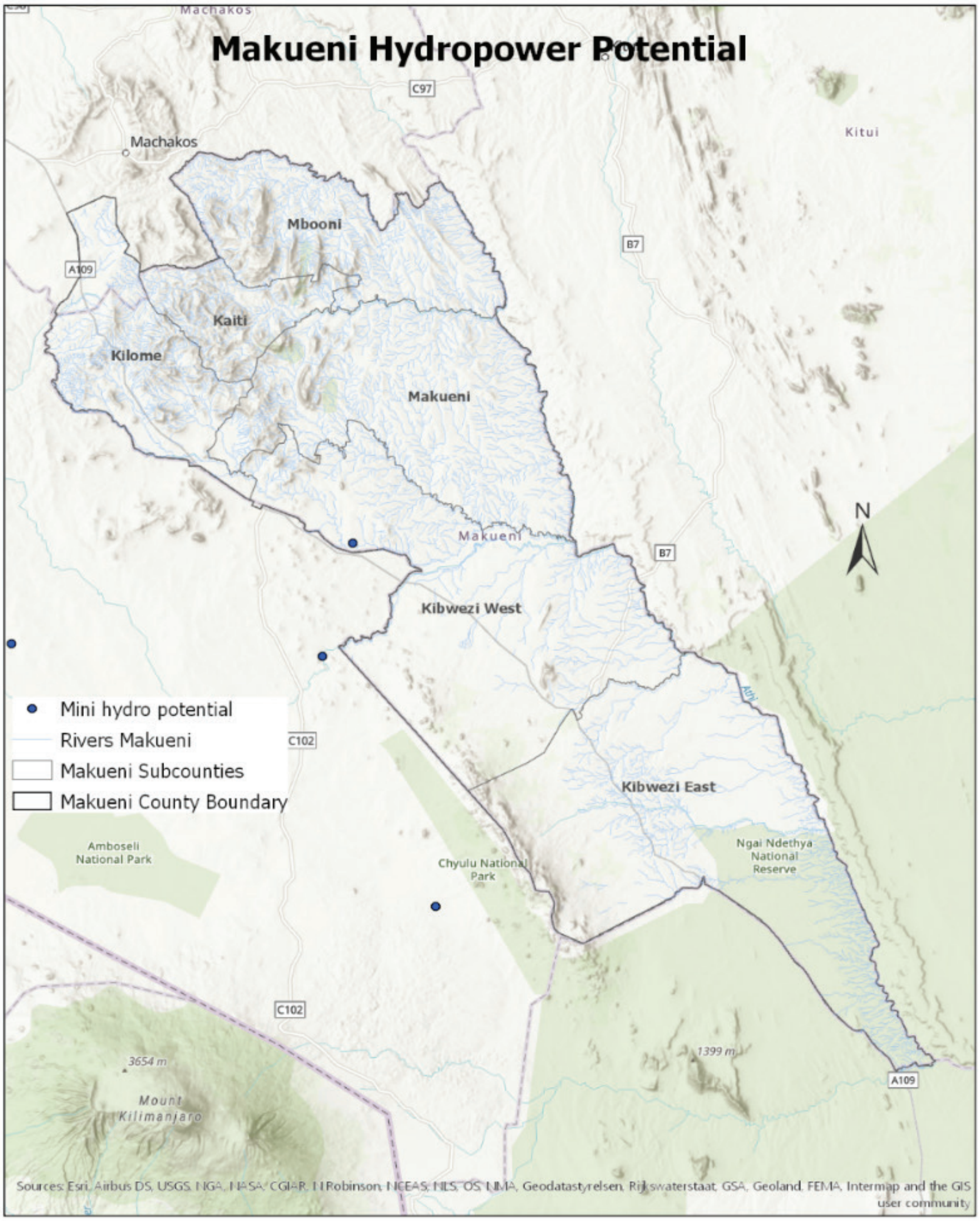


Figure 2-10: Map showing potential sites for setting up small and mini hydro power plants in Makueni.

3 ENERGY ACCESS

This chapter covers energy access for households, productive engagements, and community facilities— also termed as the locales of energy access.[20]

3.1 Electricity Access in Makueni County

3.1.1 Access to Electricity: Households

In Makueni County, 75.1% of households have electricity: 40.2% solar, 29.2% grid, and 5.7% mini-grids. Comparative analysis reveals grid access in the county increased by 9% from 20.4% in 2019 to 29.2% (Table 3-1). This is attributed to Last Mile Connectivity Program, where 31,016 households were connected at KES 1.51 billion. A slight decrease in solar usage was also recorded, which could be due to the same initiative.

Table 3-1: Electricity Access for Households in Makueni County

Technology option	2019 (%)[21]	2022* (%)
KPLC	20.4	29.2
Mini-grid connection*	-	5.7
Standalone supply (SHSs + solar lanterns)	44.0	40.2
Total (HH) connectivity	64.4%	75.1%

*2019 data was obtained from the national census which did not provide connectivity rates for mini-grids

Other sources of energy used for lighting are as shown in Figure 3-1 below.

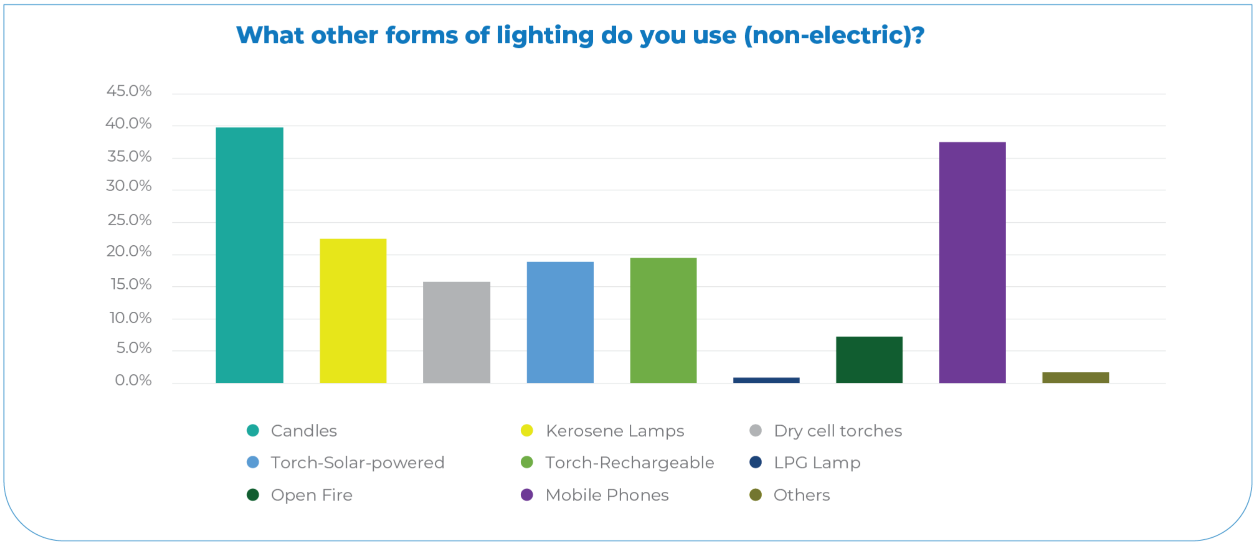


Figure 3-1: Other sources of lighting other than electricity used by households in Makueni County in 2022

3.1.1.1 Gender Analysis

A survey of 632 households in Makueni County found that 73.7% were male-headed while 25.8% were female-headed. Female-headed households enjoy higher electricity access rates however, they predominantly rely on solar home systems. As such, they spend less on electricity consumption per month compared to male-headed households who have lower electricity rates but higher grid connectivity as shown in Table 3-2 and Figure 3-2.

20 Bhatia, M., & Angelou, N. (2015). Beyond connections: Energy access redefined (ESMAP Technical Report No. 008/15). World Bank. http://hdl.handle.net/10986/24368

21 Kenya National Bureau of Statistics (KNBS). (2019). Kenya population and housing census: Volume IV. Distribution of population by socio-economic characteristics. Kenya National Bureau of Statistics. https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-4-distribution-of-population-by-socio-economic-characteristics

Table 3-2:Comparison of electricity access, the average cost of electricity, and willingness to pay disaggregated by type of household head.

Type of Household	Percentage without access (%)	Average Monthly Expenditure on Electricity (KES)	Willingness to pay for improved connection (KES)
Male-headed	54	931	658
Female-headed	49	476	402

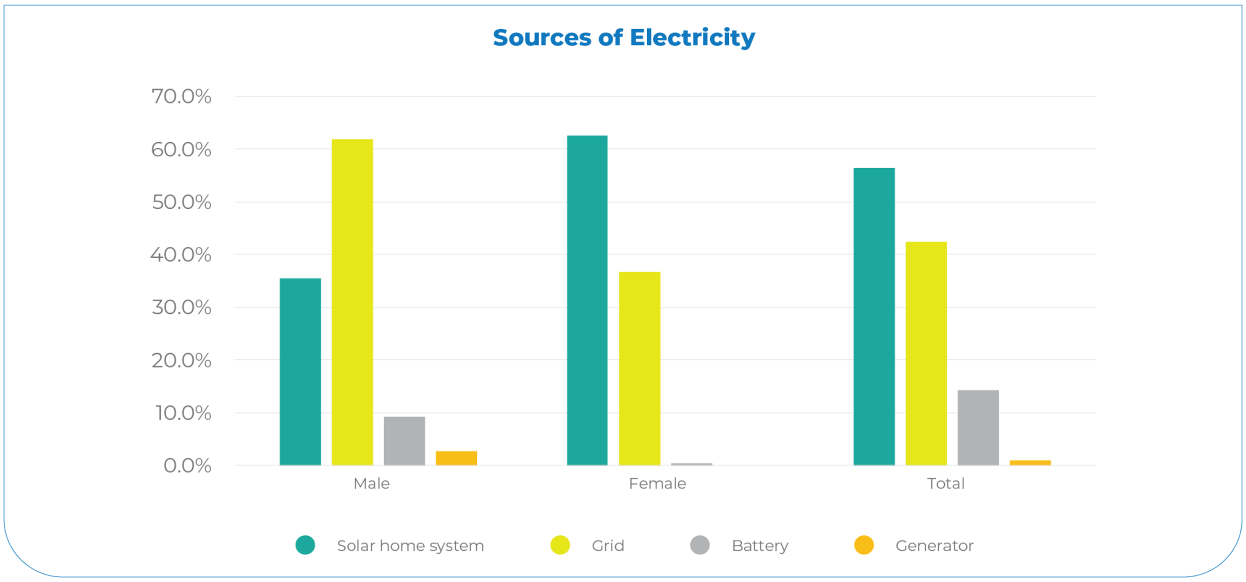


Figure 3-2: Technologies for electricity access by gender

3.1.1.2 Analysis of Electricity Access Using Multi-Tier Framework (MTF) of Energy Access[22]

The Multi-Tier Framework (MTF) is a global standard that measures the level of energy access. Developed by the World Bank and ESMAP, it measures electricity access quality across seven dimensions, offering a nuanced, tiered classification beyond the binary have/have-not metric. This analysis provides the MTF analysis for Makueni County.

i. Capacity: Only 34.9% of households in Makueni have access to electricity at MTF tier 3 or above, indicating sufficient capacity for productive uses with a basic annual consumption of 365 kWh.

ii. Availability: A mere 24.3% of households achieve tier 3 availability (electricity for 8+ hours daily), despite 29.2% having grid connections. This suggests that grid services are insufficient, impacting utility sustainability due to low consumption.

iii. Reliability: About 35% of grid-connected households experience weekly outages lasting 1-7 days, placing them at tier 3 or below in reliability due to frequent disruptions.

iv. Affordability: With the average monthly expenditure on electricity at KES 675, only households earning KES 13,510 or more can afford services by MTF standards. However, less than a quarter of households earn above KES 20,000 monthly, indicating widespread unaffordability.

v. Quality: This refers to the stability and reliability of the voltage levels provided by the electricity supply. No significant issues were found.

vi. Health & Safety: 14.8% of households reported serious injuries from electricity use in the past year, classifying them as tier 3 or lower for health and safety.

vii. Legality: this refers to whether an electricity connection is officially recognized and meet the prescribed legal and safety standards. No major issues were found under this attribute.

22 ESMAP. (n.d.). *Multi-Tier Framework for Energy Access (MTF)*. World Bank. Retrieved March 20, 2023, from **https://www.esmap.org/node/55526**

3.1.2 Access to Electricity: Educational Institutions

Educational institutions in Makueni County have an 86% electricity connectivity rate (Table 3-3), yet 20% cannot use electricity due to issues such as incomplete wiring and failed transformers, necessitating an audit to address these challenges.

Table 3-3: Main source of energy for lighting used by educational institutions

Main source of energy used for lighting by educational institutions	County Total (%)
National Grid-KPLC	85.8
Mini-grids	0.3
Other stand-alone systems (e.g. SHSs)	7.1
Generator	1.7
Rechargeable batteries*	0.8
Firewood	0.3

Table 3-4 shows comparative electricity connectivity of different types of institutions from 2019 to 2021.

Table 3-4: Electricity connectivity status for educational institutions in 2019-2021 in Makueni County

Type of educational institution	2019(%)[23]	2020(%)*	2021(%)*
Primary Schools	85.9	96	98.1
Secondary Schools	-	100	100.0
Polytechnics	46.3	78	77.8
Aggregate average	66.1%	91%	92%

**Experts Analysis from Statistical Abstract, 2022, and primary data collection, 2023*

3.1.3 Access to Electricity: Healthcare Facilities(HCFs)

A total of 53 healthcare facilities (HCFs) in Makueni County were surveyed and categorized by their levels and locations. The combined average primary electricity connectivity from all sources of the HCF surveyed during primary data collection was 84% as shown in Table 3-5.

Table 3-5: The primary lighting source for HealthCare facilities

The primary lighting source for HCFs	Rural (%)	Urban (%)	Total (%)
Drycell battery (Torch)	5.7	0	5.7
Grid-based electricity	50	80	52.8
Mini-grid based electricity	6.3	0	5.7
Solar Home System/Lanterns	18.8	20	18.9
Total	**80.8**	**100**	**83.1**

3.1.4 Access to Electricity: Trade Centres (Markets)

In 2021, 96.5% of Makueni's trade centres had electricity, marking a 42% growth from 776 in 2019 to 1,102. This can be attributed largely due to national electrification efforts.

