



NAROK COUNTY ENERGY PLAN 2022-2027



Foreword



Narok County is proud to be among the first Counties in Kenya to develop the first generation County Energy Plan (CEP) as required by the Energy Act 2019 and based on the unique energy needs of the County. This Narok CEP sets out our ambitious priorities to accelerate the achievement of Sustainable Development Goal (SDG) 7, socio-economic growth and environmental sustainability of the County for the 2022-2028 period, in accordance with the county's development objectives. Currently, Narok County has low energy access rates with 90% of the population in the County relying on solid fuels for cooking and less than 20% have access to electricity. The County Government of Narok is keen to change these statistics and improve the lives of Narok people, and Kenya at large.

An estimated budget of KES 75.5 Billion will be needed to implement the prioritized projects and programmes of this CEP. The County Government of Narok will commit necessary resources to this plan. However, we recognize that the county resources will not be sufficient to achieve the targets in this CEP. In the spirit of SDG 17, I invite other partners from the National Government, private sector, and non-governmental organizations to walk this journey with us. To implement this Plan, a County Energy Planning (and Implementation) Committee (CEPC) has been established according to the Integrated National Energy Planning (INEP) framework. The CEPC will ensure that this CEP is aligned with the County Integrated Development Plan (CIDP), reviewed and updated periodically.

HE Patrick. K Ole Ntutu
Governor- Narok County



Preface

Following the inauguration of the 2010 Constitution, and the ratification of the Energy Act 2019, County Governments are required to develop and submit a county energy plan (CEP). This CEP has been developed not only in fulfilment of these Constitutional requirements but also to ensure that county-specific needs are factored in the planning process. Narok County Government is therefore pleased to be among the first Counties in Kenya to have attained this critical milestone of developing a data driven, integrated, inclusive CEP that both addresses its needs and complies with the Integrated National Energy Planning Framework as guided by the Ministry of Energy.

The Department of Energy, Water, Environment, Natural Resources and Climate Change has played the lead role in this CEP development process. The development of this plan involved extensive consultations with various stakeholders and background research facilitated by Strathmore Energy Research Centre and World Resources Institute through funding support from the UK Government, under the UK PACT Programme. A rigorous data collection exercise from the ward level and constant engagement with the county officers as well as other stakeholders were carried out during the development of this CEP.

The County is confident that the contents of this CEP represent the aspirations of the constituents of Narok County and the County Government. The final stages of this CEP were done at an opportune time when the County was developing the County Integrated Development Plan (CIDP) 2023-2027. The projects and interventions identified in the CEP provided direct inputs to the CIDP development process. The CEP also captured the aspirations of the new County Leadership as guided by the Governor's Manifesto. This Plan will be implemented by the County Energy Planning Committee (CEPC) with guidance from the office of the Governor. I am confident that the County government will allocate substantial funding to the implementation of this CEP. Furthermore, this CEP will act as a tool for both resource mobilization from development partners as well as for coordinated projects implementation in the County. It is our hope that this Plan will accelerate the achievement of the Sustainable Development Goal 7 - Affordable and Clean energy - in the county and help stimulate the socio-economic development and environmental stewardship of Narok County. We welcome the National Government, the Development Partners and NGOs, and local communities to support us in the implementation of this CEP.

Rotich Johana Kiplangat

CECM, Department of Environment, Energy, Water, Natural Resources and Climate Change
Narok County Government



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The World Resources Institute team comprised of: Benson Ireri (Co-Project Lead), Beryl Ajwang and Clint Ouma (Energy Access and PUE), Dimitris Mentis and Douglas Ronoh (Energy Access Explorer and OnSSET), and Christine Odeph (Communications).

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Executive Summary

Introduction

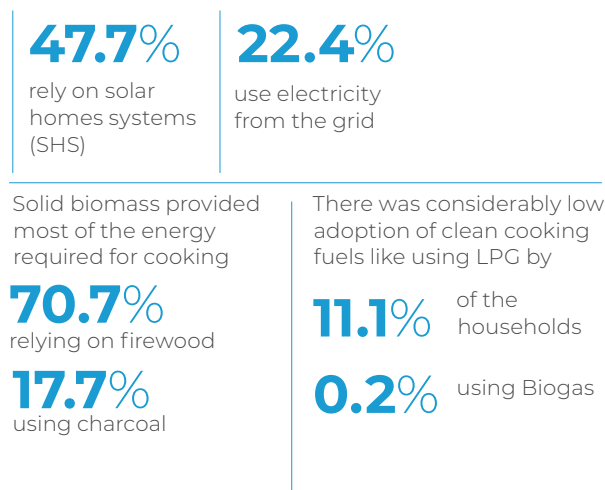
Narok County Government prepared this energy plan per the guidelines of the Draft Integrated National Energy Planning (INEP) Framework guidelines, 2020, in fulfilment of the county's constitutional mandate. The County Energy Planning process was data-driven, inclusive and participatory. Data was obtained from both secondary and primary sources. Secondary sources included, but were not limited to; records from county offices and state agencies like Kenya Power; energy resources atlases, etc. Primary data collection was undertaken using surveys from households, educational institutions, healthcare facilities, and enterprises. Key informant interviews also informed primary data collection, and respondents included energy technology providers, representatives from various state agencies and end users of agricultural productive use of energy systems. The final step of data collection was focus group discussions, which provided forums to understand community needs and opinions on the current energy system to drive their participation in the energy planning process. The focus group discussions were inclusive, targeting all spheres of the county and had special engagements for women's groups, youth groups, and persons living with disability.

A key component of the planning process was modelling, which was undertaken to inform both transitions to clean cooking and electrification in Narok County guided by national targets. Low Emissions Planning tool was used to model three scenarios that would inform pathways towards the transition to clean cooking. The Open-Source Spatial Electrification Tool was used to model three scenarios used to inform electrification pathways for Narok County. These scenarios were used to advise the County Government on various technologies, fuels and investment costs required to make universal energy access possible by 2030.

A customised version of the Energy Access Explorer (EAE) was also developed for Narok County. EAE is an open-source dynamic geospatial information system that enables stakeholders to visualise and analyse high-priority areas where access to energy should be expanded for equitable development.

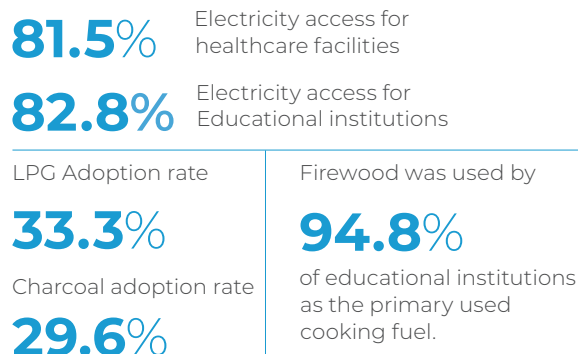
Energy Access for Households

Primary data collection undertaken in 2021 found that



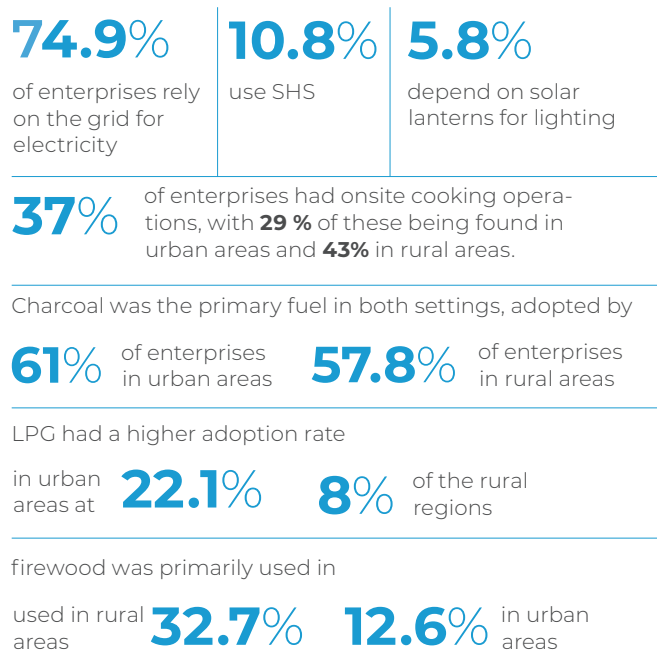
Energy Access for Institutions

Institutions assessed in the development of this county energy plan were educational institutions and health-care facilities.



Energy Access for Enterprises

Primary data collection found that



Energy Access for Productive Use of Energy

Assessment of productive uses of energy for this CEP was limited to agro-processing and water infrastructure. Narok has massive potential for adopting irrigation solutions, as only 25.4% of irrigable land has embraced this solution. Surface water from rivers and streams is used by 10% of the population, with only 4.4% using water from boreholes for drinking. Therefore, there is an opportunity to adopt the productive use of energy to distribute portable water. Cooling solutions for milk and meat also have high potential, as livestock keeping is a central feature of Narok's economy.

Towards Universal Energy Access in Narok County

This plan seeks to facilitate universal energy access in Narok County by accelerating the adoption of clean energy for cooking, lighting and productive uses and enhancing energy efficiency in the County. Specifically, an energy unit within the Department of Environment, Energy, Water and Natural Resources will be established with the mandate to implement this plan. The energy unit will comprise qualified officers to implement functions under bioenergy, energy access (electrification and clean cooking) and energy efficiency. Energy centres will also be established to create awareness of technological solutions towards energy access and efficiency across the County. The Department will need specific policies and strategies addressing energy access, energy efficiency and bioenergy to guide its operations.

A mix of grid extension and off-grid solutions like mini-grids and solar home systems are recommended for electricity access in Narok County. Collaborations with the National Government through the Ministry of Energy, private developers and state agencies like Kenya Power and Rural Electrification and Renewable Energy Corporation will be essential to implementing electrification solutions. LPG, biogas, ethanol and electricity are recommended for clean cooking in Narok County under SDG7 Scenario. A fund focusing on clean cooking will be established within the County to support the deployment of clean cooking technologies. Collaborations with the private sector to undertake feasibility studies to establish distribution chains for clean cooking solutions and off-grid solutions like LPG

and solar home systems, respectively, will be essential. Productive use of energy will play a significant role in the socio-economic transformation of Narok County.

Agro-processing is a low-hanging fruit as the majority of inhabitants of Narok County engage in agriculture through smallholder farming and livestock keeping. Further feasibility studies need to be undertaken to establish suitable interventions as well as location and technological solutions for Narok County. Implementation of this plan will cost an estimated **KES 75.5 Billion**. The table below shows the cost allocation for various activities.

ITEM	COST (KES)
Capacity building and awareness creation initiatives	KES 56 Million
Development of suitable policies and regulations	KES 33.5 Million
Electrification	KES 75.18 Billion
Clean cooking solutions	KES 18.8 Billion
Adoption of energy efficiency	KES 8.2 Million
Development of strategies for Productive Use of Energy	KES 6 Million
Total	KES 94.5 Billion



Acronymns

AD	Aerobic Digestion
BAU	Business As Usual
CAPEX	Capital Expenditure
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 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
IAP	Indoor Air Pollution
INEP	Integrated National Energy Planning Framework
IDEP	Municipality Integrated Development Plan
KenGen	Kenya Electricity Generating Company
KES	Kenya Shillings
KG	Kilogram
KIRDI	Kenya Industrial Research and
KFS	Kenya Forestry Service
LCPDP	Least Cost Development Plan
KNBS	Kenya National Bureau of Statistics
KOSAP	Kenya 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
M&E	Monitoring and Evaluation
MG	Mini-grid
MoE	Ministry of Energy and Petroleum (Kenya)
MSMEs	Micro Small Medium Enterprises
MW	Megawatt
NGO	Non-Governmental Organization
NSAs	Non-State Actors
NETFUND	National Environmental Trust Fund
ODM	Organic Dry Matter
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
SDG	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
W-to-E	Waste-to-Energy
WHO	World Health Organization
WWTP	Waste Water Treatment Plants

Introduction

Traditionally, energy planning in Kenya has been carried out on a national level by the Ministry of Energy through its agencies. However, the inauguration of the 2010 Constitution saw the country's division into 47 counties and mandated them to develop their individual energy plans. This mandate became clearer with the ratification of the Energy Act 2019. Sections 5(3) of the Act require each County Government to develop and submit a county energy plan (CEP) to the Cabinet Secretary for Energy and Petroleum in respect of its energy requirements. These county energy plans, together with plans from national energy service providers such as Kenya Power, are to be consolidated by the Cabinet Secretary into the Integrated National Energy Plan (INEP) (Energy Act, 2019)¹ The development of this CEP is motivated by these legal requirements.

This County Energy Plan is developed with the goal of; accelerating the achievement of Sustainable Development Goal (SDG) 7 and spurring socioeconomic development in Narok County. SDG 7 calls for access to affordable, reliable, sustainable, and modern energy for all – with a goal to ensure universal energy access (both electricity and clean cooking), doubling progress on energy efficiency and substantially increasing the

share of renewable energy.² This necessitates energy planning to enable government and policymakers to make informed policy and investment decisions to support the achievement of SDG7 and the development goals of the county.

Contextually, the 2019 census reported that 90% of the population in Narok County relied on solid fuels for cooking, and less than 20% had access to electricity. (KNBS, 2019)³. Therefore, efforts need to be made by the National and County governments of Narok and the private sector, donors, and financiers to attain universal energy access by 2030 as per national goals. Several initiatives are being implemented to fast-track the achievement of SDG 7 in the country generally and in Narok County specifically. A notable initiative is the Kenya Off-Grid Solar Access Project (KOSAP)⁴ which seeks to electrify marginalised communities using renewable off-grid technologies and to deploy clean cooking solutions in fourteen marginalised counties of Kenya, including Narok County.

1 Republic of Kenya, Energy Act 2019. <https://www.epra.go.ke/download/the-energy-act-2019/>

2 SDG7 (n.d.). Sustainable Development Goals. <https://www.un.org/sustainabledevelopment/energy/>

3 KNBS (2019) Kenya Population and Housing Census: Volume IV. 2019. Available at <https://www.knbs.or.ke/download/2019-kenya-population-and-housing-census-volume-iv-%204.distribution-of-population-by-socio-economic-characteristics/>

4 KOSAP Project Components. (n.d.). Kenya Off-Grid Solar Access Project. <https://www.kosap-fm.or.ke/kosap-project-components/>



SDG 7 calls for access to affordable, reliable, sustainable, and modern energy for all – with a goal to ensure universal energy access (both electricity and clean cooking), doubling progress on energy efficiency and substantially increasing the share of renewable energy.

1.1. Why Is Sustainable Energy Planning Essential for Narok County?

The use of energy, the types of energy used, the types of energy technologies used, and the lack of access to sufficient energy have far-reaching implications for a county's economic development and environmental health. Counties which implement sustainable energy and climate action plans reduce their vulnerability to energy scarcity (poverty) and climate change; they have lower energy input costs, cleaner air, and their low-carbon economies can afford them a competitive economic edge nationally and globally marginalised counties of Kenya, including Narok County.⁵

Achieving SDG 7 by 2030 will require building synergies, attracting more investments, setting more informed climate and energy targets, and understanding the financial resources and human capacity required. This calls for the development of a CEP that will consider: data on local energy resource availability, power infrastructure, socio-economic activities, citizenry priorities, linkages between energy and other developmental priorities, as well as alignment with actions of key stakeholders towards achieving broader developmental, environmental, and social objectives. As local governments manage or oversee all county activities and development, they should play a central role in determining a clear view of their counties' energy and carbon emissions. They also have direct access to their citizens and are best placed to know their needs and influence their behaviour. It is on this backdrop that this CEP is developed, as required by the Energy Act 2019, to fulfil Narok County's unique energy requirements. Figure 1.1 shows some objectives of the CEP.

As local governments manage or oversee all county activities and development, they should play a central role in determining a clear view of their counties' energy and carbon emissions. They also have direct access to their citizens and are best placed to know their needs and influence their behaviour.

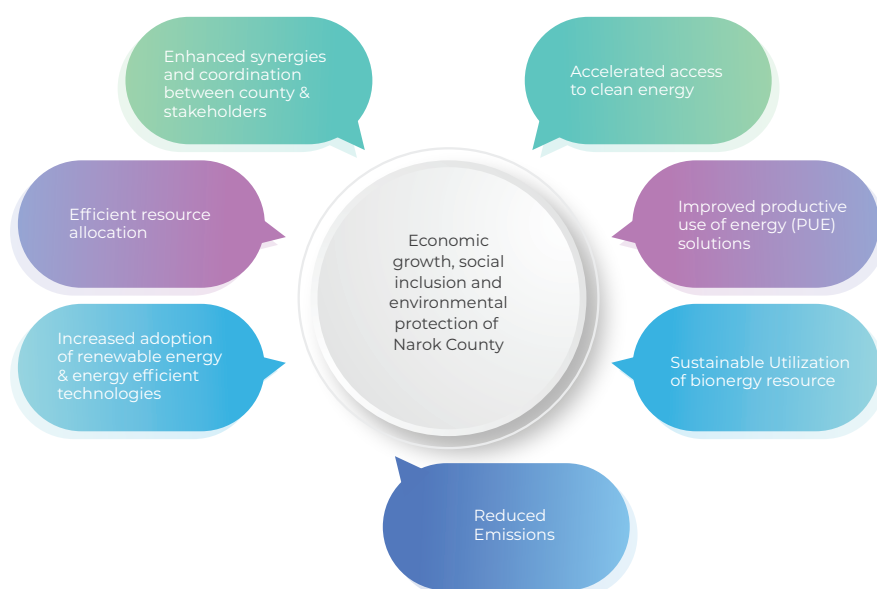


Figure 1.1: County Energy Plan Objectives

5 <https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=293&menu=1515>

1.2. History of Energy Planning in Narok County

Narok County does not have an existing energy plan since it was not a legal requirement before the enactment of the Energy Act 2019. However, the 2018-2022 Integrated Development Plan (CIDP), a document prepared by Narok county to guide development over five years, includes energy access progress and targets as well as some energy-related projects. The 2018-2022 CIDP indicates that Narok County intended to:

1. Increase energy access rates from **20% to 26%** by 2020 and to 30% by 2022;
2. Install solar-PV in at least 10 facilities;
3. Establish a waste-to-energy plant and carry out exploration of geothermal energy;
4. Develop a Renewable Energy Policy;
5. In terms of clean cooking - to promote energy-saving jikos. (County Government of Narok, 2018).⁶

Table 1.1 Describes some projects that have been implemented by the Narok County Government to enable achievement of the targets described above.

Table 1.1: Energy planning-related activities and projects mentioned in the 2018-2022 CIDP (ibid)

Project Name	Objectives	Targets	Cost (KES)	Source of funding	Time-frame	Implementing Agency
Exploration of Geothermal energy Mines	To increase energy connectivity by producing alternative sources of energy	Production of Geothermal power within 5 years	1 B	National government, County government, Development partners	2018-22	Private developer
Rural electrification	To increase energy access by at least 10%	10%	300M	National government, County government, Development partners	2018-22	KPLC, REA, Department of, Energy, Water and Natural Resources
Renewable energy policy	To develop a regulatory framework that will increase the use of renewable energy	A renewable energy policy and workplan	25M	National government, County government, Development partners	2018-22	Department of Environment, Energy, Water and Natural Resources
Off-grid solar access project	To increase energy access by fitting schools, hospitals with solar panels	At least 10 facilities fitted with solar panels	30M	National government, County government, Development partners	2018-22	Department of Environment, Energy, Water and Natural Resources
Waste-to energy plant	To reduce pollution and increase renewable	Not provided	3B	National government, County government, Development partners	2018-22	Department of Environment, Energy, Water and Natural Resources
Boreholes	Solarization of boreholes	Powering of 184 existing boreholes using solar PV	282M	County Government	2018-2022	Department of Water

⁶ Council of Governors. (2017). Narok County Integrated Development plan 2018-2022. <https://cog.go.ke/cog-reports/category/106-county-integrated-development-plans-2018-2022?download=355:narok-county-integrated-development-plan-2018-2022>

1.3. Challenges That Impede Energy Provision in Narok County.

Specific challenges impede the delivery of improved energy services, as indicated in Narok's CIDP (County Government of Narok, 2018) (ibid). These include:

- i. Limited financing and competing priorities of both county and national governments against priorities like health, education, and water. This is especially true for jurisdictions like Narok county that struggle with underdeveloped road infrastructure, underdeveloped water reticulation system and sewage systems, and poorly developed social infrastructure (schools, health, sports facilities, etc.).
- ii. Lack of technical skills to plan, design, install and maintain energy supply and distribution facilities.
- iii. Competing interests among sector stakeholders and development partners, which has led to changes in priorities based on socio and political climate and demands prevailing at one particular time.
- iv. Growing population, which has continued to exert pressure on the environment.
- v. Weak linkages between county government departments, and overlap of functions.

1.4. Process of the Development of the Narok County Energy Plan

The County Government of Narok developed this CEP with Technical Assistance from Strathmore University Energy Research Centre (SERC) and World Resources Institute (WRI) (the Project Team). A Technical Working Group (TWG) was formed and comprised officers from the County Government's Department of Environment, Energy, Water and Natural Resources and the Project Team. The TWG was chaired by the Director of the Department of Environment, Energy, and Natural Resources. The County Energy Planning Committee was chaired by the County Executive Member in charge of the Department of Environment, Energy, Water and Natural Resources, assisted by the Chief Officer. It provided overall oversight and policy guidance to the TWG during the entire process. Project funding was provided through UK Partnering for Accelerated Climate Transitions (**UK PACT**), a programme funded by the UK Government.⁷

As mentioned in section 1.1, the Energy Act 2019 necessitated the development of this CEP. The Ministry of Energy has since developed the Draft Integrated National Energy Planning Framework 2020 (the Framework) to guide and provide clarity, harmony, and standardisation in preparing energy plans. This Framework guided the development of the Narok County Energy Plan.

The CEP was developed following the procedure highlighted in Figure 1.1 below.



⁷ United Kingdom Partnering for Accelerated Climate Transitions available at: <https://www.ukpact.co.uk/#:~:text=UK%20Partnering%20for%20Accelerated%20Climate,their%20climate%20change%20mitigation%20efforts.>

1. **Stakeholder Engagement:** Stakeholder mapping and engagement were conducted to obtain relevant data and information for developing the CEP. Another goal was establishing relationships between departments in the Narok County Government and external stakeholders that would support future County Energy Planning. Through the Ministry of Energy, the National Government was engaged to gain an understanding of policy developments, projects being implemented and to obtain data. Other stakeholders engaged included: Kenya Power, Energy and Petroleum Regulation Authority (EPRA), Rural Electrification and Renewable Energy Corporation (REREC), Kenya Off-Grid Solar Access Project (KOSAP)-Narok, Kenya National Bureau of Statistics (KNBS), and the private sector - including NGOs (e.g., SNV, conservancies) as well as the community through surveys (households, SMEs, institutions, etc.) and focus group discussions (men, women, youth, PWDs, cooperatives, SMEs etc.). Other entities supporting counties in the development of energy plans, such as the Sustainable Energy Technical Assistance (SETA) Project, were also obtained to share ideas and insights. This process was continuous throughout the CEP development.
2. **Data collection:** The data collection process was kicked off by building consensus on the minimum data needs. Coordination was enhanced by developing and sharing a comprehensive and dynamic data wish list with the key stakeholders mentioned above. This was followed by secondary data collection from global, national, and subnational reports and databases available in the public domain. To verify data from secondary sources and to fill in identified gaps, elaborate surveys were used to collect quantitative data across the County, focusing on the ward level. The sample size consisted of 665 households, 58 education institutions, 27 healthcare facilities, 790 small and medium enterprises (SME) and three cottage industries. Sampling was undertaken using Cochran's formula to ensure statistical significance. The surveys were administered by use of the KoBo Collect Application installed on Android-powered devices. This provided an efficient way of getting input data at increasing levels of granularity, covering households (rural and urban), institutions, and productive uses of energy (PUE) segments.
3. **Data quality checks** were programmed in the questionnaires using skip logic to ensure only relevant questions were asked. For mapping purposes, each of the questionnaires featured a Geographic Information system (GIS) prompt that collected the coordinates of households and premises interviewed. Additional quantitative data was collected through both general energy audits and walk-through energy audits. Only County offices and county-managed facilities such as healthcare facilities and the water treatment plant were considered for energy audits. Facilities that underwent general energy audits include the County Referral Hospital, Narok Water Treatment Plant, and County Offices. The healthcare facilities and institutions that were part of the sample and were within Narok also underwent walk-through audits. Data for the general energy audit was collected from historical energy bills. Energy loggers were also used to meter the consumption of electricity during the auditing period.
4. **An inventory of building** envelope designs and energy-consuming appliances was developed. This inventory included capacity and efficiency ratings where applicable for comparison with MEP standards. For the case of Industries and Commercial Enterprises, one sample of each industry type was chosen to describe energy use in the respective industry. Apart from hotels and game lodges, all other major industries had one facility each in the County. The following industries were scoped; Hotel & Game Lodging, Maize Milling, Tea manufacturing, Sugar Manufacturing, and Tanning Industry. Energy Audit Reports for facilities that were audited were used to estimate energy consumption, while field visits were undertaken for facilities that had not been audited, and energy consumption was acquired as primary data. Qualitative data was also collected through 13 key informant interviews and 16 focus group discussions⁸. The focus group discussions involved productive use of energy segments as well as different gender and social inclusion groups. This added nuance to the survey and secondary data collected by the other methods by getting local based insights; and prioritized intervention projects and data related to people's willingness and ability to pay.
5. **Least Cost Electrification and Clean Cooking Modelling:** This was informed by the outputs of the data collection. Scenarios for Narok County's electricity future supply and demand were modelled using the Open-Source Spatial Electrification Tool (OnSSET). Clean cooking modelling was undertaken using the Low Emissions Analysis Platform (LEAP) tool, which considered firewood, charcoal, biogas and LPG as fuel options for cooking. Detailed analysis of electricity and clean cooking modelling and scenarios are found in sections 4.1.1 and 4.1.2 respectively. OnSSET is a bottom-up GIS-based cost optimization toolkit for identifying least cost technological options for electrification of un-served areas.⁹ LEAP is a widely-used software tool for energy policy analysis and climate change mitigation assessment, developed by the Stockholm Environment Institute (www.energycommunity.org). LEAP can also analyse emissions patterns of local and regional air pollutants, and assess strategies to address short-lived climate pollutants (SLCPs), making it well suited for studies on climate co-benefits of local air pollution emissions reductions, and vice versa.¹⁰

8 Semi-structured key informant interviews were carried out with 6 county department officials, 2 cooperative society officials, 2 conservancy officials, and 3 energy practitioners. This was aimed at understanding county planning processes, plans and community/business energy needs & priorities. Focus group discussions applied the same approach but, in a group, set up aimed at getting different perspectives from participants.

9 ONSSET. (n.d.). ONSSET. <http://www.onsset.org/>

10 Stockholm Environment Institute. (2017). The Long-range Energy Alternatives Planning - Integrated Benefits Calculator (LEAP-IBC). <https://mediamanager.sei.org/documents/Publications/SEI-Factsheet-LEAP-IBC-2.pdf>



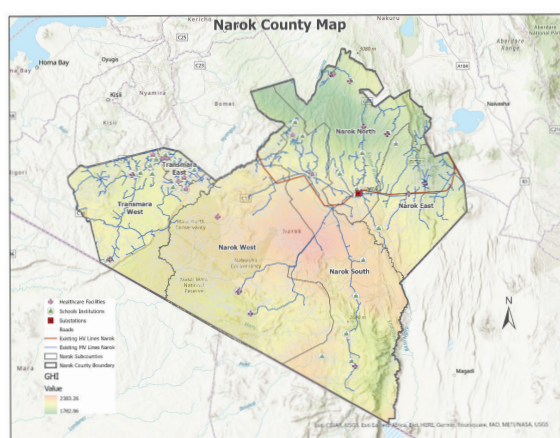
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- 6. Development of a GIS toolkit:** The CEP also involved the development of a customized version of the Energy Access Explorer (EAE), an open-source dynamic geospatial information system that enables stakeholders to visualize and analyze high-priority areas where access to energy should be expanded for equitable development. EAE also integrated outputs of least-cost electrification modelling based on the Open-Source Spatial Electrification Tool (OnSSET)).
 - 7. Gender Equity and Social Inclusion(GESI) consideration:** GESI was considered throughout the project from data collection; to obtaining gender-disaggregated data and understanding unique challenges and opportunities facing the marginalised communities. It was also considered for capacity building-to equip the county government to consider GESI in policy making and reporting-to present GESI disaggregated findings.
 - 8. CEP Document Drafting:** The CEP document was drafted in line with the INEP Framework chapters. The inputs included: analysed data collected through literature reviews, primary data collection, energy resources assessment, electricity, and clean cooking modelling inputs.
 - 9. Validation of Results:** Validation of results contained in the CEP was undertaken through presentations made to: County government officials, community members who had taken part in data collection, and development partners involved in County Energy Planning. They gave feedback that enabled the team to produce the first CEP draft. This document was then subsequently reviewed by a team of selected energy experts engaged in energy planning and Ministry of Energy staff, leading to the production of the final draft.
 - 10. Capacity building:** County officials underwent capacity building to equip them with the required skills to fully engage in the development of the CEP. The capacity building enabled county officials with the skills to review the current CEP and develop future CEPs on their own as required by the Energy Act 2019. Capacity building was undertaken in three stages: First, an introductory training on energy planning and policy targeting Chief Officers and Directors of all the departments within the county was implemented. This training's goal was enabling the trainees to understand the unique role of energy as an enabler for service delivery. An additional training focused on the fundamentals of energy planning which targeted the technical working group was also undertaken with the goal of equipping the trainees with knowledge of tools and methods used for energy planning. Finally, County officers in the technical working group participated in the entire process of CEP development as part of energy planning skills development.
 - 11. Integration of county energy planning into the CIDP:** The development of this CEP took into consideration insights as well as plans and projects provided by all the County Departments that require energy as an enabler. This CEP also identifies prioritised programs and projects for implementation in collaboration with other departments. By the time this CEP was completed, the County was beginning their sectoral workshops which led to the development of the CIDP. Technical assistance will continue during this phase to ensure all recommended projects and programs within the CEP are included in the CIDP.

1.5 County Overview

Narok county lies between latitudes 0° 50' and 1° 50' South and longitude 35° 28' and 36° 25' East. It borders the Republic of Tanzania to the South; Kisii, Migori, Nyamira and Bomet counties to the West; Nakuru County to the North; and Kajiado County to the East. The county headquarters lie in Narok Town. The county covers an area of 17,933.1(17,9331 ha) Km2 representing 3.1 per cent of the total area in Kenya and hence the eleventh largest county in the country (from CIDP 2018). Figure 1.2 shows the location of the county in Kenya.

Figure 1.2: Map showing Narok County



1.6 Demographic Features

Narok County is cosmopolitan, with the dominant ethnicities being Maasai and Kalenjin. The total population is about 1,158,000 (KNBS, 2019), representing about 2.4% of the Kenyan population. The County's annual population growth rate is projected at 4.7%, which will make the population about 1,763,000 by 2024 (ADP, 2021).¹¹ The male-to-female ratio is approximately 1:1. (49.9% male and 50.1% female) according to the 2019 Population Census. Persons living with disabilities (aged five years and above) comprise 0.9% of the population, while documented street persons were 222 of the total population (214 men and eight females). The population density in the county varies across the six sub-counties and is estimated at 65 persons per KM2. There are two major urban centres in the county, namely, Kilgoris and Narok towns. About 1,057,500 people, or 91% of the population, live in rural areas and about 9% lives in urban areas. Narok County had 238,115 conventional households with a household size of 4.8 members (KNBS, 2019).

The main cooking fuel in Narok County is biomass with firewood and charcoal serving 71.7% and 17.7% respectively. This puts a lot of pressure on the dwindling forest and vegetation resources (KNBS, 2019) and is a cause of human-wildlife conflict. Electricity access rates in the county were 20%, according to the 2019 census. Further details on Narok County's energy access can be found in chapter 3.

Table 1.2: Key attributes of Narok County (KNBS, 2019)

General Information	
Area	17,933.1 Km2 (1,793,310 Ha)
Population	1,157,873 (2019)
Population density	65 (persons/km2)
Urban population	221,571 (19.1% county population)
Rural population	936,302 (80.9%)
Number of households	238,115
Poverty rate	34% (absolute), 12% (food).

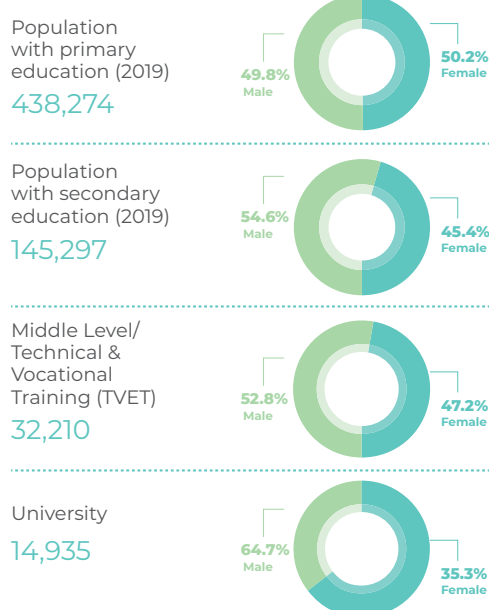
Access to basic needs/infrastructure

Mobile (population above 3 years)	34%
Internet (population above 3 years)	12% (15% male, 9% female)
Desktop computer/laptop/tablet (population above 3 years)	4.1% (5% male, 3.3% female)

Energy Access

Lighting	Mains/grid (19.7%); solar (38%); torch or solar-charged spot-lights (20%)
Cooking	Mains/grid (0.5%); firewood (72%); charcoal (18%), LPG (8.2%)

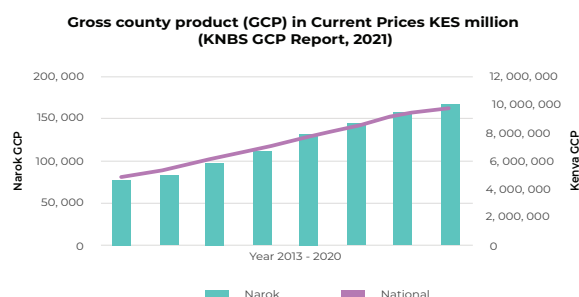
Education



¹¹ Annual Development Plan (2021). Narok County Annual Development Plan for FY 2021-2022 Available at: <https://narok.go.ke/wp-content/uploads/2021/08/NAROK-ADP-FOR-FY-2021-2022-APPROVED-.pdf>

1.7 Narok County GDP and Economic Activities

Gross County Product (GCP) is a geographic breakdown of Kenya's Gross Domestic Product (GDP) that gives an estimate of the size and structure of the 47 county economies. It also provides a benchmark for evaluating the growth of county economies over time.¹² Gross County Product (GCP) may therefore be interpreted as the "County GDP". According to the Gross County Product Report 2021, Narok County was estimated at KES 166.7 trillion, representing 1.68% of the national GDP. (ibid). The Economic Survey 2022¹³, reported that Narok County had a total revenue of KES 12 trillion with annual own source revenue share (e.g., from county taxes levies etc.) of KES 2.4 trillion; an equitable share (i.e., from the national government) of KES 8.8 trillion and a conditional grant of KES 799. trillion. Despite the county's GCP being very low compared to the national GDP, the growth is proportional to the national level, as shown in the graph below.



The main economic activities in the county include livestock rearing (exotic and indigenous), crop farming, tourism, and trade, among other activities undertaken on a small scale. Tourism is the largest contributor to the county's economy (KNBS, 2019; CIDP 2018-22). The famous Maasai Mara Game Reserve, featuring the Great Wildebeest Migration, which is one of the "Seven Wonders of the World", is in the county. Crop farming is practised by about 76% of total households in Narok (KNBS 2019). Fish farming is also an additional economic activity. There were an estimated 467 fish farmers in the county in 2020. The total fishponds are estimated at 425, with 366 fish ponds being in TransMara West and East sub-counties. Another important employment opportunity in Narok is beadwork and making Maasai attire, which interests both locals and international tourists. Mining activities include Kilimapesa gold mines in Lolgorian, quarry and sand harvesting in Narok South and Narok East Sub-counties.¹⁴

1.8 Climatic and Ecological Conditions

The county has several different agro-ecological zones. The highlands, suitable for rain-fed agriculture, experience sufficient and reliable rainfall. The lowlands are better suited for pastoralism as they experience little and unreliable rainfall. Approximately 45% of Narok County can be classified as semi-humid to humid, while 55% can be classified as semi-arid to very arid. Narok County receives between 600 and 1600 mm of precipitation per year. The north-western region of the county receives more than 1500 mm of precipitation per year. The eastern part of the county is significantly drier and colder than the rest. (ibid).

There are two dominant vegetation types consistent with the county's topography: the forests in the highlands and the lowland vegetation. Nomadic pastoralists and small-scale farmers inhabit the lowland areas. Maasai Mara Game Reserve, part of the lowlands, accounts for approximately 1,510 km² (151,000 ha) and is home to the big five: elephants, buffaloes, rhinos, lions and leopards. Firewood collection is not allowed in the game reserve. In addition, more than ten (10) conservancies are found mainly around the Maasai Mara ecosystem, being partnerships between different private landowners and communal landowners. These conservancies serve as dispersal and migratory corridors for wildlife from the Maasai Mara Game Reserve. The size of the land under conservancies is cumulatively more than 192,000 hectares. Figure 1.3 shows the location of the Greater Mara Ecosystem. (ibid).

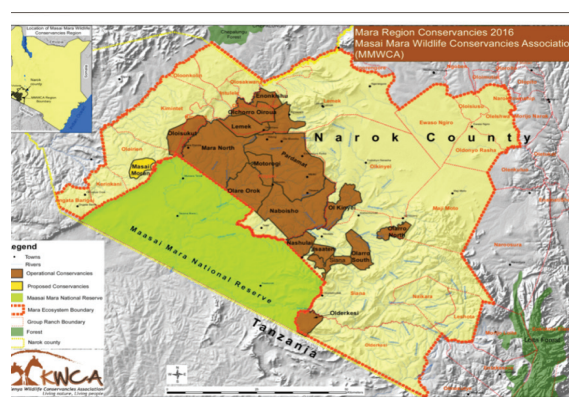


Figure 1.3: Location of the Greater Mara Ecosystem

Other lowlands, such as the slopes of Mount Suswa, are fairly vegetated, although the southern slopes are generally shallow and rocky. On the western side, the slopes are covered with densely woody vegetation indicating deep fertile soils. There are intensive agricultural activities in these areas.

¹² KNBS GCP Report (2021). Gross County Product Report. Available at: <https://africacheck.org/sites/default/files/media/documents/2022-05/GCP%202021%20Report.pdf>

¹³ Kenya National Bureau of Statistics [KNBS]. (2022). Economic Survey 2022. <https://www.knbs.or.ke/wp-content/uploads/2022/05/2022-Economic-Survey1.pdf>

¹⁴ Ibid

1.9 Policy and Regulatory Framework for the Energy Sector

Some of the policies and strategies adopted during the development of this CEP are highlighted in Table 1.2 below:

Table 1.2: Some Key policies and strategies in Kenya considered in the CEP development

Legislation	Year	Outcomes
Cross Cutting Policies, Strategies and Plans		
Kenyan Constitution 2010	2010	This is the supreme law of the Republic of Kenya and binds all persons and all State organs at both levels of government. It states that Kenya shall ensure sustainable exploitation, utilization, management and conservation of the environment and natural resources. It created the devolved system of government, consisting of the national government and 47 county governments. It distributes functions and powers between the two levels of Government as detailed in Chapter Eleven and the Fourth Schedule. In relation to the County Governments, Part 2 of the Fourth Schedule provides that they shall be responsible for county planning and development, including electricity and gas reticulation and energy regulation, but provides no specifics of what that planning should encompass.
Kenya Vision 2030	2008	Long-term development blueprint. The CEP is aligned to Vision 2030 through with energy as its enabler through productive uses of energy to stimulate economic growth and employment creation.
Energy Act 2019	2019	Mandates each County Government to develop and submit a county energy plan to the Cabinet Secretary for Energy and Petroleum in respect of its energy requirements. This necessitated the development of this CEP. The Fifth Schedule of the Act provides for the distribution of functions between the national government and county governments. The Functions of County Governments under the Act include: county energy planning, regulation, operations and development, as well as establishment of a fund for the purpose of promotion of efficient use of energy and its conservation within the county.
Kenya National Energy Policy (NEP), 2018 (KNEP 2018)	2018	The NEP indicates that the objective of the state is to ensure affordable, competitive, sustainable and reliable supply of energy at the least cost in order to achieve the national and county development needs, while protecting and conserving the environment for intergenerational benefits. In regards to clean cooking, it states that there is inadequate public awareness on the adverse health effects of the use of wood-fuel and kerosene on women and children and the inability to access and afford modern and clean energy. The policy therefore emphasises the need to undertake measures to make clean and modern energy services affordable and accessible. The CEP was developed with these objectives in mind, modelling both electrification and clean cooking.
SDG7 and SEforALL	2015	Sustainable Development Goal 7 (SDG7) calls for “affordable, reliable, sustainable and modern energy for all” by 2030. It’s three core targets are the foundation for our work: • Ensure universal access to affordable, reliable and modern energy services • Increase substantially the share of renewable energy in the global energy mix • Double the global rate of improvement in energy efficiency The CEP was developed taking these targets into consideration.
Energy Gender Policy	2019	The broad objective of this policy is to guide the mainstreaming of gender in institutions, policies and programs in the MoE and its SAGAs, County Governments and amongst the stakeholders. The specific objectives of the policy include; increasing awareness on gender in the Energy sector, promoting clean cooking solutions and environmental sustainability, ensuring compliance with the Constitution, among others. This policy’s recommendations were considered in the development of this CEP from the development data collection tools to the end of the project.

Legislation	Year	Outcomes
Kenya National Electrification Strategy 2018	2018	It is the roadmap to achieving universal access to electricity by 2022. Its principal objective is to achieve electricity access for all households and businesses in Kenya over the shortest time and at an acceptable quality of service. With the help of a geospatial planning tool, KNES identified the least cost technology options (grid extension, grid intensification, mini-grids, and standalone systems) and the associated investments required for reaching the remaining population with affordable and reliable electricity by 2022.
Least Cost Power Development Plan 2021-2030	2021	The LCPDP is a Kenya Energy Sector Report Plan that guides generation expansion opportunities, transmission and distribution infrastructure development, and the related resource requirements. The CEP considered what LCPDP speaks about in Narok County.
The 'Big Four' Agenda	2017	The agenda seeks to improve Food Security, expand Manufacturing, increase Affordable Housing and achieve Universal Health Coverage, and is dependent on the provision of adequate and competitively-priced energy. The initiatives focus on the realization of improved energy access, energy efficiency and conservation. The CEP contributes to this through capturing and planning of current and desired energy access and Productive Use of Energy and powering of health centres prioritised projects.
National Climate Change Action Plan (Kenya): 2018-2022.	2018	The plan encourages an electricity supply mix based mainly on renewable energy that is resilient to climate change, promotes energy efficiency and the transition to clean cooking that reduces the demand for biomass. The CEP focuses on renewable energy solutions and clean cooking technologies in line with this plan.

Bioenergy and clean cooking

Bioenergy Strategy	2020	Sets forth guidelines and approaches, and further identifies strategic interventions that can promote the development and sustainable utilisation of bioenergy resources in Kenya over the 2020-2027 period. At the county level, County Governments and local energy sector-associated MDAs are to spearhead the implementation of locally-relevant strategies. County governments are mandated with regulating and licensing of biomass production, transportation and distribution, biogas systems, as well as charcoal production, transportation and distribution.
The Energy Regulations of 2013 (Improved Biomass Cookstoves)	2013	These regulations set out the classes and requirements for licensing of installation, maintenance, manufacture, importation and distribution of cookstoves. However, they have never been gazetted to-date.
The Forest Conservation and Management Act of 2016:	2016	Under this Act, Kenya Forest Service is the authority mandated to "receive and consider applications for licenses or permits in relation to forest resources" and to "implement and enforce rules and regulations governing importation, exportation and trade in forest produce." The Act provides specific regulations for production, transportation and marketing of charcoal.
The Forest (Charcoal) Rules of 2012:	2012	These rules were first gazetted in 2009 and revised in 2012, for the purpose of regulating the sustainable production, transportation and marketing of charcoal. Charcoal producers and transporters must be licensed by the Kenya Forest Service (KFS); commercial charcoal producers must organise themselves into Charcoal Producers Associations (CPAs); and charcoal wholesalers or retailers should not trade with unlicensed producers.
Biofuels guidelines 2022	2022	These guidelines have been developed by the Energy and Petroleum Regulatory Authority (EPRA), and are meant to guide stakeholders on the regulation and promotion, production, transportation, storage, packaging, blending and sale of biodiesel, biogas and bioethanol. The guidelines describe the requirements and necessary approvals and certification for setting up and operating a business dealing in biogas, biodiesel, and bioethanol.

Legislation	Year	Outcomes
Environment Management and Coordination Act (EMCA) 1999	1999	The Act prescribes Environmental Impact Assessments for all projects, involving wood. The Act also advocates for promotion of widespread adoption of energy efficient technologies.
National Environment Policy, revised draft 5, 2012	2012	Advocates for promotion of alternative, less-polluting technologies to reduce pressure of forests by charcoal production and indoor air pollution from utilization. This is taken care of especially through clean cooking technologies.

Energy Efficiency and Conservation

Kenya National Energy Efficiency and Conservation Strategy (KNEECS):	2020	Section 3.1 of the Strategy recognises the Role of County Governments in Promoting Energy Efficiency and Conservation. With approval by EPRA, these functions include but are not limited to: a) Amending the energy conservation building codes to suit the local climatic conditions b) Directing compliance with the provisions of the building codes, c) Directing energy audit to be conducted by an accredited energy auditor d) Creating awareness and disseminating information for the efficient use of energy and its conservation, e) Training personnel and specialists in techniques for the efficient use of energy and its conservation, f) Taking steps to encourage preferential treatment for the use of energy-efficient equipment or appliances. In addition, County governments have a role to mobilize adequate resources to finance their relevant energy efficiency and conservation programmes/projects.
The Energy (Energy Management) Regulations	2012	Institutionalize energy audits and energy efficiency in designated facilities ¹⁵ . These regulations influenced facilities for which energy audits were taken during the development of this CEP.
The Energy (Appliances Performance and Labelling) Regulations	2016	Established Minimum Energy Performance (MEP) standards for six selected appliances that include; motors, fluorescent lamps, domestic refrigerators, and room air conditioners. The standards were applied in the development of the Energy Efficiency and Conservation Chapter of this CEP.

Narok County Specific Policies and Strategies

County Integrated Development Plan (CIDP 2018-2022)	2018	CIDP is the planning tool in county governments. All projects that are implemented within the county have to be included in the CIDP. As such, CIDP was thoroughly reviewed during development of the CEP.
The Narok County Environment Management Act, 2016	2016	The purpose of this Act gives effect to Article 69 of the Constitution to ensure sustainable exploitation, utilization, management and conservation of the environment and specifically to promote and enhance county forest cover in the following ways; regulating charcoal production; regulating sand harvesting; regulating public nuisances, including waste and disease control; regulating the mining industry within the county; controlling air pollution; controlling noise pollution; and regulating outdoor advertising; to ensure a clean and healthy environment. The Act provides for the establishment of the Narok County Environment Management Council.
Narok County Climate Change Fund Regulations, 2021	2021	Part 2, section 5 of the Regulation holds that there needs to be an established fund to be known as the Narok County Climate Change Fund which shall be used to fund climate change projects, programs and activities provided for in the Climate Finance Framework and in these regulations.

¹⁵ EPRA. (2012). The Energy (Energy Management) Regulations. Retrieved from www.epra.go.ke: <https://www.epra.go.ke/download/the-energy-energy-management-regulations-2012/>

1.10 Key Stakeholders Involved in Energy Access

Several actors are involved in the development and promotion of energy access. These include government ministries and agencies at the national level, county governments, development partners, energy developers, and financial institutions, as illustrated in Figure 1.4 below. A complete list of their key roles and capabilities are outlined in Annex 1.

