KITUI COUNTY ENERGY PLAN

EDM ENERGY DELIVERY MODELS

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CAFOD Catholic Agency for Overseas Development

THE COUNTY GOVERNMENT OF KITUI
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Caritas KITUI

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Foreword

In meeting our county mission of providing effective services and an enabling environment for inclusive and sustainable socio-economic development and improved livelihoods for all, energy is set to play an important role in achieving our county development blue print namely, Health and Sanitation, Food and water security, Women and Youth empowerment and wealth creation. The County Government of Kitui has fully taken the mandate for planning and developing energy initiatives as stipulated in the 4th Schedule of the Constitution of Kenya 2010.

As a county government, we aim to provide affordable and sustainable energy alternatives to all households. It is our goal to provide an enabling environment for all residents so that everyone is accorded similar opportunities to economic growth and environmental sustainability.

Our energy plan is in line with the county's policies, Kenya Vision 2030 framework, Constitution of Kenya, the Energy Act 2019 and the National Energy Policy 2018. Once implemented, the plans will go a long way in meeting the UN sustainable Development Goals and Contribute to the National agenda on Sustainable Energy for All.

This County Energy Plan provides a picture of the current county energy gaps and recommends solutions, both energy and non-energy components in the following sector; Household lighting, Water, Health, Agriculture, Livestock, SMSEs, and clean cooking.

It further provides for recommendations for priority investments based on the solutions developed, explains the rationale for the prioritisation and suggests criteria for finalize the list of priority investments.

Lastly it highlights steps to move from planning to demonstration and implementation of the solutions and priority investments.

We aim to work with all stakeholders in order to promote equitable access to reliable and affordable energy within the County while promoting environmental sustainability and bettering the livelihood of its residents.

Hon. Meshack Kyalo Muthusi
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KITUI

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A summary version of the CEP can be found at: https://kitui.go.ke/countygovt/ministries/ministry-of-environment-and-natural-resources

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Overview of the County Energy Plan

Section One outlines the enabling environment, namely the national and county-level policy frameworks for energy and for wider development planning (relevant legislation is listed in Annex One for reference). This includes national electrification and clean cooking targets under Sustainable Development Goal (SDG) 7, as well as Kitui County's development goals. It also discusses the status of access to electricity and clean cooking within Kenya, and the emergence of new metrics aiming to capture the multi-dimensionality of energy access.

Section Two describes the development context of Kitui County, including its topography, climate and socio-economic characteristics, using data drawn mainly from the 2019 National Census and the County's five-year County Integrated Development Plan (CIDP).

Section Three dives deeper into the energy context in the County, outlining the status of energy consumption at the household level (lighting and cooking) using the available data as well as the County's policy goals. It analyses the County's energy resource potential and highlights challenges such as deforestation arising from extensive bio-mass use.

Section Four discusses the status of energy efficiency in the County including enabling policies and gaps. Little data is available on energy efficiency for households, public institutions, and the industrial and business sector.

Section Five describes the methodology used to develop the CEP, the Energy Delivery Models (EDM) approach. It explains the rationale for why such inclusive, needs based and integrated planning approaches are needed. It also outlines how the EDM approach was adapted from community to sub-national (county) level energy planning.

Section Six is the most substantive section of the CEP. It contains seven detailed solutions developed to meet Kitui County's priority development needs as identified in the planning process plus options for Least Cost Electrification (LCE) for households. The solutions cover different development (sub)sectors and include both the energy and non-energy interventions required to meet each need. All the solutions contain costings, detailed value chain analysis and business modelling where required, and suggest delivery partners (off-grid renewable energy equipment suppliers are listed in Annex Two). Each solution also identifies where further data gathering and analysis or technical assistance is required for its optimization. An initial list of potential synergies between the different solutions or solution components for aggregation and to provide economies of scale is also provided.

The Section begins by modelling the LCE options to deliver *a range of levels of energy access*, in line with a tiered approach. The other solutions discussed are as follows:

- Better quality, reliable **household lighting** for general purpose use
- **Water**: improved access to clean, affordable, and reliable water for drinking and general-purpose needs in households
- **Health**: improved provision of health services for communities in remote and poorly served areas
- **Agriculture**: improved income for smallholder farmers from irrigated and rain fed crops

- **Livestock**: improved yield and productivity of small-scale livestock (poultry and dairy) farmers across Kitui County
- **Micro, Small and Medium Enterprises (MSMEs)**: improved business capacities to deliver quality products and services for communities in remote and poorly served areas, and increased revenue of existing MSMEs
- **Cooking**: improved access to cleaner, faster, reliable, and more affordable fuels and technologies for cooking for households in Kitui

Section Seven makes recommendations for priority investments based on the solutions developed, explains the rationale for the prioritisation and suggests criteria for finalizing decision-making, in addition to additional data and analysis required to finalize the list of priority investments.

Finally, **Section Eight** suggests next steps to move from planning to demonstration and implementation of the solutions and priority investments. As well as highlighting the importance of targeted stakeholder outreach to build understanding and buy-in to the solutions, it describes the process for resource allocation via the county budgetary cycle as well as suggestions of co-financing sources (Annex Three contains a mapping of potential co-financiers).

Contents

1. Introduction: the policy context for county energy planning

1.1 National energy targets and goals

The Government of Kenya (GoK) has identified energy as one of the key enablers of the economic pillar of its Vision 2030 development blueprint (Republic of Kenya, 2008. Under the Third Medium Term Plan (2018-2022), the government aims to improve energy infrastructure through extending and strengthening the national power transmission network and increasing the generation through investment in cheaper renewable energy (RE) source (Republic of Kenya, 2018a). The aim is to create a cost-effective energy supply regime that is reliable and appropriate for meeting household needs, as well as supporting industrialization, food security and job creation for economic growth.

Policies and strategies guiding the energy sector in Kenya are set out under the National Energy Policy (NEP) of 2018 (Republic of Kenya, 2018b). These policies and strategies are aligned with the Constitution of Kenya (Republic of Kenya, 2010) and with Kenya's Vision 2030. The NEP vision is "affordable quality energy for all Kenyans". Its objective is to ensure affordable, competitive, sustainable, and reliable supply of energy at the least cost to achieve national development needs, while protecting and conserving the environment for inter-generational benefits.

The NEP proposes a roadmap to increase Kenya's installed power generation capacity, from 1,664MW in October 2013 to around 6,652MW by 2024. In the medium to long term, the government aims to develop energy technologies are least cost considering the capacity factor, capital and discount rates. As of December 2017, installed generation capacity had reached 2,336 MW. The remaining additional capacity is to be achieved through a mix of geothermal energy (1646 MW), natural gas (1050 MW), wind- (650MW) and Coal (1920MW) working with independent power producers (IPPs) under a Public Private partnership (PPP) framework (Republic of Kenya, 2018c).

1.2 SDG 7 on access to affordable, reliable, sustainable, and modern energy for all

In 2015, Sustainable Development Goal (SDG) 7 on ensuring access to reliable, affordable, sustainable, and modern energy for all by 2030 was adopted. Its precursor was the UN's *Sustainable Energy for All* (SEforALL) Initiative launched in 2013. The adoption of SDG 7 acknowledges the enabling role modern energy can play in supporting delivery of other development goals, including health, education, job creation, inclusive economic development, and gender equality (Alstone et al., 2015). Modern energy access can also deliver co-benefits for wider environmental sustainability and climate protection through sustained transitions to modern energy cooking services (Batchelor et al., 2019) and deployment of solutions powered by distributed renewable electricity (DRE). It is estimated that DRE solutions are the least-cost option for around two thirds of those currently living without electricity globally (IEA et al., 2019).

1.3 Strategies to achieve SDG 7 in Kenya

To meet the goals of Vision 2030, the GoK has set ambitious national targets for energy access, efficiency, and renewable energy, as part of its SE4ALL Action Agenda, and in response

to SDG 7. These targets are: first, universal access to electricity by 2022,[1] and to clean cooking fuels and technologies by 2028;[2]; second, improving the annual energy intensity rate by -2.785% by 2030; and third, increasing the share of renewable energy in the national energy mix to 80% by 2030.

It is important to note that in the baseline year of 2012 for universal access to electricity, only 23% of households in Kenya (or 1.97 million households) had access to grid electricity. The baseline year for access to clean cooking solutions is 2013. According to a market assessment by the Clean Cooking Alliance (CCA) in 2013, about 3.2 million households had access to improved cookstoves (CCA, 2013).

The government launched the Kenya Electrification Strategy (KNES) in 2018, in line with the NEP (Republic of Kenya, 2018d). KNES provides a roadmap to achieving the 2022 universal access to electricity target. KNES recognizes the key role played by distributed renewable solutions (off-grid options, mini grids, and stand-alone solar systems) to complement centralised grid extension and densification. Although the KNES (2018–2022) estimates that about 38,661 household connections will be best provided through mini grids in Kenya, other analysis estimates that between 660,000 and 2.1 million household connections could be achieved through mini grids, representing 17-58% of current non-electrified households in rural areas (Action to Ambition, 2018). Based on this range, mini grids could supply between 180 and 570 GWh of electricity in Kenya by 2030.

Energy efficiency can be a major contributor to delivering energy access as well as climate action through mitigation, and other co-benefits associated with efficiency improvements. The SDG 7 efficiency target aims to double the rate of improvement in energy efficiency by 2030.[3] The GoK has put in place enabling reforms to promote energy efficiency and conservation measures including the Energy Management Regulations of 2012, requiring regular energy audits by large-scale energy users; and the Energy (Solar Water Heating) Regulations of 2012 requiring installation of solar water heaters by establishments using more than 100 litres of hot water per day. Between 2010 and 2013, Kenya Power and Lighting Company (KPLC) installed energy-saving Compact Fluorescent Lamps (CFL) in residential houses replacing inefficient incandescent bulbs. Further, GoK has a target of installing solar water heaters in at least 800,000 units of residential buildings by 2020. In terms of wider societal action, the Kenyan Association of Manufacturers (KAM), through the Centre for Energy Efficiency and Conservation (CEEC), has been conducting energy audits, energy efficiency campaigns, and training of industry personnel in energy efficiency.

1.4 Measuring Energy Access

Progress on SDG 7 is currently measured by binary assessments of physical infrastructure within households ie does the household have an electricity connection, and do they use clean fuels and technologies as their main means of cooking? 'Clean cooking' is interpreted as a mixture of fuels and technologies that does not result in emissions of carbon monoxide and soot (particulate matter: PM 2.5) that exceed the limits set by the World Health Organization

1 The baseline year for access to electricity for Kenya is 2012.
2 The baseline year for access to clean cooking solution is 2013
3 Energy intensity is measured in terms of primary energy and GDP. https://sdg-tracker.org/energy#targets.

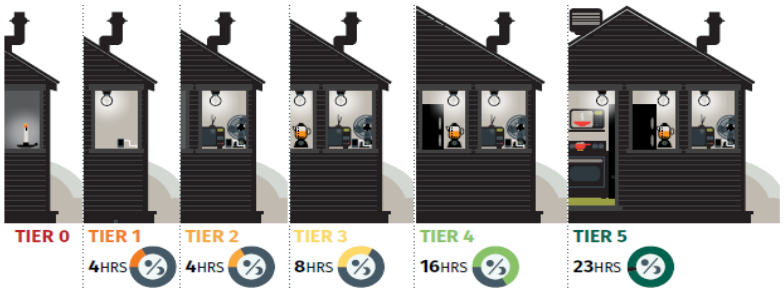
(WHO, n.d.). In practice, this means: stoves that use electricity or gaseous fuels such as LPG, natural gas or biogas; liquid alcohol fuels, and solar-powered cookstoves.

In the future, advanced cookstoves that burn solid fuels much more cleanly than traditional fires may also be included (ODI, 2020).

This is a good start, but it tells us nothing about the quality of energy access for these fuels and energy technologies, nor about other energy needs inside and outside the home. In the language of SDG 7, it does not tell us if energy fuels or technologies are affordable, reliable (and for how many hours a day), safe or healthy to use for the range of activities that people need energy for in the home and in their community.

As part of an emerging consensus around the need for more meaningful metrics that can capture all the various aspects of energy access: see, for instance, Bhatia and Angelou (2015) - the World Bank's Energy Sector Management Assistance Programmes (ESMAP) has developed the *Multi-Tier Framework for Measuring Energy Access* (MTF) to better understand the quality of different types of energy services that people have access to at home and in their community. The MTF defines energy access as "the ability to avail energy that is adequate, available when needed, reliable, of good quality, convenient, affordable, legal, healthy and safe for all required energy services" (World Bank Group, n.d.).

The MTF approach goes beyond the traditional binary measurement of energy access - for example, having or not having a connection to electricity, using or not using clean fuels in cooking - to capture the multi-dimensional nature of energy access and the vast range of technologies and sources that can provide energy access, while accounting for the wide differences in user experience. The MTF approach measures energy access provided by any technology or fuel based on a set of attributes that capture key characteristics of the energy supply that affect the user experience. Based on those attributes, it then defines six tiers of access, ranging from Tier 0 (no access) to Tier 5 (full access) along with a continuum of improvement (see Figure 1). Each attribute is assessed separately, and the overall tier for a household's access to electricity is the lowest applicable tier attained among the attributes (Bhatia and Angelou, 2015).



Tier 0

Electricity is not available or is available for less than 4 hours per day (or less than 1 hour per evening). Households cope with the situation by using candles, kerosene lamps, or dry-cell-battery-powered devices (flashlight or radio).

Tier 1

At least 4 hours of electricity per day is available (including at least 1 hour per evening), and capacity is sufficient to power task lighting and phone charging or a radio (see table 1). Sources that can be used to meet these requirements include a Solar Lighting System (SLS), a Solar Home System (SHS), a mini-grid (a small-scale and isolated distribution network that provides electricity to local communities or a group of households), or the national grid.

Tier 2

At least 4 hours of electricity per day is available (including at least 2 hours per evening), and capacity is sufficient to power low-load appliances—such as multiple lights, a television, or a fan (see table 1)—as needed during that time. Sources that can be used to meet these requirements include rechargeable batteries, an SHS, a mini-grid, or the national grid.

Tier 3

At least 8 hours of electricity per day is available (including at least 3 hours per evening), and capacity is sufficient to power medium-load appliances—such as a refrigerator, freezer, food processor, water pump, rice cooker, or air cooler (see table 1)—as needed during that time. In addition, the household can afford a basic consumption package of 365 kWh per year. Sources that can be used to meet these requirements include an SHS, a generator, a mini-grid, or the national grid.

Tier 4

At least 16 hours of electricity per day is available (including 4 hours per evening), and capacity is sufficient to power high-load appliances—such as a washing machine, iron, hair dryer, toaster, and microwave (see table 1)—as needed during that time. There are no frequent or long unscheduled interruptions, and the supply is safe. The grid connection is legal, and there are no voltage issues. Sources that can be used to meet these requirements include diesel-based mini-grids or the national grid.

Tier 5

At least 23 hours of electricity per day is available (including 4 hours per evening), and capacity is sufficient to power very high–load appliances—such as an air conditioner, space heater, vacuum cleaner, or electric cooker (see table 1)—as needed during that time. The most likely source for meeting these requirements is mini-grid or the national grid.

Figure 1 The MTF tiers of energy access

The World Bank has now launched the *Global Survey on Energy Access*, using the MTF approach. The first phase is being carried out in 17 countries across Latin America, Africa, and Asia. The survey's objective is to provide more nuanced data on energy access, including access to electricity and cooking solutions.

Rather than posing a simple yes/no question, the MTF surveys ask households about their energy use and evaluate household access to electricity and clean cooking across different dimensions using two separate, six-tier systems. They also consider energy access beyond household use, for community services and productive uses. As of 2020, MTF surveys have been carried out in only 16 countries, including Kenya (Dubey et al, 2019). Global tracking of energy access progress against SDG 7 (involving several international agencies) combines these surveys with standard binary assessments in the annual *Tracking SDG 7: The energy progress report*.[4]

1.5 Tracking Progress on SDG 7 in Kenya

4 See https://trackingsdg7.esmap.org/.

According to the latest *Tracking SDG7: Energy progress report* (IEA et al., 2020), Kenya has made significant progress towards achievement of its SEforALL Action Agenda targets. As of 2018, 75% of the population had access to electricity with annualised increment of 7% between 2010 and 2018. This leaves about 13 million people in the country without electricity access.

In addition, 10% of the population in the country had access to clean cooking solutions in 2018, 24% in urban areas, and less than 5% in rural areas. This means that over 44 million people had no access to clean fuels and cooking technologies in 2018 (IEA et al., 2020). While the goal of universal electrification is within reach, progress on clean cooking is very slow: an annual growth rate of 0.5% between 2010-2017. The annual growth rate falls short of the required annual growth rate of 3% if the 2030 targets are to be achieved.

In terms of energy efficiency, the compounded annual growth rate of energy intensity (%) in Kenya between 2015 and 2017 was -2.1%. For the renewable energy (RE) target, RE accounted for 71.8% of total share of energy consumption in Kenya in 2017, with solid biomass energy constituting 68.4%, hydro 1.3% and geothermal, 2% (IEA et al., 2020).
The National Census (KNBS, 2019, p. 338)) shows the distribution of households in Kenya based on fuels used for lighting and cooking (see

Table 1*and*

Table *2*

County/ Sub-County	Conventional Households	Type of Lighting Fuel (%)														
		Mains Electricity	Paraffin Pressure lamp	Paraffin Lantern	Paraffin Tin lamp	Gas Lamp	Wood	Solar	Torch/ Spotlight-Solar Charged	Torch/ Spot light-Dry cells	Candle	Battery (Car/Charged)	Generator (Diesel/Petrol)	Biogas	Not Stated
KENYA	12,043,016	50.4	0.3	6.6	9.6	0.2	2.8	19.3	5.2	3.8	1.3	0.4	0.1	0.0	0.0
Rural	7,379,282	26.3	0.4	9.4	13.9	0.2	4.3	29.9	8.1	5.8	1.0	0.6	0.1	0.0	0.0
Urban	4,663,734	88.4	0.2	2.2	2.8	0.1	0.3	2.4	0.7	0.7	1.8	0.1	0.0	0.0	0.0

Table 1 Percentage distribution of conventional households by main lighting fuel

Over half (50.4%) of households reported using electricity from the main gird as a source of lighting, as shown in

. This is followed by solar PV at 19.3%. Urban households have the highest use of grid electricity at 88.4% whereas rural areas have the highest use of solar PV for lighting at 29.9%.

County/ Sub-County	Conventional Households	Type of Cooking Fuel (%)							
		Electricity	Paraffin	Gas (LPG)	Biogas	Firewood	Charcoal	Solar	Not Stated
KENYA	12,043,016	0.9	7.8	23.9	0.5	55.1	11.6	0.2	0.0
Rural	7,379,282	0.4	1.6	5.6	0.3	84.1	7.7	0.2	0.0
Urban	4,663,734	1.7	17.7	52.9	0.7	9.2	17.7	0.0	0.0

Table 2 Percentage distribution of conventional households by main cooking fuel

At the national level, 55.1% of all household use firewood to meet their cooking and heating needs (see Table 2), followed by use of LPG at 23.9% and charcoal at 11.6%. LPG is the most used fuel in urban areas (52.9% of households).

1.6 Energy Access Initiatives

The GoK, including working in collaboration with other international energy actors, have targeted energy access through various initiatives, mostly aimed at electricity access. For a full list, see SEforALL et al. (2020, p. 16).

Market-based energy access approaches are increasingly being deployed for dissemination and scale up of modern energy services, including in the cooking sector, along with increased RE. by independent producers thanks to enabling reforms (see below). This includes the Kenya Off-grid Solar Access Project (KOSAP) initiative aimed at providing access to modern energy (electricity and clean cooking) to 16 marginalized and underserved counties (Republic of Kenya, 2018e). KOSAP aims to incentivize clean cookstoves distributors to establish sustainable supply chains in the eight underserved counties. The various types of financing subsidy provided to businesses is intended to result in lower, more affordable prices for consumers.

However, end user uptake and the sustainability of RE interventions remain low. One reason for this is that promoters of new energy technologies tend to focus on the supply side and do not pay sufficient attention to demand-side issues such as the affordability of products and services by last-mile consumers.

The market challenges are compounded by weak institutional and policy frameworks and in the approaches taken towards energy access planning. These include the fact that industrial power provision often takes precedence within (sub)national policy agendas, electricity access receives greater attention that clean cooking solutions, and electricity access is usually focussed on access to household lighting, rather than to higher levels of power for community services and productive uses.

Recent research into the impact of the various energy access initiatives undertaken in the country (SEforALL et al., 2020) finds, first, that promoting energy access (connections) is inherently different from promoting energy use (consumption) and that for poor and vulnerable groups to be able to consume energy services and products, they require recurring support. Social protection approaches to delivering energy access ("energy safety nets") used

in several countries may have useful learning to offer in terms of delivering energy services to the poorest and most vulnerable. In the case of Kenya, linkages with the National Safety Net Programme (NSNP) could help identify and target beneficiary households thus informing more effective design and implementation of future energy access initiatives.

Second, gender considerations have not been integral to the planning and implementation of Kenya's energy access programming to date, even though energy poverty impacts men and women differently. Interventions to promote energy access and use should target the household member most affected, recognizing that this may not be the household's energy decision maker.

Finally, for electricity access, the lifeline electricity tariff as currently designed, supports consumption by poor and vulnerable households but is inefficient, given it also supports many non-poor households.

Suggested ways to address these policy gaps are that the GoK, first, strengthen coordination between the Ministry of Energy and Ministry of Labour and Social Protection through the creation of an inter-ministerial committee. Second, gender considerations could be strengthened and instutionalised in the design, implementation, and evaluation of energy access programming by mandating the Cabinet Secretary to introduce a Gender Mainstreaming Regulation under the 2019 Energy Act.

Third, the lifeline electricity tariff could be changed from the current threshold of 100 kWh per month to improve its targeting and increase support for poor and vulnerable households, including by introducing an ultra-low tariff for users consuming up to 20 kWh per month.

Finally, an overarching recommendation is that the GoK explicitly introduce a regulation on energy safety nets to ensure they are part of the enabling policies toolkit. This could be done as part of 2019 Energy Act implementation and the current review of the Social Assistance Act.

1.7 Current Policies and Regulations

The foundational policies for energy planning in Kenya were established in the 2004 Sessional Paper No. 4 on Energy (Republic of Kenya, 2004). Its vision was to "promote equitable access to quality energy services at least cost while protecting the environment'" (p.vii) and it proposed the creation of the Rural Electrification Authority (REA) to accelerate rural electrification. A lifeline tariff for domestic users using up to 50 kWh per month was envisaged (recognizing that the tariff must cover the cost of generation). LPG and biogas were also to be promoted as cleaner fuels for household cooking. The policy further recommended establishment of the Energy Regulatory Commission (ERC), an independent energy regulator whose mandate was to set electricity and petroleum prices and tariffs, issue licenses and permits, support energy planning, and provide legal oversight to the sector among other duties. The importance of public disclosure of energy prices was highlighted in the policy.

In 2006, the Energy Act No.12 (Republic of Kenya, 2006) operationalised the 2004 NEP, establishing the ERC. Since then, ERC has overseen tariff setting including revision of the lifeline tariff. REA was also established to implement the rural electrification programme (REP) and manage the REP Fund for areas considered economically unviable for electrification by licensees. The REP Fund is sourced from a levy of up to 5% of the electricity consumed in the

country plus budget appropriations, donations, grants and loans, interests from bank deposits, and from other programmes, as approved by the MoE.

A Feed-in Tariff (FiT) Policy was adopted in 2008 and revised in 2012 (Republic of Kenya, 2012) to allow power producers to sell electricity generated from renewable energy sources to an off taker at a pre-determined tariff within a given timeframe. The policy has been helpful in accelerating investment in electricity generation from RE sources such as wind, geothermal, biomass, small hydro, biogas and solar energy.

Other key regulatory policies for the energy sector include: the Geothermal Resources Act No. 12 (Republic of Kenya, 1982), enacted to control the exploitation and use of geothermal resources; the Petroleum (Exploration and Production) Act (Republic of Kenya, 1984), now superseded by the Petroleum Act of 2019 (Republic of Kenya, 2019), enacted to regulate the negotiation of petroleum agreements by the Government; and the Petroleum Development Fund Act (Republic of Kenya, 1991) enacted to establish the Petroleum Development Fund and imposition of a Petroleum Development Levy.

The governance of energy planning at national and county level is articulated in four key frameworks. First, the Constitution of Kenya (Republic of Kenya, 2010), which outlines the role of national and county government on energy planning; second, the County Governments Act (Republic of Kenya, 2012) which provides for county government powers, functions and responsibilities to deliver services; third, the NEP (Republic of Kenya, 2018) which outlines policies and strategies for energy sector, include the role of both national and county governments; and finally, the Energy Act 2019 (Republic of Kenya, 2019) which aligns the legal and regulatory framework of the energy sector with the Constitution and articulates more clearly the roles of the national and county governments in relation to energy sector development in the country.

The Constitution provides for a two-tier governance structure where roles and responsibilities are shared between the GoK and Kenya's 47 counties. In relation to energy sector governance, Part 1 of the Fourth Schedule states that the GoK is responsible for: (a) protection of the environment and natural resources with a view to establishing a durable and sustainable system of development including water protection; (b) energy policy including electricity and gas reticulation and energy regulation; and (c) public investment. The role of county governments under Part 2 of the Fourth Schedule includes responsibility for county development planning including electricity and gas reticulation and energy regulation.

In response to calls to consolidate the multiple regulations relating to energy sector development, including promotion of renewable energy and regulation of midstream and downstream petroleum and coal activities, and to operationalize the NEP 2018, a new Energy Act came into force in March 2019 (Republic of Kenya, 2019).

Article 5 (1) mandates the Cabinet Secretary for Energy to "develop, publish, and review energy plans with respect to the coal, renewable energy and electricity sectors" (p. 25) in consultation with relevant stakeholders with an aim of ensuring that energy services are reliable and are delivered at the least cost. Article 5 (2) requires all national energy service providers to develop and submit to the Cabinet Secretary plans for provision of energy services in accordance with their mandates. Article 5 (3) requires all the 47 County Governments to individually develop and submit a County Energy Plan (CEP) to the Cabinet Secretary that

responds to the energy needs of the county. The Cabinet Secretary is then required under Articles 5 (4) to consolidate the plans produced in accordance with Articles 5 (2) and 5 (3) into an integrated national energy plan (INEP).

The INEP will be reviewed every three years. However, the Cabinet Secretary is required under Article 6 to prepare and publish a report on the status of its implementation within three months after the end of each financial year (p. 26).

The Energy Act 2019 thus creates the opportunity for the MoE to ensure more coordinated and needs-based national energy planning through its mandate for development, implementation and monitoring of energy policy and integrated planning in consultation with relevant stakeholders, development of County Energy Plans (CEPs) and creation of a conducive investment environment, including formulation of guidelines with relevant county agencies on the development of energy projects.

Other Acts of parliament that are relevant to the development of the energy sector in Kenya can be found in Annex 1.

The development context in Kitui County

1.8 Overview of Kitui County

***Location and Administrative Structure*:** According to the *Kitui County Energy Outlook* (SEAF-K, 2017), Kitui County is located about 160km east of Nairobi, and is the sixth largest county in Kenya. Kenya National Bureau of Statistics (KNBS) (2019). According to the National Census (KNBS, 2019, Volume I), the land area is 30,429.5 km2. The County is divided into eight (8) sub-counties: Kitui Central, Kitui West, Kitui East, Kitui South, Kitui Rural, Mwingi North, Mwingi Central and Mwingi West. These are further sub-divided into forty wards.

Climate and topography: According to SEAF-K (2017), the County is characterized as having an arid and semi-arid climate, with low -lying topography (the altitude ranges from 400m to 1800m above sea level). Rainfall distribution is erratic and unreliable, ranging from 500mm to 1050mm per annum. The maximum mean annual temperature ranges between 26°C and 34°C and the minimum between 14°C and 22°C. There are two annual rainy seasons. The long rains fall in the months of March to May and the short rains in October-December.

Demography: According to KNBS (2019, Volume I), the total population of Kitui is just over one million people (1,136,187), comprising 549,003 men and 587,151 women with 33 intersex. There are 262,942 households in the County with an average household size of 4.3 people. The population density is the ninth lowest in the country, at 37 people per square kilometre. Kitui and Mwingi are the major urban centres.[5] Other upcoming centres include

5 Defined as a town with a population between 10,000 and 250,000. (Cities and Urban Centres Act, 2012).

Mutomo, Kwa Vonza, Migwani, Tseikuru, Kabati, Tulia, Katse, Ikutha, Mutitu/ Ndooa, Zombe, Kyusyani, Kyuso and Nguni.

Overall, over 48.3% of the population in Kitui County of 5 years and above are in employment, with a similar percentage of people outside the labour force in 2019 (KNBS, 2019, Volume IV). At the national level, about 47.7% of the population above 5 years of age are working, while about 46% are outside the labour force. About 3.2% of the population in Kitui County were looking for employment.

Table ***3*** below shows distributions of population by sex in term of those working, seeking work and those outside the labour force at national level and in Kitui County.

Sub-County/Sex	Total	Working	Seeking Work/ No Work Available	Persons outside the Labour Force2	Not Stated
National (Kenya)	**41,235,190**	**19,677,401**	**2,621,158**	**18,927,688**	**8,943**
Male	20,317,125	9,789,958	1,478,110	9,044,599	4,458
Female	20,916,821	9,886,838	1,142,914	9,882,589	4,480
KITUI	1,004,160	486,486	31,902	485,625	147
Male	481,638	218,838	19,558	243,184	58
Female	522,497	267,636	12,342	242,430	89

Table 3 Distribution of Population Age 5 Years and above by Activity Status, Sex, County (p. 162 & p. 167)

The percentage of those in urban areas in employment is slighter higher than the county average at 52.5% of the urban population as shown in

Table *4* below.

Sub-County/sex	Total	Working	Seeking Work/ No Work Available	Persons outside the Labour Force2	Not Stated
KITUI	**45,165**	**23,703**	**4,146**	**17,314**	**2**
Male	21,149	11,839	1,891	7,418	1
Female	24,016	11,864	2,255	9,896	1

Table 4 Distribution of Urban Population Age 5 Years and above by Activity Status, Sex, County (p. 167)

In rural Kitui, 48.2% were in employment as shown in

Table *5* below, according to KNBS (2019, Volume IV).

Sub-County/sex	Total	Labour Force			
		Working	Seeking Work/ No Work Available	Persons outside the Labour Force2	Not Stated
KITUI	**958,995**	**462,783**	**27,756**	**468,311**	**145**
Male	460,489	206,999	17,667	235,766	57
Female	498,481	255,772	10,087	232,534	88

Table 5 Distribution of rural population age 5 years and above by activity, status, sex and county (p. 167)

Household consumption & expenditure:[6]

According to the most recent data available (2015), the national average mean monthly consumption expenditure (food and non-food) per capita (KES) in Kenya was 7,811 and the median was KES 5,830 (in rural areas, this was 5,326 and 4,282 respectively for mean and median expenditure respectively) (KNBS, 2018).

This compares to a mean monthly expenditure per adult equivalent in Kitui of KES 5,478. The median total expenditure figure is much lower at 4,082. Of the mean monthly figure, KES 3,424 was food expenditure and KES 2,054 non-food expenditure (62.5% vs. 37.5%). The percentage figures for food expenditure are in line with the national picture for rural households (64.7%; for peri-urban areas the figure is 58%)

In terms of percentage food consumption, this equates per household to 56.9% from purchases, 6.5% from stock, 31.7% from own production and 4.8% from gifts. This means Kitui inhabitants have a higher level of food consumption from own production (31.7%) than the national average (18%) and somewhat higher than the percentage for rural (%) urban areas (27.7 and 21.7% respectively).

Poverty rates:[7] Kitui was not classified among those counties with high levels of extreme poverty although at 12.8% of individuals, the incidence of extreme poverty is above the

6 The measure of welfare used in KNBS (2018) is not income-based but rather based on consumption expenditures "in line with past poverty reports for Kenya (GoK, 1997, 2000 and 2007) and international best practice."

7 The poverty indicators used are as follows: 'Food Poverty: households and individuals whose monthly adult equivalent food consumption expenditure per person is less than Ksh 1,954 in rural and peri-urban areas and less than Ksh 2,551 in core-urban areas respectively are considered food poor or live in "food poverty". Overall Poverty: households and individuals whose monthly adult equivalent total consumption expenditure per person is less than Ksh 3,252 in rural and peri-urban areas and less than Ksh 5,995 in core-urban areas are considered to be overall poor or live in "overall poverty". Hardcore or Extreme Poverty: households and individuals whose monthly adult equivalent total consumption expenditure per person is less than Ksh 1,954 in rural and peri-urban areas and less than Ksh 2,551 in core-urban areas respectively are considered to be hardcore poor or live in "hardcore or extreme poverty".' (KNBS, 2018, p. 44).

national average of 8.6% (11.2% in rural areas and 6% in peri-urban areas) and Kitui was recognised as a county with concentrations of extreme poor populations (KNBS, 2018, p. 54).

In terms of people living in overall poverty, Kitui has a higher percentage than the national average. 47.5% of people were classified as living in poverty compared to 36.1% nationally (40.1% in rural areas; 27.3% in peri-urban areas) and 39.3% of households, compared to 27.4% nationally (32.6% in rural areas; 21.1.% in peri-urban).
Almost half of the county's children were living in poverty (49%), higher than the national average of 41.5 (43.9% in rural areas; 30.2% in peri urban).
In terms of people living in food poverty, Kitui is also above the national average. In 2015, 39.4% of people were classified as living in food poverty (versus the national food poverty rate of 32%; 35.8% in rural areas; 29.1 cent in peri urban), along with 40.2% of children (35.8% nationally; 38.5 in rural areas; 31.3% in peri urban).
Main economic activities: The main economic activities include agriculture comprising of food, cash crops and livestock; tourism; trade and industries like cotton ginnery, fruit processing plants and maize milling. The county has deposits such as coal, limestone, granite, gypsum, vermiculite, sand, and gemstones (SEAF_K, 2017). For instance, Mui and Kyuso are rich in limestone and there are plans for excavation in the future. Gypsum is present in Mwingi South and gemstone at Tharaka and Tseikuru. Sand harvesting and mining of gemstones is done primarily by the local artisans.

1.9 Kitui County Development priorities

The five-year Kitui County Integrated Development Plan (CIDP) outlines the priority policies, programmes, and projects of the County Government. The current CIDP (2018-2022) aims to "[mainstream] the development agenda outlined in the Governor's Manifesto and accords priority to programmes and projects that support the goals of the Third Medium-Term Plan (MTP III, 2018-2022) and Kenya Vision 2030." (County Government of Kitui, 2018a, p. 52).

The MTP III (Republic of Kenya, 2018a) aims to put the economy on a high growth path and foster its social-economic transformation. Aligned with this, the overall mission of the Governor's office is to "provide effective County services and an enabling environment for inclusive and sustainable socio-economic development and improved livelihoods for all" (County Government of Kitui, 2018a, p. 64). The Governor's Manifesto has five pillars: food security and water; Universal Health Coverage (UHC); education and training; Women, Youth & People with Disabilities (PWDs) Empowerment; and Wealth Creation. The Pillar on Wealth Creation "supports the realization of the Third Medium-Term Plan goals on expanding manufacturing and is in tandem with the 'Manufacturing' development Agenda under the 'Big Four'" (County Government of Kitui, 2018a, p. 52).[8]

Priorities for the County Government outlined in the CIDP include supporting value addition in agriculture and livestock industries given that "food security cannot be guaranteed without provision of water due to the semi-arid climatic conditions in the County" (p. 52). Given these climatic challenges, irrigation and programmes to enhance access to water such as water harvesting, drilling of boreholes, and extensions of water piping are also to be given priority.

8 The "Big Four" are manufacturing; housing; food security; and universal health coverage. The Big Four development agenda growth targets include the following: Guaranteeing food security and nutrition to all Kenyans by 2022; Raising manufacturing sector's share to GDP to 15% by 2022; Universal Health Coverage thereby ensuring quality and affordable healthcare to all Kenyans; and Developing at least five hundred thousand (500,000) affordable new houses for Kenyans by 2022.

Investments in education and training, and Women, Youth & PWDs Empowerment are also seen as critical to fostering "equitable and inclusive growth".

In her foreword to the CIDP, the Governor also outlines a commitment to "environmentally friendly development, as a result, we shall be pursuing various environmental adaptation and mitigation measures including promotion of drought resistant crops, clean energy, water harvesting, tree-planting and conservation of water-catchment areas" (p. 11). The County's priority development programmes and objectives for 2018-22, and how they link to the Sustainable Development Goals (SDGs), are summarised below (County Government of Kitui, 2018a, p. 8).

Kitui CIDP 2018-2022 objectives/priority programs	**Integrated SDGs**
○ Food security and water ○ Ending drought emergencies ○ Access to certified inputs to enhance agricultural productivity ○ Expansion of irrigation schemes	Goal 1: End poverty in all its forms everywhere Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
○ Universal Health Coverage (UHC): quality and affordable healthcare ○ Combating communicable and non-communicable disease	Goal 3: Ensure healthy lives and promote well-being for all ages
○ Pro-poor support programmes: Bursary support to needy students ○ [Free Early Childhood Development Education (ECDE)]	Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
○ Promote values and principles of governance as provided in Articles 10 and 232 of the Constitution	Goal 5: Achieve gender equality and empower all women and girls
○ Increased access to water (drilling of boreholes, water dams and extending piping network) ○ Ending open defecation ○ Participation by local communities in water management ○ Implementation of WASH programs in Schools	Goal 6: Ensure availability and sustainable management of water and sanitation for all
○ Increased access to electricity including off-grid for public institutions ○ Promotion of alternative energy efficient technologies to conserve forests	Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all
○ Wealth creation: agriculture and livestock value addition ○ Support to SMEs including access to finance	Goal 8: Promote sustainable economic growth, full and productive employment and decent work for all
○ Support development of cottage industries ○ Promotion of agricultural value addition ○ Implementation of Community-Level Infrastructure development	Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
○ Implementation of pro-poor support programs	Goal 10: Reduce inequality within and among countries
○ Urban development planning to ensure access of all to basic services	Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable
○ Sustainable management of natural resources	Goal 12: Ensure sustainable consumption and production patterns
○ Implementation of Ending Drought Emergencies initiatives (Mitigation and adaptation)	Goal 13: Take urgent action to combat climate change and its impacts

○ Water catchment conservation and Rehabilitation ○ Tree growing to improve forest cover	Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss
○ Ensure effective, accountable, and transparent institutions at the County level ○ Combat corruption at the County level ○ Ensure participatory and representative decision-making at the County level	Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
○ Strengthen own source revenue mobilization	Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

Table 6 Linkages between the Kitui CIDP and the SDGs

The solutions developed in this CEP are also aligned with many of the sectoral (Ministerial) priorities (County Government of Kitui, 2018a, pp. 83-121). They will also contribute to delivering the overall outcomes of the Governor's specific priority programme on Community Level Infrastructure Development Programme (CLIDP) of "improved social economic lives and living standards of Kitui County residents", as well as many of the sector-specific objectives" (pp. 64-75).

The holistic and integrated nature of the solutions and the identification of synergies between different sectoral solutions developed through the county energy planning process (see Section 5) are also aligned with the priorities of the Treasury to ensure "effective economic planning and prudent management of public resources", including through additional resource mobilization (p. 78).

The Energy Context in Kitui County

1.10 Overview - the context for county energy planning

As discussed, the GoK, including working in collaboration with other international energy actors, have targeted energy access through various initiatives, mostly aimed at electricity access. For a full list, see SEforALL, CAFOD, ODI and EED Advisory (2020). This includes the Kenya Off-grid Solar Access Project (KOSAP) initiative aimed at providing access to modern energy (electricity and clean cooking) to 16 marginalized and underserved counties (Republic of Kenya, 2018e).

Counties have already been targeted by various national and international energy actors, and market-based energy access approaches are increasingly being deployed for dissemination and scale up of modern energy services. For example, county-level adoption of renewable energy technologies such as clean cookstoves and solar home systems. Through promoting understanding of new technologies and employing initial-use incentives to stimulate supply and demand, policymakers are aiming to build an enabling environment for entrepreneurs to establish and sustain energy markets made up of producers, distributers, retailers, marketers, consumers, after-sales support, and financial services.

While these ongoing efforts have helped increase availability of clean energy technologies within counties, end user uptake and the sustainability of RE interventions in Kenya's counties remain low - with significant regional variations both in terms of levels of energy access and reliability of supply. One reason for this is that promoters of new energy technologies tend to focus on the supply side and there is little attention paid to demand-side issues such as the affordability of products and services by last-mile consumers, their preferences and practices in terms of using energy technologies and fuels, which can be determining for acceptance and sustained uptake of services and products (see Section Five). Such barriers are complex that energy businesses/enterprises alone do not have the financial capacity, capacity building resources and knowledge/capacity on socio-cultural and political economy issues to address them.

The market challenges are compounded by weak institutional and policy frameworks and the approaches taken towards energy access planning. Industrial power provision often takes precedence within (sub)national policy agendas, while electricity access receives greater attention than clean cooking solutions and electricity access is often focussed on household lighting, rather than higher levels of power for productive uses. Finally, there is a lack of capacity and awareness of the need for more inclusive and integrated energy planning approaches to realize the benefits of energy as an enabler of wider development and to tailor services to meet demand or end-user needs, including to disaggregate the needs of different end user groups (for further discussion of this point, see Section Five).

These limitations are further accentuated by the following gaps or challenges in relation to county energy planning:

- Gaps in data and analysis: insufficient or poor-quality data on levels of access, as well as on the energy needs of end users operating in varied social contexts
- Technical capacity gaps within county governments, in terms of both policies and regulatory policies, technology options, as well as knowledge of energy as an enabler of wider development
- Institutional capacity including for project coordination and cross-sectoral planning with other stakeholders operating in the energy sector, including for data sharing and analysis and for inclusive planning, for instance to ensure end user and stakeholder engagement and meaningful in planning processes.

These data and capacity gaps impede the ability of county governments and other stakeholders to understand the specific energy needs in function of the county context. This includes identifying RE resource potential, energy efficiency gaps and solutions, current grid electrification coverage, and how energy services can support the achievement of the county's development priorities. This limits the ability of county governments to:

- Identify clearly what energy services are needed to meet their development priorities, disaggregate the needs of end users, and identify the gaps or barriers to meeting these development needs, including socio-cultural factors such as preferences and practices
- Develop viable, least-cost solutions for delivering energy services that will meet the development needs and be sustainable (not just financially but also socially and environmentally)
- Leverage support for delivering/implementing the solutions through collaboration with other stakeholders such as businesses, national government agencies and development organisations

- Identify and enact the required enabling policies and identify co-financing options and partners.

1.11 Kitui County energy goals

Kitui's energy vision as articulated by the Ministry of Environment and Natural Resources (MENR) is "to be the leading county in the utilization of electricity, alternative/renewable sources of energy and gainful utilization of minerals in a sustainably managed and healthy environment" with the mission of "improv[ing] the livelihoods of Kitui people through the provision of varied and reliable sources of affordable energy and increased levels of minerals investments in a sustainably managed environment" (County Government of Kitui , 2018a, p. 78).

The MENR's own priorities as they relate to energy service provision (County Government of Kitui, 2018a, p. 78) are as follows:

- Awareness creation of alternative sources of energy
- Rural electrification of institutions and households in partnership with REA and KPLC
- Installation of solar security lights
- Installation of solar-powered pumps
- Establishment of woodlots for fuel
- Establishment of Energy Centres
- Promotion of modern technology kilns and briquetting technology

The Kitui County Energy Outlook (SEAF-K, 2018) highlights the critical role of energy in enabling and driving inclusive and sustainable socio-economic development across all sectors in Kitui. Meeting many of the County's priority development objectives will require increasing provision of reliable, affordable, and sustainable energy services, in addition to other supporting interventions:

> As water provision sector continues to develop, demand for irrigation and pumping also increases, requiring more energy. Other sectors bound to increase energy demand include health and sanitation, education, and agriculture sector particularly for food processing. As incomes increases and urbanization intensifies, household demand for energy will also rise. (SEAF-K, 2018, Executive Summary)

The CIDP equally identifies "multiple constraints" to realizing its transformation vision. These include the following "[a] low resource base, harsh climatic conditions, infrastructure gaps, high levels of poverty, and low access to social economic services such as education, health, water and sanitation, and energy." (SEAF-K, 2018, p. 64).

1.12 Energy for lighting

According to the 2019 Kenya Population and Housing Census (KNBS, 2019, Volume IV), households in Kitui make use of a range of energy sources and appliances to meet their needs for lighting, cooking and other services. In terms of lighting, 44% of households in the county

employ solar powered technologies as their primary source of lighting. This is followed by electricity (17.1%) and paraffin-based solutions (23.7%).