23 Kenya National Bureau of Statistics (KNBS). (2019). *Kenya population and housing census: Volume IV. Distribution of population by socio-economic characteristics*. Kenya National Bureau of Statistics. https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-4-distribution-of-population-by-socio-economic-characteristics

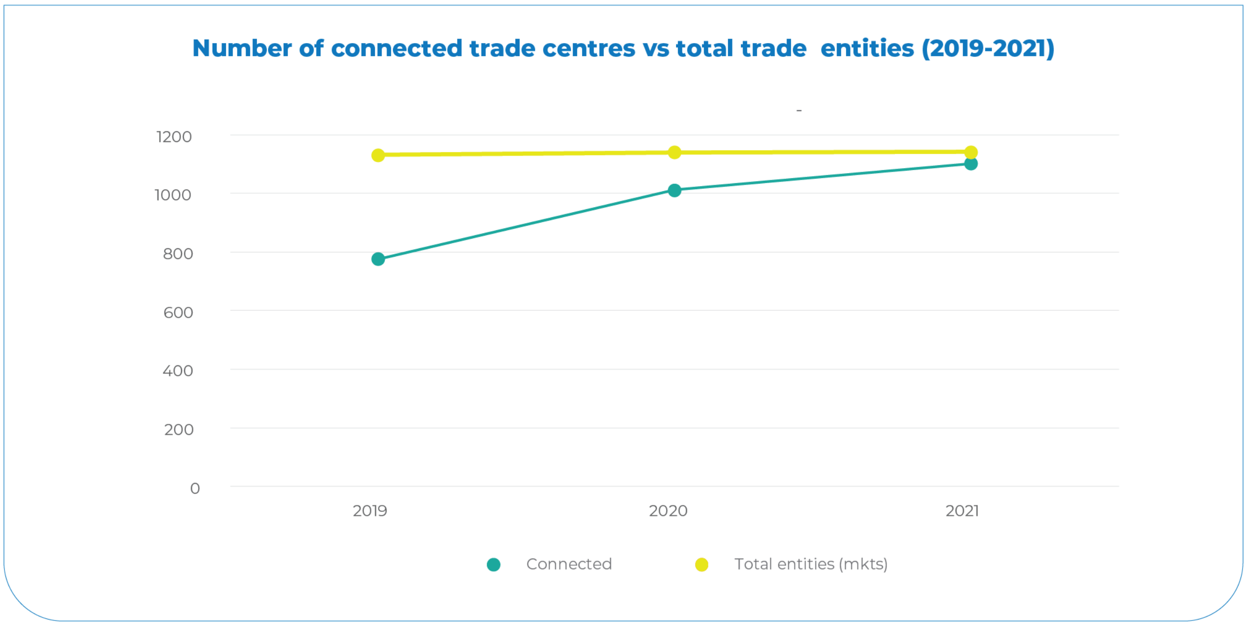


Figure 3-3: Number of connected trade centres vs total entities (2019-2021)

Despite increased streetlight installations in market centres, issues of quality persist, leading to breakdowns and reduced functionality. Ultimately, these lead to heightened insecurity.

3.1.5 Access to Electricity: Businesses (MSMEs)

In Makueni County, 80% of businesses rely on the national grid for electricity, with usage at 90.6% in urban areas and 75% in rural areas. Solar comes in at a distant second (10%). Figure 3-4 shows the source of electricity by sub-county. The average monthly electricity expenditure is KES 4,750, with businesses in urban areas spending three times more than those in rural areas. Unreliable electricity and slow response to outages by Kenya Power hinder MSMEs competitiveness.

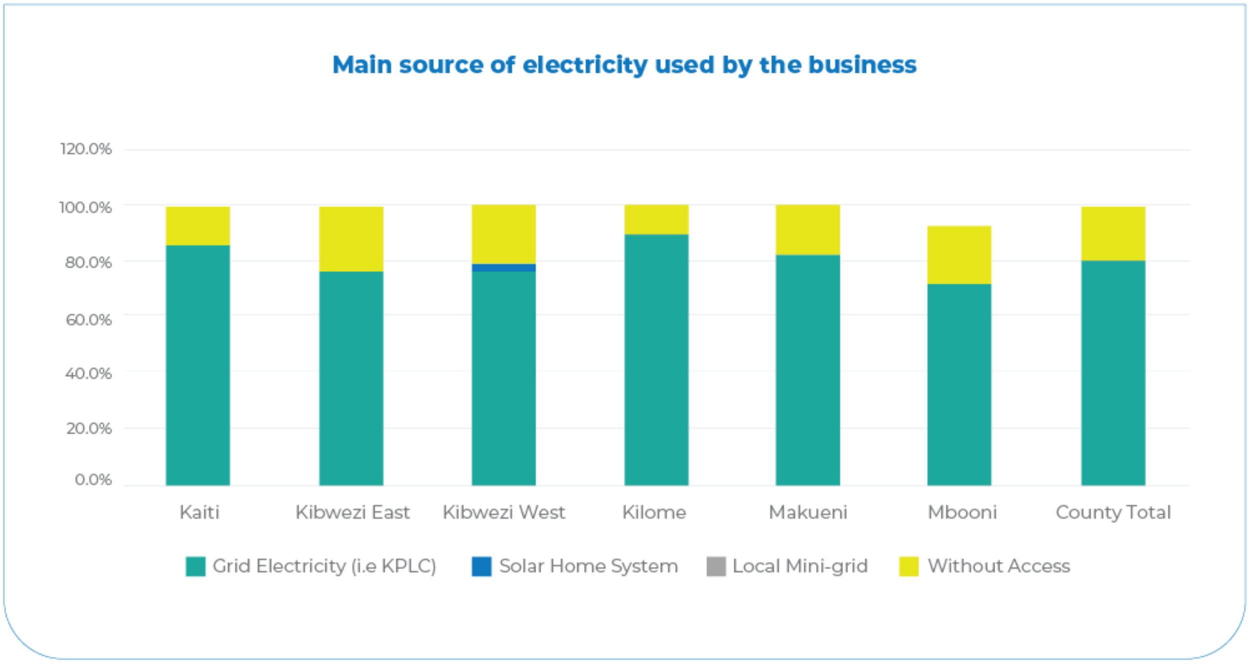


Figure 3-4 Main sources of electricity used by businesses

3.2 Progression to universal access to electricity

This section details GIS modelling for Makueni's cost-effective electrification from 2023 to 2032, covering baseline analysis, scenarios, and barriers to electrification.

3.2.1 Baseline Electrification Data

Makueni's electricity infrastructure as depicted in the Energy Access Explorer includes MV and HV lines, substations, transformers, and a mini-grid, as shown in Figure 3-5

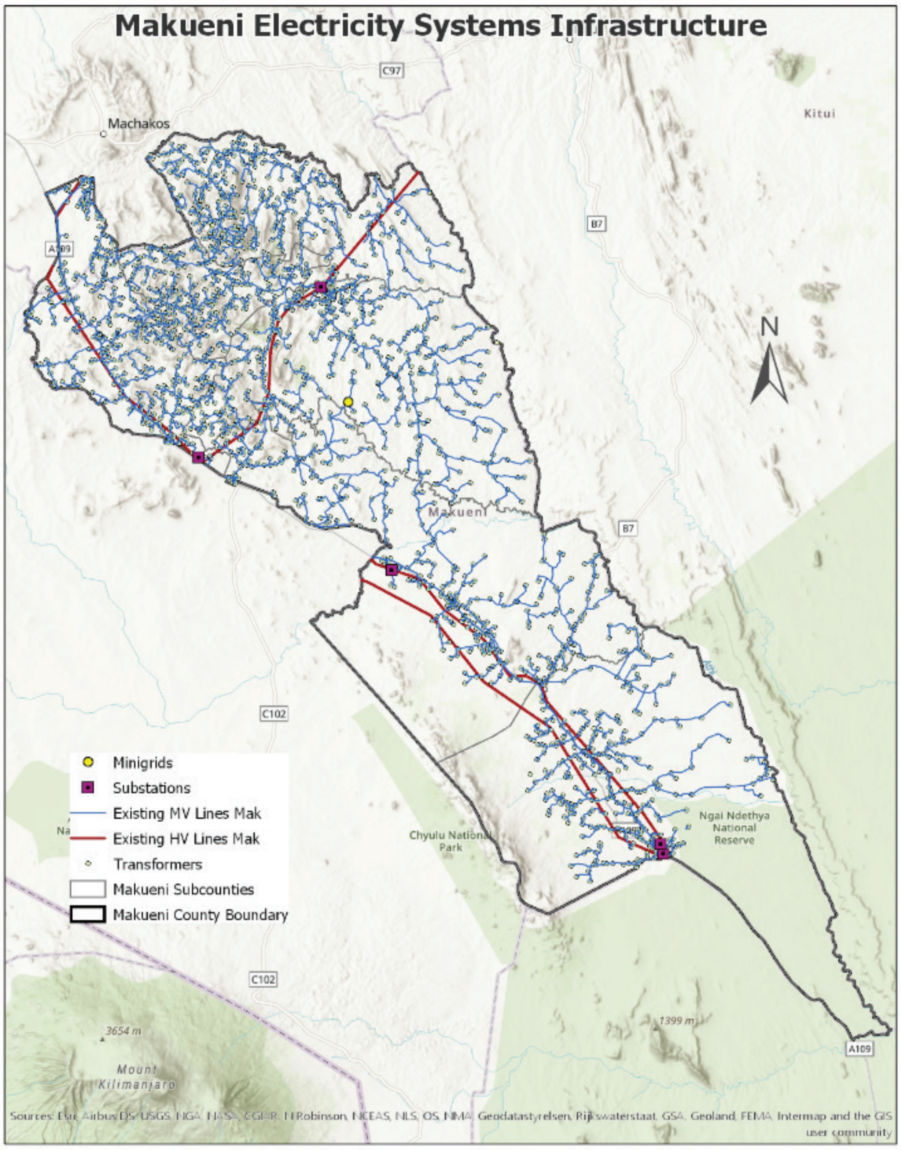


Figure 3-5: Electricity Systems Infrastructure

The Energy Access Explorer (EAE) is an online platform integrating energy demand and supply data to identify areas for expanding clean energy access. A more detailed overview of the EAE can be found on the Energy Access Explorer website[24]

3.2.2 Future energy access outlook (and scenarios)

The Open-Source Spatial Electrification Tool (OnSSET)[25] was used to model cost-effective electrification strategies for Makueni County. It aimed at achieving universal access by 2028, with an alternative scenario for 2026, and maintaining it through 2032 against population growth. This GIS-based tool evaluates grid, mini-grid, and standalone systems, selecting the lowest Levelized Cost of Electricity (LCOE) option for each area. Although Productive Use of Energy (PUE) data was unavailable for integration, future updates will incorporate it by connecting PUE loads to nearby household electrification solutions. The analysis began with 2019 data, focusing on access expansion as per the Multi-Tier Framework (MTF).

3.2.3 Scenarios Description

Three electrification scenarios for Makueni County were modelled: Low Demand, High Demand, and High Demand with Forced Grid Intensification, targeting universal access by 2026 and 2028.

Scenarios were developed to determine possible electrification pathways for Makueni County as shown in Table 3-6 below.

Table 3-6: Key Assumptions for the various scenarios modelled.

Assumption category	**Domestic Electrification-Low Demand**	**Domestic Electrification-High Demand**	**Domestic Electrification - High Demand, Forced Grid Intensification**	**Domestic Electrification - High Demand, Forced Grid Intensification - *(broken down at Sub- County level***
Demand Side assumptions	• Normal/expected population growth at 1.1% • Tier one* of demand for rural consumers and tier four for urban consumers • 100% electrification rate by 2028 • 100% electrification maintained with additional demand due to population increase factored up to 2032	• High population growth at 2% • High electricity demand target (Tier 3* of consumption for rural areas and tier 5 for urban areas) • 100% electrification rate by 2026 with another scenario reflecting universal access by 2028 • 100% electrification maintained with additional demand due to population increase factored up to 2032	• High population growth at 2% • High electricity demand target (Tier 3-rural areas* and Tier 5-urban areas) • 100% electrification rate in 2028 • 100% electrification maintained with additional demand due to population increase factored up to 2032	• High population growth at 2% • High electricity demand target (Tier 3* consumption in rural areas and tier 5 in urban areas) • 100% electrification target in 2028 • 100% electrification maintained up to 2032
Supply side assumptions	• Low generating cost for the grid (0.047$/kWh) • PV capacity cost as defined by the user. • Prioritisation of least cost electrification technologies (grid, mini-grids, and solar home systems	• High generating cost for the grid (0.059$/kWh) • PV capacity cost reduced by 25% • Prioritisation of least cost electrification technologies (grid, mini-grids, and solar home systems)	• High generating cost for the grid (0.059$/kWh) • • PV capacity cost reduced by 25% • Forcing grid electrification for areas that are within a 2km distance from the grid and allowing selection of least cost technologies for areas that are beyond this distance.	• High generating cost for the grid (0.059$/kWh) • PV capacity cost reduced by 25% • Forcing grid electrification for areas that are within a 2km distance from the grid and allowing selection of least cost technologies for areas that are beyond this distance

*Tiers of demand are used to approximate demand in rural and urban areas and not to define electrification solutions

3.2.3.1 Domestic Electrification -Low Demand Scenario

Figure 3-6 shows the technology choice per settlement in 2032 while Table 3-7 shows the capacity required for electrification in the domestic electrification -Low Demand scenario.