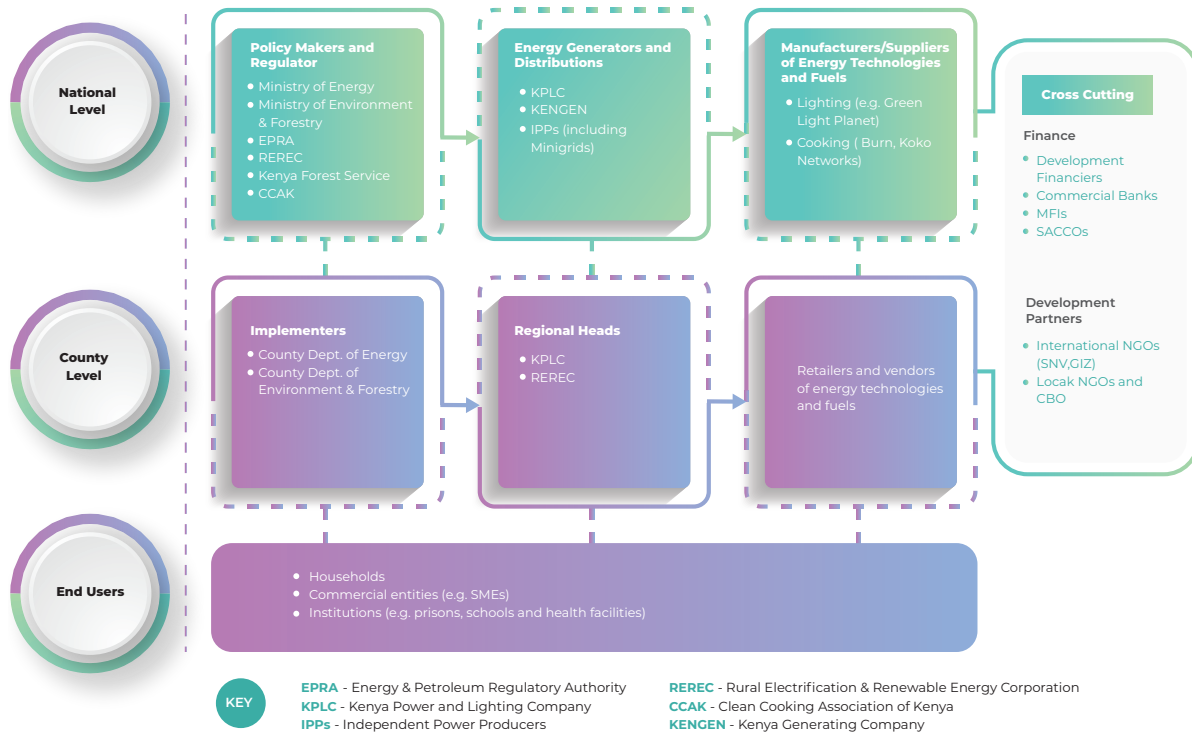
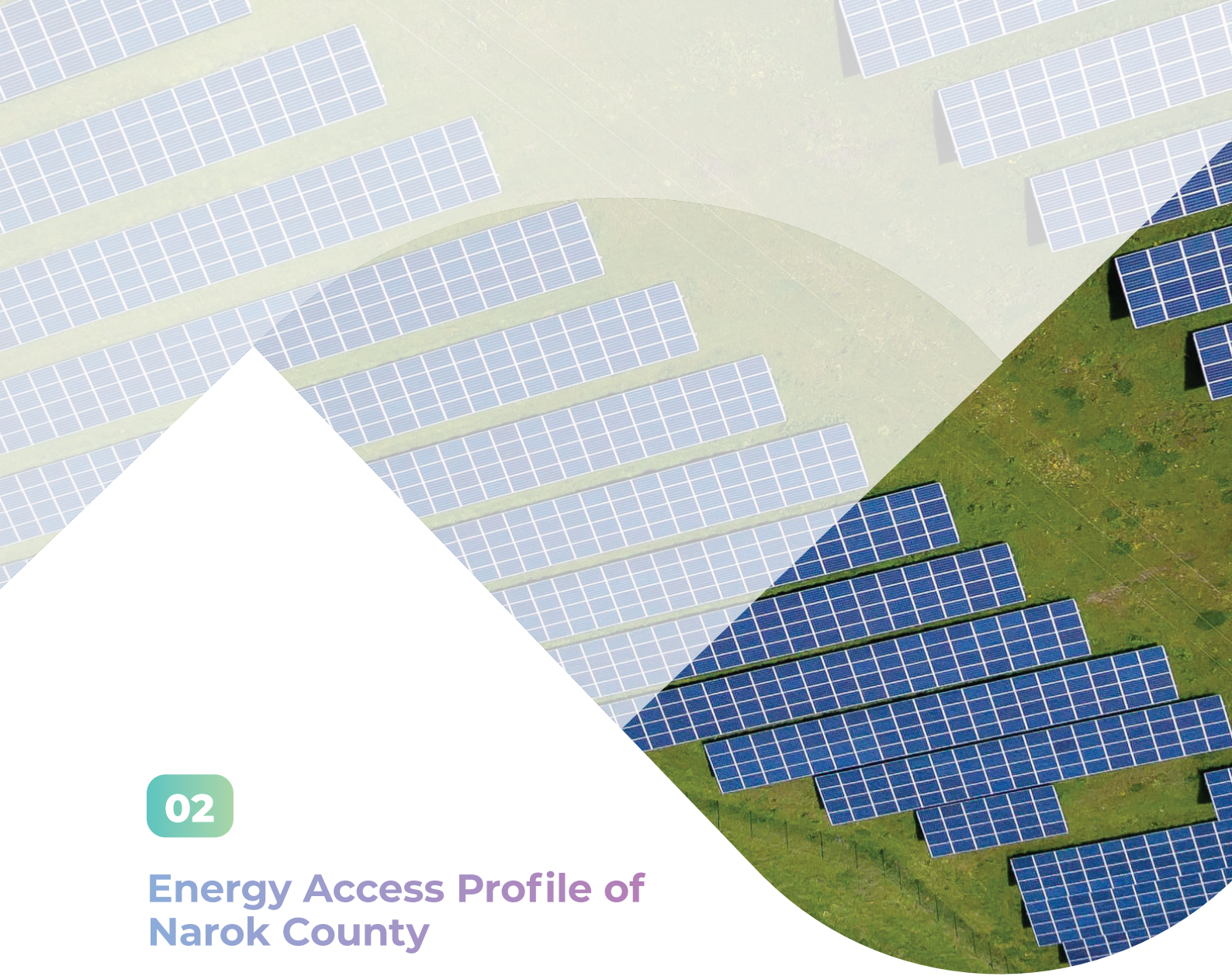


Figure 1.4: Stakeholders involved in the development and promotion of energy access



02

Energy Access Profile of Narok County

As mentioned in section 1.6, Narok County has a total population of 1,158,000. About 9% live in urban areas, while 91% live in rural areas. Low energy access rates characterise the county. As described in section 1.5, only about 20% of households are connected to the grid, with 38% using solar home systems. On the other hand, 88% of households use solid biomass (firewood and charcoal) for cooking and (water) heating. Due to the low access rates to energy, Narok County was identified by the Government of Kenya (GoK) as one of the 14 underserved counties in the country and targeted to benefit from the Kenya Off-grid Solar Access Project (KOSAP).

This chapter provides a detailed analysis of the energy access situation in the county. Data from the 2019 National Population & Housing Census was used to provide the baseline, then compared against primary data that was collected by SERC and WRI in 2021 - to provide general trends in access to energy (for households). About 10.5% of the households that participated in the data collection came from urban centres, while 89.5% were drawn from the rural areas. The selection of the sample size was done in a manner to reflect the spread of the population between the two divides across the county. Overall, 68.9% of the participating households were male-headed, while only 31.13% were female-headed. Data from other secondary sources, including CIDP, supplemented with the 2021 survey was used to provide the general state of access to electricity for lighting, cooking, as well as for powering social and productive loads for institutions - healthcare facilities, education institutions, infrastructure services (e.g., street lighting, water pumping), and SMES.

2.1 Energy Access Trends in Narok County

The following section presents findings from the data collection and review:

2.1.1 Energy Access in Households

2.1.1.1 Lighting

According to the 2019 National Population and Housing census, majority of the households in Narok county use solar home systems for lighting, at 37.7%, followed by solar torches at 20%. Electricity from the grid is the third, providing lighting for about 19.7% of the households. Tin lamps, firewood, dry cells, paraffin lanterns and dry cell torches are used by a smaller proportion of the households at 5.6%, 5.5%, 4.5% and 4.1% respectively. Candles, car-charged batteries, and generators are used by a very small proportion of the households at 1.4%, 0.9% and 0.1% respectively. Figure 2.1 shows the percentage of households' use of different devices for lighting across the county.

% Distribution of HHs by Main Type of Lighting Fuel

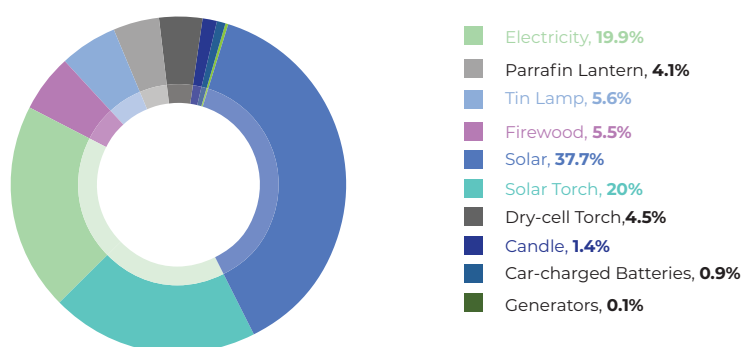


Figure 2.1: Percentage Distribution of HHs by Main Type of Lighting Sources, 2021

Figure 2.2 counties shows that Narok North sub-county has the highest population of households connected to the grid at 42.8%, followed by Narok East and Transmara west with 23.8% and 14.6% respectively. This significant population of HHs connected to the grid can be attributed to the densely populated nature of the sub-counties as compared to Narok South, Narok West and Trans Mara East which have the lowest percentage of households connected to the grid at 8.8%, 6.2% and 9.2%, respectively.

The use of Paraffin for HHs lighting, which is prominent in Transmara West with 22% of the HHs using this fuel, followed by Narok East and Transmara East sub-counties where about 16% and 11% of the HHs, respectively, used this source of energy for lighting. Narok North, Narok South and Narok West sub-counties have the least population of HHs using paraffin for lighting with less than 10% (6.4%, 3.2% & 3.2% respectively) of the HHs relying on this source of energy for lighting.

SHS are mainly used in Narok West and Transmara West where 43% of HHs in both sub-counties use this source of energy for lighting. In Narok East, about 40% of the HHs rely on this technology for lighting, while 35% of the HHs in Narok South use it. In both Narok North and Transmara East, 32% of the HHs rely on this source of energy for HHs lighting.

% Distribution of Lighting Fuels per Sub-county

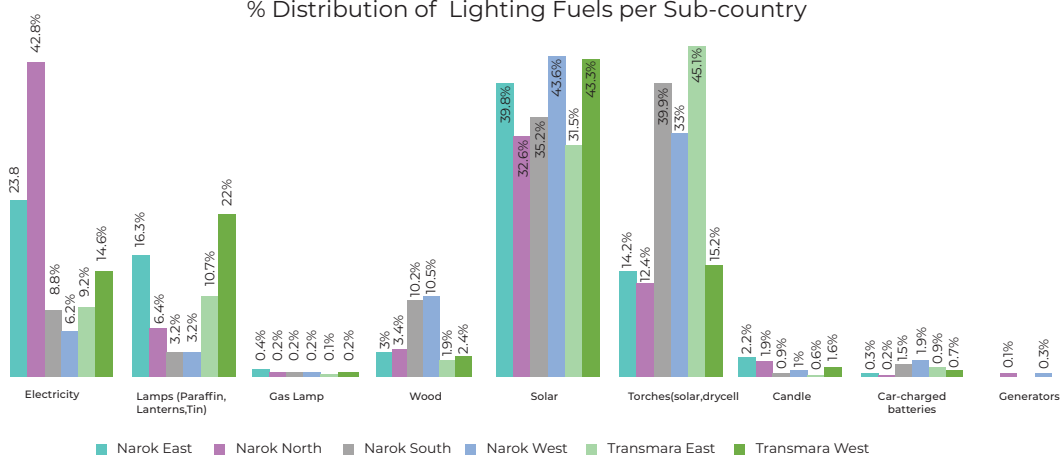
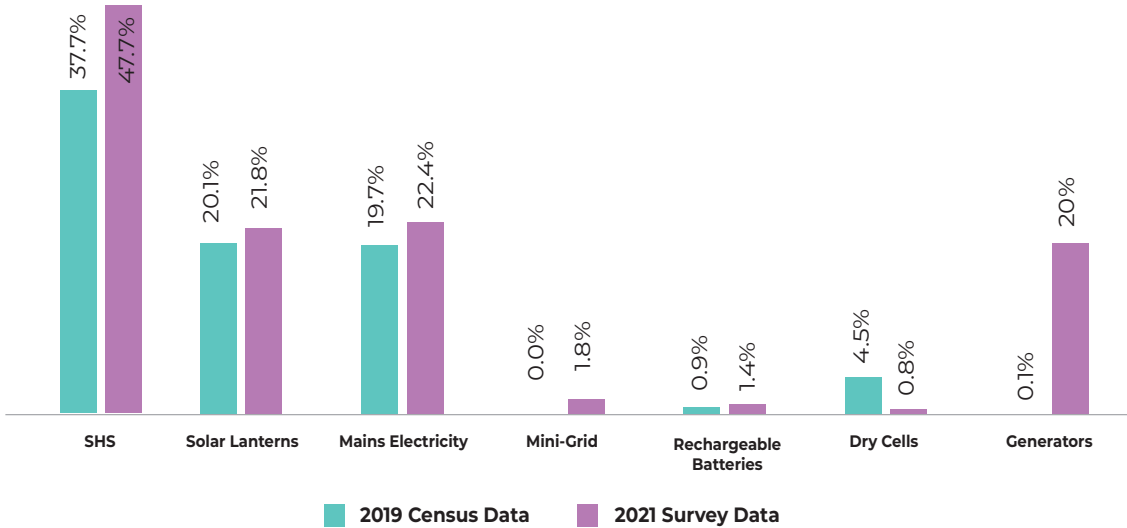


Figure 2.2: Household use of lighting fuels in percentages per sub-county in Narok

Following the 2021 primary data collection, it was revealed that 47.7% of the households in Narok County used SHS – a 10% increase from 37.7% that used the same technology in 2019. This growth can be attributed to the rolling out of the KOSAP project. Also, 22.4% use electricity from the grid – a 2% increase from the 19.7% that used electricity from the grid in 2019. The use of Dry Cell Torches, which was most prevalent in Narok South, dropped from 4.5% in 2019 to 0.8% in 2021. This drop can be linked to the increased use of solar lanterns and SHS as well as increased grid connectivity across the county. Figure 2.3 below shows a comparison in the adoption of different technologies for HH lighting in Narok county between 2019 and 2021.



2.1.1.2 Cooking and Water Heating

Data from the 2019 census, as illustrated in Figure 2.4, revealed that firewood is the dominant source of fuel for cooking and (water) heating in Narok County, providing energy for more than two-thirds (71.7%) of the households in the county. This is considerably higher than the 2019 national average of 55.1%. This can be attributed to the high population of people residing in the rural parts of Narok county, coupled with the low penetration of clean cooking fuels in the county. Charcoal is the second most popular cooking fuel, followed by LPG at 18% and 8% respectively. Such high dependence on firewood and charcoal has a huge environmental impact as most HHs cut down a lot of trees for firewood, while at the same time exposing families to risks of Household Air Pollution (HAP). The risk is particularly high for women and children who are always the ones in the kitchen preparing meals.

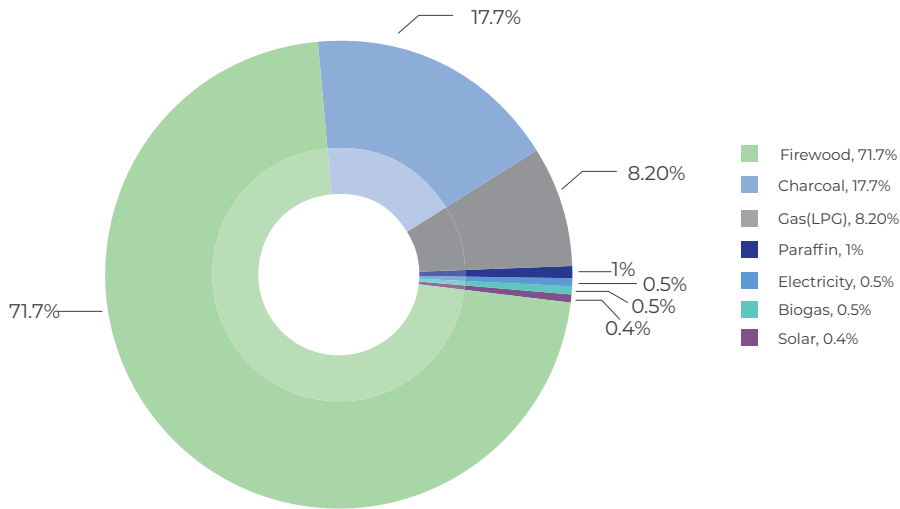


Figure 2.4: Distribution of Primary Cooking fuels in Households, 2019

Primary data collected in 2021 revealed little change in adoption of the different sources of energy for cooking and heating (from 2019 census). However, use of LPG for cooking grew by about 3%, reaching 11.1% in 2021. The low rate of adoption of cooking fuels such as electricity, biogas, ethanol and solar has been attributed to challenges rising from cost of technologies and their associated fuels, together with limited supply-distribution chains¹⁶.

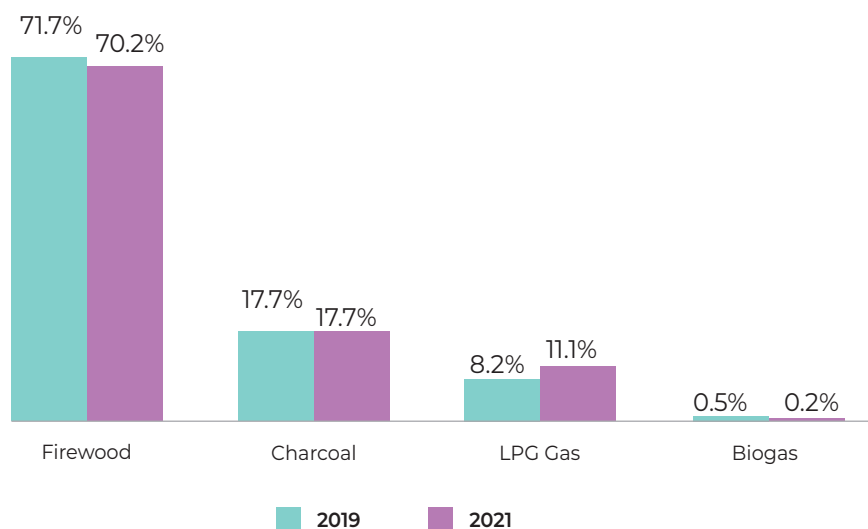


Figure 2.5: Trends in Household Cooking fuel usage from 2019 to 2021

Analysis at sub-county level as shown in Figure 2.6 revealed that firewood consumption was highest in Trans-mara East Sub-County where about 97% of households relied on this fuel for cooking and heating, followed by Narok South and Narok West sub-counties, both of which had about 86% of their households using firewood. On the other hand, charcoal consumption was highest in Narok North, an urban sub-county, where about 34% of the households used this form of energy for cooking and heating.

While LPG gas is not a common source of energy for cooking in Narok County, quite a significant proportion of the population (19%) of households in Narok North use this source of energy for cooking and water heating. This could be driven by the well-established distribution channels for LPG cylinders and refilling stations in Narok North sub-county as compared to most of the other areas across the county.

Percentage & Distribution of the Main Type of Cooking Fuel Across Narok Sub-Counties

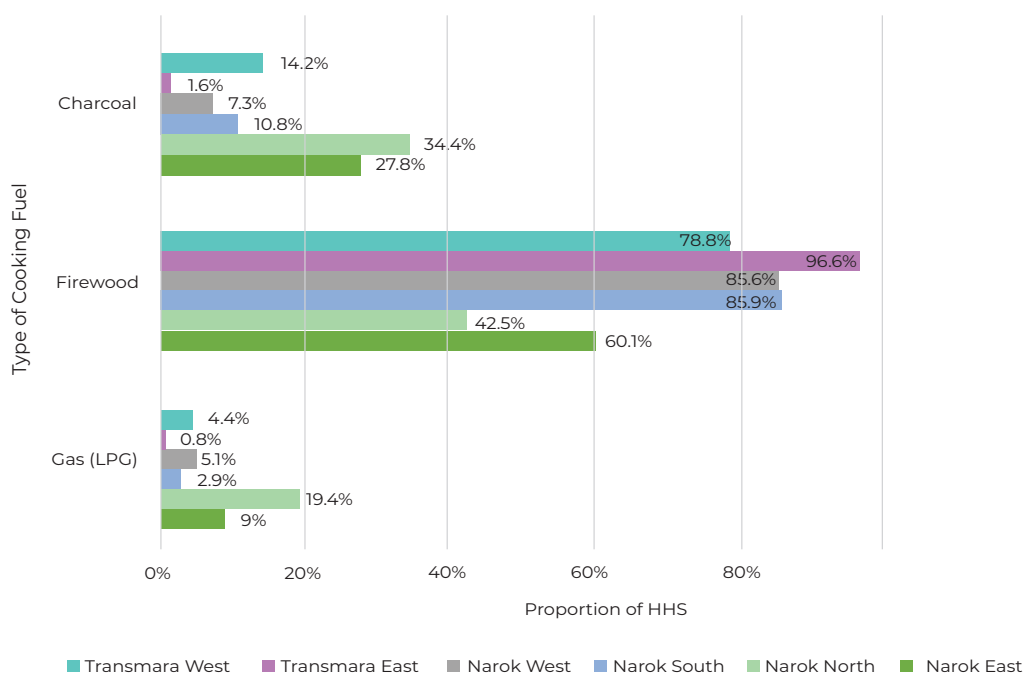


Figure 2.6: Percentage and distribution of Main HH cooking Fuel by Sub County

16 MOE 2019 - Kenya Clean Cooking Sector Study 2019. Available online at: <https://eedadvisory.com/wp-content/uploads/2020/09/MoE-2019-Kenya-Cooking-Sector-Study-compressed.pdf>. Accessed 23/01/2023

In terms of cooking technologies, traditional three stone stoves emerged as the most popular technology, used by more than half (55.6%) of the HHs in Narok county. This is followed by improved traditional stones (kuni mbili), which is used by 15.3% of the HHs. Ordinary jikos are used by about 13% of the HHs. Gas cookers are used by less than 10% of the HHs (about 9%).

Figure 2.7 below shows the primary cooking devices used in households in Narok in 2021.

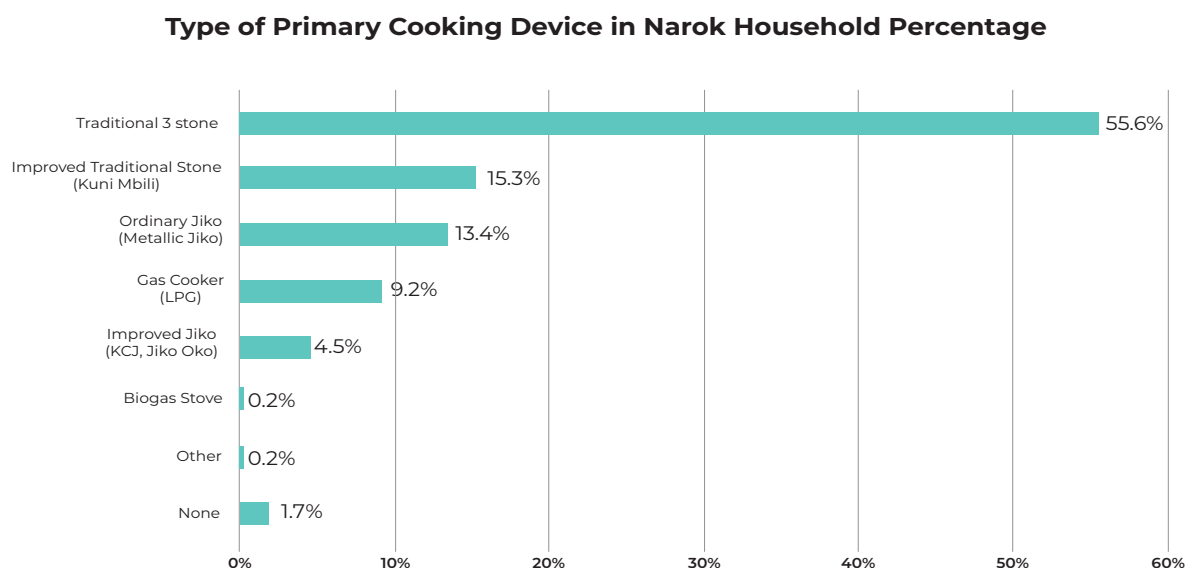


Figure 2.7: Types of primary cooking devices used in households

Table 2.1 shows the primary cooking fuel in urban and rural households disaggregated by gender. In urban households there is a heavier reliance on firewood for cooking in male headed households (39.5%) compared to female led at (31.3%). Comparatively, more female led households use LPG (28.13%) than male led households (26.32%). This could be contributed to by the fact that in female led households, women are the decision makers. Focus group discussions held in Narok County revealed that women are typically tasked with cooking in Narok County. As such, in female led households' tend to more readily adopt less burdensome clean cooking technologies to relieve themselves of the challenges faced when cooking with firewood. In a focus group discussion held in Narok West women predominantly from female lead households indicated that firewood had become scarce and not only did they suffer from smoke inhalation, they also faced threats from wild animals while collecting the firewood. During the focus group discussion, a participant told of a woman who had been chased by an elephant as she attempted to collect firewood. Additionally, another respondent indicated that inability to access firewood may lead to incidences of gender based violence in their homes. An incidence was narrated of a woman in the community who had to flee her home when her husband beat her after she was unable to cook due to lack of firewood. These women indicated that they would not only be happy to purchase clean cooking stoves but also sell them within their community as they did not have these technologies available to them.

Table 2.1: Primary Cooking Fuel for Rural and Urban Households by Gender of Household Head

Primary fuel for cooking	Urban			Rural			Overall Average	
	Male	Female	Average	Male	Female	Average	Male	Female
Firewood	39.47%	31.25%	35.71%	75.24%	72.00%	74.29%	57%	52%
Charcoal	31.58%	37.50%	34.29%	15.00%	16.57%	15.46%	23%	27%
Biogas	0.00%	0.00%	0.00%	0.24%	0.00%	0.17%	0%	0%
LPG	26.32%	28.13%	27.14%	9.52%	8.57%	9.24%	18%	18%
Crop residues	0.00%	0.00%	0.00%	0.00%	1.14%	0.34%	0%	1%
None	0.00%	3.13%	1.43%	0.00%	0.57%	0.17%	0%	2%
other	2.63%	0.00%	1.43%	0.00%	1.14%	0.34%	1%	1%

2.1.1.3 Household Electrical Appliance Ownership

Figure 2.8, adapted from the 2019 Census and the 2021 HH survey, shows ownership of some of the appliances across the county. While statistics do not show sources of electricity used by these assets, they can illustrate electricity demand in the county.

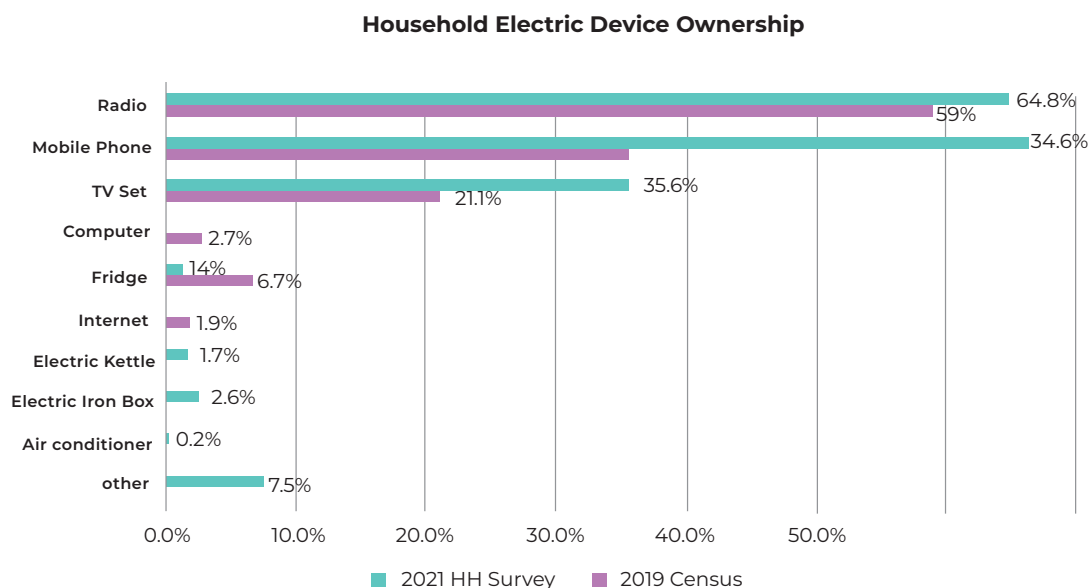


Figure 2.8: Percentage Distribution of Conventional Households by Ownership of Selected Household Assets in Narok County

According to the 2019 census data, radios were the most common electrical appliances used in Narok county - at 59%, followed by mobile phones at 34.3%. However, the trend changed significantly with mobile phone ownership almost doubling by 2021 to become the most common electrical devices across the county, owned by 66.2% of the population compared to 64.9% who owned radios. This could be driven by the increased uptake of solar home systems discussed in section 2.1.1.1, which enable mobile charging at household level.

The third most common electrical device in the county was TV sets whose ownership rose from 21.1% in 2019 to 35.6% in 2021. While increased uptake of TV sets may have been driven by increased uptake of the solar home systems, there is a possibility that the capacity of these systems could not power these appliances. As such, further research is recommended to ascertain the observations, especially for fridges whose ownership reduced.

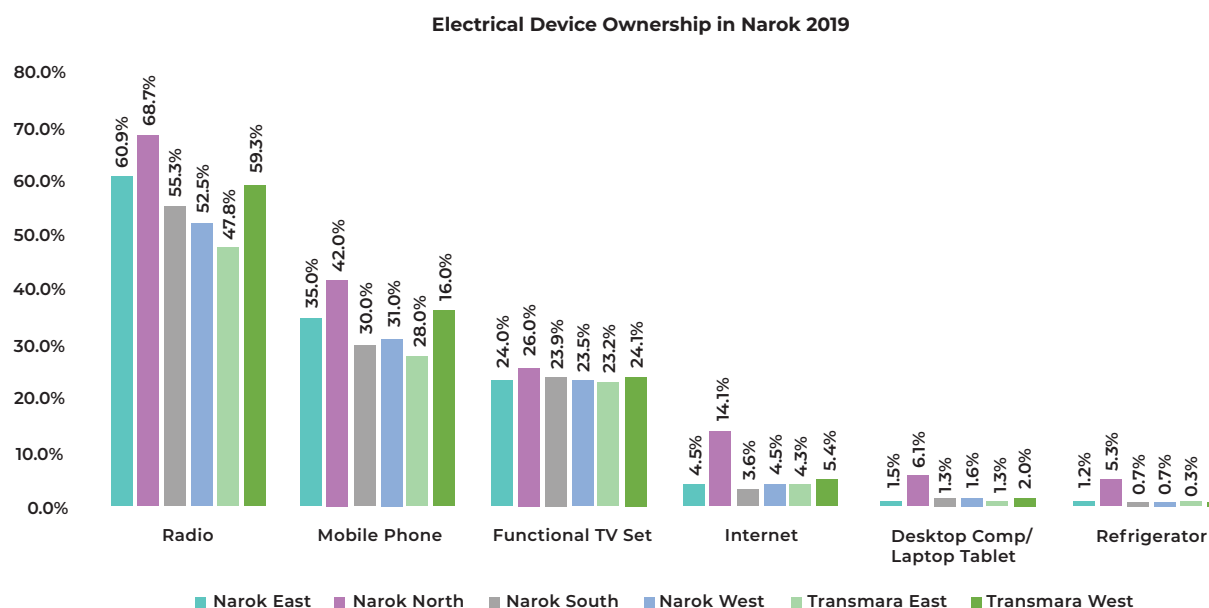


Figure 2.9: Electrical Device Ownership in Narok 2019

Figure 2.9 is a graph evaluating the statistics of electrical device ownership at the sub-county level, using the 2019 Census data. The evaluation revealed that Narok North had the highest penetration of electrical device ownership in the county while Trans Mara East had the lowest rate. Further, Trans Mara East was the only sub-county where less than half the population owned a radio.

2.1.2 Energy Access for Healthcare Facilities

The healthcare facility structure in Kenya is divided into six levels with the first five (level 1 - 5) being managed by the county government and the final, level six - National Referral Hospitals, managed by the national government¹⁷. The primary survey sampled 27 Healthcare Facilities (HCF) in Narok, ranging from level 1 to 5.

The most common type of HCF in Narok were the level 3 hospitals representing 16 (59.3%) of the sampled facilities, and refer to health centres, maternity and nursing homes. Level 2 hospitals (dispensaries and clinics) were the second most common types of HCF in the region with a representative sample of 8 (29.63%). Level 5 hospitals (county referral and large private hospital) were represented by 2 facilities (7.4% of the sample) while the least common was a level 1 facility (community services) which represented 3.7% of the sampled HCFs.

Energy consumption by healthcare facilities could be influenced by size, location and operating hours. For example, primary data collection revealed that 85.2% of the facilities are open 24 hours while the rest only operate during the day. While the energy consumption profiles of each facility may vary, the analysis and reporting was undertaken on healthcare facilities collectively to understand energy access trends of the entire health sector of Narok county.

Primary data collection was the only data source for healthcare facilities as this consumer segment was not covered by the National Population and Housing Census.

2.1.2.1 Lighting

The survey revealed that 81.5% of the sampled healthcare facilities (HCFs) rely on electricity from the grid for lighting, while diesel generators and solar lanterns each provided lighting for 7.4% of the facilities. Only 3.7% of the HCFs utilised stand-alone solar PV for lighting as shown in Figure 2.10. The large percentage of healthcare facilities connected to the grid as compared to households could be influenced by a program implemented by REREC, which sought to electrify all public facilities including healthcare facilities in the country¹⁸.

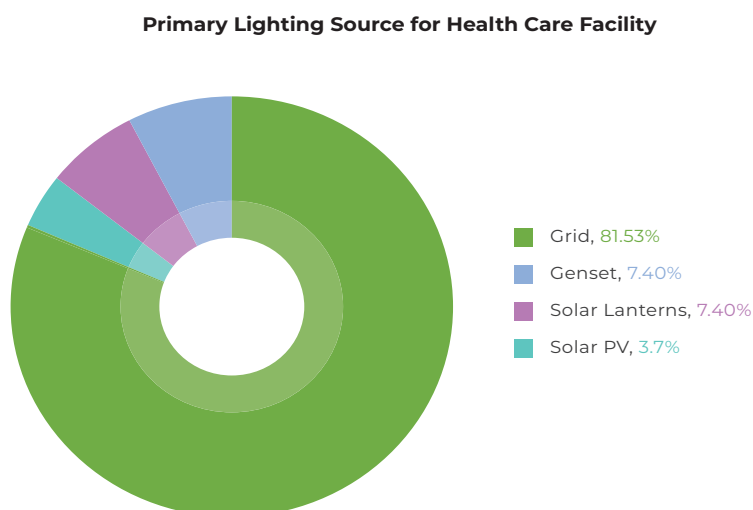


Figure 2.10: Primary lighting source for Healthcare Facilities

2.1.2.2 Cooking

An analysis of cooking fuels from the primary data identified charcoal as the dominant primary fuel for cooking (33.3%) in HCFs, followed by firewood (29.6%) and LPG (29.6%) as represented in Figure 2.11. Despite the high access to the grid, none of the HCFs reported using electric cooking devices as a primary stove. Also, 7.45% of the HCFs did not have cooking operations on their premises.

The ability of electric cooking technology to meet the cooking volume needs of the HCF could be a factor limiting their adoption. Further, this combination of high electricity access versus low electric cooking adoption is common in several African and Asian countries. Several factors can be attributed to the trend, including: cost of electricity and electric cooking appliances or perceptions around the same, awareness, cultural cooking practices, quality and reliability of electricity, and the type of electric cooking devices or technologies available¹⁹.

17 Action For Transparency - Kenya's Health Structure and the Six Levels of Hospitals. Available Online: <https://actionfortransparency.org/kenyas-health-structure-and-the-six-levels-of-hospitals-roggkenya/>. Accessed: 18/01/2023

18 REREC: Electrification of Public Facilities - Available Online at: <https://www.rerec.co.ke/electrification-public-facilities.php>. Accessed 23/01/2023.

19 MECS 2020: Electric Cooking: Needs Challenges and Way Forward. By Jyoti Parikh, Jon Cloke, Elisa Puzzolo, Daniel Pope and Chandrashekhar Singh. Available Online at: https://mecs.org.uk/wp-content/uploads/2020/12/77550-MECS-Briefing-Paper-Electric-Cooking_p4.pdf. Accessed 19/01/2023

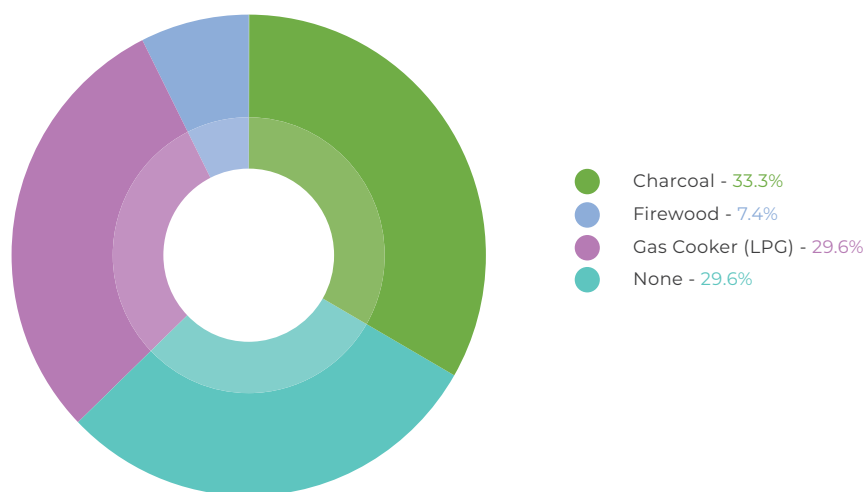


Figure 2.11: Types of Cooking Fuels for Narok HCF in 2021

Figure 2.12 below depicts a graph showing the types of cooking devices used in Narok's HCFs in 2021. As expected, the majority of HCF utilise LPG cookers because their primary fuel is LPG. There is potential to enhance energy efficiency of this sector by targeting the stoves used by firewood and charcoal consumers.

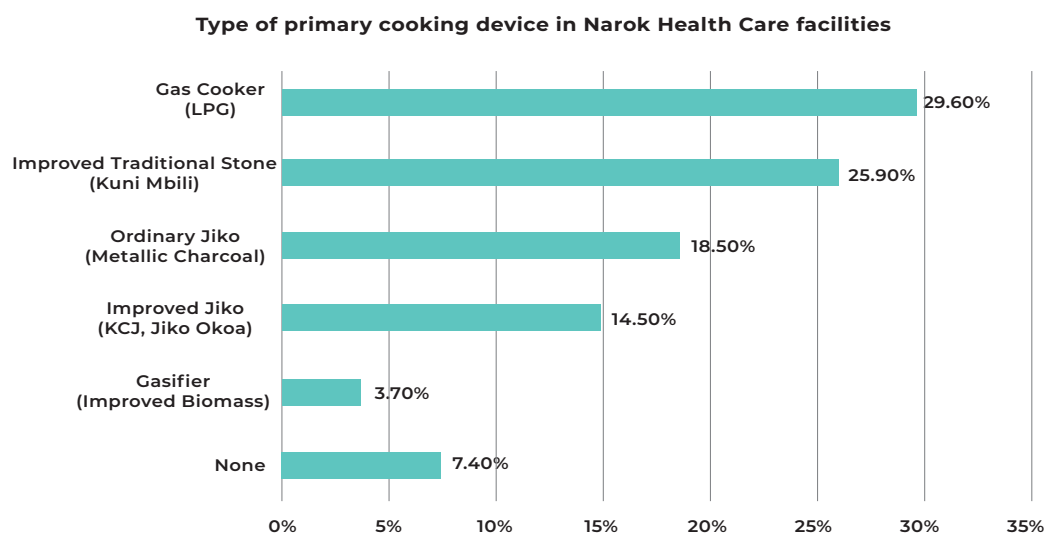


Figure 2.12: Type of Primary Cooking Devices in Narok HCFs in 2021

However, the outcome of the survey revealed some variations between primary fuel, versus cooking devices used by the HCFs. For example, while 37% of the HCFs interviewed during the survey reported using LPG as their primary fuel for cooking and heating, only 29.6% reported using gas cookers as the primary cooking device. These variations can be attributed to factors such as fuel stacking²⁰. In such cases, multiple cooking devices such as gas cookers, improved traditional stone and improved jikos could be used simultaneously, making it challenging for respondents to disaggregate the primary from secondary cooking device.

20 World Bank 2020: Understanding cookstove and fuel stacking to achieve SDG7. Published online on 22/11/2020. Available online on: <https://blogs.worldbank.org/energy/understanding-cookstove-and-fuel-stacking-achieve-sdg7#:~:text=As%20cooking%20in%20developing%20countries,combinations%20within%20the%20same%20household>. Accessed 19/01/2023

2.1.3 Energy Access for Learning Institutions

2.1.3.1 Lighting

82.8% of education institutions in Narok county rely on grid electricity for lighting, while another 7% use solar PV. Generators and mini grids are used by 3.4% and 1.7% of the institutions, respectively. The high rate of connectivity to the grid for education institutions can be attributed to the government's rural electrification programme implemented by RREC, which sought to electrify public facilities.

2.1.3.2 Cooking

94.8% of the education institutions use firewood, while close to 35% use charcoal. Only 3.4% use electricity while the remaining 1.7% use other sources such as gas cookers. Figure 2.13 below shows that most institutions use the three 3-stone jiko as their primary cookstove, followed by improved traditional stones (kuni mbili), and ordinary institutional cookstoves was third. LPG cookers were used by less than 10% of the institutions. Despite the high potential for biogas in Narok due to easy access to feedstock (animal dung) from livestock, adoption of this source of clean energy for cooking remains very low (at 1.7%) due to limited awareness, coupled with high investment costs.

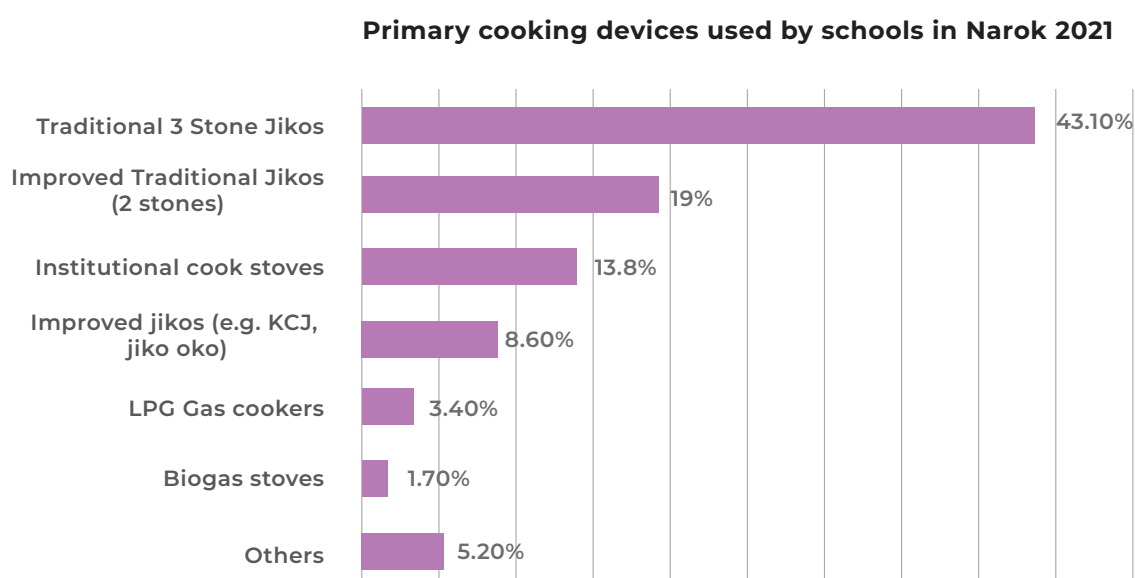


Figure 2.13: Primary Cooking Devices Used by Schools in Narok 2021

As with Healthcare Facilities, education institutions stack cooking devices and fuels. As such, while 94.8% of the institutions reported using firewood as the main cooking fuel, only about 75.9% of the institutions reported using firewood-based cooking devices (Traditional 3 stone jikos, Improved traditional jikos - 2 Stones, and Institutional cookstoves) as their primary cooking appliance.

2.1.4 Energy Access for Infrastructure Services

The county infrastructure services include energy access for street lighting and community services such as water supply and distribution. Due to limited information on specific street lighting solutions, this section focuses on water services.

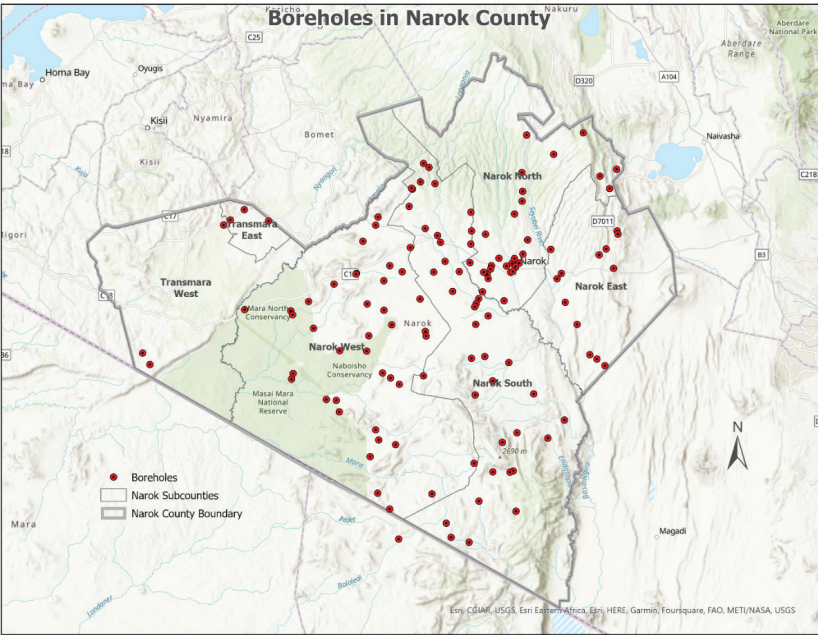
Agriculture is a significant contributor to revenue in Narok as such provision of water for irrigation is an essential service. Narok's irrigation capacity is significantly underserved since only 25.48% of its potential irrigable land (3,140 Ha) is under irrigation.

The county also facilitates access to water by building dams, water pans and digging boreholes. Water distribution is achieved through a network of pipes and by equipping boreholes with pumps. In 2018, the county set plans in place to build 163 new boreholes and upgrade 184 existing ones by equipping them with solar pumps by 2022. The status of this initiative features in the CIDP review.

Figure 2.14 depicts a map with the locations of 136 active county-operated borehole projects in Narok County. As of April 2022, 72 of these boreholes were operational and 5 were under construction. Yet 40 were not fully operational due to breakdowns, stalled pumps and incomplete installations with two under rehabilitation, while 19 are planned for future construction. Since 2022 marks the end of Narok's 2018-2022 CIDP, it is possible that some of the boreholes will feature in the next CIDP.

The 2019 National census revealed that the most common source of drinking water in Narok was streams and rivers, used by 10.3% of the households, while boreholes only provided about 4.4% of the households. Sourcing drinking water from surface streams and rivers significantly raises the risk of contracting and propagating water borne diseases. By increasing access to clean water from boreholes, the county can reduce its disease burden and enhance the welfare of its constituents.

Narok county water department intends to use solar powered pumps to access water from all new boreholes in the county. As such, solar energy will play a central role in the distribution of potable water in the County.



The 2019 National census revealed that the most common source of drinking water in Narok was streams and rivers, used by **10.3%** of the households, while boreholes only provided about **4.4%** of the households.

Figure 2.14: Distribution of County-Operated Boreholes in Narok³

As part of the water infrastructure, Narok County had set plans to build systems and water treatment plants in Kilgoris and Narok Town to help manage the liquid waste generated by 2022. These facilities will require access to reliable electricity to operate water treatment systems. The water waste management systems also have the potential to generate centralised biogas that could be used for electricity generation and contribute to the achievement of universal electricity access.

2.1.5 Energy Access for Micro, Small and Medium Enterprises (MSMEs)

Primary data collection revealed that the majority of MSMEs²¹ (59%) were found in rural areas while 41% were found in urban areas. A gender analysis revealed that 56% of the businesses are male owned while 44% are female owned. Table 2.2 below shows that gender analysis of enterprise ownership was similar in urban and rural areas.

Table 2.2: Gender of Urban and Rural MSME Owners

Rural/urban	Gender of MSME Owner		
	Male	Female	Total
Urban	56.36	43.64	100
Rural	55.53	44.47	100
Total	55.83	44.17	100

The most popular type of business in the county were restaurants, hotels and informal eateries (semi-permanent structures where food is cooked and served) followed by salons and barber shops. The type of business operated varied significantly between urban and rural areas as seen in Figure 2.15. Most of the restaurants, salons & barber shops interviewed during the survey are found in the rural parts of Narok because the county's population is predominantly rural, as mentioned in the section 2.1.1.2.

SMEs undertaking welding together with informal roadside enterprises (road-side make shifts) such as those selling roast maize, fried fish and other food products were more prevalent in urban areas. They were typically found at bus stops, markets, busy streets and other commercial areas where activities are fast-paced because they provide “food-on-the-go” as opposed to restaurants and eateries where you need to sit and dine. This could also explain their prevalence in urban areas. These businesses need to be supported to have clean energy services and energy efficient technologies. Figure 2.14 below describes the location of the MSMEs that took part in the survey.

21 MSMEs are businesses with between 1 and 99 employees.

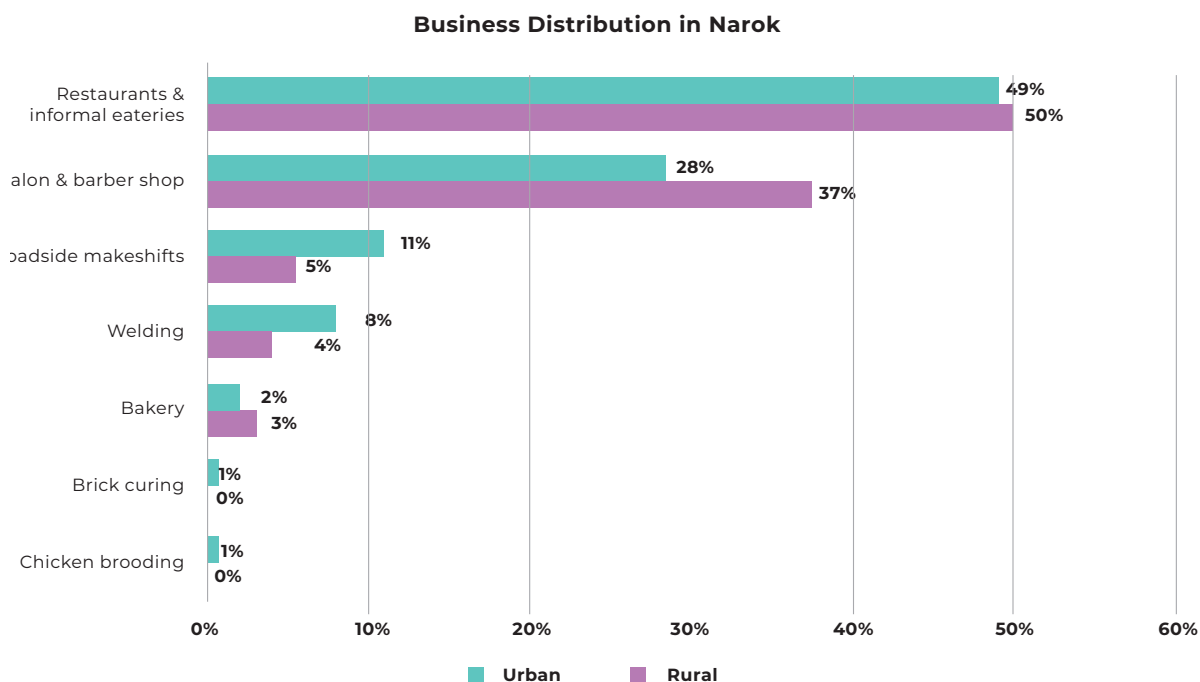


Figure 2.15: Types of Small Businesses Found in Narok

2.1.5.1 Lighting

The primary source of energy for lighting for MSMEs, both in rural and urban settings, is electricity from the grid as can be seen in Figure 2.16. The study revealed that 86.46% and 66.88% of urban and rural businesses respectively rely on grid electricity for lighting. SHS provide lighting services for about 11% of MSMEs, while solar lanterns provide energy for about 6% of businesses. Primary data collection also revealed that while most of the businesses rely on grid power, their average monthly spending on diesel for generators was seven times higher than that of electricity, with diesel expenditure standing at KES 7,530, compared to that of electricity at Ksh 1,080.