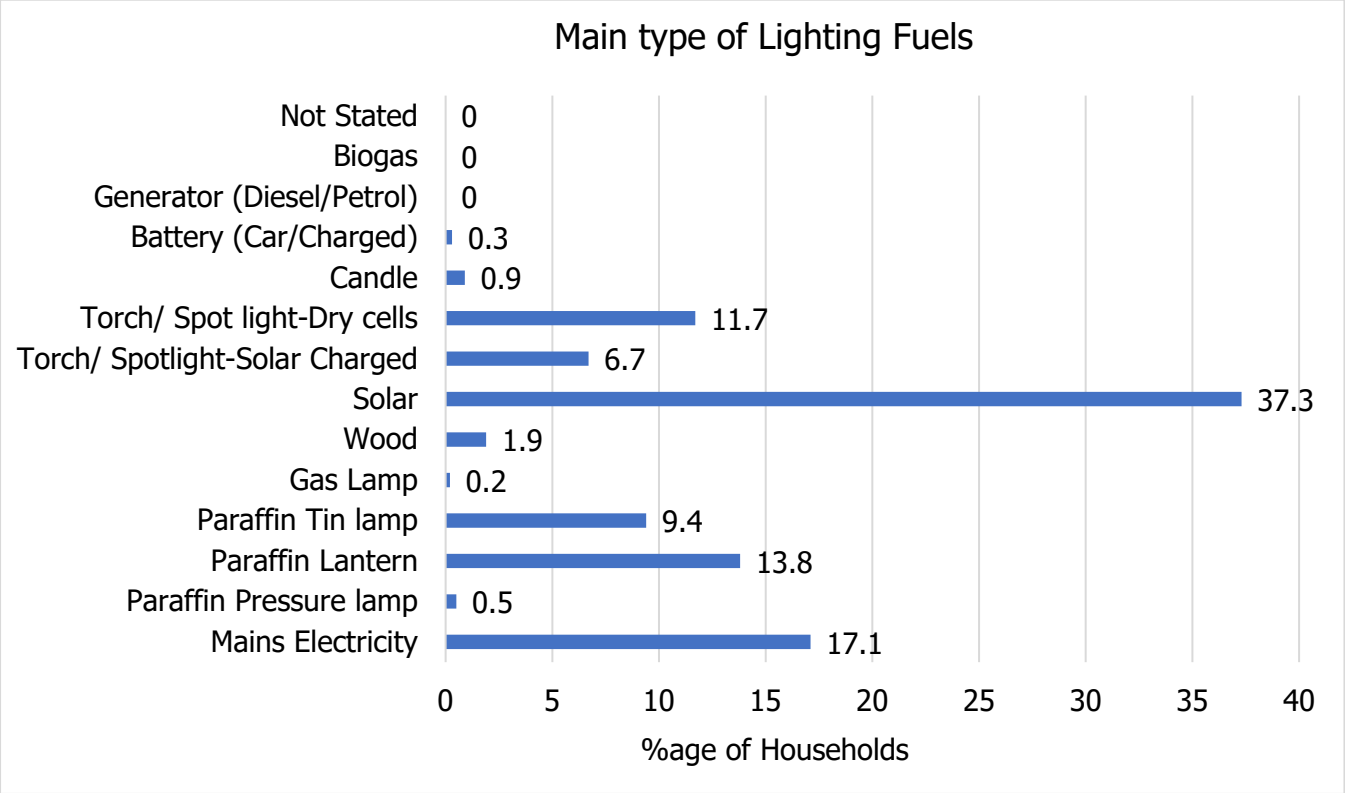


Figure 2 Percentage Distribution of Conventional Households by Main Type of Lighting Fuel in Kitui County

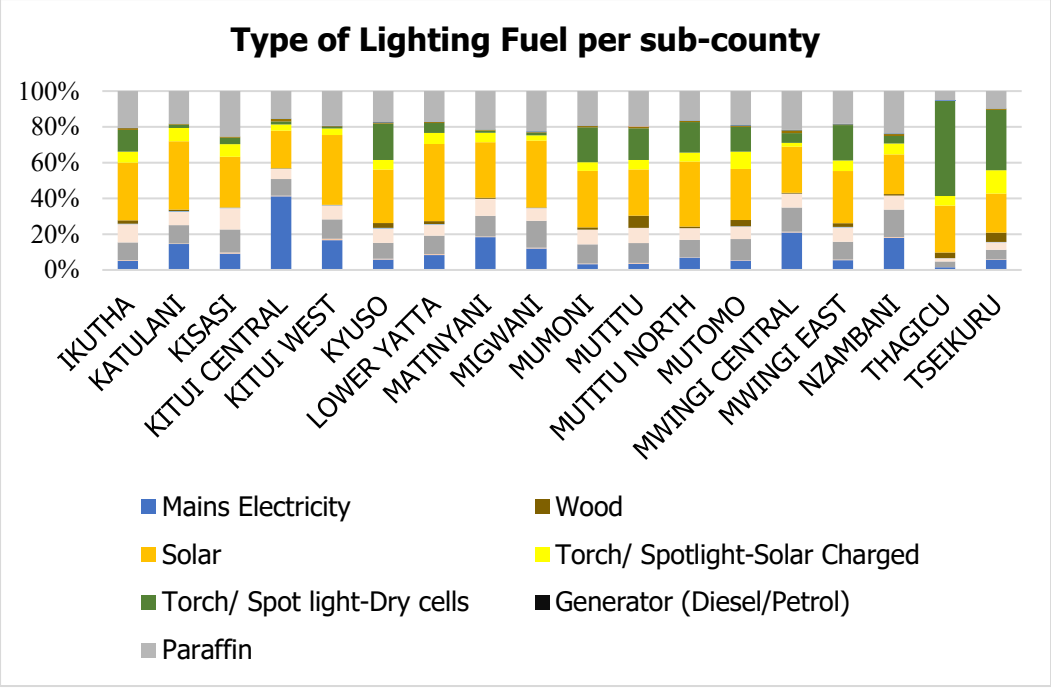


Figure 3 Type of lighting fuel per sub-county

1.13 Energy for cooking

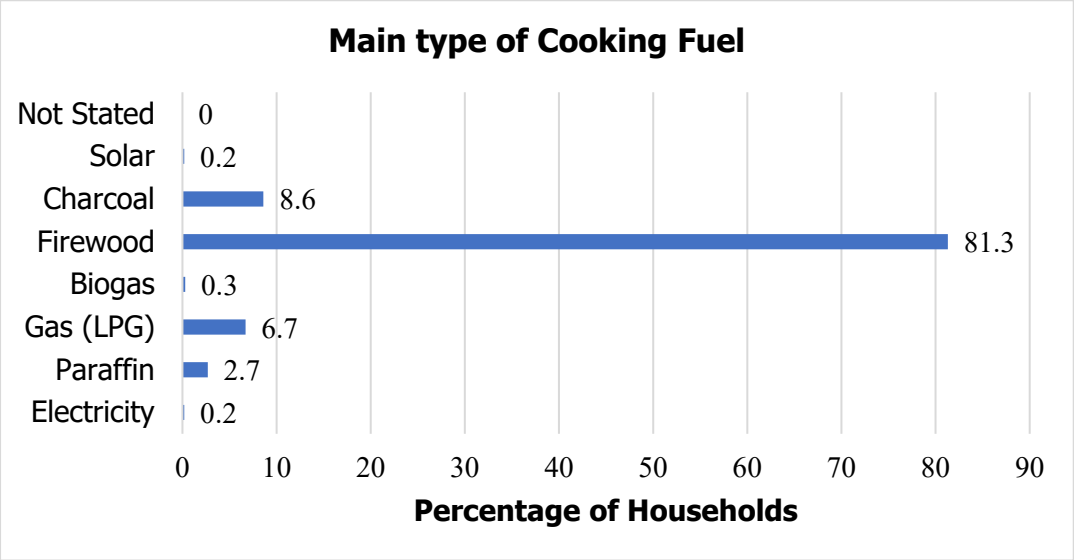


Figure 4 Distribution of Conventional Households by Main Type of Cooking Fuel in Kitui County

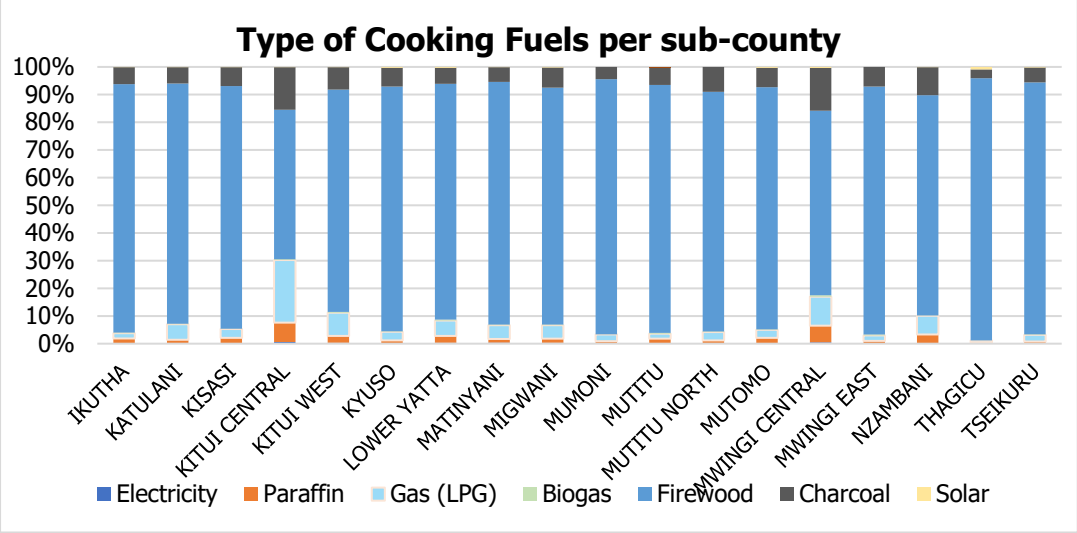


Figure 5 Percentage Distribution of Conventional Households by Main Type of Cooking Fuel in Kitui sub-counties

Based on data obtained from the National Census (KNBS, 2019, Volume IV) households in Kitui county can be classified into four broad categories based on the type of fuels they use to meet their cooking needs, namely:

- **Category I: Households using firewood**: 81.3% or 235,371 households reported using firewood as their main fuel type for cooking.
- **Category II: Households using charcoal**: about 8.6% or 22,516 households in Kitui County use charcoal to meet their cooking needs.
- **Category III: Households using kerosene** - 2.7% or 7,069 households used kerosene for cooking.

- **Category IV: Households using clean or improved fuels and technologies**: 7.4% of households, i.e. LPG (6.7%); biogas (0.3%), solar thermal (0.2%) and electricity (0.2%).

However, it is important to highlight the lack of granular data on how households use these fuels, including distribution of households that explicitly use a single fuel type and those that are practicing fuel/technology stacking. In addition, there is no data on the drivers of different fuel and technology use. Such data gaps make it impossible to have a full, disaggregated picture of fuel usage in Kitui County and its drivers, which impacts on the county government's ability to develop viable solutions to address the priority need for clean and improved cooking solutions.

Category I: Households using firewood

These households are located mainly in rural and peri-urban areas of Kitui County and source firewood from farmlands, forests, and purchase from local markets according to the Kitui County Energy Outlook (SEAF-K, 2017). Those who collect firewood from farmlands or forests are reported to do so for up to 8 times in a month depending on household size and cooking frequency. Those who purchase firewood spend between KES 200 to KES 500 per purchase, dependent on the market location and bundle size, and the fuel will last a household for two weeks to one month. There is lack of data on households that purchase firewood and those who do not pay for firewood. However, according to one survey (GROOTS Kenya, 2017), the majority of households access firewood without making any payment.

In terms of cooking technologies, about 67% of households relying on firewood use Three Stone Open Fires (TSOF) to meet their cooking needs (GROOTS Kenya, 2017). Using the 2019 Census data for population in Kitui County, this would equate to approximately, 142,613 households. Again, there is a lack of data on whether the households in this category use firewood/TSOF exclusively, or practice fuel/technology stacking. The remaining 33% of households use different forms of improved cookstoves such as Jiko Kisasa and Rocket stoves, but it also unclear whether this is combined with use of other cooking technologies.

Category II: Households using Charcoal

Approximately 22,516 households in Kitui County use charcoal to meet their cooking needs. The consumption rate ranges between 10 to 35 Kgs per month. 20% of these households especially in rural areas produce charcoal for their own consumption (ie do not purchase it), while 80% purchase the commodity from local suppliers/retailers. The price range for charcoal in Kitui county in 2017 was between KES 20 to KES 30 per KG (SEAF-K, 2017). This implies that a household spends between KES 200 to KES 1050 per month on charcoal. According to Makee at al. (2016) rural communities in Kitui County engage in charcoal production as a fall-back strategy for income generation especially during years of severe drought (see also Section 3:3). About 35.4% of households using charcoal utilise traditional metallic charcoal stoves. About 64.6% of households use a certain form of improved charcoal stove (SEAF-K, 2017, p. 17), most commonly, the Kenya Ceramic Jiko (which is owned by 87.6% of households with improved cookstoves). It is important to note that most of these households (82%) do not use the improved cookstoves on daily basis, citing the high price of charcoal as the main barrier (Groots Kenya, 2017).

Category III: Households using kerosene

kerosene is mostly used as a secondary fuel for cooking. Monthly consumption ranges between three to four litres for most households, although some consume between 10 to 15

litres (SEAF-K, 2017). In monetary terms, this means most households spent KES 231 to KES 310 per month and a few households spent upfto KES 773/to KES 1160 per month on kerosene (based on a retail price of KES 77.29/litre).[9] However, it should be noted that this monthly consumption data includes use of kerosene for lighting. There is no disaggregated data on kerosene usage for cooking or lighting in Kitui County.

kerosene stoves are either pressurised or have wicks. According to SEAF-K (2017), households using kerosene fuel and stoves have raised concerns regarding its use, including change in colour, smell and the production of large quantities of soot during its use which affect breathing. However, there is a lack of data on such health impacts, and on the specific types of kerosene stove owned or used by households in Kitui.

Category IV: Households using clean or improved fuels and technologies (electricity, LGP, Solar and biogas)

Slightly over 7.4% of all households in Kitui County use different forms of improved or clean fuels and cooking technologies, according to the 2019 Census. As with all categories of fuel usage in Kitui County, there is little robust data on use of such cooking solutions and technologies, including whether households use them exclusively or practice fuel/technology stacking.

1.14 Energy resource potential

According to the County Government of Kitui (2018, p. 52), the following natural resources are present in Kitui County, with the following opportunities and constraints for their optimal utilization. The CIDP also highlights the need for appropriate technologies and for an improved regulatory environment, proper legal frameworks and more public private partnerships to ensure sustainable management of the County's natural resources.

Name of Natural Resource	Dependent Sectors	Status, Level of Utilization & Scenarios for future	Opportunities for optimal utilization	Constraints to optimal utilization	Sustainable Management strategies
Energy - Solar	Energy, Commercial and Domestic Use	Unexploited	Increased electricity supply Reduced energy costs Reliable energy Green energy transition	Inadequate technology and infrastructure High costs of exploiting	Appropriate technology and infrastructure
Minerals Coal	Energy, Industry	Unexploited	Employment	High costs of exploiting	Appropriate technology and infrastructure

9 Calculation based on kerosene prices in Nairobi for the month of May-June 2019. The Energy Petroleum Regulatory Authority (EPRA) issues prices for petroleum products every month

Name of Natural Resource	Dependent Sectors	Status, Level of Utilization & Scenarios for future	Opportunities for optimal utilization	Constraints to optimal utilization	Sustainable Management strategies
Limestone			Increase own source revenue Alternative livelihoods	Inadequate technology; infrastructure	Appropriate legal framework
Forests	Agriculture, Industry and Energy	Over-exploited for charcoal	Green energy Alternative technologies	High dependency on wood fuel	Regulate the industry
Underground water	Agriculture, industry and services	Unexploited	Increased access to water Irrigable agriculture	High costs of exploiting Inadequate technology; infrastructure	Appropriate technology Public private partnership

Table 7 Natural Resource Assessment

The energy source viewed as having the highest potential in Kitui, in terms of meeting the CIDP priorities of increased access to electricity including off-grid for public institutions and promotion of alternative energy efficient technologies to conserve forests, is solar power (p. 53).

1.15 Solar power

According to the Global Solar Atlas (n.d.), the solar potential in Kitui is significant, particularly in the north of the County. Figure 6 shows the long-term yearly average Global Horizontal Irradiation (GHI) in Kitui County, with the average GHI exceeding 2,000 kWh/m^2. This implies a high potential for photovoltaic electricity production (see righthand map, Figure 6). The average potential photovoltaic power output is 4.34 kWh/kW-peak per day. In other words, a small residential PV system could supply on average more than 1,500 kWh per year.

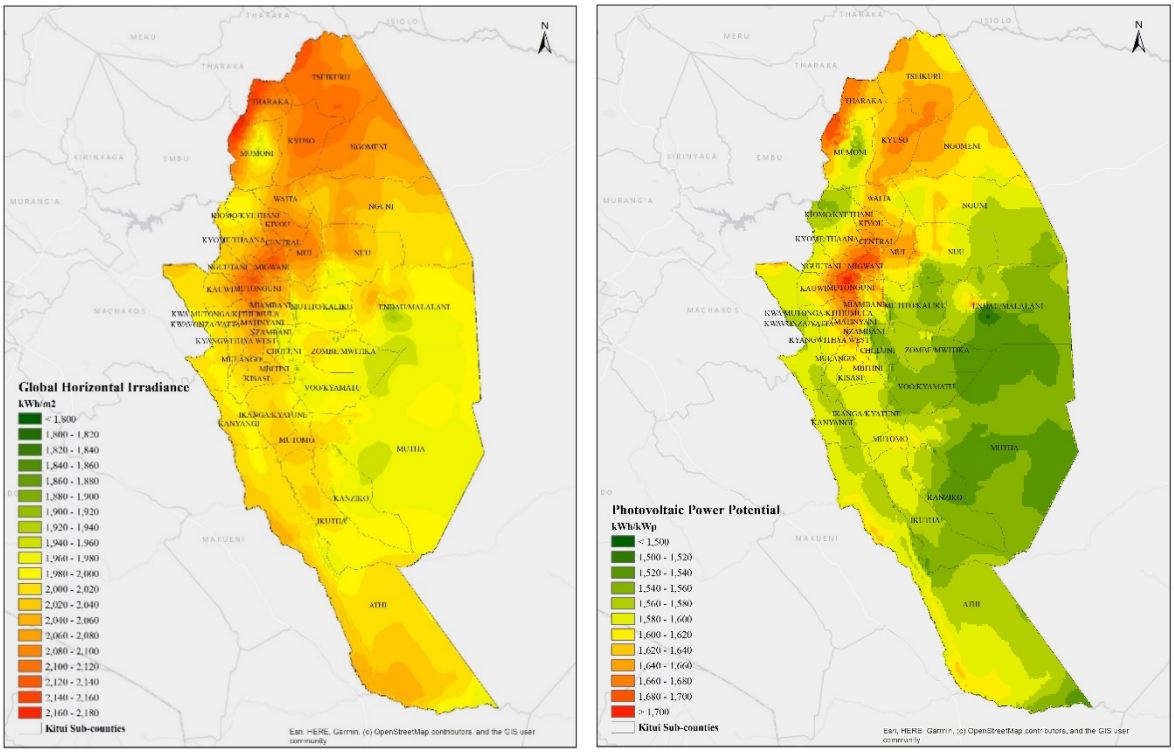


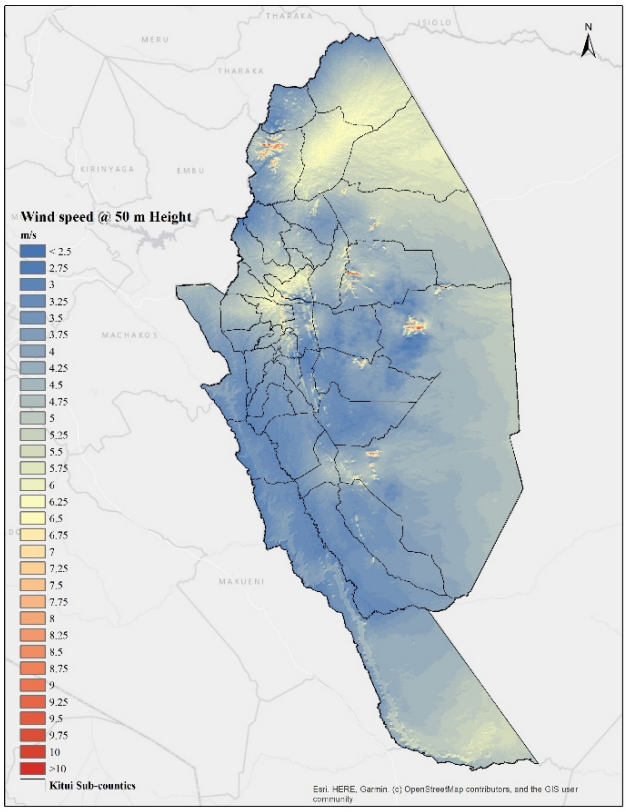
Figure 6 Long-term yearly average of global horizontal irradiation (GHI) in kWh/m^2 (on the left) and long-term yearly average of potential photovoltaic electricity production in kWh/kW-peak (on the right), covering the last 25 years (1994-2018)

Source: Global Solar Atlas (n.d.)

1.16 Wind power

The topography of Kitui County is characterized by hills and ridges in areas such as Mumoni, Mwingi North Sub County, Mutitu, Kitui East Sub County, Mutha, Kitui South Sub County and the plains of Kitui Rural Sub County. These hills and ridges are essential for providing a channelling effect, making them suitable sites for investment in power generation using wind power technologies.

The *Global Wind Atlas* (n.d.) is 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. The capacity factor is defined as the is the average power generated, divided by the rated peak power - or the amount of energy produced by a wind turbine compared to the energy produced if the machine ran at its rated power over a given period. It is used as a performance parameter for comparing the potential for wind power generation at different sites. Geospatial analysis and maps show that 33% of the area in Kitui has capacity factors higher than 20%, an initial indication of potentially suitable sites for wind power installations (see **Figure 7Figure** *1* below).



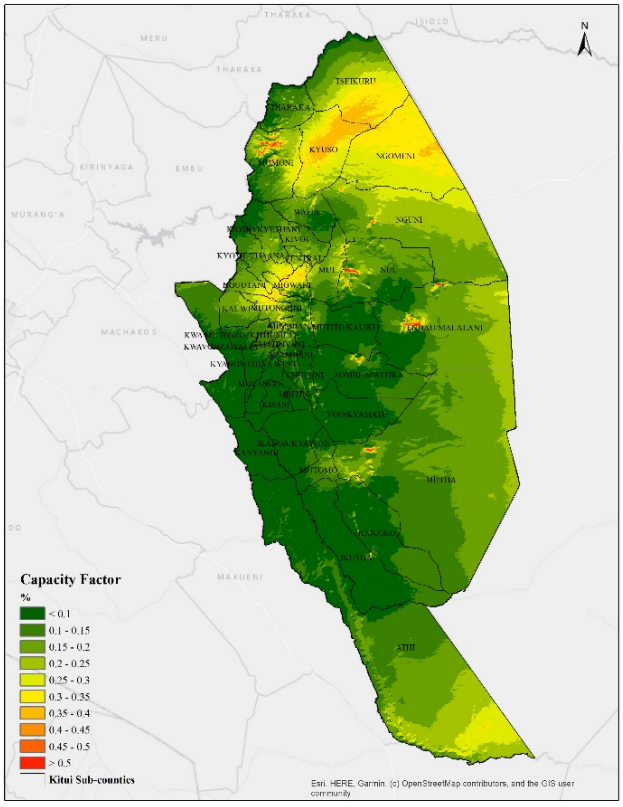


Figure 7: Mean annual wind speed at 50 meters heights (on the left) and Wind power capacity factor (on the right)

Source: Global Wind Atlas (n.d.)

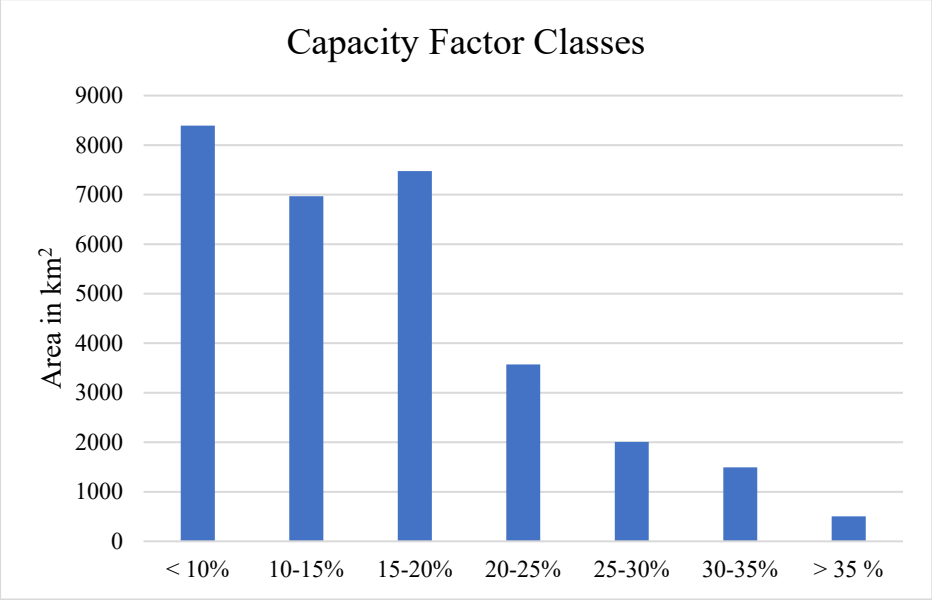


Figure 8: Capacity Factor Classes in Kitui County.[10]

Athi, Nguni, Ngomeni, Kyoso, Tseikuri, Endau account for 80% of the areas in Kitui with high-capacity factors. In other areas of the County, according to SEAF, 2017 (p. 40), local communities have invested in mechanical wind systems for water pumping: a technology which can be potentially up-scaled to improve access to water.

To promote wind energy development on a commercial scale, the Kenyan government has introduced a feed-in tariff (FIT) policy to attract private investment. The FIT policy provides a fixed tariff of US $ Cents 11.0 per kilowatt-hour of electrical energy supplied in bulk to the grid operator at the interconnection point. This tariff applies to wind power plants (wind farms) whose effective generation capacity is above 500 kW and does not exceed 100 MW.

1.17 Biomass, including firewood and charcoal

Biomass is mainly consumed in the form of firewood and charcoal but there also other forms like crop residues, pellets, briquettes, 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 discussed in Section 3:2, over 81% of households in Kitui county use firewood as their main source of cooking fuel and another 22, 516 households use charcoal to meet their cooking needs. Apart from for domestic use, charcoal is also produced in Kitui for sale due to its portability and convenience, adding value to firewood. According to SEAF-K 2017 (p. 44.), one ton of wood will retail at Ksh. 1000 (2017 prices).[11] Over 90% of charcoal in Kenya, including in Kitui County, is produced using traditional inefficient earth kilns (Kenya Forest Service (2013). If the same quantity of wood were converted to charcoal in a modern kiln, it

10 Authors' calculation, using data from the Global Wind Atlas. The different Capacity Factor classes are created using the Reclassify tool and the area is summarized in classes using Zonal Statistics as Table tool in GIS environment. Global Wind Atlas (n.d.).
11 Prices vary depending on the location.

would produce 300 kilograms of charcoal, equivalent to 7.5 bags of charcoal weighing 40 kilograms. At the market price (2017) of KES. 500 per bag in the rural areas, this will fetch approximately KES. 3,750 or in urban areas with a bag retailing at KES. 1,300, KES. 9,750 for 7.5 bags of charcoal (SEAF-K, 2017).

According to SEAF-K 2017 (p. 43), there is a growing imbalance between biomass energy supply and demand in Kitui, with a deficit of almost 60%. This imbalance exerts considerable pressure on forest and vegetation stocks and accelerates the processes of land degradation and desertification.

The biomass energy supply potential for Kitui County is estimated at 266,777m^3 for firewood and 143,426 m^3 for charcoal while the demand stands at 490,557 m^3 and 428,212 m^3 for firewood and charcoal respectively (Ministry of Environment, 2013). This leaves a negative net balance of 508,342 m^3 - see Figure 9 below (SEAF-K, 2017, p. 35).

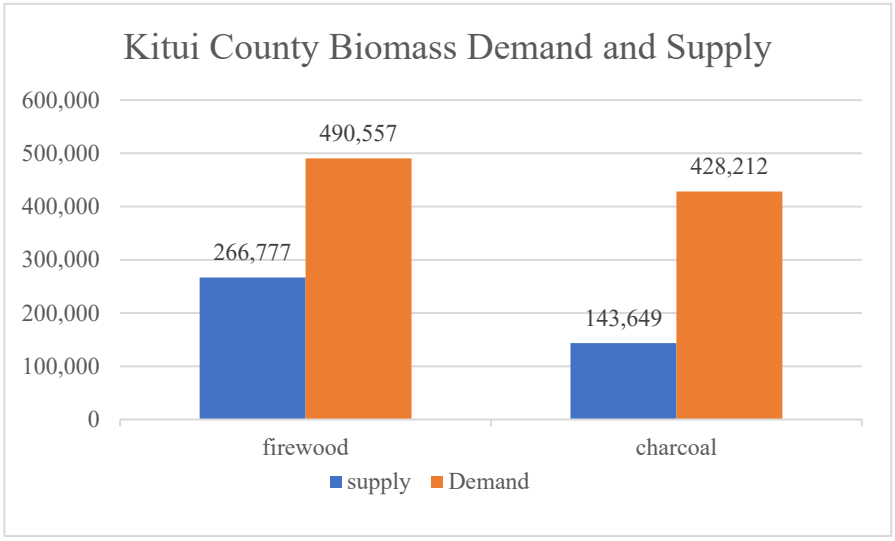


Figure 9 Biomass demand and supply in Kitui County

One consequence of this imbalance between supply and demand is deforestation. According to Global Forest Change (University of Maryland, 2020), between 2000 and 2018, approximately 1.87 thousand hectares of tree cover was lost in Kitui,[12] a 5.7% decrease in tree cover releasing 125 thousand tons of CO_2 (Zarin et al, 2016). In the same period, only 715ha of trees were gained (Global Forest Watch, n.d.).[13] However, some studies (Mwampamba et al., 2013; Aabeyir et al., 2016) Doggart et al., 2017;) have challenged this dominant narrative that charcoal production and use inevitably leads to environmental degradation, arguing that it is possible to produce charcoal without degrading the woodland by protecting the harvested areas from cultivation, grazing and fire, hence allowing natural regeneration.[14]

12 The methodology is taken from Hansen et al, 2013.
13 The latest data was accessed in March 2020.
14 Aabeyir et al. (2016) and Mwampamba (2013) argue that the regenerative capacity of woodlands is generally high, and that woodland degradation is a post-harvest management issue.

In 2018, Kitui County Government effected a ban on charcoal production and transport within county borders, aimed at addressing the degradation of forests in Kitui (County Government of Kitui, 2018a. b). Prior to 2018, most of the charcoal produced in the county was destined for major urban centres and cities outside Kitui County such as Thika and Nairobi thus the charcoal trade was ostensibly driven by extra-county demand.

The County Government has attempted to support the actors in the charcoal value chain to develop alternative livelihoods by equipping them with skills and equipment to produce fuel briquettes as a substitute to charcoal. Further data and analysis, including value chain analysis and market mapping, is needed to determine the viability of fuel briquette production as an alternative income-generating activity for commercial charcoal producers, as well as substitute for charcoal to meet household cooking needs.

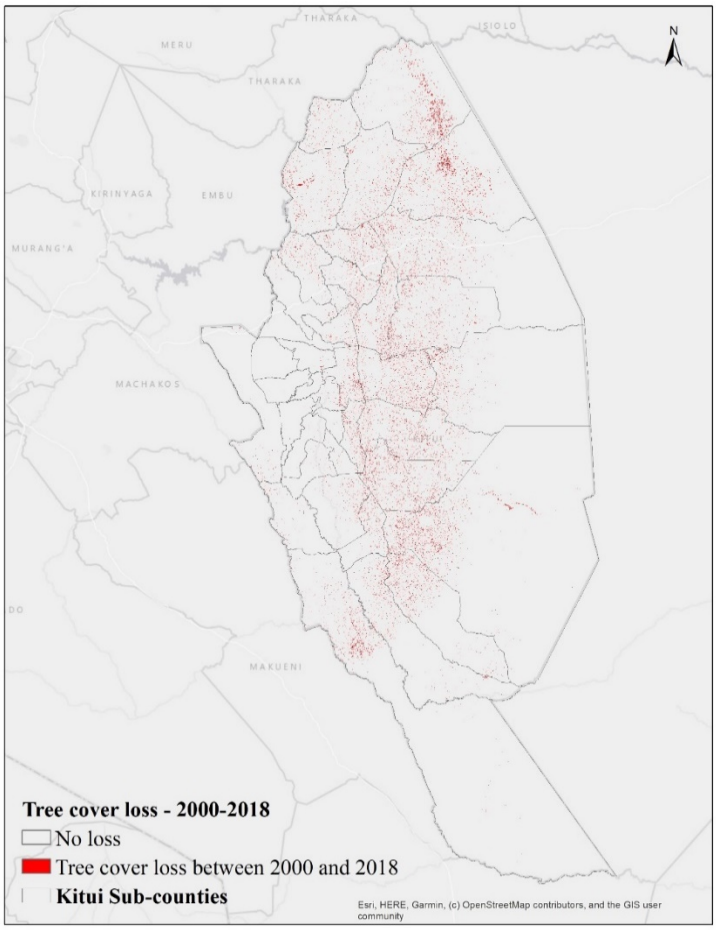


Figure 10: Tree cover loss in Kitui County between 2000 and 2018 (University of Maryland, 2020)

1.18 Coal

Kitui County has coal deposits in the Mui basin, extending approximately 500 Km^2 in four blocks from Zombe/Mwitika Ward (Block A) to Kivou/Ithumbi Ward (Block D). Prospecting in the Mui basin was carried out by the Ministry of Energy and Petroleum (MoEP) and completed in 2014. Quantification of the coal deposits in block C found to be more than 400 million MT

of reserves. The deposits were found to range in ranking from lignite to sub-bituminous with calorific values ranging from 16 to 27 MJ/kg (Oguge, 2017).

In 2011, the concessions for Blocks C & D were awarded to Fenxi Mining Industry Company of China and Great Lakes Corporation of Kenya (Miriri, 201 Concessions for blocks A and B were awarded to a consortium, Liketh Energy Investments and HCIG Energy Investments in 2015 (Business Daily Africa, 2015).

Coal mining: in particular, the type of resource and the open pit coal mining technology proposed in the Mui Basin: is associated with serious negative environmental and social impacts (Oguge, 2017). Despite the lack of available documentation, one study identified serious potential impacts and documented community concerns relating to the proposed projects in the Mui Basin (Oguge, 2017). According to this study, no Environmental and Social Impact Assessment (ESIA) report and other key documentation mandated under Kenyan law had been submitted to the National Environment Management Authority (NEMA) by the concessionaire Fenxi Mining for Blocks C & D (Oguge, 2017).

Community members interviewed during the research cited the availability of, and access to, water as key development challenge in the Mui Basin. The main types of water sources in Mui Basin are dry riverbeds and seasonal streams (65%), boreholes and shallow wells (35%), and water pans (<1%). Challenges to food production cited were recurrent dry spells (90%), followed by lack of farm inputs (25%), flooding (22%), lack of access to markets (12%), and lack of adequate land (12%). This raised concerns regarding the intensive water usage of potential coal extraction, given its potential to exacerbate the existing challenges in relation to water availability. The study recommended that a water footprint assessment be carried out to provide a clear indication of current freshwater appropriation in the basin, as well as to assess the impacts of any future mining activities on water resources.

Most households (79%) in Mui Basin live on the ancestral land. Although land is the main asset in the community, only 3% of respondents to the research had title deeds, underlying potential challenges with land acquisition, and compensation for any resettlement proposed due to mining activities. Concerns over land appropriation for mining activities and displacement of communities were raised during the research (Oguge, 2017). Furthermore, there appeared to have been little community consultation in the project planning, including little awareness or understanding of a Benefit Sharing Agreement (BSA) signed with Fenxi Mining in December 2013. Compensation had not been discussed nor issues of concern properly acknowledged.

The report recommended more structured, transparent and meaningful participation of the communities potentially impacted by mining activities, including in assessment and management of the potential environmental, social and human rights risks and benefits from the coal mining project, as per Article 69(1) of the Constitution of Kenya and the Mining Act of 2016 (Oguge, 2017).

The County Government of Kitui (2018a, p. 52) recognises the need for greater community sensitization and participation in mining sector projects, for improved land adjudication, titling and acquisition of title deeds in areas with potential minerals resources and, overall, the need for development of a county policy on mining/compensation and resettlement.

In July 2019, the National Assembly's issued a report on the proposed mining activities in the Mui Basin relocation (National Assembly, 2019). The Departmental Committee found various irregularities, along with an overall lack of community engagement, and failure by the Ministry of Energy to complete environmental impact assessments, feasibility studies and resettlement

action plans. It recommended formation of a Local Liaison Committee to ensure greater community participation and education, resurveying and verification of land titles and concerns relating to land ownership, and assessment of cultural impacts.

Energy Efficiency

1.19 Overview

Overall, there is a lack of data on rates of energy consumption and energy efficiency in Kitui County. There is also no analysis available publicly on the barriers to improving energy efficiency at the three levels of households, public institutions, and the business and industrial sector.

Potential barriers and constraints that might hinder energy efficiency interventions include the following:

- Lack of awareness/information and technical knowledge on energy efficiency and conservation in different line ministries and public institutions
- Lack of data/poor quality of data on energy consumption in different sectors and at the level of households and public institutions
- Lack of public awareness on the benefits of energy efficiency and conservation measures
- Affordability/high upfront cost of investing in energy efficient appliances and equipment
- Availability of energy efficient appliances and equipment (at the county level)

However, there are also clear opportunities to promote energy efficiency through use of more efficient appliances and consumption of more efficient fuels and technologies in most of the solutions developed to meet the priority development needs in this CEP.

1.20 Energy efficiency gaps at household level

As part of the solution to provide better quality household lighting for general purposes, appropriate consideration should be given to the most energy efficient solutions, in terms of both off-grid electricity systems and lighting equipment.

For example, the 2019 National Census indicates that while most grid-connected households in Kitui use energy efficient Compact Fluorescent Lights (CFL), a study commissioned by the Ministry of Energy in 2017 finds that a significant number (one fifth) use filament bulbs which are high in energy consumption (Atkins, 2017, p. 44).

A study undertaken by World-Wide Fund for Nature (WWF) revealed that in a majority of households, the bulbs rating was 40 watts with some as high as 100 watts (cited in SEAF-K, 2017). Although KPLC undertook a significant campaign to increase uptake of energy efficient lightbulbs, the ongoing use of the filament bulb points to a significant opportunity to improve energy conservation. However, further research is needed to understand the barriers to uptake of more efficient appliances for both lighting and other household uses, including refrigerators, iron boxes and water heaters in the urban areas of the county to identify the most appropriate interventions, including public education initiatives, to promote use of energy efficient appliances.

1.21 Public Institutions

There are opportunities to increase energy efficiency of the built environment, given that public buildings including government offices, large health and other educational institutions represent some of the leading energy consuming institutions in the county. UN-Habitat reports that on average, buildings in East African countries are responsible for up to 57% of national electricity consumption, representing more than the energy used for both transport and industry (UN Habitat, 2016, Slide 3).

Well-designed buildings use less energy as they require lower maintenance compared to ordinary buildings. However, there is no publicly available data to understand the energy consumption of public buildings in Kitui County. An energy audit would be required to map the levels of energy consumption based on the design of the buildings, as well as potential opportunities for improving efficiency through changes to building design.

In terms of energy consumption by public institutions for cooking/heating and lighting, electrification of public health and educational facilities present opportunities to ensure providing or improving electricity access also promotes energy efficiency through the energy systems and appliances selected. Improved basic health services through dispensaries (level two) & health centres (level three) for communities in remote & poorly served areas was identified as a priority need during the CEP needs assessment (see Section Six).

According to the Ministry of Health (County Government of Kitui, 2015), Kitui County has 240 public health facilities including 212 level two facilities (dispensaries), 56 level three facilities (health centres), 11 level four (county referral) and one level five facility (national referral hospital). There are also four private hospitals, 44 private clinics and ten nursing homes. Data gathering to develop the solution to provide improved access to basic health services from dispensaries and clinics (levels two and three) highlighted that 25% of level two and 75% of level three facilities were grid connected. 45% of level two facilities have a solar-powered electricity system and 23% of level three facilities. 30% of level two and five% of level three facilities are unelectrified.

The needs assessment process also highlighted issues with reliability of the electricity service across grid-connected and off-grid powered facilities, and a lack of mandated appliances in facilities. There is thus an opportunity through provision of mandated appliances to level two and three facilities, as a component of the health solution, to provide the most energy efficient appliances.

There are 3,213 public schools in the county including 1,518 Early Childhood & Development Education (ECDE); 1,316 Primary Schools; 373 Secondary Schools; and three Tertiary Education institutions (one university & two institutes of technology).

According to SEAF-K (2017), firewood provides 70% of all energy needs for cooking and heating in public institutions, charcoal provides 28% while LPG provides 22%. There is little data available on energy consumption for cooking and heating in public institutions or the barriers to improving the efficiency of their energy consumption, but as the solution on access to clean cooking discusses (see Section Six), use of more efficient fuels and technologies for institutional cooking could present an important opportunity. More accurate and granular data on the heating and cooking needs and practices of public institutions is essential to develop an effective strategy for improving their energy efficiency.

1.22 Industrial and Business Sectors

Kitui County has nine established industries including: one cotton ginnery, one bakery, two

fruit processing plants, one factory for the manufacture of building materials, one maize milling factory, one honey refinery, one printing press and one plant for water purification and packaging. There is also numerous micro, small and medium enterprises (MSMEs) in the County. As discussed in the solution developed to respond to the priority need of strengthening enterprises' ability to source and deliver quality products and services, especially for remote or poorly served communities (see Section Six), a lack of reliable electricity services for both on-grid and off-grid MSMEs, and limited access to efficient appliances and equipment were identified as key gaps.

Ninety-one percent of MSMEs surveyed source electrically operated equipment from other MSMEs. Consequently, the equipment is probably more expensive and perhaps less reliable and/or of lower build quality than if they were sourced from a larger, known distributor of equipment. In addition, equipment typically found in rural communities is usually older, using less efficient and outdated designs and internal components. High efficiency appliances can reduce electricity generation requirements for off-grid electricity systems and thus reduce complexity and costs for these systems. For grid applications, higher efficiency appliances can reduce equipment running costs, while at the aggregate level also reducing demand on the overall grid, which can simultaneously increase grid services to other MSMEs across the grid.

The MSMEs solution envisages the following activities to develop an accurate baseline on the electricity needs and energy consumption of MSMEs operating in different sectors in the County:

1. **Map the distribution chain of high efficiency appliances:** Understanding linkages, efficiencies, and incentives in distribution chains. Look for links with the Kenya Bureau of Standards (KBS) and global programmes, such as Efficiency for Access, and look for aggregation opportunities through supporting institutes like business associations or link to procurement large programmes or projects such as KOSAP to leverage cost savings through aggregation.

2. **Link efficient appliance suppliers with retail outlets and local agents:** IIED's Energy Change Lab in Tanzania effectively built relationships between actors in rural distribution chains by acting as a trusted third party. It is possible that this success could be replicated in Kitui. There may be opportunity to build on Kenya Renewable Energy Association (KEREA)'s previous work of certifying actors along the energy access supply chain to ensure that only high-quality products and services, including crucial after-sales services, reached customers. This involved a centralised hotline that consumers could access for information on certified agents and resellers in their area.

1.23 Priority actions to improve energy efficiency

First, the County Government can use the opportunities offered by the CEP implementation to increase energy efficiency in specific sectors/departments and institutions in Kitui County targeted by the CEP solutions. Second, the County Government can undertake data gathering on energy consumption within the different sectors targeted in the solutions, including through energy audits of public institutions. Third, CEP solution implementation can build the understanding Kitui county officials in different line ministries on the co-benefits of energy efficiency, and the wider importance of energy conservation and efficiency. Fourth, the Kitui County Government can use outreach around the CEP to educate citizens in Kitui on the importance of energy efficiency and conservation measures.

Going forward, the County Government could undertake an 'energy efficiency policy audit' to determine what the current enabling policies are for improving energy efficiency/conservation across public and private sectors in the County, identifying any policy gaps in terms of regulations, efficiency standards and procurement including product/technology benchmarks etc.

Finally, there is an opportunity to build short and longer-term collaboration with relevant external stakeholders, including the Kenya Association of Manufacturers' (KAM) Centre for Energy Efficiency and Conservation (CEEC), KEREA, the Kitui Energy Centre in Kitui and civil society organisations in relation to the actions outlined above.

The Process for County Energy Planning

1.24 Methodology and rationale: the need for more inclusive and integrated planning approaches

The CEP was developed using an inclusive and integrated planning methodology called the **Energy Delivery Models** (EDM) approach. This approach has been developed by the Catholic Agency for Overseas Development (CAFOD) and the International Institute for Environment and Development (IIED) over the past decade.

The rationale for using this approach is that there is currently a gap between the type of planning approaches that research and practitioner experience of designing energy services shows are needed to realize the full benefits of energy as an enabler of many development areas and the top-down way, technology-driven approaches currently used to plan and deliver energy services, where energy is planned as a standalone infrastructure investment rather than a service that can help deliver wider development impacts and meet end users' wider needs.

Reviews of research and practitioner experience show that socio-cultural and contextual factors have a significant impact on acceptance and sustained uptake of energy solutions, and on the overall viability and impact of services (Brown et al., 2015). Behaviour, preferences, and practices: as well as affordability - influence end users' choice of, and willingness to pay for, energy fuels and technologies: often decisively. This is well recognized by energy for development experts (particularly as relates to the lack of progress on uptake of clean cooking solutions), but rarely acknowledged by energy planners, let alone operationalised through new planning approaches.

In reality, lack of consideration of end-user demand, the socio-cultural as well as other factors driving this, and the local context for service delivery has often resulted in failed or sub-optimal service delivery. This has direct financial costs and also indirect negative social and economic costs in terms of the "energy access opportunity costs" or unrealized development benefits for target groups of end users. It can also result in a chilling effect, where end user mistrust or disappointment generated through a failed intervention impacts negatively on future uptake of energy services and products.

If energy is understood as a service that can help meet the development needs of target end users across different sectors, and target end users and wider stakeholders are included in service planning, the impact of energy investments is enhanced and resources deployed more effectively, leading to greater sustainability of the energy service and improved integration into wider development planning. In summary, more inclusive (needs-based) and integrated approaches to planning energy serves can:

- Maximise the development impacts of energy interventions
- Ensure financial, environmental and social sustainability of the service
- Support early identification of energy linkages in other sectors & build synergies between solutions, promoting cross-sectoral integration of energy services
- Create buy-in from stakeholders including in this context from the county government, development partners, private sector and wider civil society
- Ensure solutions are appropriate & cost effective for specific target groups and their contexts through disaggregation of demand to understand their needs

- Promote scalability through aggregation of solutions or components of solutions (eg business models or supporting services)
- Move rapidly from planning to implementation by identifying and engaging co-financiers and service providers throughout (in this case, from the CEP to investment-ready solutions)

In turn, effective needs-based energy planning requires:

- Cross-sectoral awareness raising on the role of energy as an enabler and coordination of planning across development sectors
- Data gathering and analysis to identify and design the energy and non-energy components of holistic solutions, including disaggregated data on the needs of different groups of end users so that solutions can be tailored to meet these
- Identification of cross-sectoral synergies between solutions) and opportunities for aggregation of (energy and non-energy components of) solutions to allow for economies of scale
- Engaging stakeholders and delivery partners including private sector, civil society, development agencies & co-financiers along the planning process to ensure it can move swiftly to testing and to implementation

1.25 Status of CEP development and planning challenges

In terms of applying these insights to the CEP process in Kenya, it is first worth noting that only a small number of CEPs have been developed or are under development to date.[15] In terms of the planning approaches used, these are disparate, but the majority of CEPs appear to have been developed with minimal cross-sectoral engagement or end user, public, private sector and other stakeholder participation. In most CEPs, energy services are not designed as enablers to meet the development needs of different groups of end users within the specific county context (including the county government development objectives outlined in the CIDPs). Energy service planning does not appear to have been integrated into other development sector planning processes, and the CEPs do not contain costed, sustainable solutions and priority investments that can facilitate county government budget allocation (through ADPs) and attract co-financing from other national and international agencies. All these factors point to a potential weakness in turning the CEPs into investment-ready implementation plans and their utility in informing effective integrated national planning.

The following challenges to effective county energy planning were identified both during the process for developing the Kitui CEP, and from analysis of CEPs, CIDPs and county energy planning capacities undertaken to develop the county capacity building component of the Sustainable Energy Technical Assistance (SETA) programme due to begin in July 2021.

First, challenges relating to data availability, accessibility and quality, as well as data analysis and sharing between different county-level ministries and actors, and from national level agencies to the counties (also related to the second point below), to inform energy planning

[15] This is evidenced in the CEP mapping and assessment of county energy planning capacity carried out under the MoE/EU *Sustainable Energy Technical Assistance* (SETA) programme due to begin in July 2021 and which will offer support to all counties to build their capacity on inclusive and integrated energy planning and to implement their mandate under the Energy Act 2010 and forthcoming Integrated Energy Planning (INEP) Framework.

at the county level (this includes data on levels of energy access, current grid coverage and connectivity and energy consumption, RE energy resource potential, EE potential, RE supply chains etc.). Specific data gaps were identified in the development of solutions to mee the priority needs identified in Kitui County across all sectors (see Section Six for more detail).

Second, the lack of coordination and knowledge sharing between the energy department and other county sectoral line ministries within counties, and by departments and ministries across counties. Apart from the gaps in horizontal coordination and learning, there is also a lack of knowledge sharing and coordination between sub-national (county) and MoE and other national level energy service providers, as well as national sectoral ministries. This includes knowledge of energy as an enabler of progress in different development sectors (the potential "development dividend" of energy access); the opportunities offered by DRE and energy efficient (EE) technologies to scale up access to modern energy. This has made it difficult for counties to develop a clear understanding of the social, economic, and environmental co-benefits and challenges of planning energy services to meet wider development objectives.

Third, there are a range of institutional capacity gaps within county energy departments and nexus ministries. These include a lack of technical capacity concerning different RE and EE technology options, enabling policies and business and financing models for scaling up DRE services. Equally important, there is a lack of experience and capacity in counties governments to undertake cross-sectoral planning, and lack of knowledge on inclusive and integrated planning approaches.

There appears to have been little opportunity for structured knowledge-sharing, or capacity building efforts within and between county governments (peer-to-peer learning), with other county level stakeholders, and between counties and national energy service providers and agencies (MoE, KPLC, REREC etc) and with external stakeholders (private sector, development partners, civil society) to address the challenges in county energy planning. This is with the exception of some initiatives, for instance by GIZ. In particular, there has been no targeted capacity building for county governments to build their understanding of the added value of more inclusive and integrated planning approaches and how to deploy them in county energy planning.

Overall, this has resulted in:

1. Minimal integrated and inclusive energy planning at sub-national level that effectively identifies which energy solutions are required in function of the specific priority development needs in each individual county; the development of sustainable solutions to meet energy and non-energy gaps preventing these needs being met, as well as identification of synergies between solutions and opportunities for aggregation of (components of) solutions to maximize the impact of energy service provision across different sectors and attract co-financing; and linked to this,
2. A failure to take full advantage of the potential for deploying DRE solutions in support of cost-effective, needs, and data-driven planning.

Addressing these coordination, knowledge, data, and technical capacity gaps to optimise CEP development requires more than just technical assistance in the form of a series of training activities. It requires filling the critical knowledge gap among county (and national) government actors and other relevant stakeholders around integrated planning approaches, and building sustained institutional capacity to use them, including ongoing horizontal and vertical cross-learning and knowledge-sharing.