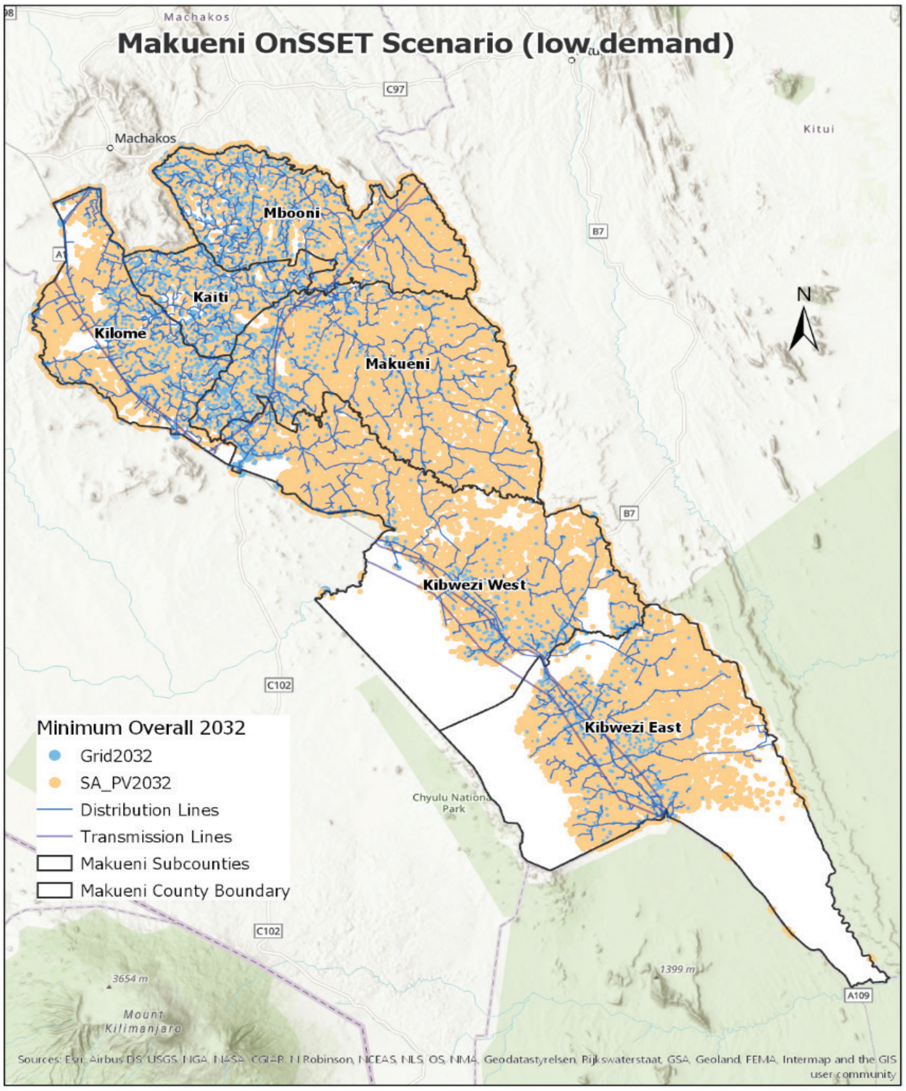


Figure 3-6: Domestic Electrification-Low Demand Scenario Results

Table 3-7: Capacity Required for Electrification in the Domestic Electrification-Low Demand Scenario

Technology	2028 (MW)	2032 (MW)	Total (MW)
Grid	16.1	3.3	19.3
Stand Alone (SA) PV	2.3	0.04	2.34
Total	**21.6 MW**		

The model selected grid and solar PV for Makueni's electrification as the least cost option for electrification, with grid expansion at 19.3 MW as shown in Table 3-7. The cost for this scenario is estimated at USD 132.5 million with 85% of this investment going to the grid as shown in Table 3-8.

Table 3-8: Investment (USD) required for Domestic Electrification-Low Demand Scenario in 2028 & 2032.

Technology	2028 (Million USD)	2032 (Million USD)	Total
Grid	105.0	7.4	112.4
Stand Alone (SA) PV	19.91	0.21	20.12
Total	**132.5**		

3.2.3.2 Domestic Electrification -High Demand Scenario

Figure 3-7 illustrates the preferred electrification technology per settlement by 2032, with Table 3-9 detailing the required technology capacities.

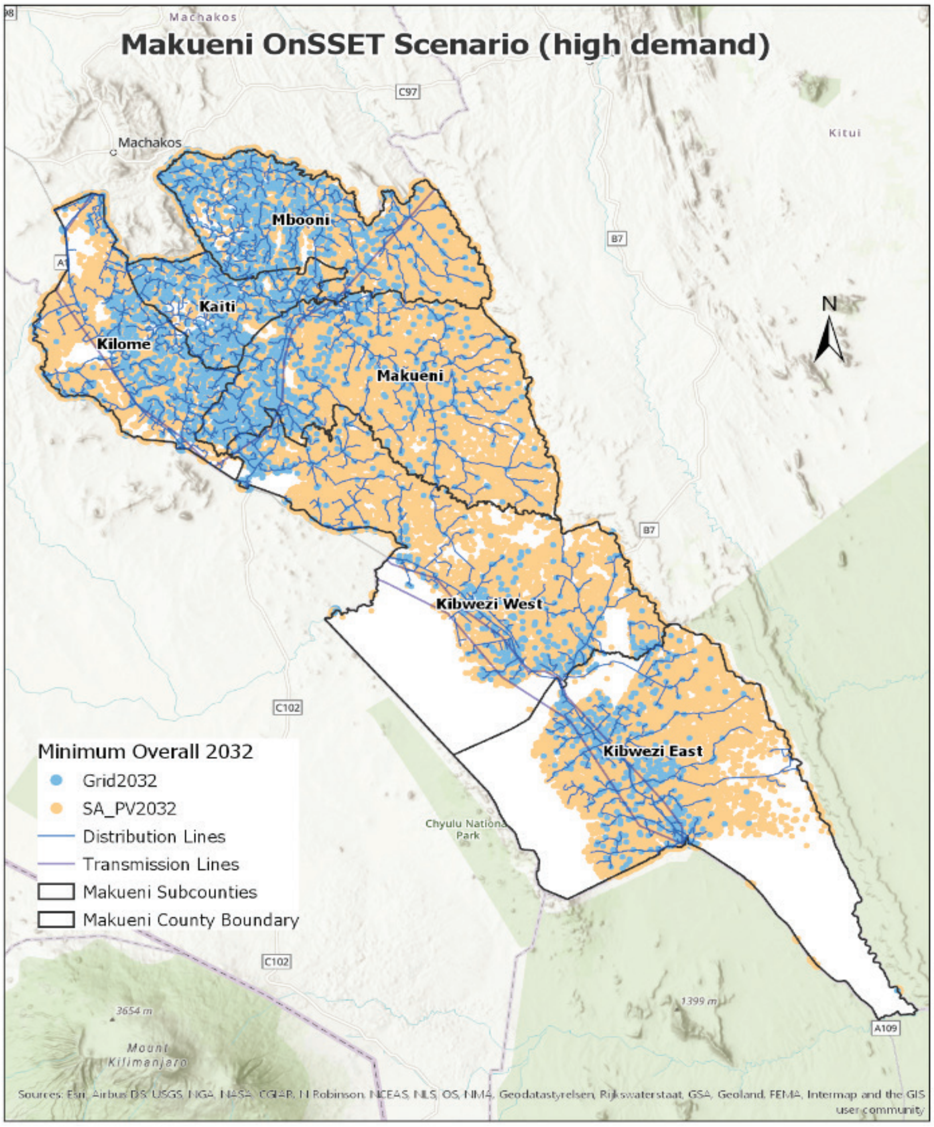


Figure 3-7: Domestic electrification high demand scenario by 2032

Table 3-9: Capacity of Electrification Technologies Required

Technology	2028 (MW)	2032 (MW)	Total (MW)
Grid	35.6	7.2	42.7
Stand Alone (SA) PV	50.8043	2.9007	53.605
Total	**96.4 MW**		

The High Demand Electrification Scenario requires more capacity for increased demand, leading to higher investment costs (Table 3-10) than the Low Demand Scenario due to expanded grid and solar systems, and population growth. Innovative financing or subsidies are needed for sustainability and livelihood improvements.

Table 3-10: Investment (USD) required for Domestic Electrification High Demand Scenario in 2028 & 2032

Technology	2028 (Million USD)	2032 (Million USD)	Total
Grid	166.4	14.3	180.6
Stand Alone (SA) PV	170.3	9.3	179.5
Mini-grid (MG) PV	0 0		0
Mini-grid (MG) Hydro	0.024	0.004	0.028
Total	**360**		

3.2.3.3 Domestic Electrification -High Demand Scenario (Universal Access by 2026)

This scenario targets universal electricity access by 2026, with Figure 3-8 and Table 3-11 outlining technology choices and required capacities for electrification based on established assumptions.

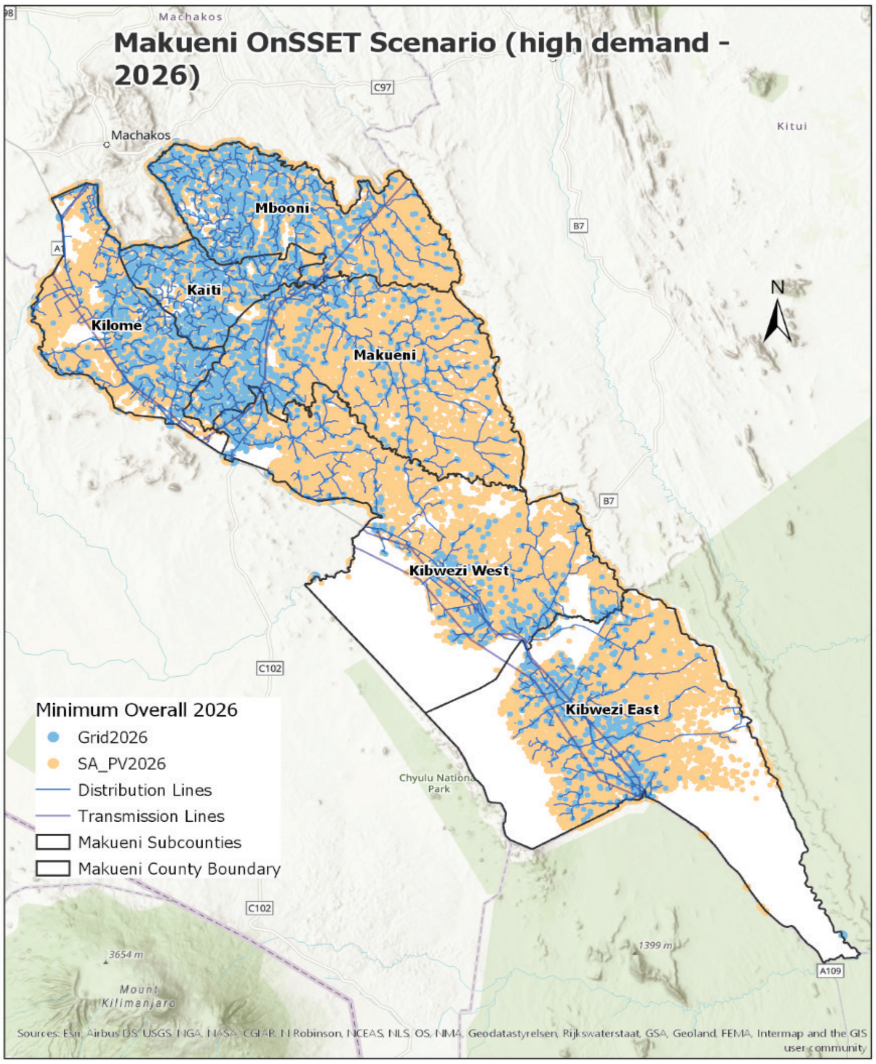


Figure 3-8: Domestic electrification high demand scenario by 2026

Table 3-11: Capacity of Electrification Technologies Required

Technology	2024 (MW)	2026 (MW)	Total (MW)
Grid	31.4	4.0	35.4
Stand Alone (SA) PV	47.204	0.9309	48.205
Total			**83.7 MW**

This scenario suggests boosting capacity by 83.7 MW to reach universal electrification by 2026, a figure lower than that for the equivalent scenario by 2032. Given the anticipated smaller population in 2026 relative to 2032, and assuming a steady population growth rate across both scenarios, the demand will be lower. Consequently, the investment costs for this scenario (Table 3-12) are also expected to be less than those of the earlier scenario.

Table 3-12: Investment (USD) required for Domestic Electrification High Demand Scenario in 2024 & 2026.

Technology	2024 (Million USD)	2026 (Million USD)	Total
Grid	148.8	10.9	159.7
Stand Alone (SA) PV	158.523	4.6089	163.1322
Total	**322.9**		

3.2.3.4 Domestic Electrification - High Demand Grid Intensification Scenario

This scenario focuses on extending the grid within a 2km radius to achieve 38.4 MW capacity, targeting areas near existing networks to boost access for rural and urban households due to high demand. Electrification technology choices per settlement by 2032 and the capacities of these technologies are shown in Figure 3-9 and Table 3-13, respectively.