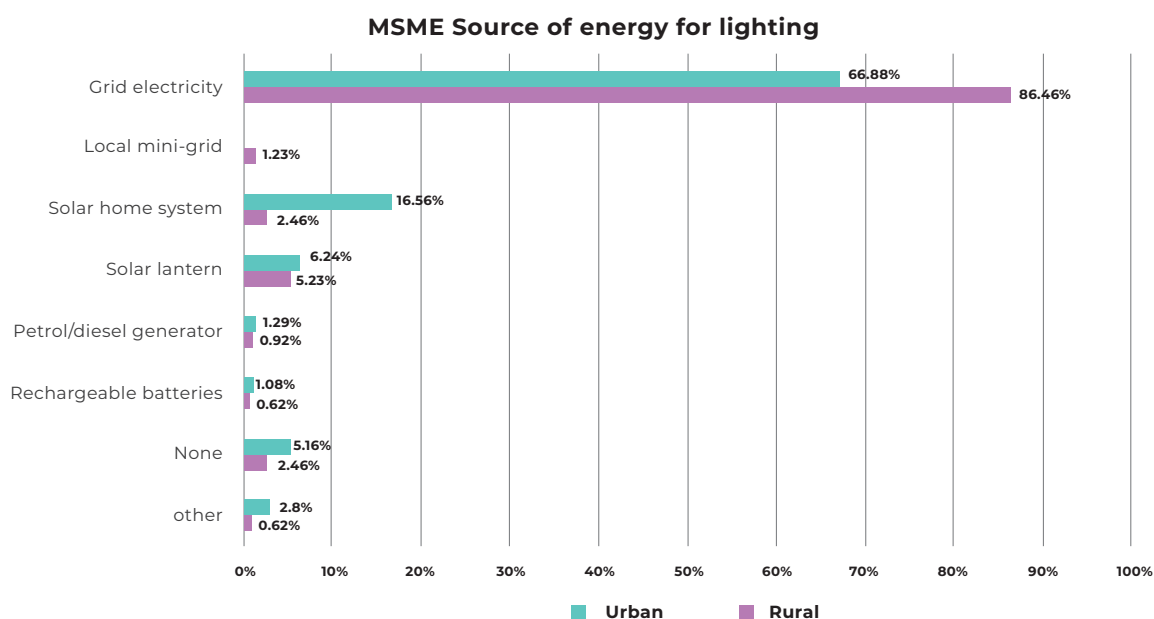


Figure 2.16: Sources of lighting energy for business

An analysis to disaggregate lighting energy use by area and urbanisation as shown in Table 2.3 indicates the following: In urban areas, majority of male-owned businesses (91.94%) use grid electricity for lighting while the percentage of women-owned businesses using the same source of energy for lighting is 71.88%, reflecting a difference of approximately 20%. A similar trend is observed in rural areas where 81.52% of male-owned businesses and 64.34% of female-owned businesses rely on the grid for lighting, a difference of about 17.18%.

More women-owned businesses rely on off-grid technologies for their lighting needs. In urban areas, for example, approximately 20% of females utilise a mix of mini-grids, solar home systems, solar lanterns and generators for lighting. In rural areas, the percentage of women using off-grid technologies is even higher at 26%. A technology difference is observed based on location with 13% of women in urban areas using solar lanterns and 17% of women in rural areas using solar home systems.

Using lighting sources as a proxy for grid connectivity indicates that more male-owned (81.5%) than women-owned businesses (64.3%) have access to grid electricity. This could be driven by the nature of businesses owned, for example, activities like welding, which require high tier access are typically undertaken by men. It could also mean that the men have better access to capital in order to run larger operations which have grid connectivity such as commercial restaurants and barber shops.

These findings are consistent with contexts in other countries within sub-Saharan Africa such as Zambia and South Africa where women were found to engage in informal enterprises including informal restaurants while men had formal establishments. In Zambia in particular, these men were able to access electricity connections and receive significant benefits such as expand their services and increase their operating hours.

Table 2.3: Lighting source disaggregated by Gender and Geography

Primary source of electricity for the MSME	Urban			Rural			Overall Average	
	Male	Female	Average	Male	Female	Average	Male	Female
Grid Electricity (i.e., KPLC)	91.94%	71.88%	83.18%	71.09%	56.80%	64.74%	81.52%	64.34%
Local Mini-grid	0.00%	3.13%	1.36%	0.00%	0.00%	0.00%	0.00%	1.57%
Solar Home System	1.61%	2.08%	1.82%	16.59%	17.16%	16.84%	9.10%	9.62%
Solar Lantern	2.42%	13.54%	7.27%	5.69%	8.28%	6.84%	4.06%	10.91%
Petrol/diesel generator	0.81%	1.04%	0.91%	0.47%	1.18%	0.79%	0.64%	1.11%
Rechargeable battery	1.61%	0.00%	0.91%	1.42%	1.18%	1.32%	1.52%	0.59%
None	1.61%	6.25%	3.64%	2.84%	10.06%	6.05%	2.23%	8.16%
Other	0.00%	2.08%	0.91%	1.90%	5.33%	3.42%	0.95%	3.71%

2.1.5.2 Cooking

Primary data collection revealed that 37% of MSMEs in Narok had cooking operations on their premises with 29 % of these being found in urban areas and 43% in rural areas. Cooking was undertaken by restaurants, informal eateries, roadside makeshifts, and bakeries interviewed. Figure 2.17 shows the primary type of cooking fuel used by these businesses.

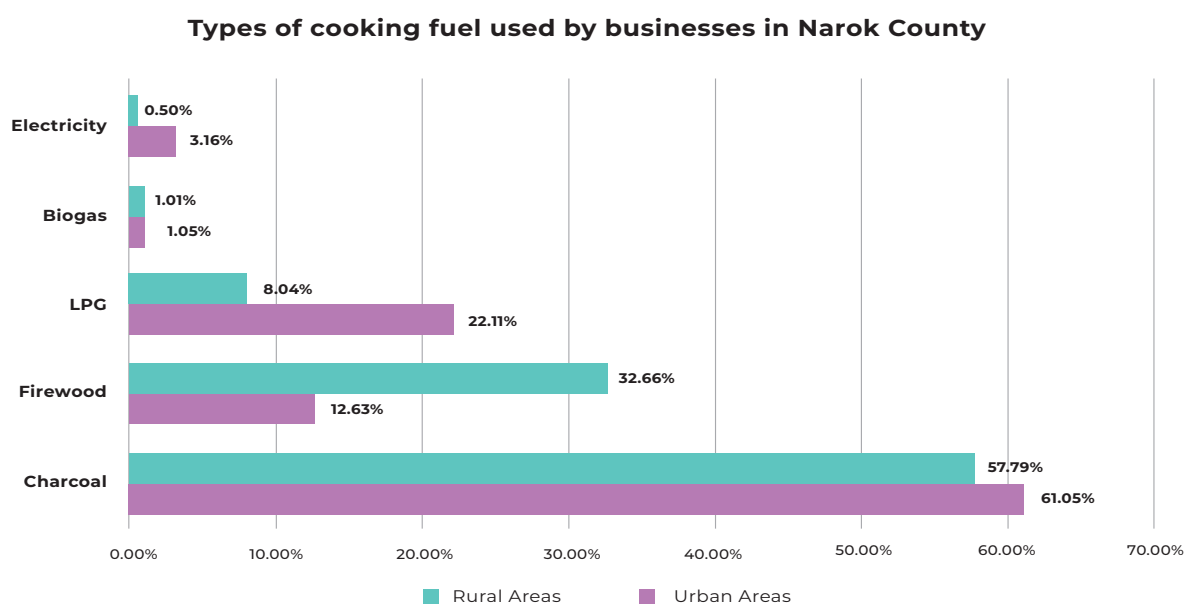


Figure 2.17: Primary type of cooking fuel for MSMEs in Narok

Charcoal is the dominant cooking fuel for businesses in urban and rural areas at 61% and 58% respectively. LPG, on the other hand, is the second most common cooking fuel for MSMEs in urban areas while firewood is used in the rural areas. As expected, 49.3% of the MSMEs in Narok used ordinary jikos as their primary cooking device as shown in Figure 2.18. The second most common cooking device (24.10%) for SMEs was Improved Traditional Stone (Kuni Mbili).

Type of primary cooking device in Narok SMEs

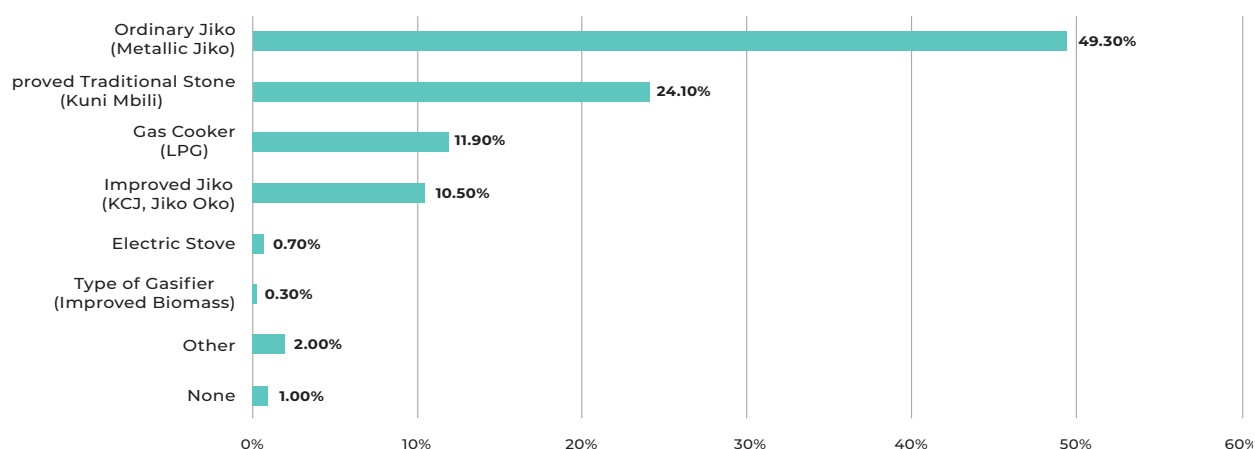


Figure 2.18: Primary cooking device in Narok MSMEs

Table 2.4: Primary Cooking Fuel in Urban and Rural MSME by Owner's Gender

Primary fuel for cooking by the business	Urban			Rural			Overall Average	
	Male	Female	Average	Male	Female	Total	Male	Female
Firewood	15.38%	8.82%	11.67%	39.76%	32.53%	36.14%	27.57%	20.68%
Charcoal	65.38%	70.59%	68.33%	50.60%	62.65%	56.63%	57.99%	66.62%
LPG	19.23%	14.71%	16.67%	9.64%	3.61%	6.63%	14.44%	9.16%
Electricity	0.00%	5.88%	3.33%	0.00%	1.20%	0.60%	0.00%	3.54%

Table 2.4 above features the primary types of cooking fuel used by the MSMEs disaggregated by gender. According to the findings, more men-owned businesses use firewood in both urban and rural areas by 6.6% and 7.2% respectively. On the other hand, more women-owned businesses use charcoal in urban and rural areas by 5.2% and 12% respectively. LPG has more uptake by men-owned businesses in urban and rural areas by 4.52% and 6.03% respectively. This data indicates that interventions to enhance clean cooking transition can adopt gender-based strategies as it seems because there is significant difference on the adoption of fuels.

2.2 Sectoral Breakdown of PUE Opportunities

The broad definition of productive uses of energy projects (PUE) is in reference to energy consumption for income generation or welfare improvement. PUE is mostly focused on improvements in rural enterprise, agriculture, health and education²²

For this section, the CEP team will focus on a narrower definition of PUE, which refers to "Agricultural, commercial and industrial activities involving energy services as a direct input to the production of goods and provision of services"²³

The Narok CIDP highlights projects in various sectors of the county government targeted because of their high potential for creation of employment opportunities, increasing county competitiveness and revenue generation. They may be derived from the Kenya Vision 2030 (to be implemented in collaboration with the National Government) or from the County Transformative Agenda. Table 2.5 below provides a summary of the major PUE opportunities in Narok County.

22 K. Kapadia - Worldbank 2004: Draft Productive Uses of Renewable Energy. A Review of Four Bank-GEF Projects. Available Online at: <https://web.worldbank.org/archive/website00530/WEB/PDF/KAPADIAP.PDF>. Accessed 19/01/2023.

23 L. Mayer-Tasch - GIZ 2013: Promoting Productive Use of Energy in the Framework of Energy Access Programmes. Available Online at: <https://sustainabledevelopment.un.org/content/documents/4738mayer.pdf>. Accessed 19/01/2023

Table 2.5: Major PUE opportunities in Narok County

Sector	Activities
Agriculture and Livestock	Setting up fish hatcheries and fish farms
Environment, Energy, Water & Natural Resources	Establishment of solid and liquid waste management and recycling facilities Drilling of 163 new boreholes and installation of solar-powered submersible pumps in schools & local communities Upgrading of 184 existing boreholes to rely on solar power
Trade, Industrialization & Cooperative Development	Electrifying informal industries (Jua Kali fabrication, garages, welding, cutting, power tooling etc) Street lighting and high intensity security flood lights Cooling facilities for milk, meat, fish and other food preservation Milling and grain grinding.

2.3 Summary of Major gaps in Narok County and key Recommendations

The list below provides a summary of the major gaps (policy, economic, and technological) experienced in Narok County, which have continued to plague the energy sector in Narok:

1. Narok county experiences low rates of access to energy - both for lighting, cooking and for productive use.
2. Lack of an enabling environment necessary to facilitate development & implementation of innovative energy access projects.
3. Access to finance by end-users to purchase clean energy technologies for productive use, as well as household lighting & clean cooking remains significantly low.
4. The county lacks necessary data to facilitate inclusive & integrated energy planning.
5. Limited awareness on viability of RE technologies by households, MSMEs, & institutions across Narok County.
6. Narok county lacks an institutional framework and human resource capacity to address energy access challenges in the county.

Below we provide some of the major recommendations to address these gaps.

2.3.1 Policy, Regulatory and Governance Interventions Recommendations

1. There is need to establish (and empower) an energy unit, or a stand-alone department responsible for energy matters only at the county.
2. Develop and implement policies and regulations to facilitate implementation and uptake of clean energy in Narok County (both for lighting and clean cooking).
3. Establish energy centers and promote establishment of RE demonstration sites across the rural parts of Narok county.
4. Establish & facilitate a county platform for regular data gathering (under the planned M&E policy).

2.3.2 Economic/Financial Recommendations

1. Develop and implement policies & strategies, as well as partnerships with strategic development & financing organisations including impact investors, NGOs and Private sector actors to provide end-user financing products.

2.3.3 Technical Recommendations

1. Develop solar powered water pumping & irrigation schemes in each ward.



03

County Energy Resources Assessment

The following resources were found available in Narok County: Geothermal, hydropower, solar, wind and bioenergy. The resource potential of these energy sources is discussed in detail in the following sections.

3.1 Geothermal Power

Kenya's power infrastructure greatly relies on geothermal power which inputs about 42% (KPLC, 2021)²⁴ of power to the national grid, making it the 8th largest producer of geothermal energy in the world as of 2021²⁵.

Geothermal resources are largely domiciled in the rift valley areas of Kenya with an estimated potential of between 7000 – 10000 MW spread over 14 prospective sites²⁶. However, as of 2021, Kenya has a current installed geothermal energy capacity of 713 MW²⁷ which is well below the potential if adequately exploited.

In Kenya, geothermal power is largely exploited and managed by the Geothermal Development Company (GDC). GDC is tasked with developing steam fields and selling of geothermal steam for electricity generation to Kenya Electricity Generating Company PLC (KenGen) and other independent private investors.

In Narok, a plan is underway to set up a geothermal power plant in Suswa with construction estimated to begin in 2023. The Suswa Geothermal Project has an estimated potential of 750MW, which will be developed in phases. The first three phases will develop a total of 300MW, with each phase developing 100MW²⁸. If implemented, this project will greatly contribute to the overall power output supply in Kenya.

3.2 Hydropower

Hydropower remains one of the main sources of power supply for Kenya's electricity sector. It accounts for about 45% of KenGen's total installed capacity²⁹. The total installed large hydropower capacity in Kenya is 826 MW. However, the small hydropower potential in Kenya is estimated to be 3,000 MW, of which less than 30 MW has been exploited and only 15 MW supply the grid³⁰.

According to resource assessment results of small and mini hydropower potential in Sub Saharan Africa carried out by KTH Division of Energy Systems Analysis³¹, about 10 sites were selected in Narok County as potential sites for setting up small and mini hydropower plants. Most countries recognize "mini" hydropower systems as systems that generate more than 100 kW but less than 1MW and "small" hydropower systems as systems that generate more than 1MW but less than 10 MW.³²

The map in Figure 3.1 shows the locations of these 10 identified sites in Narok County. From the map, most of these sites are concentrated towards the eastern parts of Narok along or near the borders of Narok East, Narok South and Narok North while 2 other sites are located in the western parts of Narok County at or near the borders of Narok West and Transmara West. The rivers where the selected sites fall include: Seyabei, Narok, and Ewaso Ng'iro rivers in the eastern parts while in the western parts, the sites fall along river Mara and Amala.

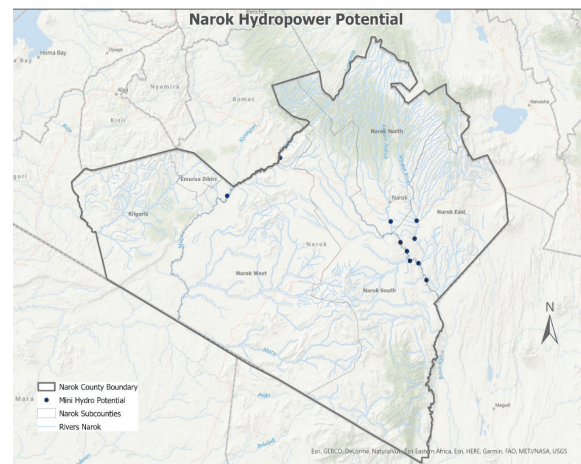


Figure 3.1: Map showing potential sites for setting up small and mini hydropower plants in Narok

The total power output for all the 10 sites was calculated to be about 12.22 MW. This means that if exploited, hydropower could become a useful source of energy for Narok County.

3.3 Solar Power

According to the Global Solar Atlas³³, the solar potential in Narok is significant, particularly in the central parts of the county. Figure 3.2 below shows the long-term yearly average Global Horizontal Irradiation (GHI) in Narok County with the average GHI being about 2,163 kWh/m². This implies a high potential for photovoltaic electricity production (Figure 3.3). The average potential photovoltaic power output is about 4.71 kWh/kW-peak per day. In other words, a small residential PV system could supply on average more than 1,700 kWh per year.

24 KPLC. (2021). KPLC Annual Report 2021. Available at: <https://www.kplc.co.ke/img/full/KPLC%20Annual%20Report%20and%20Financial%20Statements%20for%20the%20year%20ended%2030.6.2021.pdf>. (Accessed 10/02/2022).

25 KenGen. (2022). Hydro. Available at: <https://www.kengen.co.ke/index.php/business/power-generation/hydro.html>. (Accessed 10/02/2022).

²⁶KPLC. (2021).

26 EPRA. (2022). Geothermal. Available at: <https://renewableenergy.go.ke/technologies/geothermal-energy/>. Accessed 10/02/2022

27 GDC. (2022). Suswa Geothermal Project. Available at: <https://www.gdc.co.ke/suswa.html>. (Accessed 10/02/2022).

28 Ibid

29 KenGen. (2022)

30 EPRA. (2022). Hydro Energy. Available at: <https://renewableenergy.go.ke/technologies/hydro-energy/>. (Accessed 10/02/2022).

31 Korkovelos, A. (2016). Sub Saharan Africa - Small & Mini Hydropower Potential. Available at: <https://energydata.info/dataset/small-and-mini-hydropower-potential-in-sub-saharan-africa>. (Accessed 10/02/2022).

32 KEREAA.(2023). Small Hydro. Available at:<https://kereaa.org/renewables/small-hydro/>.(Accessed 1/27/2022).

33 Solargis. (2018). Available at: <http://globalsolaratlas.info/>. (Accessed: 20/02/2022).

Global Solar Atlas. 2018. Retrieved from <http://globalsolaratlas.info/>. Accessed through Energy Access Explorer, [02/05/2022]. www.energyaccessexplorer.org.

Note: Datasets are on long-term yearly average of global horizontal irradiation (GHI) in kWh/m² and potential photovoltaic electricity production (PVOUT) in kWh/kWp, covering the period 1994–2018.

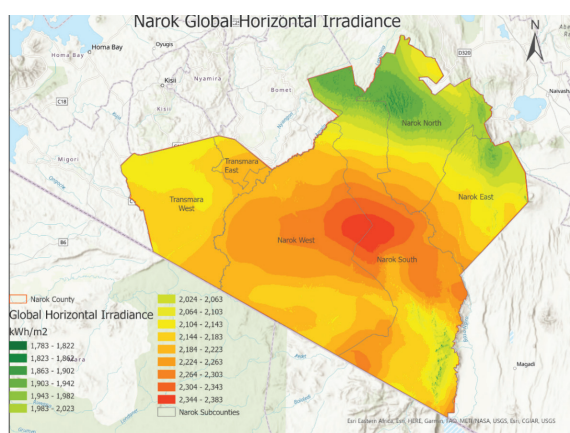


Figure 3.2: Long-term yearly average of global horizontal irradiance (GHI) in kWh/m² in Narok County

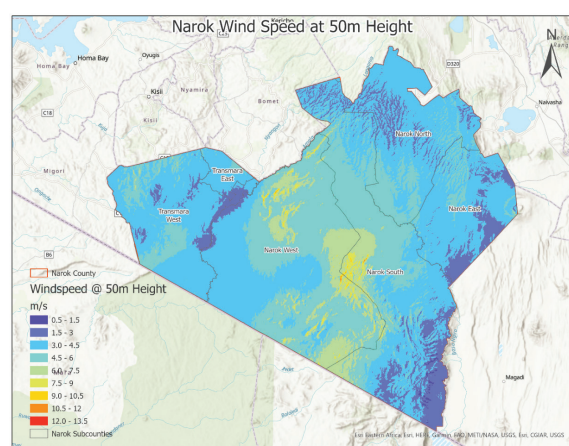


Figure 3.4: Mean annual wind speed at 50 metres heights for Narok County

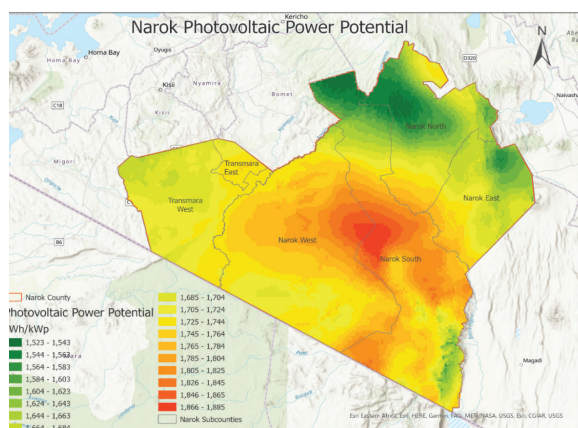


Figure 3.3: Long-term yearly average of potential photovoltaic electricity production in kWh/kW-peak in Narok County

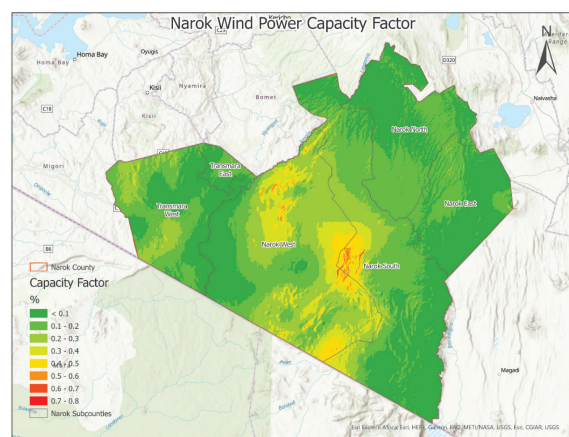


Figure 3.5: Wind power capacity factor for Narok County

3.4 Wind Power

The Global Wind Atlas³⁴ provides data that was used to visualise the mean annual wind speed (Figure 3.4) and the wind power capacity factor of Narok County (Figure 3.5). The capacity factor is used here as a measure of the wind power potential at different sites.

The capacity factor is defined as the average power generated, divided by the rated peak power (the amount of energy actually produced by a wind turbine compared to the energy produced if the machine ran at its rated power over a given period of time). It is used as a performance parameter for comparing the potential for wind power generation at different sites.

According to the wind speed map of Narok County, higher wind speeds of above 6m/s at a height of 50m are located towards the central parts of the county within Narok West and Narok South sub counties. This translates to an equally higher capacity factor in the same areas as is evident in the chart in Figure 3.6, which compares the average wind power capacity factors across the sub counties of Narok.

Narok West and Narok South have wind power capacity factors of 15% and above as shown in Figure 3.5, an initial indication of potentially suitable sites for wind power installations.



Figure 3.6: Wind Power Capacity Factor values (%) in Narok County using data from the Global Wind Atlas, calculated by authors

34 DTU. (2022). Global Wind Atlas. Available at: <https://globalwindatlas.info/>.(Accessed: 20/02/2022).

Note: GWA - An open access, web-based application that maps the mean annual wind speed and the wind power capacity factor across the world at high-resolution.

3.5 Bioenergy Resources

Bioenergy in Kenya is typically consumed in the form of solid biomass as firewood and charcoal. Other forms of biomass include crop residues or animal dung which provide energy needs for cooking, heating, drying or electricity production. Biomass energy resources are derived from forests - closed forests, woodlands, bush lands, grasslands, farmlands, and plantations, as well as from agricultural and industrial residues.

As mentioned in section 1.8, Narok County has two dominant vegetation types: the forests in the highlands and the lowland vegetation. The highlands of Narok County are forested and also host large-scale farmers as they have rich volcanic soils suitable for intensive agricultural production and potential for growing wheat, barley, maize, beans and potatoes as well as production of wool sheep and dairy farming. The forests have three distinct tenure categories: forestlands managed by the National Government; forestlands managed by the County Government of Narok; and forest or woodlots within private /group ranches.

Table 2.1: Main forests in Narok County as classified by their tenure

Forest	Size (Ha)	Status
Forests Managed by National Government		
Transmara (Nyangores, Nairatia, and Olunguruone forest stations)	32,000	Moist
Oi Posimoru	17,000	Moist
South Mau	136	Moist
Forests Managed by the County Government of Narok		
Maasai Mau	46,000	Moist
Nyakweri		Moist
Loita	20,000	Lowland dry forest
Enosupukia	11,000	Moist
Forests in Private/Group Ranches		
Located in all sub-counties	34,000	Varied

A land use cover map of Narok County was created using data extracted from ESRI 2020 Land Cover Map. Protected areas were extracted from the land cover map using data derived from World DataBase of Protected Areas 4 (WDPA4). Available boundary layers of gazetted, county, and community forests were superimposed onto the satellite-based land cover map using GIS analysis. The resulting map is as shown in Figure 3.7. It shows that the areas towards the north and south of Narok have great biomass potential in the form of tree cover and crops residue (due to large concentration of cropland) while the central regions of Narok have a majority of their land covered in scrubs/shrubs.

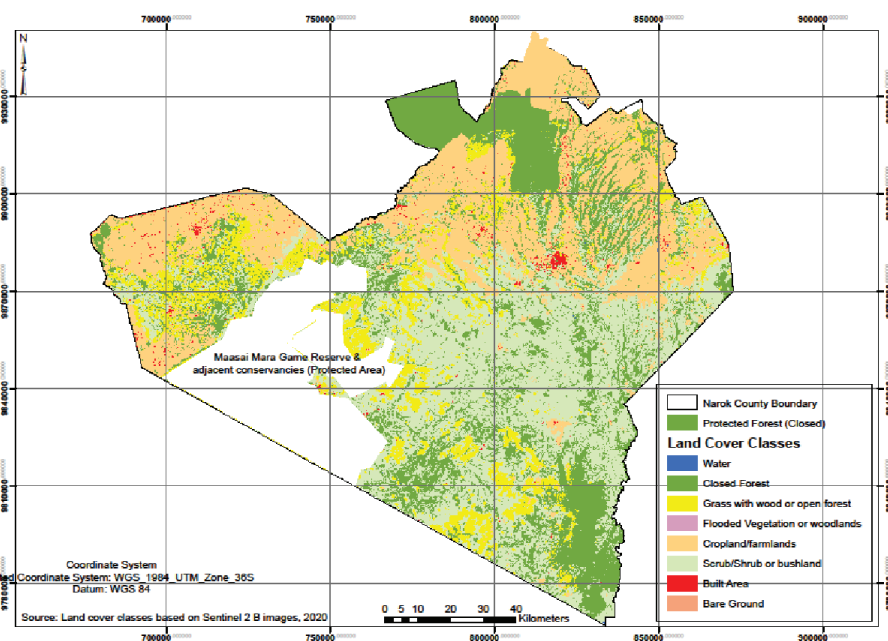


Figure 3.7: Coverage of woody biomass of Narok County

As shown in Figure 3.8 below, tree cover and crops occupy a combined area of around 816,507 Ha, approximately 50% of the total unprotected area in Narok, thus illustrating the great potential for biomass in Narok. Bushland mainly dominates the central and southern parts of Narok County and occurs outside protected areas, covering approximately 540,000 Ha, and is assumed to also provide biomass energy needed by households, institutions, healthcare facilities and the small and medium enterprises and/or cottage industries. Distribution of these land use/land cover types across the sub-counties of Narok County was accomplished by superimposing the administrative layer onto the forest layer, and cross-tabulation analysis conducted.

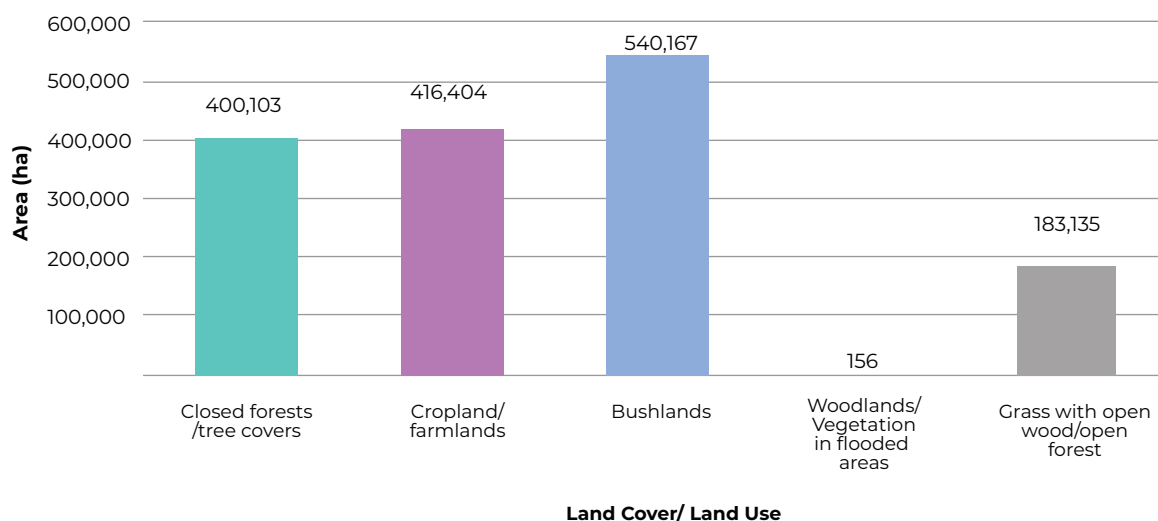


Figure 3.8: Land Use/Land Cover for Narok County

Within the settlement areas, the County statistical data reported that 1,350 farms were engaged in forestry in 2016. The primary data collected revealed that the overall land size is 7.7 ha per household. Additionally, the average size of land under natural forest or woodlot (naturally growing on-farm) across the county was reported as 1.8 ha. These statistics, however, vary between sub-counties. Similarly, the size of land under planted (or managed) forest or woodlot (planted trees on-farm) was reported as 0.14 ha for the whole county population. The summary of sub-county statistics is reported in Table 3.1.

The expected areas under trees (EAT) in hectare (ha) is then computed Equation 3.1³⁵

Equation 3.1

$$EAT = \mu * p * PNH$$

EAT is the expected area under trees,

μ

is the mean area in hectares under trees per given household and the calculated mean on-farm forests/woodlots per household is reported in Table 3.1;

p

is the proportion percentage expected to be under trees on the basis of individual household land size. Assumed value is 23% calculated using the formula below

$$p = \left(\frac{1.8}{7.7} \right) * 100$$

PNH

is the projected number of households.

Equation³⁵

Table 3.1: Summary of sub-county statistics on household's access to land (ha), natural and planted forests or woodlots on-farm (ha)

Variables used for estimating areas under trees on private land	Transmara East	Transmara West	Narok East	Narok North	Narok South	Narok West
# of households (?)	20,506	50,132	25,078	59,996	46,723	38,678
Household's access to land (ha)	1.21	5.26	4.45	8.09	6.88	25.50
Planted forests/woodlots (ha)	0.04	0.08	0.04	0.08	0.04	0.00
Natural forests/woodlots (ha)	0.04	0.49	1.70	0.53	0.77	1.34
Mean on-farm forests/woodlots (ha) per household (μ)	0.08	0.57	1.74	0.61	0.81	1.34
Expected areas under trees (ha)	377	6,572	10,036	8,417	8,704	11,921

The Global Forest Watch³⁶ has reported continued loss of woody vegetation cover in Narok County. The loss is driven by the economic activities and the traditional lifestyle of most residents of Narok County which contributes to massive use of charcoal and wood products. Forest loss driven by agricultural expansion, charcoal production and illegal logging has been reported in the high potential uplands of Narok³⁷ including Maasai Mau Forest in Narok North sub-county (County Government of Narok, 2018). Moreover, following land sub-division in most of the former group ranches in Narok County, individual landowners invite migrant charcoal producers to clear their land and produce charcoal^{38, 39}. Nyakweri forest in the former Transmara district, for example, is being degraded at an alarming rate. In Narok South sub-county also, production of charcoal was rampant, and women were particularly involved in this business. This trend is reflected all across the county, where land is being converted into agriculture for crops such as maize and wheat.

3.5.1 Estimation of base-year sustainable supply from woody biomass cover

Sustainable supply of wood fuel from protected forests and farmlands was calculated based on Equation 2.1⁴⁰:

Equation 3.2

$$SS = AAP * H$$

Where:

AAP

is the average annual productivity of forest lands and it varies. On farmlands, AAP of woody biomass is assumed to be 1.44 m³/ha/year while outside farmlands, it was assumed to be 0.79 m³/ha/year, being the average of respective productivity of closed forests/tree cover; woodlands or vegetation in flooded areas; and bushlands (MoE, 2002).

H

is the land area for each land cover type and,

SS

is the Sustainable Supply.

36 Global Forest Watch: Forest Monitoring, Land Use. Available online: <https://www.globalforestwatch.org>. (Accessed on 8 September 2022).

37 Ndegwa G, Sola, P., Iiyama M, Okeyo I, Njenga M, Siko I., Muriuki, J. (2020). Charcoal value chains in Kenya: a 20-year synthesis. Working Paper number 307. World Agroforestry, Nairobi, Kenya. DOI <http://dx.doi.org/10.5716/WP20026.PDF>

38 Mundia et al. (2009) Analysis of Land Use/Cover Changes and Animal Population Dynamics in a Wildlife Sanctuary in East Africa. RS.

39 Bedelian, C. (2012) Conservation and ecotourism on privatised land in the Mara, Kenya: The case of conservancy land leases. LDPI.

40 Giothimi et al., 2012

The calculated sustainable supply for woody biomass for Narok County is summarised in Figure 3.9 disaggregated by sub-county.

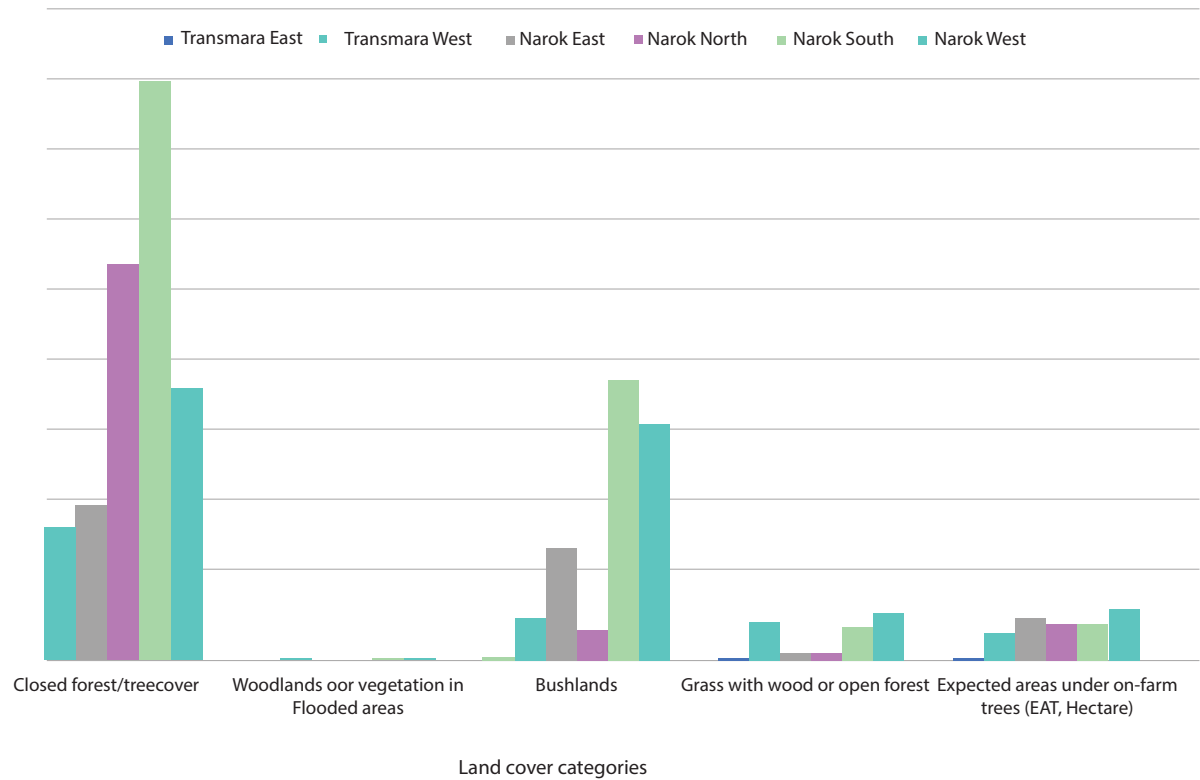


Figure 3.9: Sustainable supply of wood fuel across Narok County, disaggregated by sub-county

The total sub-county supplies of woody biomass were converted from m³ to kg. Wood density is species and age specific⁴¹. For example, Mango tree, one of the densest wood species found in Kenya, has a density of 675 kg/m³_{solid_bone-dry}⁴² while *Pinus patula*, a common pine planted in Kenya and one of the lighter woods found in Kenya averaging 450 kg/m³_{solid_bone-dry}⁴³. For the case of woody biomass resource assessment of Narok County, an average value of 562.5 kg/m³_{solid_bone-dry} was used⁴⁴. When converted, the total annual productivity of wood is found to be 489,000 tonnes.

The sustainable production rate for biomass for energy use would be a fraction of this since not all wood can be harvested to maintain stocks (e.g., considering loss to disease etc.) as well as other uses (e.g., timber). It was assumed that half (50%) of the wood harvested would go into energy use. Further study is required to develop an exact percentage. The results of the net sustainable annual productivity of wood for energy use are summarised in Figure 3.10. It is notable that there is no statistical data informing the percentage of woody biomass harvested for firewood versus charcoal. This could be due to the illegal nature of charcoal trading within Narok County. During primary data collection, some participants were hesitant to report charcoal as the main cooking fuel for fear of repercussion.

41 Githiomi, J. K., & Kariuki, J. G. (2010). Wood basic density of Eucalyptus grandis from plantations in Central Rift Valley, Kenya: Variation with age, height level and between sapwood and heartwood. Journal of Tropical Forest Science, 281–286.

42 The Wood Database. (2017). Mango | The Wood Database—Lumber Identification (Hardwoods). <http://www.wood-database.com/mango/>

43 Adlard, P., Godwin Baily, C., & Austin, S. (1979). Wood density variation in plantation-grown pinus patula from the Viphyia Plateau, Malawi (No. 5; C.F.I Occasional Papers, p. 27). Commonwealth Forestry Institute.

44 Buchholz T, Kiama S, Kifalu H, Ronoh G, DaSilva IP, Ngunzi V 2021. Bioenergy analysis for 65 factories of the Kenya Tea Development Agency Holdings Company Ltd (KTDA). Strathmore Energy Research Centre (SERC), Strathmore University, Nairobi, Kenya, 57p.

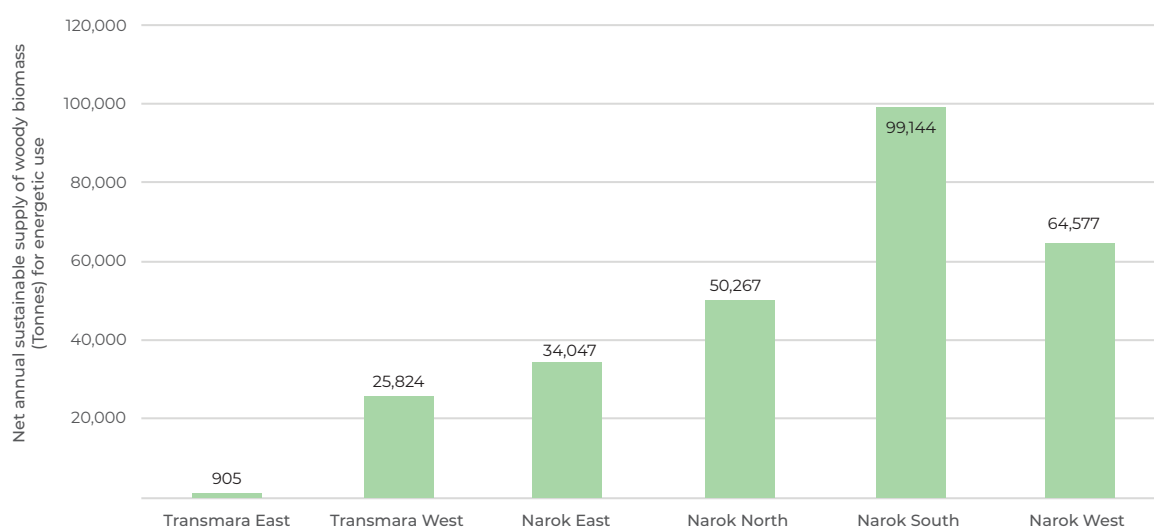


Figure 3.10: Net annual sustainable supply of wood fuel (for energetic use) from forests and on-farm woodlots & trees, disaggregated by sub-county

3.5.2 Future projections of sustainable supply of bioenergy from woody biomass

The future projections of sustainable supply from woody biomass cover accounts for the business-as-usual scenario, which is based on two key assumptions:

- The sub-division of group ranches which accelerates clearance of forest⁴⁵, and
- Annual growth rate of households, resulting in more farms with farm-forestry. It is assumed that every new household would like to mimic the other households in having part of their farmland under trees.
- The consumption of biomass is within the county with no export.

The effect of sub-division of group ranches was accounted by first estimating the annual tree cover loss in Narok County, which was obtained from Global Forest Watch⁴⁶ while the household growth rate for Narok was assumed as 1.67%²⁹. The three assumptions above were considered in calculating projected annual sustainable yield. The base year used was 2021 because land cover mapping data was not available for the preceding years. For each sub-county, the total woody biomass cover (ha) for the year 2021 was obtained by summing-up all those land cover classes previously mapped as having woody biomass.

Figure 3.11 below provides the total projected annual sustainable supply (thousand tonnes/year) from farmlands and outside farmlands. The results of this analysis were used for comparison with consumption, which is presented in section 4.1.5.

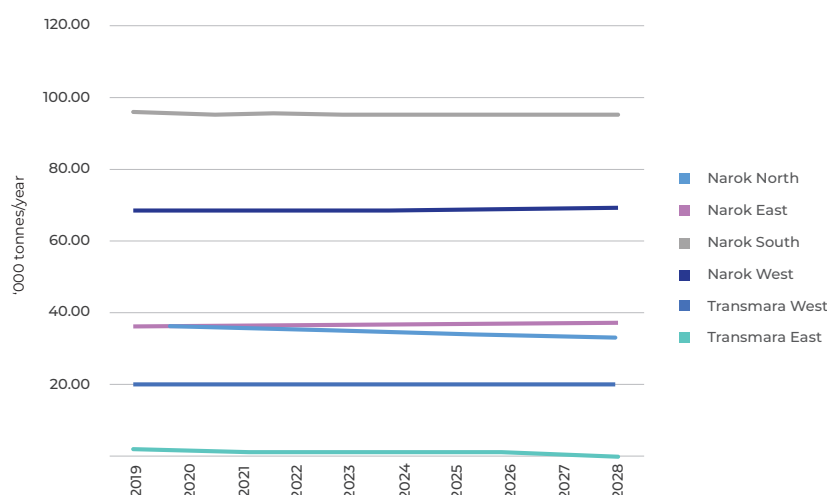


Figure 3.11: Total projected annual sustainable supply (kg/year) from farmlands and outside farmlands

45 Bailis, R. E. (2005). Fuel from the Savanna: the Social and Environmental Implications of the Charcoal Trade in Sub-Saharan Africa. PhD Dissertation, University of California, Berkeley.

46 Global Forest Watch: Forest Monitoring, Land Use. Available online: <https://www.globalforestwatch.org>. (Accessed on 8 September 2022).

The charcoal sector is organised almost entirely on an informal basis and remains largely unregulated. Although it generates a lot of revenue, almost none of its economic activities are mainstreamed into the tax system^{47, 48}. The National Government does however have regulations for the production, transportation and trade of charcoal. These are described in section 3.5.3. County interventions in bioenergy are also described in the same section.

3.5.3 National and County Interventions Governing Woody Biomass

Policies put in place by the National Government (highlighted in Table 1.2) prescribe requirements for production, transportation and consumption of woody biomass. The requirements are listed below.

1. **Production (firewood and charcoal):** Farmers, business persons, companies, cooperatives and associations producing charcoal for commercial purposes are required to have a production licence from the KFS before engaging in any production, transportation and marketing of charcoal. Landowners producing charcoal for their own consumption do not require a licence. However, as a rule, landowners are required to obtain a permit prior to clearing vegetation from any uncultivated land.
2. **Transportation:** In order to transport charcoal, one is required to have: a valid charcoal movement permit; a certificate of origin for the charcoal issued by the charcoal producer; and a purchase receipt from the charcoal seller or producer.
3. **Trade:** A person engaged in wholesale or retail trade in charcoal is required to keep a record of the sources of charcoal, and copies of the certificates of origin and the movement permits. No person or association shall engage in trade of charcoal with an unlicensed charcoal producer. The trader must also be in possession of a business licence/permit from local authority.
4. **Export/import:** No person or association shall export charcoal or charcoal products from Kenya, unless that person has obtained an export permit from the KFS. Upon approving an application, the Director will issue an export permit and a safety certificate after the applicant has paid the required amount of money. Before granting an export permit, the Director will consider the local supply and demand situation for charcoal. An export permit and safety certificate shall: (i) be surrendered to the customs officer at the port of export or where the importer requires such export permit and safety certificate, (ii) The export permit and safety certificate shall be endorsed at the port of export, and (iii) Expire either on the date specified on the two documents or when the consignment is shipped, whichever occurs first.

Interventions put in place by the County Government are as follows:

1. The inter-sectoral County Environmental Committee of Narok County Government placed a ban on charcoal production, sale and transportation, with various departments collaborating in implementing and enforcing the ban. This intervention is demonstrating the potential for collaboration around regulatory activities at the county level. Primary data collection was unable to uncover the effectiveness of this ban as residents of Narok were reluctant to speak about production of charcoal.
2. The County Integrated Development Plans (CIDP) (2018-2022) of Narok County had budgeted for protection and management of county forests; increasing forest cover by 1,800 ha and increasing area under agroforestry by 10 %. The County Government also budgeted to increase clean energy access by at least 10%, thus enhancing access to affordable, adequate and reliable energy for socio-economic transformation. In particular, the government aimed to establish a waste-to-energy plant.

3.5.4 Alternative bioenergy resources in Narok County

Besides the woody biomass, Narok County is also endowed with huge potential for other bio-energy resources. These include; crop residues and animal dung, which provide energy needs for cooking, heating, drying and has potential for electricity production.

- Briquettes or pellets can be produced from sugarcane bagasse, from sugarcane tops/leaves, and also from agricultural residues, especially those of maize and wheat.
- Biogas, quantified in normal cubic metres (Nm³), can be produced in all sub-counties and in many households given the huge population of cattle and small ruminants. Biogas from livestock dung could be used to supplement energy needs for residential cooking and space heating as it is odourless and colourless gas and burns with clear blue flame. Its use in the residential sector could substitute the use of LPG and greatly offset household expenditure and enhance transition to clean cooking.
- Biogas potentially supplied from municipal solid, sewer wastes and slaughterhouses could be used as feed-stock to run mini-grids. However, in Narok County, there is currently no power generation plant running on bio-energy. This is despite the potential of running CHP using biogas that would potentially be generated from municipal solid waste and sewer waste; from abattoir waste; and molasses.

47 Ministry of Environment and Forestry (2018). Taskforce Report on Forest Resources Management and Logging Activities in Kenya

48 UNEP (2019). Sustainability of Sugarcane Bagasse Briquettes and Charcoal Value Chains in Kenya: Results and Recommendations from Implementation of the Global Bioenergy Partnership (GBEP) Indicators. Technical report

3.5.4.1 Potential biogas production from municipal sewer waste

The principal feedstock for aerobic digestion (AD) in wastewater treatment plants (WWTPs) is sewage sludge. Sewage sludge refers to the residual, semi-solid material that is produced as a by-product during sewage treatment of industrial or municipal wastewater and is composed of primary and secondary sludge, also called mixed sludge. Other organic materials such as organic waste from households or from industries may be digested in the anaerobic reactor of the WWTP; this is then called co-digestion. Methane potentials per m³ of wastewater are generally much lower compared to solid substrates due to the low content in organic material and high-water content.