1.26 The Energy Delivery Models (EDM) approach in detail

EDM is a problem-solving and participatory approach that aims to ensure effective integrated and inclusive energy planning. It identifies and disaggregates the priority development needs of different target groups, builds understanding of the barriers and enabling factors related to the local context and identifies the 'gaps' preventing the needs being met (energy-related and non-energy related). It then works with end users and other stakeholders to develop solutions that are financially, environmentally, and socially sustainable.

The experience of piloting and using the EDM approach several countries working with communities, social enterprises and development organisations has been consolidated into the *The Energy Delivery Model Toolkit* (Garside & Wykes, 2017). The Toolkit outlines a six-step planning process which uses both existing tools (for instance, for stakeholder mapping) and also two new tools (the Delivery Model Map and the Delivery Model Canvas). The latter is an adaptation of the Osterwalder Business Canvas for designing energy: or wider - development services (Osterwalder & Pigneur, 2010). This EDM approach has now been adapted further adapted for use at a more macro-level in Kitui County, while retaining its essential features (see Section 5.1.3).

EDM starts by the target group or end-users identifying and prioritizing their development needs, including disaggregating these in relation to different types of end user (for instance, by gender). It then identifies the "gaps" or barriers that are preventing the development needs being met and develops solutions working with the end users and wider stakeholders to address the gaps and meet the development need. The gaps can be related to energy (eg lack of/unreliable/unaffordable electricity service) but equally to non-energy related factors. Non-energy gaps can include lack of supporting services (eg access to finance), and enabling environment barriers (policies, regulations etc.) but also socio-cultural barriers (gender/power relationships; socially or culturally specific behaviours and practices). Although these 'softer' factors are often considered less significant, they can be decisive, 'make or break' factors in the success or failure of a solution.

The initial solutions identified during the EDM process are then subjected to further analysis through an iterative process to optimize them for the specific context, identify and mitigate risks, and identify synergies between solutions to different needs to maximize development impact and potentially reduce costs. The final products are costed, financially, socially and environmentally sustainable solutions that are implementation ready.

These solutions can be scaled in two ways: first, through identifying synergies between (aspects of) different solutions and bundling them; second, by mapping and engaging through the planning process with different finance providers, delivery partners, and other relevant stakeholders working across solutions and sectors. The iterative and participatory nature of the planning process creates buy-in among stakeholders and partners to ensure successful delivery of the proposed solutions but equally strengthens wider problem-solving and planning capacity of participants and builds wider stakeholder understanding of the approach. Figure 11 summarises the six steps and the attributes of the EDM planning process and Fiigure 12 explains the six steps in more detail (Garside & Wykes, 2017).

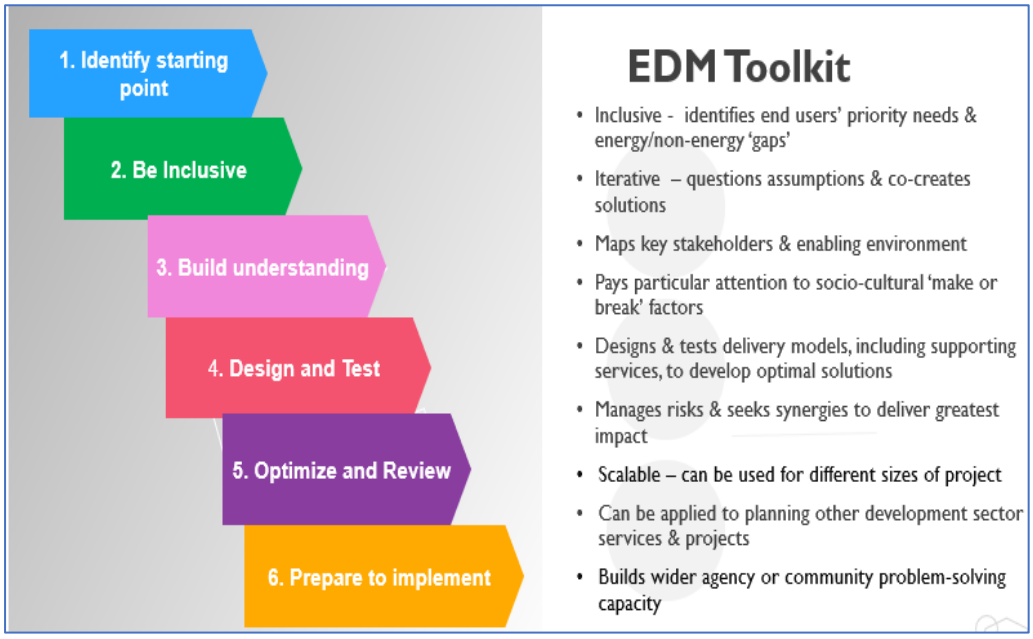


Figure 11: The attributes of the EDM process

1.27 Adapting the EDM methodology to county level planning

In November 2018, the Kitui County Government signed an MoU with CAFOD, IIED and local partner CARITAS Kitui, to use the EDM approach to develop the Kitui County Energy Plan (CEP).

In adapting EDM to develop the CEP, the approach is used at greater scale while retaining its essential features: inclusive engagement with local stakeholders, building contextual understanding and working across sectors. As outlined in Section 5.1.2 above, the planning process encountered several challenges relating to data availability and quality; technical energy capacity as well as other capacity gaps around project management, finance and integrated and inclusive planning approaches; cross-sectoral coordination; resource allocation and mobilization; and political economy issues (such as turnover in political leadership within various ministries).

The application of the EDM to county planning involved a two-stage approach (for more detail see Garside & Perera, 2021).

Stage One takes place at the **government and sectoral level**. Energy services and non-energy supporting interventions are designed to produce holistic solutions within and across development sectors at the county-level, based on an extensive, county-wide needs assessment process targeted a sample of community members and other stakeholders (see Table 9 below for the seven priority needs identified for Kitui County). Further extensive research and analysis to understand the needs and develop solutions was undertaken, including value-chain analysis, market mapping, developing business models and mapping linkages to potential delivery partners, existing initiatives and co-financing opportunities. These solutions are presented in the County Energy Plan to support evidence-based investment decisions by the County Government.

Stage two takes place at the **initiative and project level**. Priority investments identified in the CEP are mapped onto specific groups of end users and locations and optimised for those

locations, working with potential delivery partners, to move solutions to demonstration and implementation.

Figure One summarises the EDM Steps included in the two-stage county planning process in Kitui.

Figure 1: The EDM steps applied to county energy planning

Source: Garside & Perera (2021); adapted from Garside & Wykes (2017)

The CEP development process began with an in-depth, participatory needs assessment, including county-wide baselining, to identify the priority development priorities for communities and other stakeholders in Kitui (see

Table *8* below). Figure 12 below summarises the timeline and key activities for development of the CEP, while **Error! Reference source not found.** gives further information on the activities undertaken as they relate to the six steps of the EDM process.

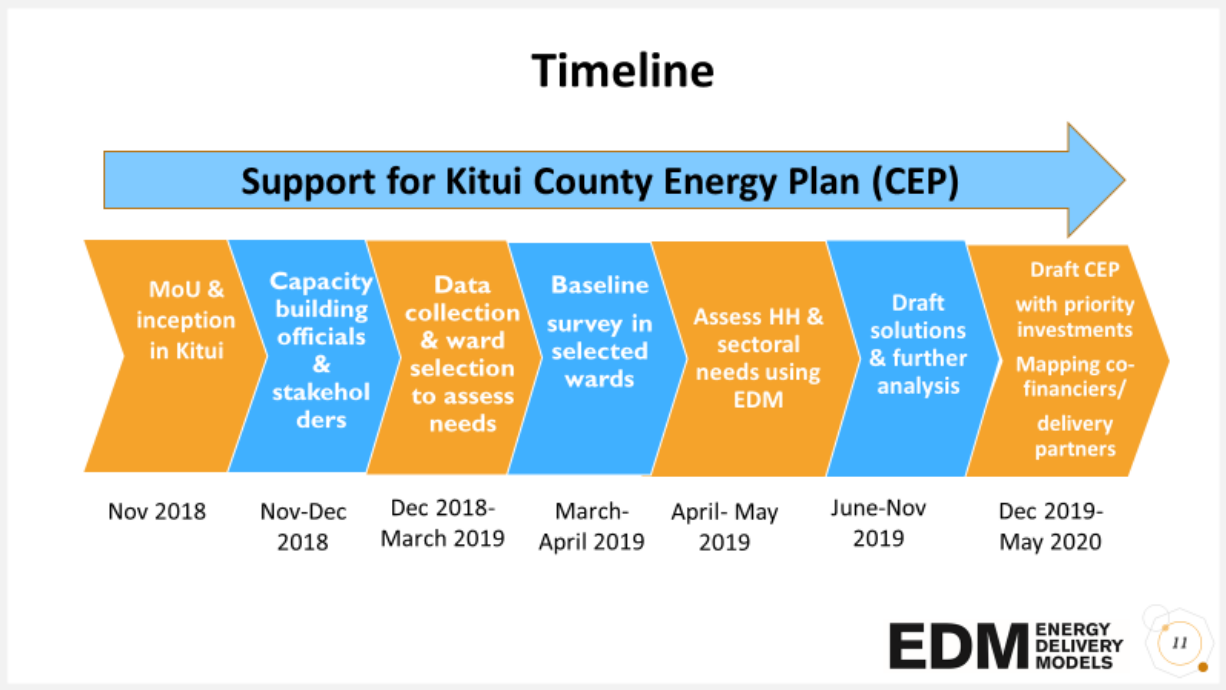


Figure 12: Timeline of key activities for development of the CEP

EDM steps	CEP Activities
Step 1 - Identify starting point **Step 2 - Be inclusive**	○ Stakeholder Mapping ○ Formation of Technical Committee ○ Targeted outreach to County Executive Committee members and County Chief Officers to build by-in ○ Public awareness raising (CSOs & PS)
Step 3 - Build understanding	○ Baseline survey household sampling, ward administrator interviews, FGDs) ○ Selection of sample wards across the eight sub-counties for more in- depth needs assessment & community engagement/sectoral workshops ○ Workshops (indicatively one per sub-county lasting 3 days) ○ Identification of priority needs for disaggregated end users & sectors; energy & non-energy gaps ○ Mapping of RE potential for CEP ○ GSI mapping of electrification status, socio-economic & demographic data plus other relevant data to assist with solution development
Step 4 - Design and test	○ Development of financially, socially and environmentally sustainable solutions to meet the priority needs ○ Additional research including finance and business modelling; identification of delivery partners and co-financing opportunities

EDM steps	CEP Activities
Step 5 Optimise and review	○ Review & optimise the solution including identifying any further gaps & supporting services required to address this; verification of costs ○ Identify risks and develop mitigation strategy ○ Identify synergies & aggregate solution (components) into investments that can attract and pool/blend public and private finance
Step 6 - Prepare to implement	○ Identify first stage implementation projects and propose options for moving towards implementation, convening relevant stakeholders
Ongoing - Steps 3-5	○ Drafting of CEP, review by county officials and validation by County Government

Table 8: Summary of CEP activities

1.28 Needs assessment process

An initial baseline survey was carried out using sampling in different locations in Kitui. This included focus group discussions (FGDs) with women's and youth groups and Key Informant Interviews (KIIs), including with Ward Administrators). The aim of the baseline survey was to collect basic demographic and socio-economic data, information on road infrastructure, levels of access to electricity and cooking fuels and technologies, access to community services (health and education), as well as information on priority development needs at the level of households, communities and livelihoods. Figure 13 below shows the scope and focus of the initial baseline survey.

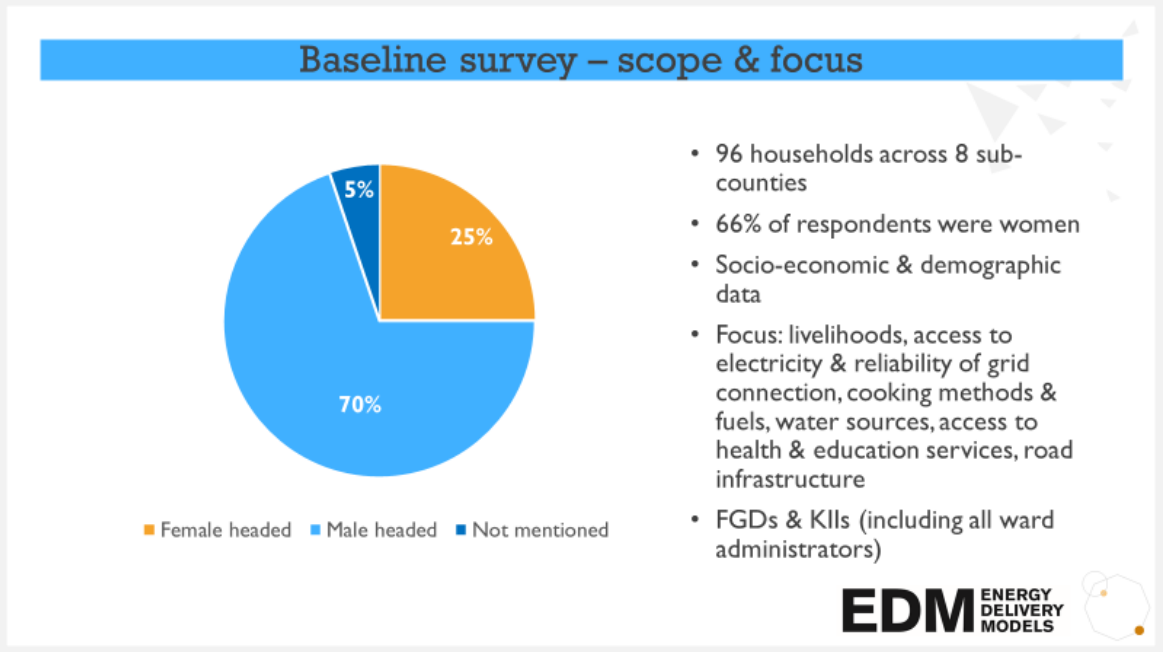


Figure 13 : Scope of Baseline Survey

The survey was followed by a series of in-depth, participatory needs assessment workshops held at ward level. Each of the eight sub-counties in Kitui was represented in this process, but wards were selected for their representativity in terms of their geographic and socio-economic characteristics, and to ensure coverage of all the key sectors in the county. Workshop participants were also selected to ensure a representative socio-economic and cultural mix and inclusion of vulnerable and marginalized groups (see

Figure 14). Further stakeholder mapping was also undertaken for the workshops.

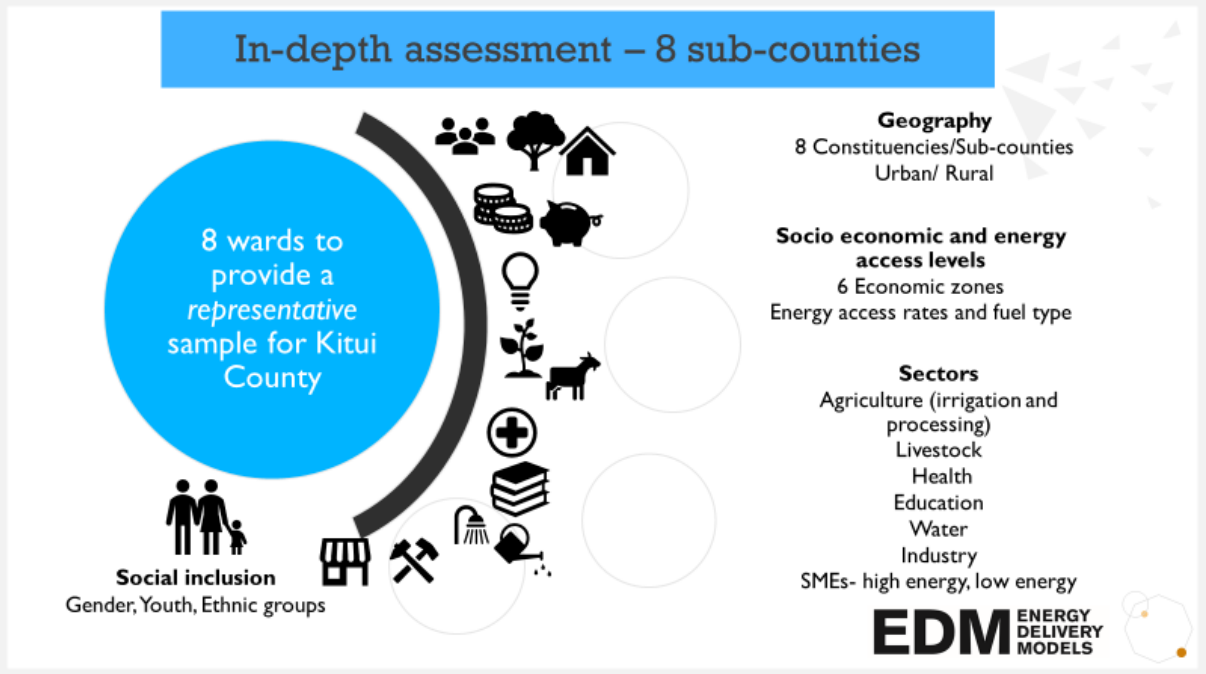


Figure 14 : Scope of Needs Assessment Workshops

The countywide needs assessment process resulted in the identification by participants, including community members and other stakeholder groups, of priority development needs for the county which were ranked in order of which were selected in the sub-county workshops as the top development needs (Table 9). It is noteworthy that there was significant consensus among the workshop participants in all the sub-counties regarding the top development needs, with the top three needs identified as improved farmer income from rain-fed crops; access to clean water in closer proximity for drinking and washing; and better access to health services in remote areas.

Priority needs- findings from the ground		
Ranking	**Need**	**Wards**
1	Improved farmer income from rain-fed crops	7/8
2	Access to clean water in closer proximity for drinking and washing	6/8
3	Better access to health services in remote areas	4/8
4	Improved productivity and income from livestock (poultry, goat keeping, cattle and dairy farming)	3/8
4	Better quality lighting for cooking and working at night (W), general purpose, learning, security	3/8
4	More reliable electricity & supporting services for existing SMEs	3/8
4	Cleaner, cheaper & faster cooking fuels & methods to reduce health impacts, costs, time and drudgery, and allow more time for relaxations	3/8

Table 9: Ranking of Priority Development Needs in Kitui

After agreement was reached among participants on the priority needs, further extensive research and analysis was undertaken to understand the gaps/barriers, including enabling policies and gaps, and specific socio-cultural barriers and enabling factors. This was then followed by solutions development to address the gaps and meet the priority need. This included value-chain analysis, and market mapping, developing business models with cash-flow as well as best practices in terms of supporting services for different solutions, and mapping linkages to existing initiatives and potential delivery partners, and co-financing opportunities.

Stakeholder engagement and partner mapping

The project has involved extensive, ongoing engagement with stakeholders and collaboration with the World Resources Institute (WRI) on least cost electrification modelling and data visualisation (including use of WRI's *Energy Access Explorer* tool).

Integrated solutions to meet priority development needs in Kitui

1.29 Overview

This section presents solutions to meet the priority development needs as follows:

- **Least cost electrification** scenarios for Kitui
- **Solution 1: Household Lighting** - better quality lighting for cooking, working at night, learning, security and general-purpose needs in households
- **Solution 2: Water** - improved access to clean, affordable, and reliable water for drinking and general-purpose needs in households
- **Solution 3: Health** - Improved provision of health services through level two (dispensary) and level three (health centres) facilities for communities in remote and poorly served areas
- **Solution 4: Agriculture** - Improved income for smallholder farmers from irrigated and rainfed crops
- **Solution 5: Livestock** - Improved yield and productivity of small-scale livestock (poultry and dairy) farmers across Kitui County
- **Solution 6:** Micro, Small and Medium Enterprises (MSMEs) -Improved business capacities to deliver quality products and services for communities in remote and poorly served areas, and increased revenue of existing MSMEs
- **Solution 7** - Cooking: Improved access to cleaner, faster, reliable and more affordable fuels and technologies for cooking for households in Kitui

In terms of the sectoral solutions (one to seven in the list above), the solution aims to address all the gaps/barriers identified to meeting the priority needs - both energy and non-energy related: in order to deliver the intended impact and ensure sustainability. The supporting services and interventions required to address the non-energy gaps/barriers are therefore integrated into the solution.

In the case of the top priority need identified: increased farmer income from rain-fed crops - it should be noted that the gaps to meeting this need all relate to non-energy factors. Further research and analysis also identified potential for increased farmer income from *irrigated* crops and the decision was taken to merge both rain-fed and irrigated crops into one solution for increasing farmer income, to maximize development income for farmers across the county.

The description of each solution is divided into three parts:

1. A **summary** of the solution components with the objectives and gaps it aims to answer.
2. An overview of the **energy and non-energy barriers or gaps** the solution aim to address to meet the community needs identified.
3. A complete set of **solutions for specific target groups**. The energy component is presented in detail including costs and interventions related to supporting services and enabling environment that need to be in place along-side energy services. The 'non-energy' aspects those that are not directly related to energy but are critical part of achieving expected impacts.

Finally, the solution includes 'next steps' to highlight immediate action needed for the detailed energy solution design and its implementation planning.

The **non-energy component** of the solution includes potential ideas for interventions and highlights sector specific programs, policies, institutions, and stakeholders to align with for cross-sectoral collaboration and leveraging finance.

1.30 Least cost electrification for all: current electricity access

As discussed in Section 3.1, according to the most recent Census data (KNBS, 2019), households in Kitui utilise a range of energy sources and appliances to meet their energy needs for lighting, cooking, and other services. More specifically, for lighting purposes, most households, in the county (44%) use solar powered technologies for lighting. This is followed by electricity (17.1%) and paraffin-based solutions (23.7%). Given the lack of recent data on grid-based electricity access, the percentage of households that uses electricity as their main type of fuel was used for the least-cost electrification modelling analysis.

1.31 Approaches to least cost electrification modelling for household access

Energy systems are inherently linked to geographic parameters, such as local energy resource availability, power infrastructure, demographics, and to social and economic activities, which are often inadequately considered in energy system modelling.

One way to address this is through integration of Geographic Information Systems (GIS) and energy system modelling helps identify the most effective electrification strategy on a geospatial basis. One of the most widely employed GIS-based electrification tools that uses geospatial data and technology to generate least cost electrification pathways is the Open Source Spatial Electrification Tool (OnSSET).[16] OnSSET is used by the World Bank's The Global Electrification Platform (GEP), an open access, interactive, online platform that allows for overview of electrification investment scenarios for a selection of countries.[17] OnSSET has been used in combination with different data sets to assess the optimal least cost electrification mix for a range of access scenarios in Kitui County.

Overview of OnSSET Toolkit

OnSSET is a bottom-up cost optimisation toolkit. It calculates scenarios for expanding access through 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). The electrification options are divided into three main categories: grid-connected, mini grids and standalone systems (eg Solar home systems or SHSs). The cost of generating electricity for all off-grid technologies is calculated according to renewable energy resource availability (eg Global Horizontal Irradiation) and the technical and economic parameters of generation technologies (eg 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.

For grid-connected electricity, the cost is based on the cost of generating electricity for the grid-connected power plants plus the marginal cost of grid extension to reach each cell. OnSSET runs an electrification algorithm to determine where grid-extension is the most cost-effective alternative to standalone or mini grid systems based on population densities, length and cost of transmission network and comparisons to the LCoE of off-grid technologies. The algorithm considers which cells should be grid-connected in an iterative process whereby connection of one cell may also lead to the connection of neighbouring cells becoming more cost-effective. The algorithm stores the additional length of medium and low voltage lines required as well as the additional reinforcement requirements of the current grid.

Modelling inputs and scenario development

OnSSET relies on the collection and preparation of several geospatial layers.

[16] http://www.onsset.org/.
[17] https://electrifynow.energydata.info/

Table *10* provides a brief description of these datasets, their functions, and the data sources used for modelling LCE in Kitui. These data sources include Korkovelos et al. (2019), Mentis et al. (2017), Moksnes et al. (2017) and Moner-Girona et al. (2019), and they have also been integrated into the World Resources Institute (WRI)'s *Energy Access Explorer* tool.[18]

Dataset	**Description**
Population density and distribution (CIESIN, Columbia University, 2016).	Spatial distribution of population density in Kitui County.
Administrative boundaries (CIESIN, Columbia University, 2016).	Spatial delineation of the administrative boundaries of Kitui County, sub-counties and constituencies
Existing and planned grid network (KPLC, 2020)[19].	Used to identify and assess the spatial distribution of currently electrified/non-electrified population
Substations (KPLC, 2020).	Current substation infrastructure used to identify and assess the spatial distribution of currently electrified/non-electrified population and options for grid extension
Road network	Current road infrastructure may be used to identify electrified/non-electrified population and their spatial distribution, and options for grid extension.
Night-time light (National Oceanic & Atmospheric Administration, n.d.)	Night-time light is used to identify the spatial distribution of currently electrified/non-electrified population
Global Horizontal Irradiation (Global Solar Atlas, n.d.)	Data on Global Horizontal Irradiation (kWh/m^2/year) over an area. This is then used to identify the suitable locations for photovoltaic systems
Wind speed magnitude (Global Wind Atlas, n.d.)	The wind speed magnitude (in m/s) is used to assess (through the calculation of capacity factors and wind turbine power curves) the suitable locations for wind power systems
Small scale hydropower potential (Korkovelos et al., 2018)	Small scale hydropower potential indicates the potential power that can be generated with mini or small hydropower plants. It includes generic environmental, social and topological restrictions.
Elevation map	Filled Digital Elevation Models (DEM) are used in several processes in the geospatial analysis (to calculate Energy resource availability, restriction zones, grid extension suitability map etc.).

[18] https://www.wri.org/initiatives/energy-access-explorer

[19] Data on grid networks received from KPLC (2020)

Slope	A sub product of DEMs, used to identify restriction zones and suitability for grid Extension (generated from the elevation map)
Land cover	DEMs are used to calculate energy resource availability, restriction zones, suitable locations for grid extension etc.

Table 10: Geospatial data used in the electrification analysis

Socio-economic parameters

The following socio-economic parameters are used to calibrate the electrification model.

Parameter	Unit	Value	Source
Population	Million people	1,136,187 (2018) 1,223,549 (2022)	KNBS (2019)
Urban population	Percentage of total population	18.9%	
Access to electricity	Percentage of total population	17.1%	
Household size	Number of people per household	Subcounty specific	

Table 11: Socio-economic parameters - Kitui County

Techno-economic parameters

Apart from the geospatial data and the socio-economic parameters, OnSSET requires techno-economic inputs related to the cost of off-grid technologies and of grid operation and extension in order to run the least-cost electrification analysis. See Tables 12 and 13 below for the transmission and distribution costs used for the modelling.

Parameter	Value	Unit
Life	30	Years
HV line cost > 69 kV	53,000	USD/km
MV line cost (11 -33 kV)	7,000	USD/km
LV line cost (0.2: 0.4 kV)	4,250	USD/km
HV to MV substation (1000 kVA)	25,000	USD/unit

MV to LV substation (400 kVA)	10,000	USD/unit
Service transformer	4,250	USD/unit
Additional connection cost per household connected to grid	125	USD/HH
Additional connection cost per household connected to mini grid	100	USD/HH
O&M costs of distribution	2%	-
T&D losses	18%	-
Cost of Grid-generated electricity	0.12	USD/kWh
Discount rate	8%	-

Table 12: Transmission and distribution costs in the model.
Sources: Korkovelos et al. (2019); Mentis et al. (2017); Moksnes et al. (2017); Moner-Girona et al. (2019).

Plant type	Investment cost (USD/kWp)	O&M costs (% of investment cost/year)	Life (years)
Mini grid Wind	3,750	2	20
Mini grid Hydro	3,000	3	30
Mini grid PV	2,105	1.5	20
Stand-alone Solar PV	1,963-14,428 (depending on system size)	2	15

Table 13: Electricity generation technology parameters used in the model
Sources: Mentis et al. (2017); IRENA (2016); Pueyo et al. (2016)

Electricity access scenarios

As discuss in Sections One and Two, there is an emerging consensus that access to energy cannot be understood simply in binary terms such as having an electricity connection or not (or cooking with clean fuels and technologies versus cooking with solid fuels in the case of cooking poverty) but must be understood as having multiple dimensions. In the case of electricity access, this means having the ability to consume electricity not simply to be connected to an electricity source. The Multi-tier Framework for Measuring Energy Access (MTF) developed by the World Bank defines energy access as 'the ability to avail energy that is adequate, available when needed, reliable, of good quality, convenient, affordable, legal, healthy and safe for all required energy services' (Bhatia & Angelou, 2015, p. 5).

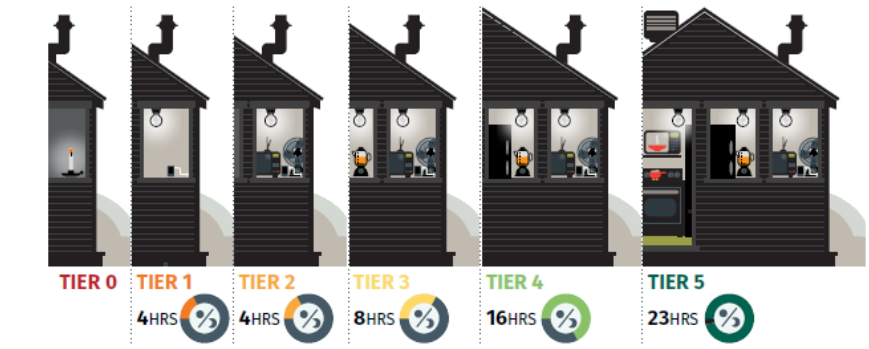
Under the MTF, access to electricity is measured based on seven attributes: Capacity, Availability, Reliability, Quality, Affordability, Formality, and Health and Safety with access defined in terms of five

tiers. Tier 0 refers to households that receive electricity for less than 4 hours per day (or less than 1 hour per evening) or that have a primary energy source with a capacity of less than 3 W (see Figure 15 for minimum requirements by tier of electricity access.) Tier One refers to households with limited access to small quantities of electricity provided by any technology, even a small solar lighting system (SLS) for a few hours a day, enabling electric lighting and phone charging.

The different attributes of electricity access are explained in Bhatia and Angelou (2015) as follows:

- *Capacity* ("What appliances can I power?"): The capacity of the electricity supply (or peak capacity) is the ability of the system to provide a certain amount of electricity to operate various appliances, ranging from a few watts for light-emitting diodes (LEDs) and mobile phone chargers to several thousand watts for space heaters or air conditioners (see Table 1; and Annex 1).
- *Availability* ("Is power available when I need it?"): The availability of supply refers to the amount of time during which electricity is available. It is measured through two indicators: the total number of hours per day (24-hour period) and the number of evening hours (the 4 hours after sunset) during which electricity is available.
- *Reliability* ("Is my service frequently interrupted?"): The reliability of electricity supply is a combination of the frequency and the duration of unexpected disruptions.
- *Quality* ("Will voltage fluctuations damage my appliances?"): The quality of the electricity supply refers to the absence of severe voltage fluctuations that can damage a household's appliances.
- *Affordability* ("Can I afford to purchase the minimum amount of electricity?"): The affordability of the electricity service is determined by whether the cost of a standard consumption package of 365 kWh a year is less or more than 5% of a household's annualized expenditure.
- *Formality* ("Is the service provided formally or by informal connections?"): If households use the electricity service from the grid, but do not pay anyone for the consumption, their connection could be defined as an informal connection.
- *Health and Safety* ("Is it safe to use my electricity service?"): The spectrum of electrical injuries is broad, ranging from minor burns to severe shocks and death. The Health and Safety attribute relates to high-risk, permanent injuries from the energy supply.

For each of these attributes, households are placed in a tier depending on the level of service as defined by the different thresholds provided.



Tier 0	Tier 1	Tier 2
Electricity is not available or is available for less than 4 hours per day (or less than 1 hour per evening). Households cope with the situation by using candles, kerosene lamps, or dry-cell-battery-powered devices (flashlight or radio).	At least 4 hours of electricity per day is available (including at least 1 hour per evening), and capacity is sufficient to power task lighting and phone charging or a radio (see table 1). Sources that can be used to meet these requirements include a Solar Lighting System (SLS), a Solar Home System (SHS), a mini-grid (a small-scale and isolated distribution network that provides electricity to local communities or a group of households), or the national grid.	At least 4 hours of electricity per day is available (including at least 2 hours per evening), and capacity is sufficient to power low-load appliances—such as multiple lights, a television, or a fan (see table 1)—as needed during that time. Sources that can be used to meet these requirements include rechargeable batteries, an SHS, a mini-grid, or the national grid.

Tier 3	Tier 4	Tier 5
At least 8 hours of electricity per day is available (including at least 3 hours per evening), and capacity is sufficient to power medium-load appliances—such as a refrigerator, freezer, food processor, water pump, rice cooker, or air cooler (see table 1)—as needed during that time. In addition, the household can afford a basic consumption package of 365 kWh per year. Sources that can be used to meet these requirements include an SHS, a generator, a mini-grid, or the national grid.	At least 16 hours of electricity per day is available (including 4 hours per evening), and capacity is sufficient to power high-load appliances—such as a washing machine, iron, hair dryer, toaster, and microwave (see table 1)—as needed during that time. There are no frequent or long unscheduled interruptions, and the supply is safe. The grid connection is legal, and there are no voltage issues. Sources that can be used to meet these requirements include diesel-based mini-grids or the national grid.	At least 23 hours of electricity per day is available (including 4 hours per evening), and capacity is sufficient to power very high-load appliances—such as an air conditioner, space heater, vacuum cleaner, or electric cooker (see table 1)—as needed during that time. The most likely source for meeting these requirements is mini-grid or the national grid.

Figure 15: MTF tiers of household electricity access

Least-cost electrification options to reach the national target of universal electricity access by 2022 as per the KNES, were calculated for six scenarios to deliver different levels of access according to the MTF tiers.

The LCE scenarios facilitate grid extension and off-grid planning. For access in urban areas, this was aimed at Tier four. For rural settlements, Tiers one to three of access are explored with two potential SHSs identified per Tier corresponding to the lower and upper end of the tier**.** The two systems per Tier for SHSs provides an indication of the spread of cost and energy service variations available in the SHS market in Kenya.

The six scenarios of the SHSs for rural settlements that are compared against costs of connections through grid extension and mini grids are summarised in

Table **14**. Complete details of energy services (including appliances and potential uses) and the end-user costs are provided in the next section- lighting solution. The USD/kW value in the last column in

Table **14** were used for the LCE calculations and have been adjusted to an 'at cost' basis. Figures are taken from publicly available retail SHS prices and include a profit margin. The Lighting Solution (see Section 6:3) uses prices seen by the consumer (including any subsidy or profit). To ensure a fair

comparison, the SHS figures have been discounted by 15% (based on discussion with industry players). **Error! Reference source not found.**

Scenario	Tier	SHS system options	Availability (min. hours)	System size (W)	Appliances	USD/KW
1.1: Tier 1 System 1	Tier 1	M400 Omnivoltaic	4	6	1 LED lights: 200lm/100lm/25lm 2 LED lights: 100lm/50lm/25lm Radio, Torch, Mobile charging adaptor	14,428
1.2: Tier 1 System 3	Tier 1	X850 DLite	4	40	1 tube light 460lm 4 LED lights: 230lm	6,924
2.1: Tier 2 System 1	Tier 2	AzuriTV	4	50	4 hanging LED lamps-150 Lm Radio, Torch, mobile charging adaptor, satellite decoder TV- 24 inch	7,420
2.2: Tier 2 System 2	Tier 2	TV Package SuNami	4	120	6 LED lights: 6W DC bulbs (~400lm) TV- 24 inch Includes household wiring by approved electricians	7,066
3.1: Tier 3 System 1	Tier 3	Customised Mobisol DC system	8	200	2 LED lights: 200lm 2 LED lights: 350lm Radio, Torch, Mobile charging adaptor 43" TV	2,473
3.2: Tier 3 System 2	Tier 3	Customised SolarNow, SolarGen,Orb Energy	8	500	12 LED lights: 6W-400lm TV, Fridge (sold separately)	1,963

Table 14: Scenario parameters for SHSs options

1.32 Results of LCE modelling

The cost optimal electrification options - grid connections, mini grid and SHSs - vary from one scenario to another. Figure 16 presents the proportion for each technology mix for new connections required for providing access for all in Kitui by 2022.

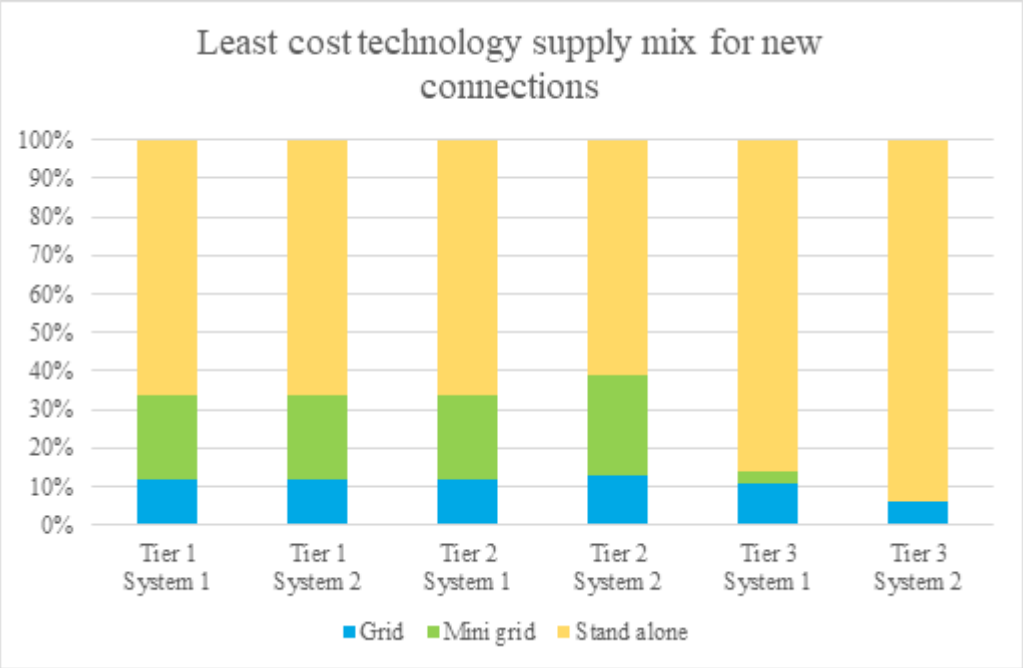


Figure 16: Least cost technology supply mix for new connections in Kitui County

The following maps present the distribution of the various supply options across Kitui County for three scenarios:

- **Rural Tier 1 & Urban Tier 4**. Figure 17 shows the geographic distribution of technologies (grid, mini grid and SHS) modelled for least cost - considering all urban areas are tier 4 and rural areas are Tier 1 (SHS Tier 1, system 1)
- **Rural Tier 2 & Urban Tier 4.** Figure 18 shows the geographic distribution of technologies (grid, mini grid SHS) modelled for least cost - considering all urban areas are tier 4 and rural areas are Tier 2 (SHS Tier 2, system 1)
- **Rural Tier 3 & Urban Tier 4**. Figure 19 shows the geographic distribution of technologies (grid, mini grid SHS) modelled for least cost - considering all urban areas are tier 4 and rural areas are Tier 3 (SHS Tier 3, system 1)

The analysis shows that standalone SHSs are the dominant least cost option for new connections in the county. Additionally, as the consumption levels increase (ie from Tier 1 SHSs to Tier 3 SHSs in rural areas), SHSs increase their share further. This is due to the much lower capital costs (USD/kW) compared to the per kW costs for a grid connection or a mini grid.

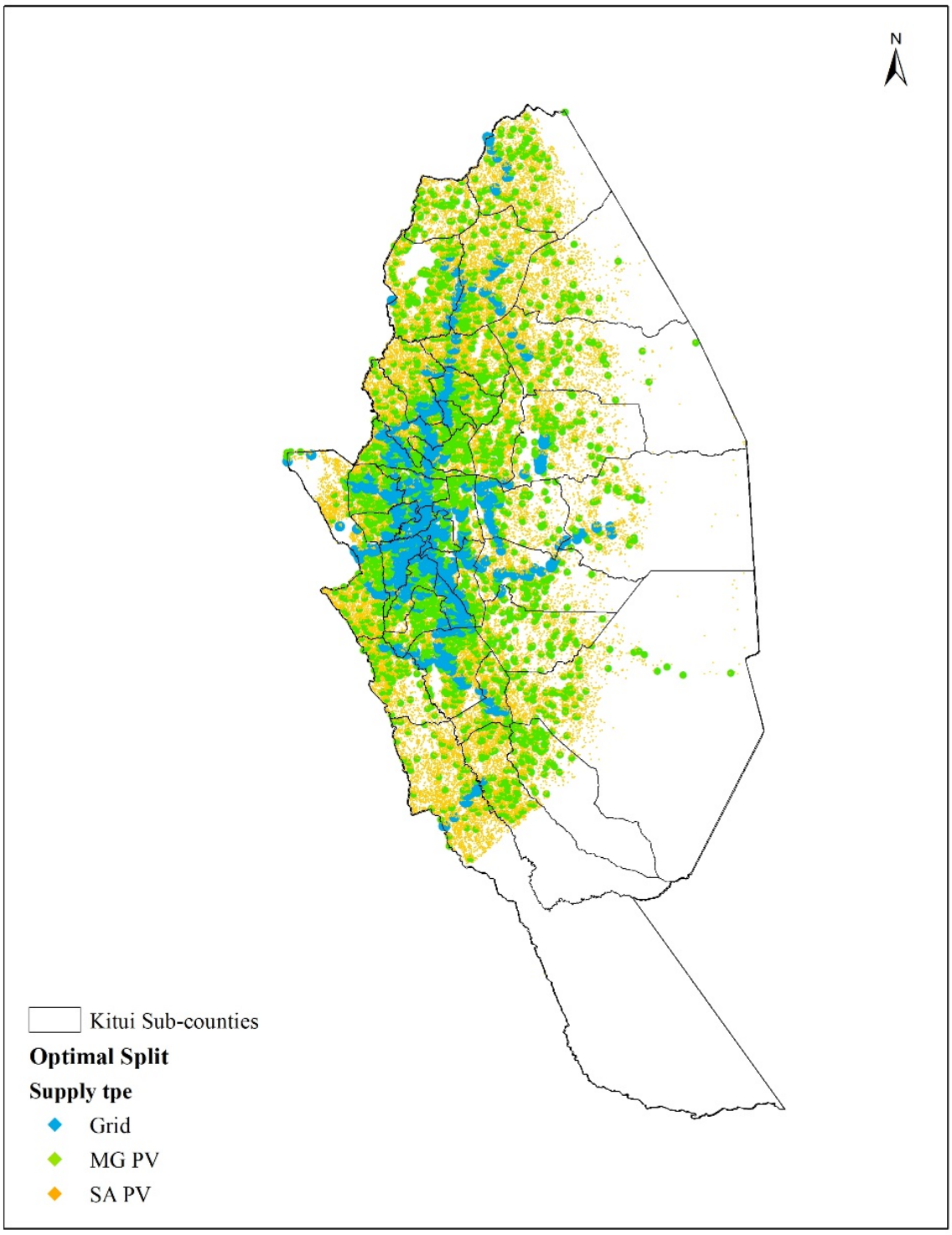


Figure 17: Least-cost electrification mix for Tier 1 access - Tier 1 System 1

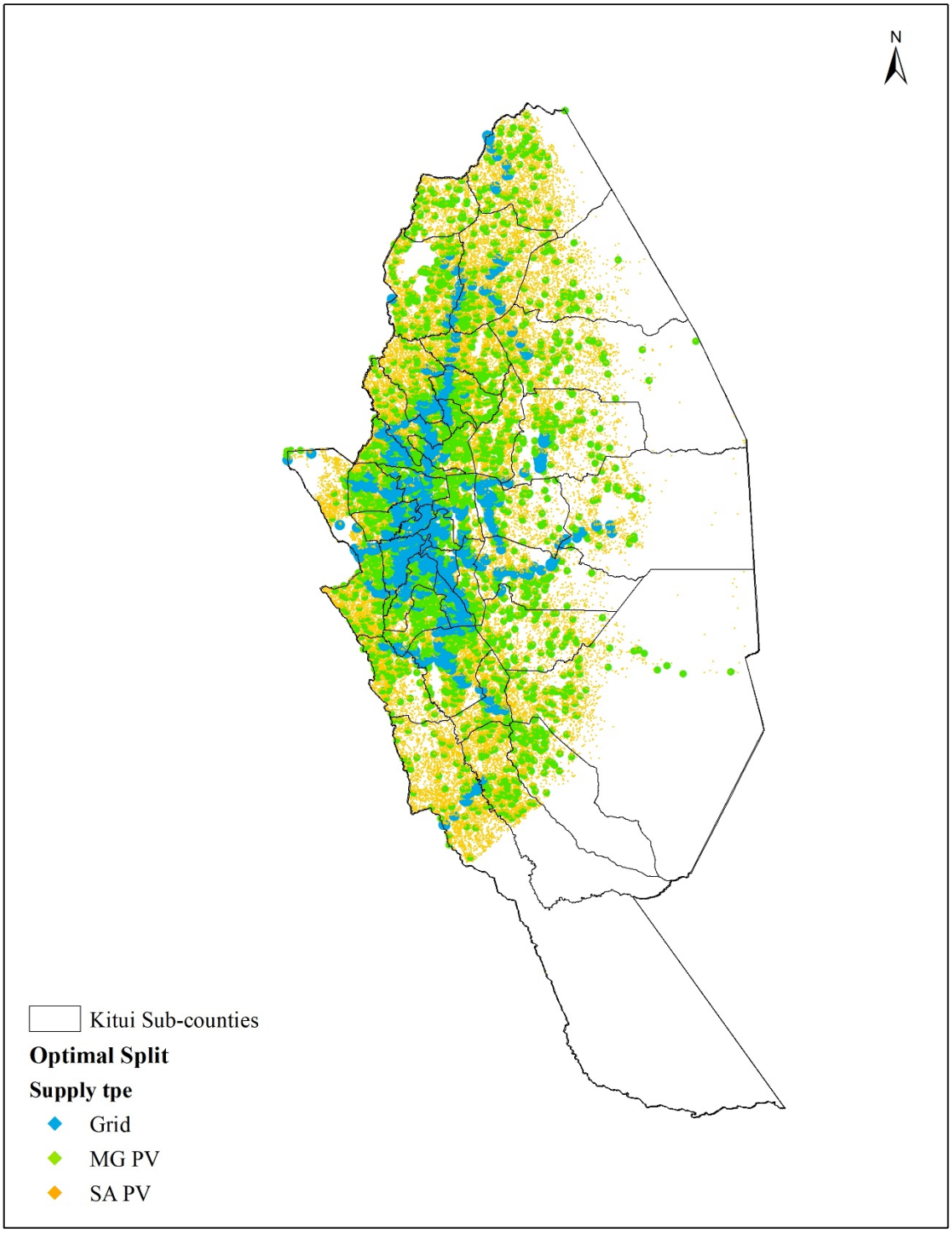


Figure 18: Least-cost electrification mix for Tier 2 access- Tier 2 System 1

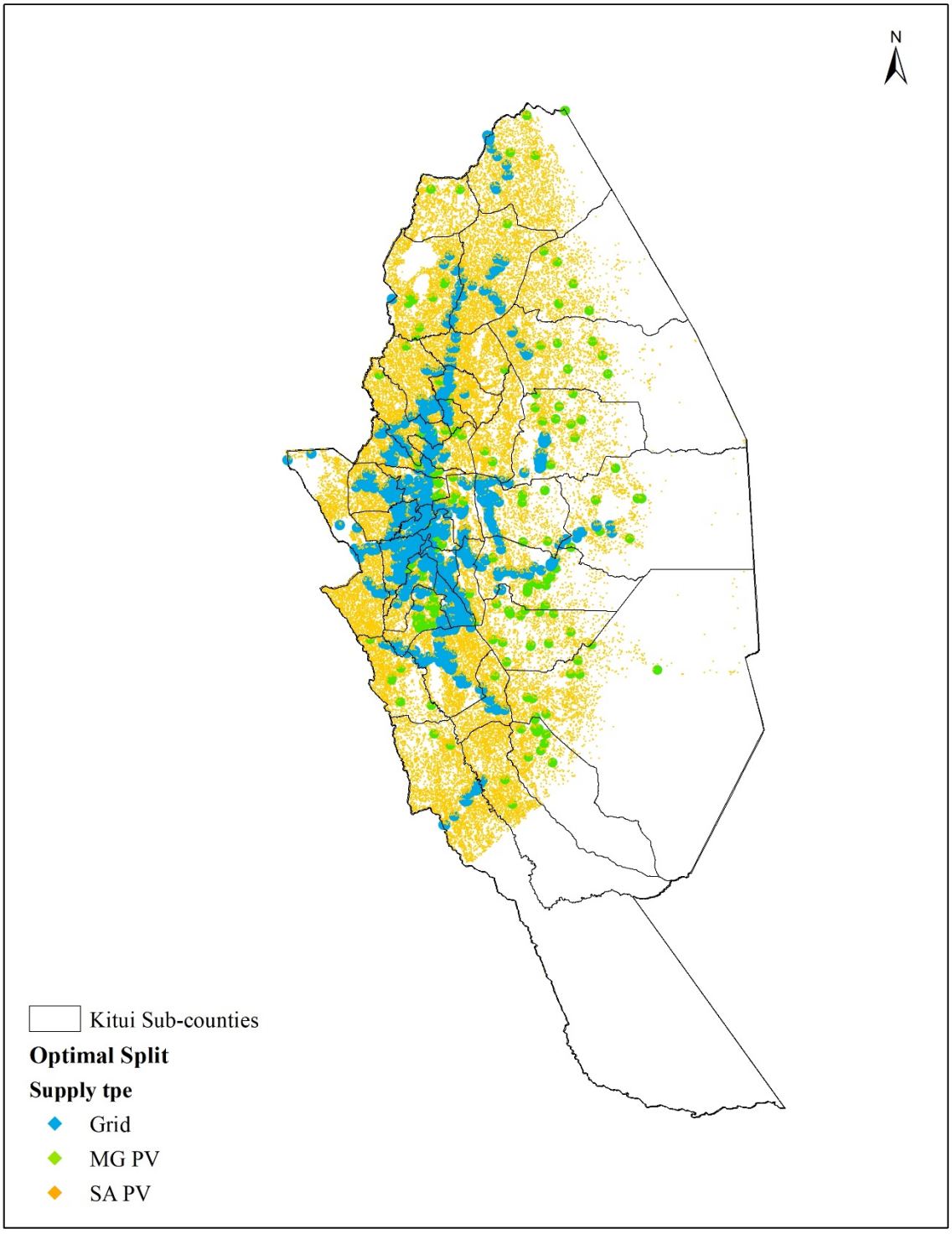


Figure 19: Least-cost electrification mix for Tier 3 access - Tier 3 System 1

As shown in **Error! Reference source not found.** and **Error! Reference source not found.** the required electricity generation capacity to reach full electrification in Kitui County ranges between around 73 MW for the lowest access scenario (rural SHS households on tier 1, system 1) and 205 MW for the highest (rural SHS households on tier 3, system 2).