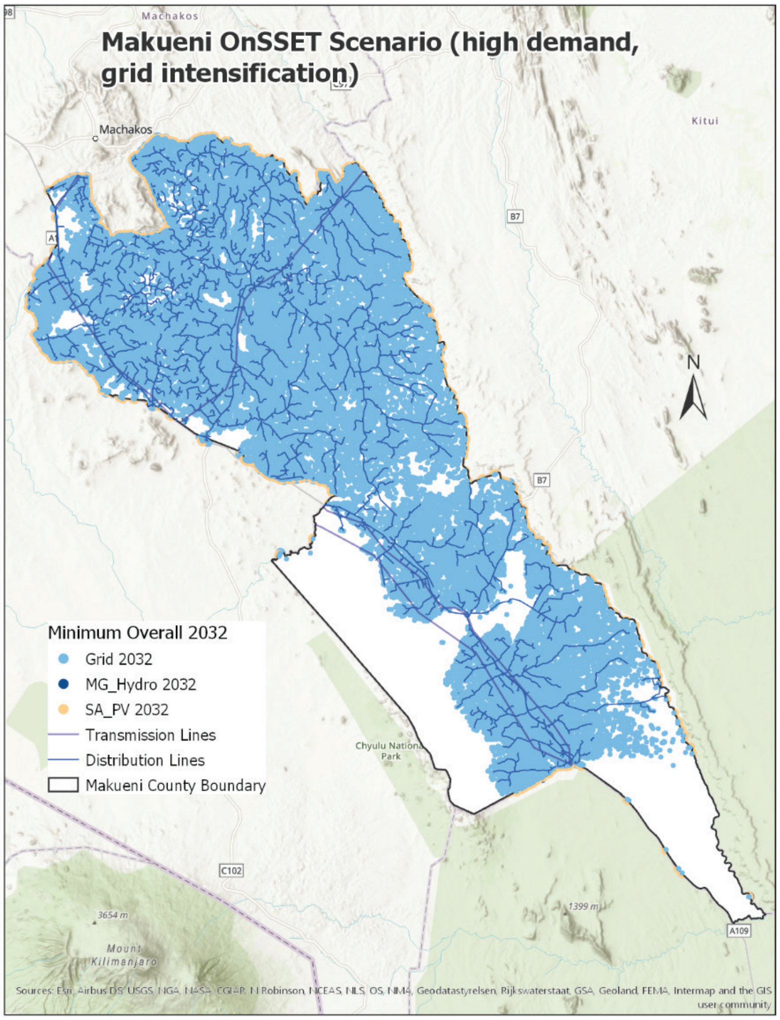


Figure 3-9: Technology choice per settlement in 2032

Table 3-13: Capacity of Electrification Technologies (MW)

Technology	2028	2032	Total
Grid	31.7	6.8	38.4
Total			**38.4**

The Forced Grid Intensification scenario requires USD 571.8 million for execution, surpassing prior scenarios' costs by emphasizing grid expansion within a 2km radius and deviating from cost-effective solutions. This strategy raises investment requirements by approximately USD 212 million, as shown in Table 3-14.

Table 3-14: Investment (USD) required in Forced Grid Scenario in 2028 & 2032.

Technology	2028 (Million USD)	2032 (Million USD)
Grid	557.1	14.8
Total	**571.8**	

3.2.4 Progress to Universal Electrification

Progress towards universal electrification from 2023 to 2032 for the three scenarios was undertaken using this scenario (forced grid electrification) and is tabulated in Table 3-15.

Table 3-15: Electricity connectivity progression

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Total connectivity of the HHs in %	55.6%	64.4%	73.3%	82.2%	91.1%	100%	100%	100%	100%	100%
HHs Population connected to solar home systems (Domestic Electrification - Low Demand Scenario)	211,799 254,158		296,518	338,878	381,237	423,597	1,952	3,904	5,855	7,807
HHs Population connected to the grid (Low demand scenario)	232,112	278,534	324,957	371,379	417,802	464,224	11,337	22,675	34,012	45,349
HHs Population connected to solar home systems (Domestic Electrification - High Demand Scenario)	229,197	275,036	320,876	366,715	412,555	458,394	6,324	12,648	18,972	25,296
HHs Population connected to the grid (High demand scenario)	260,033	312,039	364,046	416,052	468,059	520,065	19,066	38,132	57,197	76,263
HHs Population connected to the grid (Domestic Electrification - High Demand, Grid Intensification Scenario)	489,473	587,367	685,262	783,156	881,051	978,945	25,290	50,580	75,869	101,159

3.2.5 Affordability Analysis

An affordability analysis at the sub-county level for three scenarios showed gaps in projected household electricity costs versus affordability, notably at higher demand tiers from population and energy needs growth. Only the Kaiti sub-county faced an affordability gap (Table 3-16) in the low-demand scenario, underscoring the challenge of financing higher-tier electricity access.

Table 3-16: Affordability Analysis: Domestic Electrification - Low Demand Scenario[26]

Sub-county	Average amount per household spent (KES) on electricity per month (2032)	Extrapolated total electricity expenditure per year in 2032 (Million KES)[27]	Modelled Electricity Cost (million KES)	Deficit (Million KES)
Kaiti	906.3	196.7	634.3	-437.6
Mbooni	2,692.50	1,946.2	806.2	1,139.9
Kibwezi West	2,660.9	861.6	408.2	453.4
Makueni	1,058.5	1,318	396.4	921.5
Kilome	1,037.5	435.2	369.3	65.9
Kibwezi East	1,642.7	1,171.4	175	996.4
County Totals	9,998.40	5,929.1	2,789.5	3,139.6

Further info on Table 3-18 above[28,29]

26 Investopedia. (n.d.). Future value of money calculations. Investopedia. Retrieved November 20, 2022, from **https://www.investopedia.com/articles/03/082703.asp**

27 The extrapolated total electricity expenditure is arrived at by using the expected number of households (projected at a rate of 1.67%) and the average electricity expenditure in 2019 obtained from primary data collection. The model's discount rate (10%) is used to obtain the value of money in 2026. The average amount spent on electricity per household in 2026 is calculated based on the future value84 of the amount spent per household in 2021 as per the primary household surveys assuming a 10% annual increment.

28 Future value of money calculations: Available at: **https://www.investopedia.com/articles/03/082703.asp. (Retrieved on: 11/20/2022)**

Table 3-17 reveals that under the high-demand scenario, every sub-county experiences affordability gaps in electricity, due to increased energy demands and population growth. This indicates opportunities for enhancing quality of life and income via productive energy utilization.

Table 3-17: Affordability Analysis: Domestic Electrification - High Demand Scenario

Sub-county	Average amount per household spent (KES) on electricity per month (2032)	Extrapolated total electricity expenditure per year in 2032 (Million KES)	Modelled Electricity Cost (Million KES)	Deficit (Million KES)
Kaiti	906.3	196.7	1,412.5	-1,215.7
Mbooni	2,692.50	1,946.2	2,300.3	-354.1
Kibwezi West	2,660.9	861.6	1,991.2	-1,129.6
Makueni	1,058.5	1,318	2,145.6	-827.6
Kilome	1,037.5	435.2	1,223.9	-788.7
Kibwezi East	1,642.7	1,171.4	1,610.2	-438.9
County Totals	**9,998.40**	**5,929.1**	**10,683.7**	**-4,754.6**

As shown in Table 3-18, in the high-demand grid intensification scenario, affordability gaps are present only in Kaiti and Kilome, indicating that higher grid connectivity could reduce costs through economies of scale. This situation points to the necessity for creative financing strategies.

Table 3-18: Affordability Analysis: Domestic Electrification - High Demand Scenario, Grid Intensification

Sub-county	Average amount per household spent (KES) on electricity per month (2032)	Extrapolated total electricity expenditure per year in 2032 (Million KES)	Modelled Electricity Cost	Deficit (Million KES)
Kaiti	906.3	196.7	1,065.1	-868.3
Mbooni	2,692.50	1,946.2	1,403.6	542.6
Kibwezi West	2,660.9	861.6	779.6	82
Makueni	1,058.5	1,318	781	536.9
Kilome	1,037.5	435.2	665.3	-230.1
Kibwezi East	1,642.7	1,171.4	410.6	760.7
County Totals	**9,998.40**	**5,929.1**	**5,105.3**	**823.8**

3.2.6 Institutions Electrification Pathways and Statistics

Institutional electrification used a mix of grid intensification and off-grid methods, selecting the least expensive technology for institutions over 600m from distribution transformers, based on closeness to the nearest electrified settlement cluster.

3.2.6.1 Health care facilities

44 healthcare facilities were flagged as unelectrified (not connected to the grid) based on this analysis. These are symbolised in light blue in Figure 3-10 below.

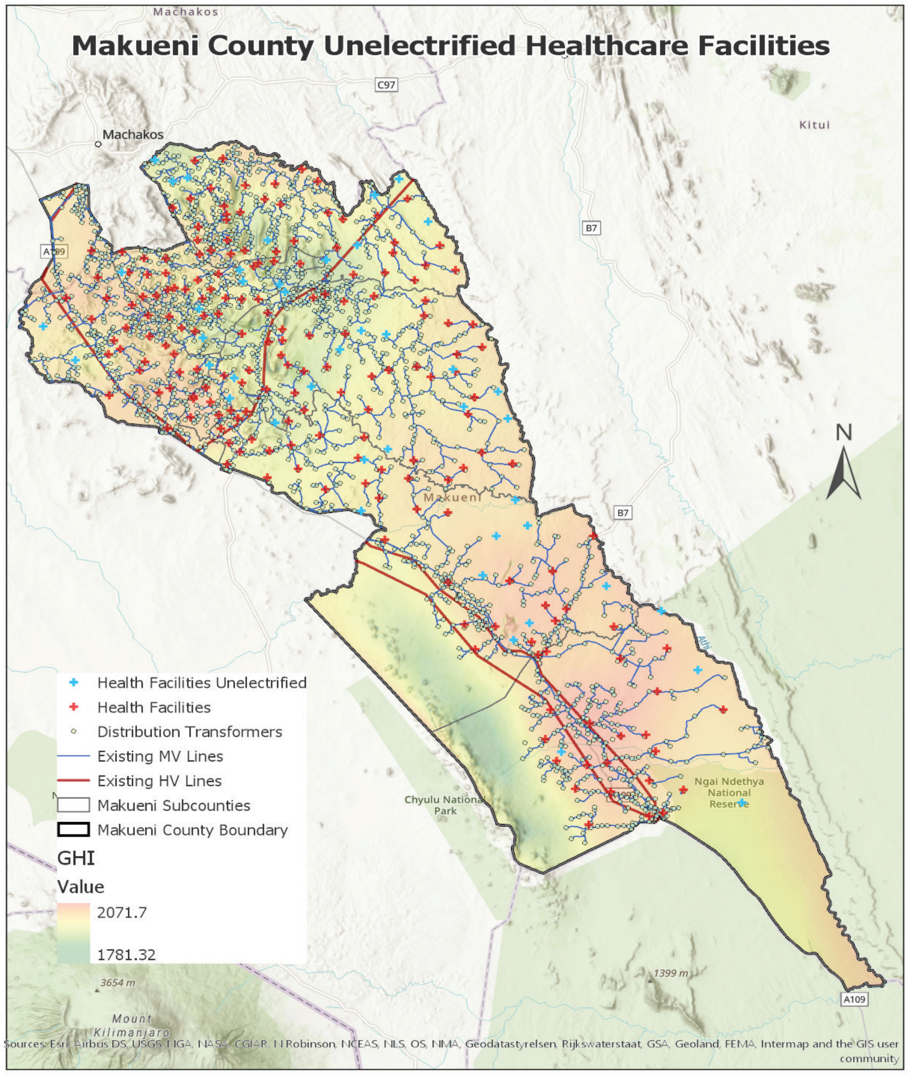


Figure 3-10: Map showing unelectrified health care facilities in Makueni County

Table 3-19 presents a summary of least-cost electrification technologies for health care facilities based on the findings from the GIS proximity analysis. The data shows that stand-alone solar PV systems will electrify 73% of healthcare facilities, with the remaining 27% connecting to the grid as the most economical choice.

Table 3-19: Electrification technologies for Unelectrified Health Care Facilities

Sub-county	Grid	SA PV	Totals
Kaiti	2	4	6
Kibwezi East	1	3	4
Kibwezi West	2	7	9
Kilome	0	3	3
Makueni	3	10	13
Mbooni	4	5	9
County Totals	**12**	**32**	**44**

3.2.6.2 Educational facilities

170 schools in the county were identified as unelectrified, depicted in blue in Figure 3-11.

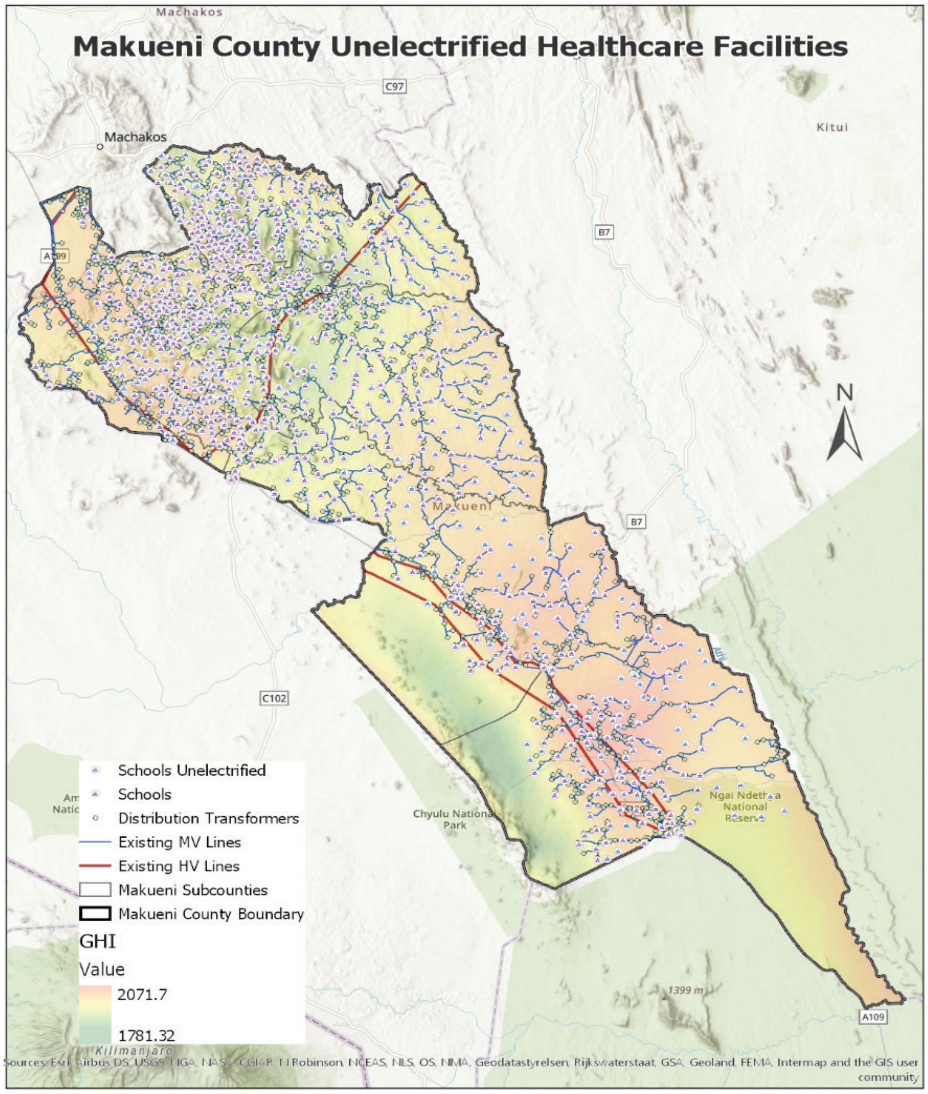


Figure 3-11: Map showing unelectrified schools in Makueni County

Table 3-20 summarizes the electrification technology options available for powering educational facilities.