According to Narok Municipality Integrated Development Plan (IDEP) 2018-2023, sanitation facilities in Narok town are: septic tanks, cesspool, and very important person (VIP) pit latrines, pit latrines (covered or uncovered), bucket, and open defecation. Households' pit latrines and septic tanks have traditionally been emptied by Narok Water and Sewerage Company's exhauster and private owned exhausters. Recently, the construction of a sewer system in Narok town was completed, with a designed capacity of 3,500 m³/day. As of March 2022, the total connection was 520, but only 270 were activated, translating to a discharge of 165 m³/day. However, connections are still ongoing aiming to reach the designed capacity. It should be noted, however, that given a projected urban population of Narok town of about 213,826 and 227,657 (for 2022 and 2024, respectively)⁴⁹ and based on 5 people per household⁵⁰ translating to potential sewer volume of about 31,000 m³/day. Therefore, the current sewer system seems to be designed for only a fraction (11 %) of the population in Narok town.

Biogas production potentials from wastewater was calculated using the parameters reported in⁵¹ and are captured in Table 3.2. Since values corresponding to municipal wastewater were not provided, they were substituted by the average values of both dairy and slaughterhouse wastewaters.

Table 3.2: Characteristics (mean values) of agro-industrial wastewaters for anaerobic digestion; Data adapted from GIZ, 2010

Substrate	COD** in wastewater (g/l)	COD** de-gradability (%)	Biogas potential (m ³ /ton COD _{rem})	Methane content (%)	Methane potential (m ³ /ton COD _{rem})	Methane potential (m ³ /ton FM**)
Coffee processing wastewater	14.3	90	375	70	265	4.3
Dairy wastewater	4	88	367	80	295	1.1
Slaughterhouse wastewater	8	77	340	69	236	1.8
Distillery stillage	90	66	390	73	290	22
Nut processing wastewater	4.2	70	330	75	250	0.7
Pineapple wastewater	5.5	85	375	75	289	1.6
Sisal decortications wastewater	11.5	87	475	84	400	4.3
*Wastewater (sewer system) of Narok Municipal	6	82.5	353.5	74.5	265.5	1.45

** Characteristics of the wastewater for the municipal sewer system of Narok town has been obtained as the average of corresponding characteristics associated with wastewaters of dairy and slaughterhouses.*

***COD refers to chemical oxygen demand. FM refers to fresh matters of sewerage.*

Estimation of potential biogas from municipal sewer system was obtained for three (3) scenarios dependent on the proportion of discharge volume to designed daily capacity:

- Scenario 1 assuming a 25 % discharge,
- Scenario 2 assuming a 50 % discharge, and
- Scenario 3 assuming 100 % designed capacity.

For the three scenarios, the sludge produced and subsequently anaerobically digested is summarised in Table 3.3 below. The potential biogas production from Narok town municipal wastewater is also shown. This potential is only a fraction as the current system seems to be sized for only a fraction of households residing in Narok Town. For the purpose of estimating potential electricity production (kWh/annum) from the biogas generated by municipal wastewater of Narok town, the conversion factors and full load hours reported in Annex 2 were used. Full load hours refer to the number of hours an electricity generator would take to produce a certain amount of electricity and should be understood in relation to the installed capacity of generation and conversion units. The calculation assumed that all methane would be used and whenever the generator is being serviced, the methane would not be released but temporarily stored.

Table 3.3: Summary of sludge produced and potential biogas production from Narok Town

Scenarios	Thickened sludge produced (m ³ /day) being 1 % of influent wastewater	Sludge produced per year (365 days) (m ³ /yr)	Potential bio-gas (methane) production from municipal wastewater (million m ³ /yr)	Potential mean electricity production (GWh/annum)
Scenario 1 assuming wastewater equivalent to 25 % designed capacity	8.75	3,194	4.2	14
Scenario 2 assuming wastewater equivalent to 50 % designed cap	17.5	6,388	8.3	27
Scenario 3 assuming wastewater equivalent to 100 % designed cap	35	12,775	16.7	55

It is notable that the actual biogas production by the Narok WWTW may vary substantially from the theoretical calculation which has been obtained mainly based on the inflow of waste into the WWTW. This is because biogas production is highly dependent on the wastewater treatment process (sludge generation) employed by the WWTW, for example; biological nutrient removal, trickling plants, plants with primary settling tanks (PSTs), etc.

Nonetheless, based on the results of theoretical calculations (Scenario 2 and 3 in Table 3.3 above), the Narok town WWTW-to-energy potential would be financially viable, based on the assumptions by SEA⁵² that large WWTWs with sewer inflow in excess of 15 million litres/day would most likely produce sufficient sludge for biogas production. Actual biogas yield will, however, require detailed feasibility studies and drawing expertise of the wastewater treatment processes operational in the Narok town WWTW. A key rationale for the project implementation would be to offset the electricity purchased and consumed by the WWTW, for example for pumping and aeration; although the surplus can be supplied to the national grid or wheeled to private users on the basis of Power Purchase Agreement. According to SEA, costs for such projects take into account the requirement to build or refurbish digesters; gas scrubbing; electricity generation engine type; transformer selection; and heat exchange system. Although most WWTWs may have digesters operated to optimise sludge management, their capacity and functionality (for example; their number, size, mixed and/heated, structural integrity, etc.) must be ascertained for biogas production. The financial model for such projects may entail sole ownership by the County Government or implemented under a Public Private Partnership with the private sector. Private stakeholders would only be interested if the return on investment (ROI) is high and usually 7-9 years as the case of such projects operated by a number of South African municipalities⁵³. The County Government would then competitively appoint a service provider to design, build, manage and operate the plant for a period of 7-10 years.

3.5.4.2 Potential biogas production from municipal solid waste (MSW)

According to the GIZ report⁵⁴, most local authorities in developing countries spend more than 30% of their budget allocation on collection and disposal of refuse but do not collect more than 50% to 70% of the total waste generated. While the generation of MSW has grown rapidly, the capacity to collect and safely dispose of the residues has declined. Most of the dump sites are not connected by all-weather roads and thus access during the rainy season is difficult or even impossible. Moreover, local authorities tend to concentrate their limited services mainly in the central business districts and the wealthier neighbourhoods with better infrastructure.

Availability of MSW in Narok County is mostly in Narok Municipality, being the headquarters of Narok County and with a population of 58,701 as per 2022 projection as reported in the Narok Municipality Integrated Development Plan (IDEP) 2018-2023. However, management of waste is not properly organised, making the urban centres of Narok County dirty and posing health challenges. Waste products of about 10% of the households are collected by the County Government, 2% by private firms while 30% of the households use garbage pits. The main types of solid waste generated were predominantly inorganic matters such as bottles, plastic papers/bags, plastic containers, polythene papers and old clothes, and organic waste like food and vegetable peels. Eighty-five percent (85%) of the waste is burnt in open spaces, which is an environmental hazard while 46% of the waste is recycled or used (i.e., papers, plastic bottles and old clothes). There is illegal dumping of solid waste in an open quarry next to Narok River and some of the dumped wastes are blown into the environmentally fragile Narok River.

Data on municipal solid waste and wastewater for Narok Town was provided by the County Government of Narok. Data for Kilgoris town was unavailable, therefore estimates were generated based on comparisons with Narok town. According to the Narok County Government, Narok town generates approximately 33 tonnes of waste and 20% of the waste is collected. This is depicted in Table 3.4 below.

52 SEA. 2017. Sustainable energy solutions for South African local government: a practical guide (Cape Town: Sustainable Energy Africa)

53 Ibid

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

Table 3.4: Volume of collected municipal solid waste in Narok and Kilgoris Town, Narok County

Town	Urban population	MSW generated per day (tons)	MSW collected per day (%)
Narok	58,239	33	20
Kilgoris	14,868	8	20

Calculation of the biogas potential for solid substrates used Equation 3.3:

Equation 3.3

$$Q_{\text{biogasfrom-msw}} = \text{FM}_{\text{collected-per-day}} * \text{Availability}_{\text{seasonality_or_days-per-year}} * \text{DM}_{\text{content}} * \text{VS}_{\text{content}} * \text{Biogas}_{\text{potential-msw}} * \text{Methane}_{\text{content}}$$

Where:

- $Q_{\text{biogasfrom-msw}}$ = biogas production potential from municipal solid waste (MSW)
- $\text{FM}_{\text{collected-per-day}}$ = Amount of residue (tons per year)
- $\text{Availability}_{\text{seasonality_or_days-per-year}}$ = Seasonal availability of the residue (for biogas production a residue should be available during the whole year or should be storable)
- $\text{DM}_{\text{content}}$ = Dry matter (DM) content of the residue (% fresh matter, FM)
- $\text{VS}_{\text{content}}$ = Volatile solids (VS) content (% DM)
- $\text{Biogas}_{\text{potential-msw}}$ = Biogas potential for the substrate (m³/t VS)
- $\text{Methane}_{\text{content}}$ = Methane content in the biogas (%)

The suitability of different solid substrates for anaerobic digestion can be expressed by the methane potential per ton of fresh matter (FM). GIZ in their report⁵⁵ documented a list of the substrates (both solid and wastewater) and their average characteristics were used, noting that values would in reality be expected to vary strongly because of differing values reported in literature and known from practice. Conversion factors of methane to either electricity production or thermal energy reported were used for calculation in this study (see annex 2). Based on the calculations, potential biogas production from municipal solid waste for Narok and Kilgoris towns, respectively, are summarised in Table 3.5.

Table 3.5: Municipal solid waste for Narok and Kilgoris Towns and estimate of potential biogas production

Town	Urban population	MSW generated per day (tons)	MSW collected per day (%)	Potential biogas (methane) production from municipal solid waste (m ³ /yr)	Potential mean electricity production (kWh/annum)
Narok	58,239	33	20	165,678	546,736
Kilgoris	14,868	8	20	42,296	139,578

The focus on anaerobic production of biogas from the volatile fraction of collectable solid waste assumes that the waste management system in Narok town is hierarchical, prioritising waste reduction, re-use and recycling measures, with the remaining non-recyclable fractions relegated to recovery of energy⁵⁶. Moreover, even for the non-recyclable fractions and dependent on the type of waste stream, different waste-to-energy (WtE) technologies are applicable, including (i) incineration, (ii) co-processing, (iii) anaerobic digestion, (iv) landfill gas collection, and (v) pyrolysis/gasification. In Narok town, as in other municipalities and towns in Kenya, plastic wastes share a huge proportion of urban solid waste composition, but are collected for recycling by marginalised persons and informal sector workers. The remaining fractions are mainly organic with high moisture content, which prompted the choice for anaerobic digestion as the suitable WtE technology for Narok town.

55 Ibid

56 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 für Internationale Zusammenarbeit (GIZ) GmbH

A key challenge in setting up WtE relates to inefficient waste management characteristic of most Kenyan towns and cities (including towns in Narok County), where waste is not segregated at the source, which would make the waste-to-energy (WtE) power plant inefficient. Closely related, installation of utility-size WtE plants ought to be located close to a sanitary landfill (SLF) for efficiency goals. The County Government of Narok will have to secure space for a new SLF, potentially in a site that would not constrain logistics for waste collection and dumping.

WtE power plants operate efficiently in developed countries; however, simple transfer of these technologies may be inappropriate for developing countries' conditions. Aspects such as composition of waste, waste segregation, financing models, among others, are generally different to those that inspired the growth of WtE in industrialised countries⁵⁷. On the other hand, locally appropriate technologies have not been developed and similarly, skilled manpower is unavailable. Mutz et al. (2017)⁵⁸ have further alluded that the costs associated with recovering energy from solid waste is far much too high and cannot potentially be recouped exclusively through sales of energy. They further note that even international companies experienced in investing in WtE plants are reluctant to invest in WtE in developing countries as they foresee huge legal, financial and reputational risks. Similarly, such projects would be expensive and a financial risk also to a County Government. For decision making, the County Government of Narok is recommended to conduct an independent assessment of costs and financial implications of such WtE projects. The assessment can inform whether or not to undertake a Public Private Partnership with private entrepreneurs who would be willing to test innovative technologies and 'learning-along-the way' while developing new logistics for waste segregation and transportation.

3.5.4.3 Potential biogas production from abattoirs/slaughterhouses

The meat industry produces large amounts of wastes since a substantial amount of animal weight is considered to be waste that is not intended for human or animal consumption as shown in Table 3.6. The waste is mainly composed of blood, rumen and intestinal content. Additionally, meat processing plants and slaughterhouses are known for being the big consumers of water and big generators of wastewaters⁵⁹. Water is used for sanitary purposes, processing (primarily for carcass washing after hide removal from cattle, calves, and sheep or hair removal from pigs) and technological purposes (plant washing, steam production, production of hot water, compressor cooling and production of ice water. The reported specific freshwater consumption (SFWC) from slaughterhouses and meat processing plants in their study is around 360–560 (l/head).

Table 3.6: Potential waste from different animals slaughtered and the specific freshwater consumption used in slaughterhouses

Species	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/goat	30	12	40	18	60	360

The biogas production potential from meat processing wastewater is calculated based on the data provided by the County Government of Narok for six (6) abattoirs. The animals slaughtered are mainly cattle and the small ruminants (sheep and goats) and the respective monthly slaughter in these slaughterhouses are reported in Table 3.7.

Table 3.7: Monthly slaughter in the main slaughterhouses operating in Narok County

Abattoir	Location	Monthly average slaughter figures (cattle)	Monthly average slaughter figures (sheep & goats)
Narok town	Narok town	10	40
East Africa Meat company	Ewaso Nyiro	35	20
Mareto	Ewaso Nyiro	40	10
Kirimpe	Ewaso Nyiro	40	20
Mulot	Mulot	50	1,200
Kilgoris	Kilgoris	5	15

⁵⁷ Ibid

⁵⁸ Ibid

⁵⁹ Natalija Aleksić, Aleksandar Nešović, Vanja Šušteršić, Dušan Gordić, Dobrica Milovanović (2020). Slaughterhouse water consumption and wastewater characteristics in the meat processing industry in Serbia. Desalination and Water Treatment, www.deswater.com, 190 (2020) 98–112 June. doi: 10.5004/dwt.2020.25745

For each of the slaughterhouses in Narok County, the total monthly slaughterhouse wastewater was calculated using the data on potential waste from different animals slaughtered, the specific freshwater consumption used in slaughterhouses and monthly slaughter records. It was assumed that 1,000 kg of animal waste is equivalent to 1 m³ volume while 1,000L of wastewater is equal to 1m³.

The characteristics (mean values) of agro-industrial wastewaters for anaerobic digestion as reported in Annex 3 are used. The estimation of potential electricity production (kWh/annum) from the biogas generated by slaughterhouses in Narok County, and the results reported in Table 3.8.

Table 3.8: Biogas and electricity that can potentially be generated by slaughterhouses in Narok County

Abattoir	Potential biogas (methane) production from municipal solid waste (m ³ /yr)	Potential mean electricity production (GWh/annum)
Narok town	395,736	1
East Africa Meat company	598,460	2
Mareto	599,674	2
Kirimpe	665,225	2
Mulot	8,533,817	28
Kilgoris	165,092	1

The results of the analysis demonstrate a huge opportunity for slaughterhouse wastes-to-energy through anaerobic digestion (AD) at commercial scale. The wastes are suitable for AD as they are composed of high organic contents of mostly well degradable substances. Viable projects of turning slaughterhouses wastes to biogas and ultimately to electricity generation exists, for example in Keekonyoike (Kiserian, Kajiado County), Nyongara (in Dagoretti, Kiambu County), Bungoma municipalities (Bungoma County), and in Homabay town (Homabay County).

In view of the continued increase in electricity cost, in-house use of thermal and electricity generated from slaughterhouse wastes serve as financial justification of the project as this would offset the electricity purchase costs. It is therefore important for project originators to understand that the primary driver for an investment in AD will be to meet a company's own energy and waste management needs. Nonetheless, it would be more economical if there would be a profitable use for the thermal energy generated by the CHP. As part of the recommended feasibility studies, the County Government of Narok should assess complementary business (especially SMEs) that could suitably use the thermal energy that would potentially be produced from slaughterhouses WtE plants. Viable options should also be explored during the studies, for example the opportunity to supply biogas hotels and restaurants neighbouring the slaughterhouses as being done by Keekonyoike slaughterhouse (Kajiado County). Connecting the surplus power to the national grid is currently possible in Kenya as strong regulatory frameworks for small-scale electricity generation are in place⁶⁰. However, currently, the very low FiT of USD 0.10 per kWh available for electricity from biogas and the inability to access that FiT for generation below 200 kW are two of the main barriers to investment. For small-to-medium plants, the project originators should be aware that the primary driver for an investment in AD will be to meet a company's own energy and waste management needs.

3.5.4.4 Potential biogas production from livestock population

The utilisation of animal manure and slurries as feedstock for anaerobic digestion has some advantages due to their properties:

- The naturally present and high content of anaerobic bacteria,
- The high-water content (4-8% dry material in slurries), acts as solvent for the other substrates and ensures bio-mass mixes and flows properly, and
- The high accessibility, and ease of collection as a residue from animal farming during animal confinement times (e.g., spending the night in bomas).

Cattle inherently contain methane producing bacteria in their stomachs and dung. Cow dung is therefore the most preferred feedstock for biogas generation. Other wastes from small ruminants (sheep and goats) were also considered for Narok County.

For assessment of available feedstock, the following were considered as the key indicator for assessment of available feedstock for possible amount of biogas production:

- a) The number of livestock for corresponding species cattle available (obtained from KNBS 2019 data and shown in Table 3.9).
- b) Number of days in a year the cattle spend the night in the home boma (obtained from primary data and shown in Table 3.9)
- c) Fraction of animal waste recovered for biogas production (obtained from primary data and shown in Table 3.9)
- d) Biogas yield used the IPCC (2019) parameters (13% and 18% methane for a kg of volatile solids for cattle and small ruminants, respectively).

60 Energy and Petroleum Regulatory Authority (EPRA) (2021). Least Cost Power Development Plan 2021- 2030.

Table 3.9: Key indicators in the assessment of available feedstock for biogas production sourced from primary data

County/Sub County	*# of livestock available		**Mean # of days in a year cattle/small ruminants spend in the home bomas	**Mean fraction of animal waste collected (%)	
	Cattle (Exotic and indigenous)	Small ruminants (sheep & goats)		Cattle (Exotic and indigenous)	Small ruminants (sheep & goats)
Narok East	135,365	505,132	268	25.3	26.3
Narok North	228,391	648,456	248	36.7	41
Narok South	332,656	924,200	320	52.8	55.8
Narok West	400,675	1,190,925	270	.	4.5
Transmara East	55,742	40,091	365	53.7	61.8
Transmara West	336,062	310,583	363	31.5	43.9
Narok County	1,488,891	3,619,387	305	40.5	37.3

The potential biogas production from livestock population was then estimated separately for cattle or small ruminants, being obtained by associating the number of respective livestock; total daily manure production per unit livestock; mean number of days spent by the livestock in the home bomas (animal shed); available fraction of cattle dung not collected for some other uses; percentage waste from cattle that can be recovered for biogas production; and the volatile solids as % fresh manure for specific livestock; and the biogas yield for respective livestock type.

Estimation of potential biogas production and equivalent energy (thermal or electricity) was disaggregated by sub-counties as the spatial unit. A summary of annual production estimates are reported in Table 3.10 below.

Table 3.10: Summary of estimated quantity of annual biogas production potential and equivalent energy from livestock (both cattle and small ruminants) in Narok County

Variable	Estimated total annual biogas production ('000 m ³ /yr)	Estimate total energy for cooking (thermal) from the biogas produced ('000 GJ)	Estimate total energy (electricity) from the biogas produced (GWh)
Narok East	27,740	347	55
Narok North	32,878	411	65
Narok South	41,636	520	82
Narok West	74,984	937	148
Transmara East	5,676	71	11
Transmara West	51,684	646	102

Despite the residents of Narok County being endowed with livestock which would sufficiently provide feedstock for biogas technology, the adoption of this technology is very low, at 1.4% among households, 1.0% of small and medium enterprises & cottage industries; and none of healthcare facilities and institutions. This is partly because of the relatively capital-intensive requirements to construct a biogas unit. According to SNV⁶¹, most popular household biodigester model in Kenya is one constructed in-situ using bricks and mortar, commonly 4 m³ to 6 m³, and costing an investment of about USD 500 to 700. Prefabricated models are becoming common, ranging in volume up to 12 m³ and their cost is higher (about USD 912).

Raising the required investment is challenging to most rural households in Narok County and Kenya in general. The market for household bio-digesters are perceived as unattractive and risky by most financial institutions, including local banks, micro-financial institutions (MFIs) and savings and credit cooperatives societies (SACCOs). Access to finance is therefore a key barrier to adoption of biogas technology. This is further compounded by low awareness among rural households of Narok County, about biodigester and its benefit. During primary data collection, it was reported that the existing biodigesters that were installed by a few households malfunctioned and that poor after-sales service by the private investors who installed them dampened the biogas campaign. It is recommended that the County Government of Narok should develop an incentive mechanism to encourage private stakeholders in biogas business to operate in the County and devise innovative business models that will fit the cash-inflow of households willing to install biodigesters.

3.5.4.5 Potential bioenergy production from crop residues

Assessment of crop-based biomass resource requires first, the determination of the amount of crop production. Subsequently by applying the residue-to-product ratio (RPR) to the production volume of the corresponding feedstock, the amounts of residues generated can be estimated. Thereafter, low heating values (LHVs) are used for each type of residue and are multiplied with the respective residue production volume in order to express the corresponding technical potential.

According to the Narok County Integrated Development Plan (CIDP) (2018-2022), the arable land where most agricultural activity is undertaken is approximately 850 kha. This land is mainly in Mau region, Narok North areas, Nairege Enkare in Narok East, a bigger part of Emurrua Dikirr sub-county, and Narok South and pockets of land in northern part of Narok West sub-county. Approximately 252,880 ha are under food crop while cash crops occupy an area approximately 69,339 ha. The main crops with potential for recoverable residues are maize, wheat and sugarcane. Residues are separated into the by-products of agricultural practice, which are the result of harvesting crops (e.g., stalks, husks and cobs from maize; stalks from wheat; and sugarcane top/leaves) and indirect ones originating from processing of agricultural products (e.g., bagasse from sugarcane).

From the County Integrated Development Plan (CIDP), the County produces about 200,000 tonnes of maize and 135,000 tonnes of wheat each year. The area under maize declined from 116,605 ha in 2012 to 110,079 ha in 2016. Table 3.11 shows the acreage of maize and wheat in 2021 as provided by the County Government of Narok. The acreage is used to estimate the proportion of the grain production per sub-county in Narok County. Transmara West and Narok South sub-counties were the leading producers of maize, while production in Transmara East was negligible. Narok South and Narok North sub-counties were the leading producers of wheat, while production was negligible in Transmara East and Transmara West.

Table 3.11: Grain (maize and wheat) production in Narok County, disaggregated by sub-county

Grain	Maize		Wheat	
	Hectares	Tonnes	Hectares	Tonnes
Narok East	8,500	15,639	7,500	21,774
Narok North	6,700	12,328	15,000	43,548
Narok South	38,000	69,917	22,000	63,871
Narok West	14,500	26,679	2,000	5,806
Transmara West	41,000	75,437		

Sugarcane is mainly grown in Transmara West Sub-County of Narok County, especially in Shankoe, Keiyan, and Kilgoris Central Wards. In the 2020/2021 financial year, 898,947 tonnes of sugarcane were harvested and milled, producing 92,375 tonnes of sugar. After milling, sugarcane bagasse is approximately 33-38 % of the total harvest.

According to UNEP⁶², the sugarmill in Transmara West Sub-County is already processing the bagasses into briquettes and consumes most of the briquettes internally, while the rest is sold to tea factories. The sales were highest during the 2015-2016 financial year, with an average of 45% per cent sales to tea factories. According to the report, there is a huge opportunity of selling the bagasse briquettes to tea factories, although the sales fluctuate from year-to-year: the volume sold rose between the 2014/2015 and 2015/2016 financial years, then sharply decreased in 2016/2017 and increased in 2017/2018. Some hotels in the Maasai Mara game reserve also reported some use of briquettes which were purchased from Nairobi.

In estimating the quantity of residues from maize, wheat and sugarcane, the residue-to-product ratio and also the residue recovery factor were considered for each component of residue as summarised in Table 3.12. It is notable that for majority of the crops, the residue recovery is high, apart from the tops/leaves of sugarcane of which 75 % -85 % is retained in the field as fertiliser ⁶³.

62 UNEP (2019). Sustainability of Sugarcane Bagasse Briquettes and Charcoal Value Chains in Kenya: Results and Recommendations from Implementation of the Global Bioenergy Partnership (GBEP) Indicators. Technical report

63 Mai-Moulin, T., Dardamanis, A., and Junginger, M. (2016). Biomass Use and Potential for Export from Kenya to the European Union 2015-2030. Assessment of sustainable lignocellulosic biomass potential for Kenya for export to the European Union 2015 to 2020. BioTrade2020plus

Table 3.12: Residue to product ratio, residue recovery factor and lower heating values for key residue components

Residue producing crops	Residues component	Residue to product ratio (RPR)	Residue recovery factor (RF)	LHV _{av} (GJ/t)
Maize	Stalks	1.6	80%	15
	Husks	0.2	100%	18.02
	Cobs	0.29	100%	9.69
Wheat	Wheat stalks	1	80%	17.98
Sugarcane	Sugarcane bagasse	0.38	100%	12.93
	Sugarcane top/leaves	0.22	15%	16.61
	Molasses	0.04	100%	8.5

* **Source of data:** Department of Agriculture, County Government of Narok, Mai-Moulin et al. (2016), Wekesa, A. (2013⁶⁴), Maj et al. (2019⁶⁵).

Primary data collection revealed that across Narok County, about 50 % of residues from maize crop and 40 % of residues from wheat crop were collected and used by households as fuel and animal feedstock. As revealed by the primary data, women are the main collectors of maize residues (64 %) as compared to men (56 %). However, men are the main collectors of wheat residues (48%) than women (41%). Maize residues, especially combs, have traditionally been used as fuel in rural areas and are thus collected and stored by women to complement wood-fuel resources. Wheat straw has gained prominence as feedstock for animals under the zero-grazing system, explaining its economic importance to men who occasionally sell it to merchants from other Counties.

For sugarcane, the corresponding fraction of collectable but unused residues (bagasse, tops/leaves, molasses) were obtained from literature (40%, 85%, 72%, respectively⁶⁶. Having accounted for the crop-specific residues currently used, the remaining fraction of recoverable residues was assumed as the available feedstock for bioenergy (i.e., BMP, being the available residual biomass in tonnes per year). The residue available was then converted to GJ as shown in Table 3.13

Table 3.13: Calorific value of crop-specific available residual biomass in GJ

Crop-Specific Residue	BMP _{Maize stalks} (GJ)	BMP _{Maize husks} (GJ)	BMP _{Maize cobs} (GJ)	BMP _{Wheat stalks} (GJ)	BMP _{Sugar-cane bagasse} (GJ)	BMP _{Sugar-cane top/leaves} (GJ)	BMP _{Molasses} (GJ)
Narok East	255,235	47,910	37,356	306,936	0	0	0
Narok North	104,143	19,548	15,242	266,220	0	0	0
Narok South	402,723	75,594	58,958	172,260	0	0	0
Narok West	235,628	44,299	34,486	63,162	0	0	0
Transmara East	0	0	0	0	0	0	0
Transmara West	811,098	152,250	118,712	0	1,766,754	73,911	85,580

Crop residues are a key feedstock for production of briquettes or pellets. Exploitation of crop residues is gaining ground in Narok County, courtesy of start-ups like Maa Briquette, which are converting feedstock such as maize cobs, maize stalks, waste vegetable matter and charcoal dust and waste papers, to briquettes and being supplied to households and large institutions. Users of briquettes employ the same cookstoves used for charcoal. This implies that briquettes could potentially replace the market segments currently using charcoal: 17.44 % of households; 58 % of small and medium enterprises and cottage industries; and 18 % of healthcare facilities and institutions in Narok County. Although the actual quantities of briquettes used is not reported, there is a need for a detailed study and analysis on briquettes consumption in Narok County to guide key intervention areas.

64 Wekesa, A. (2013). Using GIS to assess the potential of crop residues for energy generation in Kenya. A thesis submitted in partial fulfilment of the requirements for the Degree of Master of Forestry Science in the University of Canterbury

65 Maj, G., Szyslak-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

66 Mai-Moulin et al., 2016

Bioenergy investments have the potential to generate agricultural-related supply chain economic activities, deliver social benefits and empower poor communities^{67,68}. However, bioenergy development has been extremely constrained with a low success rate of commercial deployment in Africa⁶⁹. According to the report, key barriers to its commercial utilisation span various aspects covering biomass resource, technology, economics, finance and institutional and regulatory frameworks. Constraints relevant to Narok County include:

- ◊ Biomass resources: The high dispersal or decentralised nature of feedstock availability, especially those from smallholders scattered over the landscape; poor supply infrastructure; and high sourcing costs.
- ◊ Technical barriers to conversion: insufficient understanding amongst local players of feedstock-technology fit and a lack of technologies tailored to local contexts.
- ◊ Financial barriers: inadequate or non-existent supply chains, high costs of pre-treatment and conversion, and insufficiently robust and tested business models.
- ◊ Institutional barriers: inadequate understanding of interfaces between different supply chain stages and actors, alongside unfavourable institutional and regulatory frameworks.

In many Counties in Kenya, the briquettes sub-sector is being advanced by the private sector, especially the SMEs. Because of its potential role to enhance bio-circular economy and offsetting the bioenergy derived from woody biomass and generating green jobs, there is need for the County Government of Narok to support this nascent industry by developing incentive mechanisms that would encourage the SMEs to grow their business and develop innovative business models able to overcome those complex barriers listed above. It is notable that even a small-scale briquette plant is expensive for most SMEs or local entrepreneurs, and those willing to invest in Narok County can, for example, be given a grace period devoid of taxes and levies, as an incentive mechanism.

3.5.5 Bio-energy trade

Charcoal dominates the bio-energy trade in Narok. Evidence from primary data showed that the charcoal used by Narok residents is produced within the County, although banning of charcoal production and transportation pushed the price up. Historically, charcoal from Narok has provided roughly about 30% of Nairobi's annual supply^{70,71}. The County Government of Narok has been enforcing the ban on charcoal trade, although primary data collection revealed that charcoal is illegally exported to other Counties such as Bomet. At the height of Narok's charcoal activity, when no restrictions on transport were in place, as many as 20 lorries per day were active between Narok and Nairobi. When restrictions are heavily enforced, the number of lorries drop to fewer than five. In addition, when authorities started cracking down on charcoal trade, buyers changed tactics, opting to rely on other sources and using alternative means of transportation. For example, transportation of charcoal is camouflaged by use of small fully enclosed trucks that ordinarily are meant for transportation of other commodities like bread, flour, or similar commodities. These trucks are owned by firms in Nairobi and their drivers collude with charcoal traders, so that the truck that is supposed to return to Nairobi empty is loaded with charcoal. The range of actors in Narok's charcoal commodity chain as well as the flow of money and materials are shown in Figure 3.12⁷².

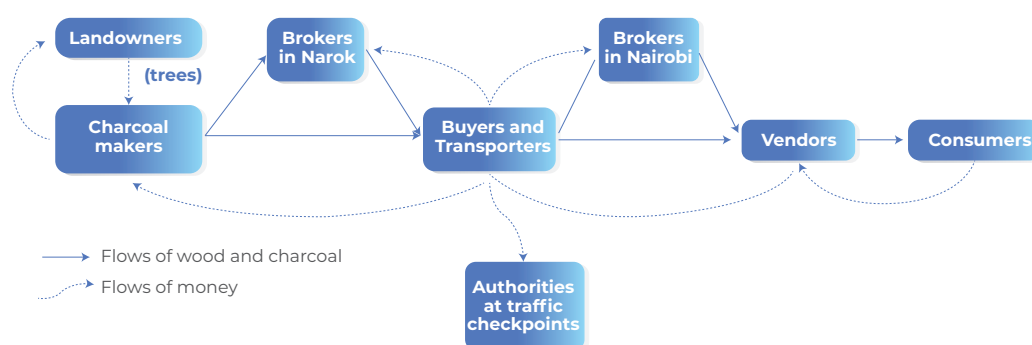


Figure 3.12: Main actors in Narok charcoal commodity chain (Source: Bailis, 2005)

67 IRENA (2017a), Biofuel Potential in Sub-Saharan Africa: Raising food yields, reducing food waste and utilising residues, International Renewable Energy Agency, Abu Dhabi.

68 IRENA (2017b), Bioenergy from degraded land in Africa: Sustainable and technical potential under Bonn Challenge pledges, International Renewable Energy Agency, Abu Dhabi.

69 IRENA (2017.a)

70 Bailis (2005)

71 KFS (2013). Analysis of the charcoal value chain in Kenya. A report commissioned by the Kenya Forest Service (KFS), coordinated by the National REDD+ Coordinating Office (NRCO) and carried out by Camco Advisory Services (Kenya) Limited. Nairobi, Kenya.

72 Bailis (2005)

From the production site, the charcoal is transported with motorbikes, bicycles, donkey carts, and on people's backs or heads to a central point along the main road.

Besides trade in charcoal, bagasse briquettes is another key bioenergy trade commodity in Narok County. According to UNEP, the sugar mill in Narok consumes most of the briquettes internally, while the rest is sold to tea factories; the sales were highest during the 2015-2016 financial year, with an average of 45% per cent sales to tea factories. According to the report, there is a huge opportunity of selling the bagasse briquettes to tea factories, although the sales fluctuate from year-to-year: the volume sold rose between the 2014/2015 and 2015/2016 financial years, then sharply decreased in 2016/2017 and increased in 2017/2018. Some hotels in the Maasai Mara game reserve also reported some use of briquettes which were purchased from Nairobi. Statistical records on quantities of briquettes used in Narok County and range of users are unavailable.

International trade is also a possibility given that the European Union has been seeking countries to supply biomass feedstock as reported by Mai-Moulin et al. (2016). According to the report, potential supply-countries would be expected to meet sustainability criteria up until 2030, which is assumed to be the availability of surplus feedstock over and beyond domestic consumption. The assessment was carried out through BioTrade2020plus financed by the European Union, and focused on the sustainable potentials for each feedstock at a county level. For Narok County, data indicating volume of surplus feedstock is summarised in Table 3.14.

Table 3.14: Volume of surplus bioenergy feedstock resources estimated by BioTrade2020plus, financed by the European Union

Key feedstock	Production Thousand tons	Residue produc- tion Thousand tons	Residue production PJ		
Offcuts	394.1	94.7	1.9		
Sawdust	394.1	33.5	0.5		
Firewood	394	33.6	0.5		
Key feedstock	Production volume Million tons	Harvested area Thousand ha	Average yield t/ha	Residue yield t/ha	Residue yield GJ/ha
Sugarcane bagasse (Transmara)	0.4	4.5	89.4	34.0	439.0
Sugarcane stalk & leaves	0.4	4.5	89.4	19.2	319.2

3.5.6 Bio-energy supply costs

In Kenya, bioenergy supply costs have been estimated for the various bioenergy potentials (for example Buchholz et al., 2021). However, additional guidance on calculating these costs can be borrowed from the work of Welfle et al. (2020), who conducted a life cycle analysis (LCA) for different *Gliricidia* cultivation and production life cycles, briquette processing and pre-treatment activities, transport dynamics and varying bioenergy end use applications. According to them, bio-energy supply cost comprises a breakdown of the whole set of costs incorporated in the biomass supply chain, considering the locations of production of agricultural and forestry for truck and train, storage costs, and pre-treatment costs. A cost-supply curve based on the costs acquired is constructed. Table 3.15 shows costs of various biomass sources. It should be noted that for Narok County, only costs available from field work or literature are reported.

Table 3.15: Summary of Bioenergy costs in Narok and at National level

Fuel type	Value Chain	Cost reported in Narok	Average National cost from literature	Source of National average cost
Firewood	Production (eucalyptus tree which is the most common on private plantation in Narok)	Not available	KES 519.5/m ³ (KES 944.5/ton)	Oballa et.al (2010)
	Transport, loading, off-loading, drying and labour costs	Not available	KES 2,500/ton.	UNEP 2019 ⁷³
	Consumption -Industry -Households	-KES 93/34-52 Kgs	-KES 1500 – 1800 / m ³ (KES 3 - 5 per kg) -KES 25/Kg	Buchholz et al. (2021) ⁷⁴ Ministry of Energy (2019) ⁷⁵
Charcoal	Production	Not available	KES 400/bag	Kajiado charcoal value chain survey (KFS, 2013) ⁷⁶ .
	Consumption- Household	KES 84/2-Kg tin	KES 63/2-Kg tin	UNEP 2019 ⁷⁷ , Primary data
Bagasse	Consumption	Not available	KES 9,666/ton	UNEP 2019

Little attention has been paid to bioethanol as a clean and easy-to-use cooking fuel for the Kenyan population. According to the report by Dalberg⁷⁸, ethanol fuel prices are at par with LPG but are still slightly more expensive than kerosene and charcoal. The report further indicates that the costs of ethanol-based cooking solutions have the potential to be the lowest in the cooking sector if bioethanol tax and tariff regimes are harmonised with other fuels. In 2011, the United Nations Development Program (UNDP) supported a pilot study on bioethanol as an alternative cooking fuel in western Kenya. The study sought to test the viability of ethanol as a clean, affordable, and easily accessible household fuel and to stimulate its demand in the country⁷⁹. As a result, ethanol is now emerging as a fuel option for domestic consumption with the potential of substituting or reducing the use of kerosene and is currently available in liquid and gel form for cooking⁸⁰. Emerging players in the ethanol market include: KOKO Networks, Leocom, Prosol Limited, IR&D Africa Limited, and Giraffe Bioenergy. Although KOKO Networks is the leading ethanol distributor (having connected 700,000 customers in Nairobi and Mombasa), it is yet to expand into Narok County. Ethanol cooking fuel for these emerging players is sourced both locally and internationally but the costs have not been published. Although the local sources of ethanol are exclusively reliant on molasses feedstock, the Kenyan Ethanol Cooking Fuel (ECF) Industry Masterplan launched in 2021 proposes increased investment into Kenya's sugar and cassava producing regions with an aim of securing sufficient feedstock for ethanol production in the country. Because Narok County has a conducive environment for growth of these two crops, there is a need for the County Government to strategically promote growth of ethanol feedstocks.

⁷³ UNEP (2019)

⁷⁴ Buchholz T, Kiama S, Kifalu H, Ronoh G, DaSilva IP, Ngunzi V 2021. Bioenergy analysis for 65 factories of the Kenya Tea Development Agency Holdings Company Ltd (KTDA). Strathmore Energy Research Centre (SERC), Strathmore University, Nairobi, Kenya, 57p.

⁷⁵ MoE (2019): Kenya Household Cooking Sector Study: Assessment of the Supply and Demand of Cooking Solutions at the Household Level

⁷⁶ KFS (2013). Analysis of the charcoal value chain in Kenya. A report commissioned by the Kenya Forest Service (KFS), coordinated by the National REDD+ Coordinating Office (NRCO) and carried out by Camco Advisory Services (Kenya) Limited. Nairobi, Kenya

⁷⁷ UNEP (2019).

⁷⁸ Dalberg. (2018). Scaling up clean cooking in urban Kenya with LPG & Bioethanol: A market and policy analysis. Available at: <https://southsouth-north.org/wpcontent/uploads/2018/11/Scaling-up-clean-cooking-in-urban-Kenya-with-LPG-andBio-ethanol.pdf> (Accessed 12 April 2020)

⁷⁹ UNDP (2020). Piloting Bioethanol as an Alternative cooking fuel in western Kenya. Retrieved from https://www.ke.undp.org/content/kenya/en/home/operations/projects/environment_a nd_energy/bioethanol.html

⁸⁰ Republic of Kenya. 2016. Sustainable Energy for All: Kenya Investment Prospectus. <https://www.undp.org/sites/g/files/zskgke326/files/migration/ke/SE4All-IP-Report-Final-10-March-2016.pdf>

3.5.7 Future bioenergy costs

There is limited data available on the costs of different types of bioenergy. According to the Society for International Development, agricultural waste prices are not covered by Kenya National Bureau of Statistics (KNBS), while firewood is mostly gathered and considered to be free. Where firewood is meant for sale, the price is not tracked by the KNBS. Primary data collection in Narok County established that the average price of a back-pile of firewood (weighing between 34 kg – 52 kg) was KES 93. During group discussions, community members reported growing scarcity of woody biomass as they had to travel for long distances (2.6 km on average) and spend many hours (2 to 3 hours on average, considering one-way journey) to collect firewood. As described in section 4.1.5 the biomass balance projects a deficit of fuelwood across four (4) sub-counties of Narok, save for Narok West whose aggregate balance is positive. In a society such as Narok whose population has traditionally been collecting firewood freely, the growing deficit will gradually lead to its monetisation and there is a need for the County Government to track the pricing dynamics.

In recent years, the nominal price of charcoal rose significantly between 2014 and 2020⁸¹. The main driver of higher charcoal prices was a 2018 government policy that suspended logging, initially meant to last for 90 days but later extended to allow reforms in forest plantation management in the country. The County Government of Narok also placed a ban on charcoal production, sale and transportation through the inter-sectoral County Environmental Committee of Narok County Government and various departments are collaborating in implementing the ban. As a result of the ban, charcoal prices for a 4-kg tin rose from 81 Kenya shillings in 2017 to 126 shillings in 2018, a 55% rise that caused considerable hardship⁸². The ban has served to make the trade more profitable as there is still no clean and affordable replacement fuel for cooking.

As biomass fuel becomes scarce, its price will continue to rise, further increasing both energy poverty and the incentive to mine more firewood and charcoal⁸³. Primary data collection revealed that in Narok County, banning of charcoal production and transportation pushed the price up. Other scenarios are as follows:

- ◊ Economic growth may cause increased incomes that may enable households to switch to cleaner, more convenient energy.
- ◊ There might also be a change in relative prices where the cost of biomass becomes higher than alternatives like electricity, LPG or local renewable energy networks.
- ◊ Alternatively, biomass may remain the lowest cost fuel, but become a product cultivated for home use or sale rather than an unsustainably mined natural resource.

The report by SusWATCH Kenya⁸⁴ elaborates the detailed modelling of costs of energy supply under the BAU and the renewable energy scenarios. The latter accounts for all efforts geared towards reducing biomass use to a sustainable level and also biomass consumption levels reduced with increasing efficiency. Modelling aggregates total costs divided in fuel costs, investment costs (annual payments on investments and interest rates) and other costs (mainly operating and maintenance costs) are as shown in Figure 3.13 and Figure 3.14. It is notable that these costs only include the energy supply costs.

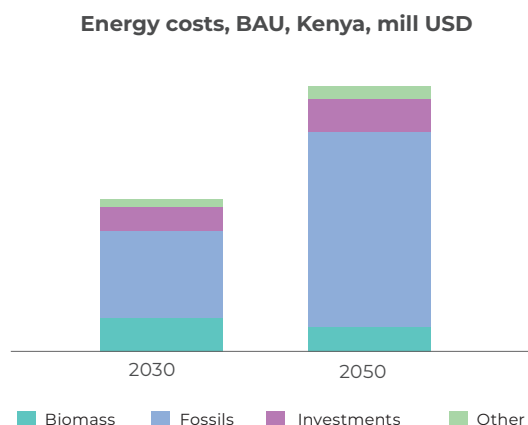


Figure 3.13: Costs of energy supply in 2030 and 2050, BAU scenario. Source: SusWATCH Kenya (2020)

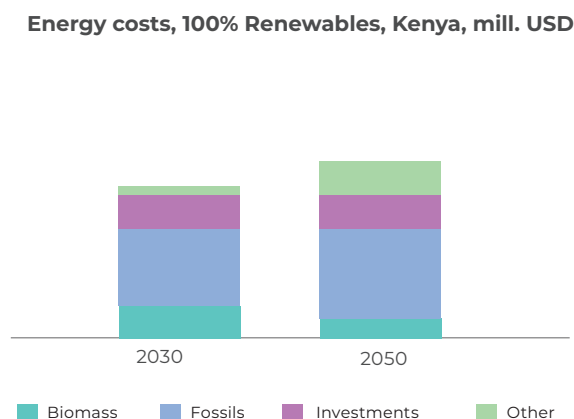


Figure 3.14: Costs of energy supply in 2030 and 2050, renewable energy scenario. Source: SusWATCH Kenya (2020)

From the figures, the national costs for biomass energy are estimated as 2,100 million USD (under BAU scenario) and 2,000 million USD (under renewable energy scenario). Estimates of future bioenergy supply costs for Narok County are obtained from the above national estimates, by assuming equal values for all the 47 counties of Kenya, thus dividing the national estimates by 47. The future bioenergy costs by 2030 for Narok County is therefore 45 million USD under the BAU scenario

81 Society for International Development (SID) (2021). Energy for what? Contemporary energy issues & dilemmas in Kenya. ISBN: 978-9914-40-351-0. Nairobi, Kenya

82 SID (2021)

83 Ibid

84 SusWatch Kenya (2020). Kenya's 100% Renewable Energy Plan-2020. East African CSOs for Sustainable Energy and Climate Action (EASE-CA) Project. Nairobi, Kenya

and 43 million USD under the renewable scenario. Cost estimates are sensitive to all inputs and especially for renewable energy scenario where the investment costs will be an essential feature, estimated as 43 million USD by 2030 for Narok County alone. Interest rate is a dynamic variable controlling the investment costs during the implementation of the renewable energy scenario.

3.5.8 Challenges affecting the bioenergy sector

Although the 2018-2022 County Integrated Development Plan (CIDP) of Narok County recognizes the importance of energy (County Government of Narok, 2018), the development of modern bioenergy in Narok County has lagged behind. This is due to constraints by several interlinked social, economic, cultural, institutional, and policy related barriers.

1. The County Government of Narok does not have sufficient institutional and infrastructural framework to grow the bioenergy function. A unit in charge of energy issues is in place and staffed but lacks the capacity to fully address the energy issues, attributed to insufficient expertise, especially in bioenergy. Energy issues are bundled and there is limited diversification on policies to address specific issues and challenges associated with the different Renewable Energy Technologies (bioenergy included). In the absence of a clear policy framework, harnessing bioenergy feedstock becomes difficult because of lack of clearly defined strategies and priorities for enhancing access. Moreover, lack of appropriate legislation limits opportunities for ensuring accountability and commitment of the county government in provision of bioenergy services. Establishment of appropriate county-level policy and legal framework on bioenergy in Narok County is constrained by apparent non-prioritization of bioenergy-related issues.
2. Narok County has limited technical capacity/expertise to facilitate the deployment of modern forms of bioenergy. Operational sophistication of biogas technology is a barrier to wider uptake. These challenges can be overcome through adaptation and localisation of technology to reduce costs, and on-the-job staff training by specialised technology providers and project developers, to build competency for installing and operating such technologies.
3. The high cost of biogas technology is a barrier to wider uptake. Although the removal of value added tax (VAT) on imported equipment for development of bioenergy (and other renewable energies) has significantly reduced the cost of products, the prevailing upfront costs are still unaffordable to many households. Poverty index in rural areas remains a concern and this can influence the ability to shift to cleaner energy technologies (NETFUND and KIRDI, 2017). Willingness to pay for technologies that are considered expensive may be low, particularly at household level. A business model that takes into account the energy needs of consumers, as well as their willingness and ability to pay should be developed by the county governments in collaboration with the private sector to enhance access to renewable energy

(and bioenergy) services. Currently, the County Government of Narok has limited or no incentives for private sector entities that would promote the development of renewable energy technologies.

4. Inadequate awareness of modern bioenergy technologies is widespread in Narok County. According to NETFUND and KIRDI⁸⁵, households with family heads who were illiterate (13 %) had very low disposable income and also low awareness surrounding renewable energy (RE) technologies. As reported by primary data, some community members are willing to invest in biogas technologies after receiving training. They also indicated that a demonstration site would be useful in convincing community members to adopt this technology. Awareness of these services, their benefits, and how to access them should be created among consumers at both county and national level.
5. Available feedstock for alternative biofuels such as bioethanol has not been quantified for Narok County. Moreover, the current level of production and use of briquettes is also not quantified. A detailed study/analysis of these bioenergy resources is recommended.

3.5.9 Policy, Regulatory and Governance recommendations

1. Developing appropriate county-level policy and legal framework on bioenergy in Narok County that addresses specific issues and challenges associated with bioenergy, therefore stimulating harnessing bioenergy feedstock supply chains.
2. Establishing the necessary institutional and infrastructural framework to grow the bioenergy services for the purpose of ensuring accountability and commitment of the county government and for supporting cross-cutting issues between the environmental and energy sectors for planning purposes.
3. Developing participatory management plans for each of the four forests managed by the County Government in order to ensure they are sustainably managed.
4. Supporting 4 pilot Group Ranches endowed with forest resources with alternative income generating activities that would complement conservation of remaining forest resources.

Economic/Financial recommendations

1. Establishing and strengthening networks to facilitate small farmers to access and effectively participate in supply chains for bioenergy feedstock, for example by encouraging growth of bioenergy co-operatives or producer companies. These cumulatively enjoin the resource-poor farmers as part of the national drive to promote biofuel production.
2. Developing Public-Private Partnerships (PPPs) towards the development of medium- to large-scale commercial energy generation plants from municipal waste, and slaughterhouses (abattoirs).

85 NETFUND and KIRDI (2017): Factors influencing Household adoption of Renewable Energy Technologies in Rural Kenya. A report of the National Environment Trust Fund (NETFUND) and Kenya Industrial Research and Development Institute (KIRDI), Nairobi, Kenya.

3. Developing incentive mechanisms for supporting micro, small and medium enterprises (MSMEs) towards stimulating transition and scaling-up adoption of modern bioenergy technologies across Narok County.
4. Adapting and localising bioenergy technology to reduce costs of installing and operating.

Technical recommendations

1. Developing wood fuels (firewood and charcoal) supply and demand master plan for the main supply and demand centres for the purpose of regulating the exploitation of current stock. This entails: undertaking tree cover inventory, classification of harvesting zones, development of conditions and technical specifications for wood fuel production and use, analysis of wood fuel flows - including allocation of firewood versus charcoal, and tracking pricing dynamics.
2. A Biomass Information System (BIS) will host data/information systems on feedstock types, production and market assessments and will also be linked with the Narok County Renewable Energy Atlas.
3. Regulating exploitation of current stock and enhancing enforcement of the legal and regulatory framework for sustainable production, distribution and marketing of biomass.
4. Promoting transition to much more efficient charcoal production methods, including carrying out demonstration, strengthening charcoal producers' associations, and supporting investment in necessary equipment.
5. Raising public awareness of more efficient energy use, including energy efficiency measures, local use of renewable energy, and new technology developments use, and scaling-up adoption of efficient cook-stoves.
6. Conducting detailed study and analysis on the feedstock availability, use of alternative biofuels such as ethanol, biogas, briquettes and pellets in Narok County, and promoting their development and use, in order to reduce pressure on the natural world and increase access to low-cost fuel.
7. Establishing incentive schemes that encourage the growth and expansion of bioenergy crops and on-farm woodlots meant for bioenergy.
8. Capacity-building of the County staff to build technical competency for installing and operating modern bioenergy technologies.