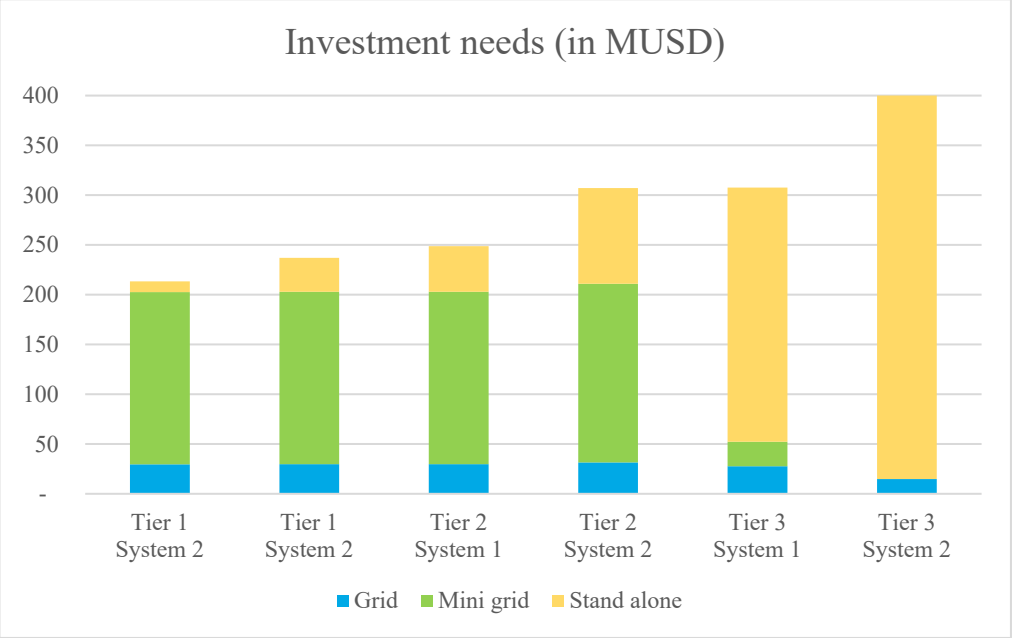


Figure 20: Investment needs (in MUSD) to reach full electrification in Kitui County

	Tier 1 System 2	Tier 1 System 2	Tier 2 System 1	Tier 2 System 2	Tier 3 System 1	Tier 3 System 2
Grid	30	30	30	32	28	15
Mini grid	173	173	173	179	25	-
SHS	11	34	46	96	255	390

Table 15: Investment needs (in MUSD) per scenario and supply type to reach full electrification in Kitui County

As Figure 20 and Table 16 above show, to reach full electrification in Kitui County, investment costs range between approximately 200 million USD for the lowest access scenario (Tier 1- System 1) and 400 million USD for the highest scenario (Tier 3: System 2). This includes the capital costs for generation, transmission, and distribution infrastructure, as well as for all off-grid systems (SHSs and mini grid technologies).

Recommended next steps for LCE

- **Strengthen institutional capacity at county level on energy investment planning**: it is important to note that the least cost electrification outlined above identifies several scenarios to help with this planning. The scenario will identify which type of technology is most suitable for the location. It does not however select the scenario or which location is prioritised: this is a political decision which would merit transparent criteria to avoid a 'wish list' of projects which do not optimise for community needs. The solutions laid out in the following section identify priority needs coming from each location, cost these, and identify power requirements. The least cost electrification combined with consideration of these demand-driven needs should help with planning. Further capacity building is also recommended to assist planners carry out effective and transparent planning and investment decision-making. This should include guidance on how to select and prioritise investments for Kitui based on community needs identified in the CEP, and the types and amounts of finance available from county Government and donors and co-

financiers. Having clear, transparent, and evidence-based approaches would also help access financing through large national programmes such as Kenya Off-grid Solar Access Project (KOSAP) in its next phases.

- **Develop a strategy to encourage increased presence of good quality SHS suppliers across the county***: See Lighting solution below*
- **Analyse the feasibility of mini grids:** Given that mini grids are potential solution for five of the six scenarios presented, MENR and KPLC should conduct pre-feasibility studies to identify potential sites for mini grids. This should consider high energy consumers such as (MSMEs), institutional consumers such as health facilities and populations living within proximity. These feasibility studies should also determine end-user affordability and set appropriate tariffs.
- **Affordability data:** *See Lighting solution below.*

1.33 Solution 1: Household Lighting - better quality, reliable lighting for households across Kitui county

Summary of problem and solution

The objective is to ensure that all households in Kitui have access to lighting to be able to carry out activities such as cooking, lighting, general purpose activities, and learning more safely and effectively.

The solution will aim to address barriers to reliable and affordable electricity such as,

- Lack of grid in remote areas and inability to afford connection and wiring costs in areas with the grid
- Low reliability of the grid due to infrastructure breakdown and power rationing
- Low access levels to off-grid solar systems and their poor management due to limited supplier availability, lack of technicians and supporting services at the local level
- Affordability issues to purchase and maintain off-grid soar systems, generators, and purchase fuel
- Lack of enabling policies and financing options for off-grid systems and more efficient appliances
- Low knowledge and awareness on off-grid lighting options and benefits for quality of light

The solution will include the following interventions:

Energy components

- **Reliable access to better quality, affordable electricity and strong maintenance provisions through:** (a) grid connectivity in areas that can be connected (b) affordable off-grid Solar Home Systems (SHS) in areas that cannot be connected to grid or planned mini grids (c) solar powered back-up systems

Non-energy components

- **Access to affordable finance options** for all household energy options, including connection costs and off-grid systems through (a) MFIs and SACCOs (b) Existing PAYG enterprises (c) Govt subsidized financing options through low interest loan programmes
- **Community awareness programmes** on energy solutions, supplier options, quality, and costs

What problem is the solution addressing?

The priority need identified was access to better quality, reliable and affordable lighting services for households to carry out various activities such as cooking, productive activities, learning; for safety and security at night; and for general purposes such as entertainment, socialising etc.

According to KNBS (2019), only 17.1% of the households in Kitui are using grid electricity for lighting as their primary source of energy. Solar Photo voltaic (PV) is the most used primary source for lighting- over 37% of the households use solar powered lighting and over six% use solar torches. Over 27% rely on kerosene lanterns & lamps and 11% rely on dry cell battery torches. The remaining two% of the households use gas lamps, wood, candles, and car batteries. None of the households use diesel or petrol generators as the primary source for lighting. A significant number of the households are therefore using

poor quality and unsafe lighting solutions. These solutions provide low quality lighting which have negative implications on activities such as reading, studying and productive use activities (eg sewing, weaving etc.) that require good quality lighting (eg more efficient types of bulbs with high levels of intensity).

SEAF-K (2017) identified that majority of the households in Kitui using kerosene require around 3- 4 litres per month with few households using between 10- 15 litres per month. With a market price of around KES 110 per litre20, most households are therefore spending between KES 300 to KES 1650 a month. The monthly bills of households connected to the grid range between KES 500 to KES 3,500.

Below are some of the key gaps identified.

Energy gaps

- **Lack of grid connectivity across the county**

  According to the 2019 National Census, sub-counties such Kitui South, Mwingi West, Mwingi North and Kitui Rural has the lowest grid connection rates (< 25% of households connected).

- **High grid connectivity costs and challenges with metering and billing cycles**

  Even where the grid distribution network is present the connection fees were too high for most households. Until recently the subsidised connection fee for a household within 600m from a transformer was 35,000 KES. However, the Last Mile Connectivity Project has halved the cost of connecting to a transformer to KES 15,000 and a monthly charge of KES 1,000 for 2 years. This has increased the number of grid connections across the country. However, for households beyond 600m from an existing transformer, the cost is still significantly high as the cost of installing the new transformer is added to the household connecting fee (Bahaj et al. 2019). With the penetration of the grid still relatively low in Kitui, many households are still unable to connect to the grid.

  This grid connection cost is also exclusive of internal house wiring that is usually undertaken by licensed electricians, most of whom charge KES 20,000-30,000 for residential houses for fittings and labour costs. Research conducted for this CEP show that this high connection is preventing households from connecting to the grid even when the grid arrives.

  The discussions with stakeholders and communities also highlighted complains related to metering of bills and inconvenient billing cycles which result in negative effects on people's usage, trust, and potential new connections. Lack of awareness among grid consumers on pre-paid and post-paid options available and limited capacity within KPLC offices to carry out awareness campaigns ('Power Clinics') are limitations.

- **Unreliable grid electricity and power rationing**

  According to KPLC (2017), an average of around four outages per month per customer, lasting on average six hours at a time occurred in Kenya. According to recent national. surveys by The World Bank's ESMAP programme using the MTF (The World Bank, 2020), unscheduled outages of the grid are much higher: 49% of those surveyed had outages anywhere between three and 14 times a week. The remaining 51% of households had less than three outages or less than two hours of outages per week. According to ESMAP, there was no major difference in reliability between the urban and rural area. While both the above sources are average nationwide averages, some stakeholders from Kitui highlighted that power interruptions can at times last up to three days per week. However, this

20 Data received from local consultant, as per published price of kerosene in April 2020.

finding needs further verification with data and evidence specific for Kitui. KPLC's published planned power interruption information could be a useful source to analyse power interruption trends in Kitui.[21] Breakdown of grid systems due to poor quality poles and transformers occur, especially during the rainy seasons. With only two KPLC offices (Kitui Town and Mwingi Central), there is a lack of technicians to provide servicing needed for the transformers and damage to grid infrastructure.

- **Breakdown of poor quality SHS, and to the lack of local technicians for repair**

For those outside the reach of the grid, solar home systems are an increasingly available option. However, inadequate knowledge for decision making on quality of systems has led to poor quality product purchase with low lighting quality and low lifetimes. There are also counterfeit products in informal markets which can add to perceptions that solar is of bad quality. Lack of know-how on maintenance and operation, and lack of access to local technicians to undertake maintenance and repair of SHSs has resulted in some shifting back to old low-quality types of fuel when SHS breakdown or unable to provide lighting as expected.

Key non-energy gaps identified

- **Lack of affordable options and low willingness to pay for SHS and more efficient appliances**

- Seasonal incomes often limit ability to maintain regular payments and high up-front costs needed for SHS was a key barrier for uptake. This is also due to lack of affordable and flexible financing options due to limited locally available supplier networks for SHSs, suitable appliances and spare parts, and lack of financing options from local financial institutions for off-grid solutions. Further challenges include lack of community awareness about quality of off-grid solutions, willingness to bear high upfront costs of higher quality SHS and lack of clarity in when the grid will arrive to their areas.

- **Issues with household infrastructure**

- Research carried out for the Kitui CEP also showed that most rural houses have at least two separate quarters- one serving as a main dwelling unit and a separate room which is usually the kitchen. Most small size SHS are not able to meet the needs of two dwellings as the systems are 'closed' and additional wiring and extensions cannot be added. Therefore, they are not often able to meet full energy needs of a household. Remote households build also lack natural light and ventilation during the day- which require some household activities during daytime to use kerosene lamps or other lighting fuel.

- **Lack of community awareness about the benefits of good quality, safe lighting**

There is less awareness on how more and better-quality lighting can help efficiencies at the household level and improve security and quality of life. More awareness is also need on risks to health from burning fuels like paraffin/poor ventilation- particularly due to indoor-air pollution which result in respiratory issues. This is often seen an issue with women and children who often stay in-doors more.

- **Lack of regulation/certification of SHS in the local market**

Low quality products are easily and cheaply available in the local markets in Kitui. Without proper regulations or certification standards, people continue to purchase poor quality generic systems,

[21] https://www.kplc.co.ke/category/view/50/planned-power-interruptions

and lose investments and trust due to fast breakdown or poor-quality lighting they produce.

- **Theft of solar panels and batteries**

  Issues around theft also affect decision making to purchase a high-cost product such as SHSs, panels and batteries which are easily portable.

Solution

Target groups: Households that currently do not have access to electricity

Energy Component

According to KNBS (2019), 83% of the households in Kitui do not use grid electricity as the primary source for lighting- and majority of these households may need new connections. Out of this around 44% are using solar powered technologies, and 11% with dry-cell battery sources. This leaves around 30% of the households without access to electricity.

Section 6:2 above shows that a combination of grid and off-grid (mini grid & SHSs) solutions are needed to provide electrification for all households in Kitui County. Therefore, the solutions for improving access to lighting include three key electrification options to bridge this gap:

1. **Option 1**: Grid connection: For households who are not connected to the grid and live within 600mfrom a grid transformer- prioritised for grid connections22
2. **Option 2**: Mini grids (solar): For remote households without access to the grid, living in areas that are unlikely to have the grid extended by 2022
3. **Option 3**: Solar Home Systems (SHS): For remote households without access to the grid living in areas that are unlikely to have the grid extended by 2022 or not economically and technically feasible for mini grids. These could also be used for households which are currently facing significant reliability issues. For SHSs, the solution includes different options based on tier of service (for Tiers 1, 2 and 3 of the multi-tier framework). The SHS calculations are based on an analysis of systems available in the Kenya market. The tables below present a higher and a lower cost option for each Tier to provide an overview of the range of capacity and energy services available from SHSs available in the market.

Points to note

- The pricing is based on market prices obtained from suppliers over April-May 2020. This is an indicative list of solutions available in the market to provide a broader understanding on energy options for lighting.
- The lighting standards from the World Bank Multi-Tier Framework (Bhatia and Angelou, 2015) has been used when categorising lighting options into Tiers of supply based on size (wattage) and availability (the total number of hours per day -24- hour period, during which electricity is available)
- It includes an analysis of activities that can be carried out from the quality of lighting available, and the size of households (in number of rooms) that would benefit from a system. This has been carried out based on information available online which indicate potential activities based on minimum light intensity available from bulbs used (lumens or lux)23

22 Based on criteria used for the last mile connectivity project

23 https://www.airfal.com/en/industrial-lighting/recommended-light-levels-common-types-of-working-activities-2875/

- In addition, analysis also includes various appliances integrated to the systems.
- Costs outlined are from the end-customer perspective ie real-world prices the customer would pay (including any subsidy or profit).

Option 1: Grid connection

Type of cost	Costs
Connection fee- within 600m (with general subsidy)	Household users pay KES 35,000 to KPLC for connection of single-phase power to their homes.
Connection fee- within 600m (under Last Mile Connectivity project- planned to roll out the 4th phase (date unknown))	Household users paid KES 15,000 for the connection provided the household is within 600m from a transformer. A charge of KES 1,000 is then added onto monthly bills for a period of 24 months.
Connection fee- beyond 600m	The cost of installing the new transformer is added to the household connecting fee
Wiring	Grid connection costs are exclusive of internal house wiring that is usually undertaken by licensed electricians, most of whom charge KES 20,000-30,000 for residential houses for fittings and labour costs.
Tariff	KES 23/ kWh

Option 2: Mini grid

According to the Kenya National Electrification Strategy (2018), currently there are no mini grids in Kitui, and none are planned to be installed by 2022. However, the optimal electrification mix for new connections based on least cost electrification modelling (presented in the Least Cost Electrification Section above) shows that mini grids are part of the mix with grid and SHSs to provide electrification for all in Kitui County. Therefore mini grids need to be taken into consideration when making electrification plans for the County.

The following figures provide an indication of mini grid costs in Kenya adapted from studies on mini grids in Kenya (New Climate Institute and EED, 2019; Hendriksen, 2019)

Capital costs	The upfront capital costs and operational costs of renewable energy mini grids vary significantly across different types of mini grids- sophistication of systems and the technologies employed. However according to this study relatively small-scale systems that are based on solar PV and can provide 24-hour electricity access through battery storage, which is representative of most new mini grids implemented in Kenya in the past two years, as well as most of the potential private sector mini grids in the pipeline. The study also highlights that renewable energy mini grids deployed in 2017 in Kenya are estimated to have a **total capital cost of approximately KES 103,000 (USD 1,000) per household connection**.

	It further notes that the Africa Mini grid Developers Association (AMDA) has reported a steady reduction in the average cost per connection across private sector built and operated mini grids as the market in Kenya and Tanzania has expanded: **the cost was USD 1,163 in 2017, decreasing to USD 934 in 2018, with further projected reduction to USD 600–700 in 2020**.
Connection fees for end-users	The connection fees also vary by developer. According to the Green Mini grids programme in Kenya the connection fees **varied between 6,600-9,500 KES (65: 95 USD)**
Tariff	Despite high grant support kWh tariffs remain high in Kenya. Price structures for end-users currently vary significantly based on the financial models employed by different systems. Cost-reflective tariffs determined by mini grid operators are higher than those offered by the main utilities in Kenya. The approved private sector **mini grid tariffs for the Green Mini grids programme range between 50- 85 KES/ kWh (USD 0.5 and 0.85/kWh)** compared to the much lower national domestic tariff KES 10/kWh. It is anticipated that this will be more closely regulated by the Draft 2017 Kenya Energy (Mini grid) Regulations, which require **all mini grids with a capacity above 100 kW to apply the national uniform electricity tariff KES 10 per kilowatt-hour (kWh) for consumption below 100 kWh per month and KES 15.80/kWh above 100 kWh.** Smaller systems may charge an additional cost recovery fee, calculated using a determined methodology.

Options 3: Off-grid SHSs from Tiers 1, 2 and 3

Tier 1- SHS		
Size- Wattage	**6 Watts**	**40 Watts**
System model/ Supplier	M400/ Ominivoltics	**X850/ DLite**
Lighting service	3 bulbs with 3 intensity settings Main LED bulb- 200lm/100lm/25lm 2 additional LED bulbs- 100lm/50lm/25lm	1 Fluorescent tube light- 460lm 4 LED bulbs - 230lm Torch: 88lm
Duration of lighting at highest intensity	Minimum: 4 hours Maximum: 6 hours	Minimum: 4 hours Maximum: 6 hours
Other energy services	Radio, Torch, Mobile charging adaptor	Radio, Torch, mobile charging adaptor
Added benefits	Warranty- 2 years	
Cash price (KES)	KES 10,500	KES 33,590
Financing options available	PAYGO: Deposit: KES 1,000 Monthly payments: KES 1,100 Time frame: 12 months	PAYGO: Deposit: KES 3,000 Monthly payments: KES 1,950 Time frame: 19 months

	Fully paid price: KES 14, 200	Fully paid price: KES 41,200
Household suitability	- The main bulb can be used outside room away using the 5m extension cable provided. - Able to provide lighting for a traditional 3 roomed traditional rural household without corridors - Individual bulbs on their own provides the opportunity to conduct activity that require less intensity lighting: entertainment, cooking etc. - By using multiple bulbs in proximity provides the opportunity to do detailed activities (such as sewing, reading, writing) - eg Using the main bulb and an additional bulb gives 300 lumens. And by sitting close to these bulbs children can read, write or study. - Has limited opportunity to illuminate multiple rooms at the same time.	- The tube light provides good intensity lighting for bigger areas in the house and provides the opportunity to carry out detailed activities (such as sewing, reading, writing etc) - Able to provide lighting for a 5 roomed modern house with corridors - Individual bulbs on their own provides the opportunity to conduct activity that require less intensity lighting: entertainment, cooking etc. - By using multiple bulbs in proximity provides the opportunity to do detailed activities (such as sewing, reading, writing) - Can illuminate more rooms at the same time and carry out multiple activities.
Target customers	Remote and low-income households in off-grid areas	Remote and low-income households in off-grid areas

Tier 2- SHS		
Size- Wattage	**50 Watts**	**120 Watts**
System model/ Supplier	AzuriTV/ Azuri Technologies	TV Package/ SuNami
Lighting service	4 LED bulbs- 150lm	6 LED bulbs (6W)- 400 lm
Duration of lighting at highest intensity	Minimum: 6 hours Maximum: TBC	Oversized system and suitable for 24 hour supply
Other energy services	Radio, Torch, mobile charging adaptor, satellite decoder, TV- 24 inch	TV- 24 Inch
Added benefits	Warranty- 2 years	- Warranty- 3 years - Includes household wiring by KPLC approved electrician - Bulbs are replaceable easily as available in local shops - Potential to use to power other DC appliances. Need to be cautious about maximum power rating for equipment that can be used and for how long.

Cash price (KES)	KES 45,000	- KES 60,000 (estimate as only available in monthly payments in the market)
Financing options available	PAYGO: - Deposit: No deposit - Monthly payments: KES 3,612 - Time frame: 32.5 months - Fully paid price: KES 117,390	PAYGO: - Deposit: KES 7,000 - Monthly payments: KES 5,200 - Time frame: 40 months - Fully paid price: KES 215,000
Household suitability	- Able to provide lighting for a 4 roomed modern house with corridors - Individual bulbs on their own provides the opportunity to conduct activity that require less intensity lighting: entertainment, cooking etc. - By using multiple bulbs in proximity provides the opportunity to do detailed activities (such as sewing, reading, writing) - Has limited opportunity to illuminate multiple rooms at the same time.	- Able to provide lighting for a 4 roomed modern house with corridors - Individual bulbs on their own provides the opportunity to conduct general or detailed activities (such as sewing, reading, writing) - Can illuminate more rooms at the same time and carry out multiple activities.
Target customers	- Rural and urban, higher income households in off-grid settings.	- Able to use the same wiring for the grid connectivity once the grid arrives. Therefore, suitable for areas where the grid extension plans or have high probability for grid extension (with good roads etc.) - Rural and urban, higher income households in off-grid settings.

Tier 3- SHS		
Size- Wattage	**200 Watts**	**500W**
System model/ Supplier	Customised DC system/ Mobisol	Customised AC-DC system/ SolarNow, SolarGen, Orb Energy
Lighting service	2 LED bulbs- 200lm 2 LED bulbs- 350lm	12 LED bulbs (6W)- 400 lm
Duration of lighting at highest intensity	Minimum: 8 hours Maximum: TBC	Minimum: 12 hours all bulbs highest intensity and TV and Fridge functioning at the same time
Other energy services	Radio, Torch, mobile charging adaptor, TV- 24 inch	TV, Fridge
Added benefits	- Warranty- 4 years - The system can be modified to meet user needs - Includes household wiring by KPLC approved electrician - Potential to use to power other DC appliances. Need to be cautious about	- Bulbs are replaceable easily as available in local shops - Able to add a fridge sold separately

	maximum power rating for equipment that can be used and for how long.	
Cash price (KES)	KES 179,000 (estimate as only available in monthly payments in the market)	KES 95,000-125,000 (depending on location)
Financing options available	PAYGO: - Deposit: No deposit - Monthly payments: KES 5,721 - Time frame: 48 months - Fully paid price: KES 274,608	Only SolarNow offers direct consumer financing for its products Orb Solectric (Orb Energy) has partnered with a number of financial institutions such as KWFT, Equity Bank and a few other banks and SACCOS that offer clean energy loans. The loans are offered with normal loan terms (11.5 interest rate)
Household suitability	- Able to provide lighting for a 4-6 roomed modern house with corridors - Individual bulbs on their own provides the opportunity to conduct general or detailed activities (such as sewing, reading, writing) - Can illuminate more rooms at the same time and carry out multiple activities.	- Able to provide good lighting for a 9 roomed modern house with corridors - Individual bulbs on their own provides the opportunity to conduct general or detailed activities (such as sewing, reading, writing) - Can illuminate all rooms and exteriors at the same time and carry out multiple activities.
Target customers	Urban or rural higher income households	- Able to use the same wiring for the grid connectivity once the grid arrives. - More suitable for those with existing grid connection (as back-up) or higher income off-grid households where the grid will arrive soon - Rural and urban, higher income households in off-grid settings.

Supporting services

- **Infrastructure maintenance**: for mini grids, fixed annual maintenance contracts with off-grid system supplier to ensure regular checks and maintenance. SHSs include a warranty.

- **Financing options:** connection or system purchase costs are the biggest barrier to entry. For grid connections, the under Last Mile Connectivity project assists with affordability through adding part of the connection fee to the monthly tariff. Mini grid connection fees tend to be lower than the grid. Those without sufficient savings will need to seek loans: for example, through MFIs, banks, or SACCOs. This is not currently standard practice, and there may be reluctance for lending for household connections from MFIs/Banks without further government intervention.

For Solar Home Systems, most tier 1 and tier 2 systems are pay-go with low deposit requirements, so the finance is built in. Companies selling Tier 3 & above products, whose solutions are often customized depending on individual customer's requirements, mostly do not offer credit. Only SolarNow offers direct consumer financing for its products while Orb Solectric (Orb Energy) has partnered with a number of financial institutions such as KWFT, Equity Bank and a few other banks and saccos that offer clean energy loans. The loans are offered with normal loan terms for each institution and usually to their customers. A quick survey shows that there are not many takers of clean energy financing from these financial institutions. SolarNow has a large presence in the western part of the country but none in Kitui. Orb Energy has an office in Nairobi only but offer countrywide services.

Enabling environment

- **Strong supplier standards**: the County government should work together with national government to develop a county list of criteria for suppliers to be eligible to win projects and install systems for county government. Related, to this to build county government capacity to promote good quality and efficient appliances as well as solar home system providers to Kitui residents (see below).
- **Efficient appliance and spare parts market**: strengthen and build the efficient appliance market and the resources required to support appliance repair
- **Community awareness:** capitalize on existing awareness programmes and develop new ones on (a) importance of energy access (b) accessing quality energy systems- grid and off grid (c) use and maintenance of off-grid systems (d) financing options for grid connections and off-grid systems

Next steps

- **Develop a strategy to encourage increased presence of good quality SHS suppliers across the county:** this would involve better engagement and communication with different suppliers to understand challenges in reaching remote communities in Kitui. This can then inform designing incentives for attracting more suppliers to Kitui (eg KOSAP incentivises suppliers to sell systems to remote areas)
- **Carry out an affordability mapping:** for example, understanding household expenditure in geographic level will inform end-user ability to pay for energy connections or systems. This will inform need for credit facilities and/or subsidies for end-customers
- **Develop a strategy to raise community awareness:** this could include media outlets such as radio programs, leaflets to inform communities on 'how to select good quality systems', prices to be aware of and financing options available for households to access connections or energy systems including subsidies and credit options.

1.34 Solution 2: Water - **improved access to clean, affordable, and reliable water for drinking and general-purpose needs in households**

Summary of problem and solution

The objective is to improve community access to clean water for drinking and other general-purpose household needs such as cooking, cleaning, and bathing/personal hygiene. However, it is important to consider water for livestock and other productive activities that may be linked to household's water demand. The solution will address the following gaps or barriers identified:

- **Reliability:** Lack of reliable and affordable electricity for water pumping
- **Functionality:** High number of non or partially functioning water points due to either poor design, poor maintenance, and lack of repair services
- **Management:** Poor governance and operation of community Water Management Committees (WMCs)
- **Demand and supply:** Lack of data on community water demand, and ground and surface water availability
- **Water quality:** Impurities in water supply due to increasing salinity, and low surface and ground water levels, and lack of treatment facilities
- **Awareness:** Lack of community and wide stakeholder awareness on the need for sustainable use of water points and available water resources

The solution comprises the following interventions:

Energy components

- **Replacing non/ partially functional diesel/petrol generators, and manually driven water points** with either standalone solar or electric with solar back-up pumping systems
- **Repair of non/partially functioning** solar or electric water pumps
- **Building new water points with solar or electric with solar back-up** in areas where there is water supply gaps
- **Establishing effective maintenance and repair function** for electricity systems, including increasing local technical capacity, and exploring remote monitoring functions and technology standardisation

Non-energy supporting services

- **Exploring options for water purification**- improving county-wide water treatment and reducing water salinity
- **Improving governance and effectiveness of Water Management Committees (WMCs)**
- **Increasing awareness** within communities, public and government agencies on need for sustainable water use and management
- **Improving county level capacity for data collection and analysis** on water demand, climate risks and water availability to develop sustainable water resource management strategies and investment plans

What problem is the solution addressing?

The need identified was improved access to clean water for drinking and to meet other general-purpose needs of communities. According to the County Government of Kitui (2018a), the average distance to the closest water point in Kitui is seven km. Research carried out for the purpose of the CEP also shows that water collection is commonly done by women and children in many rural areas of Kitui. County-wide estimates indicate that 42% of Kitui County's population has access to at least a basic water service. defined as time taken for a return trip to collection point is 30 minutes or less (KNBS, 2018).

There are two water service providers (WSPs) licensed and regulated by the Water Services Regulation Board (WASREB) which cover only about one third of the county. The remaining area is serviced by schemes developed by a range of actors. Almost all these small, rural schemes are unlicensed and unregulated by WASREB, and information on their functionality, performance, and service quality is limited.

In addition, according to the most recent census data (KNBS, 2019), over 42% of the households rely on streams or rivers as their main source of drinking water. Only around five% of the households use piped water into the dwelling or plot (Nyaga, 2019) and around nine% use public tap as the main source for drinking water. Boreholes remain the second most popular source with 13% relying on them for drinking water.

A Water Infrastructure Audit of Kitui County carried out by Oxford University in 2017 (Nyaga, 2019) located and mapped a total of 3,126 water sources spread across Kitui and their functionality. [24] This mapping found that most of these water points include hand pumps (22% of which mostly are hand dug wells and some borehole), sand dams (21%) and earth dams (19%). Out of the piped schemes 15% of the sources mapped - the majority rely on pumping. These pumping systems are powered by a range of sources: 53% by generators, 23% by solar, 11% by the grid and 13% by hybrid sources combining a primary and a back-up.

The Water Infrastructure Audit revealed that nearly 25% of all water infrastructure mapped is non-functional and 15% is partially functional. A further survey of a small number of households in Kitui showed that handpumps and kiosks provided good quality water, and cheaper compared to effort and time invested to collect water (Ferdous & Hope, 2018). However, the unavailability of water from these sources during extreme dry periods compelled people to access water from multiple sources (eg sand damns) and often from locations far away from their homes.

Below are some of the key gaps to meeting the desired outcome of improved access of communities to clean water for drinking and other general-purpose needs.

Energy gaps/barriers

- **Lack of reliable and affordable electricity for water pumping**

  According to Nyaga (2019), most piped schemes in the County are powered by diesel generators owing to the unreliability of grid electricity. These are expensive to buy and have significantly high operational and running costs compared to electric or solar powered pumps. Research conducted for the purpose of the CEP show that, for a borehole with 2m3/hr at 80m (pumping 14,000L over 7 hours), a 3-phase diesel generator and water pump (including control panel) costs almost 200,000 KES more, compared to a solar powered water pump (including panels and inverter). Similarly running

24. The Water Audit was carried out in Kitui under a collaboration between the County Government and the REACH Programme, a global programme to improve water security for the poor led by University of Oxford in collaboration with UNICEF. See: https://reachwater.org.uk/. Kitui, the programme partnered with Rural Focus Limited. The County Government has indicated that it will be carrying out a further audit soon to update its data (communication from January 2020).

costs of this diesel generator costs almost 2,700 KES per day compared to a grid connected electric pump which costs only around 200 KES to pump the same amount of water daily.

Furthermore, when diesel generators stop working due to lack of maintenance, water points may be abandoned resulting in a stranded asset. The County Government is currently implementing a hybridisation programme. This aims to replace existing community boreholes with yields of 2m3/hour or greater powered by diesel generators and hand pumps with solar-powered water pumping systems.[25] Data analysis carried out for the purpose of the CEP show that over 80% of non and partially functional water points are not included in hybridisation plans, and these waterpoints require further attention to ensure they are repaired and included in future plans and budgeting for repair, replacement with solar or electric pump and maintenance (see maps below).

- **High number of non or partially functioning water points due to poor design, poor maintenance, and lack of repair services**

Nyaga (2019) found that 40% of surveyed water points in Kitui were either partly functional (15%) or not functioning at all (25%). These failures were particularly high for generator-powered water points and piped networks which were often abandoned as a stranded asset once broken down. Hybrid systems and electric piped systems recorded higher functionality. First, according to the Audit, is that there is no standardisation for design nor quality control of water systems installed. Lack of access to technical capacity at the local level also result in poorly sized and poor-quality systems. Second, there is a lack of regular maintenance and, thirdly, a lack of repair services for the water points and their ancillary components. This is primarily due to lack of proper warranties and after sales care from system component suppliers, lack of funds for repair and replacement, and lack of trained local technicians to carry out maintenance and repair. The Water Infrastructure Audit revealed that solar systems were more functional than diesel-powered systems but where repair is needed, this takes a significant amount of time due to lack of availability of skilled technicians to service these systems. The high functionality of solar is often due to the low maintenance needs compared to diesel pumps.

Key non-energy gaps

- **Poor governance and operation of community Water Management Committees (WMC)**

Around 82% of the piped schemes in Kitui assessed in the Audit (Nyaga, 2019) are managed and operated by the beneficiary communities through WMCs. Most WMCs lack the skills required to undertake management tasks, including financial management such as bookkeeping, budgeting, and commissioning regular and independent audits of the water points and their income. The poor management of income and expenditures leading to lack of sufficient funds for maintenance and repair, is often cited as a key factor contributing to the partial or non-functionality of community managed water points. The lack of standard regulations and guidance for WMCs and of independent oversight of their financial management are also contributory factors to their por governance. Finally, land disputes between landowners and WMCs due to weak formal and informal agreements were also cited as governance issues which negatively impacted water service delivery.

- **Lack of data on community water demand and ground and surface water availability**

While the County Government's hybridisation plans are targeting community owned waterpoints, rather than privately owned waterpoints, the research conducted for the purpose of the CEP also indicates that there is a currently a gap in data to better understand which non/partially functioning water points are not included in the hybridisation initiative need to be prioritised for replacement

25 Meeting with Kitui County Government Water Department with the CEP development team (March, 2020)

based on demand and supply issues. There is no recent mapping of groundwater levels, including depletion rates, and water quality in the county.[26] A climate analysis done by Nyaga(2019) highlights that many surface water sources such as rock catchments, earth dams, and hand pumps have been constructed in areas of sequential dry periods, and during the dry period over July- September, 32% of functioning hand pumps (well or borehole) has less water due to decreased groundwater flows.

The County Government highlighted a lack of qualified staff and funding to undertake geological surveys and other research on the impacts of future groundwater levels, quality, and water demand due to population growth or other social factors or the current/future impacts of climate change and other environmental issues. In summary, better data and analysis of the current and future availability of groundwater resources is critical to support development of a sustainable water resource management strategy, including for rehabilitation of existing water points and installation of new water points. There is also a lack of policy frameworks and cross-ministerial coordination to promote sustainable groundwater use including to promote a more systematic use of rainwater harvesting techniques.

- **Impurities in water supply due to increasing salinity, and low surface and ground water levels, and lack of treatment facilities**

  During the needs assessment process carried out for the CEP, concerns were raised by communities and other key stakeholders (including from the health, education, agriculture and livestock sectors) regarding high salinity and low ground water levels affecting the availability and quality of water services in the county. However, there is little robust data about the specific impurities affecting water quality across the county. Discussions with Kitui County Department of Water and Irrigation indicate high levels of groundwater salinity in several sub-counties.[27] Results from the Nyaga (2019) showed that high salinity is widespread and more profound in borehole sources. However less than five% of the piped water schemes used some form of water treatment. Discussions with community members indicated that water treatment is mainly through use of chlorine tablets at the household level. As above, there is no recent mapping of groundwater levels and water quality in the county.

- **Lack of community and wide stakeholder awareness on the need for sustainable use of water points**

Discussions with stakeholders also highlighted lack of awareness among communities of the need to conserve water and use boreholes sustainably, including a lack of awareness of measures such as rainwater harvesting that can be used to conserve water.

Solutions

Target groups:

- Communities who have unreliable access to water from existing equipped[28] water sources due to power issues

26 The last groundwater mapping was carried out by JICA in 2004.

27 Areas with high levels of salinity according to the Kitui County Water Department include: Mwingi North (Tseikuru, Kyuso, Ngomeni); Mwingi Central (Nguni, Nuu); parts of Kitui East (Endau/Malalani, Voo/Kyamatu); and Kitui South boreholes not within the river lines.

28 As per the Water Infrastructure Audit of Kitui County (2019) the CEP assumes equipped water sources include the following:
Hand-pumps (a well or borehole with a hand-operated pumping mechanism);
Piped schemes (a water source whether borehole, rock catchment, shallow well, earth dam, or sand dam incorporating a water distribution network and/or other components such as pumping etc.); and
Water kiosks.

- Communities accessing water from non-equipped and/or unsafe water sources
- Communities who travel long distances (particularly women and children) to collect clean water due to lack of water points to meet their needs closer to their households or institutions

Energy component

- Provision of reliable access to electricity through customised solutions to address the following scenarios. The objective will be to deploy interventions for:
- Replacing non/ partially functional diesel/petrol generators, and manually driven water points with either standalone solar or electric with solar back-up pumping systems
- Repair of non/partially functioning solar or electric water pumps
- Building new water points with solar or electric with solar back-up in areas where there is water supply gaps

As noted above, the County Government is currently implementing plans for hybridisation of water points that are hand pumps or diesel powered. Data received from the County Government[29] on hybridisation and data from Nyaga (2019) on functionality of boreholes provide some clarity on which water points can be targeted for new interventions as a priority beyond existing hybridisation plans. The analysis conducted for the CEP included 1247 handpumps, boreholes and piped schemes out of which 34% were non-functional, 48% were partly functional, 15% were fully operational and 3% were under construction. Around 88% of the non-functional water points and 87% of the partly functional water points are not included in the hybridisation planning- indicating a critical need for improving the functionality of systems. The following maps indicate the non-functional and non-hybridised water points mapped against distance to grid infrastructure.

Figure 21 shows a map of non-functional and non-hybridised water points between 600m and 10km from a secondary electricity substation (also referred to as the nearest transformer or grid), and should be prioritised for solar water pumping.
Figure 22 shows a map of non-functional and non-hybridised water points within 600m from a secondary electricity substation and should be prioritised for electric pumping with/without back-up depending on reliability of the grid in specific areas.

Given lack of location data[30] it was not possible to obtain a complete view on water points beyond 10 km from the grid. These maps indicate which systems could ideally be prioritised to connected to the grid as a primary source of pumping, and which are potentially suitable for off-grid solar systems.

Table 16 summarises the non-functional and non-hybridised water points by sub county and their distance to the grid. Apart from Kitui Central where majority of its water points are within 600m from the grid and are suitable for grid connected electric water pumping systems (with back-up), the remaining sub-counties have majority (over half) of their water points beyond 600m needing stand-alone off-grid power for water pumping. Solar water pumps are the most suitable option for these water points as presented in the detailed costings below.

29 The following data sets were shared by the County Government for the purpose of this CEP: 1) 'Boreholes equipped with solar dataset': used to highlight hybridised boreholes; 2) 'Boreholes data collection template dataset' was also used to highlight hybridised boreholes; 3) 'Hybridization Boreholes data set' titled as 'Boreholes requiring hybridisation'- cross-checked with the above two data sets to identify the which boreholes were already hybridised and which are planned for hybridization.
Additional data set was received by the REACH team who conducted the Water Infrastructure Audit of Kitui County in 2019. This included data on functionality and a complete mapping of all water sources in Kitui. For the analysis against hybridisation, those waterpoints categorised as boreholes, piped schemes and handpumps.
30 Approximately 20% (or 248) of water points could not be mapped because of lack of coordinate location data. There is also a similar inaccuracy with potential duplicates (approx. 20%) where data points have the same water point serial number but different listed locations or water point types. These inaccuracies merit further follow up to improve the data set accuracy.

Sub-county	Total non-functional and non-hybridised water points	600m from the grid	Beyond 600m from the grid
Mwingi North	23	-	No location data available- therefore assumed all beyond 10km from the grid and require off-grid solution.
Kitui Central	27	14	13
Kitui West	35	17	18
Mwingi West	48	16	32
Kitui South	52	6	46
Kitui Rural	59	12	47
Kitui East	62	18	44
Mwingi Central	73	19	54

Table 16: Non-hybridised and non-functional water points by sub county and distance to grid

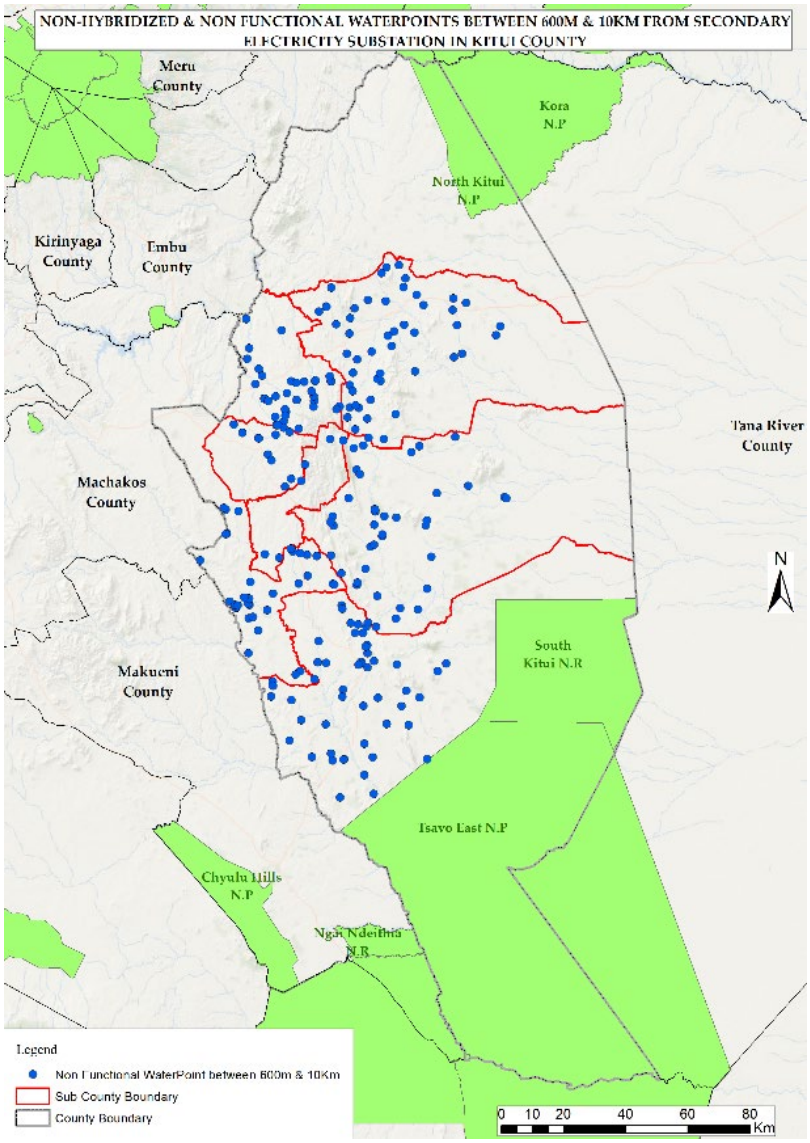


Figure 21 map of non-functional and non-hybridised water points between 600m and 10km from a secondary electricity substation or nearest transformer

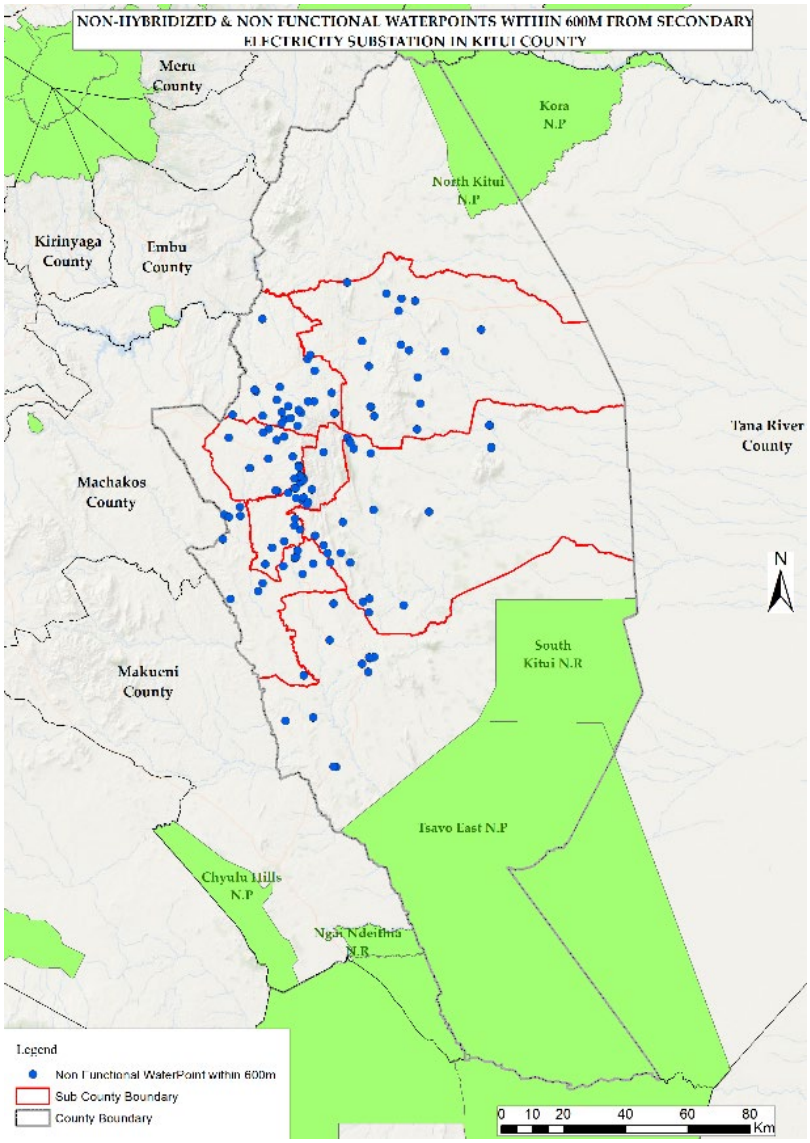


Figure 22: Map of non-functional and non-hybridised water points within 600m from a secondary electricity substation or nearest transformer

The following key assumptions have been used based on inputs from water sector experts:

- The costings below do not include any labour costs or crucial ancillary component costs (non-energy infrastructure) such as piping, tank, fencing etc. These are critical parts of any community water point and need to be consider in overall costing. According to a costing done by the County Government31 these ancillary component and labour costs (non- energy capital costs) can total to around KES 900,000 for a kiosk with a 10,000L plastic water tank and 100m pipeline extension. Consultations with experts highlight that this costing is normally overestimated by around 20-25% to account for potential price fluctuations at the time of installation.
- The table below summarises potential energy systems for water pumping for two variations of bore-hole depth- one deeper boreholes up to 150m that are usually pumped using diesel and one shallower borehole up to 100m usually used by manual pumping. The tables below provide an

31 Costing received from the County Government Water department for the Kasovoni borehole upgrading from Afridev hand pump to a solar powered motorised submersible pump, standard water kiosk with 10,000l plastic water tank and 100m pipeline extension.

indicative figure for the energy costs and the actual costing will depend on whether these are existing water points or not, whether they are functional or not and whether they are fully equipped or not.