Table 3-20: Electrification Technologies for Unelectrified Schools

Sub-county	Grid	SA PV	Totals
Kaiti	1	5	6
Kibwezi East	7	25	32
Kibwezi West	11	30	41
Kilome	2	13	15
Makueni	11	29	40
Mbooni	9	27	36
County Totals	**41**	**129**	**170**

Similar to healthcare facilities, the majority of schools (76%) will adopt stand-alone solar PV systems, while 24% will utilize grid electricity, making solar PV the appropriate option for off-grid electrification.

3.2.6.3 List of prioritized potential intervention options

Figure 3-12 highlights clusters for electrification: grid extension areas (maroon), hydropower mini-grids (purple), and standalone solar home systems (brown), based on feasibility and cost-efficiency across Makueni County. Grid densification targets Mbooni, Kaiti, Kilome, and parts of Kibwezi, while standalone solar systems are proposed for Makueni and northern Kibwezi West, requiring further detailed feasibility for effective implementation by 2032.

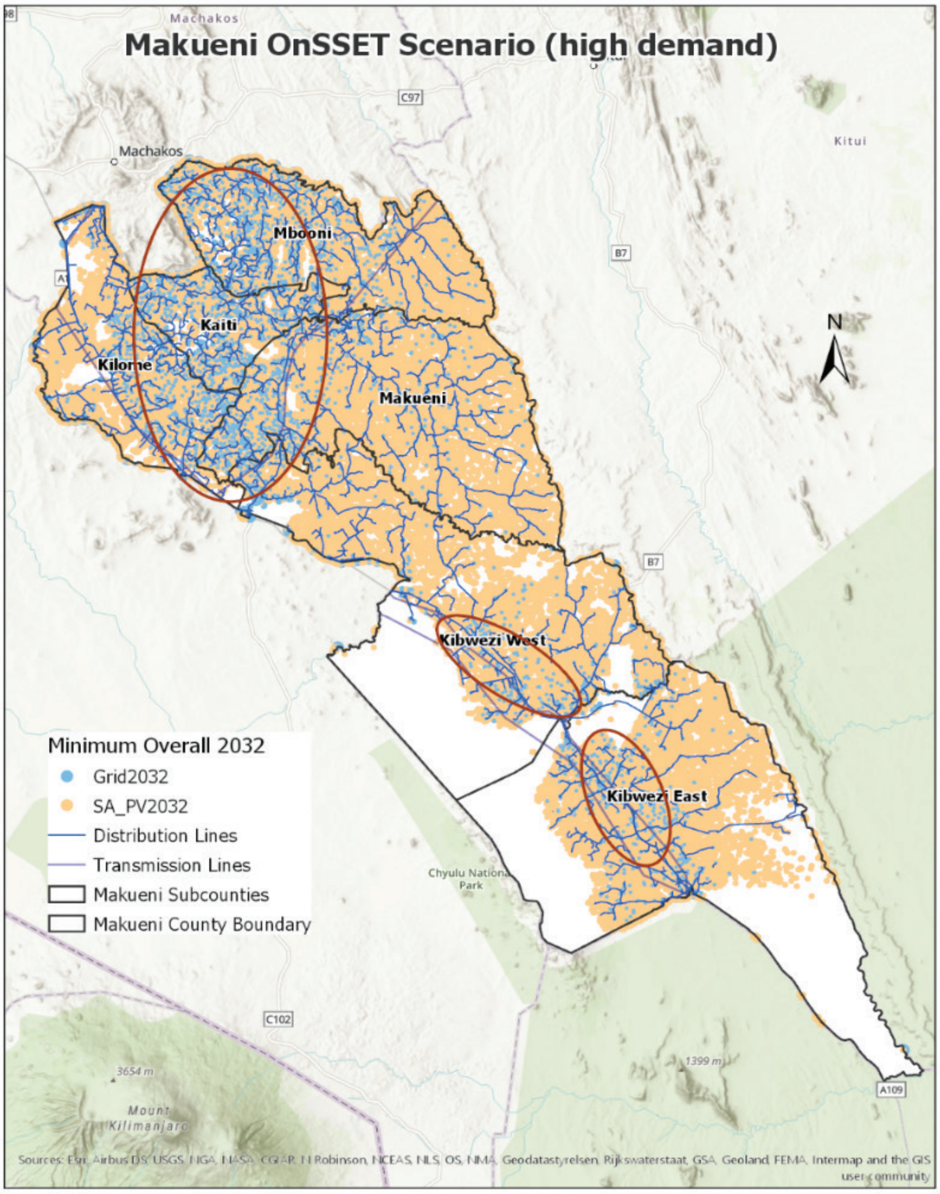


Figure 3-12: Map showing potential areas for setting up power plants

3.2.7 Barriers to increasing electricity access and potential interventions

Table 3-21 examines the barriers to accessing electricity, while Chapter 5 discusses strategies to enhance electricity access.

Table 3-21: Barriers to electricity access

Barrier	Description	Potential intervention
Distance to distribution infrastructure and transformer failures	The main reasons given by institutions in rural areas for lack of electrification was the distance from the grid or transformer and technical failures.	Install additional transformers on existing medium-voltage to connect households within and beyond 600 meters of existing distribution transformers.
High connection fees	FGDs and PUE assessments revealed that high connection fees is one of the barriers preventing grid connection with both domestic and commercial consumers.	Provide mechanisms to provide connection to low-income households in rural areas.
Low-income levels	As shown in Section 3.1.2.1, conservatively speaking, more than half of HHs have an income of less than 10,000 per month and thus cannot afford electricity services. This means that even if the HHs are connected out of public good, they will consume less electricity. The low-income levels may also hinder the ability to acquire standalone systems.	Put in place efforts to improve households' income through supportive productive use of energy programs. This involves providing access through the grid, mini-grids and SHSs with at least 200 W capacity. The goal is to ensure sufficient energy supply to stimulate productive uses, particularly targeting women and youth.
Lack of clear roadmap and coordinated efforts	Lack of integrated energy access roadmap/plan that clearly states the targets, priority areas of interventions, investments required, and concrete partnerships may be a hindrance to speedy energy access in the county.	Develop clear roadmap and policy to implement the CEP.
Limited funding	Limited funding for the energy sector due to competition with other development sectors.	Provide additional funding allocation to energy projects or come up with innovative financing models. Scaling up off grid service through subsidy scheme.

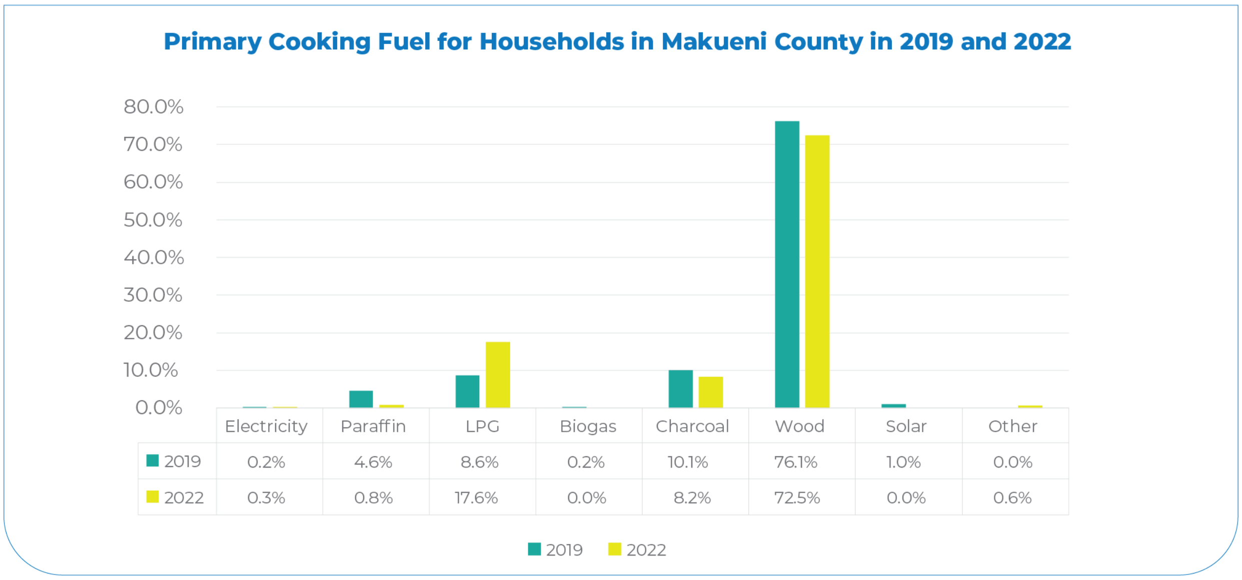
3.3 Access to Modern Cooking Solutions

The CEP aligns with the IEA's clean cooking access definition of clean cooking access, emphasizing technologies that minimize health-harming pollutants[30]. These include natural gas, LPG, electricity, bioethanol, and biogas. Under the Multi-Tier Framework for Clean Cooking[31], clean cookstoves are classified as tier 4 and above.

3.3.1 Energy for Cooking Access: Households

In Makueni, firewood remains the primary cooking fuel, dropping marginally from 76.1% in 2019 to 72.5% in 2022. Charcoal use, on the other hand, dropped from 10.1% in 2019 to 8.2% in 2022, attributed to a commercial production ban. In addition, LPG costs keep increasing, thus impacting usage.

Households with small land parcels struggle to access firewood, which is expensive. The rainy season worsens availability of firewood, and there's limited awareness of improved cookstoves.



	Electricity	Paraffin	LPG	Biogas	Charcoal	Wood	Solar	Other
2019	0.2%	4.6%	8.6%	0.2%	10.1%	76.1%	1.0%	0.0%
2022	0.3%	0.8%	17.6%	0.0%	8.2%	72.5%	0.0%	0.6%

Figure 3-13: Primary cooking fuel in Makueni County

Access to clean cooking fuels in Makueni grew from 10% in 2019 to 17.9% in 2022, mainly due to the uptake of LPG. However, increasing prices and the reinstatement of VAT[32] on LPG posed challenges to sustained use, emphasizing the importance of promoting and adopting more efficient cooking methods, such as electricity. Yet, only 0.3% of electrified households in Makueni utilize electricity for cooking, limited by issues related to cost, awareness, and reliability.

3.3.2 Energy for Cooking Access: Educational facilities (Learning institutions)

Firewood is the main cooking fuel for 95% of educational facilities, with 60% having no alternatives. There's very limited use of LPG (1.4%) and charcoal (1.1%) as secondary choices.

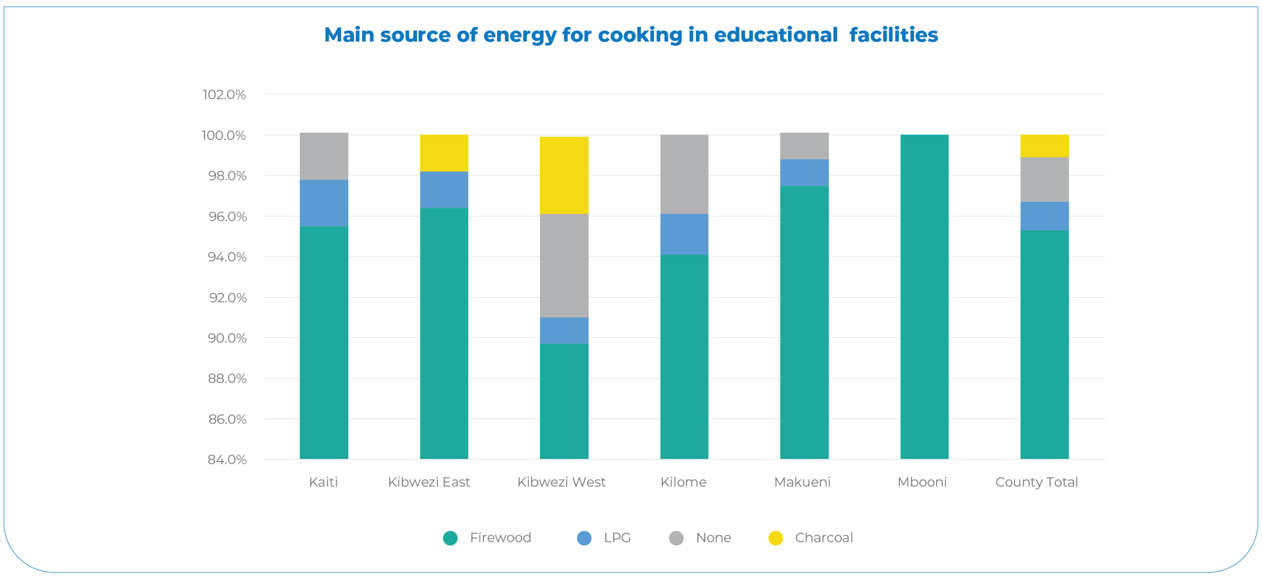


Figure 3-14: Primary source of energy for cooking in educational facilities

Given an opportunity to transition from the current primary fuel for cooking, most of the institutions preferred LPG, followed by biogas, then electricity as shown in Figure 3-15. This showed that most institutions aspire to have modern cooking fuels. There are also indications that the schools have biogas potential since it is chosen as the second most preferred fuel.