04

County Energy Access Scenarios

The Narok County leadership aims to achieve universal electricity connectivity and universal access to clean cooking fuels. Modelling was therefore used as a process to develop possible pathways towards energy access.

Three modelling tools were utilised to develop energy access scenarios. The first, termed as the Biomass Balance, was developed using an Excel spreadsheet and was used to forecast consumption of biomass (charcoal and firewood). This was then compared against the available resources determined in section 3.5. As previously mentioned, approximately 88% of the population in Narok relies on firewood and charcoal for cooking. It was therefore deemed necessary to isolate the consumption of this resource and determine its sustainability using the Biomass Balance. The second tool, Low Emissions Analysis Platform (LEAP), was used to model transition to clean cooking fuels. Using this tool, scenarios with biomass and other fuels such as LPG, biogas and electricity were used to determine possible interventions to transition to clean cooking. Furthermore, the Open-Source Spatial Electrification Tool (OnSSET) was used to develop scenarios for electricity access by considering grid and off-grid electrification technologies. Finally, an additional tool, the Energy Access Explorer, which adopts a multicriteria decision analytical algorithm was used to identify high priority areas for energy access interventions.

Transition to clean cooking and progress towards electrification were each modelled using three scenarios. The Biomass Balance as its name implies was purely used to compare forecasted biomass consumption against the resource. Different scenarios were used to model transition to clean cooking and electrification because of the different status of each of the sectors and the different modelling tools that were used. A business as usual (BAU), policy scenario and SDG scenario were developed using LEAP to analyse transition to clean cooking. The BAU scenario progressed without outside intervention in the transition to clean cooking while the SDG scenario targeted universal access to clean cooking by the year 2028 with no utilisation of solid fuels except sustainably sourced briquettes in the SME sector. Finally, the policy scenario considered moderate transition to clean cooking fuels with some remaining use of biomass by households.

While transition to clean cooking was varied and based on three scenarios, with the SDG scenario presenting universal access and the rest allowing partial transition, the electrification scenarios all worked towards universal access to electricity by the year 2026.

As reported in chapter 2, the KNBS 2019 census indicated that electricity access from the grid was approximately 19.7% while that from solar home systems was 30.7%. This indicates that approximately half (50.4%) of the population in Narok County had access to electricity. Primary data collection undertaken in 2021 indicated that the population with access had grown to 70%. A core assumption of electrification modelling was therefore that universal access was possible by 2026 using a combination of off-grid and grid-based electrification technologies. The key question to answer however was: What is the mix of technologies that would be suitable for universal electrification in Narok County? As such, the scenarios considered a mixture of grid and off-grid solutions like mini-grids and solar home systems. Variations in the scenario included; population growth rate, technology costs, and prioritisation of grid or off-grid technologies for electrification.

Another notable difference between the clean cooking and electrification modelling was the horizon. While electrification analysis had a modelling horizon of between 2019 to 2026, clean cooking transition modelling horizon extended to 2028. The difference in modelling horizon was based on guidelines from the INEP framework, which were confirmed by the Ministry of Energy.

It is worth noting that the modelling tools used (OnSSET, LEAP, and Excel) to develop the energy access scenarios had markedly different foundations. The Excel based model was a purely accounting spreadsheet-based model developed for the purpose of this CEP to develop the biomass balance. LEAP is both an accounting and an optimisation tool developed by the Stockholm Environment Institute. It can be used to model electricity capacity expansion (for generation and not distribution) and clean cooking solutions. OnSSET, on the other hand, is a geospatial modelling tool that is used to identify least cost solutions for electrification.

4.1 Biomass Balance

As previously indicated, forms of biomass predominantly used in Narok are charcoal and firewood. The following sections describe forecasts of firewood and charcoal consumption in households, institutions and healthcare facilities.

4.1.1 Households

4.1.1.1 Firewood

The national annual average firewood consumption rate of 1,349 kg per annum was used to estimate the firewood usage per household in Narok. This assumption is based on the national reports from MoE (2019). This data was used as primary data collected from households was far off the average consumption and was likely affected by reporting errors. The overall firewood quantity used for cooking was estimated based on the number of conventional households (at sub-county level), percentage of households using firewood, and the mean annual quantity (in kg) used by one household as reported in GoK, (MoE 2019).

The total amount of firewood used by households for cooking across Narok County is obtained by a summation of sub-county quantities. The results are summarised in Table 4.1, showing the households (%) using firewood and the respective quantity used at the household level, disaggregated by sub-county.

Table 4.1: Firewood consumption by households for cooking and warming houses, disaggregated by sub-county

Sub-county	Saturation of households using firewood (%)	Firewood quantity (1,000 dry tonnes/ per year)
Narok East	60.1%	20.3
Narok North	50.6%	40.8
Narok South	91.5%	57.4
Narok West	42.9%	21.8
Transmara East	92.5%	60.7
Transmara West	78.8%	53.2
TOTAL (across Narok County)	83.2%	22.9

Linear projection of firewood consumption by households was undertaken based on the expected change in saturation of firewood consumers. This change in saturation was generated based on the trend between the 2019 National Population and Housing Census and primary data collected in 2021. This trend was then assumed constant and used to forecast the values for each consecutive year. Underlying assumptions were that the average quantity of firewood consumed per household does not change over time and that the number of households had an annual growth rate of 1.67% (LCPDP 2021). Figure 4.1 shows the projected consumption of firewood by households in Narok County. It should be noted that firewood consumption was found to have declined in Narok West between 2019 and 2021. Applying this declining trend to Narok West would lead to firewood consumption of zero at the end of the horizon. As such, the average trend in consumption of firewood across Narok County was applied to Narok West.

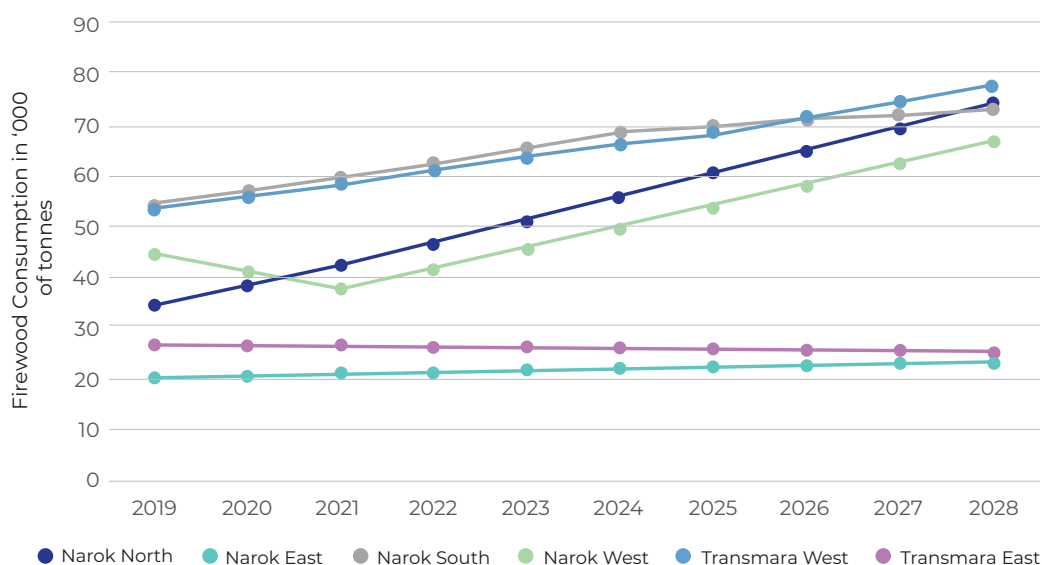


Figure 4.1: Projection of firewood consumption by households in the sub-counties of Narok County

4.1.1.2 Charcoal

The average quantity of charcoal consumed by households is 5.4 tins in a single week, although varying between sub-counties. This average does not vary much from the national average reported in MoE (2019), implying that households are able to keep records of charcoal consumption much better than records of firewood consumption. The highest mean household consumption was recorded in Narok East (7.3 tins or 6 kg) while the lowest was recorded in Transmara East (4.1 tins or 4 kg). Table 4.2 below shows the baseline charcoal consumption within the sub-counties.

Table 4.2: Annual consumption of charcoal (in tonnes) by sub-county

Sub-county	Quantity of charcoal used (tons)
Narok North	4,457
Narok East	2,708
Narok South	699
Narok West	800
Transmara West	343
Transmara East	568
TOTAL	9,575

Projection of charcoal consumption by households was calculated following the same procedure used for projecting firewood consumption. The change in saturation was generated based on the trend between 2019 national census data and primary data collected in 2021. It is assumed that the average consumption of charcoal does not change per household. Households are assumed to have an annual growth rate of 1.67%. The resulting projection of charcoal consumption (in tonnes) by households (disaggregated by sub-county) is reported in Figure 4.2. Apparently, future charcoal consumption will be on an upward trajectory in Narok East, Narok North, Narok West and Transmara East sub-counties, but on downward trajectory in Narok South and Transmara West sub-counties. Downward trajectory emerged in these counties because there was a decline in charcoal consumption between 2019 and 2021. As has been discussed, linear projection based on the trend between 2019 and 2021 was used to forecast charcoal consumption until 2028. Further investigation is recommended to develop a clearer picture of charcoal consumption in the two counties.

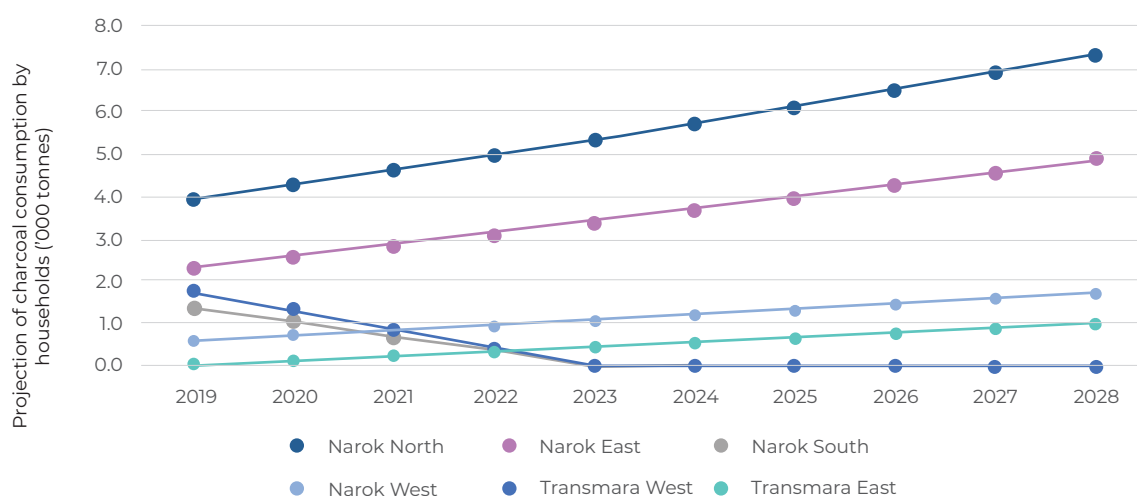


Figure 4.2: Projection of charcoal consumption by households in the sub-counties of Narok County

4.1.2 MSMEs

Similar to households, charcoal and firewood consumption was forecasted using the saturation trend developed between 2019 and 2021. Baseline consumption was obtained from primary data collection while the number of businesses was obtained from statistical data of the County Government of Narok and is summarised in Table 4.3.

Table 4.3: Overall firewood and charcoal quantity used for cooking by businesses

Cooking fuel	# of businesses operating	% of businesses using wood fuel	Mean quantity of back piles/sacks used by businesses per month	Equivalent kgs (green wood) per unit	Overall_ quantity ('000 tonnes) per year
Firewood	2,075	26	205	43	57
Charcoal	2,075	62	5	35	2.7

MSMEs are assumed to grow at a rate of 3.3 % per year⁸⁶. Forecast of firewood and charcoal consumption between 2019 and 2028 are as shown in Figure 4.3 and Figure 4.4. It is apparent from these that future consumption of firewood and charcoal in all the sub-counties will take an upward trajectory.

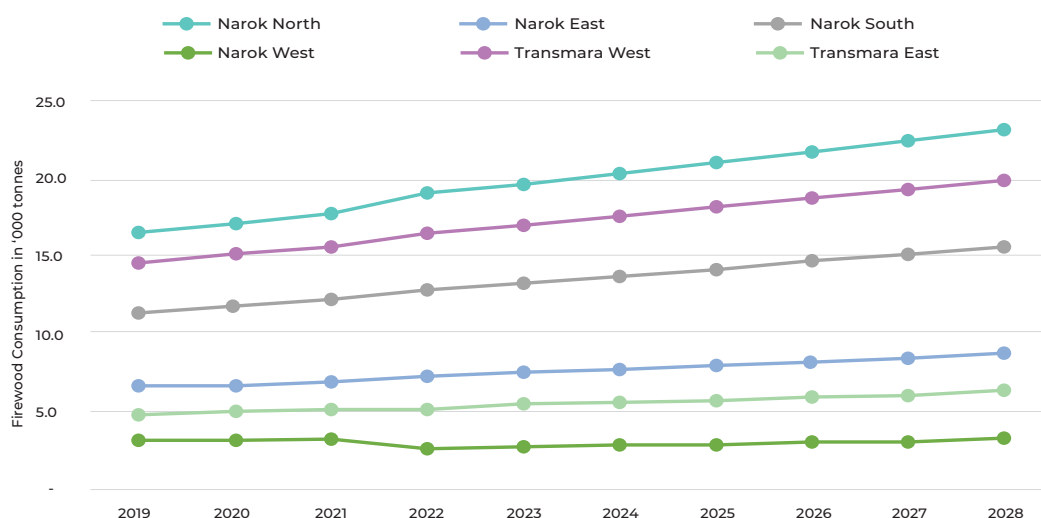


Figure 4.3 Yearly projections for the demand of firewood by businesses in Narok:

86 2018 Kenya SME Finance Survey: Online- HYPERLINK "<https://viffaconsult.co.ke/wp-content/uploads/2018/07/2018-SME-Finance-Survey-Report.pdf>" Accessed 22/11/22

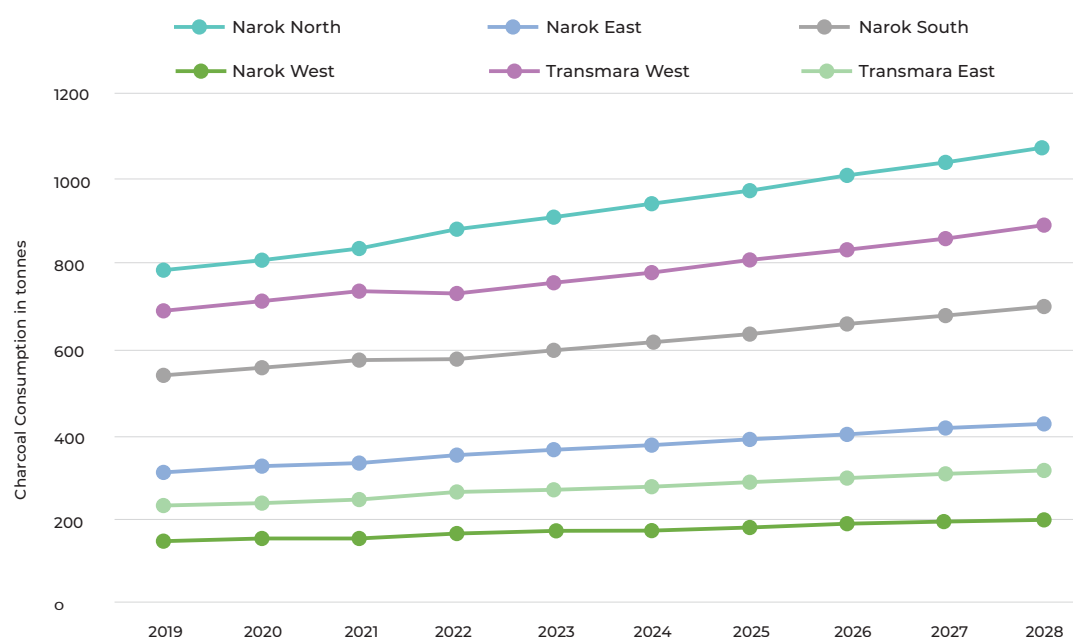


Figure 4.4 Yearly projections for the demand of charcoal by businesses in Narok

4.1.3 Healthcare Facilities

Narok County has 99 healthcare facilities as reported by the County Government. The monthly consumption (and average cost) of the different types of cooking fuels by healthcare facilities is represented in Table 4.4. A similar approach used in estimating quantities of firewood and charcoal consumption by households and by MSMEs was employed in determining the amounts of firewood and charcoal used by the healthcare facilities.

Table 4.4: Annual quantity of firewood and charcoal consumed by healthcare facilities

Cooking fuel	% Healthcare facilities using firewood/charcoal	Mean quantity of back piles/sacks used by HFCs	Equivalent kgs per unit	Overall quantity (tonnes) per year
Firewood	30	*29 back-pile	43	444
Charcoal	19	2 sacks	35	15.8

** Majority of healthcare facilities reported using back-pile as their unit of measuring firewood consumption*

The number of healthcare facilities in Narok County were assumed to increase at a rate of 3.3 % per year, similar to MSMEs. Forecasting of firewood and charcoal consumption between 2019 and 2028 used the same methodology employed for projecting consumptions by households and MSMEs. The results of the projection of charcoal and firewood consumption by healthcare facilities in Narok County is summarised in Figure 4.5.

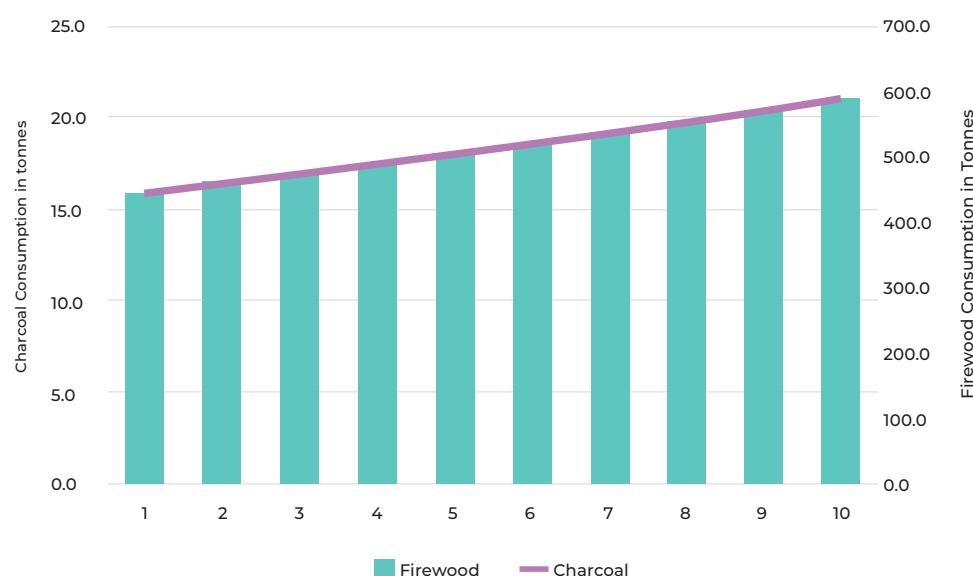


Figure 4.5: Projection of firewood and charcoal consumption by healthcare facilities in Narok County

4.1.4 Learning Institutions and Prisons

Secondary data from the study on biomass cookstoves and fuels in institutions in Kenya published by the Clean Cooking Association of Kenya was used to determine average consumption per institution. This was undertaken because large disparities were observed between primary data and national averages indicating reporting errors. Numbers and types of learning institutions and prisons were obtained from the CIDP and can be seen in Table 4.5. As shown in the table, Primary schools are the most abundant, followed by secondary schools. It should be noted that the available data was not fully disaggregated by sub-counties. Primary data was however used to determine the percentage of institutions using firewood and charcoal for cooking.

In undertaking the modelling, colleges and TVETs were merged to a single class called colleges. Also, non-formal schools were merged into secondary schools.

Table 4.5: Average firewood and charcoal consumption from learning institutions and prisons

Learning institutions	Number of inst. in 2021	Average annual firewood consumption ('000 tonnes) per institution	Average annual charcoal consumption ('000 tonnes)	Total charcoal annual consumption ('000 tonnes)	Total firewood annual consumption ('000 tonnes)
Secondary schools	139	500	6	16.7	66,025
Primary schools	664	410	1	13.3	258,628
Universities & Colleges	12	70	2	0.24	162
Prisons	2	10	0.5	0.02	10
Total	817			30.2	324,824

Projection of firewood and charcoal consumption was undertaken in a similar manner as households, healthcare facilities and MSMEs. The annual growth rate of the number of institutions was assumed to be 3.3 %. Projections in the consumption of both charcoal and firewood from 2019 to 2028 indicate minimal growth as can be seen in Figure 4.6.

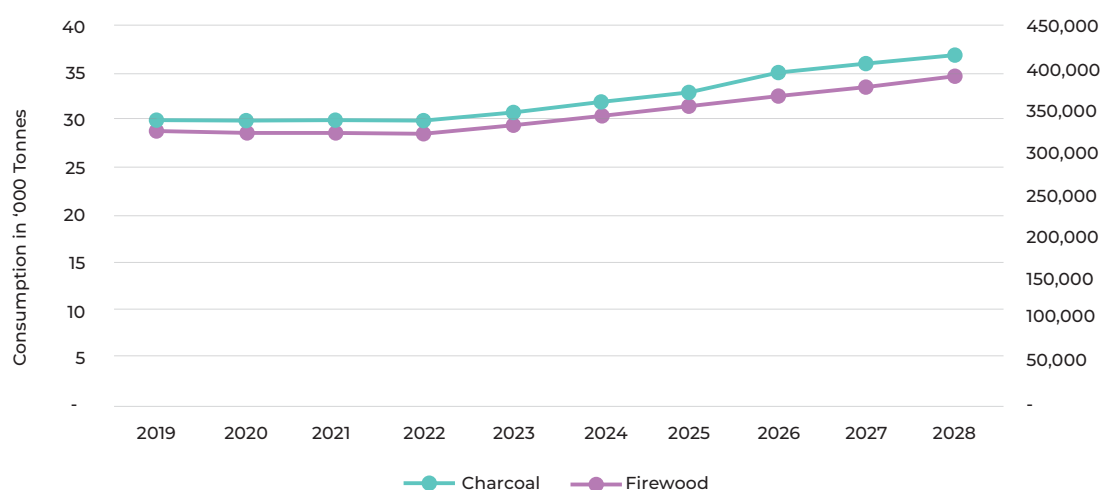


Figure 4.6: Projection of the overall sum of charcoal and firewood consumed by all learning institutions combined (Metric Tonnes)

4.1.5 Biomass Balance

In order to estimate the balance between annual biomass consumption (mainly firewood and charcoal) against annual sustainable supply from forests and on-farm woody biomass, the charcoal consumption (kg) was converted to the amount of raw wood (kg) that was used to produce the corresponding mass of charcoal using Equation 4.1.

This was added to the firewood consumption to generate total wood consumption across Narok County. Total consumption was compared to the sustainable supply of biomass that was calculated in section 4.1. This is summarised in Table 4.6 below.

Table 4.6: Balance of Consumption and Sustainable Supply of Biomass

Sub-county	Grand total consumption by all bioenergy consuming sectors in Narok County ('000 tonnes)	Total annual sustainable production by sub-county ('000 tonnes) that goes to bioenergy	Deficit of woody biomass to sustainably meet bioenergy needs ('000 tonnes)
Narok North	88,749	50	-88,699
Narok East	12,001	34	-11,967
Narok South	105,791	99	-105,692
Narok West	11,989	65	-11,924
Transmara West	67,493	26	-67,467
Transmara East	39,295	1	-39,294
Total Consumption	325,318	275	-325,043

It is notable that in all the sub-counties, base year consumption surpassed the sustainable supply from forests and on-farm woody biomass. The projected energy balance shown in Figure 4.7 below reveals a growing deficit proportional to the increase in biomass consumption across the county. Exploration of other options for cooking is therefore necessary for Narok County. The clean cooking scenarios discussed in the succeeding section offers an alternative pathway for Narok County.

Equation

4.1

$$Qty_{wd} = \frac{AMTC}{r}$$

Where:

Qty_{wd} is the quantity of wood used to make firewood

AMTC is the amount of charcoal carbonised r is the rate of recovery (in this case the r for the earth kiln is 20 %).

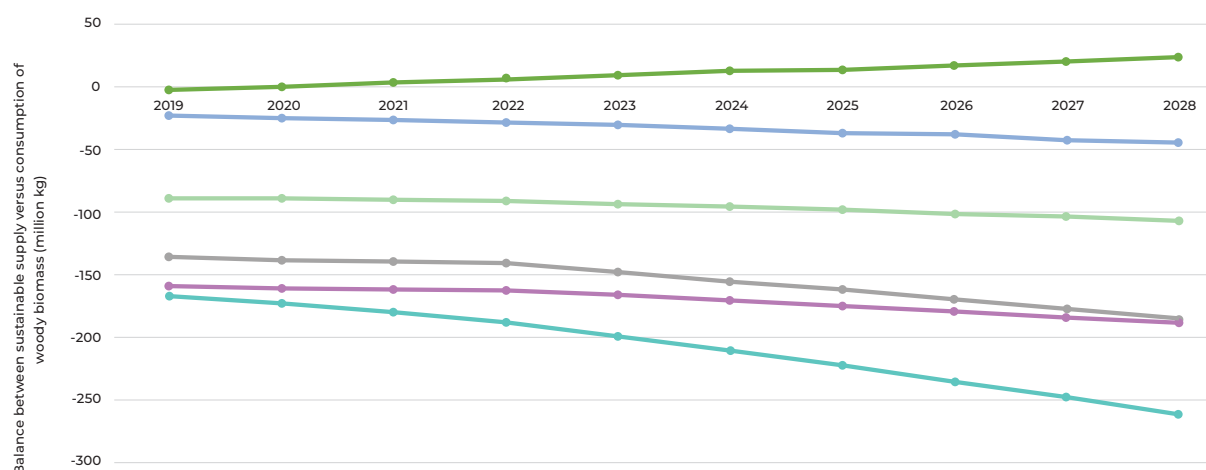


Figure 4.7: Projection of the overall energy balance (million kg) between 2019 to 2028

4.2 Transition to Clean Cooking

As previously mentioned, biomass use at its current growth rate is unsustainable for Narok County. Therefore, other cooking fuels need to be considered. This section presents three scenarios (business-as-usual, SDG scenario and policy scenario) which consider the adoption of fuels like electricity, LPG and biogas for cooking. The business-as-usual scenario considers the transition to clean cooking without outside intervention, the policy scenario, on the other hand, considers some regulatory intervention deemed possible by the County Government of Narok. Finally, the SDG scenario adopts clean cooking targets considered in the SDG 7. Table 4.7 below tabulates the interventions that were assumed for the SDG and policy scenario.

Table 4.7: Interventions in the Policy and SDG scenarios

Policy Scenario	SDG Scenario
Cookstove subsidy – 25% subsidy on the retail price of the improved and advanced cookstoves.	A complete phase out of unsustainable solid biomass in combination with traditional cookstoves and kerosene cookstoves by 2030.
Bio-digester subsidy – 25% subsidy on the price of the biogas digesters.	Modern energy cooking solutions such as the use of LPG, Bio-ethanol, Electricity and Biogas will be adopted as the primary modes of cooking in all the sectors of the county.
Enhanced fuel distribution within the county, with options for delivery of LPG especially in the urban setting while last mile access of LPG in rural areas is improved through licensing of dealers.	Enhanced fuel distribution within the county, which can be achieved through the last mile distribution planning; where the county plays a role in licensing and vetting of dealers who can stock and sell the modern cooking fuels considering the critical safety aspects in regards to handling of the fuels.
Removal of VAT on LPG	Partnering with Development Partners to incentivize clean cooking projects e.g., the county can collaborate with the African Biogas Component (ABC) project which is supporting the Government's goal of achievement of the 100% universal access to modern cooking technologies through a Result Based Finance (RBF) facility for small scale bio-digesters, with the project timeline being 2022-2025.
	Actively seeking for collaboration with UN agencies, such as United Nations Industrial Development Organisation and other development partners that have been incentivizing waste to Energy projects, so that the county's abattoir waste or municipal solid waste can be converted to useful thermal or electrical energy.
	Lobbying the National Government through the Ministry of Energy to zero rate the 8% VAT on LPG fuel to enhance uptake as was seen in 2018 when LPG had been zero rated.
	Lobbying the National Government through the Ministry of Energy to zero rate or reduce the 25% import duty and 18% VAT charged on Denatured Bio-Ethanol to enhance uptake.

As previously indicated, transition to clean cooking was modelled using LEAP. LEAP uses a wide range of input data to model scenarios aimed at reaching the set target. Different technology costs were applied to each scenario based on interventions applied. General assumptions were adopted in all of the scenarios as listed below:

- Household growth rate at 1.67% p.a.⁸⁷
- HCF, Institution growth rate at 3% p.a.
- SME growth rate is taken as 3.3%⁸⁸.
- Discounted NPV rate is 10% over the scenario lifespan
- Primary data from 2021 is used as a proxy for 2019 because it provides adoption rates of cookstoves in institutions and MSMEs

4.2.1.1 Business As Usual Scenario

As previously mentioned, the business-as-usual scenario adopts current market and societal trends to determine whether clean cooking targets can be achieved without external interventions. Table 4.8 and Table 4.9 feature the cost of fuel and cooking technology used respectively as inputs in the LEAP model. These costs were based on 2019 data which is the baseline of the study. Overall, clean cooking targets cannot be achieved with the business-as-usual Scenario.

Table 4.8: Assumptions for Baseline Cost of cooking fuels

S.no	Fuel	Price (Ksh/Kg) as at 2019
1.	LPG	108 - 150 ⁸⁹
2.	Kerosene ⁹⁰	110 ⁹¹
3.	Firewood ⁹²	4-5
4.	Charcoal	98
5.	Ethanol	85 ⁹³

Table 4.9: Cooking Technology Baseline Investment costs assumptions

S.no	Cooking Technology	Cost Range (Ksh)
1.	Improved wood stoves	2,800 – 3,600
2.	Ordinary charcoal cookstove	300 – 500
3.	Improved charcoal cookstove	2,990 – 5,300
4.	3 Kg Meko	2,000 – 3,000
5.	6 Kg Meko	3,500 – 5,000
6.	Mixed LPG -Electricity stove	28,920 – 39,250
7.	Electric Hot plates	2,000 – 5,000
8.	Induction Cookers	9,500
9.	Electric Pressure Cookers	7,000
10.	Bio- Ethanol stoves	2,300 – 7,000
11.	Biogas (Digester and cooking accessories)	50,000 – 100,000
12.	Kerosene stove	503 - 675

⁸⁷ This is the growth rate adopted in the LCPDP

⁸⁸ 2018 Kenyan SME Finance Survey

⁸⁹ The Kenya eCookbook, Beans & Cereals edition 2019

⁹⁰ Narok Primary data report indicated Urban Kes 56.7 and Rural Kes. 68.6

⁹¹ Energy and Petroleum statistics Report 2019 -EPRA accessed through <https://www.epra.go.ke/wp-content/uploads/2020/09/Energy-and-Petroleum-Statistics-Report-2019-1.pdf>

⁹² Firewood for HH is mainly collected

⁹³ Dalberg, June 2018, scaling up clean cooking in urban Kenya with LPG & Bio-ethanol, A market and policy analysis

4.2.1.2 Outcomes of Business as Usual Scenario

Figure 4.8 below is a graphical representation of the modelled energy demand under the business-as-usual scenario. It shows that the ratio of unclean cooking fuels remains high compared to clean solutions. Despite the expected rise in population, there is a marked decrease in energy demand. This contrasting outcome is due to the expected increase in the use of energy efficient cooking devices such as improved cookstoves at household and institutional levels over time. This shows that some transition to clean cooking is possible without outside intervention.

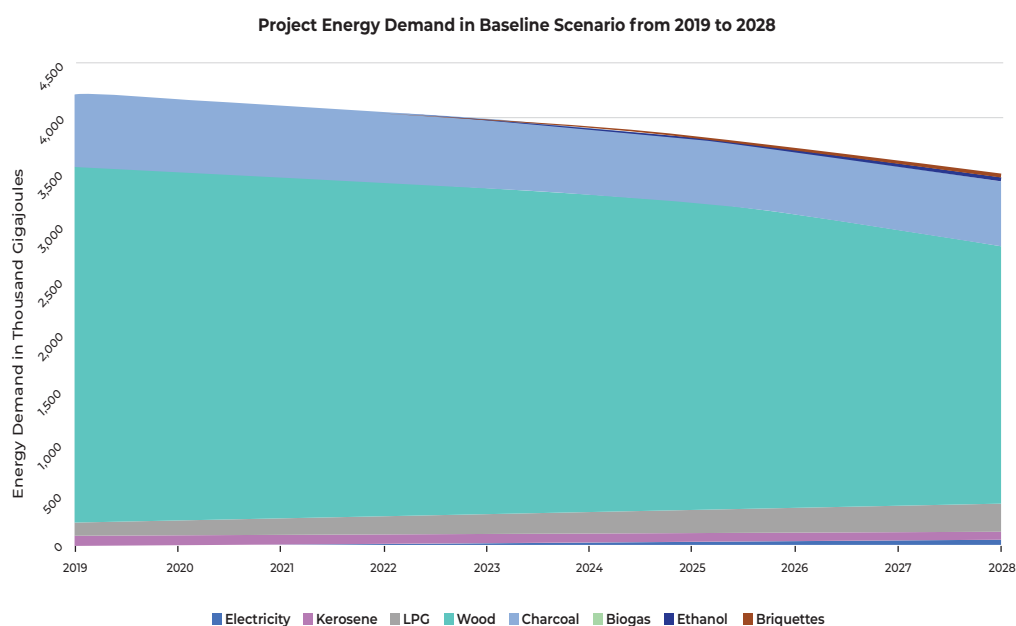


Figure 4.8: Total Energy Demand in Baseline Scenario 2019 - 2028 by cooking fuel

While there is a slight increase in LPG and Electricity demand for cooking, the market is still dominated by unclean fuels such as firewood and charcoal in this scenario.

The projected trend shows that the demand for efficient fuels such as LPG and electricity will rise while inefficient fuels such as firewood and charcoal will reduce. The improved cooking devices and fuel efficiency results in the gradual decrease in energy demand despite a steady population growth. These fuels and devices help to reduce energy demand from about 4.24M GJ to 3.15M GJ, saving about 1M GJ of energy.

4.2.2 Policy Scenario

The Policy Scenario assesses the effect policy interventions agreed upon by the Narok County Government can have in stimulating the adoption of cleaner cooking fuels and technologies in Narok. Starting from the 2019 baseline, the policy scenario employs interventions tabulated in Table 4.7.

The cost of fuel and cooking technologies in the policy scenario varies slightly from the business-as-usual scenario baseline costs because of the subsidies described in Table 4.7. Table 4.10 below shows the investment cost used in LEAP to model the policy scenario.

Table 4.10: Policy Scenario Cooking Technology Investment Costs Assumptions

S.no	Cooking Technology	Cost Range (Ksh)
1.	Improved wood stoves	2,100 – 2,700
2.	Ordinary charcoal cookstove	300 – 500
3.	Improved charcoal cookstove	2,240 – 3,975
4.	3 Kg Meko	2,000 – 2,250
5.	6 Kg Meko	2,625 – 3,750
6.	Mixed LPG -Electricity stove	28,920 – 39,250
7.	Electric Hot plates	1,500 – 3,750
8.	Induction Cookers	7,125
9.	Electric Pressure Cookers	5,250
10.	Bio- Ethanol stoves	1,725 – 5,250
11.	Biogas (Digester and cooking accessories)	37,500 – 75,000
12.	Kerosene stove	503 – 675

4.2.2.1 Policy Scenario Outcomes

Similar to the business-as-usual scenario, the policy scenario shows an overall reduction in energy demand despite a rise in the population and businesses due to improved energy efficient cooking technology, as shown in Figure 4.9.

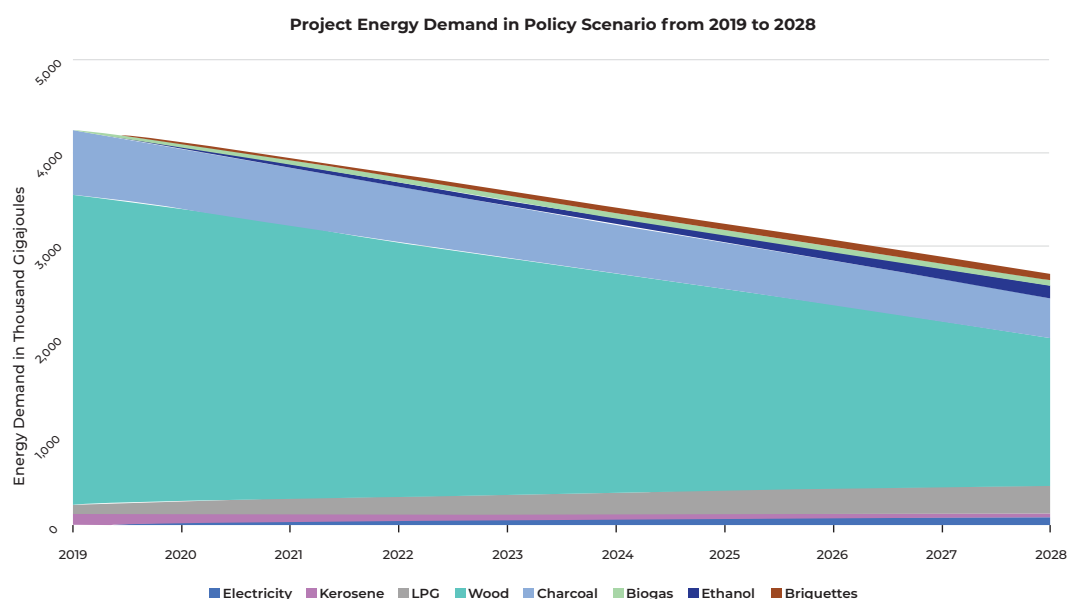


Figure 4.9: Energy demand in clean cooking Policy Scenario by cooking fuel

The model also incorporates the use of sustainably harvested briquettes to fuel improved cookstoves. The policy scenario effectively reduces the county's overall energy demand by about 1.5 million GJ from 4.24M GJ to 2.75M GJ. A significant portion of wood and charcoal remains in this scenario showing that further interventions are required to enable complete transition from biomass for cooking.

4.2.3 Sustainable Development Goal 7 (SDG 7) Scenario

This scenario adopts the SDG target of universal access to clean energy for cooking by the year 2030. Further, it also adopts Vision 2030, Kenya's developmental blueprint, where the annual GDP growth rate is 10%. It is further assumed that this economic growth will mean that consumers are able to transit to cleaner sources of energy. This scenario, however, maintains the use of biomass in the form of sustainably harvested briquettes for use in improved cookstoves, for deployment in MSMEs and educational institutions. Specific interventions adopted for this scenario are tabulated in Table 4.7

The investment costs for the SDG 7 scenario includes the reduction of bio-ethanol cooking fuel import duty from 25% to 10%, which reduces its nominal price by 15%. Investment costs for technologies and fuels in this scenario are based on interventions tabulated in Table 4.7 and can be seen in Table 4.11

Table 4.11: SDG 7 Scenario Cooking Technology Investment cost assumptions

S.no	Cooking Technology	Cost Range (Ksh)
1.	Improved wood stoves	2,800 – 3,600
2.	Ordinary charcoal cookstove	300 – 500
3.	Improved charcoal cookstove	2,990 – 5,300
4.	3 Kg Meko	2,000 – 3,000
5.	6 Kg Meko	3,500 – 5,000
6	Mixed LPG -Electricity stove	28,920 – 39,250
7.	Electric Hot plates	2,000 – 5,000
8.	Induction Cookers	9,500
9.	Electric Pressure Cookers	7,000
10.	Bio- Ethanol stoves	1,955 – 5,950
11.	Biogas (Digester and cooking accessories)	50,000 – 100,000
12.	Kerosene stove	503 - 675

4.2.3.1 SDG 7 Scenario Outcomes

Figure 4.10 shows energy consumed per fuels in the SDG 7 scenario. As previously explained, the model was set to achieve SDG targets of universal clean energy access for cooking by 2028. As such, the model completely eliminates use of firewood and charcoal by the end of the model horizon. The biomass fuel in the figure represents the use of sustainably sourced non-carbonized briquettes mainly by MSMEs whose activities involve roasting meat, maize and tubers. These businesses are expected to continue using sustainably sourced briquettes due to cultural preference for roasting these food products. The fuel requirement for the briquettes is roughly 500-1000 tonnes per annum, approximately 1-2% of the total annual fuel requirement by the county from the year 2025.

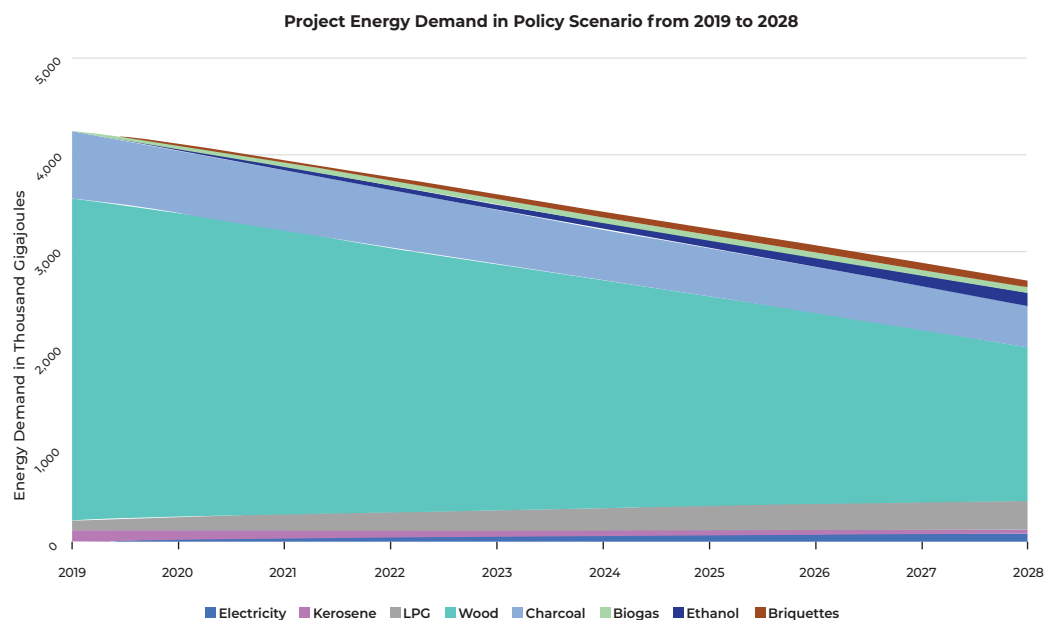


Figure 4.10: Projected Energy Demand under the SDG Scenario 2019-2028

The cost of implementing the SDG scenario is USD 150 million. While this scenario is costly to implement, it has significant benefits in terms of energy conservation/efficiency as well as health. The total energy consumption under the SDG scenario reduces from 4.2 million GJ in 2019 to 1.5 million GJ in 2030. Overall energy consumption for cooking reduces due to the adoption of efficient technologies.

4.2.4 Progress towards clean cooking

Table 4.12 and Table 4.13, present progress towards clean cooking access by households, MSMEs and institutions in the SDG scenario and policy scenario.

Table 4.12: Progress towards clean cooking access by households, MSMEs and institutions

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
HHS access to clean fuels: non-solids (%)	18%	28%	37%	46%	55%	64%	73%	82%	91%	100%
Institutions access to clean fuels: non-solids (%)	17%	28%	38%	49%	60%	71%	82%	93%	100%	100%
SMEs access to clean fuels: non-solids (%)	13%	22%	31%	40%	49%	58%	68%	77%	86%	95%
SMEs Improved cook stoves: Solid fuels (%)	35%	32%	30%	28%	26%	24%	22%	19%	17%	15%
Total access to modern cooking services (%)	16%	26%	35%	45%	55%	64%	74%	84%	94%	100%
Access to unclean cooking services (%)	84%	74%	65%	55%	45%	36%	26%	16%	6%	-

Table 4.13: Progress towards clean cooking in the Policy scenario

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
LPG (%)	18%	20%	22%	23%	25%	26%	28%	30%	31%	33%	34%	36%
Biogas (%)	0%	1%	1%	2%	3%	3%	4%	5%	5%	6%	7%	8%
Bioethanol (%)	0%	3%	4%	5%	5%	6%	7%	7%	8%	9%	9%	10%
Electricity (%)	0%	6%	6%	7%	8%	8%	9%	10%	10%	11%	12%	13%

It should be noted that the county government had a preference for the policy scenario because of the resources available. The National Government, through the Ministry of Energy, had a preference for the SDG scenario because of National policy. The County Government may therefore require additional support from the National Government and Development Partners to attain national targets for clean cooking.

4.3 Electricity

As mentioned in chapter 2, Narok has low electricity access rates and sparse population densities. It is therefore imperative that off-grid technologies like solar home systems and mini-grids be considered alongside the grid as solutions for electrification. This section presents the results of GIS modelling which sought to develop least cost electrification solutions for Narok between 2022 and 2026. This model horizon was adopted because it is prescribed in the INEP. This section is outlined as follows: First, an analysis of baseline data will be discussed then electrification scenarios will be presented together with the results obtained.

4.3.1 Baseline data

The electricity systems infrastructure in Narok consists of the national grid, which comprises the medium voltage (MV) and high voltage (HV) lines, substations, transformers and power plants. Figure 4.11 highlights this infrastructure (both existing and planned) together with the locations of some mini grids within Narok county. Table 4.14 outlines the length of existing medium and high voltage lines in Narok together with the number of mini-grids.

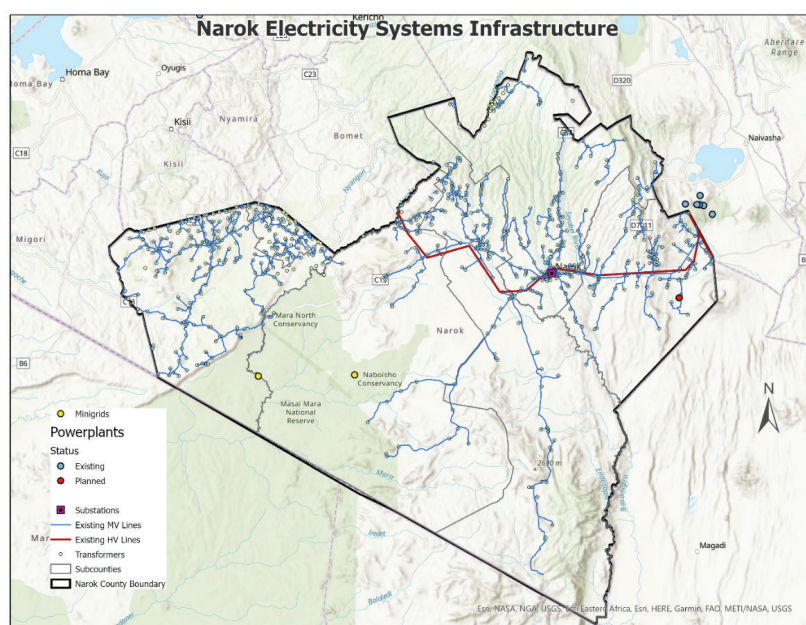


Figure 4.11 Electricity Systems Infrastructure:

Table 4.14: Summary of Existing Electricity Infrastructure in Narok County

Infrastructure	Status	Count/Length	General Location
HV Lines (KPLC, 2017) ⁹⁴	Existing	157.5 Km	Across the county
MV Lines (KPLC, 2017) ⁶⁸	Existing	2043 Km	Across the county
Substations (KPLC, 2017) ⁹⁵	Existing	1	Narok town
Transformers (KPLC, 2017) ⁹⁶	Existing	842	Across the county
Minigrids (CLUB-ER and Carbon Trust, 2019) ⁹⁷	Existing	3	Talek, Mara River

Additional baseline datasets on demand and supply of energy were integrated onto the Energy Access Explorer (EAE), an online, open-source, interactive, geo-spatial platform that enables clean energy entrepreneurs, energy planners, donors, and development-oriented institutions, among other users to identify high priority areas where energy access can be expanded. This tool uses spatial data to link energy supply with growing or unmet demand which is essential to gaining a better picture of energy access and expanding energy services to those who need it the most.⁹⁸ A more detailed overview of the EAE can be found in Annex 7 and 8.

OnSSET is a bottom-up GIS-based cost optimization toolkit that runs on python-based code for identifying least cost technological options for electrification of unserved areas. (Mentis, D. et al, 2020). It calculates scenarios for expanding access through an analysis of on-grid, off-grid and mini-grid systems and the associated investment needs. An electrification algorithm identifies and selects the technology configuration with the lowest Levelized Cost of Electricity (LCOE) for a given settlement.

94 KPLC. (2017). Kenya Electricity Network. Available at: <https://energydata.info/dataset/kenya-kenya-electricity-network>. (Accessed: 25 April 2022)

95 KPLC. (2017). Kenya Primary Substations. Available at: <https://energydata.info/dataset/kenya-primary-substations>. (Accessed: 25 April 2022)

96 KPLC. (2017). Kenya Distribution Transformers. Available at: <https://energydata.info/dataset/kenya-distribution-transformers>. (Accessed: 25 April 2022)

97 CLUB-ER and CARBON TRUST. (2019). Electrified mini-grid localities in Africa. Available at: <https://www.club-er.org/library/techno-economic-databases-324.html>. (Accessed: 25 April 2022)

98 Mentis, D. et al. (2019). EAE: Data and Methods. Available at: <https://www.wri.org/research/energy-access-explorer-data-and-methods>. (Accessed: 5 May 2022).

4.3.2 Electrification Modelling

Possible scenarios for Narok County's electricity future supply and demand were modelled using the Open-Source Spatial Electrification Tool (OnSSET). OnSSET is a bottom-up GIS-based cost optimization toolkit that runs on python-based code for identifying least cost technological options for electrification of un-served areas. (Mentis, D. et al, 2020). It calculates scenarios for expanding access through an analysis of on-grid, off-grid and mini-grid systems and the associated investment needs. An electrification algorithm identifies and selects the technology configuration with the lowest Levelized Cost of Electricity (LCOE) for a given settlement.