- The solutions below are developed with the ability to pump a minimum of 10,000 Litres of water per day. There is however lack of data on water demand in the County which require a detailed analysis to ensure that the solutions meet water demand of different households, and if water points are used for livelihoods such as livestock keeping and SMEs.

Options One and Two: replacing existing diesel pumps with solar or grid powered pumping systems

The average depth of boreholes in Kitui county stands at around 150m depth and flow rates at between 1.5 m3/hr.[32] This is also in line with the data provided by the County Government for existing pumping systems in Kitui.

1. Cost for solar powered pumping system for 80-150m depth		
Energy delivery system	Solar off-grid system: - 1.5kW peak demand and 10.5 kWh daily demand (7 hours pumping time) Appliances: Water pump and motor: 1.5KW three-phase power consumption with the ability to pump wither of the following: ○ 2.5m3/hr at 80m, which translates to 17,500L per day with 7hrs pumping time ◦ 1.5m3/hr at 150m, which translates to up to 10,500L per day with 7hrs pumping time	
Energy system costs	Capex: Energy system (panels, inverter and DC disconnect switch costs)	KES 360,000
	Capex: appliance three-phase water pump with motor	KES 116,000
	Cost of installation test and commission of pump (D&S)	KES 80,000
	Total Capex	KES 556,000
	Opex (10% of system and appliance costs with 25year lifetime)	KES 2,000
	Annual pump check	KES 15,000
Notes	It is assumed that the solar system will pump water during the daytime (7 hours of day-light available in Kitui every day)	
2. Cost for grid powered pumping system with solar back-up for 80-150m depth		
Energy delivery system	Solar back-up system as above: ○ 1.5kW peak demand and 10.5 kWh daily demand (7 hours pumping time) Appliances:	

32 According to data gathered from field visits to Davis & Shirtliff and Betterline Water Ltd, both being water pumps supply and installation companies with vast installation experience in Kitui County

	Water pump and motor: 1.5KW three-phase power consumption with the ability to pump wither of the following: ○ 2.5m3/hr at 80m, which translates to 17,500L per day with 7hrs pumping time ○ 1.5m3/hr at 150m, which translates to up to 10,500L per day with 7hrs pumping time	
Energy system costs	Capex- Grid control panel	KES 70,000
	Capex: Energy system (panels, inverter and DC disconnect switch costs)	KES 360,000
	Capex: appliance three-phase water pump with motor	KES 116,000
	Cost of installation test and commission of pump (D&S)	KES 80,000
	Total Capex	KES 626,000
	Opex (10% of system and appliance costs with 25year lifetime)	KES 2,000
	Annual pump check	KES 15,000
	Grid costs- monthly energy of 315 kWh (@23 KES/kWh tariff)	KES 7,250
Notes	It is assumed that the pump will have access to a three-phase connection. If this is a single-phase connection the cost of the pump would be approximately 20% more. However single-phase systems are not recommended as they require a lot of power for start-up and has high failure rates (low lifetime)	

Table 17: Energy delivery infrastructure options

Options Three and Four: replacing existing manual pumps with solar or grid powered pumping systems

Hand pumps are often a borehole or a well which are shallow than a borehole used for piped systems. However, it is advised to undertake an assessment on assessing the depth of handpumps carefully and consider increasing the depth of the hand pumps before installing an electricity powered pump. There is lack of data on the depth of hand pumps county wide in Kitui.

3. Cost for solar powered pumping system for 80-100m depth		
Energy delivery system	Solar off-grid system: ○ 1.1kW peak demand and 7.7 kWh daily demand (7 hours pumping time) Appliances: Water pump and motor: 1.1KW 3 phase power consumption with the ability to pump wither of the following: ○ 2m3/hr at 80m, which translates to 14,000L per day with 7hrs pumping time ○ 1.5m3/hr at 100m, which translates to up to 10,500L per day with 7hrs pumping time	
Energy system costs	Capex: Energy system (panels, inverter and DC disconnect switch costs)	KES 320,000
	Capex: appliance three-phase water pump with motor	KES 89,000

	Cost of installation test and commission of pump (D&S)	KES 80,000
	Total Capex	KES 489,000
	Opex (10% of system and appliance costs with 25year lifetime)	KES 2,000
	Annual pump check	KES 15,000
Notes	- *It is assumed that the solar system will pump water during the daytime (7 hours of day-light available in Kitui every day)*	
4. Cost for grid powered pumping system with solar back-up for 80-100m depth		
Energy delivery system	Solar back-up system as above: ○ 1.1kW peak demand and 7.7 kWh daily demand (7 hours pumping time) Appliances: water pump and motor: 1.1KW 3 phase power consumption with the ability to pump wither of the following: ○ 2m3/hr at 80m, which translates to 14,000L per day with 7hrs pumping time ○ 1.5m3/hr at 100m, which translates to up to 10,500L per day with 7hrs pumping time	
Energy system costs	Capex- Grid control panel	KES 70,000
	Capex: Energy system (panels, inverter and DC disconnect switch costs)	KES 320,000
	Capex: appliance three-phase water pump with motor	KES 89,000
	Cost of installation test and commission of pump (D&S)	KES 80,000
	Total Capex	KES 559,000
	Opex (10% of system and appliance costs with 25year lifetime)	KES 2,000
	Annual pump check	KES 15,000
	Grid costs- monthly energy of 231 kWh (@23 KES/kWh tariff)	KES 5,300
Notes	It is assumed that the pump will have access to a three-phase connection. If this is a single-phase connection the cost of the pump would be approximately 20% more. However single-phase systems are not recommended as they require a lot of power for start-up and has high failure rates (low lifetime)	

Table 18: Energy delivery infrastructure options

Maintenance and repair function for electricity systems

- **Integrating annual maintenance contracts (AMCs) and establishing a network of trained technicians with skills to install, repair and maintain water and energy infrastructure**

Lack of technicians for repair of pumping systems, and time taken to fix them were indicated as critical issues for sustainability of pumping systems. The Water and Sanitation Policy highlight policy measures which require reviewing existing well-functioning water management structures (eg private sector or

urban WSP-led models) for repair, maintenance and management of rural water infrastructure to improve performance and service delivery in rural water schemes in the county.

Currently a successful private enterprise is established in Mwingi North called FundiFix[33] which provide repair and maintenance services for rural water systems. While this does not include repair and maintenance of energy systems, the model can be replicated, or the same network of technicians can be equipped to also maintain solar systems in off-grid areas or those used as back-ups. This network can be built up to cover new installations as well, and the hybridization programme. Adequate funds, remote monitoring facilities and spare parts need to be made available for these trained technicians to undertake their job effectively. FundiFix also provides AMCs which ensures service provision for repair within three days, replacement of broken parts with new quality spares and support from professional mechanics. The customers pre-pay every month using mobile money, which builds in trust of the enterprise to continue its functions and provide services.

- **Remote monitoring facilities for all new systems**

Although not an essential function remote monitoring provides a useful maintenance function for the water points. There is evidence through piloted effort using Smart Hand Pumps in Kenya that it provides the opportunity to monitor conditions of water systems and flag any component failures prior to an actual breakdown- allowing enough lead time for companies such as FundiFix to undertake repair at a lower cost and without down time. The costs related to such initiatives are not included in the CEP, however it merits further exploration.

- **Explore standards for screening and procuring water pump and energy system suppliers who provide reliable service contracts**

Some reliable and experiences water system suppliers in Kitui (eg David & Shirtliff) provide one-year contracts which include 4 free visits quarterly to assess the functionality of the water pump. However, this does not include checks on the energy system, and not all pump suppliers provide this service. Clear guidelines should be developed on standards for screening and procuring energy system and water pump suppliers, their ability to provide after-sales services, warranty periods and their availability to respond to issues in Kitui (eg network of their technicians). These guidelines should be updated regularly and be regulated into approval processes of the County Government when new water projects are funded by NGOs, communities or other financiers.

Next steps

It should be noted that, given the limited data and information, the above is a guide only. The following are proposed next steps to further validate and refine work presented above:

1. **Collect water demand and supply data for existing water points to design energy systems and supporting services such as water purification:** collaborate with Department of Water and Irrigation on their plans for identifying various water consumption sectors, demand and the available water sources and the associated challenges better. This can initially focus on non-functional or partially functional water points that were identified in the Water Infrastructure Audit in 2017.

33 https://fundifix.co.ke/service/

2. **Mapping of new water points in areas with supply gaps to design energy systems for new water points**: **i**dentify supply issues to meet the water demand and identify the most suitable energy source based on capacity and distance to grid.
3. **Conduct county wide water sector climate risk assessment**
4. **Understand capacity and financing needs for management of water points**: undertake a survey on existing water points and their management structures to develop a complete delivery model for each water point which will address current management challenges.
5. **Identifying synergies**: linking with water needs of other sectors such as health, agriculture and livestock to develop solutions and prioritise investments for those with maximum benefits.
6. **Refine solutions and bundle/aggregate:** refine solution options and develop financing options and detailed delivery models for each water point.

Non-energy supporting services

The key supporting services required are outlined below and summarised in

Table **19**. These additional supporting services and interventions to address non-energy gaps/barriers are also essential to deliver the outcome and maximize the impact and sustainability of the energy investments. Given access to clean water is a community need that is cutting across multiple sectors (eg agriculture, health, livestock, SMEs), it is important to ensure that that the interventions are delivered in the most cost-effective and sustainable way by deepening cross-ministerial collaboration. This requires MENR and the Department of Water and Irrigation to engage closely with each other, and key ministries (eg other departments within Ministry of Agriculture, Water and Livestock, Ministry of Health etc.).

In 2019, the County Government developed a Water and Sanitation Policy (County Government of Kitui, 2019a) to provide a comprehensive framework under which development and management of water resources and provision of water and sanitation services. The Policy Implementation Matrix provides a comprehensive list of activities with annual budget estimates enabling energy and non-energy policy measures. Under this Policy the Department for Water and Irrigation aims to establish a County WASH Coordination (WASHCOORD) Forum and Technical Committee to strengthen coordination with other departments and stakeholders in the water and sanitation sector in the county. Below are several supporting services that were identified as critical for ensuing clean and safe water access for communities in a sustainable way.

1. **Exploring options for improving county-wide water treatment and reducing water salinity**

Analysis conducted for developing this CEP show that the most recent detailed Water Quality data is for Mwingi North (2018) carried out by REACH. Based on discussions with the Department for Water and Irrigation, there is a general understanding that salinity levels across Kitui are:

- High salinity levels: Mwingi North (Tseikuru, Kyuso, Ngomeni), Mwingi Central (Nguni, Nuu) Parts of Kitui East (Endau/Malalani, Voo/Kyamatu), Kitui South boreholes not within the river lines
- Moderate: Kitui Rural (Along Yatta Plateau), Mwingi West (Nguutani, Kiomo/Kyethani)

However, to develop effective solutions for water treatment the Department needs to undertake detailed water quality tests using samples from water points across the county to determine specific impurities and salinity levels. Specific water treatment and desalination options, costs and feasibility of larger water treatment plants should be assessed based on results of a water quality study.

Collaboration with entities such as Kitui WASHCOORD forum to explore and understand current efforts to address salinity. The Policy Implementation Matrix recognise activities for identifying suitable low-cost technologies and sensitising communities to use these technologies for water treatment remains a priority. In addition, there is also emphasis on formulating guidance and regulations to ensure that urban and rural WSPs adopt appropriate technologies for water treatment and desalination.

2. Improving governance and effectiveness of Water Management Committees (WMCs)

The Department of Water and Irrigation should explore ways to build capacity of WMCs on practices and systems for improving operations management and performance of water points. Several key policy measures have been highlighted in the Policy Implementation Matrix which include a focus on upscaling the capacities of rural WMCs. These solutions include:

- Developing, sensitising and enforcing a comprehensive legal, institutional and regulatory framework for rural water supply development and management in rural areas of the county.
- Undertaking a comprehensive study to categorise rural water schemes in the county and determine appropriate management models that should be applied to improve their efficiency and effectiveness in service delivery.
- Identifying training needs and providing continuous capacity building for both rural WMCs and urban WSPs to improve their efficiency and effectiveness in the provision of water and sanitation services in the county.
- Developing systems and structures, and training staff to entrench best practices in the financial management in WSPs and community water service providers to improve their effectiveness, efficiency, and commercial viability

The Department of Water and Irrigation should also explore ways to address the widespread land dispute issues, particularly when "land contribution" is done by communities. The WMCs should be provided with the appropriate support and guidance to identify and mitigate land disputed from earlier on.

3. Increasing awareness within communities, public and government agencies on need for sustainable groundwater use and management

The solution requires improving community awareness and action around groundwater conservation and rainwater harvesting and by putting regulations and incentives in place for government institutions and affiliates to set up rainwater harvesting systems and other groundwater recharge mechanisms. The Policy Implementation framework highlights several policy measures which include:

- Collaboration with relevant water institutions (eg WRA) to enforce effective systems for the management ground water resource use in the county by establishing procedures and guidelines to strengthen and control groundwater exploration and drilling activities.
- Identification of groundwater potential areas based on sustainable yields and aquifer characteristics, and collaboration with WRA in enforcing regulations on groundwater development
- Enforce regulations and guidelines for protecting vulnerable groundwater recharge areas.
- The Policy Implementation Matrix (County Government of Kitui, 2019a) further highlights the need for a county water harvesting and storage strategy, and the need for more awareness training for solutions such as rainwater harvesting and treatment. There is specific focus on policy measures such as guidelines and regulation formulation, and community awareness raising for promoting rainwater harvesting for livestock and institutions.

4. Improving county level capacity for data collection and analysis on water demand, climate risks and water availability to develop sustainable water resource management strategies and investment plans

Specific measures in the Policy Implementation Matrix refer to the need for identifying various water consumption sectors, demand and the available water sources and the associated challenges. This requires comprehensive studies to determine water demands and water resource availability for communities across the county. This also requires robust climate risk analysis when selecting water source and location for investment to mitigate water quality and reliability risks from droughts and rainfall changes. The Department of Water and Irrigation should undertake a capacity needs assessment and invest in training on technical expertise needed for carrying out demand, supply (water resource mapping and measurement) , and climate assessments effectively. The policy also promotes a Demand Responsive Approach (DRA) as a guiding tool for appropriate budgetary allocations for rural water schemes and equitably distribute funds across the county, joint planning and budgeting with key departments and institutions in the county, sensitization workshops for County Assembly and Executives on funding requirements for water and sanitation sector.

The Kitui County has a County Climate Change Planning Committees (WCCPCs) implementing the Kenya County Climate Change Fund (CCCF) mechanism. The WCCCPCs undertake consultations with local communities and are responsible for identifying and prioritising investments in local public goods such as water sources that strengthen communities' adaptive capacities. The WCCPC could provide useful data and information on water challenges and is a key stakeholder to engage when prioritising and identifying investments for energy solutions presented in the CEP (IIED, 2019).

The key non-energy/supporting services components, including suggestions for key delivery partners and existing service providers or programmes who could lead or support implementation are summarised in the table below.

As discussed above, it is critical to create stronger and better linkages between energy interventions and the ongoing programmes of the Department of Water and Irrigation (the forthcoming Water and Sanitation Policy and Bill), and initiatives in the water sector.

Supporting services	**Potential delivery partners/existing initiatives**
1. Exploring options for improving county-wide water treatment and reducing water salinity	○ Kenya Integrated Water, Sanitation and Hygiene (KIWASH)- US Agency for International Development. ○ Caritas Kitui (recent survey on water quality) ○ County WASH Coordination (WASHCOORD) Forum and Technical Committee
2. Improving governance and effectiveness of Water Management Committees (WMCs)	○ Water Services Regulation Board (WASREB) ○ Learning from projects such as Eastern Kenya Water and Sanitation improvement Project (EKEWASIP) (Makueni & ○ Kitui Counties) ○ County WASH Coordination (WASHCOORD) Forum and Technical Committee
3. Increasing awareness within communities, public and government agencies on need for sustainable water use and management	○ Various civil society organisations who are currently working in the WASH sector ○ County WASH Coordination (WASHCOORD) Forum and Technical Committee

4. Improving county level capacity for data collection and analysis on water demand, climate risks and water availability to develop sustainable water resource management strategies and investment plans	○ National Drought Management Authority ○ County Climate Change Planning Committees (WCCPCs) ○ Sustainable WASH Systems Learning Partnership (SWS), funded by the United States Agency for International Development (USAID), and the REACH Programmes ○ Engaging with agencies that has previously funded water points in Kitui Tanathi Water Service Board, Water Sector Trust Fund ○ County WASH Coordination (WASHCOORD) Forum and Technical Committee ○ Department of Agriculture and Livestock

Table 19: Non-energy supporting services and potential delivery partners

1.35 **Solution 3**: Health - **Improved provision of health services through level two (dispensary) and level three (health centres) facilities for communities in remote and poorly served areas**

Summary of problem and solution

The objective is to provide improved basic health services for communities in remote and poorly served areas through frontline facilities - Level two (Dispensary) and Level three (Health Centres). The solution will address the following gaps or barriers identified:

- **Electricity:** Lack of reliable electricity service and lack of mandated appliances in facilities
- **Supporting services**: Lack of access to medical equipment and supplies, access to clean water and skilled staff required for effective delivery of priority basic health services

The solution includes the following interventions:

Energy components

- **Provision of reliable electricity service including back-up systems** for meeting electricity needs to deliver health services required of Level two and 3 health facilities
- **Maintenance and repair service for all electricity systems** installed plus support to build wider technical capacity for ongoing operation and maintenance of electricity systems ensuring long-term sustainability
- **Provision of appropriate electric appliances** to deliver health services required of Level two and 3 health facilities

Non-energy supporting services

- **Improved access to clean water**
- **Improved provision of medical equipment and supplies** (including medicines and vaccines)
- **Increased staff retention** through access to training and improved welfare and conditions

What problem is the solution addressing?

The priority need identified was better quality basic health services by communities in remote or poorly served areas of Kitui County. These services include maternal and child health, family planning, outpatient, HIV care and treatment and immunization. They are mainly delivered through Level two facilities (dispensaries) and Level three (health clinics): data on what services are required by or mandated to the different levels of health facilities is a key gap as discussed in the sections below.

Research conducted for the purpose of this CEP indicates Level two facilities serve roughly 25-30 patients per day while Level three facilities serve between 45 and 90 patients per day. Poor service provision by these facilities impacts community health and livelihoods, including by obliging community members to travel long distances to access better-equipped health facilities (Level 4 and Level five). This also puts more pressure on these higher-level health facilities. Some of the gaps/barriers preventing this need being met are energy related but additional supporting services and interventions to address non-energy gaps/barriers are also essential to deliver the desired outcome of improved provision of health services through Level two and 3 health facilities for communities in remote and poorly served areas, and to maximise the impact and sustainability of the energy investments.

Energy gaps/barriers identified

- **Lack of reliable electricity to deliver basic health services in Level two and three health facilities**

Figure 24 shows Level two and Level three health by source of electricity based on data received from the County Government (County Government of Kitui, 2019)[34]. This data shows that there are 212 Level two health facilities and 56 Level three health facilities in Kitui County.

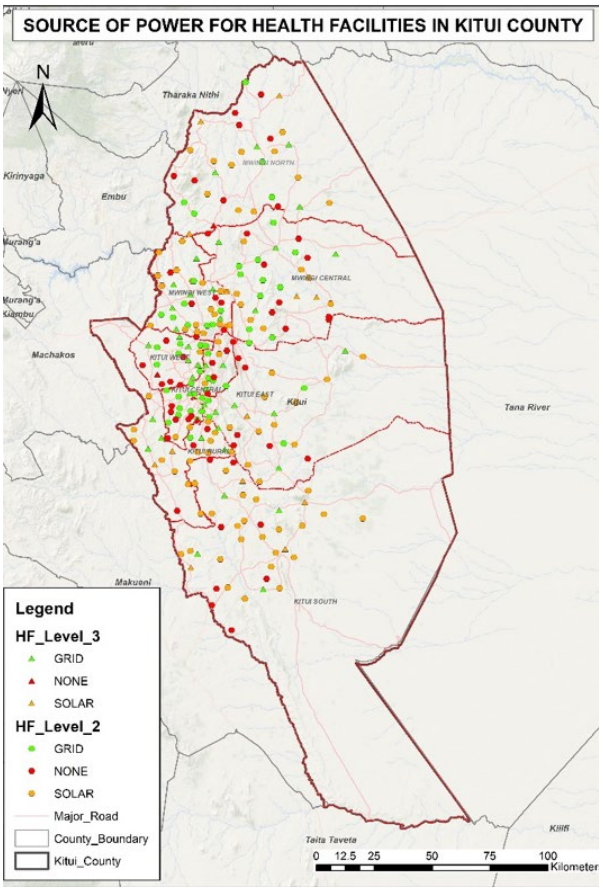
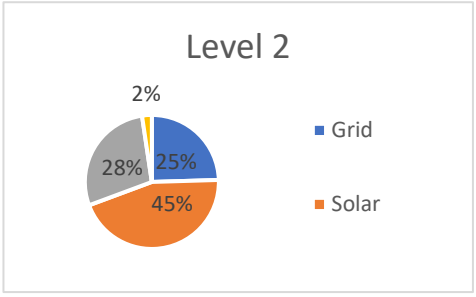


Figure 234*:* Map of Level two and Level three health facilities by source of electrification

Figures 25 and 26 show that around 28% (60) Level two health facilities are still unelectrified. Almost 72% of Level three and 25% of Level two health facilities are grid connected, but there is little data on what percentage of those connected to the grid face power outages and the regularity/duration of outages.



[34] Power source for facilities- Kitui govt data Sep 2019

Figure 24 Percentage of Level Two health facilities by source of electrification

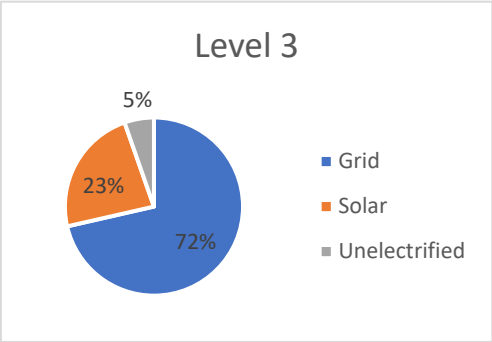


Figure 25 Percentage of Level Three health facilities by source of electrification

The functionality of the off-grid solar systems is also unclear. However, needs assessment including a sample survey of Level two and 3 health facilities in remote areas identified problems with reliability of the electricity service for both grid-connected and off-grid facilities. There are financing challenges for health facilities to get connected to electricity (CAPEX) and with the ongoing tariff, operation and maintenance (O&M) costs (OPEX) due to limited budget allocations and no clear demarcation of funding responsibilities for long term funding.

- **Lack of long-term operation, maintenance and repair services**

Responsibilities for the management of existing systems was often unclear and so was if funding required for system maintenance for its lifetime was assessed or secured up-font. It was also difficult to ascertain if funds are ringfenced from government budgets for energy costs of Level two and three health facilities. The health facilities felt that they needed more knowledge on operating and maintaining off-grid and backup energy systems: this requires capacity building for delivering operation and maintenance responsibilities.

This affected reliability of service for both off-grid (solar-powered) or on-grid (diesel or solar-powered) back-up power systems and resulted in long downtime on systems. There is a lack of trained local technicians and/or effective warranties from system suppliers. This problem also appeared to affect grid-connected facilities, where the responsibility for maintenance and repair lies with KPLC or REA (now REREC). More widely, a lack of local electricians was identified as a gap in terms of supporting the long-term sustainability of electricity services to health facilities. Addressing this could also support delivery of solutions for other priority needs identified.

One model to be implemented in Kenya to address O&M challenges is under the Kenya Off-Grid Solar Access Project (KOSAP). KOSAP aims to work with private companies who will bid for bid for the right to supply, install, and maintain solar systems at Level two and 3 facilities in a given geographic service territory, signing back-to-back supply and installation agreements and 10- to 15-year operation and maintenance contracts. While the World Bank financing will cover supply and installation, KPLC will make O&M payments funded by a service tariff charged to local governments. Given there is a substantial risk related to KPLC revenues from the tariff, the project has created a reserve fund covering six to 12 months of payments for companies in the event of payment defaults from KPLC (UN Foundation & SEforALL, 2019).

- **Challenges in provision of critical appliances to deliver services**

The field research conducted as part of the CEP show that Level two and 3 health facilities offer different types of services within the same level. There does not seem to be standard services offered across a particular level, which is partly related to levels of electrification as well as a lack of knowledge on the types of critical appliances needed to deliver the health services they are mandated to deliver as Level two and 3 facilities- including lighting systems, vaccine refrigerators, sterilization equipment etc. The World Health Organization (WHO & World Bank, 2015) has mapped service and energy requirements across three broad types of health facilities. While this is a useful resource, the energy needs vary by context, circumstance, and the level of care provided (UN Foundation and SEforALL (2019):

- 'Health posts' very small facilities operating mostly as distribution centers for medical supplies and sometimes to treat basic illnesses and injuries, have limited electricity demand. This is potentially a Level two facility as per the survey conducted in Kitui as part of the CEP.
- 'Health centres' focus on provision of essential primary health services, often including maternity care, basic surgeries, and treatment of diseases like malaria and HIV/AIDS. This can include blood banks, pharmacies, and standalone laboratories. Electricity needs of roughly 4 to 10 kWh/day stem from basic lighting, vaccine refrigerators, and lab and sterilization equipment. This is potentially a Level three facility as per the survey conducted in Kitui as part of the CEP and aligns with the energy requirement used for energy solution presented in
- Table **20**.
- 'District hospitals' and 'Regional/Provincial hospitals' offer more extensive services including surgeries, blood testing, and advanced diagnostics. They deploy a wider array of technologies, particularly for diagnostic and surgical activities. Hospitals tend to be more fully equipped and located in on-grid or 'weak-grid' urban areas, serving as central treatment centres for surrounding rural areas. These are potentially level four and 5 facilities as per the survey conducted in Kitui as part of the CEP- these are not considered in this CEP. In Kitui, equipment is often sourced from Nairobi and varies across health facilities in terms of supplier and model. Local maintenance and support of medical appliances is an issue for some health facilities due to lack of local support services as well as budget constraints.

Non-energy challenges/gaps

- **Access to clean water**

Clean water is vital for health facilities to deliver services such as child delivery, sterilisation, drinking water, and sanitary practices for patients and staff. Several health professionals and community members highlighted the need to take in their own water when visiting health facilities, even for childbirth. Lack of water in Level three facilities remains a critical issue challenge for many women during childbirth. Analysis conducted for this CEP by mapping locations of health facilities (Level two-5) against water point data received from Nyaga (2019) revealed that the nearest water source to 26% of all health facilities is non-functional[35]. Lack of adequate water storage facilities, such as rainwater harvesting tanks in these health facilities is an additional challenge. Given that Kitui is an arid and semi-arid County, sustainable management of water sources is crucial. Water salinity can also be a challenge given that surveys indicate high levels of salinity in many sub-counties.[36]

35 The nearest water source does not translate to the facility's own source of water. Therefore, it is possible that some of the health facilities mapped here have an on-site water connection or source.

36 Areas with high levels of salinity according to the Kitui County Water Department include: Mwingi North (Tseikuru, Kyuso, Ngomeni); Mwingi Central (Nguni, Nuu); parts of Kitui East (Endau/Malalani, Voo/Kyamatu); and Kitui South boreholes not within the river lines.

- **Lack of medicines and medical supplies in remote facilities**

This gap appears to be due in part to the remote location of some facilities. In the rainy season, roads are often washed out and there is no adequate planning or anticipation for supplies around the periods when this is likely. This contributes to shortages of drugs and medical supplies in remote facilities.

- **Difficulties in attracting and retaining qualified staff**

Need assessments suggest that this is attributed to the lack of motivation of staff working in remote facilities owing to poor living conditions as well as lack of regular training and refresher courses to keep staff updated.

Solutions

Targets: Level two and Level three health facilities in areas that are remote and poorly served.

Energy Components

- **Provision of reliable electricity to levels two and 3 health facilities**

Health facilities would be outfitted with either a grid connection, grid-tied system with backup, or off-grid energy system. Energy installations would be designed according to health facility type and catchment area, using government health service requirements to ensure compliance with Kenyan national health facility regulation.

An energy audit would help understand existing electricity infrastructure and any gaps in power requirements. Standardisation of the system designs according to health facility level and catchment area would reduce transaction costs and system complexities, providing cost savings and easier monitoring and maintenance of the energy systems.

Figure 26 shows unelectrified Level two and 3 facilities and their distance to the grid: within 600m, between 600m to 10km and beyond 10km. The CEP recommends that the unelectrified health facilities within 600m should be prioritised to connected to the grid with suitable back-up options, and the remaining should be provided with stand-alone solar solutions while considering any grid extension plans in the immediate term. This requires strong collaboration between the Ministry of Health and Sanitation, MENR and KPLC.

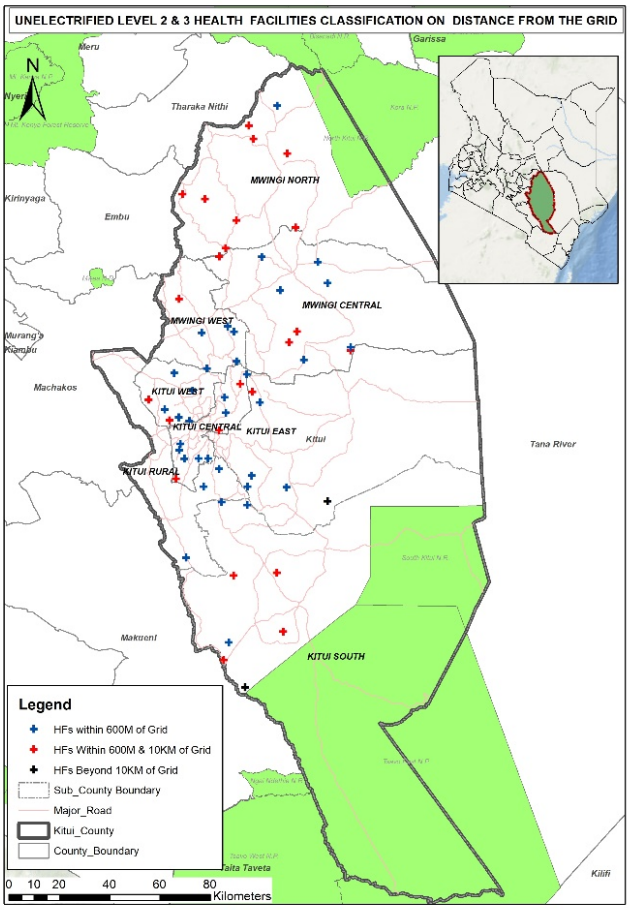


Figure 26: Unelectrified health facilities and distance to grid

Table 20 shows over 50% (33) of the unelectrified Level two health facilities can be connected to the grid as they are located within 600m from the grid.

Distance from the grid	Number of Level two	Number of Level three
Within 600m	33	2
Between 600m and 10km	24	1
Beyond 10km	3	

Table 20: Summary of unelectrified Level two and Level three health facilities and grid distance

Table **21** presents a summary of unelectrified facilities based on the sub-county is based in. Two of the three unelectrified Level three facilities are found in Kitui Central and Kitui West, both within 600m from the grid. The remaining one is in Mwingi North and requires an off-grid system. Kitui South and Mwingi North has the greatest number of unelectrified Level two facilities beyond 600m needing off-grid solutions.

Sub-County	Number of Level two & 3 health facilities	Number without electricity	Within 600m from the grid	Between 600m and 10km from the grid	Beyond 10km from the grid
Kitui Central	36	12	8	4	-
Kitui East	31	6	4	1	1
Kitui Rural	26	3	3	-	-
Kitui South	42	9	2	6	1
Kitui West	20	7	5	2	-
Mwingi Central	38	11	7	4	-
Mwingi North	32	9	1	7	1
Mwingi West	43	6	5	1	-

Table 21 Summary of unelectrified health facilities and grid distance by sub-county

Solutions

Based on the health facility level, the distance from the grid, and the reliability of the grid, the following four solution options are proposed. Each of these has been specified and costed based on the assumptions and description below to move towards identifying how many of each solution will be needed, the overall cost, and next steps.

- **Grid connected facility:** All facilities within 600m of the grid can be powered by the grid.
- **Solar or battery back-up for grid connected facilities:** All facilities currently grid-connected or within 600m of the existing grid transformer can be powered by the grid.
- **Where the grid is not reliable (proposed a minimum of 95% availability),** then these facilities will also be provided with solar or battery back-up system to ensure continuity of health service and essential 24-hour appliances such as vaccine refrigerators. Over the long term, this is a more cost-effective and environmentally sustainable solution than using diesel-powered systems as back-up for the grid.
- **Standalone solar for level two health facilities:** A standalone solar system will be used to meet the power requirements of Level two facilities beyond 600m from the grid. The system capacity is calculated at 4kW peak demand and 5kWh daily energy demand (see below for justification).
- **Standalone solar for level three health facilities:** A standalone solar system will be used to meet the power requirements Level three health facilities beyond 600m of the grid. This is calculated at 4kW peak demand and 10kWh daily energy demand (see below for justification).

The health facility power requirements need to be understood and reflected in system design. To assess the power requirements for each health facility level (2 and 3) data required is as follows: (1) health functions expected/mandated for each level (2) associated appliances and power specification of these appliances (3) frequency of usage of the appliance. (4) associated with this any anticipation of increased demand.

This data was difficult to obtain either through online documents or through requests to government. As an alternative, and to progress developing the solution to a first stage, primary research conducted as part of this planning process including a limited sample survey five Level two and two Level three health facilities that had some form of electricity supply (grid, solar, and/or generator). The purpose was to assess the on-ground health services currently being provided: where an electrical appliance is used. Then to catalogue the appliances in terms of power requirements and number of hours used by medical staff per day. This allowed for an overall quantification of system size, and associated cost.

Appliances supporting health facilities surveyed are summarised in

Table **22**. Average numbers of patients per day from the survey was 100. To note the survey focused on electrical appliances used rather than energy more generally. Water heating and cooking is generally done using biomass and is an area that needs further work, both in terms of water supply (see non-energy component below) and biomass availability/use.

Appliance	**No. of units (range)**	**Runtime per day (hours)**
Light bulbs	3-28	10-12 hours
Refrigerator	1-3	4- 8 hours
Television	0-1	14hours
Laptop	0-1	3 hours
Oxygen concentrator	0-1	3- 8 hours
Baby warmer	0-1	2hours
Resuscitator	0-1	3 hours
Room heater	0-1	2 hours
Autoclave	0-1	0.2 hours
Centrifuge	0-1	0.2 hours
Fetal doppler	0-1	10 hours
Sterilizer	0-1	2 hours
Spotlight	0-1	1 hour
Suction machine	0-1	0.5 hours
Stabilizer	0-1	6 hours

Table 22: Appliances used in surveyed level two and 3 health facilities

Based on the above, the different solutions including system specifications and cost assessments were carried out and are presented in Table 23. Given the lack of data and limited sample size, these should be considered as a guide only. The costs are included for initial system components (CAPEX) and the ongoing operations, maintenance, and remote monitoring (OPEX) services. The proposed systems are each compared to an equivalent diesel generator to show when cost savings would manifest.

	Option 1: Grid connected	Option 2: Solar or battery back-up for grid connected facilities	Option 3: Standalone solar for Level two facility	Option 4: Standalone solar for Level three facility
Energy delivery system	Single phase connections to facilities (i) within 600m from transformer (ii) between 600m to 1km from transformer	Solar or battery-only back up system for 3kW peak demand and 5kWh daily energy demand (for facilities with less than 95% availability of regular electricity supply	Solar off-grid system– 4kW peak demand and 5kWh daily energy demand	Solar off grid system– 4kWpeak demand and 10kWh daily energy demand (also aligns with WHO estimate notes in section above)
Energy system costs				
	CAPEX: ○ Connection fees Within 600m from transformer (under LMAP): KES 15,000 ○ Connection fees between 600m to 1km from transformer: KES 600,000-800,000 (estimates) ○ Monthly OPEX (tariff at 23 KES/kWh.: ○ Level two facility with 5kWh daily usage has a	CAPEX: a. Grid-powered battery back-up[37] KES 332, 000 a. Solar powered battery back-up (including solar panels, battery bank, battery inverter, protection systems, balance of system, delivery and installation, remote monitoring): KES 438, 0000 **Monthly Opex**[38] a. Grid-powered battery back-up (includes labour, remote monitoring, grid tariff to charge	CAPEX costs include: ○ Solar panels ○ Battery bank ○ Battery inverter ○ Solar controller ○ Protection systems ○ Balance of system ○ Delivery and installation ○ Remote monitoring CAPEX: KES 658,000 **Monthly OPEX** [39] KES 1,750	CAPEX costs include: ○ Solar panels Battery bank ○ Battery inverter ○ Solar controller ○ Protection systems ○ Balance of system ○ Delivery and installation ○ Remote monitoring CAPEX: KES 1,146,000 Monthly OPEX includes labour, remote monitoring, grid tariff to charge

[37] This includes battery bank, battery inverter, protection systems, balance of system, delivery and installation, remote monitoring.

[38] This includes labour for maintenance, remote monitoring costs. Figures are per month and do not include long term component replacement such as battery

[39] This includes labour, remote monitoring, grid tariff to charge batteries and battery replacement costs budgeted into monthly expenses.

	monthly tariff of around 3,450 ○ Level three facility with 10kWh daily usage has a monthly tariff of around 6,900	batteries and battery replacement costs budgeted into monthly expenses): KES 8,500 b. Solar back up (includes labour, remote monitoring and battery replacement costs budgeted into monthly expenses): KES 6,000		batteries and battery replacement costs budgeted into monthly expenses): KES 2,500
Revenues (cash-flow compared to genset40)		Battery only: payback 7 months Solar powered system: payback is 11 months	12–16-month payback period	12–16-month payback period
Notes	The costs do not include internal wiring costs	The selection of battery vs. solar powered system will depend on the hours of hours of grid service	Generator sizing is based on a number of assumptions, pricing is also variable: so a range has been given on payback period	Generator sizing is based on a number of assumptions, pricing is also variable: so a range has been given on payback period

Table 23: Electricity system options

Maintenance and repair function for electricity systems

This will be provided through:

- Ensuring all electricity system components and appliances have effective warranties and health facility staff are aware of the nearest service centre in case energy system components or health facility equipment needs repair.
- Putting in place annual maintenance contracts (AMCs) with energy system providers and equipment suppliers with a fixed fee to ensure proper preventative maintenance and repair services are rendered.
- Longer term, it may be more cost-effective to invest in improving provision of training for local electricians and mechanics through Vocational and Technical Centres (VCTs) to ensure sustainable maintenance and repair functions, while stimulating job creation.

Next Steps

It should be noted that, given the lack of data, the proposed solutions must be further optimised. The following are proposed next steps to ensure optimisation:

40 Savings on avoided usage of diesel generator, including costs of maintenance and repair. Payback period calculated is the point at which solar becomes a cheaper option.

- **Update the level of health facilities:** a reclassification of some health facilities is underway which should be used to update the maps and lists detailed above
- **Standardise facility functions and appliance specifications per level:** Develop a standardised list of health functions per level - or possibly several within a level for different facility sizes. Match this to required equipment to allow for calculating power requirements.
- **Audit all level two & 3 health facilities:** (1) identify current level of electrification, including reliability; (2) estimate current and future demand; (3) define the level of access to clean water required and current provisions for heating water and cooking. A study is underway for KOSAP on electricity demand for Level two and 3 health facilities which could support this data gathering and analysis. Designers estimate systems will range from 1.2-3.6 Wp. However, the standard specifications for different levels of facilities by Ministry of Energy and KPLC have not yet been published (UN Foundation & SEForALL, 2019).
- **Refine solutions and bundle/aggregate them:** refine solution options one to four above, and map each health facility onto a solution bundle.

Non-energy component/supporting services

The key supporting services required are outlined below and summarised in

Table **24**. Aggregating procurement and logistics services for medical supplies and equipment provision could ensure that health facilities are adequately stocked. A holistic approach to water provision could target the repair of existing water point infrastructure, and design new approaches to their management. Simultaneously, stakeholders could be involved in awareness raising around of sustainable water management policies and best practices for Kitui County, and land disputes, which hinder water access, clarified.

Improving staff retention and motivation will require further systematic analysis of which improvements would be most effective (see below). The most cost-effective and sustainable way to do this would be through deepening cross-ministerial collaboration between the MENR, Ministry of Health and Sanitation, and the County Department of Water and strengthening linkages with existing health and water sector programmes and service providers or delivery partners.

- **Adequate provision of medical supplies and equipment**

To address the issues in supply of vaccines and medicines linked to poor road networks and logistical challenges, clustering of target facilities and aggregation of supplies should be explored. The Ministry of Health and Sanitation could work with the target facilities, Kenya Medical Supplies Authority (KEMSA) and any other relevant authority or stakeholder to discuss the potential for aggregation and carry out an audit of target facilities to identify requirements, types, and periodicity of shortages etc.

Existing USAID-funded health programmes with wide coverage in Kitui[41] are providing health facilities with a range of support including infrastructure (beds, mobile clinics etc.) as well as appliances and equipment (vaccine storage, cold boxes). Further data is needed, including an equipment audit of the target facilities could determine what specific equipment is mal/non-functioning or missing and what support the USAID programmes could give.

- **Improved access to clean water**

The Department of Water and Irrigation, in collaboration with other actors and initiatives in the water sector, is working on improving access to clean water in the County through improving functionality of existing water points, as well as considering legislation (County Government of Kitui, 2019a) aimed at improving water sector governance. The Policy identifies that promotion of rainwater harvesting and storage at health institutions as a key policy measure for improving access to water. This provides an opportunity to deepen cross-ministerial collaboration to support implementation of the health solutions.

41 Kitui Central, Kitui South, Kitui East, Mwingi North, Mwingi West and Mwingi Central.

The non/ partially functional water points near target health facilities could be prioritised for repair or for hybridization. In addition, a maintenance and repair functions are required for these systems. Each facility should also have a functioning water storage system, including pumps, storage tanks and piping for rainwater harvesting. The access rights for waterpoints supplying the target facilities also need to be clarified where disputes exist and clear guidelines for management of waterpoints. This could include new or more effective water management functions (eg committees) at the target facilities with host communities who may also benefit from the same water source.

Effective systems for purification and treatment of water should be provided for each target facility, including those where water salinity is an issue. This requires assessing water quality at target facilities to identify the least-cost, most effective purification and desalination as required. Longer-term, investment in a county-wide audit of groundwater resources/aquifers as well as awareness-raising at community level, could be critical to support more sustainable water usage- See Water Solution in the CEP for costings of water systems that would be suitable solution for health facilities.

- **Staff recruitment and retention**

The solution requires addressing welfare and training issues raised by staff in target facilities, as well as concerns regarding inadequate staffing levels. Where facilities are remote and off-grid and where staff live on-site, research conducted for the CEP revealed that a more reliable electricity service and better-quality housing would improve staff motivation and retention. Further analysis would be needed to identify what specific improvements would be needed for staff quarters in a target facility.

The lack of availability, quality and/or frequency, of professional development was also identified as gaps by staff. Ensuring regular training and refresher courses were considered important motivators for retention. Exploring synergies with existing service providers and initiatives could be (cost)-effective. Afya Halisi funded by USAID runs a capacity building programme for staff at health facilities. It also provides funding for additional nurses to be stationed at the health facility to support medical staff.

Supporting service	**Potential delivery partners/linkages to existing initiatives**
Adequate provision of medical supplies and equipment	• Ministry of Health and Sanitation • Kenya Medical Supplies Authority (KEMSA) • USAID programmes: • Afya Halisi (family planning and nutrition) • Afya Kamilisha (HIV prevention and treatment).
Access to clean water	• All components • Ministry of Health • Kitui Department of Water • Kitui WASH Forum • REACH and SWS programmes • Solarization • MENR • Maintenance of systems • Fundifix (see Water Solution for more details) • Purification • Caritas Kitui (recent survey on water quality)
Staff retention and motivation	• Ministry of Health • Afya Halisi

Table 24: Summary of non-energy supporting services

1.36 Solution 4: Agriculture -improved income for smallholder farmers from irrigated and rainfed crops

The agriculture solution focuses on two options: irrigated crops (solution 4a) and rain-fed (solution 4b) agriculture. While it is only the irrigation solution that has energy components, the CEP presents an overview of solutions around rain-fed agriculture as a priority need identified by stakeholders. To realise the full benefits of irrigated agriculture, both energy and non-energy components will need to be implemented. The non-energy components are similar for both the irrigated solution and the rainfed solution: with differences noted in the solution. It is assumed that some of the farmers who practice irrigation agriculture also do rainfed farming.

Summary of problem and solution

Solution 4a: Improved income of smallholder farmers from high-value crops on farms with reliable access to water through improved irrigation and better market linkages

The objective is to improve the income of smallholder farmers with farmland within 300m of a permanent riverbed water source or reliable sand dam. Farmer income could be improved through a combination of irrigation, and better market linkages including choosing crops and growing periods to be more responsive to market trends and pricing. The solution will address the following gaps and barriers identified:

- **Electricity:** Lack of access to affordable and reliable electricity to run irrigation equipment
- **Equipment:** Lack of access to and knowledge of reliable irrigation equipment.
- **Finance:** Lack of finance for irrigation equipment and agricultural inputs
- **Good Agricultural Practices (GAP):** Lack of knowledge of irrigation farming techniques, especially for new crops & preference for flood irrigation, even where water is scarce
- **Socio-cultural:** reluctance to work together for collective marketing (aggregation), to continue to carry out GAP (after training), and to share equipment at farm level. **Security issues** for equipment left on the farm
- **Market linkages:** Lack of access to market information and inability to link with more reliable buyers

The solution included the following interventions:

Energy components

- **Provision of reliable electricity and appliances for irrigation systems:** including adapting to site specific conditions and adequate equipment security measures
- **Maintenance and repair service for irrigation systems,** plus support to build wider technical capacity for ongoing operation and maintenance of electricity systems ensuring long-term sustainability

Non-energy components

- **Improved access to recommended agricultural inputs (**seeds, fertiliser, and pesticides)
- **Provision of Good Agricultural Practice (GAP) to farmers**, including on irrigation techniques for a variety of horticultural crops, and addressing socio-cultural barriers in farmer practices & preferences through sustained mentoring and engagement
- **Improving knowledge on markets** and supporting farmer link with reliable and fair market channels
- **Improving farmer knowledge and access to inclusive financing options** for maintaining business and expanding business.

Solution 4b: improved income for smallholder farmers in dry areas of Kitui from rain-fed crops (green grams, cow peas and maize) by increasing crop yields and draught resilience through improved GAP, use of quality inputs, and improving farmers' market literacy and market linkages.

The objective is to improve the incomes of smallholder farmers in Kitui County who rely on rainfall for crop production. Improved income will be achieved by improving crop yields and draught resilience through adoption of good agricultural practice (GAP), including conservation agriculture techniques, access to quality inputs, and access to reliable markets.

The solution will address the following non-energy gaps/ barriers identified. Note that these gaps are similar to the non-energy gaps identified under irrigation solution.

- **Lack of/limited skills on Good Agricultural Practices (GAP) and the continued use of conventional farming practices, namely:**
    - ill-timed planting and erroneous intercropping practices
    - labour intensive land preparation and crop maintenance
    - poor soil and water conservation and soil moisture retention
    - poor pest and diseases control and management, including ii-timed spraying leading to low- and poor-quality yields
- **Lack of quality and affordable inputs:** including quality/certified draught tolerant seeds, pesticides, fertiliser, and equipment.
- **Lack of market for farm produce** due to lack of linkages and access to ready and reliable buyers for farm produce, as well as low prices which are attributed to market glut. Other gaps include lack of cooperatives to buy/sell farm produce and farmers lacking market literacy- including having no/limited information on and knowledge of markets for their produce.

The solution comprises the following interventions which are closely linked to the non-energy component under the irrigation solution

- **Improving farmer GAP through training and on-going support** for:
    a. Conservation Agriculture (CA) techniques to increase crop yields, draught resilience and improve soil fertility with minimal labour inputs
    b. Proper timing for planting and right intercropping practices
    c. Water conservation and rainwater harvesting techniques
    d. Control and management of crop pest and diseases including proper timing for spraying
- **Improving access to quality and affordable farm inputs** such as quality/certified draught tolerant seeds, fertilizer, pesticides, and equipment by small-holder farmers in dry areas of Kitui.
- **Improving access to reliable markets** for farm produce though improving market literacy, access to market information and better linkages to reliable buyers for the different farm produce.