32 VAT on LPG Policy Brief. (2022). *VAT on LPG Policy Brief* (Version Jan 7, 2022). Retrieved June 20, 2023, from https://mu.ac.ke/VAT_on_LPG_Policy_Brief_Jan_7_2022_3.pdf

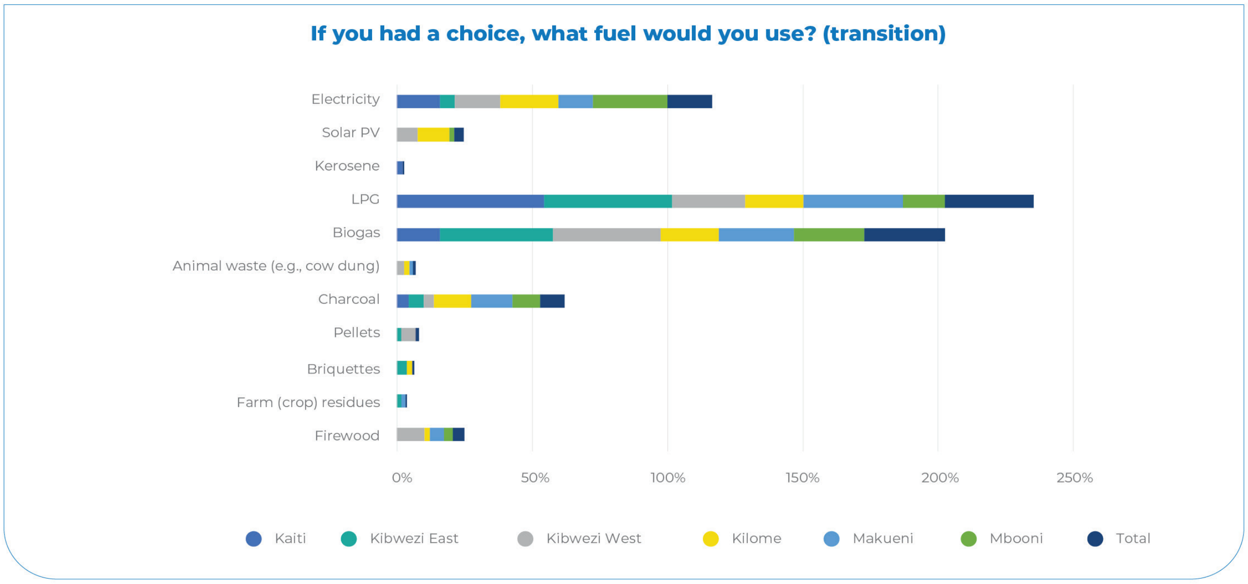
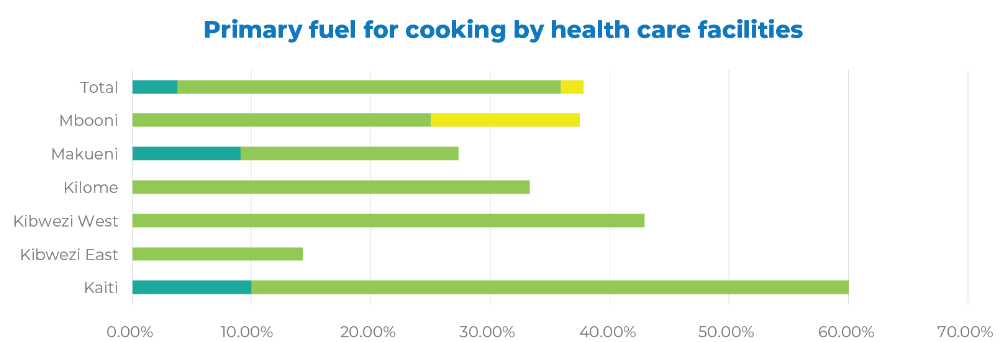


Figure 3-15: Willingness of education facilities to transition to modern cooking fuels.

3.3.3 Energy for Cooking Access: Health Care Facilities (HCFs)

37.7% of healthcare facilities have kitchens for cooking. Among them, 32.1% use LPG, 3.8% use charcoal, and 1.9% use firewood, with notable sub-county variation as shown in Figure 3-16.



	Kaiti	Kibwezi East	Kibwezi West	Kilome	Makueni	Mbooni	Total
Charcoal	10.00%	0%	0%	0%	9.10%	0%	3.80%
LPG	50.00%	14.30%	42.90%	33.30%	18.20%	25.00%	32.10%
Firewood	0%	0%	0%	0%	0%	12.50%	1.90%

Charcoal LPG Firewood

Figure 3-16: Primary fuel for cooking used by health care facilities

3.3.4 Energy for Cooking Access: MSMEs

33% of MSMEs cook in their premises, primarily using firewood (14.3%), charcoal (11.4%), LPG 4.1%, and electricity 1.7% as shown in Figure 3-17.

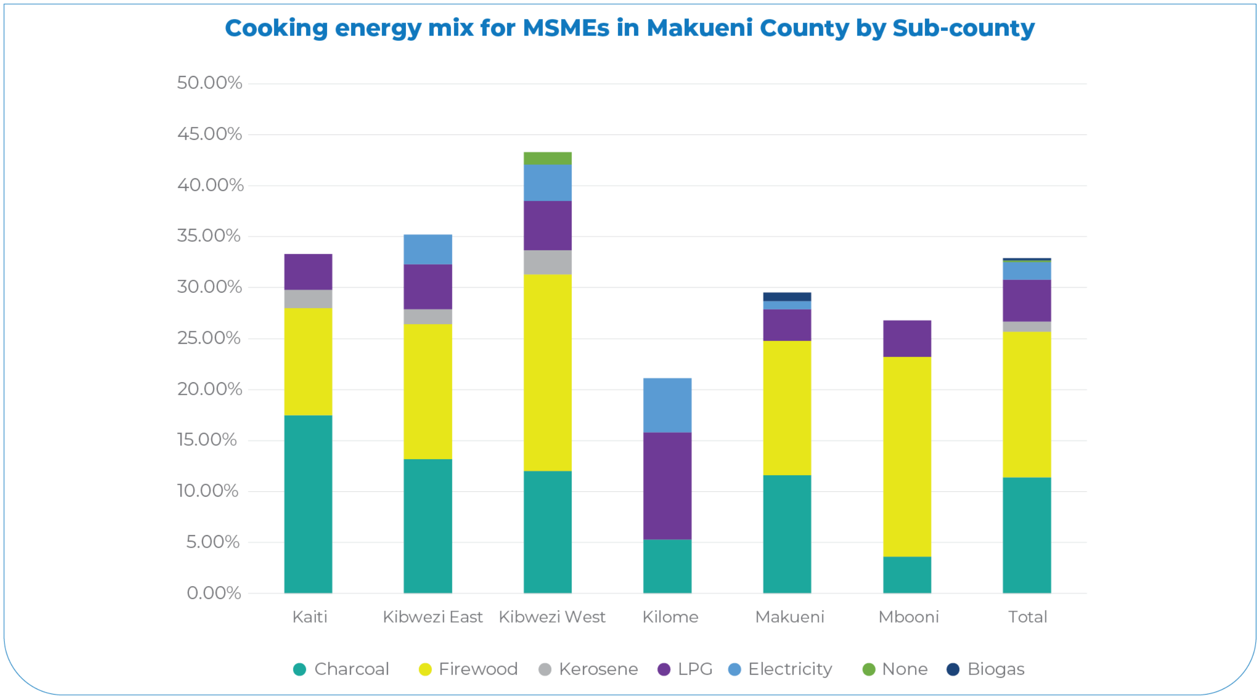
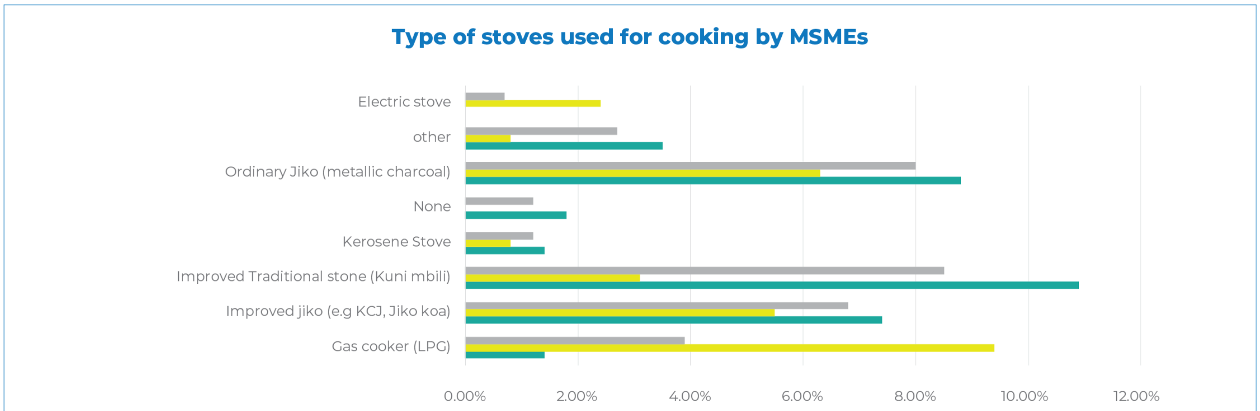


Figure 3-17: Cooking energy mix for MSMEs in Makueni County



	Gas cooker (LPG)	Improved jiko (e.g KCJ, Jiko koa)	Improved Traditional stone (Kuni mbili)	Kerosene Stove	None	Ordinary Jiko (metallic charcoal)	other	Electric stove
Total	3.90%	6.80%	8.50%	1.20%	1.20%	8.00%	2.70%	0.70%
Urban	9.40%	5.50%	3.10%	0.80%	0%	6.30%	0.80%	2.40%
Rural	1.40%	7.40%	10.90%	1.40%	1.80%	8.80%	3.50%	0%

Total Urban Rural

Figure 3-18: Types of stoves used for cooking by MSMEs

Healthcare facilities primarily use clean fuels, while households, schools, and MSMEs rely heavily on firewood.

An analysis of biomass consumption against existing supply across Makueni County shows a significant deficit (Figure 3-19), urging a transition to alternative fuels like LPG and electricity.

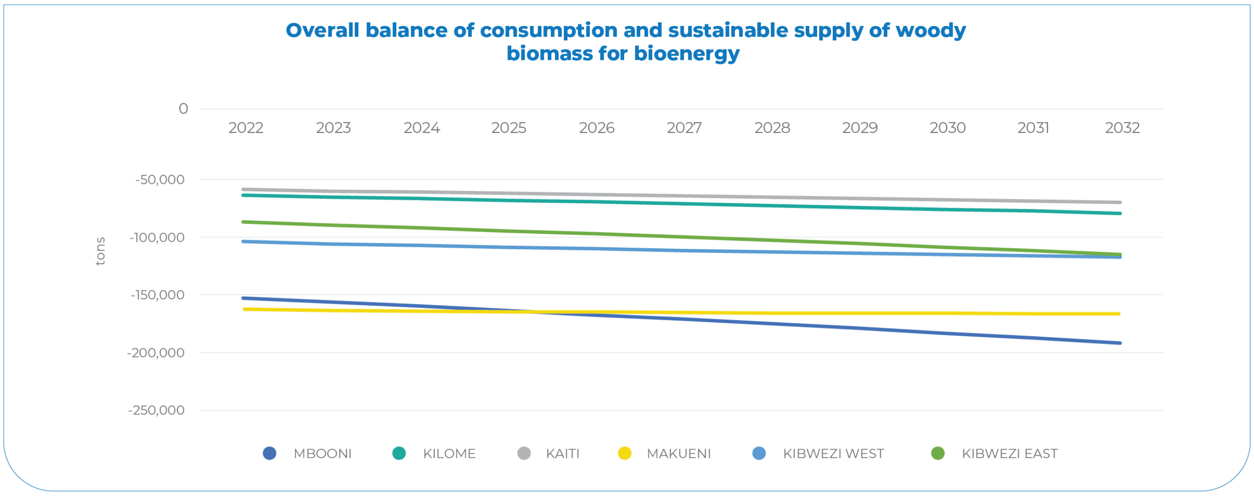


Figure 3-19: Bioenergy Balance in Makueni County

3.4 Outlook for clean cooking access

LEAP33, an integrated modelling tool, was employed to design and analyze three cooking sector scenarios, tracking energy consumption and production.

- Baseline scenario: Represents current initiatives, including MoE campaigns, biogas plant construction, and VAT exemption on LPG, reflecting existing government policy.
- Policy Scenario: Introduces additional policy interventions promoting clean cooking technologies, including subsidies for improved cookstoves.
- SDG Scenario: Aims for universal access to clean cooking energy by 2028, aligning with SDG targets and transitioning to modern cooking solutions.

LEAP modelling showed a significant reduction in cooking energy demand with clean cooking adoption. Total energy demand dropped from 5.2M GJ to 2.0M GJ in 2032 under BAU, Policy, and SDG7 scenarios as shown in Figure 3-20.

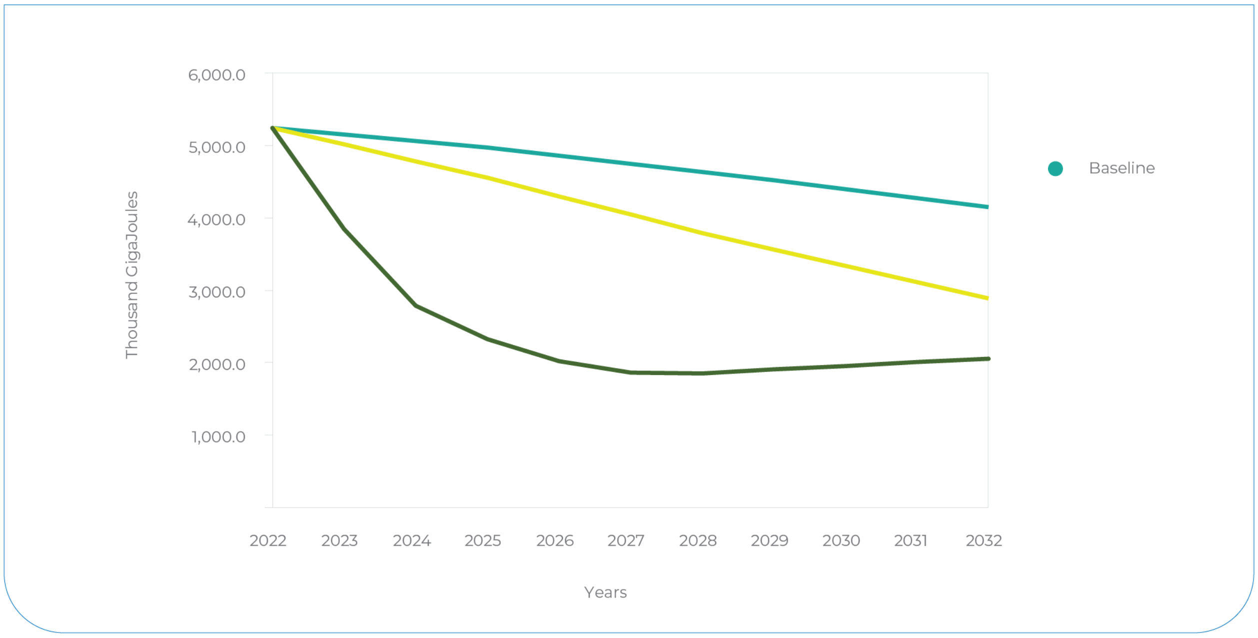


Figure 3-20: Energy Demand Comparison per Scenario (2022-2032)

33 Stockholm Environment Institute (SEI). (n.d.). *LEAP: Low Emissions Analysis Platform*. SEI. Retrieved March 20, 2023, from https://www.sei.org/projects-and-tools/tools/leap/

The implementation of the Baseline scenario is projected at USD 286 million, incorporating the expense of current national government policy interventions. The Policy scenario is estimated to cost USD 298 million and achieving SDG 7 requires USD 380 million as shown in Figure 3-21.