The LCOE from a specific source represents the final cost of electricity required for the overall system to break even over the project lifetime.

Equation 4.2 gives the formula used for calculating LCOE for a particular technology considers:

Equation 4.2

$$LCOE = \frac{\sum_{t=1}^n \frac{I_t + O\&M_t + F_t}{(1+r)^t}}{\sum_{t=1}^n \frac{E_t}{(1+r)^t}}$$

Where:

- I_t Investment expenditure for a specific system in year t ,
- $O\&M_t$ the operation and maintenance costs,
- F_t the fuel expenditures,
- E_t the generated electricity,
- r the discount rate,
- n the lifetime of the system.

The electrification options are divided into three main categories: grid-connected, mini grids and standalone systems (e.g. Solar home systems or SHSs). The cost of generating electricity for all off-grid technologies is calculated according to renewable energy resource availability (e.g. Global Horizontal Irradiation) and the technical and economic parameters of generation technologies (e.g. capacity and capital cost factors). For mini grids, an additional cost for the distribution network is added. Then for each cell, the most cost-effective off-grid technology is selected.

As was previously mentioned, OnSSET is a GIS-based tool and therefore requires data in a geographical format. In the context of the power sector, necessary data are shown in the list below:

Distribution of HV lines (current & planned)	Location of Substations & Transformers	Elevation & Slope Administrative boundaries
Distribution of MV line	Wind speed	Population distribution
Location of Substations & Transformers	Location of Small Hydropower potential sites	
Road network	Land Cover	
Global Horizontal Irradiation	Night time light	

These layers were processed in a GIS software to create an input file (table) for the OnSSET model. Additional data were used and input parameters are described in Annex 5.

Various scenarios were developed at both county and subcounty level to model the least cost technology option for electrification to achieve universal electrification by the year 2026. Annex 6 explains in more detail alternative scenarios made possible through the OnSSET modelling tool. Tiers of access were derived from the multi-tier framework which acknowledges that energy access is not binary. It is based on the principle that people will get access to different services from energy as their access levels or consumption grows. Table 4.15 below shows the growing access to energy services depicted by the multi-tier framework as the energy access levels grow.



Table 4.15: Multi-tier Matrix for Measuring Access to Household Electricity Supply⁹⁹

		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Peak Capacity	Power capacity ratings (In W or daily Wh)		Min 3W Min 3Wh	Min 50W Min 200 Wh	Min 200W Min 1.0 kWh	Min 800W Min 3.4 kWh	Min 2kWh Min 8.2 kWh
	Services		Lighting of 1,000 lmhr/day	Electrical lighting, air circulation, television, and phone charging are possible			
Availability (Duration)	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
	Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs

99

It should be noted that these scenarios did not explicitly consider data on productive use of energy, because geolocated information on PUE was not available at the time this plan was developed and a county wide data collection exercise to incorporate information on PUE would have gone beyond the time horizon of this study. It was therefore assumed that productive use would be able to connect to household supply. The base year for this analysis was set at 2019. OnSSET provides results for an intermediate year and the final year. The intermediate year was set at 2024 while the final year as previously mentioned was 2026.

The three scenarios (Domestic Electrification-Low Demand, Domestic Electrification High Demand, Domestic Electrification High Demand with Forced Grid Intensification) developed for this CEP are detailed in Table 4.16 below while the following sections describe the results obtained from modelling the scenarios.

99 ESMAP. (2015). BEYOND CONNECTIONS Energy Access Redefined. Technical Report 008/15. Available at: https://mtfenergyaccess.esmap.org/data/files/download-documents/full_report_beyond_connection.pdf (Accessed: 5 Sep 2022).

Table 4.16: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 population growth at 3.3% » Tier one of electrification for rural consumers and tier four for urban consumers » 40% electrification rate in 2024 » 100% electrification in 2026	» High population growth at 4% » High electricity demand target (Tier 2 of consumption for rural areas and tier 5 for urban areas) » 40% electrification rate in 2024 » 100% electrification in 2026	» High population growth at 4% » High electricity demand target (Tier 2-rural areas and Tier 5-urban areas) » 40% electrification rate in 2024 » 100% electrification in 2026	» High population growth at 4% » High electricity demand target (Tier 2 consumption in rural areas and tier 5 in urban areas) » 40% electrification target in 2024 » 100% electrification in 2026
Supply side assumptions	» Low generating cost for the grid » 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 » 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 » PV capacity cost reduced by 25% » Using grid electrification for areas that are within a 2km distance from the grid.	» High generating cost for the grid » PV capacity cost reduced by 25% » Using grid electrification for areas that are within a 2km distance from the grid.

4.3.2.1 Domestic Electrification -Low Demand Scenario

Figure 4.12 shows the technology choice per settlement while Table 4.17 shows the capacity required for electrification in the domestic electrification scenario. Table 4.17 also displays the technology names that are referred to on the map legend in full.

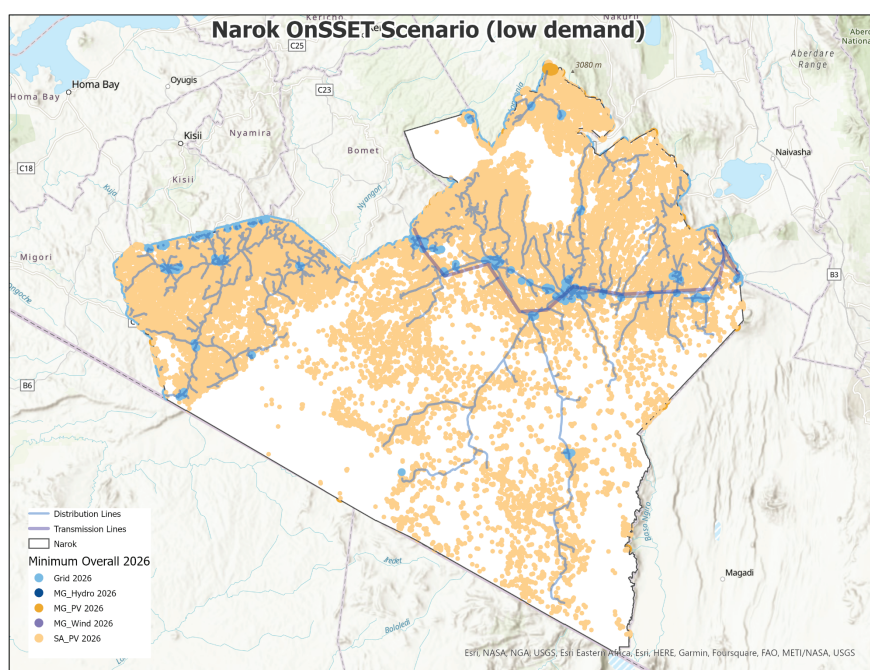


Figure 4.12: Domestic Electrification-Low Demand Scenario Results

Table 4.17: Capacity Required for Electrification in the Domestic Electrification Scenario

Technology	2024 (kW)	2026 (kW)	Total (kW)
Grid	529.1	61.3	590.4
Stand Alone (SA) PV	0	2,991.2	2991.2
Mini-grid (MG) Diesel	0	0	0
Mini-grid (MG) PV	0	25.2	25.2
Total	3,606.8		

The model selects the grid, standalone solar PV and solar PV mini grids as least cost options for electrification. Solar PV has the highest capacity at 2.9MW. This could be due to the lack of productive use as this scenario focused on domestic electrification. The sparse population density in Narok may have also contributed to this.

The investment costs required to implement this scenario are tabulated in Table 4.18 below. The total costs for deploying this scenario is USD 50 million. Fifty five percent (55%) of this investment is allocated to grid expansion and densification.

Table 4.18: Investment (USD) required for Scenario for Domestic Electrification-Low Scenario in 2024 & 2026

Technology	2024 (Million USD)	2026 (Million USD)	Total
Grid	24.0	3.5	27.5
Stand Alone (SA) PV	0	22.4	22.4
Mini-grid (MG) PV	0	0.09	0.09
Total	50.1		

4.3.2.2 Domestic Electrification -High Demand Scenario

The map in Figure 4.13 shows the technology choice per settlement in 2026 for the domestic electrification scenario while Table 4.19 shows the capacity of technologies required for electrification.

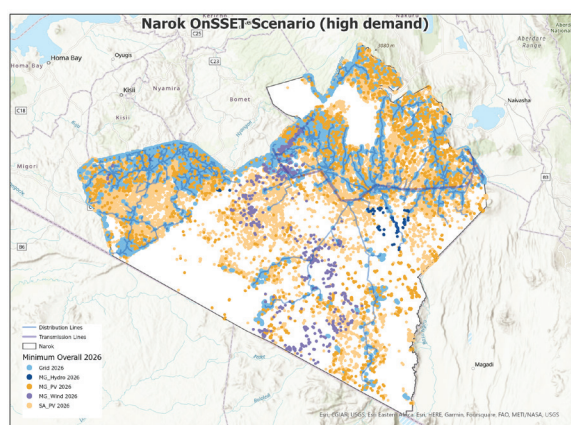


Figure 4.13: Domestic electrification high demand scenario

Table 4.19: Capacity of Electrification Technologies Required

Technology	2024 (MW)	2026 (MW)	Total (MW)
Grid	13	15.6	28.7
Stand Alone (SA) PV	0	26.1	26.1
Mini-grid (MG) PV	0	9.8	9.8
Mini-grid (MG) Wind		0	
		2.6	
		2.6	
Mini-grid (MG) Hydro	0	0.085	0.085
Total			67.4

From Table 4.19 above, we note that the technologies proposed to be used for electrification are similar to Domestic Electrification - Low Demand Scenario. However, there is an addition of wind and hydro mini-grids by the year 2026 for electrification. This indicates that resources become commercially viable with higher populations. It should be noted that the model considers supply side costs and not the end user costs of consumption. As such, while it may be cheaper to construct mini-grids, it has been proven that the costs of consumption for the end user could be as much as five times higher than the grid, particularly when there is no productive use. Innovative financing models or subsidies through projects such as KOSAP may therefore need to be applied where mini-grids are a least cost option. Productive use of energy also needs to be promoted in areas where mini-grids are suggested to make the investments more sustainable in the long run while improving the livelihoods of the communities there. Stand-alone diesel and diesel mini-grids are still absent from the technology choices. However, this is likely influenced by the higher diesel costs used in this scenario. The investment costs for this scenario are described in Table 4.20. As expected, they are higher than the Domestic Electrification Scenario-Low because of the higher population to be electrified.

Table 4.20: Investment (USD) required for Scenario Domestic Electrification High Demand Scenario in 2024 & 2026

Technology	2024 (Million USD)	2026 (Million USD)	Total
Grid	84.7	134.67	219.3
Stand Alone (SA) PV	0	125.3	125.3
Mini-grid (MG) PV	0	44.9	44.9
Mini-grid (MG) Wind	0	8.9	8.9
Mini-grid (MG) Hydro	0	0.53	0.53
Total	399.2		

4.3.2.3 Domestic Electrification - High Demand, Grid Intensification Scenario

This scenario forces grid electrification (intensification) in areas that are 2km away from the grid. This means that the model will prioritise grid extension and densification in areas that are within a 2km radius from the grid, whether or not it is a least cost option.

Figure 4.14 shown below describes the technology choice per settlement in 2026 while Table 4.21 shows the capacity of electrification technologies used. Figure 4.15, on the other hand, shows the least cost electrification technology distribution by 2026. As expected, this scenario deploys significantly more grid electrification with a total of 34.8 MW as compared to the previous scenarios 28.7MW. This naturally causes a reduction in the deployment of other technologies like solar home systems and mini-grids as compared to the Domestic Electrification-High demand scenario. Reduction in deployment of solar home systems and mini-grids causes reduction in overall capacity at 52.8MW as compared to the previous scenarios at 67.4MW.

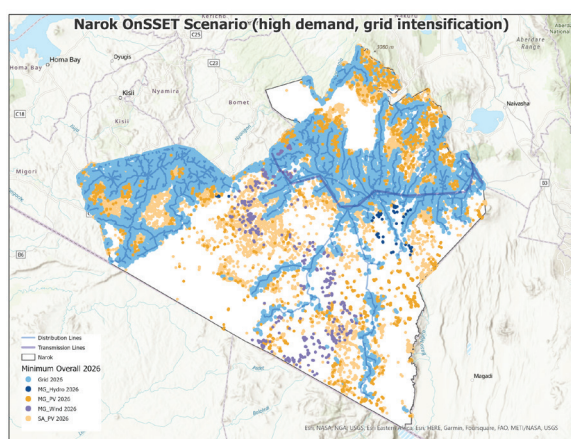


Figure 4.14: Technology choice per settlement in 2026

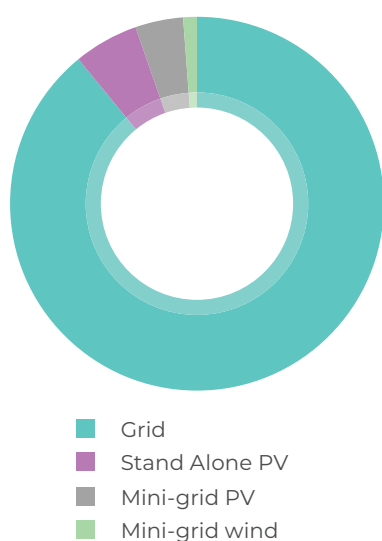


Figure 4.15: Least cost electrification technology distribution by 2026

Table 4.21: Capacity of Electrification Technologies (MW)

Technology	2024	2026	Total
Grid	26.4	8.4	34.8
Stand Alone (SA) PV	0	9.2	9.2
Mini-grid (MG) PV	0	6.6	6.6
Mini-grid (MG) Wind	0	1.9	1.9
Mini-grid (MG) Hydro	0	0.062	0.062
Total	52.8		

Table 4.22 shows the investment costs required to deliver this scenario at USD 599.3 million, which is significantly more than the previous two scenarios. This can be attributed to forcing the model to depart from least cost solutions for electrification and utilise the grid a 2km radius. Despite the reduced capacity, this scenario will cost more to implement than the previous scenario by approximately USD 200 million. This can be attributed to the cost of grid expansion.

Table 4.22: Investment (USD) required in Forced Grid Scenario in 2024 & 2026

Technology	2024 (Million USD)	2026 (Million USD)
Grid	461.9	56.1
Stand Alone (SA) PV	0	44.5
Mini-grid (MG) PV	0	29.7
Mini-grid (MG) Wind	0	6.6
Mini-grid (MG) Hydro	0	0.40
Total	599.3	

Progress towards universal electrification by 2026 was undertaken using this scenario and is tabulated in Table 4.23 below. This is the recommended electrification scenario. While it may be more costly, the grid allows consumers to pay less for consumption, particularly as compared to mini-grids where electricity can cost up to 5 times more. Further, grid consumers can also acquire more appliances without considering or acquiring increased system capacity as compared to solar home systems. Additionally, grid electrification is likely to be conducive for productive use of energy due to lower electricity costs and sufficient electricity supply.

Table 4.23: Electricity connectivity progression

Year	2019	2020	2021	2022	2023	2024	2025	2026
Total connectivity of HHs (%)	20%	21.30%	22.40%	30.17%	37.94%	45.70%	72.85%	100%

4.3.2.4 Affordability Analysis

The Domestic Electrification - High Demand, Grid Intensification Scenario was broken down to sub-county level with the goal of undertaking a more granular affordability analysis. Affordability analysis was undertaken to determine the ability of the households to pay based on a comparison between levelized cost of electricity in this scenario and average electricity expenditure per household.

Affordability analysis was based on the high demand, grid intensification scenario because it is likely that the areas within close proximity to the grid will be electrified by this technology. The results of this analysis can be seen in Table 4.24 below.

Table 4.24 Affordability Analysis

Sub County	Average amount per household spent (KES) on electricity per month (2026)	Extrapolated total electricity expenditure per year in 2026 (Million KES)	Modelled Electricity Cost	Deficit (Million KES)
Narok North	906.7	733.0	610.762	122.3
Narok East	1,249.8	422.3	211.8	210.5
Narok South	876.1	551.6	674.6	-123.1
Narok West	563.7	293.6	372.0	-78.4
Trans Mara East	897.1	247.9	98.4	149.5
Trans Mara West	734.4	496.1	425.6	70.4
County Totals	898.7	2,919.6	2,393.3	526.3

Further info on table above^{100, 101}

From Table 4.24, it can be seen that some sub counties (Narok South and Narok West) would have a deficit between what they can afford to pay for the electricity while Narok North, Narok East, Transmara East and Transmara West would be able to pay for the selected technology of choice (assuming current affordability situation remains constant).

It is therefore necessary to source additional funding or innovative financing models to meet the deficit for the sub counties that would be unable to pay for the proposed solutions.

4.3.3 Institutions Electrification Pathways and Statistics

Institutional electrification was considered through grid densification. Proximity analysis was undertaken to establish institutions that were 600 metres and above from the grid. These institutions were assumed to be unelectrified. The unelectrified institutions were further extracted and overlaid with outputs from the County OnSSET Forced Grid Scenario. Finally, using GIS proximity analysis, the institutions were assigned a least cost electrification technology option based on the solution assigned to the nearest settlement cluster. The sections below present the results found for electrification of healthcare facilities and schools.

4.3.3.1 Healthcare facilities

A total of 75 healthcare facilities were thus flagged as unelectrified in the county (**not connected to the grid**). These are symbolised in light blue in Figure 4.16 below.

¹⁰⁰ Future value of money calculations: Available at: <https://www.investopedia.com/articles/03/082703.asp>. (Accessed on: 11/20/2022)

¹⁰¹ *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 value⁹⁴ of the amount spent per household in 2021 as per the primary household surveys assuming a 10% annual increment.

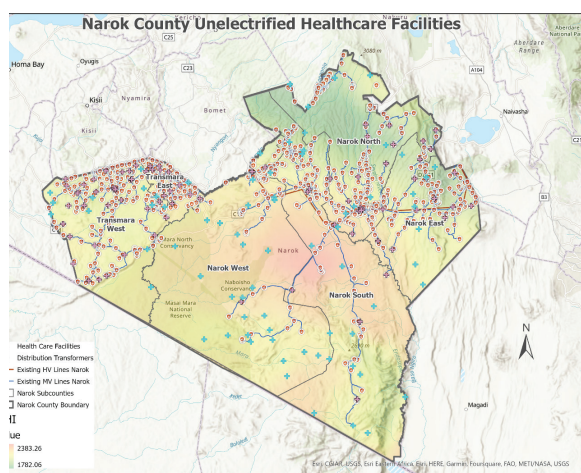


Figure 4.16: Map showing unelectrified healthcare facilities in Narok County as identified by GIS analysis (using the assumption that a facility 600m and more is not connected to the grid).

Table 4.25 below summarises least cost electrification technologies for healthcare facilities based on the findings from the GIS proximity analysis.

Table 4.25: Electrification technologies for Unelectrified Healthcare Facilities

Sub County	Grid	SA PV	MG PV	MG Hydro	MG Wind	Totals
Narok North	7		1			8
Narok East	4	2	4			10
Narok South	7	6	2			15
Narok West	9	16	3		2	30
Transmara East						
Transmara West	9	1	2			12
Narok County Totals	36	25	12	0	2	75

The findings in Table 4.25 indicate that the majority of healthcare facilities (48%) are electrified by the grid. This is closely followed by standalone solar PV at 33%. This indicates that a large number of healthcare facilities are further from the grid as compared to households.

4.3.3.2 Schools

A total of 265 schools were flagged as unelectrified in the county (**not connected to the grid**). These are symbolised in blue in Figure 4.17 below.

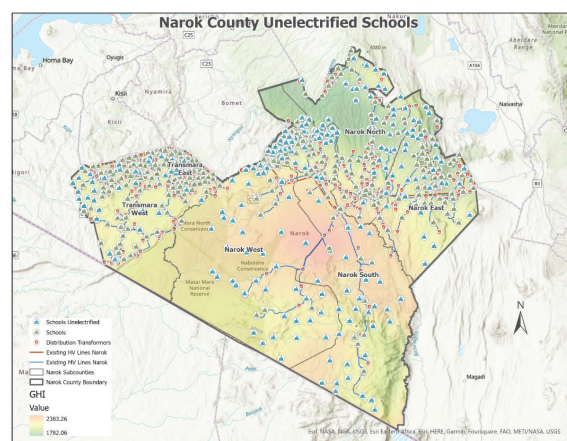


Figure 4.17: Map showing unelectrified schools in Narok County as identified by GIS analysis (using the assumption that a school 600m and more is not connected to the grid).

Table 4.26 below summarises electrification technologies that can be used to electrify schools.

Table 4.26: Electrification Technologies for Unelectrified Schools

Sub County	Grid	SA PV	MG PV	MG Hydro	MG Wind	Totals
Narok North	28	11	13			52
Narok East	12	6	7	1		26
Narok South	33	16	11		2	62
Narok West	38	27	5		9	79
Transmara East	7	1				8
Transmara West	23	11	4			38
Narok County Totals	141	72	40	1	11	265

Majority of schools are electrified using the grid (53%) followed by stand-alone solar PV (27%). This indicates that more schools than healthcare facilities are found close to the grid.

4.3.3.3 Suggested electrification projects

Based on the results of the OnSSET high demand, grid intensification scenario described in section 4.3.2.3, the output map was analysed to identify clusters of population settlements that have a similar electrification technology solution. This was undertaken in order to identify potential areas for setting up electrification projects using the most feasible and least cost technology choice.

On Figure 4.18, clusters of population settlements that have the same recommended technology choice for electrification have been circled using different colours. Potential areas for setting up solar mini grids have been circled red, while those that have potential for setting

up mini grids using hydropower have been circled dark blue. Additionally, potential areas for setting up mini grids using wind have been circled green.

The remaining areas are mainly those suitable for extending the grid and setting up standalone solar home systems which are uniformly distributed and colourized differently. Areas suitable for grid extension are mainly concentrated 2km proximity to the grid while that for standalone solar are randomly distributed but mostly much further away from the areas where grid could be extended or where mini grids could be set up.

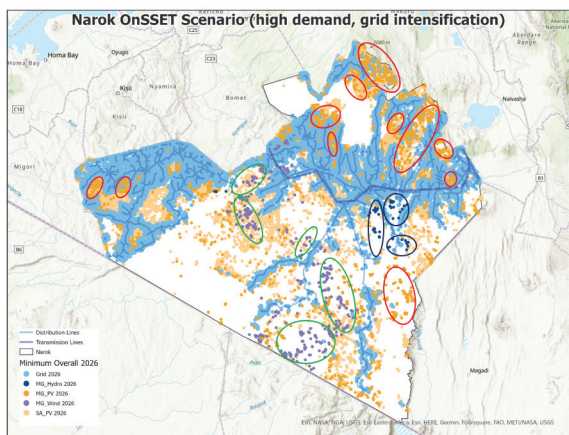


Figure 4.18: Map showing potential areas for setting up power plants using various least cost technology options in Narok

More detailed feasibility and technical analysis would need to be done to determine the exact design, capacity and actual end users of the proposed power plants that would meet the needs of the unelectrified population identified and ensure universal access to electricity to all in Narok by 2026.

4.4 Policy and Governance Recommendations

1. Implement clean cooking tax incentive and subsidy program with the goal of reducing costs of clean cooking technology and fuels (LPG, Bioethanol)
2. Strengthen and implement policy and regulatory instruments and strategies that prioritise clean cooking solutions; Transition All Private and Public Institutions (Boarding Schools, Hospitals, TVET, Prisons, etc) from use of biomass cooking fuels to higher tier cooking Solutions by 2026 and clean cooking by 2028.
3. Build and strengthen political goodwill to accelerate a sustainable clean cooking transition: Sensitize politicians (particularly MCAs) to invest in clean cooking solutions within their Wards.

4.5 Economic and Financial Recommendations

- i. Develop clean cooking solution partnerships with development partners and the private sector to seek financing and develop business models that will enhance deployment of clean cooking solutions.
- ii. Develop PUE strategies to stimulate energy demand and improve socio-economic conditions in Narok County.

4.6 Technical Recommendations

- Develop a last mile distribution plan with clean cooking fuel and technology suppliers.
- Clean cooking technology awareness campaign: Work hand in hand with RREC at the county level and communities to create awareness on clean cooking solutions.
- Implement an electrification program based on results provided in 4.3.2.3.

^[1] Narok CIDP 2018 - 2022

^[2] 2019 Census

A decorative graphic at the top of the page features a row of light bulbs. On the left, three incandescent bulbs are shown in a row, partially obscured by a white diagonal shape. On the right, a single LED bulb is shown in a larger, circular frame, also partially obscured by the same white shape. The background is a gradient of green and yellow.

05

County Energy Efficiency and Conservation Measures Assessment

Energy Efficiency (EE) entails using less energy to perform the same task. Efficient technologies, which can perform the same tasks while consuming less energy are typically adopted for this. Energy Conservation (EC), on the other hand, is associated with reducing energy consumption through the prevention of wasteful use of energy, for example switching off lights when a room is not in use. The use of alternative renewable sources of energy also contributes to energy conservation efforts.

This Chapter describes the assessment of energy efficiency and conservation practices in Narok county covering County public buildings, households, public institutions, public health centres and commercial industries as envisioned in the INEP guidelines. The assessment of commercial industries was limited to compliance to energy management regulation as the facilities are private entities with restricted access for public reporting.

5.1 Energy Efficiency and Conservation Standards and Benchmarks

Assessment for energy efficiency in Narok was undertaken using minimum energy performance standards (MEPS) originating from Kenya Bureau of Standards (KEBS) together with guidelines from: Kenya National Energy Efficiency and Conservation Strategy 2020 (KNEECS); Kenya Green Building Society; and the Excellence in Design for Greater Efficiency (EDGE) framework. MEPs from KEBS were used to assess the energy efficiency of appliances; including covering motors, fluorescent lamps, domestic refrigerators and room air conditioners. In the absence of national standards, the EDGE tool was used to develop MEPS for buildings. Guidelines from KNEECS were utilised to determine energy efficiency of households, industry, buildings, transport and agriculture. The following section describes the guidelines and standards that were used.

5.1.1 Minimum Energy Performance Standards

Energy (appliances energy performance and labelling) regulations established six MEP standards through the Kenya Bureau of Standards (KEBS) covering motors, fluorescent lamps, domestic refrigerators and room air conditioners. The standards state that each of the units listed above shall have an Energy Guide Label visibly attached to the front of the unit stating the 'Energy Star Rating' of the unit. The higher the star rating, the higher the energy efficiency level. The KEBS standards utilised are listed below ;

- » **KS 2449-1: 2013 (Rotating Electrical Machines):** This Standard specifies the minimum energy performance standards (MEPS) requirements for electric motors with ratings from 0.73 kW and up to but not including 185 kW¹⁰² through the minimum energy efficiency values that a motor shall meet in the Kenyan Market.
- » **KS 2463: 2019 (Non-Ducted Air Conditioners):** This Standard specifies the ratings of a single-package and split-system non-ducted air conditioners employing air cooled condensers and is limited to systems employing a single refrigeration circuit with one evaporator and one condenser. The energy efficiency of air conditioners is measured using the Energy Efficiency Ratio (EER) that is a ratio of cooling power output to power input
- » **KS 2464-2: 2020 (Refrigerating Appliances):** This Standard specifies the Minimum Energy Performance Standard (MEPS) requirements for household vapour compression refrigeration appliances, cooled by internal natural convection or forced air circulation that can be connected to main power, including refrigerating appliances that are used in the commercial sector. Units traded in the Kenyan market are required to possess a minimum of 1 STAR¹⁰³.

While appliances could be assessed using the national standards briefly described above, Kenya is yet to develop nationwide standards for buildings. As such, the 'Excellence in Design for Greater Efficiency' (EDGE) was used to compute MEPs for this consumption cat-

egory. The energy use index (EUI) was used to provide energy performance metrics for assessment of building energy performance. EUI is measured by the total energy used within a building in a year, expressed as kilowatt hour (kWh), per gross floor area (m²) or equivalent of value units, normally presented as kWh/m²/yr. The MEP standard works inversely to match the EUI guideline

5.1.2 Excellence in Design for Greater Efficiency (EDGE)

EDGE (EDGE, 2022) is a green building certification system that allows assessment of the most cost-effective ways to incorporate energy and water efficiency in buildings such as offices, homes, hotels, hospitals and retail spaces. It was developed through the International Finance Corporation (IFC), a member of the World Bank Group. The EDGE system can be used to compute building efficiency metrics such as EUI that can be used to benchmark a base case scenario with minimal energy efficiency measures to an improved case where energy efficiency measures have been applied.

5.1.3 Kenya National Energy Efficiency and Conservation Strategy (KNEECS)

As discussed in Chapter 1, KNEECS provides a roadmap in energy efficiency and conservation in five identified priority sectors as follows; households, buildings, industry & agriculture, transport, and power utilities. It also includes strategies and targets for the aforementioned priority sectors referenced in this report and which have been presented in Annex 11.

5.1.4 Kenya Green Building Society Guidelines (KGBS)

Guidelines for green buildings¹⁰⁴ also provide specific parameters that should be adopted in building design to enhance energy and water efficiency and focus on effective passive building design. This design incorporates solar thermal performance, water and energy conserving measures in the building orientation, building envelope and building appliances and fixtures to maximise the potential for heating and cooling, solar water heat heating, as well as encouraging natural lighting to reduce the need for additional cooling, heating or lighting during the day. The design also provides for use of efficient low flow water appliances and waste water harvesting and recycling. Further details of the design guidelines have been presented in Annex 11.

5.1.5 Energy Efficiency Assessment of Narok County

The energy efficiency assessment in Narok County covered buildings, industry and commercial activities, households and institutions. The general energy efficiency management assessment in the county shows that the county does not have an operational functional energy efficiency team/committee. Energy efficiency is then carried out as part of the functions of the Department of Environment, Water and Energy while the Committee in Energy within the legislative county assembly enacts laws and regulations for governance.

102 KEBS KS 2449-1: 2013

103 KEBS KS 2464-2: 2020

104 IFC. Sintali. (March 2020). *EDGE Expert Training: Guidelines for Green Buildings*. Nairobi: IFC

Individual facilities such as key buildings; including county buildings, hospitals, water treatment plants and institutions operate their own individual energy programs with their technical officers. There is evidently low synergy between programs in county facilities and the Department of Environment, Water and Energy. A training needs assessment revealed that Narok County officers had limited technical capacity in energy efficiency. Further, there was limited technical capacity within the various industries, institutions and facilities operating in Narok.

The County does not have a building code in energy efficiency and the current national building code is outdated and does not adequately cover energy efficiency. This has reduced capacity to enforce energy efficiency standards. The National Strategy, however, makes provision for development of country-wide building code/standards that cover energy efficiency that the County may support and implement.

There is inadequate mainstreaming and funding of energy efficiency programs. Energy has been allocated limited resources and priority has been given to energy access. Energy efficiency is so far embedded within technical improvements programs, particularly during replacement of failed equipment.

5.1.6 County Office Buildings and Referral Hospital

From the energy efficiency assessment carried out, the dominant installation in County buildings was lighting, air conditioning and refrigeration in selected executive offices, information and technology (IT) rooms, and speciality treatment rooms in the case of County Referral Hospital. Cooking and hot water systems were only assessed at the County Referral Hospital. Speciality treatment and diagnostic equipment were not considered as they required speciality assessment.

5.1.6.1 Building Envelope Design and Orientation

Most of the buildings assessed were compliant with the KGBS Guidelines in building orientation of east to west as illustrated in Figure 5.1 that minimises solar heating and reduces requirements for artificial cooling. Examples of such buildings include: the County HQ Offices, Departments of Environment, Energy and Water, Public Works and Water Services offices. The County Referral Hospital building, on the other hand, was oriented on the NorthEast to SouthWest plane that has a higher absorption rate of solar heating, creating a higher cooling load for treated spaces. It is recommended that future buildings be built in the East to West Orientation.

Most of the buildings assessed had wide shaded walkways and roof overhangs along the long walls that assist in building passive cooling and reduce artificial cooling requirements. Several trees grown around most of the County buildings assist in passive cooling of the buildings, a practice that is commendable.

The building envelopes were largely natural quarry stone with lighter coloured paint as predominant wall colouring for both external and internal walls that is compliant to the standards. A few buildings observed at the County referral hospital were painted with dark colours. These colours absorb more heat which is not desirable, especially in the case where the buildings were treated with air conditioning therefore not compliant to the building standards. Additionally, darker internal walls absorb indoor lighting. As these buildings were old, it is therefore recommended that the walls be retrofitted with light coloured paint during repairs and restoration maintenance.

Most of the building envelopes have large windows that assist in use of passive lighting, therefore reducing the requirements for artificial lighting. There were no windows with multi glazing in all facilities studied; however, the computer room of the county offices and the CT scan building of the hospital were observed to use e-coated windows. These locations are treated with permanent air conditioning and the coating assists to repel solar heating ingress and complies to the building standards. Figure 5.2 shows the building envelopes for the outpatient and CT scan sections of the County Referral Hospital.



Figure 5.1: Buildings orientation



Large windows enhance use of natural lighting. The light wall colour reflects away heat.



e-coated windows reduce heat ingress in treated spaces. The dark wall colour however absorbs heat.

Figure 5.2: Walls and windows

There was no usage of air conditioning in most occupied areas with the exception of a few executive offices and technical zones such as computer rooms and speciality treatment/operation areas for the case of the hospital. The use of passive lighting and ventilation is compliant with the building's standards.

5.1.6.2 Building Lighting Points

The predominant installed lighting was fluorescent and LED in most Narok County buildings as shown in Figure 5.3. However, it was observed that there is a gradual transition of fluorescent to LED whenever failure of inefficient bulbs occurs.



Figure 5.3: Lighting

The lighting point fixture by type in assessed County buildings is shown in Table 5.1. It shows that 52.4% of installed lighting bulb points is efficient LED type and 47.3% of installed lighting points are fluorescent bulbs with a few high-pressure sodium lamps observed at the County offices outdoor flood lighting at 0.3% of lighting points¹⁰⁵. There is generally good progress in adoption of energy efficient lighting in County buildings, especially for the Referral hospital at 80.8%.

Table 5.1: Lighting types

Facility	LED	Fluorescent	Other
	Bulbs	Bulbs	Bulbs
Narok Referral Hospital	80.8%	19.2%	0.0%
County Office HQ	26.5%	72.8%	0.7%
County Department Offices	43.6%	56.4%	0.0%
Total	52.4%	47.3%	0.3%

Lighting in all buildings was manually controlled. There was mixed performance in lighting control where some areas had lighting switched off when not in use while several areas still operated lights when not needed; such as several offices, common areas such as washrooms and outdoor areas of the County Referral Hospital. It is recommended that outdoor lighting and common areas be fitted with automated light control switching such as daylight sensors for outdoors and occupancy sensors for common areas.

5.1.6.3 Buildings Cooling and Refrigeration Systems

As previously mentioned, most of the spaces in the county buildings are passively cooled with the exception of a few executive offices in County Offices and speciality treatment rooms observed at the County Referral Hospital. These include; computer rooms in all facilities and CT scan, X-ray, laboratory, renal, ICU & HDU, and theatre and mortuary sections of the hospital.

The energy efficiency ratio (EER) of most of the air conditioning (AC) units in County buildings do not meet the minimum energy performance (MEP) standards of at least 1 STAR rating as shown in Table 5.2 where only 8% of installed units meet the MEP out of a total of 26 sampled units in County Public Buildings¹⁰⁶.

Table 5.2: AC Energy Efficiency Ratio

Location	EER< MEP	EER>MEP	Total
County Referral Hospital	14	2	16
County HQ Offices	10	0	10
Total	24	2	26
%	92%	8%	

Other cooling systems installed are refrigerators largely in the hospital laboratories, maternity wards and public health offices used for vaccine storage. Out of a total of 19 cooling units (refrigerators, deep freezers and chillers) only 3 units meet the MEP standards where 1 unit was rated 2 star and the other two units rated 1 star.

Building heating is minimal, restricted to a few space heaters at the maternity section of the hospital. There is generally minimal space heating in county public buildings.

5.1.6.5 Buildings Water Efficiency

The efficiency of water installations in County Offices and the County Referral hospital is presented in Table 5.3 and shows a 69% adoption rate of dual flush toilet, 36% adoption rate of low flow aerated sink faucets¹⁰⁷. Most of the urinals observed were standard and this is an area of improvement as standard urinal flushes even when units are not in use during low occupancy periods such as night time, weekends and holidays.

Table 5.3: Water faucets in County Offices and the County Referral Hospital

Water Fixtures	Low flow	Standard Flow
Sink taps	36%	64%
Toilet flush	69%	31%
Urinals	0%	100%
Total	52%	48%

Sample of a low flow aerated faucet and a standard lamina flow faucet installed in County Buildings is shown in Figure 5.4.



Figure 5.4: Faucets installed in County Buildings

5.1.6.6 Water Heating

Water heating was predominantly observed in the in-patient section of the County referral hospital. All showers were instant hot showers as shown in Figure 5.5 which are more efficient than standard electrical bulk heaters (geysers).

Hot water use was also observed in laundry washing machines that had inbuilt electric heaters and in the hospital laboratory. One electric bulk heater was installed in the surgical ward for sterilization. The laundry section was observed to dry most linen in the sun with the exception of surgical linen that was dried in the drying machine.

There were insignificant hot water requirements at the County offices. Minimal hot water use was found in the county offices mini-kitchens other. There were no solar water heaters observed in the assessed county buildings.



Figure 5.5: Hot water shower

5.1.6.7 Cooking

The County Referral hospital is the only facility that undertook major cooking. Most of the County hospital cooking was through firewood with LPG used for minor meals. The facility has installed an institutional improved cook stove shown in Figure 5.6 which is used for most of the cooking. While it is considered more efficient than the three stone cookstove, transition to full time use of LPG would be desirable as it is cleaner and more energy dense.



Figure 5.6: Cook stove NRH

¹⁰⁶ Ibid

¹⁰⁷ Ibid

5.1.6.8 Renewable Energy

Most of the County Buildings have not adopted the use of renewable energy sources such as solar PV solar thermal. A small solar PV plant (2.4kW) is installed at the laboratory block of the County Referral Hospital.

5.1.6.9 Energy Use Index

Using the EDGE modelling tool, a base case (lower limit) and an improved case for county offices energy use index was generated. The results which are tabulated in Table 5.4 show that the base case is 46 kWh/m²/yr and improved case of 15kWh/m²/yr for offices¹⁰⁸. The improved case can then be used as a benchmark of EUI. Where additional systems for comfort are required, the appropriate combination of the virtual case scenario can be added to give the total EUI.

Table 5.4: EUI Offices (EDGE, 2022)

Offices EUI: kWh/m ² /yr						
	Base Case			Improved Case		
	Base	Virtual	Total	Improved	Virtual	Total
Computers	15		15	11		11
Lighting	28		28	2		2
Fan		14	14		15	15
Cooling		52	52		57	57
Heating		6	6		6	6
Other	3		3	2		2
Total EUI	46	72	118	15	78	93

The average energy consumption in County HQ Office building is approximately 42,132 kWh per year of electricity and 4,055 kWh per year of diesel generated electricity, a total of 46,187 kWh per year¹⁰⁹. The total built gross floor area is approximately 2,565 m². The EUI for the County Offices is then 18.01 kWh/m²/yr. The base case EUI for a similar building such as the County Offices and operating similar appliances based on the EDGE tool is 46 kWh/m²/yr. The Improved case EUI for a similar building has been determined as 15 kWh/m²/yr¹¹⁰. The EUI in county offices is therefore better than the base case. However, an improvement of 3 kWh/m²/yr is still required to attain the improved case benchmark. This may be realised through implementing recommended energy efficiency measures such as retrofitting efficient lighting, air conditioning and efficient water faucets.

The energy consumption in the rest of the detached County Ministry Offices is much lower and EUI not computed. However, general recommendations and benchmarks recorded for the County HQ Offices can be applied.

Similarly, an analysis of the county referral hospital's EUI reveals that the average energy consumption in Narok Referral Hospital is approximately 985,712 kWh per year¹¹¹. The total built gross floor area is approximately 6,780 m². The EUI for the County Offices is then 145 kWh/m²/yr. Using the EDGE tool, the base case EUI for a similar building such as the Hospital based on the EDGE tool is 280 kWh/m²/yr while the Improved case EUI for a similar building has been determined as 155 kWh/m²/yr¹¹². This is tabulated in Table 5.5. The actual EUI of the County Referral Hospital at 145 kWh/m²/yr is comparable to the EDGE recommended Improved case EUI. This is as a result of a substantial usage of passive lighting, ventilation and laundry sun drying with LED lighting at 80.2% adoption rate and minimal usage of space treatment in inpatient wards and general outpatient zones except in speciality areas such as CT scan, X-ray, ICU, renal, theatre and computer rooms.

Whereas the energy consumption of other Health Centres is much lower, these benchmarks can still be applied.

¹⁰⁸ EDGE. (2022). *EDGE App*. Retrieved from Excellence in Design for Greater Efficiency: <https://app.edgebuildings.com/project/allBuildings>

¹⁰⁹ KPLC. (2021). *KPLC Utility Bills*.

¹¹⁰ EDGE. (2022).

¹¹¹ KPLC. (2021). *KPLC Utility Bills*.

¹¹² EDGE. (2022).

Table 5.5: Hospital EUI (EDGE, 2022)

Hospital EUI: kWh/m ² /yr						
	Base Case			Improved Case		
	Base	Virtual	Total	Improved	Virtual	Total
Catering	49		49	36		36
Hot water	77		77	26		26
Lighting	52		52	19		19
Fans		17	17		16	16
Equipment	76		76	55		55
Laundry	26		26	19		19
Cooling		38	38		27	27
Heating		36	36		10	10
Total EUI	280	91	371	155	53	208

5.1.7 Households, Learning Institutions, Health Centers and MSME

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

5.1.7.1 Energy Efficiency in Households

The adoption of electrical lighting bulbs for urban and rural households is shown in Table 5.6. Only 49% of households have adopted usage of efficient LED type lighting, 42% of households use compact fluorescent lamps (CFL) also referred to as 'energy saver' while 15% use fluorescent lamps. It should be noted that in many cases, a single household had multiple types of bulbs. Whereas the fluorescent and CFL lights are more efficient than incandescent and halogen lamps, the LED type is much more efficient and effort is required to have households fully transition to full use of LED lights.

Five percent (5%) of households were found to use incandescent lamps while 2% had halogen lamps. These lamps have low energy efficiency and all effort is required to discourage their use.

Table 5.6: Household Electrical Lighting Bulb

Household lighting bulbs	Urban	Rural	Total
Use LED bulbs	44%	50%	49%
Use CFL bulbs	55%	39%	42%
Use fluorescent bulbs	7%	17%	15%
Use Incandescent bulbs	0%	6%	5%
Use halogen bulbs	0%	2%	2%

As discussed in section 2.1.1.2, 55.6% of households still use the traditional three stone stove while 13% are using the ordinary metallic jiko. Effort therefore needs to be made to enhance adoption of improved traditional cookstoves and other efficient cooking technologies like LPG cookers.

5.1.7.2 Energy efficiency in Learning Institutions

The adoption rate of lighting bulbs in education institutions is shown in Table 5.7 where 39% employ energy efficient LED bulbs. Energy savers were the most widely used lighting bulbs at 55% followed by fluorescent bulbs at 51%. It should be noted that in many cases, a single institution had multiple types of bulbs. Whereas, the use of energy saver and fluorescent is more efficient than incandescent, institutions require to be encouraged to transition to full use of LED as this offers much higher energy efficacy. A few incandescent bulbs are still in use in 2% of the institutions, which should be discouraged as these have low energy efficacy.

Table 5.7: Lighting bulbs in institutions

Institutions lighting bulbs	Urban	Rural	Total
Use LED Bulbs	50.0%	36.6%	38.8%
Use CFL Bulbs	62.5%	53.7%	55.1%
Use Fluorescent Bulbs	37.5%	53.7%	51.0%
Use Incandescent bulbs	0.0%	2.4%	2.0%
Use Halogen Bulbs	0.0%	0.0%	0.0%
Use Other Bulbs	0.0%	0.0%	0.0%

The adoption rate of cookstoves discussed in Section 2.1.3.1 shows 43% of institutions still use the traditional three stone stove as the primary stove, 19% have an improved traditional stove and 14% have institutional cook stove. Only 9% of the institutions have installed improved cook stoves¹¹³. A wider adoption of improved cookstoves will enhance better energy efficiency and reduce firewood consumption.

5.1.7.3 Energy Efficiency in Health Centres

Energy within health centres is consumed in specialized diagnosis and treatment equipment, lighting, refrigeration and space treatment (cooling or heating) in a few high care areas.

The adoption rate of lighting bulbs in level 1 to 4 Health Centres shown in Table 5.8 shows where 35% of the Health Centres employ energy efficient LED bulbs. Energy savers were the most widely used lighting bulbs at 58% followed by fluorescent bulbs at 31%. It should be noted that a single health centre had more than one type of lighting bulb. Whereas the use of energy saver and fluorescent bulbs is more efficient than incandescent bulbs, institutions require to be encouraged to transition to full use of LED as this offers much higher energy efficiency. A few incandescent bulbs are still in use in 8% of the Health Centres.

Table 5.8: Lighting bulbs in Health Centre

Health Center lighting bulbs	Urban	Rural	Total
Use LED Bulbs	50%	28%	35%
Use CFL Bulbs	25%	72%	58%
Use Fluorescent Bulbs	50%	22%	31%
Use Incandescent bulbs	0%	11%	8%
Use Halogen Bulbs	0%	0%	0%
Use Other Bulbs	0%	0%	0%

The cook stoves adoption rate in healthcare facilities as discussed in Section 2.1.2.2 shows that while adoption of LPG stoves is higher than in households or education institutions at 30%, traditional three stone cookstoves are still being used by 26% of the healthcare facilities, 15% operate improved 'jiko' stoves while 19% have improved traditional cookstoves. A wider adoption of improved cookstoves will enhance better energy efficiency and reduce firewood consumption.

5.1.7.4 MSMEs

MSMEs are diverse in products and services produced. Common electricity using appliances that cut across include; lighting, refrigeration, air conditioning and cooking.

The adoption rate of lighting bulbs in SMEs is presented in Table 5.9 where 42% of the facilities employ energy efficient LED bulbs. Energy savers were the most widely used lighting bulbs at 50% followed by fluorescent bulbs at 14%. A few incandescent bulbs are still in use in 2% of the facilities, which should be discouraged as these have low energy efficacy.

Table 5.9: Lighting bulbs in SME

SME lighting bulbs	Urban	Rural	Total
Use LED Bulbs	37%	46%	42%
Use CFL Bulbs	45%	53%	50%
Use Fluorescent Bulbs	19%	10%	14%
Use Incandescent bulbs	5%	5%	5%
Use Halogen Bulbs	2%	1%	2%
use other types	1%	0%	1%

Charcoal is the primary source of cooking fuel for the SME that have kitchen facilities at 59% adoption rate followed by firewood at 26% adoption rate that is discussed in Section 2.1.5.2. There is substantial use of cleaner cooking fuels such as LPG at 13% adoption rate.

The adoption rate of cookstoves indicates that 49% of SMEs use ordinary metallic jiko while 24% use the improved traditional stove at 24%. There is substantial use of improved jiko at 11% while LPG gas stove adoption rate is at 12%. There is therefore potential to enhance cooking efficiency by increased adoption of more efficient technologies like LPG stove and improved traditional jikos.

Appliance adoption across the households, education institutions and MSMEs was low. Health Centres had the highest adoption rate. The adoption may increase with higher electricity access rates. Utilisation of KEBS MEP standards to guide procurement of appliances will enhance energy efficiency across the county.

5.1.8 Energy Consumption in Industries

The largest industry in Narok County with substantial energy consumption is the hospitality sector which is composed of game lodges spread out in Masai Mara reserve and several other hotels within Narok town. A few other manufacturing facilities include; one tea factory, one sugar factory, two maize millers and a tannery plant. Commercial buildings such as malls are located in Narok Town. Other significant energy consumers are large institutions such as the Masai Mara University. The following is a summary of energy use in the industry that is shown in Table 5.10. It should be noted that these facilities were not audited and such information was obtained from key informant interviews with relevant personnel.

Table 5.10: Major Industries in Narok County

No	Industry	Annual Electrical (approx.)	Annual Thermal (approx.)	Annual Cooking (approx.)	Processes
1	Hotels & Lodges Qty: 5 star: 25 4 star: 8	600 MWh mostly diesel generated. Only 2 have solar PV generator	Minimal process heat	LPG 20,000 kg	Lighting, air conditioning and cooking and minor use in office equipment.
2	Sugar processing Qty: 1 factory	121 GWh generated from bagasse fired steam to turbine	Process steam heating from steam turbine exhaust steam	Minor staff kitchen mostly charcoal fired with minimal LPG use	Operation of plant motors, lighting and process heating with steam. Minor use in office equipment.
3	Tea processing Qty: 1 factory	2.65 GWh mostly grid supplied	18 GWh process steam from wood fired boiler	Minor staff kitchen mostly LPG fired approx. 312 kg per year	Operation of plant motors, lighting and process heating with steam. Minor use in office equipment.
4	Leather processing Qty: 1 factory	180 MWh supplied as 51% solar PV, 33% grid and 15% diesel generators	195 MWh process heat fired by furnace oil boiler		Operation of plant motors, lighting and process heating with steam. Minor use in office equipment.
5	Water treatment & pumping Qty: Major: 1 Others: 10 Boreholes: 35	500MWh [Narok WT&P station]			Operation of pump motors, lighting and minor use in office equipment.
6	Maize milling Qty: 2				Operation of motors, lighting and office equipment.
7	Milk coolersQty: 26				Operation of motors, refrigeration plant and lighting.
8	Abattoirs				Manual operation. No energy used.

5.1.9 Energy Efficiency in Transport

Efficiency assessment for the transport sector was not undertaken due to data scarcity. General recommendations are therefore provided.

According to KNEECS, fuel consumption in the transport sector is currently on the rise with road transport accounting for 80% of domestic freight and passenger traffic. 30% of all the vehicles in the country are more than 15 years old¹¹⁴. This has led to poor efficiency and high operating cost.

Railway transportation is also on the rise. This is significant to Narok County as the standard gauge railway line (SGR) terminates in Suswa town. This has the potential of offering mass bulk transportation and there are plans for further extension to the west of the Country.

¹¹⁴ KNEECS. (2020)

5.2 Barriers towards Energy Efficiency and Conservation

The assessment of required energy efficiency and conservation measures requires technical and financial resources. The following are some of the major constraints the County faces in implementing actions on energy efficiency and conservation measures.