What problem are the solutions addressing?

The priority need identified was improving income of small-scale farmers in Kitui County through improving and promoting irrigation in the county on farms where there is a reliable source of water and improving yields and draught resilience for rainfed crops in dry areas of Kitui County. In addition to gaps relating to lack of farm-side practices for growing higher value horticultural crops and high yielding draught resilient rainfed crops (including lack of GAP and quality farm inputs), farmers in the county also have a limited

knowledge of markets. This combined with limited uptake of irrigation and conservation agriculture techniques has resulted in poor market linkages beyond local markets: either by farmers accessing markets directly or through middlemen.

Kitui County is divided into seven agro-ecological zones that generally experience erratic rainfall. According to Kitui County Government (2018), the main crops grown in the county include cereals such as maize, sorghum, and millets; pulses such as green grams, cowpeas and pigeon peas; root crops that include cassava, sweet potatoes and arrow roots; industrial crops like cotton, sisal and sunflower, and horticultural crops (fruits and vegetables) including mangoes, pawpaw, watermelons, tomatoes, kales, onions and bullet chillies.

From the latest data (2016)[42], the highest crop production in the county was of maize and sorghum with an average of 10,858MT and 11,989MT respectively. The value of these crops was KES 361.9 million and KES 299.7 million respectively. The total annual average crop production for cereals is 80,680MT valued at KES 4.24 billion, 771MT for industrial crops valued at KES 29.04 million and 36,950MT for horticultural crops valued at KES 990 million (County Government of Kitui, 2018a). Available data from 2016 indicates that Kitui is the leading producer of green grams in the country producing an average of 14,602 MT every year. The crop has also been reported to be a major contributor of income in the county accounting for approximately KES 1.2 billion.

The table below summarises the available data on production volumes, land area and value in Kitui County for the high value horticultural crops analysed for this solution. These crops were selected because they would benefit from irrigation to grow through the year and to plan harvesting with market demand to optimise farmer income. All these crops are currently grown in Kitui, but local supply is not meeting demand. Figure 28[43] below illustrates the volume of tomatoes grown in Kitui compared to neighbouring counties.

Figure 29 shows the sources of horticultural crops to wholesalers in local Kitui markets. Research conducted for the CEP indicates significant supply into local markets from outside the county for all crops except lower-value kale. This is particularly the case for tomatoes and onions, and one key reason why the middlemen are more active for these crops.

	2017			2018		
Crop	**Acreage (Ha)**	**Production (MT)**	**Value (KES)**	**Acreage (Ha)**	**Production (MT)**	**Value (KES)**
Watermelon	122	2,250	45,740,000	219	5,335	122,280,000
Kales	408	7,015	124,850,000	610	5.811	183,912,500
Tomatoes	311	6,743	245,790,000	735	13,588	459,685,000
Spinach	240	1,912	53,310,000	242	1,902	54,240,000
Bulb onions	56	376	17,070,000	169	1,625	69,695,000

Table 25 Production and value of the target value chains.

42 Kitui County CIDP 2018-2022, Available online at http://repository.kippra.or.ke/handle/123456789/587

43 Harrison M, (2020) Tomato Farming in Kenya: How to Make Money Growing Tomatoes

Source: Horticultural Crops Directorate, 2018. Research by EAMDA (2020)

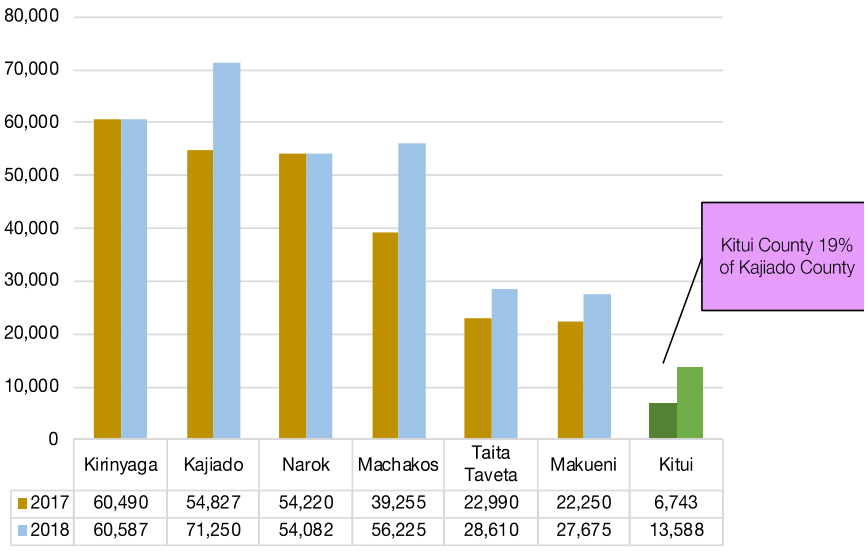


Figure 27 Performance of Top 6 Tomato Producing Counties in Kenya

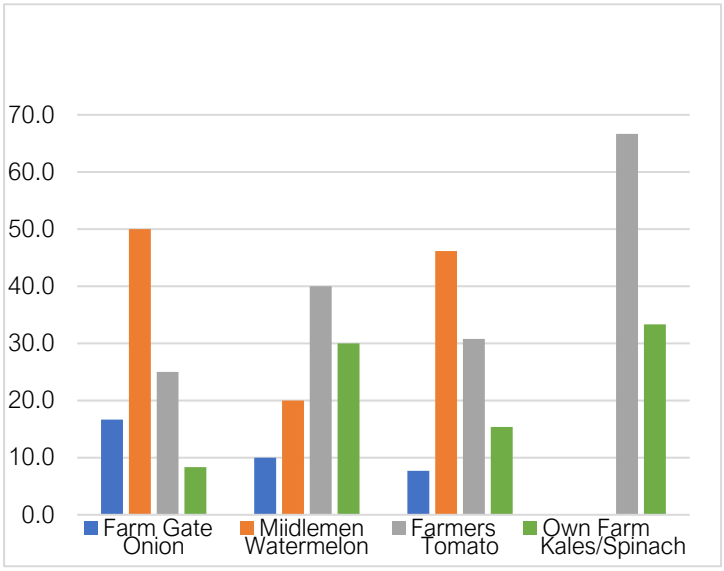


Figure 28 Sources of Horticultural Produce Supply to Wholesalers in Markets in Kitui County

Kitui is classified as a semi-arid county and is generally perceived, including by local farmers, as having water scarcity issues and very limited rainfall between the two main wet seasons (the long rains from March-May and short rains from late October to December). In recent years, the rains have been variable and are being impacted by climate change. According to the CIP (County Government of Kitui, 2018a), Kitui's topography is suitable for irrigated crop production although only 1,850 Ha (1.3%) of arable land is currently utilised for irrigated production against a potential land area of 11,095 Ha.

The CIDP also notes that the potential for exploitable irrigation can be expanded even up to 500,000 Ha through the development of the Tana and Athi River basins**.** The county's whole land mass lies within the

Tana River drainage basin except a narrow strip along the south and southwest border draining into the Athi River. These two rivers form the northern, western, and southern boundaries of the County.

The County has 5 irrigation schemes in Yatta/Kwavonza, Tseikuru, Zombe/Mwitika, Kitui Rural and Kyangwithya West wards, and 31 irrigation clusters. Irrigation clusters cover a total acreage of 40.6 Ha producing assorted vegetables and green maize[44]. There is also a new ambitious project proposal, the 'Kiomo Kyethani Integrated Water Project' (yet to be fully funded), to divert water from Kindaruma dam to Mwingi West and Mwingi central: a flow of 10,600 m3 per day potentially benefitting 2,100 farmers across 550 Ha of farmland. [45]

Kitui has an existing network of sand dams which capture river water during rainy seasons for use in the dry seasons: which have potential to be used for irrigation. The following table also notes the potential for further sand dam development across the county.

River	Subcounty
Tyaa	Mwingi West/Mwingi Central
Thunguthu	Mwingi North
Enziu	Mwingi Central/ Kitui East
Mwania	Mwingi Central
Thua	Kitui Central/ Kitui East/ Kitui South
Tiva	Kitui Rural/Kitui South
Kalundu	Kitui Central/ Kitui rural
Nzeeu	Kitui Central/ Kitui Rural/ Kitui South
Ikoo/Mui	Mwingi West/ Mwingi Central/ Kitui East
Mwitasyano	Kitui Rural
Mwiwe	Kitui Rural/ Kitui South

Table 26: Potential rivers for further sand dam construction[46]

Figure 29 presents a map of farmland (arable land, based on IPAC, n.d.) in Kitui County within 300m from a permanent river, major river or a sand dam (based on Nyaga, 2019). This is considered a reasonable distance for water pumping. The total land available is 61,400 Ha (614 km^2 or 152,000 acres) or around 4% of the total farmland in the county. The remaining farmland is assumed to be mostly rainfed. It should be noted that further analysis is needed to determine which of these sand dams could be used for irrigation: analysing annual quantity of supply versus demand for farming and other uses. However, the potential for significant increase in irrigation in the county is clear, both in the short term through existing water use and as parallel projects to the water development schemes outlined above.

44 One scheme in Tseikuru ward in Mwingi North sub county grows assorted vegetables and cotton whereas the schemes in Kyuso and Mumoni wards grow assorted vegetables and watermelons.
45 Information provided by the Kitui County Ministry of Water Agriculture and Livestock
46 Information provided by the Kitui County Ministry of Water Agriculture and Livestock

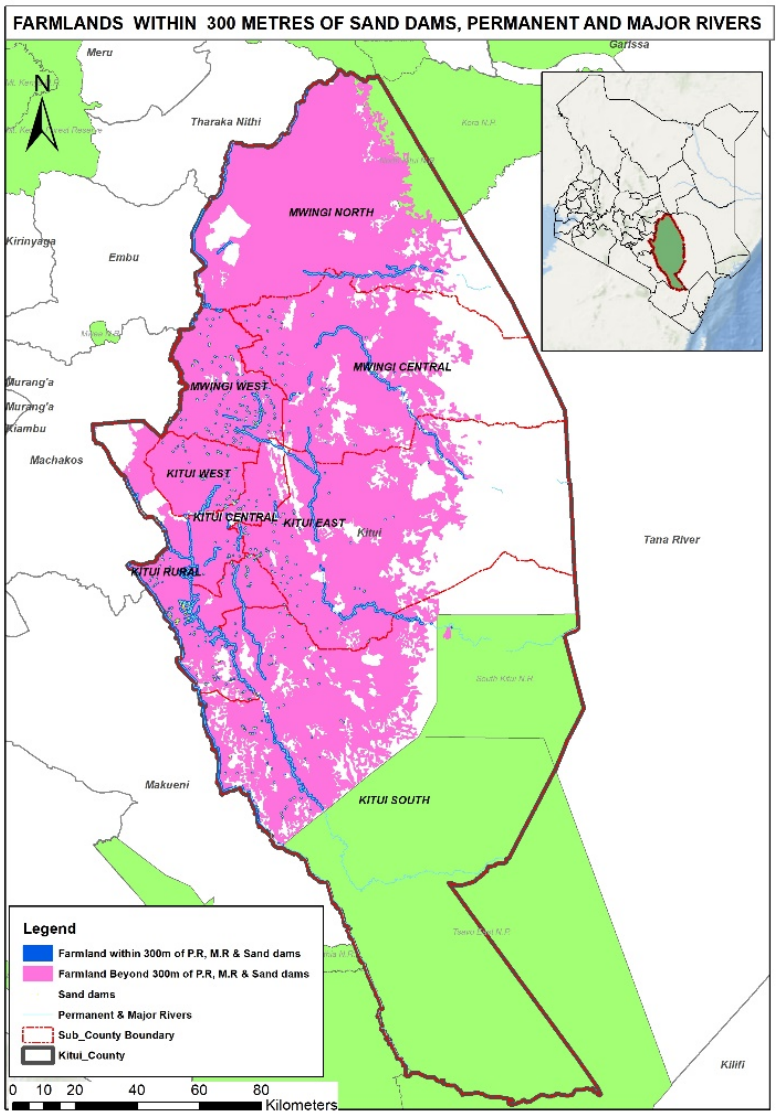


Figure 29: Currently farmed land mapped to sand dams, permanent and major riverbed water sources

The solution proposed below involved further research and analysis to test this finding, as well as to identify the barriers to irrigation, and other non-irrigation related barriers to improving farmer income on farms that are within 300m of permanent riverbed or sand dam water sources. There is also potential for irrigation in areas near boreholes in combination with drip irrigation and other water conservation techniques. However, further analysis would be needed to evaluate water supply and demand in specific locations.

Solution 4a: Energy gaps

- **Electricity and equipment**

  There is a lack affordable and reliable power for operating appliances, ie irrigation systems, with the potential to increase horticultural production. There is also a lack of access to and knowledge of reliable irrigation equipment.

  In Kitui the most common form of powered irrigation in use is self-contained and portable petrol (or diesel) pumps. These are of variable quality, and knowledge on which pumps are most appropriate for

a farm context is limited. Irrigation techniques commonly used are furrow, flood, and bucket: the latter being common for manual irrigation. Other forms of power generation and equipment for pumping, such as solar powered drip irrigation, are an option but are currently limited.

Figures below show distance of farmland in Kitui from the grid. As per Figure 30 there is some potential to connect farms to the grid for irrigation purposes, but this is limited. Therefore, majority will require off-grid irrigation pumps.

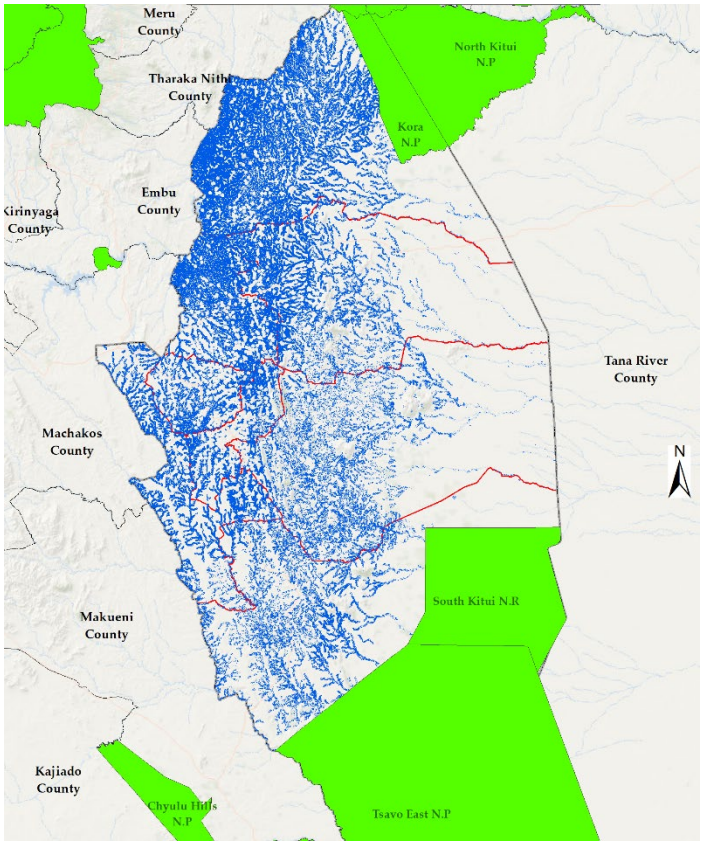


Figure 31: Farmland 600m from the grid

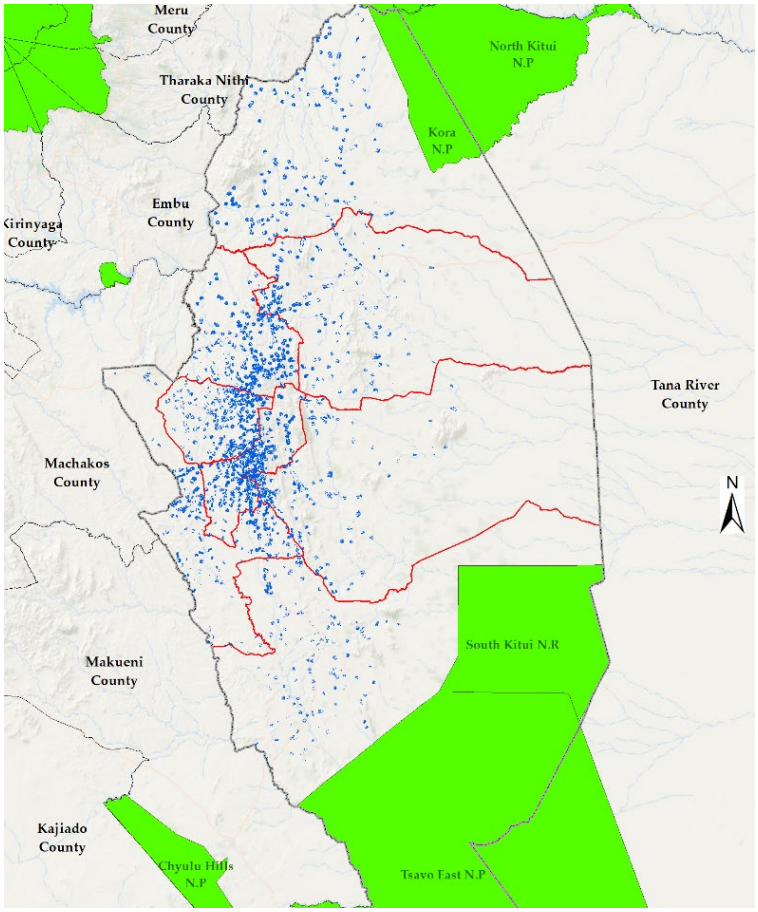


Figure 30: Farmland over 600m from the grid

Solar powered irrigation is increasingly popular in Kenya and has strong environmental advantages. Many solar powered systems use drip-irrigation which uses significantly less water, and the renewable energy decreases farm emissions. However, the upfront costs of solar are high, and equipment is more difficult to source locally. In addition to the more specialist pump and separate solar equipment which are not one unit or kit but need to be matched by an expert, drip lines and tanks are also need.

Suppliers such as Davis & Shirtliff can assist with this but farmer knowledge to engage with the suppliers is low and technical assistance is expensive. Changing to drip irrigation also requires changes in farmer practice, and farmers may be reluctant to move away from techniques they are already using.

- **Maintenance and repair service for irrigation systems**

This is lacking, both in terms of qualified local technicians and farmers budgeting for and actively maintaining equipment. Many national or donor programmes have in the past budgeted for the capital costs of equipment for farmers but not considered ongoing maintenance issues.

One interesting project in Kitui which did consider maintenance as part of programme design was the CAFOD Community Based Green Energy programme which ran from 2011-14 and which organised groups of farmers to grow horticultural produce using drip irrigation and green housing A useful study of the impacts of the project (CAFOD & IIED, 2017) found the need to tailor equipment specifications to specific use contexts and locations, rather than a one size fits all system design. Learning included addressing issues like preventing pumps and driplines being clogged with mud through a more customised design and regular maintenance by farmers operating in highly silted river. The green houses (as part of the equipment specification) were good for some locations and not others. Addressing some of the knowledge and behaviour change issues needed for a switch to intensive horticultural crop production was also key.

The above points to the need for better understanding the differing farm-level needs and contexts across the county before deploying solutions. Agriculture extension officers and the county government are already assisting with this but have limited time and budget. Local maintenance of more specialist equipment can also be difficult. However, there is scope to improve identification and bundling of different farm usage types and contexts so that a range of irrigation system designs can be deployed to fit purpose: and maintenance capacity for those systems deployed alongside.

Solution 4a & 4b: Non-energy gaps

- **Lack of Good Agricultural Practices (GAP) including ingrained socio-cultural practices**

Many farmers in Kitui lack knowledge of irrigation farming techniques, especially for new crops (see also discussion on market linkages below). Where powered irrigation is taking place, most farmers in Kitui are using generator powered pumps using flood or furrow irrigation. This is the case even where water is scarce. Several farmers or farmer groups are also using drip irrigation: usually where solar pumping systems have been donated or subsidised as part of a donor project.

There is a challenge here in not only addressing knowledge gaps, but in changing engrained ways of doing farming in a context where: (1) there is still a majority preference for rainfed crops and use of mechanisation is very limited (2) there is a high perceived risk in borrowing (3) trust between farmers and being part of a farmer group is limited: past bad experience of groups falling apart or promised market gains from switching.

Like in irrigated agriculture, small scale farmers relying on rainfall for crop production lack knowledge of the good agricultural practices (GAP) necessary for rainfed farming. This has led to poor crop performance consequently leading to low crop yields. The following are the specific gaps associated with limited GAP in Kitui:

- **Lack of knowledge and use of Conservation Agriculture (CA) principles** to increase crop yields and improve soil fertility with minimum labour requirements. CA is defined by food and Agriculture Organisation of the United Nation as "a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment". There are three principles underpinning CA approach of which farmers in Kitui County have limited knowledge:

    - *Minimum soil disturbance*. According to FAO (2007), this is essential to maintaining minerals within the soil, stopping erosion, and preventing water loss from occurring within the soil. It saves soil organic levels for a longer period and still allow the soil to be productive for longer periods. It also reduces destruction of soil micro and macro-organism habitats that is common in conventional ploughing practices.

    - *Maintaining permanent organic soil cover* by leaving the previous season's residue on the field. Organic soil cover can allow for growth of organisms within the soil structure. The growth will break down the mulch that is left on the soil surface to produce a high organic matter level which will act as a fertilizer for the soil surface. The presence of mulching reduces the velocity of run-off and the impact of rain drops thus reducing soil erosion and runoff (Hobbs et al., 2007, pp. 1-13). This type of ground cover also helps keep the temperature and moisture levels of the soil at a higher level rather than if it was tilled every year (FAO, 2007).

    - *Practicing diverse crop rotations or crop interactions as a disease control* against other preferred crops (Hobbs et al., 2007, pp. 1-13). This process will not allow pests such as

insects and weeds to be set into a rotation with specific crops. Rotational crops will act as a natural insecticide and herbicide against specific crops. Not allowing insects or weeds to establish a pattern will help to eliminate problems with yield reduction and infestations within fields. Crop rotation can also help build up soil infrastructure. Establishing crops in a rotation allows for an extensive build-up of rooting zones which will allow for better water infiltration (Hobbs et al., 2007). For mechanization, the approach is no-till seeding/planting with residue handling and minimum soil disturbance with tractors (Friedrich, n.d.) or oxen drawn equipment.

- **Insufficient crop pests and diseases control**

This is caused by farmers incapacity to identify specific pests and diseases for crops thus end up using the wrong approach of control including chemicals. This consequently leads to poor timing for spraying leading to low- and poor-quality yields. Out of 379 farmers interviewed in parts of Kitui Rural and Kitui South sub-counties by the organisation Sahelian Solutions (SASOL) during a baseline study on conservation agriculture, over 88% of them (333 farmers), indicated they had no knowledge of CA (SASOL, 2020).

- **Lack of quality farm inputs**:

About 50% of the smallholder farmers plant local seeds which are not improved while others use recycled seeds (NAFIS, 2018). All these seeds are low yielding and less resistant to crop pests and diseases. There appear to be several reasons for farmers continued use these seeds:

- High prices of certified seeds making them unaffordable to farmers. For example, research conducted for this CEP indicated that the cost of certified maize available in Kitui is almost 5 times more than the cost of ordinary/recycled seeds.[47]
- Limited availability of the certified seeds in local markets as major stockist do not have outlets in remote areas, given the lack of demand
- Reported cases of counterfeit seeds in the rural remote areas in Kitui County have resulting in poor or non-crop germination has eroded the confidence on farmers on certified seeds.[48]
- Another contributing factor is the beliefs of the local farmers that recycled seeds are most suited for their farms as they have adapted to the soils and other ecological aspects.

Interesting learning from work conducted by Caritas Kitui under the Trocaire programme *Community Resilience and Climate Change Adaptation in Drought Affected Communities in Kitui, Tharaka Nithi and Embu Counties* points to a mix of reasons that new GAP face adoption challenges. First, continued mentoring of farmers and peer-learning is needed rather than one-off trainings. One way to do this is through demonstration farms - with learning by doing having proven better at encouraging uptake than traditional classroom teaching. However, there are challenges with keeping these demonstration farms operational: partly because of the distance to travel to farms (over-come with smaller and closer 'baby' demo farms), and also because of a donor dependency culture where some group members wanted to be paid to work in their farms, under 'cash-for-work' (instigated by one programme and thus fostering that expectation)49. More generally farmers can be reluctant to change practice until they can see the benefits, which makes fostering (peer) trusted first movers an important consideration.

47 Data provided during KIIs with Kenya seed company Ltd, Kithimani Agrovet, & Ditui Town Cereal Outlets, Kitui Town.

48 Reported during the Community workshops carried out as part of the CEP methodology, 2019.

49 Information provided by project partner Caritas Kitui.

Other local socio-cultural issues also need to be considered in any proposed solution. There is a reluctance to share equipment at the farm level and associated issues about perceived ownership and responsibility for maintenance. This would point towards irrigation systems being individually owned if possible. Theft of equipment is also a commonly perceived risk. Proposed solutions for high value items such as irrigation systems need to address security concerns.

- **Market linkages: lack of access to market information and inability to link with more reliable buyers**

Across Kitui, there is very limited understanding of different markets; prices vary significantly across counties, and within local markets at different times of the year. Most farmers in Kitui rely on informal channels to access market information. Some farmers sell directly into local markets, but the alternative for most farmers (and to access more distant markets), is selling through middlemen - resulting in lower profits.

Promising efforts have been made to better map value chains of several crops and understand the business models of each of the chain actors. National programs like the Agricultural Sector Development Programmes (NAFIS, 2018), which is now in a second funding phase, aim to combine more traditional approaches to build supply of agricultural commodities (supply push) with efforts to orient demand towards small-scale producers (demand pull) by working with intermediaries in the value chain. This includes aggregating produce and linking into bigger buyers. In Kitui county government, and other stakeholders such as SASOL and Caritas Kitui have been working on such approaches to aggregation and buyer linkages.

Yet more needs to be done to deliver increased value for small-scale farmers. Irrigation at the farm-production end has the potential to unlock higher value crops. As noted above there is more water potential for irrigation than yet utilised: and yet more on the horizon with new water projects. However high-value horticulture production comes with a different set of risks, including rapidly changing market prices with little local knowledge, and lack of reliable buyers with associated crop perishability issues: potentially making the middleman issue worse than dry-goods, especially for more distant markets.

Rainfed crops faces constant risk of low prices because of oversupply of the produce to local market and lack of reliable buyers. Attributed to majority of farmers planting similar crops and harvesting at the same period. This risk is amplified by farmers lacking market information and the need to sale the produce quickly to address pressing financial needs.

Box 1: Market dynamics of high value horticulture crops

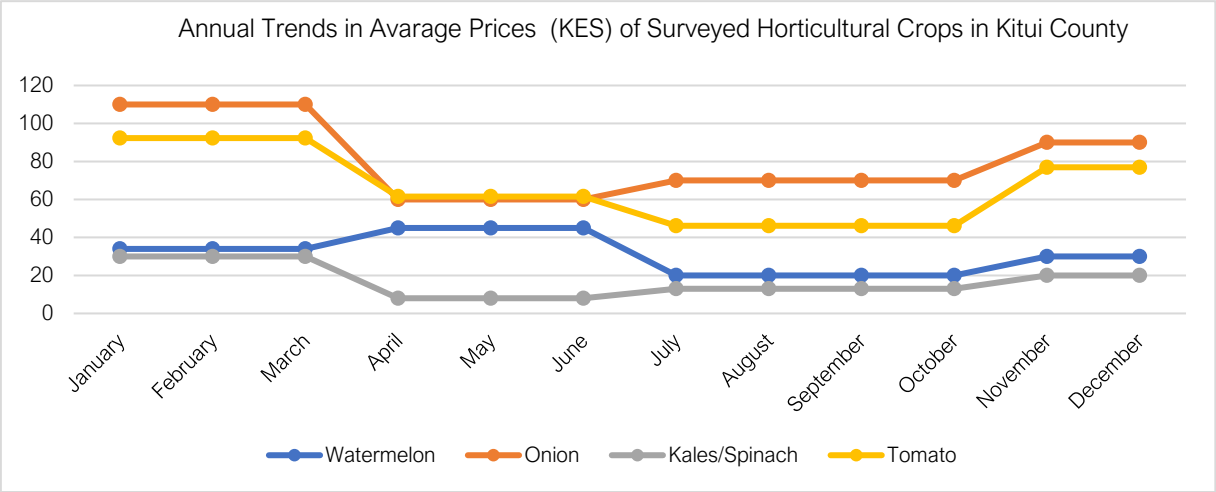
Research conducted as part of this work focused on mapping high value horticultural products currently farmed in Kitui with demand in both local markets and further afield. From initial scoping, the focus was limited to four horticultural value-chains - tomatoes, onions, watermelon, and Kale. When analysing the prices and trends, onions generally had higher price value than the other horticultural produce studied, with average annual monthly prices ranging between KES 60 per kg (April to June) and KES 110 (January to March). A lot of onions reportedly came in from Tanzania during high supply period of July to October, reducing prices further in local markets within the County.

Watermelon prices were lowest at an average of KES 20 per kg during the high supply period of July to October, and highest (KES 45 per kg) from April to June (as the long rains progressed). This was because farmers planted watermelon towards the end of the cropping season to avoid rains that destroyed the crop at maturity stages. To manage this problem most of the crop is also grown by irrigation along the rivers in the dry season. These factors combine to cause high watermelon supply from July to October. Kales and spinach fetched lowest prices in the market, indicating the low value of the crop compared to the other horticultural produce covered in the study.

Market **price trends in Kitui local markets across the year**

Source: EAMDA (2020)

illustrates the price trends in local Kitui markets from a market study carried out as part of this work.



Market price trends in Kitui local markets across the year

Source: EAMDA (2020)

When considering the above prices as part of the overall business model for growing these crops: including input costs and yield per acre - the most lucrative crops are tomatoes followed by onions. Tomatoes can have a yield of 26 metric tonnes (MET) per acre for hybrid varieties: as reported by traders in local Kitui markets. Tomatoes present a good opportunity for sale in the January to March period, where there is less competition from imported crops from Tanzania.

Farmers can also obtain good prices for onions in the April to June period: indicating a good fit with a tomato, onion cycle: which can be rotated with Kale in the third season.

In terms of accessing markets, the study did not identify any significant farmer aggregation activities in the marketing of the crops analysed (watermelon, onion, tomato, kale and spinach) in

Kitui County. This was apparently due to the low production levels and lack of irrigation to support off-season production. However, there is significant demand for onions, tomatoes, and kale in local markets. Indeed, large volumes of tomatoes and onions were supplied by middlemen from other countries and neighbouring countries: indicating more local demand than supply (see Figure 31). The farmers were also the single largest suppliers overall these horticultural produce to the wholesalers in the local markets surveyed.

So there is much potential for Kitui farmers to supply to local markets. Aggregation to sell horticultural products for sale to wholesalers and traders into other markets is also possible, but with a higher barrier to entry than supplying local markets. This would indicate that careful growing using powered irrigation to optimize prices in local markets may be a good initial strategy to increase farmer income: with potential to later expand in to more distant markets through further work in aggregating and creating buyer linkages.

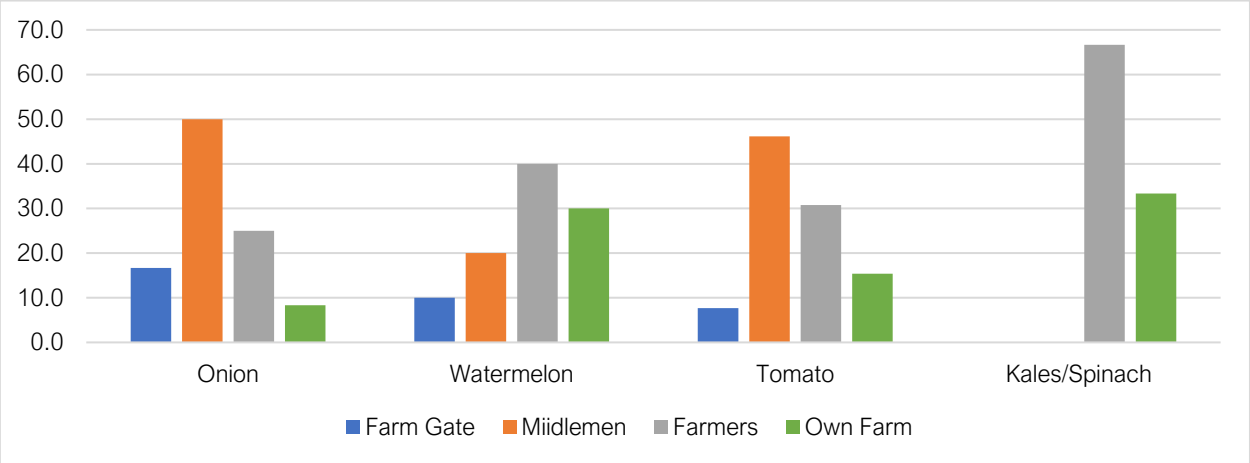


Figure 31: Sources of Horticultural Produce Supply to Wholesalers in Markets in Kitui County

Solution 4a: Irrigation of high-value horticultural crops

Target groups

Farmers near permanent riverbed water or reliable sand dam sources with some savings or other income. Access to finance for a loan is required as well as savings needed in the range of KES 110k-500k depending on the irrigation solution used. Poorer farmers could be included through support for negative cash flow in the first year

Business model

The aim of this solution is to ensure that farmers near reliable riverbed or sand dam water supplies can use powered irrigation to grow high value-horticultural crops. The solution presents cost-revenue and profit calculations based on selected high-value crops with a 3-crop rotation: farming the highest value crop first to minimise negative farmer cash flow and timing for highest market prices. The energy component of the solution presents several different system options: each with pros and cons. Site surveys are recommended to choose the optimal solution. Non-energy component activities are also key to the overall business model success.

Energy Components

- **Provision of reliable electricity and irrigation equipment**

Irrigation systems need reliable power every day to ensure that the anticipated yield is achieved. Systems also need to be adequately sized for the horticultural crops under production. The business model also needs to work ie the crops grown must yield sufficient profits to pay for the system cost, maintenance, and sufficient profit to make this attractive over other activities (the opportunity cost for the farmer).

The solutions described below is based on the market analysis on optimal crops and growing cycles (from a markets perspective- see section above on market linkages). This of course must be combined with realities of growing the crops on the ground. As part of this County Energy Plan, some work has been done on the agronomy component of a solution to illustrate feasibility and a demonstration solution. However more work is needed to tailor the solution to the soil, climate, and sizes of individual farms. As such the solution is illustrative that the potential for powered irrigation is there. The profits could be significant if the energy and non-energy components of the solution come together.

The following four options are presented in detail:

- **Standalone solar powered system for drip irrigation**: for many farms where grid connectivity will not be possible in the near future or where only occasional mobility of equipment is needed. Drip irrigation uses water more carefully, and the renewable solar power makes this overall the most environmentally friendly option. It has a high initial cost.
- **Standalone petrol generator system for drip irrigation**: This retains careful use of water through drip irrigation but has a higher carbon footprint from petrol use. It has a lower entry capital expenditure cost but higher operating costs
- **Standalone petrol generator system for furrow-based irrigation**: This is the cheapest option overall with a portable pump for ease of moving between locations. However, it has significantly higher water consumption. Pump operating costs are higher the other options because of fuel costs and pump maintenance but there is no irrigation infrastructure to maintain, meaning overall opex is less than the other options.
- **Grid connected system for drip-based irrigation**: for the locations where the grid can be accessed and fixed location pumping is fine, opex costs are lower than the petrol option with drip irrigation (2) but higher than (3) when considering the overall maintenance of the pump and irrigation system (3 does not have drip irrigation lines).

Key Assumptions

- **Water requirements**

When understanding the irrigation system requirements, there is also a question of whether the system should provide powered irrigation for 100% of water requirements and hence be oversized when considering supplemental rainfed irrigation. The example solution below has included supplemental rainfed irrigation. Table 27 shows modelling for the water requirements for growing three horticultural crops over the year, tomatoes, onion and spinach, so that the different harvests align with peak market pricing (see above on market linkages for more details).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm/month)	39	29	118	231	58	4	5	5	7	83	294	137

Irrigated water requirement (m3/day)	**18.8**	**17.4**	**11.3**	**0.0**	**18.2**	**17.6**	**12.3**	**17.2**	**10.8**	**10.4**	**0.0**	**13.4**

Table 27 Irrigated water requirements for three-crop cycle in Kitui climate

Source: Energypedia (n.d.), PAEGC (2012)

The total water requirement can be met with a 20m^3 per day tank and drip irrigation system.

- **The crop cycle** used in the example is:
  - Oct-Jan- Tomatoes
  - March-June- Onions (bulb)
  - July-Sep- Kale

- **Primary energy needs and appliances**

  Choosing an irrigation system depends on the electricity generation option as well as the approach to irrigation used. There are advantages and disadvantages with each. As noted above, furrow irrigation is common in Kitui, yet it uses a lot of water. Drip irrigation systems can more precisely dose: and have the added advantage of making solar generation a more economically viable electricity generation option.

- **Customised solutions for each farm depending on farm size and farming practice.**

  However, the following are common combinations of electricity generation for pumping and irrigation systems that are used in Kenya which are used to cost irrigation delivery for the above crop cycle on a 1-acre plot. Certain irrigation solutions will require changes in farmer practice: for example, drip Irrigation is done in the evening and the morning to maximize utilization of water.

- **Drop of market prices affects the return on investment**

  Revenue figures are based on market research conducted as part of this work. Yields are also based on hybrid varieties chosen for the Kitui climate. Variations in these will impact revenues and the overall profitability of the model.

- **All suppliers offer products on cash basis**

Farrmers can use savings or loans to purchase the solution. The solution below is modelled considering there is a loan facility available for the farmer, and with a system CAPEX deposit requirement of 30%. Please refer to the notes section of each solution option in Table 28 for anticipated savings needed to meet negative cashflow forecast from the deposit and first season operating costs.

Energy system options

Table 28 below summaries the different energy system options outlined above within the context of the overall farm business model. Included are cost assessments for the energy system, and for other farm inputs. Anticipated revenues are given. A 5-year loan model is used to with a farmer deposit requirement

of 30% to calculate (1) the cash-flow breakeven point: when will the farmer start seeing positive net cash flow (2) the overall savings needed before the breakeven point to pay the deposit and manage other costs. Finally, the estimated profit for each option is given for year 1, years 2-5 (continued credit payment) and year 5 and beyond (no credit payment).

1. Stand-alone solar for drip irrigation		
Energy delivery system	Solar powered irrigation pump and tank sufficient for 20m3 drip irrigation per day	
Energy system costs	Capex: Energy system and pump (pump, panels, structure, cabling, panel security)	KES 543k
	Capex: Irrigation system (drip irrigation tank and lines, security fencing and concrete housing for the pump)	KES 561k
	Total CAPEX	**KES 1104k**
	Deposit amount for a CAPEX loan (30%)	KES 331k
	Opex: Cleaning of panels, silt removal and maintenance of pump	KES 2.8k/month
Non-energy costs	Good Agriculture Practices training, market knowledge and aggregation (not costed here - see below)	
	Average farm inputs (seeds, fertiliser, pesticides, labour) (190k/year)	KES 15.8k/month
Credit/month for energy system and appliances	Monthly credit payment: ○ Loan taken by farmer for Capex of energy and irrigation systems: assuming a 30% deposit requirement ○ 12% interest rate over 5 years	17.2k/month
Average monthly expenses		KES 35.8k
Annual expenses		KES 430k
Average revenue of sales per year		KES 3.36m/year
Net annual profit First year (including credit payment and deposit cost)		KES 2.6m
Net annual profit Years 2-5 (including credit payment)		KES 2.93m
Net profit (monthly)- year 5 onwards (without credit payment)		KES 3.154m
Breakeven point: farmer cash flow (with credit) turns positive		Month 5
Notes	It is assumed that a 30% deposit of CAPEX costs will be put down by farmers or sourced through additional policy intervention. **With loan deposit and other input costs during the first season it is recommended the farmer has savings of KES 500k** ○ Note that average monthly costs are calculated on an annual basis and divided by 12. Farmer Cash flow is an important consideration for seasonal income: and is considered in the full calculations, including the recommended savings and break-even point.	

	○ Based on farming 1 acre of land with crop rotation timed to optimise farmer income in markets and highest value crop during the first season improve farmer cash flow at start up. ○ Costs include security: 5-metre-high tamper proof fence, solar panel welding and lockable control panel, security fencing and concrete housing for the pump. ○ Costs include a 16% VAT figure	
2. Standalone petrol pump system for drip irrigation		
Energy delivery system	Genset petrol powered pump and tank sufficient for 20m3 drip irrigation per day	
Energy system costs	Capex: Energy system and pump (pump, piping, cabling)	KES 80k
	Capex: Irrigation system (drip irrigation tank and lines, security fencing and concrete housing for the pump)	KES 532k
	Total CAPEX	**KES 612k**
	Deposit amount for a CAPEX loan (30%)	KES 184k
	Opex: Fuel, silt removal and maintenance of pump	KES 4.8k/month
Non-energy costs	Good Agriculture Practices training, market knowledge and aggregation (not costed here - see below)	
	Average farm inputs (seeds, fertiliser, pesticides, labour) (190k/year)	KES 15.8k/month
Credit/month for energy system and appliances	Monthly credit payment: ○ Loan taken by farmer for Capex of energy and irrigation systems: assuming a 30% deposit requirement ○ 12% interest rate over 5 years	13.6k/month
Average monthly expenses		KES 54.8k
Annual expenses		KES 658k
Average revenue of sales per year		KES 3.36m/year
Net annual profit First year (including credit payment and deposit cost)		KES 2.52m
Net annual profit Years 2-5 (including credit payment)		KES 2.7m
Net profit (monthly)- year 5 onwards (without credit payment)		KES 2.87m
Breakeven point: farmer cash flow (with credit) turns positive		Month 5
Notes	○ It is assumed that a 30% deposit of CAPEX costs will be put down by farmers or sourced through additional policy intervention. **With loan deposit and other input costs during the first season it is recommended the farmer has savings of KES 300k** ○ Note that average monthly costs are calculated on an annual basis and divided by 12. Farmer Cash flow is an important consideration for seasonal income: and is considered in the full calculations, including the recommended savings and break-even point. ○ Based on farming 1 acre of land with crop rotation timed to optimise farmer income in markets and highest value crop during the first season improve farmer cash flow at start up. ○ The pump is portable and can be stored remotely for security purposes ○ Costs include a 16% VAT figure	
3. Standalone petrol pump system for furrow-based irrigation		

Energy delivery system	Genset petrol powered pump: direct pumping to furrows	
Energy system costs	Capex: Energy system and pump (pump, panels, structure, cabling, panel security)	KES 80k
	Total CAPEX	**KES 80k**
	Deposit amount for a CAPEX loan (30%)	KES 24K
	Opex: Fuel, silt removal and maintenance of pump	KES 3.4k/month
Non-energy costs	Good Agriculture Practices training, market knowledge and aggregation (not costed here - see below)	
	Average farm inputs (seeds, fertiliser, pesticides, labour) (190k/year)	KES 15.8k/month
Credit/month for energy system and appliances	Monthly credit payment: ○ Loan taken by farmer for Capex of energy and irrigation systems: assuming a 30% deposit requirement ○ 12% interest rate over 5 years	1.8k/month
Average monthly expenses		KES 21k
Annual expenses		KES 252k
Average revenue of sales per year		KES 3.36m/year
Net annual profit First year (including credit payment and deposit cost)		KES 3.084m
Net annual profit Years 2-5 (including credit payment)		KES 3.108m
Net profit (monthly)- year 5 onwards (without credit payment)		KES 3.123m
Breakeven point: farmer cash flow (with credit) turns positive		Month 5
Notes	It is assumed that a 30% deposit of CAPEX costs will be put down by farmers or sourced through additional policy intervention. **With loan deposit and other input costs during the first season it is recommended the farmer has savings of KES 110k** ○ Note that average monthly costs are calculated on an annual basis and divided by 12. Farmer Cash flow is an important consideration for seasonal income: and is considered in the full calculations, including the recommended savings and break-even point. ○ Based on farming 1 acre of land with crop rotation timed to optimise farmer income in markets and highest value crop during the first season improve farmer cash flow at startup. ○ The pump is portable and can be stored remotely for security purposes ○ Non-energy costs do not include landscaping labour for furrow-based irrigation ◦ Costs include a 16% VAT figure	
4. Grid connected system for drip-based irrigation		

Energy delivery system	Grid connected pump and tank sufficient for 20m3 drip irrigation per day	
Energy system costs	Capex: Energy system and pump (pump, panels, structure, cabling, panel security)	KES182k
	Capex: Irrigation system (drip irrigation tank and lines, security fencing and concrete housing for the pump)	KES 561k
	Total CAPEX	**KES 743k**
	Deposit amount for a CAPEX loan (30%)	KES 223k
	Opex: Grid electricity, silt removal and maintenance of pump	KES 3.4k/month
Non-energy costs	Good Agriculture Practices training, market knowledge and aggregation (not costed here - see below)	
	Average farm inputs (seeds, fertiliser, pesticides, labour) (190k/year)	KES 15.8k/month
Credit/month for energy system and appliances	Monthly credit payment ○ Loan taken by farmer for Capex of energy and irrigation systems: assuming a 30% deposit requirement ◦ 12% interest rate over 5 years	11.6k/month
Average monthly expenses		KES 30.8k
Annual expenses		KES 370k
Average revenue of sales per year		KES 3.36m/year
Net annual profit First year (including credit payment and deposit cost)		KES 2.767m
Net annual profit Years 2-5 (including credit payment)		KES 2.990m
Net profit (monthly)- year 5 onwards (without credit payment)		KES 3.129m
Breakeven point: farmer cash flow (with credit) turns positive		Month 5
Notes	It is assumed that a 30% deposit of CAPEX costs will be put down by farmers or sourced through additional policy intervention. **With loan deposit and other input costs during the first season it is recommended the farmer has savings of KES 350k.** ○ Note that average monthly costs are calculated on an annual basis and divided by 12. Farmer Cash flow is an important consideration for seasonal income: and is considered in the full calculations, including the recommended savings and break-even point. ○ Based on farming 1 acre of land with crop rotation timed to optimise farmer income in markets and highest value crop during the first season improve farmer cash flow at start up. ○ Costs include security: Five-metre-high tamper proof fence, solar panel welding and lockable control panel, fencing around, and a security fencing and concrete housing for the pump ○ Costs include a 16% VAT figure	

Table 28: Electricity system options for irrigation

Maintenance and repair function for electricity and irrigation systems

This will be provided through:

- Ensuring all electricity system components and appliances have effective warranties from equipment suppliers and farmers are aware of the nearest service centre in case of non-functioning system components or equipment.
- Building in an element of maintenance cost into the model. This will not cover the cost of replacing the entire system but will help with ongoing pump maintenance and repair. The model will also allow the farmer to save for system replacement costs.
- Longer term, it may be cost-effective to invest in improving provision of training for local electricians through Vocational and Technical Centres (VCTs) to ensure sustainable local maintenance and repair functions.

Next steps for the energy solution

It should be noted that, given the limited data and information, the above is a guide only. The following are proposed next steps to further validate and refine work presented above:

1. **Mapping of sand dams that can be used for irrigation.** This initially focus on sand dams that were identified in the Water Infrastructure Audit in 2017
2. **Conduct analysis of annual quantity of supply versus demand for farming and other uses.**
3. **Collaborate with Department of Water and Irrigation** on their plans for identifying various water consumption sectors, demand and the available water sources and the associated challenges better. Map the supply and demand on a per water source basis for each planned irrigation location.
4. **Validate data on water requirements** for different types of horticulture crops by engaging with the Agriculture and Livestock Department who provide farmers with seed varieties and other extension services
5. **Develop demonstration project:** testing out a range of the irrigation solution options above with farmer groups to identify any challenges
6. **Refine solutions and bundle/aggregate:** given the above, refine solution options and develop financing options and detailed delivery models

Non-energy components

The non-energy components issues align very closely with the solution proposed for rain-fed below with a few key differences. Please refer to the rainfed solution, noting the following:

- Rainfed agriculture puts more emphasis on adoption and use of conservation agriculture techniques. The horticultural crops will use different techniques, however the approach to training (the process) would be similar.
- Crops in rainfed agriculture are mainly drought tolerant varieties of pulses and cereal (maize) which are high yielding. Horticultural crops in the irrigation solution must suit he climate (hours of sunlight etc) but are less constrained by water scarcity. The horticulture business model also includes use of high-yield varieties such as 'money maker' tomatoes.
- Access to finance is required for both solutions. However, the amount of finance and savings required for the horticultural business model outlined above is significantly higher than for rainfed solution. To note the profits are also significantly higher.