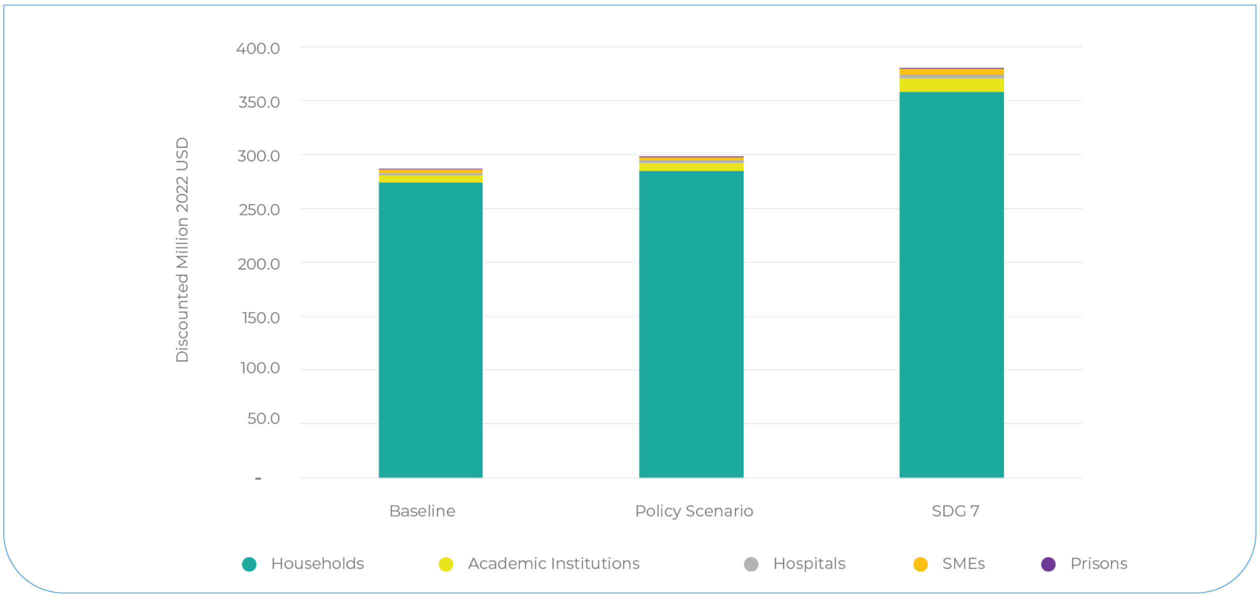


Figure 3-21: Cumulative Cost 2022-2032 Per Scenario Discounted at 10% to 2022

The consumption of electricity for cooking increases in all the scenarios. The demand increases from 0-0.05MW, 0-2.5MW, and 0-6.8MW in baseline, policy, and SDG scenarios respectively.

3.5 Barriers to clean cooking solutions access

Table 3-22 outlines the significant obstacles to expanding the use of clean cooking technologies in Makueni County.

Table 3-22: Barriers to clean cooking access in Makueni County

Barrier	Description of key issues
Institutional Barriers	• Clean cooking access is usually hindered by fragmented objectives between ministries (departments) e.g., between energy and environment departments. • To date, it is not clear which department in the Government of Makueni County is championing clean cooking and there is no roadmap for its development. • Cooking fuel/technologies have not been accorded attention e.g., little attention is given to cooking technologies in key government documents e.g. CIDP, ADPs etc. • Official data regarding cooking fuels, technologies, producers etc.
Policy shifts	• As highlighted in section 3.3.1, rising costs of LPG due to reintroduction of VAT had pushed some households to abandon the fuel and switch to firewood.
Limited Fuel and Stove supply (ICS, LPG, Ethanol stoves etc.)	• ICS producers are small-scale. • LPG Supply chain is limited mainly to major urban areas like Wote, Kibwezi etc. with little presence in village trading centres.
Low income	• Low incomes and lack of infrastructure in rural areas undermine the initiative to convert rural household cooking to LPG, bioethanol, e-cooking, etc.
Low access to reliable electricity	• Besides the perception of the high cost of cooking using electricity, low rates of reliable electricity access (currently at 29%) are also a major barrier to electric cooking.
Cost/Affordability	• Most households in Makueni still depend on firewood because they collect it from the local environment freely (rural) or purchase it at low prices (urban) compared to most modern fuels. So they are unlikely to switch to modern fuels if they are unaffordable.
Limited awareness of clean cooking fuels and technologies	• Most people of Makueni are not aware of clean cooking fuels and technologies e.g. bioethanol, e-cooking, etc.

3.6 Clean cooking intervention options

This section delves into the various strategies and measures that can be implemented to promote the adoption of clean cooking technologies. These include:

- Strong leadership and financial support are crucial for achieving universal clean cooking access in Makueni County.
- Expand LPG distribution with fiscal incentives for low-income households to increase clean cooking access.
- Implement a 25% subsidy for Improved biomass cookstoves, aiming for wider adoption in rural areas.
- Enhance bio-ethanol stove adoption through distribution, incentives, and awareness campaigns targeting women and youth.
- Develop large-scale and domestic biodigesters through Public-Private Partnerships, focusing on waste-rich areas.
- Promote electric cooking in urban areas with reliable electricity and higher incomes through incentives.
- Collaborate with organizations for clean cooking in schools and communities, and explore carbon market access.

4 ENERGY EFFICIENCY AND CONSERVATION

Energy Efficiency (EE) focuses on using less energy for the same tasks with efficient technologies, while Energy Conservation (EC) involves reducing consumption through behaviors like switching off lights when not in use and using renewable energy sources. This Chapter assesses EE&C practices across Makueni County's public buildings, households, institutions, and industries.

4.1 Energy Efficiency and Conservation Standards, Benchmarks and Guidelines

The guidelines that were used to conduct energy efficiency assessments were obtained from the Kenya National Energy Efficiency Strategy, Minimum Energy Performance Standards, The Excellence in Design for Greater Efficiency (EDGE), and the Kenya Green Buildings Society (KGBS) guidelines[34].

4.2 County Office Buildings and Level 4&5 Hospitals

The assessment was limited to building envelope design, lighting, air-conditioning as well as cooking and hot water systems as described in the sections below. The assessment found lighting, air conditioning, and refrigeration as top energy consumers.

4.2.1 Building Envelope Design and Orientation

The KGBS Guidelines advise that buildings should orient east-west, and use reflective colours, shading devices, and insulated windows to minimize heat gain. They also recommend a 30% window-to-wall ratio for optimal lighting and reduced solar thermal load.

The county public buildings' assessment showed varied east-west orientation. County Offices and Makueni Hospital aligned east-west, while others like Trade and Treasury Departments were south-north and some had dark roof colours.

Table 4-1: Building envelope design

Building Envelope	Offices %	Hospitals %	Average %
Building Orientation (East to West)	36	100	63
Light Color Exterior Walls	61	70	65
Light Color Roof	21	30	25
Window Shading	14	10	13
Window to Wall Ratio	48	40	44
Walls Shading/Trees along facades	50	70	58

Most county public buildings use LED bulbs, the most efficient lighting, except the County Referral Hospital, which mainly uses fluorescent lighting as shown in Table 4-2.

Table 4-2: Lighting Efficiency in Makueni Public Buildings

Lighting Use & Efficiency	County Office %	Sub-county & Dept. %	Makueni L5 Hosp. %	Sub-county L4 Hosp. %	County Average* (All buildings) %
Lights ON and not in Use	0	14	0	23	15
Occupancy Sensor (indoor)	no	no	no	no	n/a
Daylight Sensor (outdoor)	no	no	yes	no	n/a
LED bulb	73	61	4	45	52
Fluorescent bulb	27	36	94	36	40
CFL (Energy Saver) bulb	0	3	2	18	8
Incandescent/Halogen bulb	0	0	0	1	0
Other bulbs	0	0	0	0	0

* *The County average is weighted across the populations in sub-counties and is not a simple average of sub-county averages.*

The assessment showed manual lighting management with 15% of lights on in unoccupied rooms observed as 'on', indicating mixed energy conservation performance. Only the County Referral Hospital had daylight sensors for outdoor lighting, with no occupancy sensors found in any assessed buildings.

34 IFC, & Sintali. (2020). *EDGE Expert Training: Guidelines for Green Buildings*. Nairobi: IFC.

4.2.2 Buildings Cooling and Refrigeration Systems

Most county public buildings use passive cooling, except for executive offices and specific hospital areas such as IT rooms, and hospital diagnostic and procedure rooms. Refrigerator use was limited to hospitals. Most of the air conditioning (AC) units in county buildings do not meet the minimum energy efficiency ratio as the standard. Table 4-3 shows the proportion of air conditioning units whose EER was equal to or above the specified standard and refrigerators that meet the MEPS.

Table 4-3: Energy Efficiency Ratio

Cooling Equipment Efficiency	County Offices %	Sub-county & Dept. Offices %	Makueni L5 Hosp %	Sub-county L4 Hosp. %	County Average *(all buildings) %
AC % above min EER	100	33	35	18	39
Refrigerators % meeting MEPS		75	0	0	15

**The County average is weighted across the populations in sub-counties and is not a simple average of sub-county averages.*

4.2.3 Buildings Water Efficiency

The assessment of water appliances revealed that the adoption of low-flow appliances is low as shown in Table 4-4. Also shown is the penetration rate of rainwater harvesting and wastewater recycling.

Table 4-4: Water appliance efficiency

Water faucets & Appliances	County Offices %	Sub-county & Dept. Offices %	Makueni L5 Hosp %	Sub-county L4 Hosp. %	County Average (All buildings) %*
Low flow appliances	81	27	13	18	27
Rain water harvesting	0	50	0	50	42
Grey water treatment	0	0	0	0	0

** The County average is weighted across the populations in sub-counties and is not a simple average of sub-county averages.*

County offices had high adoption of low-flow faucets and water closets, with some facilities using pit latrines and sub-county facilities implementing rainwater harvesting, but none had grey water recycling systems installed.

4.2.4 Water Heating

Water heating in hospitals focused on inpatient areas, and hybrid technologies like instant heated showers and solar heaters, with several showers lacking heating, as shown in Figure 4-1.

Figure 4-1: Hot water appliances.

Solar water heating and instant heaters are efficient, but the referral hospital's solar water heating system underperformed due to unreliable water supply, leading to reliance on less efficient electric bulk water heaters. Most facilities wash laundry with cold water and a few use machines with electrical heaters.

4.2.5 Cooking

Most county facilities, mainly hospitals, use LPG for cooking due to its cleanliness and efficiency. There was minimal use of firewood and charcoal, with one hospital using both gas and charcoal.

4.3 Renewable Energy and Energy Efficiency

County facilities are increasingly adopting renewable energy, with solar PV systems installed in places such as referral hospitals and Mbooni sub-county offices. Over 33% of these facilities have solar installations, with plans to expand capacity as needed. Households, Learning Institutions, Health Centres and MSMEs

This section describes energy efficiency in households, learning institutions, health centres and MSMEs.

4.3.1 Energy Efficiency in Households

The households in Makueni County have a high adoption rate of highly efficient LED lighting bulbs as shown in Table 4-5.

Table 4-5: Household lighting bulb by Sub-county

Light Bulb	Kaiti %	Kibwezi East %	Kibwezi West %	Kilome %	Makueni %	Mbooni %	Average* (all sub-counties) %
LED	100.00	70.00	71.13	88.89	91.49	77.97	79.79
Fluorescent	7.14	0.00	14.43	4.44	0.00	0.00	5.82
Energy Saver	0.00	76.67	46.39	11.11	10.64	25.42	31.85
Incandescent	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Halogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	3.09	0.00	0.00	0.00	1.02

* *The County average is weighted across the populations in sub-counties and is not a simple average of sub-county averages*.

Kaiti and Makueni sub-counties led in LED bulb adoption, with minimal use of inefficient incandescent and halogen bulbs, and significant use of CFL and fluorescent bulbs. Transition to LED is encouraged for higher efficiency. 67% of households use traditional three-stone cookstoves, and 38% use inefficient metallic ones, with only 26% adopting improved cookstoves. Efforts to shift towards more efficient options like LPG are needed.

4.3.2 Energy Efficiency in Learning Institutions

Learning institutions have a low adoption rate of LED lighting bulbs. The most used light bulbs are CFLs, followed by fluorescents. Inefficient incandescents and halogens are still prevalent, especially in institutions in Kaiti and Kilome. Transitioning these institutions to efficient lighting is crucial. LED bulbs offer the highest energy savings. Rural and urban adoption rates of efficient bulbs are at 16%, indicating a need for improvement.