5.2.1 Financial Resources

The annual budgetary allocations for the Department of Environment, Energy and Water Resources in the financial year 2020/21 was only KES 368.4 million (3.27% of total Narok Budget) whereas 49% (KES 179.4 million) was allocated for development activities¹¹⁵. Most of these funds are utilized in enhancing energy access which is very low in the county. In addition to county funds, there are development partners but their projects of interest also lie within the energy access domain. For example, several investment partners contributed to the installation of solar PV plants, which were mostly used to operate boreholes. Financial resources then remain the biggest constraint in enabling energy efficiency and conservation practice.

A possible solution for this is a proper project plan with accurate financial life cycle cost assessment followed by a measurement and verification process that will confirm that projected energy savings are being realised. Such an approach which indicates the period in which CAPEX costs can be recovered may justify project financing. Implementing energy efficiency projects in phases can also reduce the initial CAPEX requirements and allow for savings to be used in refinancing subsequent phases of the project.

Improved financial analysis together with measurement and verification can also enhance adoption of third-party energy financing models such as credit from various financiers as well as grants from donors and development partners. Further power purchase agreement (PPA) may also be adopted in the case of renewable energy sources to cheaper energy and reduce operational costs.

5.2.2 Access to quality appliances

Energy technology has been changing over the years and appliances are getting cheaper as more product development is undertaken. However, access to such technology remains a challenge as the County lacks sufficient subject matter experts to assist in the selection of suitable appliances. The prevalence of low-quality products in the market is also a challenge. This has led to cases of newly installed energy efficiency technology such as LED lighting that failed well before its expected lifetime and are eventually replaced with traditional fluorescent lighting which is a setback in the quest for energy efficiency. Experts assisting in the vetting of products before procurement would reduce or eliminate such occurrences.

5.2.3 Energy Management Teams, Governance & Training

There is insufficient expertise in the county on energy issues in general and energy efficiency and conservation specifically. Recruitment of suitably skilled individuals needs to be undertaken to support the energy docket in the county. Further, these individuals can receive relevant training on the subject to upskill them to effectively manage energy efficiency and conservation programs. Additionally, governance of energy management at national, county facility levels need to be enhanced with clearly defined energy policies and governance structures. Further, documented energy management plans and energy measurement and monitoring systems need to be adopted.

5.3 Recommendations

The following section is a summary of the recommended actions for the county buildings, households, institutions and industries. It is based on the energy efficiency assessment done in Narok County, energy policies in Kenya and best practices.

5.3.1 Policy & Governance Recommendations

1. Partner with the National Government and Kenya Green Building Society to develop a building code specific for Narok County that promotes green passive buildings and contains energy efficiency and conservation standards in accordance with section 193(a) of the Energy Act 2019. The building code should capture efficient/green building envelopes, lighting, cooking, motors, refrigeration systems, thermal systems etc.
2. Require County (public) buildings, facilities and industries in Narok County that meet the legal threshold of annual energy consumption of 180,000kWh to comply with the energy management regulations in accordance to section 193 of the Energy Act 2019; develop and implement energy policy and carry out energy audits. According to the EPRA, only 4 facilities have carried out Energy Audits in Narok County as of June 2022 (EPRA, 2022).
3. Create an energy efficiency and conservation inspection team to complement EPRA to enforce compliance with minimum energy efficiency performance standards specified for designated buildings and facilities in accordance with section 190 of the Energy Act 2019.
4. Take all measures necessary to create awareness and disseminate information for efficient use of energy and its conservation; benefits of adopting energy efficient technologies for cooking, water, lighting and refrigeration systems.

5.3.2 Financial Resources Recommendations

- Establish a fund for the purposes of promotion of efficient use of energy and its conservation within the County in accordance with section 194(1) of the Energy Act 2019.

¹¹⁵ Narok County. (2020). *Narok County Estimate Budgets 2020-2021*.

5.3.3 Technical Recommendations

1. Support/ensure capacity building for relevant county officers and facilities managers in the training of Certified Energy Auditors and Managers to support compliance.
2. For county hospitals, incorporate solar water heating systems in the electric bulk water heater in the surgical ward, laundry washing machines and laboratory in order to preheat hot water and reduce electricity consumption by at least 30% of hot water grid energy requirements.
3. Transition the county buildings (especially hospitals) to cleaner fuels such as LPG, biogas or electricity.
4. Substitute at least 25% of grid electricity with renewable solar PV electricity in all County buildings and facilities e.g., water treatment plant to reduce emissions associated with fossil fuels and reduce energy costs
5. Create demonstration centers to showcase efficiency appliances.





06

Cross-Cutting Issues

This section focuses on cross-cutting issues in energy access including; gender issues, environment and climate change, risk and disaster management, communication, innovation, research, and development.

6.1 Gender issues

Like in most other regions in Kenya, culture plays a big role in determining the roles men and women play in the community in Narok. Insufficient access to modern energy and existing patterns of energy use, processing, and collection increases the burden of work on women. Furthermore, women's limited ability to make decisions within the household and community restricts their ability to influence processes and resource allocations on issues, including energy (UNDP, 2021)¹¹⁶

During primary data collection, it was established that electricity access would be beneficial to children as they would be able to undertake their school work at night. In terms of productive use of energy, women who are engaged in beadwork would be able to extend their working hours and do this from their homes at night. Men who undertake work that requires electricity such as welding, running posho mills and barber shops had reported difficulty in conducting their business due to unreliable power supply occasioned by frequent power losses, thus affecting their productivity. Enhanced reliability would thereby increase their productivity and in doing so their income. Agricultural based cooperatives which were led by both genders, and which focused on milk cooling, reported that increased reliability of electricity would enhance their income.

Modern electric cooking technologies such as induction cookers and infrared stoves could also become attractive and reduce the drudgery felt by women in obtaining biomass, particularly due to the rising cost of LPG and biomass scarcity. However, reliability concerns may hinder this. Equally, electricity access can play a big role in reducing most of the labour-intensive household chores such as fetching of water for household use, watering animals and irrigation through electric pumps. Electricity supply can thus play a big role in changing this narrative and improving people's livelihoods in the community.

While access to energy services would not necessarily guarantee gender equality, it helps in relieving women and girls of the drudgery associated with their daily tasks and provides them time for income-generating opportunities and education (UNDP, 2017).¹¹⁷

6.2 Environment and climate change

Narok County, like most parts of Kenya, has experienced significant effects of climate change over the years. Key highlights on climate change in Narok are reported in the Narok County Climate Risk Profile (2021)¹¹⁸ compiled by MoALF (2021) as follows:

- In the last 20-30 years, climate change has affected Narok County, with rainfall seasons becoming more unpredictable.
- Prolonged dry spells and droughts negatively affect crops like maize and livestock like sheep, dairy cow, and local chicken.

- Intense precipitation over a short duration causes flash floods that destroy crops and property.

Narok County, like most parts of Kenya, has experienced significant effects of environment and climate change over the years. This is especially hard felt in Narok since most households are reliant on agriculture and livestock keeping as a primary source of income and livelihoods.

Most of the community-based organizations interviewed during the focus group discussions conducted in Narok County acknowledged the effects of environment and climate change in Narok with many saying this has significantly changed their ways of life. For example, traditionally, many relied on firewood and charcoal for cooking since this was easily available, now these resources have become very scarce (and even banned in the case of charcoal) due to over-exploitation.

Livestock rearing has not been spared either since the rains are not as predictable as before, leading to pastoralists travelling for longer distances to get pasture and water for their animals.

Some of these effects could have been self-inflicted due to insufficient awareness on effects of climate change and cultural practices like clearing of trees by pastoralists to spot predators from afar.

The need for energy, specifically electricity, to increase adaptation to and tackle some of the effects of environment and climate change in Narok cannot be over-emphasized. Electricity can be used to power irrigation systems to solve the issue of rainfall unreliability, cool farm outputs like milk to increase their value, process farm outputs and diversify sources of livelihoods to reduce over-reliance on agriculture in Narok.

However, while employing electricity to counter the effects of climate change, there is a need to focus on renewable energy like solar (of which there is an abundance of the same in Narok) or geothermal in order not to further these effects through generation of electricity.

6.3 Risk and disaster management

Climate risks pose a threat to Narok County's value chains, particularly agriculture, due to extreme weather conditions such as drought, extreme rainfall, and flash floods.

Narok County has in the recent past faced the menace of the locust invasion. During the focus group discussions conducted across the various sub-counties of Narok in 2021, community members reported that the swarms raided farms, open spaces and grazing fields, especially in Narok North, causing unprecedented destruction on crops and pastureland. The swarms contributed to reduction of crop yields and pasture - putting food security and livestock life in question.

¹¹⁶ Strathmore Energy Research Centre. (2021). Gender Equality and Social Inclusion (GESI) in the energy sector. Available at: <https://serc.strathmore.edu/gender-equality-and-social-inclusion-gesi-in-the-energy-sector/>. (Accessed: 30 April 2022)

¹¹⁷ UNDP. (2017). Gender, Energy and Policy (UNDP). Available at: <https://africa.unwomen.org/en/digital-library/publications/2017-b/11/a--review-of-energy-policies-in-east-and-southern-africa>. (Accessed: 30 April 2022).

¹¹⁸ MoALFC. 2021. Climate Risk Profile for Narok County. Kenya County Climate Risk Profile Series. The Ministry of Agriculture, Livestock, Fisheries and Co-operatives (MoALFC), Nairobi, Kenya.

Other risks include: dwindling natural resources and unavailability of rangeland resources, especially in the key dry-season grazing areas; and increased inflow of people from highland areas to lowlands in search of productive natural resources.

6.4 Communication

The primary communication devices in Narok during the primary data collection were radios, followed by mobile phones. With more than half and in some cases three quarters of the residents relying on these electronics, there is a growing demand for electric charging options. The use of mobile phones in Narok has almost doubled from 34.3% to 66.7% in the two years between 2019 and 2021. There was also an increase in radio usage from 56.90% to 64.81%. This increase in electric communication devices increases the demand for modern energy.

6.5 Research and Development

Extensive research and development is necessary to achieve cost effective yet sustainable energy access solutions for Narok County and the rest of the nation. Research focusing on cost reduction from off-grid generation technologies such as mini-grids, solar home systems and integration of solar home systems to form nano-grids may be beneficial to Narok, which has high potential for off-grid technologies.

Narok County could also benefit from research that focuses on business models for deploying off-grid and clean cooking technologies such as biogas and LPG. Innovation in financing could enhance access to clean energy technologies for Narok County, which has high poverty levels.

Further, research could inform the development of productive use initiatives. As previously mentioned, Narok has a large population that relies on agriculture and livestock keeping. Fish farming is also gaining popularity. Agro-processing with focus on cooling and irrigation therefore has potential to enhance socio-economic development in the county. Further work could be undertaken to identify high impact projects and develop suitable business models for off-grid agro-processing technologies.



07

Projects and Programs

This chapter presents projects and programs that are recommended to enhance sustainable modern energy access and enhance energy efficiency and conservation within Narok County. Specific projects and programs can be seen in Table 7.1.

The proposed projects and programs are the result of in-depth research and consultations with the county officials, relevant stakeholders and assessment of household survey data and high-level Focus Group Discussions with CSO, CBOs and various County Department Officials.

Table 7.1: Projects and Programs recommended to enhance energy access and energy efficiency in Narok County

CATEGORY > POLICY						
Gap	Recommendation Program/Project	Specific Activities	Implementing Agency	Budget (Kes)	Timelines	Status (New/ On-going)
Lack of institutional framework and human resource capacity to address energy access and energy efficiency challenges in the county	Establish (and empower) an energy unit, or a stand-alone department responsible for energy matters only at the county	Develop institutional framework for an energy unit in the county	Narok County Government	KES 5,000,000	2023	New
		Recruit qualified energy officers to fill the different roles required	Narok County Government	KES. 36,000,000	2023	New
		Establish (and facilitate) a CEP Committee with membership drawn from all county departments and other stakeholders to enable effective implementation of the energy projects & plans	Narok County Government	KES. 4,000,000	2023	New
Lack of an enabling environment to facilitate development & implementation of innovative energy access projects	Develop and implement policies and regulations to facilitate implementation and uptake of clean energy in Narok County (both for lighting and clean cooking)	Develop forest management plans complete with demand and supply master plan for firewood & charcoal	Narok County Government, KFS	KES 3,000,000	2024	New
		Develop bio-energy policy and regulation aimed at driving adoption of biogas fuel and technologies by Narok Households	Narok County Government, Ministry of Energy	KES. 1,000,000	2024	New
		Lobby National Govt (through MoEP & National Treasury) for removal of VAT on LPG & introduction of a 25% subsidy on biogas and ethanol.	Narok County Government, MoE	KES. 2,000,000	2024	New
Lack of data to facilitate inclusive & integrated energy planning	Establish & facilitate a county platform for regular data gathering (under the planned M&E policy)	Establish & facilitate a county platform for regular data gathering (under the planned M&E policy)	Narok County Government	KES 8,000,000	2024	New
Low compliance to the Energy Management Regulations. Only 4 designated facilities have carried out Energy Audits in Narok County.	Require compliance to Energy Management Regulations for industries and facilities that operate in Narok County.	Create and train an energy efficiency inspection team to complement EPRA to enforce compliance to Energy Management for designated facilities and industries in accordance to section 193 (b&c) of the energy Act 2019	Narok County Government, EPRA	KES. 1,500,000	2024	New
Lack of Narok County specific building code. The current national building code is also outdated and does not contain EE&C standards	Partner with the National Government and Kenya Green Building Society to develop a building code specific for Narok County that promotes green passive buildings	Develop Narok County building code in accordance with section 193(a) of the Energy Act 2019 that promotes green passive buildings and contains energy efficiency and conservation standards	NCG, National Government, Kenya Green Building Society	KES. 20,000,000	2025	New

CATEGORY > ECONOMIC

Gap	Recommendation Program/Project	Specific Activities	Implementing Agency	Budget (Kes)	Timelines	Status (New/On-going)
Lack of access to finance by end-users to purchase clean energy and efficient technologies for agricultural PUE	Develop and implement policies & strategies, as well as partnerships with strategic development & financing partners; including DFIs, impact investors, NGOs, and Private sector actors to provide end-user financing products	Collaborate with development partners to conduct comprehensive mapping of agricultural PUE opportunities across the county, together with willingness and ability to pay, as well as potential viable business & financing models	Narok County Government, Development Partners	KES. 3,000,000	2025	New
		Undertake consultations with strategic partners (DFIs, NDOs, Impact investors etc.) to identify potential financing interventions to extend access to financing for acquisition of PUE appliances	Narok County Government, Development Partners	KES. 3,000,000	2024	New
		Collaborate with LPG manufacturers & distributors to conduct feasibility and market assessment to inform expansion of distribution networks across the county	Narok County Government, LPG companies	KES. 3,000,000	2024	New
Limited awareness on viability of RE and energy efficient technologies by HHs, MSMEs & institutions across Narok County	Establish energy centers and promote establishment of RE demonstration sites across the rural parts of Narok county	Establish and equip an energy center (including recruitment and training of competent staff as well as procurement & installation of necessary equipment) to lead awareness campaigns for different viable RE and energy efficient technologies	Narok County Government, REREC, EPRA	KES. 15,000,000	2024	New

CATEGORY > TECHNICAL

Gap	Recommendation Program/Project	Specific Activities	Implementing Agency	Budget (Kes)	Timelines	Status (New/On-going)
Low rates of access to energy (for lighting, cooking and for Productive Use) in Narok County	Establish a clean cooking fund in the county to support the deployment of clean cooking technologies in Narok County at a subsidized rate.	Leverage on support from KOSAP to establish a fund that would enable transition of cooking through the SDG scenario that will see 36% of the County cooking with LPG, 8% with biogas, 10% with bioethanol, 10% with electricity. The Fund can be used to subsidize acquisition of technologies		KES. 150Million	2024	
	Extend the grid by a capacity of 34.8 MW	Extend the grid to specific regions in all wards within Narok. GIS based results from OnSSET will be provided as an accompaniment to this report and will be used to guide locations	County Government of Narok/ SACCOS/CBOs	KES. 65.1 Billion	2023-2026	New
	Promote standalone solar home systems to increase access to energy for lighting for sparsely populated households across Narok County	Leverage on KOSAP to distribute 306,667 Stand-Alone Solar systems in sparsely populated areas across rural parts of Narok	Devt Partners, Narok County Govt, Private Sector	KES. 5.5 Billion	2023-2026	
	Collaborate with the National Government to accelerate installation of solar mini-grids across 12 sites, & installation of wind and hydropower mini-grids across 5 sites.	Collaborate with national government agencies (through EPRA & REREC) to facilitate installation of 4 wind power mini-grids with a total capacity of 1.9MW in Mara, Siana, Naikarra and Maji Moto/Naroosura Wards.	Narok County Government, REREC, Private Developers	KES 830 Million		New

Gap	Recommendation Program/Project	Specific Activities	Implementing Agency	Budget (Kes)	Timelines	Status (New/ On-going)
Low rates of access to energy (for lighting, cooking and for Productive Use) in Narok County	Collaborate with the National Government to accelerate installation of solar mini-grids across 12 sites, & installation of wind and hydropower mini-grids across 5 sites.	Collaborate with national govt agencies (EPRA & REREC) to facilitate installation of one 0.062 MW hydropower mini grids at the border of Narok North, Narok South, and Narok East Sub-counties.	Narok County Government, REREC, Private Developers	KES. 50Million		New
		Collaborate with KOSAP project to install 12 solar PV mini-grids in Keyian, Lolgorian, Olokurto, Melelo, Melili, Ildamat, Suswa, Keekonyokie, Maji Moto/Naroosura, Mara, and Siana Wards to increase supply of electricity access by 6.6 MW	National Govt, Dev Partners, County Govt, Private Sector	KES. 3.7 Billion	2023-2026	New
		Collaborate with development partners to undertake feasibility study to identify appropriate locations for establishing demonstration sites for biogas digesters, as well as the amount of waste (feedstock) needed for the demonstration sites		KES. 2 Million	2023-2026	New
		Initiate partnerships with major institutions; targeted households (community opinion leaders) and donor funded programs like SNV's Kenya Biogas Programme to establish biogas demonstration sites across the county.		KES 12 Million	2024	New
Lack of sufficient quantitative data on available feedstock for alternative biofuels e.g., bioethanol/biodiesel, and current level of production and use of briquettes	Conduct detailed study and analysis on the amount of feedstock that is available and use of alternative biofuels	Collaborate with development partners and research institutions to undertake a comprehensive feasibility study and investment requirements for: Bioethanol, Biodiesel, and Briquettes in Narok county	Narok County Government	KES 4 Million	2025	
High wastage of energy among county government buildings and institutions due to hight adoption of inefficient lighting and water fixtures as well as leaving lights on even when not in use	Retrofit inefficient light and water fixtures	Retrofit inefficient lighting bulb with efficient LED bulbs in all county buildings, health centres and institutions		KES 8.1 Million		
		Replace inefficient water fixtures with low flow faucets				
	Install light control systems across all county government buildings and institutions	Install light control systems Carry out behaviour change sensitization for security personnel & office staff	Narok County Government	KES 1 Million	2023-2026	

Total: KES 75.6 Billion

Implementation, Coordination, Monitoring and Evaluation

The attainment of universal energy access by 2028 in Narok County is dependent on the implementation of policies, programs and projects proposed 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 Narok County government will be crucial, while vertically, coordination with national government agencies, including MoEP, as well as other institutions such as REA and KPLC, among others. In addition, collaboration with the private sector; including commercial banks, partners including Development Financing Institutions (DFIs) such as the African Development Bank (AfDB), World Bank (WB), CSOs, and CBOs-among others, will be key.

The Department of Water, Energy, Environment and Natural Resources will be responsible for overall coordination of the process. A strong monitoring and evaluation framework, developed jointly by the department of Water, Energy, Environment & Natural Resources, to-

gether with the Department for Finance & Economic Planning, and with inputs from the other departments, as well as the other stakeholders will be required to track progress and provide insight that can be used for correction during the implementation of the plan. This will be important in ensuring successful implementation of the CEP. To ensure successful implementation of the CEP, a capacity building exercise focused on the here will also be training components to build capacity for the implementation and coordination of new solutions, technologies and approaches.

The next sections of this chapter describe the implementation, coordination and monitoring and evaluation (M&E) framework for the CEP. The procedures detailed in this chapter were derived from consultative meetings held with the Narok County officials over the duration of the CEP development process.

8.1 Implementation and Coordination

For effective implementation of the energy plan, a CEP Planning & Implementation Committee composed of representatives from the different county departments and other relevant stakeholders from both the county and national government has been proposed. The County Executive Committee Member (CECM) responsible for Energy, Water, Environment & Natural Resources will chair the Planning & Implementation Committee, deputised by the Chief Officer (CO) from the same department. To ensure effective integration of plans & budget with other relevant departments, the CO responsible for Finance, Economic Planning, ICT and E-Government will be the Co-Vice Chair for this committee. Other members of the committee will include: Directors of the relevant departments from the County Government; Representatives of the National Government/Projects (e.g., MoEP, KOSAP etc); Representatives of the Semi-Autonomous Government Agencies (SAGAs), including KPLC and REREC; and representatives of the Non-State Actors, including Development partners working in the relevant sectors (energy, agriculture, livestock, health etc.), as well as private sector representatives. Ad-hoc Project Implementation Teams (PIT) will be constituted depending on specific projects that will be earmarked for implementation. The CEP Planning & Implementation committee will meet on a quarterly basis to track implementation of the projects and programmes, as well as provide advice on necessary interventions needed for successful execution of the energy plan.

To ensure political and administrative support with the top county government leadership, the County Cabinet will serve as the steering committee under the leadership of the County Governor. The CEC for Water, Energy, Environment and Natural Resources will provide the steering committee with frequent updates on the implementation of the energy plan. To ensure alignment and coordination with the national level structures and leadership, the Governor will keep close liaison and communication with the Cabinet Secretary for Energy & Petroleum, as well as the Council of Governors' (CoG) technical committee for Infrastructure and energy.

For successful implementation of the plan, integration of the priority (CEP) projects within the CIDP and the Annual Development Plans (ADP) will be critical. However, as stakeholder consultations on the development of the 2023 - 2027 CIDP for Narok County was underway at the time of finalising this CEP, efforts will be made to ensure that proposed projects under this plan will be integrated and aligned with the CIDP (2023 – 2027), and ultimately, into the ADP.

Figure 8.1 below illustrates the constitution of the proposed CEP Planning & implementation committee.

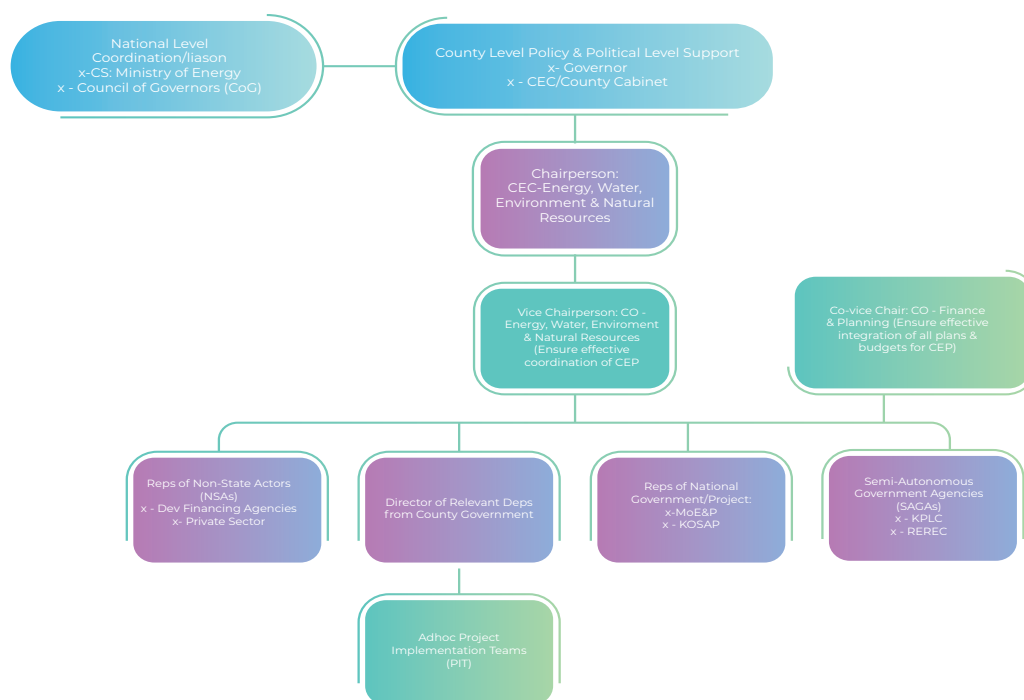


Figure 8.1: Constitution of the County Energy Planning & Implementation Committee

Table 8.1: Constitution of County Energy Planning & Implementation Committee

Sectors	Organizations
County Ministries/ Departments	CECM for Energy, Water, Environment & Natural Resources
	Chief Officer, Energy, Water, Environment & Natural Resources
	One (1) representative of the County Commissioner
	CECM responsible for Finance, Economic Planning, ICT and E-Government
	The County Executive responsible for Finance
	CECM responsible for Lands, Housing, Physical Planning and Urban development
	CECM responsible for Water, Environment and Natural Resources
Other Stakeholders/ Co-opted members	One (1) representative from KPLC
	One (1) representative from REREC
	One (1) representative from KFS County Representative
	Technical County Officer(s) responsible for Coal, Renewable Energy and Electricity.
	Council of Governors
	*County Assembly member
	*Community Groups rep
Co-opted National Energy Entities oper- ating in the County (1)	EPRA
	KENGEN
	GDC
	KETRACO
Co-opted members to provide technical and capacity building support (1)	CSOs, CBOs, private sector

8.2 Monitoring and Evaluation Framework

The M&E Officer under the department of Energy, Water, Environment & Natural Resources will be the primary focal focal point for monitoring and evaluation of the implementation of the CEP. He/She will liaise with the different departments and stakeholders with responsibility for implementation of CEP to collect data and information for development of quarterly progress reports. The Director of Monitoring and Evaluation from the Governors Development Unit will provide advisory support, while ensuring high level visibility of the progress for implementation of the energy plan. To ensure timely access to quality and reliable data, the M&E Policy currently under review should ensure that mechanisms for regular data collection from all the departments is mainstreamed across the county functions. A Monitoring & Evaluation framework has been developed as shown under table 9.1, highlighting output indicators that will be used to track implementation of the CEP.

Recommendations

For the successful implementation of this CEP, it is recommended that:

1. The Department of Environment, Water, Energy and Mineral Resources should establish a Directorate of Energy equipped with technical officers with energy related skills.
2. Overall capacity building on energy to support establishment of energy offices.
3. Ratification of the energy policy and development of M&E tracking tools to support implementation of the energy plan. The M&E officer will be in charge of this at the county in collaboration with M&E focal point from the Governors Development Unit. .

Table 9.1: Monitoring and Evaluation Framework for CEP implementation

Program/Project	Output	Indicators	Baseline (2023)	Mid-target (2025)	End -Target (2027)
Establish (and empower) an energy unit, or a stand-alone department responsible for energy matters only at the county	An energy unit or a standalone energy department established within Narok County with capacity to develop and implement policy for bioenergy, energy efficiency and energy access functions	Amount of funding from Narok county budget set aside to facilitate establishment & running of energy unit/department	50%	100%	XXX
		A fully fledged energy unit/ department established and operational	0	100%	100%
		Number & qualification of staff members with clear job descriptions and work plans recruited to work in the energy unit/department	0	100%	100%
	CEP planning & implementation committee established & facilitated to operate/function	CEP planning & implementation committee in place	0	100%	100%
Develop and implement policies and regulations to facilitate implementation and uptake of clean energy in Narok County (for lighting, cooking & PUE)	Relevant policies and regulations necessary to facilitate implementation & uptake of clean energy in Narok county developed and adopted	Number of county forest management plans complete with demand and supply master plan for firewood & charcoal developed	0	50%	100%
		A bio-energy policy and regulation for Narok county developed and adopted	0	1	1
		A biogas policy and strategy developed	0	1	1
		25% subsidy on biogas and ethanol introduced	0	25%	25%
		VAT on LPG removed	16%	0	0
Establish & facilitate a county platform for regular data gathering (under planned M&E policy)	A county data platform for collection and centralised storage of data established and operational	Data platform in place	0	1	1
		Amount and quality of data sets collected, stored, and can easily be accessed when needed	50	100	300
Require compliance to the Energy Management Regulations for industries and facilities that operate in Narok County	Energy efficiency inspection team created and trained to enforce compliance to EM Regulations for designated facilities in accordance to section 193 (b&c) of the Energy Act 2019	Energy efficiency inspectorate staff trained.	0	100%	100%

Partner with the National Government and Kenya Green Building Society to develop a building code specific for Narok County that promotes green passive buildings	Narok County building code developed	Building code available and accessible to users	0	100%	100%
Develop & implement policies and strategies, as well as establish partnerships with strategic development & financing partners including DFIs, impact investors, NGOs and Private sector actors to provide end-user financing products	Financing products for energy end-users established and accessible by the communities	Number, location and size of different PUE sites across Narok county identified and mapped out	0	100 (PUE sites)	100 (PUE sites)
		Number of potential viable business & financing models that can be used to unlock investment for PUE opportunities	0	10 (models)	10 (models)
		Report on the level of community members' willingness and ability to pay for clean energy products developed	0	2 (reports)	2 (reports)
		Amount of financing available for end-users from Narok county (from local financing institutions, impact investors, and development partners etc)	Ksh. 5M	Ksh. 50M	Ksh. 200M
		Amount of financing for RE technologies accessed by end-users to procure for different RE solutions	Ksh. 5M	Ksh. 50M	Ksh. 200M
Establish energy centers and promote establishment of RE demonstration sites across the rural parts of Narok county	County Energy center established and equipped	County energy centers established, equipped & functioning	0	1	1
		Number of awareness campaigns undertaken across the county (on different viable RE technologies)	0	100	300
	RE demonstration sites established across different locations in the county	Number of RE demonstration sites established across the county	0	20	40
Collaborate with the National Government to accelerate installation of solar mini-grids across 12 sites, & installation of wind and hydropower mini-grids across 5 sites.	Solar, wind, and small hydro power mini grids installed across Narok county	4 wind power mini-grids with a total size of 1.9MW installed across the county	0	0.95MW	1.9MW
		1 hydropower mini grids with a total size of 0.062 MW installed in the county	0	0	0.062MW
		12 solar PV mini grids with a total size of 6.6MW installed across Narok county	0	3.3MW	6.6MW

Extend grid to supply 34.8 MW	Additional 34.8MW to the grid supply in Narok County to supply the households identified as potential clients for grid supply.		0	26.4MW	34.8MW
Promote standalone solar home systems to increase access to energy for lighting for sparsely populated households across Narok County	306,667 standalone solar home systems adopted by households across Narok County	A total of 306,667 Stand-Alone Solar systems distributed across Narok County	0	153,334	153,333
Conduct detailed study and analysis on the amount of feed-stock that is available and use of alternative biofuels	Study on amount of feed-stock available in Narok county	Study conducted and report shared with, and validated by stakeholders	0	1	1
Replace all inefficient water and lighting fixtures across all county buildings and institutions	Inefficient bulbs and water fixtures replaced with efficient ones across all county buildings & institutions	Percentage of inefficient bulbs and fixtures replaced/retrofitted with efficient ones	53%	75%	100%
Install light control systems (human or automated) across for common and outdoor lighting in county government buildings and institutions	Light control systems installed across all county buildings & institutions	Number of county government buildings and institutions fitted with light control systems in all their rooms Carry out behaviour change sensitization for security personnel & office staff carried out	0	100%	100%

Annex 1: Key Stakeholders Involved in Energy Access

Institution/Actors	Roles	Capacity
National Level Stakeholders		
Ministry of Energy (MoE)	- o Responsible for development & management of National Energy Policies, regulations & guidelines - o Coordination of KOSAP - o Delivery of national government's commitments - o Promotion of rural electrification programme - o Responsible for energy Regulation, Security and Conservation - o Responsible for development of hydropower - o Responsible for the promotion of Renewable Energy	- o Technical capacity at the national level on policy formulation - o Limited human capacity to provide support to all the counties - o Presence of an Energy Officer at the county level, mandated to coordinate the implementation of the KOSAP project - o Mobilization of donors to support the delivery of energy sector commitments
Kenya Forestry Service (KFS)	- o Undertake development and management of National Environment & Forestry related policies - o Leads development of re-forestation initiatives - o Responsible for protection & conservation of Natural environment - o Promote innovation and appropriate technologies for sustainable utilization of natural resources - o Enhance climate change resilience & low emission development pathway in all economic sectors	- o Formulate national policies on environmental conservation and forestry protection - o Limited reach on granular scales as they rely on sub-national governments to implement their policies - o Create objective policies and goals that must be interpreted and developed by implementing bodies and organizations - o Limited manpower to implement or reinforce large scale regulations and policies
Kenya Power & Lighting Company (KPLC)	- o Responsible for providing affordable, reliable, and accessible electricity - o Responsible for building & maintaining the power distribution and transmission network - o Retails (sells) electricity to consumers - o Responsible for planning for sufficient electricity generation and transmission capacity to meet demand	- o Presence of regional and county business office/manager - o Reliability & affordability of power is a key challenge - o Limited capacity to meet national demand

Institution/Actors	Roles	Capacity
Rural Electrification & Renewable Energy Corporation (RREC)	- o Implementation of rural electrification projects, including electrification of Public Facilities in rural areas - o To develop & promote use of RE, including establishment of RE mini grids in off grid areas - o Develop & update rural electrification master plans - o To manage rural electrification programme funds - o To adapt and adopt technology on utilization of biomass, biodiesel, bioethanol, charcoal, fuelwood, solar, wind, tidal waves, small hydropower, biogas, co-generation and municipal waste - o To support establishment of energy centres in the counties - o To promote local capacity for the manufacture, installation, and O&M of RE technologies such as bio-digesters, etc. - o To undertake feasibility studies and maintain data with a view to availing the same to developers of RE resource - o To provide technical and other capacity building support to County Governments in the discharge of the function of electricity reticulation and energy regulation	- o Formulation of collaborative frameworks that can bridge the corporation's limitations in personnel, technical capacity etc. between the GoK, County Governments, Development partners and IPPs, etc. - o Facilitates the development of frameworks, strategies, and implementation programs for renewable energy power generation projects across the country - o Sources funds for rural electrification program - o Financial limitations exist due to the sparse distribution of households in large expanses of land in rural areas - o Limited human resource capacity at implementation levels without sub-national and sub-county operation partners - o Delays due to land acquisition, technical capacity, structural constraints, road access and logistics challenges during project roll out - o Maintenance resource constraints
Energy & Petroleum Regulatory Authority (EPRA)	- o Regulate generation, transmission, distribution, supply, and use of electrical energy - o Regulate production, conversion, distribution, supply, marketing, and use of renewable energy - o Co-ordinate the development and implementation of national energy efficiency and conservation action plan	- o Limited manpower and reach at the national and sub-national levels - o Poor visibility and public understanding of EPRA
Elected MPs from the County	- o Delivery of political commitments - o Push for development projects in their constituencies - o Overseeing identification of priority projects to be funded using the National Government's Constituency Development Fund (NGCDF) - o Overseeing implementation of development projects at the constituency level	- o Political commitments need to be informed, guided and regulated by professional personnel and regulatory bodies for feasibility - o Effective at driving stakeholder engagement and public social engagement in project approval and implementation - o Can drive the prioritization of projects based on needs at constituency and ward levels

Institution/Actors	Roles	Capacity
County-level institutions & stakeholders		
Dept. of Energy	- Formulation and implementation of sector policies and strategies in Environment, Natural Resources, Water and Irrigation and approval of sector plans and projects - Development & implementation of the CEP - Promoting energy conservation and developing relevant alternative RE technologies - Training on energy efficiency strategies	- Limited financial budget from the county government budget to achieve its mandate - Limited human resource capacity to deliver on the department's mandate - Some natural resources within the county such as geothermal energy, forests and rivers are under the national government jurisdiction and cannot be fully exploited by the county government authorities.
Elected Members of County Assembly (MCAs)	- Delivery of their political commitments (as captured in their campaign manifestos) - Push for development projects in their respective wards - Overseeing identification of priority projects to be funded using the Ward Development Fund (WDF) - Ratify the County Energy Plan - Overseeing implementation of development projects at the ward level	- Promotion and proposition of energy access challenges at sub-county and ward level - Raise concerns, complaints and feedback from ward and sub-county challenges
Private Sector Institutions and Stakeholders		
Commercial banks	- Providing credit facilities to RE vendors and end-users - Providing loans for end-users of RE - Providing investment financing e.g., funding agricultural projects	- Limited technical capacity and human resource for complex project valuation and as such need to partner/consult with objective parties for effective due diligence - Field/ range of influence depends on the specific bank's jurisdiction as an international, national, sub-national or sub-county financial institution
RE Suppliers/Vendors	- Supply and installation of RE technologies including standalone solar, PV etc. - Supply of Improved Cook Stoves (ICS)	- Range of operations is limited by access to finance and estimated return on investment - Have access to skilled personnel with relevant technical capacity to implement projects - Operate within boundaries set by county authorities through land use permits, way leaves, PPA's - Limited by public awareness of new technologies. As such, they need to disseminate information and build local capacity for providing technical support

Institution/Actors	Roles	Capacity
Mini-grid developers	- Supply, installation, & commission of RE mini grids - Connection of clients (HHs & businesses) to the mini grids	- Financial capacity determined by the source and cost of investment capital - Currently supply power to one client -KPLC -who in turn sell to the public residents - Projects limited by availability of natural resources (wind/solar) and proximity to end users
SMEs	Consumption of energy	- Create markets for energy producers - Provide the anchor load for solar mini grids. The demand from SME during the day enhances the profitability of developers who provide lighting for homes at night

Development partners

Development Financing Institutions	- Financing development initiatives in the county, including; energy, agriculture, health etc. - Supporting county government in the development of sector strategies & capacity development	- Must work within the territorial jurisdiction defined by their fund management structures - Create programs to support local organizations, companies, and researchers to develop solutions/projects in line with their mandates
Development agencies (GIZ, SNV)	- Support Implementation of on-the-ground energy projects - Mobilization and capacity building of county government and community	- Work with the county government to define and implement shared goals - Guided by access to finance, local policy structures and project sustainability beyond funding period - Project roll out and implementation is guided by the environmental impact assessments (EIA), availability of natural resources, social impact and ROI

Annex 2: Conversion factors and full load hours used for the calculation of biogas potentials

	Total energy (kWh/m ³ methane)	Efficiency of heat generation (%)	Efficiency of electricity production (%)	Full load hours (CHP) (h/year)
Min	10	38	30	7,000
Max	10	42	36	8,000

Annex 3: Average characteristics for municipal solid waste

DM content (% FM)	VS content (% DM)	Biogas potential (m ³ /ton VS)	Methane content (%)	Methane potential (m ³ CH ₄ /ton VS)	Methane potential (m ³ /ton FM)
45	60	398	64	260	85

Annex 4: Assumptions for SDG Scenario

Source of Energy/Technology	Annual Specific fuel consumption		Urban (Adoption Rate)	Rural (Adoption Rate)		
	Urban	Rural	2019 (%)	2028 (%)	2019 (%)	2028 (%)
LPG Cookstoves	74.8kg ¹¹⁹	41.6kg	27	55	9.74	45
Conventional charcoal cookstoves	364kg ¹²⁰	411kg	33	0	11	0
Improved charcoal cookstoves	208 ¹²¹ kg	235kg	7	0	4	0
Three Stone Open Fire (TSOF)%	1232kg ⁴	1362kg	24	0	59	0
Improved wood cookstoves	784kg ¹²²	867kg	12	0	15	0
Kerosene	88Litres	125Litres	28	0	3	0
Biogas ¹²³	-	135m ³	-	-	0.2	30
Electricity (hot plate/induction cookers)	1318kWh	1318kWh	-	5	-	5
Electric Pressure Cookers (EPC)	800kWh	800kWh	-	10	-	5
Bio-Ethanol	3500MJ ⁹	3500MJ	-	30	-	15
Briquettes	200Kg ¹²⁴	200Kg	-	0	-	0

Total number of MSMEs considered in the model was 2,075. The baseline and end year fuel adoption rates for MSMEs are shown in Table 3.8.

¹¹⁹ National Feasibility Study: LPG for Clean Cooking in Kenya 2019

¹²⁰ 2019 Kenya Household Cooking Sector Study

¹²¹ This is calculated based on the efficiency of the conventional charcoal stove being taken as 21% and improved charcoal being taken as approximately 36.75%

¹²² Correlated with the TSOF data based on the assumption that the TSOF has an efficiency of approximately 14% and improved cookstoves 22%.

¹²³ The 135m³ is correlated with the LPG consumption based on the assumption that 2.1m³ Biogas is equivalent to 1kg of LPG, source https://energyencyclopedia.info/wiki/BLEENS_-_Biogas,_Liquefied_Petroleum_Gas,_Electricity,_Ethanol,_Natural_Gas,_and_Solar.

¹²⁴ The consumption is co-related with the charcoal consumption as per the Kenya Briquette Industry Study, GVEP 2010

Table 3.8: Types of cooking fuel for MSMEs in Narok

S.no	Type of Cookstove	Consumption p.a.	Adoption rate (%)	
			2019	2030
1.	Charcoal	2100Kgs	59.6	0
2.	Improved wood cookstove	6360Kgs	24.1	0
3.	LPG	564Kgs	11.9	90
4.	Electric	7300kWh ¹²⁵	0.7	15
5.	Briquettes ¹²⁶	2940Kgs	-	15

The baseline and end year fuel adoption rates for healthcare facilities are as shown in Table 3.9.

Table 3.9: Types of Cooking Fuels for Healthcare Facilities

S.no	Type of Cookstove	Annual specific consumption (Kg/PP/Year) ¹²⁷	Adoption rate (%)	
			2019	2030
1.	Improved Firewood Cookstove (ICS)	344.65	25.93	0
2.	Conventional Charcoal Cookstove	59.62	18.52	0
3.	Improved Charcoal Cookstove	37.46	14.81	0
4.	LPG Cookstove	7.6759	29.63	100
5.	Electric Cookstoves		11.1	
6.	Fireless cookers		3.7	
7.	Briquettes Stoves	52.44 ¹²⁸		0

The baseline and end year fuel adoption rates for healthcare facilities are shown in Table 3.10.

Table 3.10: Type of cookstove for learning institutions

S.no	Technology/Cookstove	Annual Specific consumption (Kg/PP/year)	Adoption Rate (%)	
			2019	2030
1.	TSOF	222.075	43.1	0
2.	Improved Wood Cookstove (ICS)	124.58	32.58	0
3.	Conventional Charcoal cookstove	19.481	5.17	0
4.	Improved Charcoal Cookstove	3.421	8.62	0
5.	LPG	45.45	3.45	100
6.	Biogas	10M ³	1.72	20

The baseline and end year fuel adoption rates for prisons are shown in Table 3.11

Table 3.11: Type of cookstove for prisons in Narok

S.no	Technology/Cookstove	Cost (USD)/stove	Annual Specific Consumption (Kg/PP/yr)	Annual Specific Consumption (Kg/PP/yr)	Adoption Rate (%)	
					2019	2030
1.	Improved wood Cookstove ICS	700	385.74	280	100	-
2.	Biogas	5848 ¹²⁹	10M ³	10M ³	-	30
3.	LPG	10000	45.45	45.45	-	100

¹²⁵ Commercial deep fryers take 17-24kW of power and a batch of fries takes 5min so consumption per batch 1.5-2kWh. With an assumption of 10batches per day consumption per day is taken as 20kWh.

¹²⁶ Sustainably sourced non-carbonized briquettes that can be used for SMEs that roast maize or cook on the roadside.

¹²⁷ Data from the 2018 Study on use of Biomass Cookstoves and Fuels in Institutions in Kenya

¹²⁸ The figure is related to the charcoal consumption based on the Kenya Briquette Industry Study, GVEP 2010

¹²⁹ Cost Implication of Installing a Fixed Dome Biogas Plant in Kenya – accessed through <http://www.kenpro.org/cost-implication-of-installing-a-fixed-dome-biogas-plant/>

Annex 5: OnSSET python and specs file input parameters

Python input parameters

The values for the parameters in the table below were already filled in the OnSSET Python files. However, some of these were updated with new Narok county specific values obtained from various published sources¹³⁰.

Parameter	Description	Unit	Value used
BASE_YEAR	The base year of the analysis. Note that this parameter is highly related to the input GIS data, which should, if possible, be calibrated towards this year (e.g. the population distribution map should represent the base year values).		2019
END_YEAR	The final year of the analysis.		2026
Scenario	The input value here represents the annual electricity consumption per household that is expected to be achieved, by the end year.	kWh/hh/year	Tier 1 – Rural HHs Tier 4 – Urban HHs
sa_diesel_capital_cost	The capital cost (per capacity unit) of a stand-alone diesel generator.	\$/kW	938
sa_pv_capital_cost	The capital cost (per capacity unit) of a stand-alone PV module.	\$/kW	3321
mg_diesel_capital_cost	The capital cost (per capacity unit) of a mini grid diesel generator.	\$/kW	721
mg_pv_capital_cost	The capital cost (per capacity unit) of a mini grid PV system.	\$/kW	3051
mg_wind_capital_cost	The capital cost (per capacity unit) of a mini grid wind powered system.	\$/kW	2538.8
mg_hydro_capital_cost	The capital cost (per capacity unit) of a mini grid hydropower system.	\$/kW	2589
existing_grid_cost_ratio	Incremental cost increase for extension of the grid from an electrified settlement to an un-electrified one. Default value set at 10%.	ratio	
discount_rate	The discount rate applied to different technology configuration choices throughout the period of analysis.	ratio	0.08
grid_cell_area	The size of each grid cell used in the study area. This value typically ranges between 1 and 10 km ² .	km ²	1

Specs-file input parameters

The inputs in the table below were entered in an .xlsx file used as an input in the model. Note that some of the inputs changed in the sub counties analysis to represent the specific values for each sub county.

¹³⁰ https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/11297/ER190_CostandReturnsofRenewableEnergyinSubSaharanAfricaA-ComparisonofKenyaandGhana.pdf?jsessionid=8162AFB81DA2399DB72152506B6C1B8?sequence=1
<https://iopscience.iop.org/article/10.1088/1748-9326/abc7de>

Parameter	Description	Unit	Value used
County	Enter the name of the study area		Narok
Pop2019	The population of the selected area in the base year.	People	1,157,873
UrbanRatio2019	The ratio of urban population in the selected area in the base year.	Ratio	0.07
Pop2026	The projected population ¹³¹	People	1,550,829
UrbanRatio2026	The ratio of urban population in the selected area in the end year.	Ratio	0.1
NumPeoplePerHHRural	Number of people per household in rural areas	People	5.6
NumPeoplePerHHUrban	Number of people per household in urban areas	People	4
DieselPriceLow	The low price of diesel. Used in the calculation of the operational costs for diesel generators (in both mini grid and stand-alone systems).	\$/liter	NA
DieselPriceHigh	The high price of diesel. Used in the calculation of the operational costs for diesel generators (in both mini grid and stand-alone systems).	\$/liter	NA
GridPrice	The cost of which the national grid generates electricity. This value is based on the mix of technologies used in the country.	\$/kWh	
GridCapacityInvestmentCost	The investment required per unit of additional capacity for the national grid. This is an average value based on the mix of technologies used in the country.	\$/kWh	2,772
GridLosses	This value represents the country's average technical losses on transmission and distribution.	Ratio	0.1
BaseToPeak	This value represents the ratio between the base and peak load in the selected country. It is used for sizing the necessary capacity to be installed per settlement in order to cover the respective demand.	Ratio	0.85
ExistingGridCostRatio	Incremental cost increase for extension of the grid from an electrified settlement to an un-electrified one. Default value set at 10%.	Ratio	0.1
MaxGridExtensionDist	The input parameter sets the maximum distance for which the grid can be extended in order to electrify a settlement due to techno-economic considerations. The default value in the model is 50km.	km	50
ElecActual	The electrification rate in the selected area in the base year. What ratio of population is electrified?	Ratio	0.224
MinNightLights	Nighttime light is an indicator retrieved by NASA's satellite imageries and it represents light intensity over a geographical area. The value ranges from 0 to 63 with higher values representing higher light intensity over the night. The input parameter sets the minimum light intensity value under which the model will consider a settlement as electrified.	[0-63]	0
MaxGridDist	The input parameter sets the maximum distance from the existing or planned grid network under which the model will consider a settlement as electrified.	km	1

¹³¹ Kenya Open Data. (2016). Socio-economic data of Kenya. Available at: <https://kenya.opendataforafrica.org/SEDK2015/socio-economic-data-of-kenya-2011?region=1000630-narok&indicator=1011900-population-growth-rate>. (Accessed: 10 June 2022)

MaxRoadDist	The input parameter sets the maximum distance from the existing or planned road network under which the model will consider a settlement as electrified.	km	0.5
PopCutOffRoundOne	These input parameters set the minimum population value under which the model will consider a settlement as electrified. If the value at Round one is not satisfactory, the program will move on to Round two (make sure that round two has a higher value than round one.)	People	5,000
PopCutOffRoundTwo			10,000
UrbanCutOff	This input parameter sets the minimum population value under which the model will consider a settlement urban	People	100

Annex 6: OnSSET Scenarios Combinations

Scenario Parameters	Choice	Explanation of choice options
Population Growth	0, 1	Expected population in the country by the end year of the analysis; 0: low population growth, 1: high population growth
Target_electricity_consumption_level	0, 1, 2	0: low electricity demand target (e.g., U4R1), 1: high electricity demand target (e.g., U5R3), 2: use the custom residential demand target layer (from GIS)
Electrification_target_5_years	0, 1	0: low electrification target in the intermediate year (e.g., 35%), 1: high electrification target in the intermediate year (e.g., 60%)
Grid_electricity_generation_cost	0, 1	0: low generating cost for the grid (e.g., 0.047), 1: high generating cost for the grid (e.g., 0.059)
PV_cost_adjust	0, 1, 2	0: PV capacity cost as defined by the user, 1: PV capacity cost reduced by 25%, 2: PV capacity cost increased by 25%
Diesel price	0, 1	0: low diesel price, 1: high diesel price
Productive_uses_demand	0, 1	0: not including productive uses of electricity, 1: including productive uses of electricity
Prioritization_algorithm	0, 1, 2	0: least cost prioritization, 1: forced grid within 1km, 2: forced grid within 2km

Annex 7: Energy Access Explorer (EAE) – Application in Energy Planning

What is Energy Access Explorer?

Energy Access Explorer (EAE) is an online, open-source, interactive, geospatial platform that enables clean energy entrepreneurs, energy planners, donors, and development-oriented institutions to identify high priority areas where energy access can be expanded. Using spatial data to link energy supply with growing or unmet demand is essential to gaining a better picture of energy access and expanding energy services to those who need it the most (Mentis et al, 2019).¹⁰⁸

EAE synthesizes several geospatial data to visualize and analyze **demand** for energy services.