Solution 4b: Improved yields and resilience of rain-fed crops - green grams, cow peas and maize

Target group

Householders depending on rainfall to grow maize, cow peas and green grams in less than 4.8 acres of land (Smallholder farmers) in drier areas of Kitui county. Two categories of farmers are considered: (i) those who can afford to hire mechanised equipment (tractor drawn); (ii) those who cannot afford to hire mechanised equipment for land preparation.

Given the semi-arid climatic conditions in Kitui County, and the increasing impacts of climate change on reliability of rainfall patterns and increase in temperature, calls for stakeholders to support uptake of drought tolerant and improved crop varieties that can thrive in such climatic conditions. Drought tolerant maize varieties[50] are suitable for Kitui Central and adjacent parts of Kitui Rural since the areas receive between 400-600mm per season which is suitable for maize. Pulses such as green grams[51] and cow peas[52] require between 250-400mm of rainfall per season, conditions characteristic of drier lowlands stretching from the north (Tseikuru, Kyuso, Mwingi, Ngomeni,Nguni, and Nuu), through the Yatta plateau, the eastern areas (Mutito and Mwitika), and southern areas such as Mutomo, and Ikutha.

To increase the yield for these crops, a pronged approach will be used ie promotion of good agricultural practices-specifically, putting into practice conservation agriculture principles through hands-on trainings, follow-ups and mentorship support by lead farmers to ensure skills on CA are put into practice; improving access to draught tolerant certified seeds in remote areas of the county through pooling of resources for collective purchase. The use of lead farmers will also play significant role in demystifying some of the cultural barriers, such as the continued use of local/recycled seeds. The proposed approaches have been proven in Kitui by SASOL foundation and Caritas Kitui, who have supported farmers on various components of GAP, including CA, access to draught tolerant certified seeds and other farm inputs.

Promoting use of Good Agricultural Practices (GAP)

- **Increasing uptake of conservation agriculture (CA) practices**

  To support smallholder farmers to build their knowledge and skills on use of CA principles, the following interventions are proposed: note that these interventions are not prescriptive, but smallholder farmers are encouraged to adapt the general principles to meet their specific situations/context.

1) Training farmers on CA techniques. Four trainings will be carried out as follows:

   a) Situational analysis - understanding the importance of CA, its principles and precision planting Crop rotation patterns, intercropping systems, correct spacing, and soil fertility.
   b) Weed management including appropriate tools and practices (eg shallow weeding). All options would be explored including physical, biological, and chemical control. Mechanical/physical control options include shallow scraping with sharp hand-hoes, hand pulling and slashing which are suitable for very small areas. Biological control, by means of keeping the soil surface covered and competing out weeds is achieved with crop associations and cover crops under-sown in the main crop before harvest and covering the soil until the subsequent main crop establishment (Kienzle & Sims, 2015).

50 KDV1 (KARLO), KDV 4 (KARLO), Duma 43 (Seedco Ltd.), DH02 (Kenya Seed company Ltd) characterized by early maturity, tolerant to diseases and water stress and high yielding as compared to the traditional varieties.
51 KS 20(KARLO & Dry land seed company), N26(KARLO, Dryland seed company)
52 M66(KARLO), K80(KARLO)

c) Pre- and post-harvest crop handling (factors that can lead to on-farm crop produce loss, factors causing post-harvest losses, and how to handle produce after harvesting to maintain high quality produce).

2) Support for farmers to use mechanized CA. At this point, it important to note that we lack data on types of mechanization available in Kitui, the demand, affordability, and viable management models for use of these equipment. The mechanisation intervention looks at two categories of farmers:

   a) Farmers who can afford to hire tractor drawn equipment: For these farmers, CA mechanization focuses on the shift from conventional disc ploughs to chisel plough. These farmers are encouraged to from already existing service providers in Kitui county. For example, the tractor-drawn chisel ploughs can be hired from the Agricultural Mechanization Services (Kitui) at a cost of KES 1000/- per acre.
   b) Farmers who cannot afford tractor drawn equipment: have the option of using normal ox-drawn plough. We lack concrete data on how many farmers own/have access to oxen and ox-plough, the demand, and affordability for this form of mechanization in Kitui County.

3) Hands on training on water harvesting and conservations through use of enhanced Zai pits, also known as planting pits (Inades Formation, n.d.). Because of the simplicity of technology, smallholder farmers will be taken through a one-day training on the construction of the Zai pits. These are permanent planting holes/pits for rainwater harvesting and maximum soil moisture retention. Farmers will be taken through the following process:

   a) First Step of digging a pit of measuring 2×1×0.3M in the farm. Note that the pit size can be of different dimensions depending on crop to be planted and amount of rainfall the areas receives
   b) Second Step: Farmers will be trained on how fill halfway the dug pit with organic matter such as dry leaves, maize straws, etc. The organic matte will serve in conserving moisture content and increase manure in the pit as the organic matter decomposes with time. Important consideration is use organic matter that will decompose within short time to benefit the crops.
   c) Third Step: Farmers will be taken through the process of filling the zai pit with a mixture of manure and topsoil after the organic matter. The ratio of the manure to the topsoil mainly depends on the level of fertility of the top soil and on average the ratio is 1:3. The filled organic matter and the manure take between 20-25 cm leaving space on top for water accumulation and mulching. The soil is then mixed evenly. This pit will be ready for planting once the rains commence. However, in case of planting during dry season, farmers will be taken through the 4th step (see below).
   d) Fourth Step: The zai pits are then irrigated when farming is done during the dry season and the intended crops planted. Farmers will be trained on how to cover the Zai pits with mulch to reduce evaporation and improve soil fertility. Mulching also suppresses weeds further reducing costs of weed management significantly. It is important to note that, once the zai pits have been constructed, it can be used consecutively for 3 years (6 planting seasons) before they are reconstruction following the 4-step process articulated above. After successful constructions of the pits, farmers will be trained on how to intercrop maize with legumes (based on farmer choice) including cow peas, beans and dolicos lab for nitrogen fixation, and diversification for risk reduction. The legumes also serve as soil covers and hence increasing soil moisture retention. A single pit accommodates 20 maize plants and 10 leguminous plants. An acre of farm accommodates 650 pits.

To ensure that farmers adopt and use good agricultural practices including the conservation agriculture techniques, the following proven approaches by local organisations such as Caritas Kitui, Sasol, and others for provision of extension services are proposed in **Error! Reference source not found.** below:

- **Cluster approach**: For efficient extension service delivery, the smallholder farmers are grouped into clusters based on their geographical location and crop varieties in the farm. Every cluster is managed by an Agricultural Extension Officer responsible for GAP trainings including CA and follow ups.
- **Lead farmer methodology**- Lead farmers have played critical role in extension service delivery. Lead farmers are selected based on their performance in year 3, willingness to assist other farmers and acceptability by their counterparts. They are then trained on CA and GAPs, roles and responsibilities, data collection (to aid in farmer tracking), extension strategy and record keeping. A lead farmer visits at least 15 farms in a month. Worth noting that lead farmers are volunteers and require support in terms of logistics for them to deliver extension services. For example, SASOL support their lead farmers with KES 500/- for communication each a month in the busy months of March, April, July, August, September, and October. These are key months as they are also involved in farmer tracking in CA practices as well as production data.
- **Group meetings**- Each farmer group has a specific day for their meetings every week. The Agricultural Extensionist will schedule a visit with a specific objective based on the seasonal calendar. In such meeting, the farmers will discuss their progress and/or challenges based on their observations in the farms. The Officer will then identify individual farmer needs and arrange a farm visit to address such needs.
- **Need based farm visit and on farm training-** The Agricultural Extensionist will visit identified farmer(s) to verify farmers claim. Based on his/her observation, the Officer then offer personalized advice or on-farm training.
- **Farmer to farmer visits**: Farmers are encouraged to visit their neighbours within and outside their farmers' groups and observe practically what is happening. These peer-to-peer learning experiences boost self-confidence and the understanding that best practices can as well be replicated in their farms since they are within same locality with similar ecological conditions.

Table 23: Approaches for enhancing adoption and use of good agricultural practices

- **Integrated Pest Management (IPM)**

Farmers will be sensitized on the impact of crop pest and diseases on crop yields, types of pests and diseases that affect different crop families. Some of the common pests affecting smallholder farmers in Kitui include aphids, beetles, caterpillars, powdery mildew, and rust (SWAp, 2010). Farmers will be equipped with skills on integrated pest management of crops pre and postharvest. For pre-harvest pest control, farmers will be guided on how to carry out proper crop rotation and associations- how to rotate pulses with cereals each planting season. Crop rotation curbs pest and disease build up in the soil by breaking the pest and disease cycle. For post-harvest, farmers will be guided on proper sun-drying of farm produce and use of hermetic bags for storage.

- **Improving accessibility to quality/certified seeds by farmers**

Based on the experience from local organisations such as SASOL and Caritas Kitui, the following approaches have worked

a) Bulk purchase of certified seeds through pooling of resources. Based on Sasol experience, seed pooling has worked well with farmer groups that practice group savings and loaning schemes (Table banking). These farmers are able to use their savings kitty and/or share outs to pay for the purchase of certified seeds. When the savings are used, the members pay back in instalments based on group constitution and quantity of seed received. It is worth mentioning that major seed stockists are willing to avail bulk consignment at the field level.

b) Demand creation through sensitization of smallholder farmers on benefits of using certified seeds in term of resistance to pests and diseases, adaptability to water stress and higher yields. Sensitization on the importance of quality seeds is key to farmer buy-in and experimentation by those who can afford. Organisations such as Sasol and Caritas have been sensitizing farmers on the importance of using certified seeds through farmer field days and the use of lead farmers

- **Improving farmers market literacy and access to markets**

1) **Improving farmers' market literacy**: this will be promoted through a package of training in a participatory manner. Training needs assessment will need to be carried out to inform customisation of training programmes. The different trainings targeting specific farmers will aim to build their understanding of markets and improve farmers' ability to sale their farm produce.

2) **Marketing information support**: actors like SASOL, Kitui County Government, Caritas Kitui etc. have previously scouted for important market information such as available buyers for different crops, quantities of produce needed, prices and the terms of payment and passed this information to the farmer groups for decision making.

3) **Marketing associations**: SASOL and Caritas Kitui have encouraged formation organized marketing groups (associations) for easy market linkages. These entities are easier to link with buyers as they have representatives who can enter into agreement on behalf of members and a joint account is also available for fund deposits if they sell collectively. Such associations aggregate their produce through owned stores and/or rented space. They rent space for short duration (2 months) to facilitate the aggregation and collection of the produce by the buyer. Some level of success has been reported for this model, but further research is required on how this approach can be made stronger.

4) **Promoting linkages to strategic market platforms and/or identifying better market linkages**: this will require further in-depth market research and analysis including consideration of the findings of the participatory market mapping farmer training. To date, the following market channels are currently being used by farmers in Kitui to sell the target crops:

    a) For grain cereals, some farmers use marketing platforms that connect them with prospective buyers. These include the East African Grain Council (EAGC) and Farmshine. Both have an e-market platform where they register farmer groups and aggregators to be able to access available buyers for specific crops. For groups to be registered there is a process of profiling and certifying especially with EAGC. The pros and cons documented to date include availability of ready buyers (pro) and sometimes prices may be low.

b) For green grams, three categories of buyers have been identified through preliminary research:

i. Exporters - These are buyers who buy for export to India mainly, for example Capital Reef
ii. Intermediaries - They either sell to the exporters or they add value and sell through supermarkets mainly eg Spice World
iii. Local aggregators- These sell to the intermediaries and exporters. They also stock for the local market eg Benjo, Daystar

Solution Component	Costs/inputs	Revenues	Implementing partners
Improved GAP through CA: Tractor drawn chisel plough for farming green grams	**Training costs** ○ Training on GAPs; 4 modules each costing **KES 1200/**- per farmer- (Land preparation, Planting, weed control and pest and disease management). **Implementation costs** ○ Farm lease= 2500/- per year (2 seasons) ○ Land preparation/ripping using tractor with chisel plough (tractor hire) =1,000 per season ○ Seeds(4kg) =1000/- ○ Manure(1ton) =800/- ○ Planting- labour = 300/- ○ Pest/disease control =500 ○ Harvesting =4800/- ○ Threshing=500/- ○ Preservation=200/- ○ Storage=250/- **Total cost = KES 11850-.** **Note:** the cost of renting land will not be incurred during the 2nd planting season within the same year hence profit margins are expected to increase	**Revenue generated** ○ One acre yields average 450 Kgs (compared to 193 Kgs using conventional methods) ○ 450 kg of green grams sold at a profit of KES 2553 per kg =11,250 in one season. (Average selling price is KES 60/- per kg)	○ Ministry of Agriculture-Kitui County ○ Caritas Kitui, ○ SASOL ○ Participatory Action for Integrated Development (PAFID) ○ Farmers and farmer groups

53 This is the average profit per kg which may vary from season to another and place to place based on the local market (retailers)

Improved GAP through CA and Rainwater harvesting Enhanced zai pits for farming maize and cow peas. Zai pits are permanent planting holes measuring 2×1×0.3M for rainwater harvesting and maximum soil moisture retention. A single zai pit accommodates 16 maize plants and 11 leguminous plants yielding 2.4 kg of maize and 0.5 kg of legume crop. An acre accommodates 650 such pits Varieties for Maize- Duma 43 and cow peas- M66	**Training Cost** ○ Training on GAPs; 4 modules each costing **KES 1200/-** per farmer- (Land preparation, Planting, weed control and pest and disease management). ◦ Training on enhanced zai pit making (1 session)- **KES 300** per farmer per season. **Implementation cost** ○ Seeds- - maize 5kg=KES 1375 - cow peas 1kg= KES 200 ○ Land lease=1000 per year (2 seasons) ○ Land Preparation- KES 65000 (cost for making 650 zai pits) ○ Planting=KES1200 ○ Manure=KES 800 ○ Pest/disease control= KES100 ○ Harvesting=KES 1200 ○ Threshing=KES 2100 ○ Preservation=KES1400 ○ Storage = KES5250 **Total=KES7962554** **Note:** The cost of advanced Zai-pit will be incurred once after every 3 years. Therefore, the profit for the consecutive seasons will be higher	○ Maize -1560 Kg per acre. Sold at a profit of KES 18/- per Kg= 28080/- (Average selling prices is KES 25/Kg) ○ Cow peas - 325kg per acre. Sold at a profit of KES 10/- per kg = 3250/- (average selling price is KES 20/- per Kg **Total profit generated for both maize and cow peas is KES 31330/- per acre**	○ Ministry of Agriculture - Kitui County ○ Caritas Kitui ○ SASOL ○ Participatory Action for Integrated Development (PAFID) ○ Farmers and Farmer groups
Assumptions ○ Ripping by itself is a land preparation technique, assuming it will be done in an existing farm, there will be no other land preparation required. Farmers will use own prepared compost manure thus no extra cost for fertilizers ○ Rains will be sufficient ○ Farmers will be precise in planting to achieve correct plant population and they will practice at least two CA principles (minimum soil disturbance & permanent soil cover). ◦ Different Sub-Counties favour different leguminous crops, maize is applicable in all. Farmers will choose the legume type for maize intercrop based on this preposition.			

54 Bulk of the cost is borne by zai pits preparation. Zai pits will take three years (six seasons) before they are repaired.

Table 29: Summary of costs for solution for improving smallholder farmer incomes from green grams, cow peas and maize)

Table *29* shows the summary of costs for solution for improving smallholder farmer incomes from green grams, cow peas and maize) by increasing crop yields through improved GAP, use of quality inputs (seeds), and better marketing of produce through improving farmers' market (costs are per acre).

1.37 Solution 5: Livestock - Improved yield and productivity of small-scale livestock (poultry and dairy) farmers across Kitui County

Summary of problem and solution

The objective is to improve the income of small-scale livestock farmers (poultry and dairy) in Kitui County. Specifically, supporting them to increase the productivity of the livestock and increase sales of livestock products. The solution will address the following gaps and barriers:

- **Electricity:** Lack affordable and reliable power for operating appliances that has the potential to increase livestock production
- **Appliances:** Lack of access to good quality appliances required to improve livestock management and increase yield and diversify produce/products
- **Inputs:** Lack of access to affordable inputs (eg water, drugs, vaccines, feed, nutrients etc.)
- **Veterinary care:** Lack of access to timely veterinary care services for disease control and vaccination and high costs of drugs and vaccines
- **Extension services:** Lack of local livestock extension officers for training and supporting livestock farmers on livestock management
- **Market links:** Lack of access to market information and inability to link with more reliable buyers

The solution includes the following interventions:

Energy components:

- **Provision of reliable electricity, including back-up systems for powering electric incubators** targeting independent small-scale poultry (indigenous chicken) farmers, and hatcheries (formed as farmers groups registered as cooperatives)
- **Provision of reliable electricity for local feed production** using chaff-cutters for small-scale dairy and meat farmers keeping cattle and goats
- **Maintenance and repair service** for all energy systems installed and the appliances

Non-energy components

- **Improved access to clean water** for livestock farmers
- **Improved veterinary service provision** in local veterinary offices
- **Improved farmer knowledge and skills** on livestock management strategies, inputs, business skills, and ensuing women and youth participation in such interventions
- **Improved knowledge on markets** and supporting farmers link with reliable and fair market channels
- **Improved farmer knowledge and access to inclusive financing options** for maintaining business and expanding business

What problem is the solution addressing?

The priority need identified was improving income of small-scale livestock farmers in Kitui County. The most common livestock sectors in Kitui include poultry, cattle and goats.[55]

Poultry keeping

Poultry keeping is practiced by many households in Kitui. According to the latest Census data (KNBS, 2019), around 58% of the households in Kitui practice poultry, and of these, almost 97% (over 147,000 households) keep indigenous 'Kienyenji' chicken. The County Government data indicate this to be even higher- according to Kitui livestock office database as many as 97% of households in Kitui practice poultry. A county wide survey is needed to understand poultry production dynamics better. Indigenous eggs and poultry meat contribute significantly to food security and income of many households in the county.

On average each household manage a flock size of around 15 chicken, and practice village or backyard production with minimal management and produce enough for household consumption and sell irregularly. Research shows that women (as high as 60% in some western counties in Kenya) own poultry, particularly when done in small-scale, and tasks related to routine management and marketing of eggs and live birds are mostly undertaken by women with the assistance of children (KARI, 2007; ILRI, 2018). Research at the county level show that there is a high demand within the county and outside for indigenous eggs and meat and has significant potential to be a main source of income to most of the households. This requires improving productivity of these small-scale poultry farmers through the provision of dedicated poultry management techniques such as incubators and knowledge to maintain an increased commercially viable flock size and increase production cycles (from the current 2 cycles to 12 cycles), while ensuring access to reliable buyers with better prices.

Cattle and goat keeping

This is the second most practiced type of livestock farming in Kitui with around 36% and 57% of the households keeping cattle and goat respectively (KNBS, 2019). According to Kitui livestock office database, as many as 70% of households in Kitui are keeping goats. Cattle and goat are kept for both meat and dairy production. Achieving high and sustained livestock productivity depend heavily on nutrition provided to the livestock. Most cattle and goat farmers in Kitui practice zero-grazing where feed is brought to the animals rather than sending them out to pastures. Research show that due to high costs of importing fortified feed, most livestock farmers in Kitui use locally available pasture or crop residues. This local feed is often consumed inefficiently by cattle and goat, which relate to low quality and reduced yield, and high wastage of resources at the farmers' end. Research carried out for this CEP show that interventions that can improve feed production locally using chaffcutters has significant potential for improving consumption and palatability of feed thus increasing yield of cattle and goat. In Kitui men collect feed while women do the feeding- and using chaff cutters can reduce the time both men and women spend preparing livestock feed.

Additional support for accessing other inputs such as water and drugs/vaccines, ensuring quality of production (eg abattoirs, milk cooling etc.) and identifying reliable market linkages are also critical for improving overall value chain.

55 Apiculture (bee keeping) is a new livelihood promoted in Kitui. The initial field research has shown that that there is only a very small number of farmers focusing on beekeeping with a low energy demand for small-scale production compared to other livestock. Therefore, detailed solution is not considered a priority within the timeframe this CEP was produced.

- **Dairy Cattle:** There are around 3,865 households (1.5% of total households in the county) keeping 2-3 dairy cows per household on average (KNBS, 2019). According to Kitui County livestock experts and consultations with dairy farmers and cooperatives, the dairy cow breeds found in Kitui are mostly crosses of Ayrshires, Friesian and Guernsey, and the average daily milk production is around 4-5 litres of milk per cow compared to the potential of 15 litres a day per cow [56,57] . There is a significant deficit in the milk production to meet the county's demand for milk - the county wide annual milk production remains at 4.2 million litres against the annual demand of 100.4 million (SEAF-K, 2017). Mwingi and other parts of the county has imported milk from Meru and Embu Counties, and now face restrictions involving trading milk. The current primary source of milk includes packaged milk from established milk cooperatives which does not reach rural areas due to poor transport network (Mwende & Bosma, 2019). Improving local milk production can therefore help bridge this gap and has gained significant interest from the County Government. Goats are often kept for both dairy and meat production, and specific measures for dairy goats is not common due to low market channels.

- **Meat Cattle and Goats:** According to KNBS (2019), 35% of the households in Kitui keep cattle owning around 3-4 cattle per household on average- around 97% of the households keep indigenous cattle, with the remaining keeping more exotic cattle types for beef. The census data shows that around 57% of the households in Kitui keep goats, with each household owning around 9-10 goats. Meat is a higher value produce and improving quality of goat through better feed, can increase value and access better market channels. In addition, the current production does not meet the demand for meat in the county- the annual average production of beef is around 3,077 tonnes and around 1466.6 tonnes of goat meat whereas there is a demand of 32, 120 tonnes of beef and goat meat (SEAF-K, 2017).

Energy gaps/barriers

- **Lack affordable and reliable power for appliances with potential to increase livestock production**

Lack of reliable power supply impedes poultry farmers from increasing their production using appliances such as lighting for daylight mimicry that can stimulate hens to lay more eggs, electric incubators for artificial hatching of eggs and infra-red lights for providing heat needed for brooding chicks. Egg incubation for instance is a sensitive process as the temperature needs to be maintained for the whole incubation period of 21 days. Community engagement and research in Kitui highlighted that while most farmers lack knowledge on these approaches and the ability to purchase appliances, lack of reliable power adds to the challenges for uptake of technologies such as egg incubation. Although several donor-funded programmes have conducted incubation demonstration sites for groups of farmers with some positive results, there have been issues with the power sources used. Voltage fluctuations and power outages of the grid, and poorly designed and low-quality solar systems used either as back-up or as stand-alone affect the efficiency of incubation systems leading to loss of eggs and income. Similar experience has been reported by larger commercial hatcheries using electric egg incubators. These challenges have affected farmers' trust to invest in incubators.

Lack of grid connections limits farmers who keep goat and cattle from using appliances such as chaffcutters. Research show that in Kitui, given the semi-arid and dry land areas, the availability of fodder and pasture for feed is often very limited specially in dry seasons. There is also Increasing pressure on arable land for cultivation of cash crops, hence reducing land for green fodder and pasture production. Discussions with local farmers highlight that currently only around half of the feed can be consumed by

56 The production rate here is an average from across multiple breeds and not specific for a breed of cows

57 Information provided in KII by Kitui County Livestock Expert based on Kitui County Enterprises Livestock Strategy Paper (not shared)

the animals as farmers are unable to access and operate appliances such as chaff-cutters to cut and mix fodder into small pieces to increase the consumption and digestibility by the animals.

- **Lack of access to good quality appliances required to improve livestock management and increase yield and diversify produce/products**

Availability of appliances such as incubators and chaffcutters in the local markets is quite limited. While the more urban centres like Kitui Town and Mwingi Central have limited number of retailers, farmers lack understanding of the quality of these appliances, and are not able to compare across to make informed decisions on quality, price, warranties and suitability to their contexts. Donor funded demonstration projects that focused on incubators have been often brought in by one-time suppliers and not focused on building a local value chain for appliances.

Non-energy gaps/barriers

- **Access to clean water**

Availability of clean water is critical for animal health and productivity. Research show that during dry season, they and animals can travel up to an average of 40km to get water (Opio et al., 2011). In Kitui, lack of water supply in most part of the year hinders the yield and health of most livestock. Lack of planning of water points for livestock has also resulted in community disputes and further contamination of clean water for human consumptions.

- **Lack of access to timely veterinary care services for disease control and vaccination and high costs of drugs and vaccines**

Livestock diseases cause mortalities and significantly reduce quality and quantity of produce. Timely access to veterinary services is critical to ensure that diseases are treated, and the spread is controlled. Most farmers highlighted the challenges in having to travel long distances to access veterinary care, and lack of trained staff at the local level which can often delay treatment and control. Most farmers are also challenged by high prices of vaccines and drugs which need to be bought from private veterinary care providers often with high transport and time costs. This combined with lack of awareness on disease impacts, most farmers rarely practice vaccination as a livestock management technique.

Discussions with county livestock experts have highlighted that Kitui has one Head Office at County level, 8 sub-county stations each with a veterinary surgeon and 40 ward level stations with Animal Health Assistants. All veterinary stations at county, sub-county and ward level are supplied with grid power but face frequent interruption of power supply which can affect storage facilities and general service functions. The experts also highlight that there is lack of appliances such as deep freezers for producing ice for cooling-boxes that can transport drugs and vaccines to remote farms, refrigerators for storing drugs and vaccines and computer systems (including printers and photocopiers) that are useful for surveillance of disease outbreak, data storage and knowledge sharing. There is a gap in understanding status of veterinary service provision across the county, appliances needs, energy demand and energy supply issues in the county.

- **Lack of local livestock extension officers for training and supporting livestock farmers on livestock management**

Limited number of livestock extension officers and inability to access their services in a timely manner were challenges identified from most farmers in Kitui. Lack of these trusted communication channels

often impact farmers' ability to understand critical livestock management techniques and accessing good quality inputs for maintaining livestock at the same size and for a good quality that can result in improved income. These limitations mean, farmers in Kitui lack access to advice on type of inputs (eg breed types, drugs, feed supplements) and equipment (eg housing, water feeders, housing etc.) that should be adopted, and guidance on purchasing and using them.

- **Lack of access to market information and inability to link with more reliable buyers**

Most farmers in Kitui rely on informal channels to access market information and are often exploited by middlemen at low prices. Women poultry farmers often sell eggs and birds for meat at the farm gate or at the local market. Most dairy farmers sell their milk through informal channels (eg neighbours, friends etc.) and milk sales are often done by women. Cooperatives are used in some instances for birds and milk sales- but is not common practice in Kitui despite the potential for strengthening market links through aggregation. There is lack of trust and capacity among farmers to link collectively to market for inputs and the sale of livestock products- which if addressed would strengthen the ability to attract more reliable buyers who will have better bargaining power for prices. Most current good-practice examples in Kitui where collective market links are used, come through external support projects (eg Farm Africa/ Kitui Development Centre, TroCair/ Caritas Kitui etc.). Limited mapping on livestock markets which also hinders opportunities to better understand opportunities for more commercial production.

- **Limited access to appropriate financing**

EDM workshop participants highlighted a lack of access to banking services and affordable credit, such as loans for purchasing appliances and energy systems, and working capital for inputs as main gap for maintaining a business. Inability to present the collaterals required from financial institutions is a highlighted as a main challenge for MSMEs across Kitui (see Section on MSMEs). For women farmers and women led MSMEs, who often lack ownership of land and assets, and decision-making power on finances- accessing credit financing is even more farfetched.

Solutions: Poultry farming

Target groups

- Independent poultry farmers, particularly women, interested in expanding or starting small-scale commercial production of indigenous poultry products
- Farmers groups registered as poultry cooperatives
- Entrepreneurs (particularly youth) setting up hatcheries as MSMEs

Energy Component

- **Provision of reliable electricity, including back-up systems for lighting and electric incubators**

The target group will include women or men who are currently keeping indigenous chicken as back-yard poultry with a small number of chicken and those who are interested in starting a more commercial poultry business. The following attributes make expansion of poultry keeping of indigenous chicken more attractive as a commercial option than promoting commercial breeds such as broiler chicken: Initial investment is less compared to investment needed for commercial breeds;

they are more tolerant of harsh conditions and disease and can be allowed to range freely; feed can be easily sources locally compared to special feed needed for commercial breeds; and increasing market locally and externally given consumer preferences for taste of indigenous chicken meat and eggs.

Primary energy needs and appliances considered for poultry production include the following (based on GIZ 2016; SELCO, 2019).

- **Lighting for poultry housing**- Daylight mimicry by extending number of light hours to 12: 14 hours per day, in order to stimulate hens to lay more eggs. As indigenous chicken is often reared free-range during day time, the lighting requirements are limited at different stages, and can be kept to limited amounts.
- **Electric egg incubation**: Electric incubators can increase hatching rate to 80%. It requires a constant temperature range of 36 to 39°C and relative humidity range of 50% to 70% for 21 days. A stable electricity supply is required to provide these conditions during the whole incubation period. Any change in temperature, even for a short period can impact production rates.
- **Heat for brooding**: Following hatching, artificial brooders are required to produced heat for 4 weeks, as the hens are unable to naturally brood many chicks. Paraffin lamps/ stoves are commonly used for this purpose and infrared lamps (1100 -250 W) provides a safer and cleaner option but are not often viable in off-grid settings given high power requirements.

The following **key assumptions** have been used based on analysis from poultry experts:

- Introduction of electric incubation can increase production cycle from 2 cycles to 12 cycles in a year. This allows farmers to diversify their poultry products to more high value products (such as meat birds, pullets, breeding cocks etc.) sales and increase their income significantly.
- The commercial viability of the business which include electric incubation (off-grid or grid connected with back-up) will require expanding the currently common flock size of around 9 chicken per household, and ensuring the flock is continuously maintained at the same size. The solution proposes independent farmers to have a flock size of 50 and cooperatives/ SMEs who will function as a hatchery.
- Capital costs are estimated based on local expert knowledge and assuming the farmer must set up from start, even if they are expanding from backyard poultry to a more commercial practice.
- The calculations are based on estimates using basic principles for system design and provide indicative values. The data was obtained from field work in Kitui, inputs from poultry experts, pricing from a limited number of suppliers and desk research. They do not represent exact costs and require more triangulated data and analysis prior to designing a more detailed investment plan.
- There is lack of data on how much light intensity (in terms of Lumens) poultry houses should have for indigenous chicken breeds to optimise their production cycles. This determines the type and size of light bulbs required, adding into the capital and operational costs, and off-grid system sizing. Further inputs and clarification from poultry research institutions in Kenya is needed. The solution presented below is with the assumption of using a 10W LED bulb used for general purpose lighting for 4-5 hours a day.
- Given high-load requirements for infra-red lighting, solutions with standalone systems do not include infra-red lighting and will continue to use paraffin lamps. For grid connected solutions infra-light is introduced assuming a 100W infra-red bulb to be used for 24/hours daily to meet the continuous heating needs of chicks. This data needs to be further investigated as it is based on estimates.

While there is a need to have customised solutions for each farmer depending on the flock size, the following solutions are detailed out as potential options for independent farmers, cooperatives/ SMEs or more commercial hatcheries:

- **Stand-alone solar for independent off-grid farmers**. These farmers will need an incubator with a capacity of 100 eggs and manage a flock size of 50 birds.
- **Back-up for grid connected independent farmers** facing power shortages for 8 hours. These farmers will manage a flock size of 50 birds and require an incubator with the capacity of 100 eggs.
- **Stand-alone solar for a poultry cooperative** to function as a hatchery where poorer farmers who cannot afford to own independent incubators can bring their eggs for a low price. These cooperatives can have an incubator for 300 eggs. Cooperatives also act as a link to markets. By linking with various buyers, they provide services such as quality control, inputs and management advice and training, and act as a collection point for buyers. Existing farmer groups will benefit from a well-managed functioning incubator to build up their income and transforming to a poultry business.
- **Back-up for a grid connected poultry cooperatives** to function as a hatchery for poorer farmers who cannot afford independent incubators.

Maintenance and repair function for electricity systems

This will be provided through:

- Ensuring all electricity system components and appliances have effective warranties, service contracts and farmers are aware of the nearest service centre in case of non-functioning system components or equipment. Access to local level technicians guaranteed by the supplier or the County government would be essential for ensuring there is less downtime of systems.
- Longer term, it may be cost-effective to invest in improving provision of training for local electricians through Vocational and Technical Centres (VCTs) to ensure sustainable maintenance and repair functions.

The success and the sustainability of these poultry businesses will depend significantly on support received for the non-energy gaps raised above, and a summary of solutions for these are presented under non-energy component of the solution below.

Table 30 summarises the different solutions including system specifications (where appropriate) and cost assessments.

Stand-alone solar system for independent off-grid farmers		
Energy delivery system	Solar off-grid system: 140W peak demand and 3.12 kWh daily demand Appliances: o Egg incubator for 100 eggs (AC/DC; 130W) for 24 hours' daily o Lighting (10W LED bulb) 4-5 hours daily	
Energy system costs	Capex: Energy system (including panels, batteries, inverter, controller and installation fee)	KES 249, 000
	Capex: Appliance costs (incubator and LED bulb)	KES 30,850
	Opex (10% of system and appliance costs with 25-year lifetime)	KES 93

	Battery replacement (in 5 years) as a monthly cost	KES 2,333
	Monthly kerosene[58] costs for the brooder- 9 litres per month for 100 chicks	KES 933
Non-energy costs	Non-energy capital costs (50 pullets, housing and other equipment etc.)	KES 51,200
	Average monthly expenses on inputs (feed, water, vaccines, labour etc,) and non-energy opex (annual replacement of feeders etc.)	KES 25,722
Credit/month for energy system and appliances	Monthly credit payment: ○ Loan taken by farmer for Capex of energy system and the appliances ○ 30% interest rate over 3 years	KES 10,106
Average monthly expenses (including energy system opex and battery replacement savings)		KES 27,068
Average revenue of sales per month		KES 52,867
Net profit (monthly)- First 3 years (including credit payment)		KES 15,693
Net profit (monthly)- year 4 onwards (without credit payment)		KES 25,798
Notes	○ It is assumed that the non-energy capital costs of KES 51,200 will put down by farmers from their own savings, support from friend/ family etc. ○ This business model uses kerosene brooder as infra-red light is not economically feasible ○ The costs do not include internal wiring costs for poultry houses. ○ Battery replacement is required in 5 years- this is currently spread across the cash flow as a separate monthly cost	
Back-up for independent grid-connected farmers		
Energy delivery system	Battery-only back up system for 140W peak demand and 3.12 kWh daily demand for poultry farms that face maximum of 8-hour power shortage per day. Appliances: ○ Egg incubator for 100 eggs (130W) for 24 hours daily ○ Lighting (10W LED bulb) 4 to 5 hours daily ○ Infra-red light (100W) for 24 hours daily (see assumption)	
Energy system costs	Capex: Energy system (batteries, controller and installation fee)	KES 60,800
	Capex: Appliance costs (egg incubator, LED light and infra-red light)	KES 31,850
	Opex (10% of system and appliance costs with 25year lifetime)	KES 154
	Battery replacement (in 5 years) as a monthly cost	KES 847
	Grid costs- monthly energy of 167 kWh (@23 KES/kWh tariff)	KES 3,843

58 kerosene prices are from March 2020 in Nairobi. These vary monthly and by region as announced by the government.

Non-energy costs	Non-energy capital costs (50 pullets, housing and other equipment etc.)	KES 51,200
	Average monthly expenses on inputs (feed, water, vaccines, labour etc,) and non-energy Opex (annual replacement of feeders etc.)	KES 23,918
Credit/month for energy system and appliances	Monthly credit payment: ○ Loan taken by farmer for Capex of energy system and the appliances ◦ 30% interest rate over 3 years	KES 3,356
Average monthly expenses (including all energy costs)		KES 32,108
Average revenue of sales per month: sales of a variety of poultry products that include table eggs, fertile eggs, one-month chicks, four-month pullets, breeding cocks, mature meat birds, culled birds and manure		KES 52,867
Net profit (monthly)- first 3 years (including credit payment)		KES 20,718
Net profit (monthly)- year 4 onwards (without credit payment)		KES 24,104
Notes	○ It is assumed that the non-energy capital costs of KES 51,200 will put down by farmers from their own savings, support from friend/ family etc. ○ This business model an infra-red light for brooding ○ The costs do not include internal wiring costs for poultry houses. ○ Battery replacement is required in 5 years- this is currently spread across the cash flow as a separate monthly cost	
Business model and financing for Options 1 and 2	**Potential business model** Business cases above (options 1 and 2) shows that an average farmer income can increase significantly by making improvements to the poultry production cycles, but require additional upfront investments for increasing flock size, purchase energy and non-energy appliances and energy system. Therefore, poorest farmers therefore may not be able to adapt this business model unless they can access financial support in the form of affordable credit or grants. **Financing** Financing support such as targeted subsidies for the poorest farmers (particularly women farmers) and/ or concessional loan programmes for purchasing energy systems and appliances could increase income generation potential significantly. The 'Non-energy component/supporting services' section below discuss more on financing solutions.	
Stand-alone solar for off-grid poultry farmers' group cooperatives functioning as a hatchery		
Energy delivery system	Solar off-grid system: 170 W peak demand and 3.86 kWh daily demand Appliances: ○ Egg incubator for 300 eggs (160 W) for 24 hours daily ◦ Lighting (10W LED bulb) 1 to 2 hours daily	

Energy system costs	Capex: energy system (including panels, batteries, inverter, controller and installation fee)	KES 317, 000
	Capex: Appliance costs (incubator and LED bulb)	KES 55,850
	Opex (10% of system and appliance costs with 25-year lifetime)	KES 124
	Battery replacement (in 5 years) as a monthly cost	KES 2,917
	Monthly payment for member managing and maintaining the system	KES 2,500
Average monthly expenses (including energy system, opex and battery replacement savings)		KES 5,541
Average revenue of sales per month- egg incubation		KES 6,375
Net profit (monthly) for the cooperative		KES 8,34

Farmer income

Assuming each farmer gets an opportunity to incubate around 300 eggs at least once a year (one cycle), each farmer can have an estimated average annual net profit of KES 26,000.

This is provided that the farmers sell the produced chicks as 1-day chicks, 4-month-old pullets and 5-month-old mature hens. This assumption includes farmers annually spending around KES 33,000 as inputs and around KES 6,000 for purchasing at 300 fertile eggs for incubation. Poultry will be an additional source of income for these farmers. It helps them improve their income in an organised manner compared to the irregular back-yard poultry they previously kept.

Notes	○ It is assumed that the primary non-energy cost is space for keeping the incubator which will be for free from the group member maintaining the incubator and solar system ○ The costs do not include internal wiring costs ◦ Battery replacement is required in 5 years- this is currently spread across the cash flow as a separate monthly cost

Back-up for grid-connected farmers' group cooperatives functioning as a hatchery		
Energy delivery system	Battery-only back up system for 170W peak demand and 3.86 kWh daily demand for poultry cooperatives that function as hatcheries that face maximum of 8-hour power shortage per day. Appliances: ○ Egg incubator for 300 eggs (160 W) for 24 hours daily ○ Lighting (10 W bulb) 1 to 2 hours daily	
Energy system costs	Capex: Energy system (batteries, controller and installation fee)	KES 116,650
	Capex: Appliance costs (incubator and LED bulb)	KES 55,850
	Opex (10%) of appliance costs	KES 92
	Battery replacement (in 5 years) as a monthly cost	KES 847
	Monthly payment for member managing and maintaining the system	KES 2,500
	Grid costs- monthly energy of 116 kWh (@23 KES/kWh tariff)	KES 2,663
Average monthly expenses (including costs and battery replacement savings)		KES 6,102

Average revenue of sales per month- egg incubation	KES 6,375
Net profit (monthly) for the cooperative	KES 2,73
Farmer income- same as above	
Notes	○ It is assumed that the primary non-energy cost is space for keeping the incubator which will be for free from the group member maintaining the incubator and solar system ○ The costs do not include internal wiring costs ○ Battery replacement is required in 5 years- this is currently spread across the cash flow as a separate monthly cost
Business model and financing for Option 3, 4	**Potential business model** ○ The aim of this business model is to ensure that poorer farmers can access incubators for hatching their eggs. This has been practiced in several donor funded projects, however had issues related to informal set up and management of the energy systems. ○ Already existing common interest farmer groups (with around 15 farmers each) require support to transform into more formal entities (eg cooperatives) and have capacity to manage the systems and their use effectively. One option is for a selected suitable member of the group to manage the incubator and provide incubation services to other members for a fee. And this member can be paid a service fee from the income generated. This requires capacity building on skills such as bookkeeping and good planning to ensure each farmer get an opportunity to incubate. Any additional net-profit can go into a table banking fund for the members' future needs, or maintenance of the systems. **Financing** ○ Capital costs: Contributions from the group members (for e.g. <50%) can come in equal amounts from the group members and additional support from a grant ○ For a hatchery which is a SME would require concessional finance to be able to finance the back-up options. ○ The 'Non-energy component/supporting services' section below discuss more on financing solutions.

Table 30 Electricity system options for poultry

Solutions: Dairy cattle farming

Target groups

- Individual farmers who are currently keeping dairy cattle
- Farmer groups registered as diary cooperatives
- Entrepreneurs (particularly youth) interested in starting local feed production and sales MSMEs

It should be noted that solution does not present a specific business model for keeping cattle and goat for meat. However, the principle of improving feed processing/preparation through use of chaffcutter to enhance feed consumption is valid for dairy and meal yield improvements of cattle and goat. While goats are used for milk supply, there is less data on market potential for goat milk. Therefore, this solution primarily focuses on improvement for dairy cattle.

Energy Component

- **Provision of reliable power for local feed processing using chaffcutters for small-scale dairy and goat farmers**

To achieve higher yield from livestock, it is essential to provide enough feed and fodder. As noted in the gaps section, there are several challenges in Kitui in sourcing suitable fodder for cattle and goat given climate challenges and competition for land with cash crops. It is common practice in Kitui to leave long un-chopped fodder and straws on the floor in front of animals. Often the animals only eat leafy portion and leave dry stems which ultimately end up as mulch. Experts highlight that practice appears wasteful, with almost 50% of the supply in this form going to waste. Cutting fodder into smaller pieces (chaffing the fodder) using a chaff cutter is often recognised as a good practice for increasing feed consumption and reduce wastage of feed resources. It is important that farmers receive sufficient livestock management advice and training on how to locally prepare the feed with the right mix of nutrients and on what locally available crop and residues are most suitable. This is discussed briefly under the non-energy components/supporting services section below.

Primary energy needs and appliances

- **Power for chaff cutters:** chaff cutters are available in the local market. While some can be operated manually, electric and petrol operated chaff cutters are commonly used in grid connected and off-grid or poor grid areas, respectively.

Key assumptions used

- It is assumed that the dairy farmers already own 2 dairy cows, have housing for the cows, hay burn for hay storage and other livestock handling equipment (eg hand pump for parasite spraying, warmers etc.). The main capital cost considered is the chaffcutter.
- Improving feed utilisation and provision of enough water can increase the dairy yield per cow from 4L/ day to around 15L/ day
- Assumed that only 70% of the milk produced will be sold and the remaining will be kept for household consumption and for the calf. The main target market is the local market at farm gate or through cooperatives.

Electric chaffcutters for grid connected dairy farmers keeping two dairy cows		
Energy delivery system	Electric Chaff cutters: o Electric motor 1.5KW, 240V and an Automatic Voltage Stabiliser (AVS) o Output of up to 500kg per hour ◦ Monthly usage (to produce 300kg of feed for 2 cows) is approximately 40 mins, which is a monthly demand of around 1kWh	
Energy system costs	Capex: electric chaff cutter and AVS	KES 68,000
	Maintenance costs: Regular greasing, gears replacement every 6 - 12 months, depending on usage.	KES 5,500
	Grid costs- monthly energy of 1 kWh (@23 KES/kWh tariff)	KES 23

Non-energy costs	Average monthly expenses on inputs (feed, water, vaccines, labour etc.)	KES 9,000
Credit/month for energy system and appliances	Monthly credit payment: ○ Loan taken by farmer for purchasing the chaff-cutter ◦ 30% interest rate over 3 years	KES 2,500
Average monthly expenses (including electricity costs)		KES 9,500
Average revenue of sales per month: sales of 70% of milk produced 10 months a year, heifers and manure		KES 34,200
Net profit (monthly)- First 3 years (including credit payment)		KES 22,300
Net profit (monthly)- year 4 onwards (without credit payment)		KES 24,700
Notes	○ A petrol driven generator up to 5kW in size (See below Option 6) could be used to power the electric motor as a grid back-up system. ○ Portable generators of varying quality are available in the market ranging from KES 25,000 to KES 75,000.	
Petrol chaffcutters for off-grid or poor grid dairy farmers keeping two dairy cows		
Energy delivery system	Petrol Chaff cutters ○ Petrol motor 4.5KW petrol engine size ○ Output of up to 500kg per hour ○ Fuel consumption of 1L/hour ◦ Monthly demand (to produce 300kg of feed for 2 cows) is approximately 40 mins, which is a monthly demand of around 1L of petrol	
Energy system costs	Capex: Petrol engine chaff cutter	KES 50,000
	Maintenance costs: Regular greasing, gears replacement every 6 - 12 months, depending on usage.	KES 5,500
	Engine maintenance every 3-6 months, replace oil & air filter	KES 833
	Petrol costs[59]- monthly energy of 1 kWh (@110 KES/ litre)	KES 73
Non-energy costs	Average monthly expenses on inputs (feed, water, vaccines, labour etc.)	KES 9,000
Credit/month for energy system and appliances	Monthly credit payment: ○ Loan taken by farmer for purchasing the chaffcutter ○ 30% interest rate over 3 years	KES 1,800
Average monthly expenses (including electricity costs)		KES 10,400
Average revenue of sales per month- Sales of 70% of milk produced 10 months a year, heifers and manure		KES 34,200
Net profit (monthly)- First 3 years (including credit payment)		KES 22,000
Net profit (monthly)- year 4 onwards (without credit payment)		KES 23,800

59 Petrol prices are from March 2020 in Nairobi. These vary monthly and by region as announced by the government.

Notes	
Business model & financing for Option 5, 6	**Potential business models** 1. Independent farm ownership of chaffcutters o It is likely that existing dairy farmers in Kitui are potentially wealthier and has enough space to accommodate dairy cattle. However, an income survey across the cattle keeping households needs to be carried out to understand this further. o The two solutions (5 & 6) above show that farmers with sufficient saving and capacity to take loans can own their own chaffcutter and make profit. In addition, they can process feed during wet season to meet demands for dry season. o Given that the chaffcutter will be used only 40 minutes a month to produce the 300 kg feed that 2 dairy cows require, the machine will be left idle for the rest of the time. Therefore, the farmer can use this as a business opportunity to produce extra feed for selling to other livestock farmers or renting the chaff cutter to other local livestock farmers. 2. Farmers' groups registered as cooperatives o For poorer farmers or those who start a keeping dairy cows newly, the above model is not viable due to high upfront costs. Therefore, individual adoption rate will be lower. o A sustainable model for reaching more farmers would be to establish farmers' groups who are registered as dairy cooperatives to purchase and manage a chaffcutter for its members at a low fee. 3. Entrepreneurs who own MSMEs o Independent entrepreneurs can set up MSMEs for feed production o MSMEs set up by youth could increase local feed production in Kitui. One such example is the Dairy Ventures Self Help Group in Meru County (Wambui, 2019): a youth run business for producing animal fodder for dairy farmers. They use a shredder instead of a chaff cutter as it provided the opportunity to shred mature fodder such as maize. The ten members of the group contributed made monthly savings in a SACCO and received grant support from an NGO to purchase the fodder shredder. The shredder is diesel powered and mobile and is being transported in the county and to other neighbouring counties. The group hires labour when needed and the dairy farmer pay for transport and the wages. Each group member also provides maize from their own farms for shredding and re-sell. **Financing** o Targeted subsidies and concessional finance would support independent farmers (particularly women), cooperatives and enterprises to purchase energy systems and the appliances needed. o The 'Non-energy component/supporting services' section below discuss more on financing solutions. **Future energy needs to consider**

	○ Dairy farmers as production and scale increase could invest in more innovative and efficient solutions such as solar milking appliances ○ As production increase dairy cooperatives or independent farmers may need support to purchase milk chillers. There is also the need for farmers to link better with dairy cooperatives.