4.3.3 Energy Efficiency in Health Centres (Levels 1 to 3)

The adoption of efficient LED bulbs in Health Centres, particularly in Kibwezi East and Kilome, is low. Health Centres mainly use CFL and fluorescent bulbs, with inefficient incandescent bulbs being the most used in Makueni and Mbooni, necessitating a shift to efficient LED lighting. Health facilities in urban areas have higher LED bulb adoption than those in rural areas, highlighting the need for energy efficiency programs focused on rural facility lighting.

Table 4-6: Health centres light bulb adoption

Light Bulb adoption %	Kaiti	Kibwezi East	Kibwezi West	Kilome	Makueni	Mbooni	*County average (All sub-counties)
LED	20.00	0	21.40	0	27.30	12.50	17.00
Energy saver	30.00	42.90	35.70	66.70	18.20	62.50	37.70
Fluorescent	40.00	0	28.60	0	18.20	0	18.90
Incandescent	0	0	0	0	18.20	12.50	5.70
Other	0	14.30	0	33.30	0	0	3.80

** The County average is weighted across the populations in sub-counties and is not a simple average of sub-county averages.*

4.3.4 MSMEs

In Makueni County, MSMEs commonly use electricity for lighting, refrigeration, air conditioning, and cooking, with low LED adoption, notably in Kibwezi East. Most MSMEs use CFL and fluorescent bulbs, with inefficient incandescent bulbs prevalent in Kaiti, Kibwezi West, and Kilome. These sub-counties need to transition to efficient LED lighting.

Table 4-7: MSMEs light bulb adoption

Lighting Bulb adoption %	Kaiti	Kibwezi East	Kibwezi West	Kilome	Makueni	Mbooni	*County Average
LED Bulb	36.80	0	24.10	10.50	19.40	14.30	18.40
Energy saver bulb	49.10	67.60	49.40	57.90	61.20	67.90	59.00
Fluorescent	0	5.90	0	10.50	2.30	1.80	2.40
Incandescent bulb	7.00	1.50	9.60	10.50	6.20	1.80	5.80
Other bulbs	0	4.40	0	5.30	1.60	1.80	1.70
None	0	4.40	3.60	5.30	5.40	3.60	3.90

** The County average is weighted across the populations in sub-counties and is not a simple average of sub-county averages.*

4.3.5 Energy Consumption in Industries

Makueni County hosts a few energy-intensive industries, including a fruit processing factory, a bio-diesel plant, and commercial farms, with less intensive ones like coffee and dairy plants. For more information, refer to the main technical report.

4.4 Barriers towards Energy Efficiency and Conservation

The county's major constraints in implementing energy efficiency measures include financial resources and technical capability shortages.

4.4.1 Financial Resources

The county's limited funds from the national exchequer and grants restrict equipment efficiency upgrades, impacting energy-efficient choices, yet it plans to foster energy service companies (ESCOs) involvement in energy efficiency programs.

4.4.2 Access to Quality Appliances

The market's influx of sub-standard energy appliances, such as unreliable LED lighting, hinders efficient adoption rates, urging the County Government to enforce quality control measures within its jurisdiction.

4.4.3 Energy Management Teams, Governance & Training

The county has formed energy teams for efficiency programs but needs capacity building for competent officers and compliance inspection per the Energy Act, requiring resources for policy development and energy management systems.

5 CROSS-CUTTING ISSUES

5.1 Gender and Social Inclusion

Traditional gender roles expose women to indoor pollution from firewood use, while the financial strains of transitioning to cleaner cookstoves affect both genders. Market mismatches between fuels and technologies favour charcoal users, leaving firewood users disadvantaged. Men feel the burden of buying alternative fuels, with poverty exacerbating firewood access issues. Poor quality of clean cookstoves forces a return to traditional methods. Both genders seek reliable electricity for business, noting the limitations of solar power compared to the grid. PLWDs struggle with access to cooking fuels and appliances, advocating for more accessible services. Additionally, youth face significant employment challenges.

5.2 Environment and Climate Change

Climate change has led to unpredictable rainfall, affecting crops and bee farming. The government's restrictions on firewood and charcoal collection to mitigate climate change have made these resources scarce and expensive, impacting residents. There's a call for tree-planting initiatives and support for agricultural practices like irrigation to enhance sustainability and reduce reliance on rain-fed agriculture. Support could be channelled through existing farmer self-help groups.

5.3 Risk and Disaster Management

Significant challenges with the grid infrastructure include damaged electricity posts, low supply affecting businesses, appliance damage due to voltage surges, and unreliable electricity with long restoration times. Kenya Power must strengthen and improve the grid's quality for safety and better service.

5.4 Communication

During public consultations for the CIDP, it became evident that there were shortcomings in citizen engagement on energy issues, with some people feeling marginalized because they received invitations to forums late or they were not invited at all. The community seeks involvement in all project phases, not just planning. Access to energy is valued for its role in powering communication devices such as mobile phones, radios, and TVs. Television is particularly seen as aspirational for its ability to provide information and facilitate connection.

5.5 Research and Development

Research and development in Makueni County focuses on improving energy access and productive use, with an emphasis on e-mobility for government vehicles and agricultural motorbikes. Strategies include adoption plans, grid impact assessments, and converting combustion engines to electric ones to promote broader e-mobility adoption.

6 SUMMARY OF PROJECTS/ PROGRAMS AND BUDGET

This section offers a concise overview of various projects along with their allocated budgets, serving as a snapshot of the broader initiatives detailed in the Master Technical Report. This summary is designed to guide readers towards the detailed information available in the Master Technical Report, ensuring they have access to all necessary details for informed decision-making.

Table 6-1: Programmes and Budget

Item	Cost (KES)
Electricity Access and Productive Use of Energy	72.2 B
Grid densification, intensification and extension	27.3 B
The hydroelectric power (HEP) development program	15.1 B
Solar power development programme	TBC
Installation of standalone solar home systems	27.1 B
Feasibility study for the provision of power for two industrial parks in the CIDP III	7 M
Mapping and development of attractive wind projects	6 M
Solarisation of Health Care Facilities (HCFs)	500 M
Schools electrification program	680 M
Installation of 10kW solar plant and electric fences installation in Kilala Dairy Centre	5 M
Electrification of agricultural cooperatives with pilots at Kathozweni, Kikima, and Kilala Dairy processing plans	2 M
Mwaanzi Booster Solar Station powered installation and associated pipeworks	9 M
Provision of appropriate power solutions for domestic water projects in Makueni County	5 M
Powering 43 small scale irrigations schemes earmarked in CIDP	870 M
Powering cold storage facilities	650 M
Provision of affordable and reliable energy solutions for agricultural processing plans (feasibility study)	3 M
Development of PURE investment prospectus (IP) for resource mobilisation	10 M
Bio-energy supply and clean cooking	1.9 B
Promotion of commercial farming of bioenergy crops	3 M
County programme on landscape restoration and woodfuel development	60 M
Equipping CTTIs with the capacity to offer training on improved cookstoves and alternative bioenergy	8 M
Enhancement of private sector participation in alternative sources of bioenergy	16 M
Awareness creation of clean cooking	3 M
Promotion of cookstoves and Fuels MSMEs	2 M
e-cooking	3 M
LPG investment to increase uptake of 13kg to 40% and6 kg LPG to 70% in urban and rural areas respec-tively	1.8 B
Energy Efficiency	153.5 M
Capacity building and development on energy efficiency	4.3M
Development of an e-mobility strategy	2 M
Conversion of county government 2-wheelers from internal combustion engines to electric mobility	50 M
Cross-cutting recommendations (energy policy, establishment of energy centres and energy access fund)	517 M
Establishment of energy centres	12 M
Development of energy policy	5 M
Establishment of energy access fund	500 M
Total	KES 74.9 B

7 IMPLEMENTATION, COORDINATION, MONITORING AND EVALUATION

The attainment of universal energy access by 2028 in Makueni County is dependent on the implementation of policies, programs and projects suggested in this document. This will require both horizontal, as well as vertical coordination with state, as well as Non-State Actors (NSAs). Horizontally, collaboration across various departments within Government of Makueni County will be crucial, while vertically, coordination will be required with national government agencies, including the Ministry of Energy, as well as other institutions such as REA and KPLC, among others. Additionally, collaboration with private sector, development partners, Micro-Finance Institutions (MFIs), civil society organisations (CSOs), community-based organisations (CBOs), among others, will be key.

For effective coordination, the Department of Infrastructure, Transport, Public Works, Housing and Energy will spearhead the process. A strong monitoring and evaluation framework will be required to track progress and give insight that can be used to correct performance to ensure impactful implementation. This framework should be collaboratively developed by the same department in conjunction with the Department for Finance, Planning, Budget & Revenue. Additionally, input from other stakeholders should be considered.

The rest of this chapter focuses on the implementation, coordination and monitoring and evaluation (M&E) framework for the Makueni 2022 CEP. There will also be training components to build capacity for the implementation and coordination of new solutions, technologies, and approaches. The procedures detailed in this chapter were derived from consultative meetings held with officials from the Government of Makueni County over the duration of the CEP development process.

7.1 Implementation and Coordination

Overseeing the implementation of the plan will require strengthening of technical energy expertise in the county government. The Directorate of Energy will be staffed with additional experts with prerequisite skills to enhance its capacity. It may include redeployment of officers who were appointed to support development of the energy plan from different departments. Capacity building initiatives highlighted in Chapter six will also be useful in fast tracking the implementation of the CEP. This may include redeployment of officers who were appointed to support development of the energy plan from different departments. This particular group of officers have received significant training during the development of the plan. Capacity building initiatives highlighted in Chapter six will also be useful in fast tracking the implementation of the CEP.

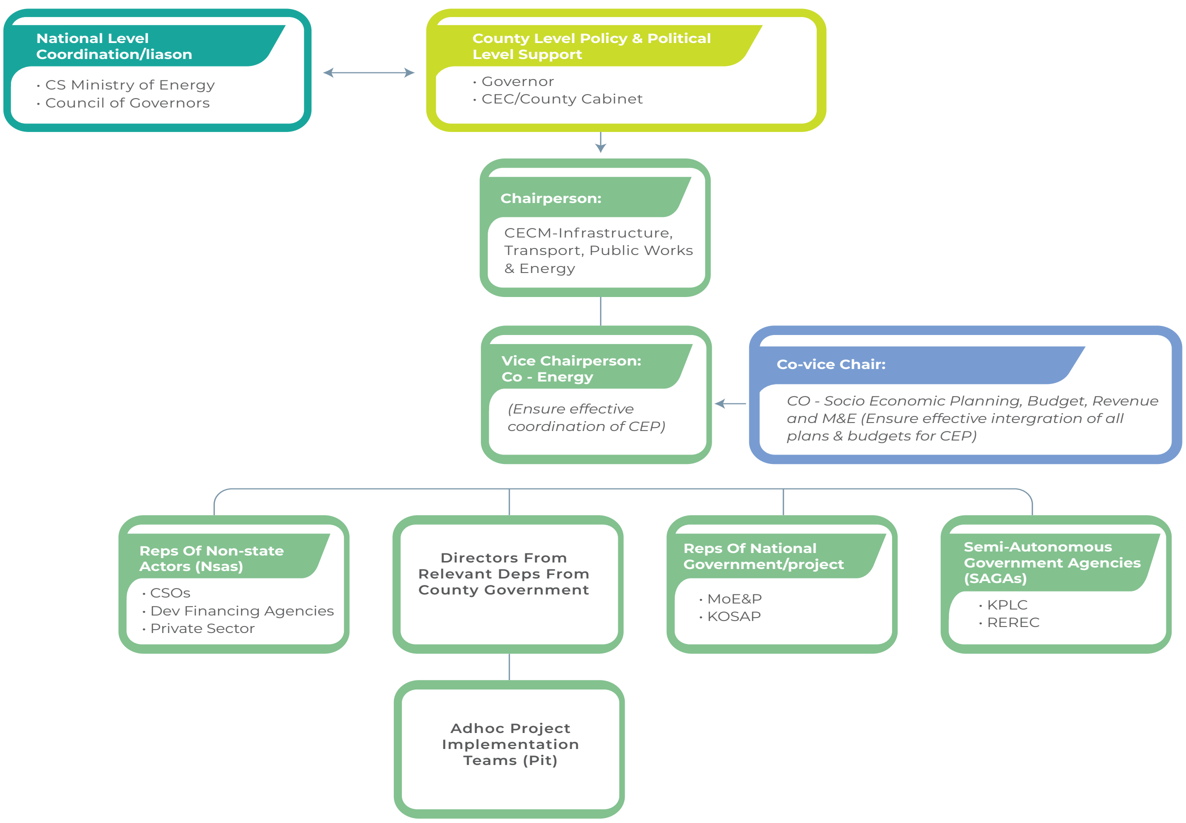


Figure 7-1: Constitution of the Proposed County Energy Plan Implementation Committee

While the Government of Makueni County is keen to promote a 'one-government-approach' in the management of its programmes and projects, consultative process during the development of the CEP revealed two major approaches currently being used to allocate budget for implementation of projects in the County. The first approach is where a particular department takes full responsibility for the design and allocation of resources for the implementation of projects that fall under its mandate. During key informant interviews, it emerged that this approach to budgeting may make the financial load too heavy for one department to carry, hindering resource efficiency and effectiveness in project implementation.

The second and most preferred approach is the integrated planning and budgeting, particularly in programs and projects that require coordination between different departments. This approach enhances collaboration working with each department, thus not only contributing financial resources but also technical expertise for success. The government will adopt this approach during implementation of all county CEP programs and projects to ensure success and mitigate against the implementation constraints.

7.2 Monitoring and Evaluation Framework

Monitoring and evaluation of the CEP will be led by the M&E officer attached in the Department from Monitoring and Evaluation directorate. The officer will submit a bi-annual progress report to the M&E directorate with a copy to CEP – IC and the Technical Working Group. Monitoring will focus on programs and projects recommended within the CEP. The insights obtained during the monitoring will be used to undertake corrective measures and ensure the implementation is within the planned path. Periodic evaluation will also be carried out. This will involve both ex-ante evaluation and ex-post evaluation of projects, programs, and policies that are in the CEP. Table 7-1 provides a Monitoring and Evaluation Framework with clear targets and indicators that will be used to guide CEP implementation.