- Demographics, including;
 - population density
 - poverty rates
 - asset ownership etc.
- Social and productive uses, including;
 - schools
 - health clinics
 - agricultural activities, etc. to visualize demand for energy services.

Similarly, EAE incorporates data to represent current or potential **supply** of energy services. These include:

- resource availability (including wind, solar, small-scale hydropower etc.),
- power infrastructure (including transmission, distribution, and generation networks)

Furthermore, it incorporates important data on:

- environment (such as protected areas and forest cover),
- access to finance (such as finance service providers)
- and other categories (such as refugee settlements)

EAE enables all users to make multi-criteria decision analysis on-the-fly and identify high-priority areas where access to energy should be expanded.

Beyond its visualization and analytical capabilities, EAE functions as a dynamic geographic information system and data repository which reduces software engineering and data transaction costs for both data providers and users. Its unique backend infrastructure comes with an easy to navigate Content Management System and allows admin users with limited or no GIS and programming expertise to add data and metadata in a simple manner.

Using Energy Access Explorer in electrification planning

How can Energy Access Explorer help energy planning agencies?

Energy Access Explorer identifies areas where electrification and socio-economic development can be linked to meet the needs of the poor. It can complement the cost optimization planning tools that energy planners already use, providing a bottom-up representation of electricity affordability and demand.

Furthermore, Energy Access Explorer functions as a Dynamic Geographic Information System which enables energy planning agencies with limited or no GIS capacity to better process, store, manage and update data in a cost-effective manner.

Using the tool, planning agencies and energy ministries can identify areas where there are households, schools, health clinics and other facilities, but no connection to the grid. Supplying electricity to these areas is essential to socio economic development, improving quality of life, upgrading basic health and education services and boosting gender equality.

EAE Architecture

EAE is a Dynamic Geographic Information System, with an open source, adaptable web-architecture. Beyond its visualization and analytical capabilities, EAE's unique backend infrastructure provides:

- Automated Data Processing to minimize resource requirements when it comes to harmonizing and integrating new data.
- Dynamic database and efficient data storage to optimize data transactions and configurations.
- Customized Content Management System which allows admin users to better process, store, manage and update EAE in a cost-effective manner.
- A modular API that connects the backend of the application with the front-end and enables users to generate rapid, high-resolution visualizations and prioritization analysis on the fly.
- Variety of Baseline Maps; including names of places and satellite imagery .

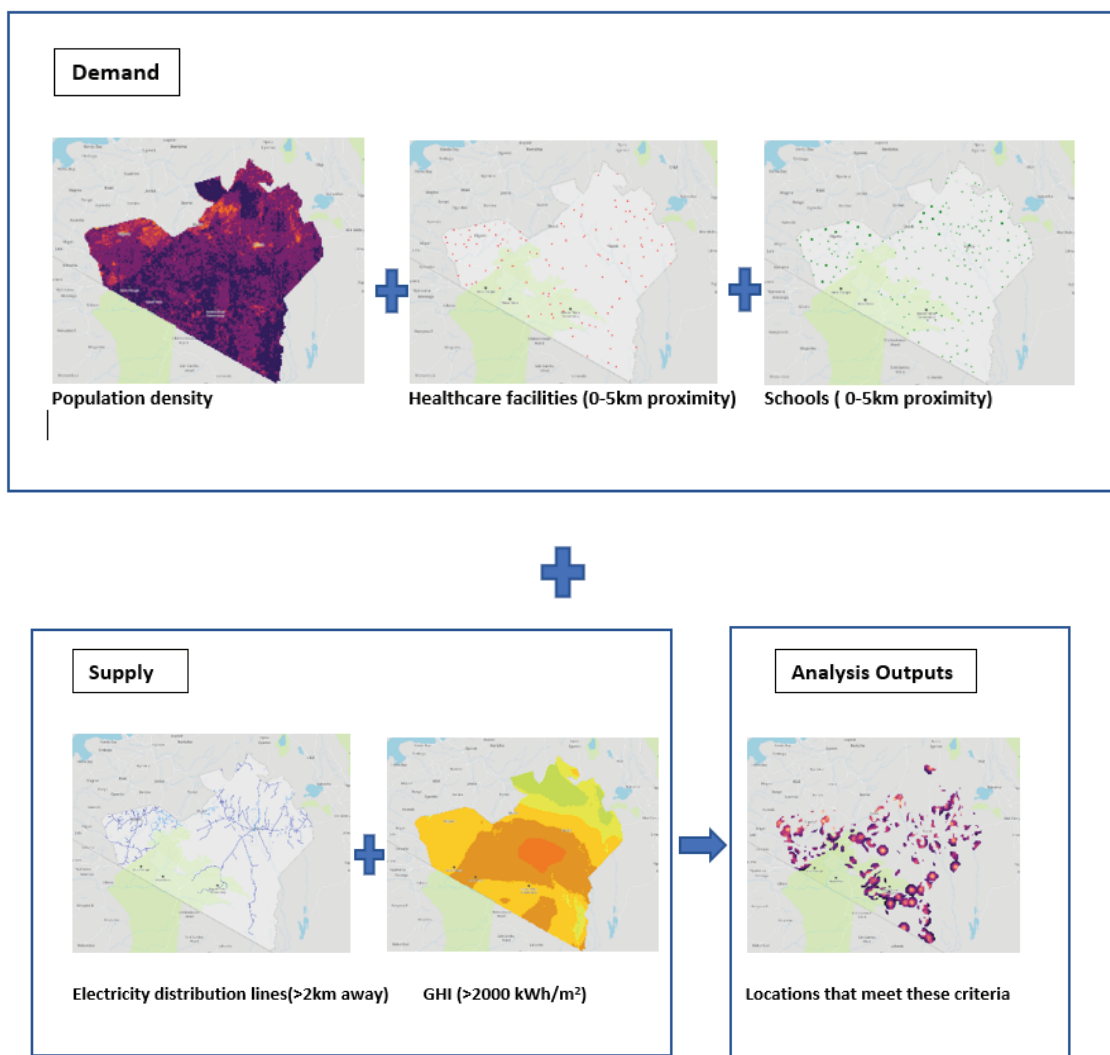
A more detailed table outlining EAE functionalities has been added at Annex 7.

Electrification prioritization analysis example using the EAE for Narok County

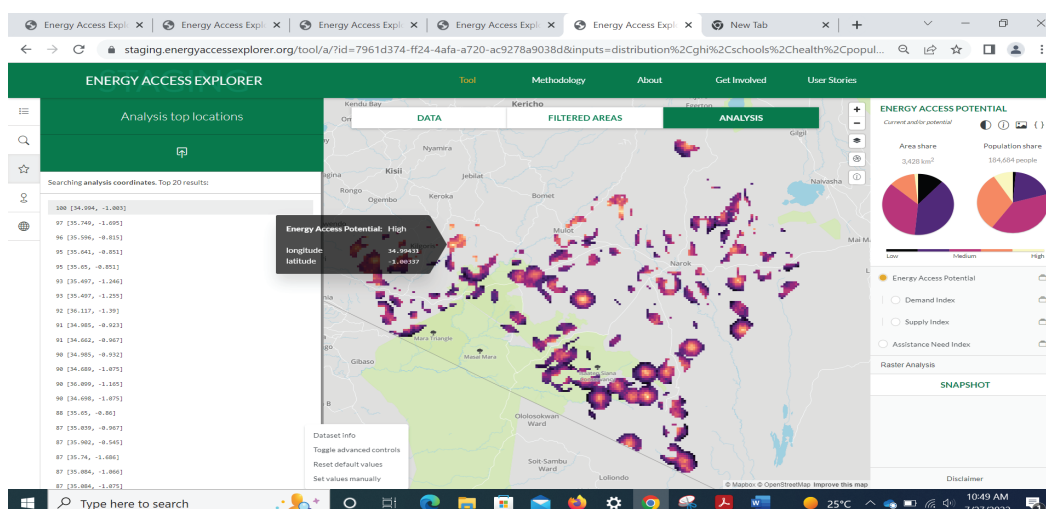
As has been mentioned previously, the EAE for Narok County was developed as part of developing this CEP and can be used to generate interactive on-the-fly spatial and quantitative datasets to show where energy demand is, and supply is lacking based on the unique perspectives of each user.

The example below shows a prioritization analysis to indicate areas in Narok County which are far away from the main electricity distribution lines, close to schools and healthcare facilities, high population density and have good solar potential.

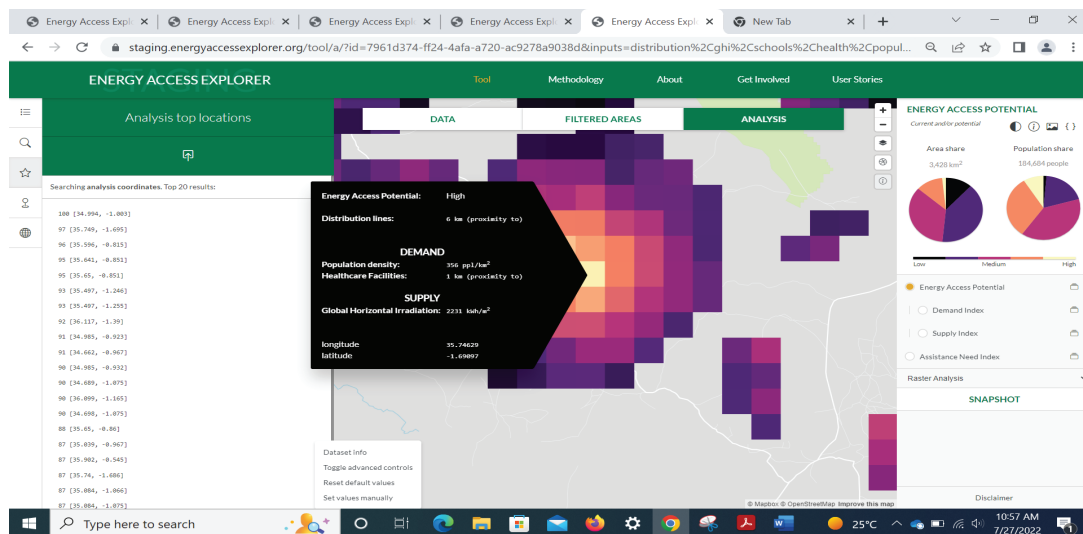
Datasets loaded on both demand and supply categories as well as the filters used are indicated in the images below.



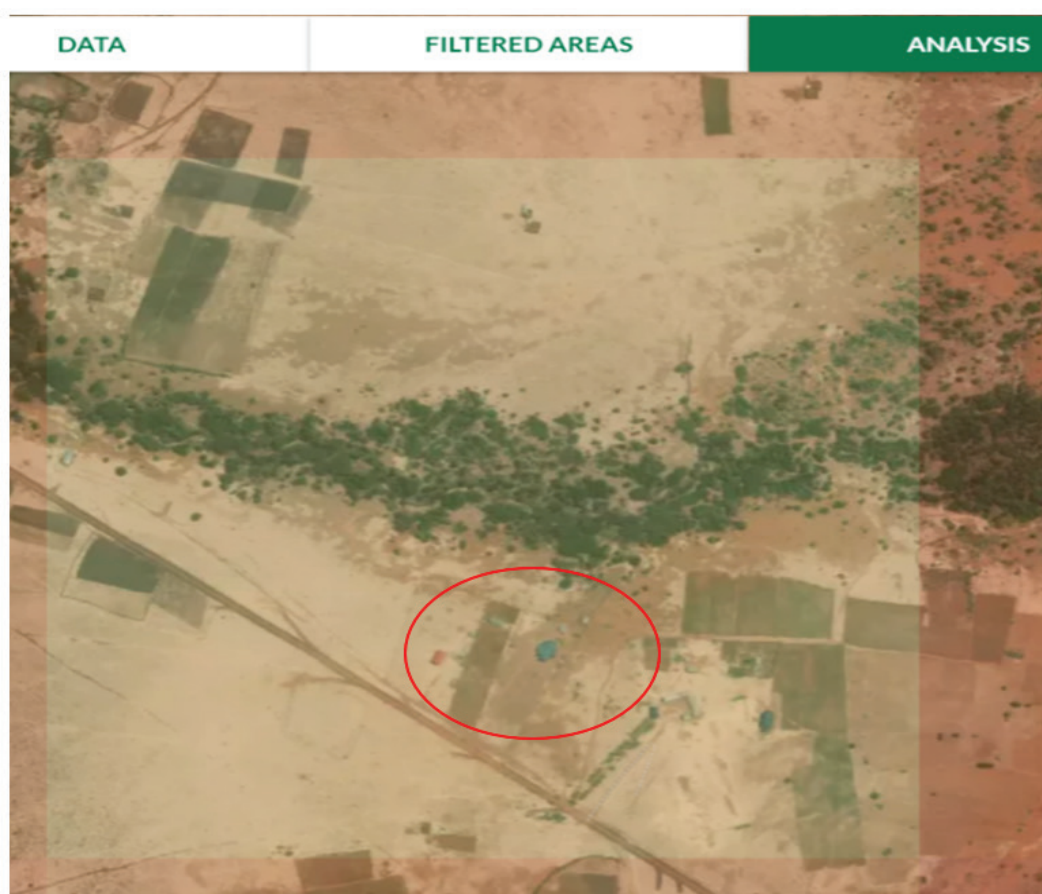
The figures above are eExamples of Energy Access Explorer's high-resolution, multi-criteria prioritization analysis. This analysis identifies priority areas which are close to healthcare and education facilities, far from the power network and where solar potential is significant. This is a sample analysis. Users can combine more than 25 geospatial datasets and generate custom prioritization analysis, maps and reports based on their criteria and perspectives.



Analysis results based on the above criteria. Total population living in the above filtered out areas are ca184,684. EAE also lists the top 20 priority areas based on the user defined criteria.



Additional level of detail for one of the top 20 locations based on the user defined criteria. For this location, the population density is 356 people/km², proximity to the closest healthcare facility is 1km, distance to the closest distribution line is 6km - indicating that this area is not connected to the grid -, and the Global Horizontal Irradiation is 2231 kWh/m², illustrating significant potential for solar energy.



Top locations identified compared with satellite imagery. The image above shows the location identified in the analysis as in the previous figure. You can see some buildings enclosed in the red circle towards the bottom right that could be the healthcare facilities identified to be 1km away.



The image on the right shows another top location that has a number of houses (some examples circled in red) indicating potential households to be electrified as well as farms that could benefit from productive uses of energy for agriculture.

Analysis results outputs

As is evident above, EAE uses multi-criteria analysis to identify areas of interest to expand energy access where it's needed the most. It does this by combining various combinations of datasets on demand and supply and applying different user-defined filters that factor in proximity and weighting of the datasets selected to come up with locations that meet the defined criteria for expanding energy access.

One of EAE's analytical outputs is a high resolution, geospatial map that shows the areas in the geography selected that meet the criteria for the analysis e.g., in this case, close to productive uses of energy (schools, healthcare facilities), are far from the electricity distribution lines and have great potential for solar energy.

In addition to the map, the panel on the right displays various summary statistics such as the total area and population share of areas that meet these criteria are also given relating to either the Energy Access Potential Index, Demand Index, Supply Index or Assistance Need Index. These indices range from low to medium to high and are colored differently on the map with areas with high potential tending towards bright yellow while areas with lower potential tending towards black color.

For the Energy Access Potential Index, areas with higher energy demand and supply potential are characterized with higher index values; thus it would make sense to start electrifying these areas first. More details on the methodology and these indices can be found in the EAE: Data and Methods technical note.¹³²

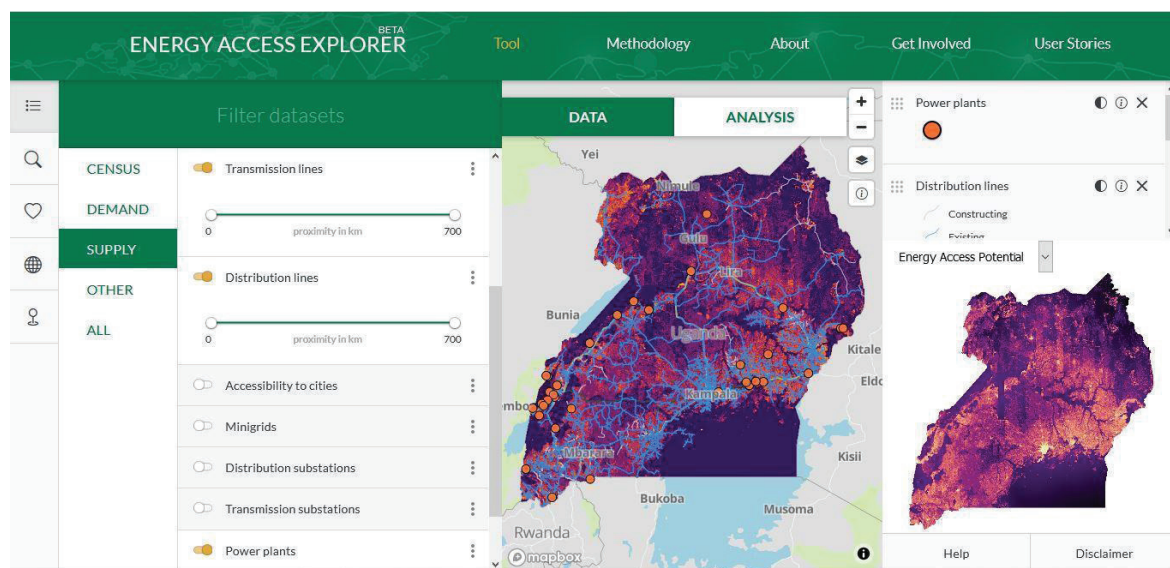
Finally, you can export the report of this analysis by clicking on Snapshot (bottom of the results panel on the right) and go through the summary graphs, visualize the summary table and export, and review the pdf and csv reports.

It is noteworthy that thanks to EAE's dynamic nature, visualizations and prioritization analysis are updated on the fly once new or updated data are integrated in the platform. This saves data & analysis users a significant amount of resources and time when it comes to generating or updating geospatial prioritization analysis.

¹³² Mentis, D. et al. (2019). EAE: Data and Methods. Available at: <https://www.wri.org/research/energy-access-explorer-data-and-methods>. (Accessed: 5 May 2022).

Annex 8: EAE Functionalities – Front-end and Back-end Front-end

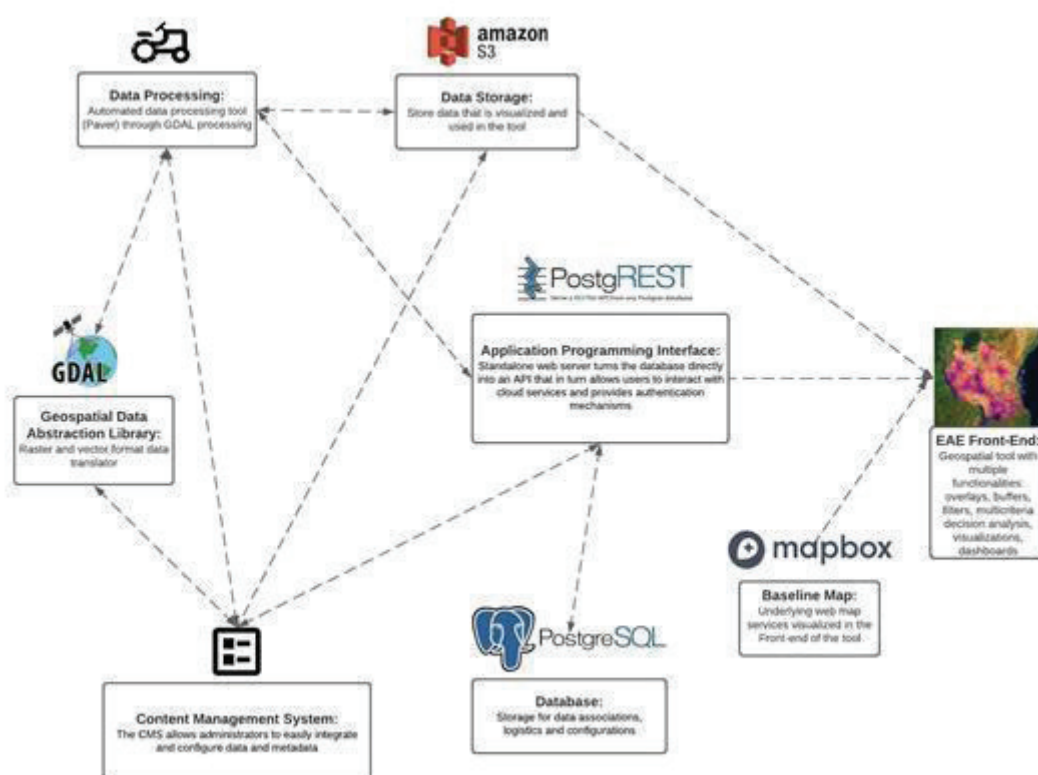
Functionality
Select and visualize geospatial data
User friendly interface
Overlay data
On the fly high resolution multi-criteria decision analysis that provides 4 different “heat maps”/ analytical outputs. These include and prioritize areas of interest as defined by users' custom criteria and selections.
Apply queries, filters and buffers
High resolution multi-criteria analysis (1 km ²)
List high-priority areas
View on desktop and mobile phone internet browsers
Customizable base maps (e.g., satellite, light, dark plus labels)
View in a public version
View in a password protected version
View in an off-line version
Zoom-in feature to select smaller administrative divisions and see custom versions of the app (including input data and outputs of the analysis) for these areas
Search for and summarize the top 10 locations in terms of the select indicators or the analytical outputs (for instance, show the 10 best locations with the highest wind speed or the 10 best locations with the highest Energy Access Potential
Develop custom summary reports and dashboards
Search for coordinates or areas of interest
Save and download analysis
Visualize temporal data to track progress



EAE's front end provides the user interface for loading data, applying queries, filters and performing multi-criteria analysis, among other functions listed above.

Back-end

Functionality	Status
User friendly interface	Launched
Ability to add data in different resolutions, types, formats	Launched
Ability to add metadata	Launched
Modify visualizations/symbology	Launched
Categorize data and change the order in which they appear in the front-end	Launched
Automated data processing	Launched
Enable searchability of data	Launched
Sorting of data	Launched
Dynamic database	Launched
Efficient data storage	Launched
Last update feature	Launched
Staging site for testing	Launched
Link with AWS	Launched
Link to other cloud services	Launched (admin can choose)
A modular API – connects back end and front end	Launched
Add new multi-criteria analysis defined by administrators	Staging – under development



EAE Architecture

Annex 9: Sub county OnSSET Scenarios

This involved conducting similar electrification modelling analysis as was done at county level on forced grid

electrification scenario but with inputs including the GIS datasets, model parameter inputs used at sub county level.

Forced Grid Electrification Scenario Parameters

This scenario combination similar to the third scenario in the county analysis made use of the following assumptions:

- High population growth at 4%
- Tier 2 consumption in rural areas and tier 5 in urban areas
- 40% electrification target in 2024
- 100% electrification in 2026
- High generating cost for the grid (e.g., 0.059)
- PV capacity cost reduced by 25%
- Not including productive uses of electricity
- Forced grid within 2km radius of the grid

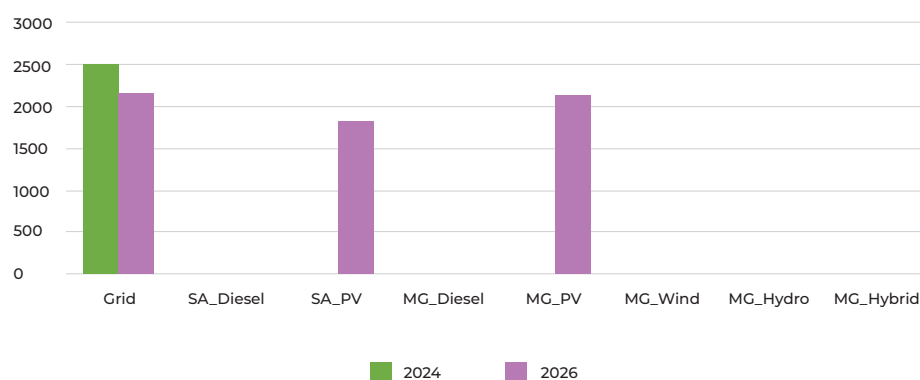
Narok North Sub county

Results

Capacity in kW required in 2024 & 2026 in Narok North

Technology	2024	2026
Grid	2,499.9	2144.9
SA_Diesel	0	0
SA_PV	0	1,813.7
MG_Diesel	0	0
MG_PV	0	2,128.2
MG_Wind	0	0
MG_Hydro	0	7.8
MG_Hybrid	0	0

Capacity Required (kW) Narok North Scenario



Investment (USD) required (2024 & 2026)

Technology	2024	2026
Grid	60,112,442.7	22,614,508.3
SA_Diesel	0	0
SA_PV	0	8,688,204.9
MG_Diesel	0	0
MG_PV	0	9,712,442.7
MG_Wind	0	0
MG_Hydro	0	43,895.8
MG_Hybrid	0	0

Investment Required (USD) Narok North Scenario

70000000

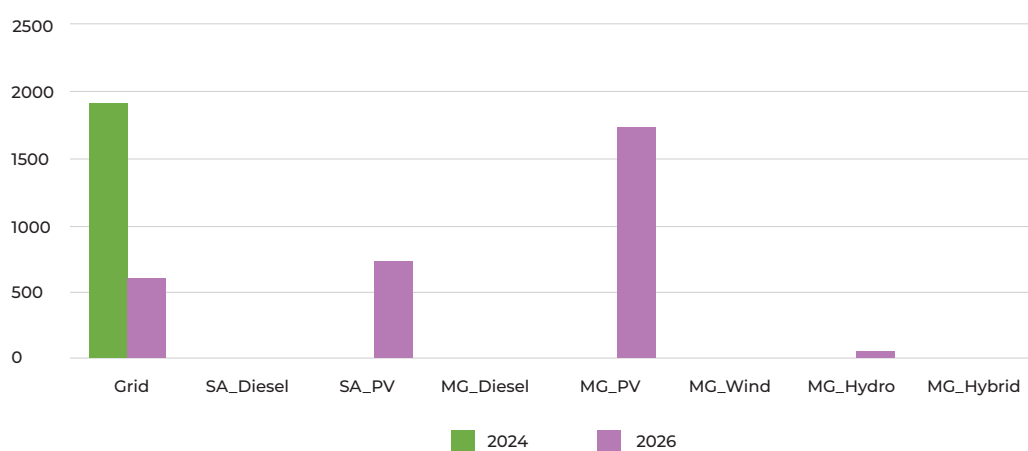
Narok East Sub county

Results

Capacity in kW required in 2024 & 2026 in Narok East

Technology	2024	2026
Grid	1,920.5	604.9
SA_Diesel	0	0
SA_PV	0	714.7
MG_Diesel	0	0
MG_PV	0	1,728.0
MG_Wind	0	0
MG_Hydro	0	35.2
MG_Hybrid	0	0

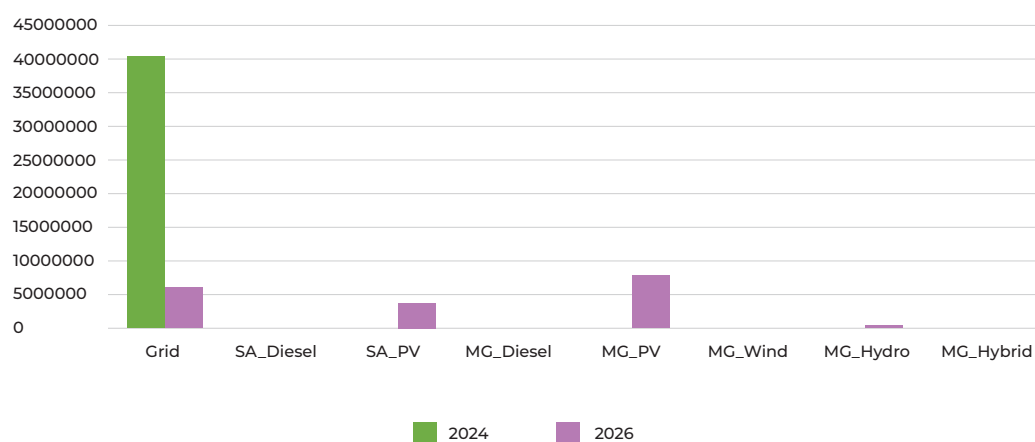
Capacity Required (kW) Narok East Scenario



Investment (USD) required (2024 & 2026)

Technology	2024	2026
Grid	40,240,472.9	5,537,319.0
SA_Diesel	0	0
SA_PV	0	3,423,765.0
MG_Diesel	0	0
MG_PV	0	7,615,219.0
MG_Wind	0	0
MG_Hydro	0	192,077.1
MG_Hybrid	0	0

Investment Required (USD) Narok East Scenario



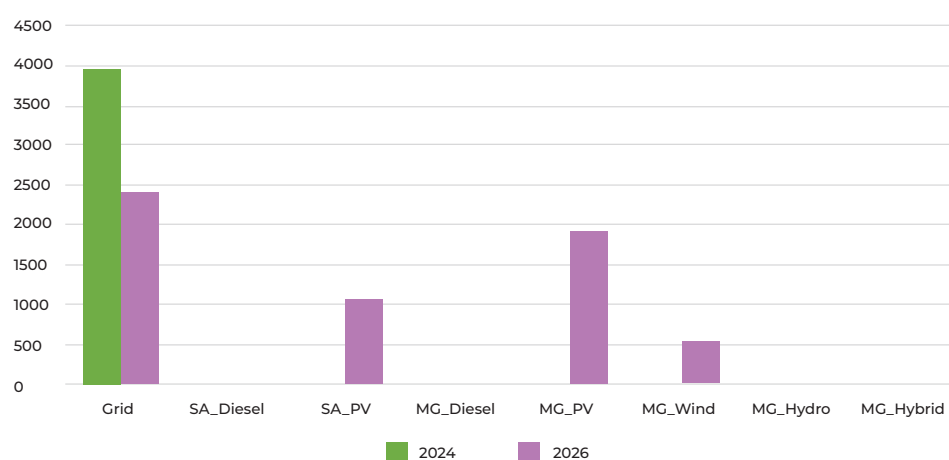
Narok South Sub-county

Results

Capacity in kW required in 2024 & 2026 in Narok South

Technology	2024	2026
Grid	3,932.7	2,394.1
SA_Diesel	0	0
SA_PV	0	1,076.3
MG_Diesel	0	0
MG_PV	0	1,916.2
MG_Wind	0	535.0
MG_Hydro	0	9.1
MG_Hybrid	0	0

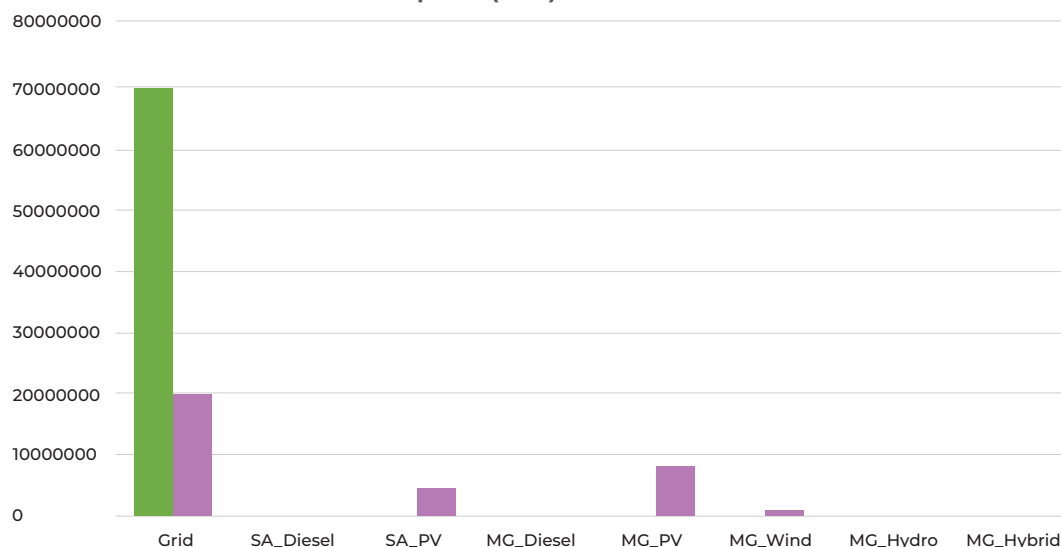
Capacity Required (kW) Narok South Scenario



Investment (USD) required (2024 & 2026)

Technology	2024	2026
Grid	69,114,440.6	21,302,070.6
SA_Diesel	0	0
SA_PV	0	5,156,090.3
MG_Diesel	0	0
MG_PV	0	8,465,404.3
MG_Wind	0	1,749,214.2
MG_Hydro	0	39,061.4
MG_Hybrid	0	0

Investment Required (USD) Narok South Scenario



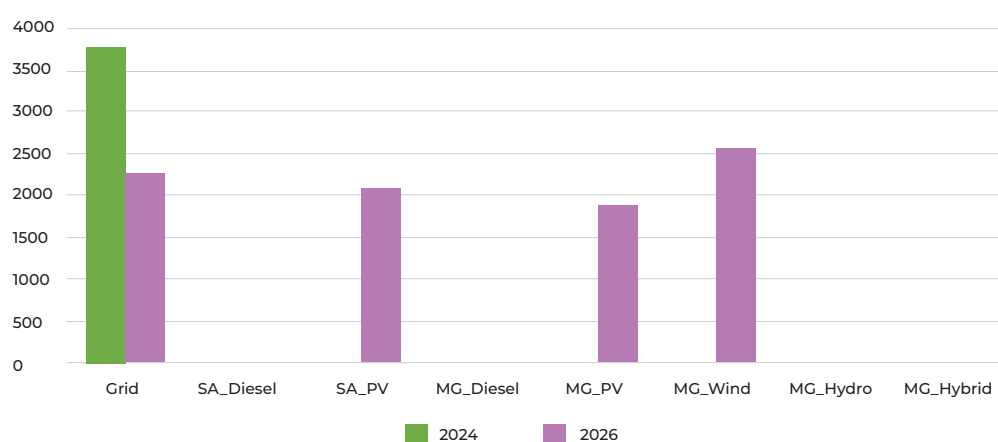
Narok West Sub-county

Results

Capacity in kW required in 2024 & 2026 in Narok West

Technology	2024	2026
Grid	3,792.0	2,257.2
SA_Diesel	0	0
SA_PV	0	2,090.9
MG_Diesel	0	0
MG_PV	0	1,905.9
MG_Wind	0	2,571.5
MG_Hydro	0	1.5
MG_Hybrid	0	0

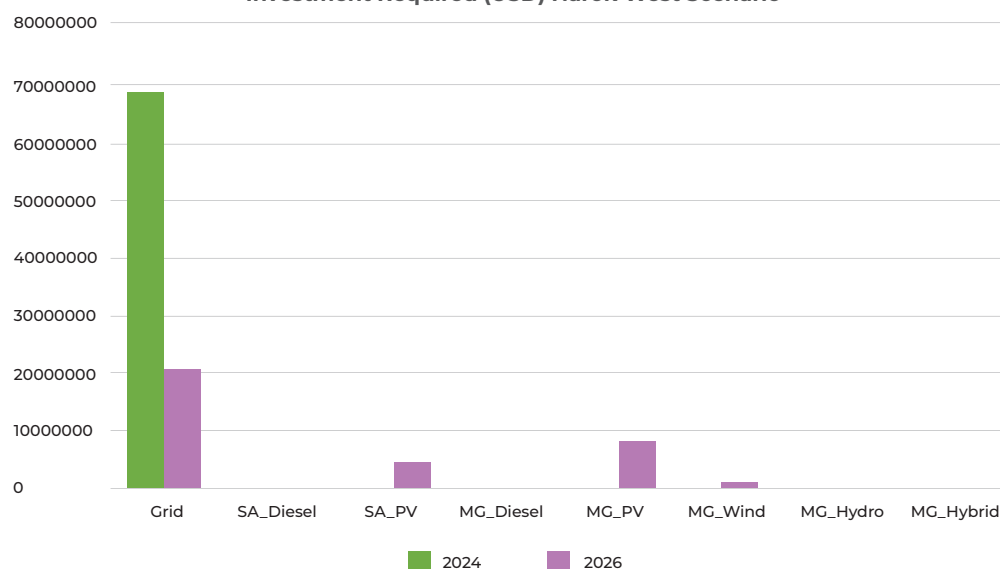
Capacity Required (kW) Narok West Scenario



Investment (USD) required (2024 & 2026)

Technology	2024	2026
Grid	43,552,678.9	18,630,907.1
SA_Diesel	0	0
SA_PV	0	10,016,296.7
MG_Diesel	0	0
MG_PV	0	8,514,381.6
MG_Wind	0	8,525,129.7
MG_Hydro	0	12,756.5
MG_Hybrid	0	0

Investment Required (USD) Narok West Scenario



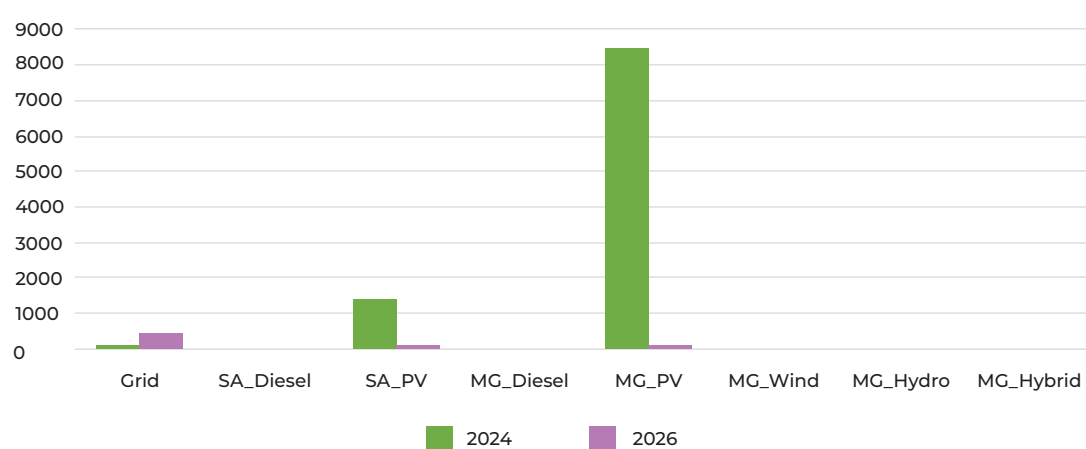
Transmara East Sub-county

Results

Capacity in kW required in 2024 & 2026 in Transmara East

Technology	2024	2026
Grid	64.2	456.4
SA_Diesel	0	0
SA_PV	1,332.5	98.6
MG_Diesel	0	0
MG_PV	8420.6	81.8
MG_Wind	0	0
MG_Hydro	0	0
MG_Hybrid	0	0

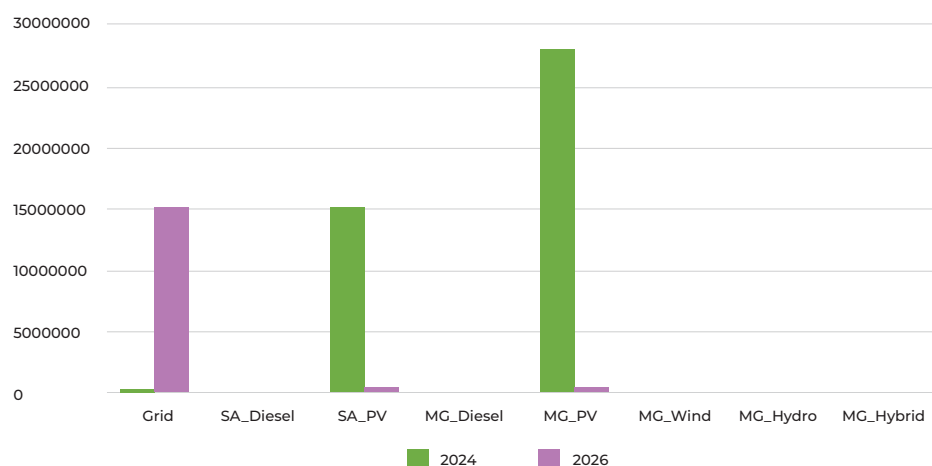
Capacity Required (kW) Transmara East Scenario



Investment (USD) required (2024 & 2026)

Technology	2024	2026
Grid	395,057.5	15,050,691.7
SA_Diesel	0	0
SA_PV	15,158,176.6	472,387.2
MG_Diesel	0	0
MG_PV	27,884,638.2	382,826.1
MG_Wind	0	0
MG_Hydro	0	0
MG_Hybrid	0	0

Capacity Required (USD) Transmara East Scenario



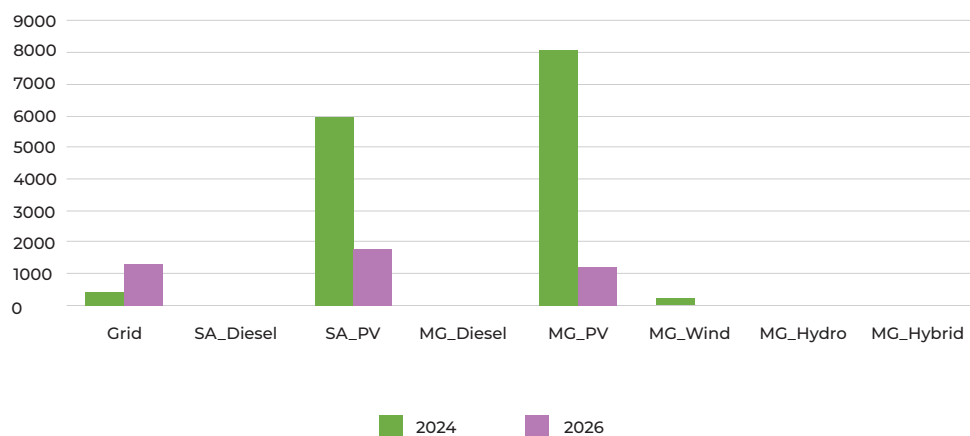
Transmara West Sub-county

Results

Capacity in kW required in 2024 & 2026 in Transmara West

Technology	2024	2026
Grid	384.9	1,308.7
SA_Diesel	0	0
SA_PV	5,956.4	1,795.5
MG_Diesel	0	0
MG_PV	7,971.1	1,310.4
MG_Wind	153.7	0
MG_Hydro	0	0
MG_Hybrid	0	0

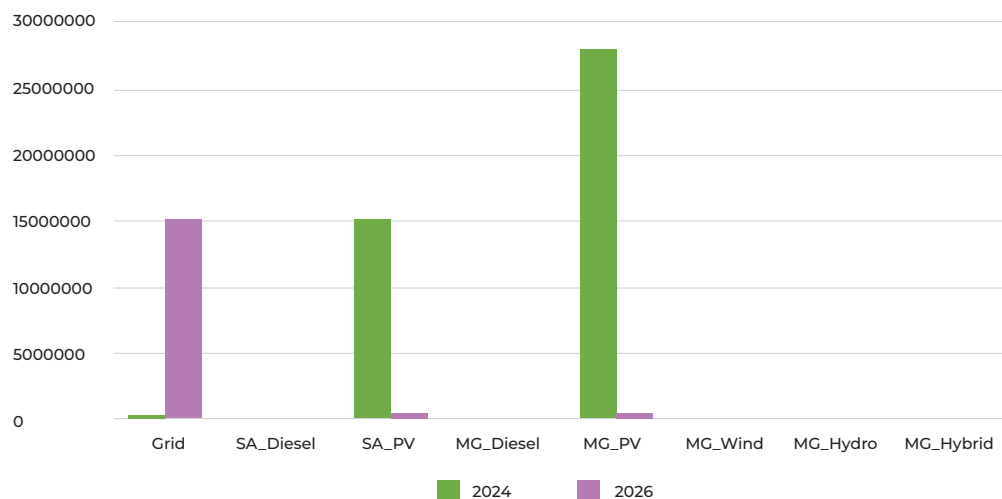
Capacity Required (kW) Transmara West Scenario



Investment (USD) required (2024 & 2026)

Technology	2024	2026
Grid	2,299,234.2	78,901,945.4
SA_Diesel	0	0
SA_PV	86,056,823.1	8,600,942.7
MG_Diesel	0	0
MG_PV	31,332,972.9	5,963,441.4
MG_Wind	701,789.5	0
MG_Hydro	0	0
MG_Hybrid	0	0

Capacity Required (USD) Transmara West Scenario



Annex 10: Affordability Analysis Full Results

The table below illustrates the findings of the affordability analysis:

Sub-County	Average amount per hh spent (KES) on electricity per month	Future Value of Average amount per hh spent (KES) on electricity per month in 2026	Total Households (2019 Census)	Total Households (2026)	Extrapolated total electricity expenditure per year in 2026 (KES)	LCOE*Electricity Consumption (KES) on scenario to achieve universal energy access in 2026	Deficit (KES)
Narok North	563	906.7	59,996	67,371	733,023,428.4	610,762,918.6	122,260,509.8
Narok East	776	1,249.8	25,078	28,161	422,347,413.6	211,838,043.5	210,509,370.1
Narok South	544	876.1	46,723	52,466	551,585,551.2	674,698,712.1	-123,113,160.9
Narok West	350	563.7	38,658	43,410	293,642,604	372,021,998.3	-78,379,394.3
Trans Mara East	557	897.1	20,506	23,027	247,890,260.4	98,384,955.27	149,505,305.13
Trans Mara West	456	734.4	50,132	56,294	496,107,763.2	425,660,907.3	70,446,855.9
County Totals	558	898.7	241,093	270,729	2,919,649,827.6	2,393,367,535	526,282,292.6

Definitions of some terminologies used in the table above

LCOE – Final cost of electricity per kW required for the overall system to break even over the project lifetime for the selected least cost technology choice

Electricity Consumption – Residential demand tier of choice*Population projected for 2026

- Residential demand tier -Consumption per capita per year for a certain efficiency level (Tier 1-rural; and Tier 4-urban)
- Population projected for 2026 – assuming high pop growth rate of 4% pa since the released 2019 census result per sub-county

Assumption: 1 USD-120 KES

Household growth rate: 1.67% p.a (MoE -LCPDP, 2021)¹³³

¹³³ MoE. (2021). LCPDP 2021-2030. Available at: <https://communications.bowmanslaw.com/REACTION/emsdocuments/LCPD%202021.pdf>. (Accessed: 10 May 2022).

Annex 11: Energy Efficiency Standards and Benchmarks

KNEECS (2020) strategies and Targets

Objectives	Indicators	Status (2019)	Target by 2025
Improve the energy efficiency of household electrical appliances	Electricity consumption of household appliances	961 GWh (6 kinds of appliances) a Projected target	3% annual increase in efficiency to the base case level in 2020
	Number of appliances covered by MEPS	6MEPS, covering motors, air conditioners, fridges, CFLs, magnetic ballasts, and fluorescent lamps	10 MEPS – Additional MEPS for LEDs, computers, TVs, and cook stoves
Improve the energy efficiency of household thermal energy	1. MEPS for cookers and fuels 2. Testing lab for cookers and fuels 3. Communication and awareness strategy 4. Reviewed CAP 5. Bio Energy strategy formulated	70% households using biomass fuel	50% households utilizing clean energy
Improve fuel economy performance and reduce CO2 emissions in Kenya in the transport sector	Average fuel consumption (light duty vehicles) per 100 km travelled Average CO2 emission per km travelled	Average fuel economy = 7.5 L/100km Average CO2 emission = 181.9 g/km	6.5 L/100km 160 g/km
Increase the adoption of E-Mobility	Share of electric/hybrid vehicles in total vehicles imported into Kenya	0%	5% of imported electric cars annually
Develop Minimum Energy Performance Standards for Buildings	1 Minimum Energy Performance Standard developed and gazetted	0	1
Building Energy Use Index	Establish Baseline Energy Use Index for Buildings in Kenya	0	1
Improve the energy performance of new buildings in Kenya	Share of newly built floor area compliant with energy efficiency requirements in the total building stock	0	10%
Building cooling	Adopt American Society of Heating, Refrigerating and Air-Conditioning Engineers buildings energy conservation standards or equivalent for public and commercial buildings	0	2
Improve the energy efficiency of lighting in existing public buildings	Lighting load in public buildings	0	50%
Promotion of new green public buildings	Design and construction of energy-efficient/green public buildings	0	20
	Ensure 25% of buildings under affordable housing are green buildings	0%	25%

Increase the reach of successful industrial energy efficiency programmes	Number of audited facilities	1,800	4,000
Improve the acceptance of energy audits and implementation of energy audit recommendations	Number of certified energy efficiency professionals	70 licensed EE professionals	120 licensed EE professionals
Enhance the implementation of recommended EE measures	Estimated industrial energy savings	Current estimated annual savings level from programmes: 177,000 MWh/20MW demand/51m litres heavy fuel oil/1.8m litres industrial fuel oil	885,000 MWh/100MW demand/250m litres heavy fuel oil/9.0m litres industrial fuel oil
	No. of ESCOs created and undertaking EE projects	0	5
Improve EE in the agricultural value chain in off-grid areas	Demonstration projects for EE in Productive Use of Energy activities in agricultural value chain in off-grid areas. Target projects include pumping water systems, cold chains, and grain milling.	0	5

Summary of Kenya Greed Buildings Design Guidelines

- Building envelope insulation that isolates the building from the outside environment for passive cooling.
- Using reflective or light-coloured walls and roofing materials or installing a roof garden to reduce heat flow into the building.
- Building orientation that minimises façades facing east and west to reduce solar heat ingress.
- Design windows with shading devices or roof overhangs to minimise solar heat ingress. Growing trees outside buildings helps in reducing solar heat ingress.
- Use of high thermal performance glass such as double glazed or reflective film to shield external heat ingress.
- Design for optimum natural lighting and cooling with window to wall ratio (WWR) to provide adequate natural light with minimum solar heat ingress.
- Where artificial lighting is needed, then use of high efficacy LED lighting to be employed e.g., to attain a max of 3W/m² per 100lux¹³⁴ for offices.
- Design for light zoning that allows specific lights to be switched on only where required. The use of lighting automation such as timers, motion and daylight sensors to be employed to operate lights when needed.
- Design for natural draught ventilation. Where artificial ventilation and air conditioning is required, then high efficiency ventilation units to be employed.
- Design to allow onsite electricity generation such as Solar PhotoVoltaic (PV).
- Design buildings to allow for solar water heating installation
- Design for water use efficiency that includes use of low flow faucets, rain water harvesting, grey water treatment and reuse.
- Apply Energy Efficiency Management principles in buildings during operations that include energy monitoring, metering and sub-metering and efficient use of lighting, appliances and utilities.