Table 31: Electricity system options for dairy farmers

Next steps

It should be noted that, given the limited data and information, the above is a guide only. The following next steps are proposed to further validate and refine the solutions.

1. **Mapping of market for different livestock products:** a market mapping exercise should be carried out to validate the information above on the market availability and identify potential market channels for different livestock products. This would provide a basis for obtaining interest and buy-in from existing and new farmers for investing in energy systems to improve their production rates.
2. **Mapping of livestock farmers across the county and their level of energy us:** the livestock extension offices already have significant amount of data of different livestock farmers across the county. This data should be used to identify geographic locations of different types of livestock farmers, specific challenges unique to the different areas (for example access to grid, water, and market links) and capacity of the farmers to expand.
3. **Map target groups and identify their characteristics**: work closely with ongoing programme implementers such as KDC, Caritas Kitui to identify where ongoing programmes are carried out, functioning livestock cooperatives and data collected through baseline data collection activities. In addition, engage with local financiers and cooperatives to identify target groups based on their experience.
4. **Understand capacity and financing needs**: undertake awareness training and community engagement activities to identify livestock entrepreneurs, and specific financing and capacity gaps of entrepreneurs.
5. **Refine solutions and bundle/aggregate:** refine solution options 1-6 and develop financing options and detailed delivery models for target groups of farmers.

Non-energy components/supporting services

The key supporting services required are outlined and summarised as below. These additional supporting services and interventions to address non-energy gaps/barriers are also essential to deliver the outcome and maximize the impact and sustainability of the energy investments for livestock.

- **Improved access to clean water for livestock farmers**

  Access to clean water is critical for health and productivity of livestock. Livestock production requires significant amount of water throughout its value chain. The Kitui County Water and Sanitation Policy (2019) highlight that the water demand in livestock sector (not only limited to indigenous poultry, cattle and goats discussed in this CEP) will increase by three-fold in 2030 (from 5 million m^3 in 2019 to 15 million m^3 in 2030). Water use for livestock contributes to water depletion and pollution trends is high (ie water contamination by manure and waste) (IFAD, 2010). Access to clean water is also a community need that is cutting across multiple sectors (eg agriculture,

health, livestock, MSMEs), and same water sources are often used by multiple types of users. Careful planning of watering points, and designing solutions that aim to improve access to clean water, while minimising the impacts of the livestock sector on water resources require close collaboration between the key departments within Ministry of Agriculture, Water and Livestock, and other ministries such as MENR and Ministry of Health.

With livestock being a key income source for most of the people in Kitui it is critical that the Department for Agriculture and Livestock work closely with the Department for Water in establishing the key activities recognised in the Kitui County Water and Sanitation Policy (County Government of Kitui, 2019a). Interventions for improving water access also require inclusive approaches that encourage participation of communities in plans and strategies for managing livestock water resources. Some key interventions to prioritise in the immediate term include:

- Assessment of current and projected water demands for different types of livestock (eg dairy cows require significantly more water than beef cattle), versus water supply in the county.
- Identification of the different types of uses of existing water points and prioritise rehabilitation of those water points with multiple uses including livestock production (see Water Solution in Section 6:4).
- Mapping of potential water sources in marginal areas and areas that face extended droughts, and development of strategies for financing and developing reliable water sources in marginal areas for livestock use (feasibility studies, construction, monitoring, maintenance etc.)e.
- Assessment of the type of water conservation technologies/techniques suitable for livestock farmers, awareness raising and training on suitable water harvesting and conservation techniques.
- Training and capacity building for water management committees on better governance and management of water points, mitigating potential conflicts between different users and enhancing protection of water points.

- **Improving service provision in veterinary offices**

Improving access to veterinary services is important to ensure that diseases are prevented, controlled and treated in a timely manner- as poor healthcare of livestock result in mortality and low productivity with significant negative impacts on income of households depend on livestock for food and or consumption. The CIDP (2018) recognises the need for provision of veterinary services across the county. When implementing the interventions in the Kitui's CIDP, ADP and the CE, the Department of Agriculture and Livestock should give special attention to the status of veterinary service provision in the county and how improvements can be made:

- Conduct a survey across all County, Sub-County and Ward level veterinary stations to identify gaps in service provision compared to mandated services and develop strategy for financing and addressing these gaps. The survey should include analysing the demand for services in the veterinary centres and availability of qualified veterinary staff to provide services, availability of appliances and equipment for service delivery, power requirements and grid back-up options for electricity for veterinary centres in poor-grid areas. The demand survey should be analysed to identify strategies for reaching more remote farmers who are currently unable to access support in a timely manner (eg identifying private practitioners who can be mobilized to meet veterinary needs, purchase of motor-cycles for veterinary officers to travel to remote farms, provision of mobile phones to extension officers to link with farmers etc.).

- Increasing awareness on need for vaccine and medicine use, hygiene, and animal breeding among farmers for better uptake of veterinary services, and ensure farmers are aware of any additional costs for accessing veterinary support (eg transport costs for medicines and officers)
- Build capacity of local veterinary officers to conduct disease surveillance and reporting so that disease outbreaks can be controlled efficiently. Explore mobile phone technology applications for disease surveillance and reporting, and potential donor driven interventions (eg FAO, USAID etc.) to pilot in Kitui county).[60]

- **Improved farmer knowledge and skills on livestock management strategies, inputs, business skills**

Livestock extension officers who focus on specialist advice for livestock production are instrumental in ensuring famers receive the most appropriate advice on livestock management aspects. This advice often includes feed and nutrition requirements of livestock, knowledge on suppliers of various inputs and appliances that can improve production, appropriate action for drought preparedness. Some key action for addressing the current gaps in Kitui county around livestock extension services include:

- Undertake participatory needs assessments with groups of different livestock farmer groups at the sub-county level to understand their priority needs better- including household dynamics in livestock management, role of women and youth
- Capacity building programs for livestock extension officers and increasing number of livestock extension officers servicing the county, and provision of infrastructure such as motor bikes and mobile phones to reach more remote livestock farmers
- Undertake supplier mapping for inputs across the various livestock value chains, and collaboration with private sector suppliers and NGOs on training and capacity building for extension officers and farmers. One potential company to explore market opportunities and suitable business models for Kitui is Sidai[61-] (a company that supplies quality inputs, on-farm services and conduct business and technical training to farmers across Kenya through its networks of officers and distributors).
- Identifying effective cost-recovery strategies that can free public resources to provide livestock extension services for poorer livestock farmers (eg higher chargers for larger and more commercialised farmers, clustering of farmers in a specific area for training and support etc.)
- Develop crop-livestock integration strategies and business models where crop farmers can sell their produce as feed (eg cotton, sunflower seeds and maize are commonly used to meet nutrition needs of dairy cattle) and livestock farmers can sell manure to crop farmers.
- Explore potential for collaborating with veterinary staff and centres- information dissemination, use of veterinary centres for parallel support with separate extension staff etc.
- Identify demonstration projects, and support government training centres where farmers can 'learn by doing' and can see tangible results to increase adaption rates of technologies (eg egg incubators, chaffcutters etc.), while ensuring that lessons from past and ongoing projects are considered in design and implementation of these projects.[62] It is also important to engage with

60 For instance, FAO supports Kenya's animal health workforce to sharpen disease response skills. See: http://www.fao.org/kenya/news/detail-events/en/c/1073996/

61 Information from Sidai Company website: http://www.sidai.com/index.php

62 Some key examples include Poultry Production and Marketing Project (2013-2014); Accelerating Rural Women's Access to Markets and Trade in Nukuru and Kitui Counties (2012- 2017); Community Resilience and Climate Change Adaptation in Drought Affected Communities in Kitui, Tharaka Nithi and Embu Counties (2016- 2019), Agricultural Sector Development Support Programme Phase I & II (2017-2022)

organisations such as CARITAS Kitui, Kitui Development Centre (KDC) and Farm Africa who have previously implemented projects in Kitui.

- **Increasing women and youth participation and leadership in livestock businesses, producer organizations and farmers' groups.**

Project interventions must be designed to support and strengthen women's roles in the various livestock value chains. Given livestock businesses are often strongly integrated within households it is important to ensure that both women and men are included in engagement and training activities, and that improving women's role in decision making and income sharing from family-owned farms will not lead to unintended consequences within the households.

Surveys and needs assessments should collect data disaggregated by gender to understand women's roles and responsibilities in the family- particularly in indigenous poultry production where women do not often have ownership of poultry and access to income, although they manage production, marketing and sales of the poultry enterprise. It is important to link with local community-based organisations who have strong networks with women's groups such as Grassroots Organizations Operating Together in Sisterhood (GROOTS) and programmes such as Agricultural Sector Development Support Programme Phase II (ASDSP II, 2017-2022) (County Government of Kitui, 2019b) which looks closely at role of women in indigenous poultry value chain.

In addition, farmers will benefit from interventions that can build business skills which is discussed in detail under the MSME section below.

- **Improved knowledge on markets and supporting farmer link with reliable and fair market channels**

Identifying specific market linkages throughout the value chains for different types of livestock produce requires a dedicated and comprehensive study. Some projects have already started addressing market barriers and strengthening market systems in Kitui working with both private and public sector actors, across various agriculture value chains. Linking with these existing programmes will contribute significantly to the success and the sustainability of the energy solutions presented in this CEP and identifying what further interventions are needed. Two key interventions are:

- The Kenya Crops and Dairy Market Systems Activity (KCDMS) (2017- 2022) is 5-year project funded by UNSAID under its Kenya Feed the Future programme- currently working on strengthening dairy, fodder/feeds, indigenous poultry and horticulture value chains in multiple counties including Kitui (USAID, 2021). This will have direct contributions to the poultry and dairy solutions presented in the CEP.
- National Agricultural and Rural Inclusive Growth (NARIG) (2016 -2021) is a World Bank funded project in multiple counties including Kitui which aims to link farmers or farmers groups across priority value chains to markets. Poultry is one of the priority value chains being assessed in Kitui under the NARIG programme (The World Bank,

Based on community and stakeholder discussions, and review of key report son livestock markets in Kitui (Mwende & Bosma, 2019), some key interventions to consider in terms of market building include:

- Addressing capacity gaps within the County Government to understand markets for priority livestock produce. This includes working closely with existing programmes and understanding the market dynamics better. Assessment should include identifying the different market stakeholders, times at which price fluctuations happens and the contributing factors for that, proximity of

livestock markets and slaughterhouses to the farmers or farmers groups, market dynamics (eg who dictates the market and who makes profits), traders outside the county and points and challenges faced by farmers and other actors in the value chain.

- Promoting organised farmers ground registered as cooperatives for production or as collection centres and establishing quality control measures can help farmers or farmers groups to have higher value for their livestock produce. This includes identifying needs of these cooperatives and equipping them appropriately (eg dairy chillers, egg incubators, reliable power sources, administrative equipment, ICTs etc.). Interventions in Kitui led by GROOTS and KDC show that working with farmer groups for improving production quality and sales through aggregation in the indigenous poultry sector has helped farmers link with buyers who pay much higher prices compared to local markets.
- Identifying and improving established cooperatives and other value chain players is also important to build trust among farmers for increasing aggregation among them. For instance, according to livestock experts Kitui has 4 known dairy cooperatives -63 of which 3 are with milk chillers, but face grid reliability issues to power the chillers continuously. Similarly, abattoirs would need appropriate appliances for processing and storage as the production increase. Some existing poultry cooperatives such as KICOPO and Nguku already have strong market links and have established business models among the farmers which would need further analyses to identify potential for replication.
- Business model. Members and non-member bring their milk daily and the cooperative manage the cold chain and then resell the milk within the urban areas.

- **Improved farmer knowledge and access to inclusive financing options for maintaining business and expanding business**

Most livestock farmer in Kitui access limited amounts of financing through family sources. Improving livestock farmers' access to finance require dedicated support through training- MSME Solution below presents several intervention ideas on how to attract funding for addressing financing needs of MSMEs. In addition to this several specific activities to consider for livestock farmers include:

- Understanding the financing needs of livestock farmers and the ability to access different types of finance available - particularly needs and ability of women and youth engaged in the livestock value chain.
- Identifying and linking with existing Village Savings and Loans Associations (VSLAs) and Savings and Credit Cooperative Societies (SACCOs) to extend their memberships to marginalised farmers. This would require interventions that incentivise existing SACCCOs and VSLAs to increase their reach, and interventions that encourage livestock farmers to join these VSLAs and SACCOs.
- Training support targeting marginalised farmers with similar interests to set up more informal saving groups such as VSLAs. These training can focus on setting up the group's governing structure, identifying reasonable minimum savings amounts or membership fees that each member can save regularly, financial education to identify the suitable interest rate for the specific group etc. The KCDMS programme aims to strengthen the crop and dairy VSLAs in Kitui and other counties by providing VSLA members and farmer groups with financial education and entrepreneurship training with the aim of strengthening their business and raising funds that address specific needs of the farmers groups or cooperatives (CARE, 2014).
- Linking with financial institution like Agricultural Finance Cooperation, Cooperative Bank and Equity Bank who have shown greater interest in livestock enterprises. For instance, together

63 1. Kyangwithya Cooperative in Kitui Central sub county; 2. Mutonguni dairy cooperative in Kitui West sub county; 3. Chuluni dairy at Kitui East sub county; and 4. Matinyani cooperative society

with GROOTS Equity Bank Kitui branch has been implementing a World Bank seed fund to support livelihoods of rural women engaged in poultry and agribusiness in Kitui (Onwong'a, 2019).

- Building farmer awareness on insurance, and linking farmers with appropriate financiers to access insurance packages against crop failures, climate impacts or market volatilities
- Linking livestock solutions to targeted interventions such as the Partnership and Innovation Fund (PIF) under the KCDMSD programme in multiple counties including Kitui. The Fund provides grants to establish youth driven enterprises or groups, and activities let by various actors to support women and youth in the target value chains.[64]

Key non-energy/supporting services components

Supporting services	Potential delivery partners/existing initiatives
Improved access to clean water for livestock farmers	○ Department of Water and Sanitation ○ Kitui County Water and Sanitation Policy (2019); Kitui County Hybridisation plans for water points ○ Water Services Regulation Board (WASREB) ○ County WASH Coordination (WASHCOORD) Forum and Technical Committee
Improving service provision in veterinary offices	○ Department of Agriculture and Livestock ○ County, Sub-County and Ward level veterinary stations ○ Support to animal health workers across Kenya by agencies such as FAO and USAID ○ Private veterinary service providers (eg local practitioners)
Improved farmer knowledge and skills on livestock management strategies, inputs, business skills, and ensuing women and youth participation in such interventions	○ Department of Agriculture and Livestock ○ Private sector companies (eg Sidai) ○ Livestock programme implementation agencies, such as CARITAS Kitui, Kitui Development Centre (KDC) and Farm Africa ○ GROOTS Kitui ○ Programmes: Poultry Production and Marketing Project (2013-2014); Accelerating Rural Women's Access to Markets and Trade in Nukuru and Kitui Counties (2012- 2017); Community Resilience and Climate Change Adaptation in Drought Affected Communities in Kitui, Tharaka Nithi and Embu Counties (2016- 2019), Agricultural Sector Development Support Programme Phase I & II (2017-2022)

64 Feed the Future Kenya Crops and Dairy Market Systems. See: https://www.agrilinks.org/activities/feed-future-kenya-crops-and-dairy-market-systems

Improved knowledge on markets and supporting farmer link with reliable and fair market channels	○ Kenya Crops and Dairy Market Systems Activity (KCDMS) (2017- 2022)- USAID ○ National Agricultural and Rural Inclusive Growth (NARIG) (2016 -2021)- World Bank
The Improved farmer knowledge and access to inclusive financing options for maintaining business and expanding business	KCDMS programme aims to improve agricultural opportunities for smallholder farmers, youth, and women, through agricultural market: led savings and lending by strengthening the capacities of VSLAs.

Table 32: Non-energy supporting services and potential delivery partners

1.38 Solution 6: Micro, Small and Medium Enterprises (MSMEs) -Improved business capacities to deliver quality products and services for communities in remote and poorly served areas, and increased revenue of existing MSMEs

Summary of problem and solution

The objective is to strengthen MSME's ability to source and deliver quality products and services, especially for remote or poorly served communities. When implemented, the solution will address the following barriers or gaps:

- **Electricity:** Lack of reliable electricity services for both on-grid and off-grid MSMEs, and limited access to efficient appliances/equipment
- **Skills and knowledge:** Lack of supporting services including enterprise linkages along value chains, business management and financial skills, and enterprise financing.

These solutions first aim for more reliable access to electricity, and then a programme of capacity building for technical and business skills that will also establish linkages different actors along the value chains, followed by mentoring, specifically for MSMEs in rural areas, to maximise the impact and sustainability of the energy and training investments, while building demand for the energy solutions.

The solution includes the following:

Energy components

- **Strengthen energy access** through (1) affordable solutions for targeted MSMEs; (2) lobbying and engaging KPLC to proactively engage with and prioritise MSME needs; and (3) extending the distribution channel reach for quality off-grid energy systems and ultra-high efficiency appliances

Non-energy supporting services

- **Comprehensive MSME training programme** that provides (1) better linkages and networking along the value chains, between businesses, and to customers; (2) basic business skills and business finance training and mentorship to apply skills learned in basic business trainings into real world; and a (3) network of 'champions' to demonstrate and showcase new skills and equipment.

What problem is the solution addressing?

According to KNBS (2016), Kitui County has a total of 88,200 micro, small, and medium enterprises (MSMEs). Of these, 16,700 are licensed MSMEs (split Micro 97.5% and Small 2.5%),[65] while the majority (71,500 MSMEs) are unlicensed. This means that most MSMEs are operating outside of government structures, while not consistently contributing mandated taxes and fees, and unable to access many types of finance. Important to note is that Kenya is 56th in the world in the 2019 World Bank's *Ease of doing business rankings* (The World Bank, 2019a), gaining rank significantly in the last decade. Sub-national data is available for 11 counties but unfortunately Kitui is not one that has data available. Higher business formality and gender equality are characteristics of countries that ranked higher on the World Bank's 'Ease of Doing Business' metrics (The World Bank, 2014).

65 KNBS defines the size of enterprises by numbers of employees: micro (1 to 9 employees), small (10 to 49 employees), medium (50 to 99 employees).

In Kenya, like countries around the world, MSMEs have highlighted that appropriate and tailored finance is difficult to access (Kasule et al., 2016). Most MSMEs in Kitui also operate outside supporting business infrastructure and services. For example, in the survey sample (KNBS, 2016),[66] only 9% of MSMEs belong to an Association, and only 18% use mobile money. Indeed, even most licensed MSMEs do not have contracts for their goods and services with neither distributors nor customers. Contracts can allow for better planning and cash flows and support business growth. A 2015 UNDP study suggested that the MSMEs interviewed in Kitui saw several deterrents to regularizing their businesses: perceptions of complex tax regimes, perceptions of non-harmonised laws between county and national level, and perceptions of unfair labour laws (Wairimu, 2015). However, the same study suggests that those same MSMEs in Kitui lack clear understanding of government policies and processes. This could simply show a need for MSMEs to have better access to public policies and general business knowledge. In addition, Kenya has substantially increased its standing in the ease of doing business metrics since this study was published, suggesting that business processes are getting clearer and easier to follow.

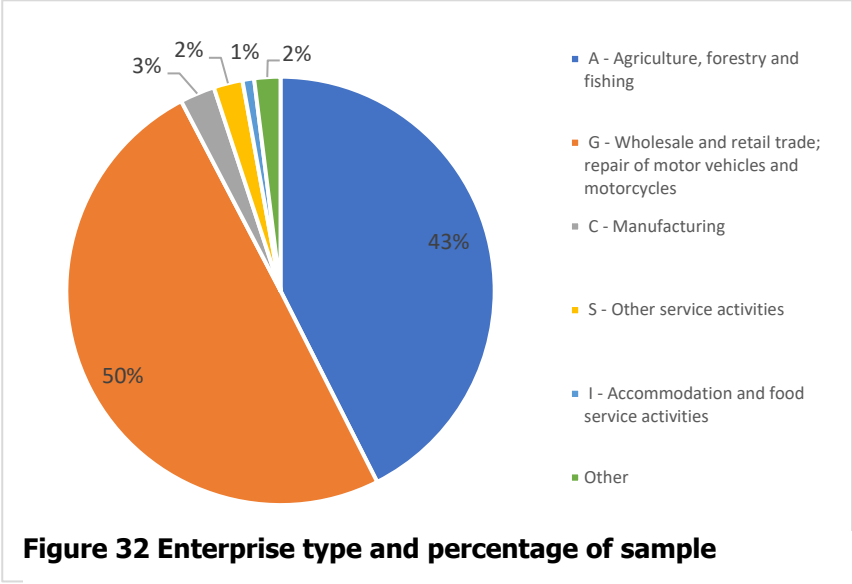


Figure 32 Enterprise type and percentage of sample

Figure 32 shows that, of this sample size, 93% are categorised under the International Sustainability and Carbon Certification (ISCC) as 'A - Agriculture, forestry and fishing' or 'G - Wholesale and retail trade; repair of motor vehicles and motorcycles'. In other words, most MSMEs in Kitui are engaged in agriculture and general trade. As far as ownership, male and female owners are roughly split at 41% and co-male and female owners are at 17%.

MSMEs in Kitui generally face a variety of business constraints. 15% of the MSMEs felt that poor roads and transport was the biggest challenge, and 13% further stated that the related challenge of market access was their biggest constraint. Logistical challenges can delay business deliveries and reduce revenues. Interestingly, 12% cited local competition as the biggest challenge to their businesses, which may reveal levels of distrust between entrepreneurs. 11% struggled with finance issues (customer debt, inadequate capital, and debt). 24% of MSMEs cited various other individual yet interrelated constraints (eg customer frequency, poor security, shortage of stock, interference from authorities, and so on).

MSMEs do not keep books to monitor their transactions and financial records, mostly because entrepreneurs perceive that there are no benefits in doing so. Security is an issue for energy systems

66 KNBS interviewed a total of 454 Kitui MSMEs. Some Kitui specific, and statistically significant data is available in the report, but only for select variables. While the data itself is publicly available, statistically significant data analysis for more variables in the Kitui dataset would require more resources for full analysis. For the purposes of this solutioning, the sample size of 454 MSMEs is considered reasonable to understand some of the issues facing MSMEs in Kitui for the purposes of this analysis.

and other parts of the business including equipment, supplies and inputs. There needs to be a deeper understanding around issues such as theft to design appropriate mitigation actions.

Many MSMEs in Kitui County struggle with interrelated problems that must be addressed with a comprehensive set of solutions. The solutions presented in the CEP aim to address many of the challenges outlined below by strengthening the resilience of MSME value chains, while leveraging energy access to enable better MSME services. Figure shows the challenges highlighted by MSMEs in the KNBS 2016 MSME Survey.

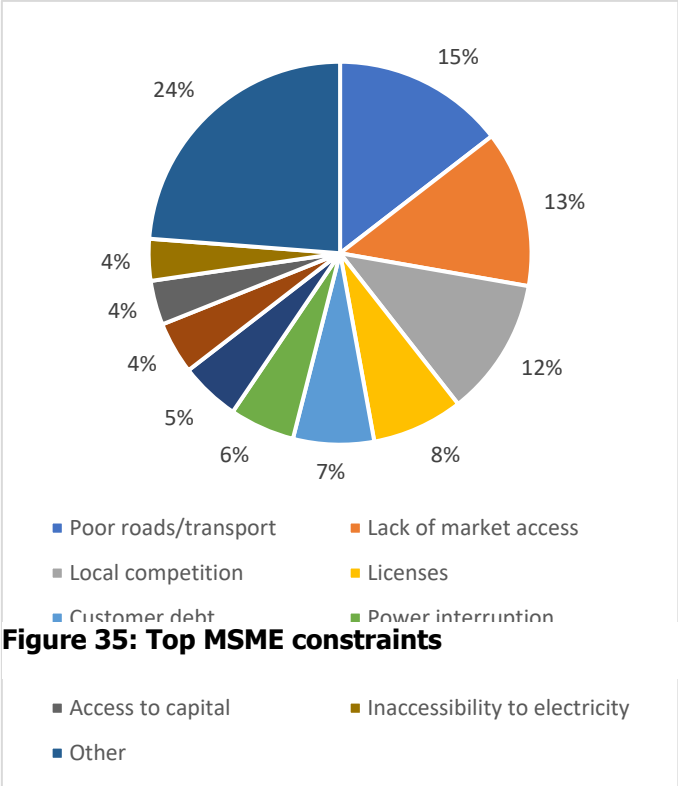


Figure 35: Top MSME constraints

Energy gaps/barriers

- **Lack of reliable electricity for MSMEs to use to deliver better products and services to communities**

Around 10% of MSMEs surveyed see electricity as the major constraint facing their enterprises. Specifically, 6% see 'power interruption', presumedly from the grid, as the major constraint and another 4% see 'inaccessibility to electricity' as the major constraint, which may include off-grid areas but also premises that are close to grid infrastructure. Important to note is that 38% of these enterprises are not connected to electricity and they may not understand the potential for electricity in enabling their service or product offerings for enhancing productivity or profitability. Consequently, these numbers may represent an underreporting of electricity as an issue for MSMEs. The MSME participants of workshops carried out as part of the methodology for developing this CEP highlighted electricity constraints to their enterprises, they framed in terms of reliability, access, and affordability.

- **Challenges in accessing appliances, especially high efficiency appliances**

Ninety-one percent of MSMEs surveyed source electrically operated equipment from other MSMEs. Consequently, the equipment is probably more expensive and perhaps less reliable and/or of lower build quality than if they were sourced from a larger, known distributor of equipment. While distributors can offer warranties on equipment, an important component of increasing uptake, smaller MSMEs usually are unable to do so due to the additional costs, expertise, and supply chain linkages needed. In addition, equipment typically found in rural communities is usually older, using less efficient and outdated designs and internal components. High efficiency appliances can reduce electricity generation requirements for off-grid electricity systems and thus reduce complexity and costs for these systems. For grid applications, higher efficiency appliances can reduce equipment running costs, while at the aggregate level also reducing demand on the overall grid, which can simultaneously increase grid services to other MSMEs across the grid. This would also be of interest to KPLC in managing grid services.

Key non-energy gaps

- **Limited access to suppliers and markets**

Fifteen of the MSMEs surveyed (the highest percentage of the population sample) cited 'poor roads and transport' as the main constraint for MSMEs in Kitui, while 13% report that a lack of access to markets is the major constraint facing their enterprises. 70% of respondents stated that the road to access their enterprise is in 'bad' condition. MSMEs in rural areas face additional logistics challenges and costs. Moreover, only 7% of surveyed MSMEs have contracts in place for goods and services for their clients and for their suppliers. Enforceable contracts between MSMEs can allow better planning along value chains and for cash flow purposes. Strengthening linkages along value chains formally (contracts) and informally (networks) can help reduce MSMEs costs and increase efficiencies.

Kitui County already has an online portal to register businesses[67], which is a big step forward in mainstreaming the process, but reportedly is running a bit slow. EDM workshop participants highlighted challenges around registration, but this could be related to the general lack of understanding of how government policies and processes work, or a lack of knowledge on using the online process. 8% of MSMEs surveyed stated that 'licenses' were a major constraint to their enterprises. Anecdotally, licensed businesses have better trust and standing within communities, can attract more customers and profit, and can grow as a result.

- **Limited finance and business skills inherent in MSMEs**

Forty-seven percent of surveyed MSMEs cited 'management' as a top training competency that needed strengthening. Business counselling and technical advice both were reported at 11% respectively. Across types of MSMEs, most agree that training would help increase enterprise efficiency and abilities to compete. Indeed, 12% of surveyed MSMEs reported 'local competition' as a main constraint to their enterprises, which was reinforced from EDM workshop participants' comments. This highlights issues of trust between MSMEs, especially between those of the same MSME type, which reduces opportunities such as costs savings in aggregating MSME demand for appliances and goods in the distribution chain.

Poor transport infrastructure and linkages constrain goods and services. Without better market linkages, local markets are easily saturated by similar products and goods, which increases competition and corrupt practices to gain an 'edge' over the competition (Wairimu, 2015).

67 The Kenya Tarde Portal, County Licenses (https://kenyatradeportal.go.ke/counties/licenses/p/field_county_value/Kitui) shows no information available for Kitui County, while other counties have licensing fees and other information available.

Only 5% of MSMEs surveyed spent resources on marketing activities. Marketing is important to differentiate from other MSMEs, build a positive reputation, and to attract new customers as well as attract and solidify relationships within value chains. Beyond skills enhancement, most MSMEs surveyed have mobile connectivity, but only 18% use mobile money in their enterprise. Mobile money platforms offer efficiency and automation gains by giving valuable information to entrepreneurs about sales and cash flows.

1. Limited access to appropriate financing

EDM workshop participants highlighted a lack of access to banking services and affordable credit, such as working capital for inputs, as major gaps across MSME types. Additionally, many MSMEs provide customers with credit to purchase their products or services. However, 7% of surveyed MSMEs cited customer debt as a major constraint to enterprises, which reduces MSMEs capital availability for restocking, investment, and profit. Also, 4% highlighted access to capital as a major constraint. In general, studies and reports highlight financial constraints as major and recurring issues across MSME types and locations in Kenya and across countries globally, so this finding is not surprising.

Solutions

Targets: low and high powered MSMEs in rural and peri-urban areas

Energy component

An MSME's choice of energy system depends on many factors such as business location, sales track record, years in business, and so on. Assuming access to quality components and installation, MSMEs that show consistent revenue generation and manageable business input costs could pay back an energy system loan with 20% interest within a 36-month tenor for most of the energy options listed in. As shown in the table below. low-powered MSMEs are particularly well placed to acquire solar-powered energy systems to meet their needs. An incremental approach to purchasing energy systems may be best for MSMEs with lower profit margins, whereby MSMEs move through modular energy systems as their ability to generate revenue increases.

MSMEs within 600m of a transformer would benefit from subsidised connection fees and tariffs that KPLC offer under the Last Mile Connectivity Project (LMCP). Coupled with a battery-back up system, MSMEs could manage loan payments over a 36-month period. Adding solar panels for full autonomy from the grid allows for maximising profits in the long term. However, for MSMEs with highly variable revenues and costs, it may be best to choose the lower cost option in the short term, which in most cases is the grid, even with its reliability and quality issues. Solar panels can be added later in properly designed systems. Higher powered MSMEs choices are more limited due to their power requirements (see below).

The training and mentorship programme in section 'non-energy component/supporting services should package bank financial products with reputable energy delivery company systems and appliance companies to MSMEs that fit the programme criteria. This will help simplify, streamline, and popularise energy options for MSMEs.

Power Category	MSME Type	Appliances	Rural Options		Rural/Peri-urban options	Urban/Peri-Urban Options	
			Option I - Generator	Option II: Solar stand-alone	Option V: Mini grid	Option III: Grid-tied backup	Option IV - Grid

Low-powered	ICT Centres	3 desktop computers 3-in-1 printer/ copier/ scanner Laminator	**20,000 KES** 1 kVA petrol Generator	**97,300 KES** One - 100Ah battery 1000W Invertor 13A Charge Controller Two - 150W panels	**15,000 KES** Subsidized connection fee **84.2 KES/kWh Tariff**	**79,300 KES** One - 100Ah battery 1000W Invertor 13A Charge Controller	**15,000 KES** Subsidized connection fee and **10.9 KES/kWh Tariff**
	Salon Barbershop	Handheld hair dryer Standing hair dryer Hair clippers Hair clippers	**50,000 KES** 1 kVA petrol Generator	**374,500 KES** Four - 200Ah batteries 5000W Invertor 30A Charge Controller Six: 200W panels	**15,000 KES** Subsidized connection fee **84.2 KES/kWh Tariff**	**300,500 KES** Four - 200Ah batteries 5000W Invertor 30A Charge Controller	
High-powered	Metalworking	Welding machine	**142,000 KES** 5KVA petrol welding generator	*Not technically or financially viable at the moment.*	**15,000 KES** Subsidized connection fee **84.2 KES/kWh Tariff**	*Not technically or financially viable at the moment.*	
		Air compressor Angle grinder	**52,000 KES** 6KVA petrol generator				
	Woodworking	Wood lathe Table saw Jigsaw Wood sander	**111,000 KES** 4.2KVA diesel generator		**15,000 KES** Subsidized connection fee **84.2 KES/kWh Tariff**		
	Posho mill	Milling machine	**87,780 KES** 7.5 kW (10HP)		**15,000 KES** Subsidized connection fee **84.2 KES/kWh Tariff**		

Table 33 MSME Energy System Options

It is important to note that some of the energy needs of low powered MSME in off-grid or poor-grid areas (eg groceries and tailors who require lighting solutions to function after dark) will benefit from SHSs that are available in the market. See Lighting Solution which present off-the shelf SHS options available in Kenya with different levels of size, appliance suitability and duration of use.

Low-powered MSMEs

ICT Centres and Salons will benefit most in the long-term in an investment in stand-alone solar power systems. While the upfront costs are highest and necessitate a larger loan, high-quality stand-alone systems do not have down time or monthly electricity consumption costs associated with generators, mini grids and the grid. Once the loan is paid off, components (batteries, invertors, and charge controllers) would need to be replaced at different intervals and would require further loans or careful management of cash reserves. ICT Centres and Salons near the grid could lower costs by purchasing a back-up battery system with a grid connection. If designed correctly, solar panels can be added later to the battery backup systems to increase autonomy from the grid. General trading MSMEs with particularly low power requirements would benefit most from solar home systems described in the lighting solutions of this report (GOGLA, 2019).

High-powered MSMEs

MSMEs that require larger equipment such as milling, and welding machines have fewer options for energy sources because of the greater power requirements of such equipment. Solar stand-alone systems are currently not well placed for Agri-processing equipment, but the sector is working to technically adapt solar power for certain equipment (Efficiency for Access, 2020).[68] Therefore, generators, mini grids, and the grid are the only viable options for these higher powered MSMEs. Mini grids often offer better reliability than grids, but also can have much higher tariffs. Additionally, mini grids with smaller generation capacities (approximately below 50kW, which are usually solar powered) cannot absorb the larger start up requirements of these pieces of equipment. Generators are a good option as the supply infrastructure to maintain and repair them are in place, but petrol and diesel shortages can hurt business revenues.

Next steps

1. **Map supply and distribution of energy systems in Kitui working with Kenya Renewable Energy Association (KEREA): KEREA** is an independent non-profit association dedicated to facilitating the growth and development of renewable energy business in Kenya.[69] Identify availability of different types of MSME energy systems, how MSMEs currently procure off-grid electricity systems, quality control mechanisms, and after-sales services.
2. **Engage with potential energy suppliers and installers:** this includes distributors and engineering, procurement, construction, and commissioning (EPCC) companies. The aim is to understand their products, services, requirements, and available incentives for MSMEs across the sub-counties in Kitui County. (See the section below on non-energy component/supporting services to see how this programme aims to better link supply and value chains) It will be important to popularise KPLC connection terms (how to connect, connection timeline, service level agreements, quality of power, etc).
3. **Aggregate MSME demand for energy systems:** work with MSMEs in communities to aggregate demand for off-grid products and services to enable companies to expand their reach more quickly, streamline offerings, and reduce costs. This will include better understanding demands for different types of MSMEs. A good way to achieve this is through the training support listed in section 'non-energy component/supporting services.

4. **Enabling environment:** this includes as a priority lobbying and engaging KPLC to proactively engage with and prioritise MSME needs through the Kitui County Government, Chamber of

68 Efficiency for Access, CLASP, Energy 4 Impact, and others are working on the technical end of solar-powered milling machines, but the capabilities of current iterations do not meet the needs of the Kenyan market, where customer preference is for more finely milled products.
69 Kenya Renewable Energy Association (KEREA).

Commerce, Council of Governors, business associations, and other institutes that hold influence in Kitui County and can engage with KPLC and any other Independent Power Providers (IPPs). As part of the training and mentoring programme in section 'non-energy component/supporting services', the curriculum should incorporate modules on increasing awareness of energy systems and advocacy activities.

It is important to note is that men are more likely to own businesses that require higher amounts of energy (high-powered MSMEs), so any additional provision of energy services is likely to benefit men more than women entrepreneurs by default (University of Oslo et al., 2019). Consequently, implementation of any energy access activities must be careful not to reinforce existing power dynamics. Programmes should seek out women entrepreneurs to identify barriers and priorities and programme design should incorporate ways to break down barriers and meet priorities. Also, a programme must identify barriers that women face to participate in such a programme (which may be different from men) and find ways to reduce those barriers to increase women's ability to participate.

Additional steps for improving the (perceived) reliability of power to grid-connected MSME

5. **Map structures within the county to support collaboration** with KPLC and REA on issues such as transformer breakdowns, delays in reconnection, relaying information on how to get connected, appropriate tariff setting with the regulator, and so on.
6. **Identify and plan for alternative energy sources:** verify the cost, suppliers, financing options for alternatives such as solar-powered inverter systems, solar standalone systems for smaller shops, to act as backup or alternative for the grid (See initial costs in **Error! Reference source not found.**, this will be done in *Step A* above Energy solutions for MSMEs).
7. **Increase awareness of energy delivery services:** Through the programme outlined below in relation to non-energy component/supporting services, increase community awareness of KPLC and REA programmes (such as LMCP) and other energy solutions.
8. **Encourage and popularise membership in business associations:**[70] this would be an integral part of the MSME training and mentor programs to aggregate demand and increase advocacy efforts collectively around energy access.
9. **Work with KPLC to better plan and communicate power outages**: Kitui County Government should work with KPLC to consult communities on outage timings and best methods and mediums of communication for consideration into better planned outages.[71] KPLC should be included in training programmes to participate and understand MSMEs constraints and to facilitate discussions around energy systems.

Additional steps for enhancing distribution channel reach for quality off-grid energy systems and ultra-high efficiency appliances

An important part of designing energy systems is the total electrical load required by the MSME. MSMEs often only have access to older equipment that requires greater amounts of power. High efficiency appliances can reduce energy demands and reduce overall energy system costs. It may be that some

70 In a sample of 456 MSMEs only 41 of 456 MSMEs report being members of an association and only 10 report being members of the Chamber of Commerce)

71 Based on IIED's experience in Tanzania with ESMI and 'Better Power' programmes, this type of engagement benefits both communities and the utility as it allows them to reach common ground on energy delivery issues and limitations. Better communication also allows MSMEs to better plan production around outages.

MSMEs need to invest more in higher efficiency appliances to reduce their lifetime energy system costs, and avoid the need to oversize energy systems, which adds complexity and cost.

10. **Map the distribution chain of high efficiency appliances:** Understanding linkages, efficiencies, and incentives in distribution chains. Look for links with the Kenya Bureau of Standards and global programs such as Efficiency for Access, and look for aggregation opportunities through supporting institutes like business associations or link to procurement large programmes or projects such as KOSAP to leverage cost savings through aggregation
11. **Link efficient appliance suppliers with retail outlets and local agents:** The Energy Change Lab in Tanzania had success in building up relationships between actors in rural distribution chains by acting as a trusted third party. It is possible that this success could be replicated in Kenya. There may be opportunity to build on KEREA's previous work of certifying actors along the energy access supply chain to ensure that only high-quality products and services, including crucial after-sales services, reached customers. This work also had a centralised hotline that consumers could access for information on certified agents and resellers in their area.
12. See 4(b) for **linkages to other sectors**

Non-energy component/supporting services

- **Comprehensive MSME training programme that provides (1) better linkages and networking along the value chains, between businesses, and to customers; and (2) basic business skills and business**

The key supporting services required to bolster and expand MSMEs are varied across individual entrepreneurs, men and women, as well as sizes, types and locations of MSMEs. However, in general MSMEs benefit from improved market linkages along value chains, strengthened business and technical skills, links to appropriate financing, moving towards formalisation such as securing licenses and membership in business associations, and promoting graduates or 'Champions' from training programs as paragons and mentoring them in their stores.

Figure 33 A comprehensive training structure

As proposed, a lean but comprehensive skills development and market linkages programme would train selected clusters of MSMEs across Kiuti on essential skills, coupled with a mentorship programme to help entrepreneurs retain and apply the skills in their individual enterprises. Evidence shows that trainings are only effective in the long-term if followed up with coaching or mentoring (Robb et al., 2014). The programme should be built to respond to the complexity of needs that differ across communities, individuals, men and women.

There is mixed evidence on the effectiveness of trainings that target technical and financial business skills. A programme around Nairobi has indicated positive benefits from a basket of business training, mentorship, and market linkages (see Figure 33) for MSMEs (Waweru, 2019). Other evidence indicates that it is more effective to teach entrepreneurial skills, using psychological mechanisms that enhance personal initiative rather than targeting business skills. Instead of targeting specific technical or financial hard skills, the focus should be on sharpening entrepreneurs' ability to differentiate their business, anticipate issues, strengthen resilience, and plan and prepare long-term better (Campos et al., 2017; Smith & Shankar 2015).[72] Building these skillsets will establish more demand for energy services. Evidence shows that it is important to build demand for energy services as energy access initiatives are rolled out (see Box 1).

Box 1 - The importance of building electricity demand

IIED's research shows that demand for electricity does not necessarily grow organically in communities with energy access, which threatens the sustainability of energy systems. Implementing activities that build demand is crucial for expanding access, including grid and off-grid, which typically face similar challenges where demand does not grow organically. Through the Energy Change Lab, IIED has implemented productive uses of energy activities that show promise around generating community demand. This includes trainings and follow up support for productive uses of energy (PUE), a network of PUE Champions to help in raising community awareness, cinema nights that showcase technical skills, and demonstration of various appliances where community members can watch and ask questions. Community members gave positive feedback and partner organisations have adopted the activities.

Countries with stronger MSME sectors often have two important factors: low levels of informality and wider gender inclusion. Consequently, any training and mentoring programme should build best practice for promoting a gender balance into the design and implementation of activities, such as targeting women entrepreneurs as participants (and removing the barriers to their participation in trainings) and designing modules and mentorships that seek to reduce the additional barriers to success that women typically face. The programme should use women facilitators and mentors as much as possible. There are a high number of female-owned businesses in the KNBS survey, but a comprehensive programme should specifically consider and account for the needs of female entrepreneurs. Also, the programme should seek to formalise MSMEs through licensing, associations, and financing.

Evidence from Tanzania shows the importance of a mix of approaches to build community demand for energy such as: providing examples, demonstrations, and practical learning opportunities. Materials should be produced in communities' 'mother tongue' with examples and practicalities that are relatable to the contexts (Johnstone et al., 2019). Linkages along value chains and between businesses are

[72] Campos et al. (2017) define personal initiative "as a self-starting, future-oriented, and persistent proactive mindset. Such a mindset implies a readiness to act as a result of cognitive, affective, and motivational orientation and organization that is in tune with solving entrepreneurial challenges."

important. This programme should aim to build collaboration and market information sharing between parties.

In general, government's role to support MSMEs should be limited to creating and nurturing space for MSME financing, as well as fostering business registration, access to finance, and accommodative tax policies (Robb et al., 2014).

As shown in the Table below, each training would be about three hours long to cater to entrepreneurs' tight schedules and availability and be spread across 12 sessions. The trainings could be compressed into four weeks or spread across 12 weeks depending on entrepreneur preferences and needs. Economies of scale could be leveraged if expanding the programmes, and synergies found in aggregating training costs. There are further cost savings if leveraging technology to supplement mentoring visits and/or training. Further cost-savings or funding could be leveraged by using university or polytechnic student facilitators, and sponsorships from banks, MFIs, or business associations. The costs of facilitation are based on the Chamber of Commerce's cited costs, with additional data collection, project design, and 20% overhead cost assumptions.

It should be noted that, given the limited data and information, the above is a guide only. The following is also needed to further validate and optimise the proposed energy components and the non-energy supporting services components of the solution.

1. **Undertake data collection and analysis to identify MSME energy needs and supporting service needs:** this includes enhanced analysis of the Kitui data from MSME Kenya Survey 2016, working closely with the Ministry of Trade and Chamber of Commerce representatives in Kitui. In addition, more data can be collected for a sample size of MSMEs in rural and peri-urban areas in Kitui to better target the energy component (grid or off-grid) and the comprehensive training programme.
2. **Engage with Department of Agriculture and Livestock to** map MSMEs in the livestock and agriculture sector and their energy and training needs.
3. **Optimise and bundle/aggregate the solutions**, including and developing financing options and detailed delivery models for targeted MSMEs.
4. **Gather more detailed information from MSMEs**: to provide a targeted Kitui MSME programme, more data on specific MSME types and locations are needed to select, optimise, and cluster the training sessions, mentorship, and identify market linkages, which would be gathered in the inception phase of the programme. Data is also needed for MSME needs, constraints, priorities and so on, which will be used to tailor the curriculum, training methods, and mentorship activities appropriately.
5. **Design programme, implement, and iterate.** The programme uses phases to 'learn by doing' and to apply best practices for Kitui in subsequent programme phases. Experimentation and iteration should be built into the programmes design, so called 'adaptive management'.
6. **Identify champions to demonstrate skills.** The initial participants would also be trained to become 'Champions' within their community, demonstrating techniques and highlighting best practices to customers and other MSMEs in the area. There is evidence that with the right incentives, 'Champions' can help popularize the skills and techniques.73

73 IIED's work with the Energy Change Lab in Tanzania shows that properly incentivised rural 'champions' can have outsized impacts on their communities.

	Option I: Initial intervention	Option II: Scale-up phase	Option III: Graduating people considered 'ultra-poor'
Target	○ 160 Entrepreneurs ○ 8 sub-counties, 8 clustered cohorts ○ 20 entrepreneurs per cohort	○ 1280 Entrepreneurs ○ 8 sub-counties, 8 clustered cohorts ○ 20 entrepreneurs per cohort	○ 160 Entrepreneurs ○ 8 sub-counties, 8 clustered cohorts ○ 20 entrepreneurs per cohort
Entrepreneur selection criteria	○ 'Growth entrepreneurs' (Robb et al, 2014)74	○ 'Growth entrepreneurs'74	○ People living on less than World Bank's $1.90 per day (Banerjee et al., 2015)[75]
	○ High proportion of participants should be women	○ High proportion of participants should be women	○ High proportion of participants should be women
	○ Target MSMEs outside of major urban areas of Kitui and Mwingi	○ Target MSMEs outside of major urban areas of Kitui and Mwingi	○ Target rural areas
	○ In operation > two years76	○ In operation > two years76	
	○ Licensed and unlicensed MSMEs, and members of Associations and those who are not members	○ Licensed and unlicensed MSMEs, and members of Associations and those who are not members	
Categorization	○ Low-powered energy grouping	○ Low-powered energy grouping	○ Low-powered energy grouping
	○ High-power energy grouping	○ High-power energy grouping	○ High-power energy grouping
Recommended Modules	❖ Business operations and management	❖ Business operations and management	❖ Business operations and management

74 Evidence shows that it is important to distinguish between 'subsistence entrepreneurship' versus 'growth entrepreneurship', where subsistence entrepreneurs do not actively seek to grow their businesses beyond simply hiring family members. Nurturing growth entrepreneurs has the potential to spur innovation and competition and build local economies.

75 Evidence shows that if priorities and budgets allow, an MSME programme can target the ultra-poor, successfully building up the skills and structures essential to establish thriving businesses. While expensive and resource intensive, data shows that it can pay for itself within a year through impacts over that first year.

76 According to the KNBS 2016, MSMEs that have been in operation less than two years are more vulnerable to closure than those that have been operating for more than two years. If targeted, these MSMEs have a better chance of using the skills they learn to strengthen their business practices to survive and thrive following the programmes.

	❖ Linkages along value chains	❖ Linkages along value chains	❖ Linkages along value chains
	❖ Marketing	❖ Marketing	❖ Marketing
	❖ Business associations	❖ Business associations	❖ Business associations
	❖ Financial skills and linkages	❖ Financial skills and linkages	❖ Financial skills and linkages
	❖ Incorporating ICT	❖ Incorporating ICT	❖ Incorporating ICT
Activities	○ Training (36 contact hours)[77]	○ Training (36 contact hours)	▪ Grant of a productive asset (chosen by the entrepreneur)
	○ Mentorship (4 visits over 4 months)	○ Mentorship (4 visits over 4 months)	○ Training and support for the chosen asset
			○ General life-skills coaching
			○ Weekly consumption support for a fixed period
			○ Access to savings account
			○ Health information or services
			○ Weekly interactions with the households throughout the year
Approximate cost	~KES 5,356,800	~KES 42,854,400	~KES 79,685,632
Expected return on investment	-~30% MSME increase in profit -Programme pays for itself within one year[77]	-~30% MSME increase in profit -Programme pays for itself within one year	- 2-3x return on investment (Sulaiman & Misha, 2016) - 37% increase in earnings - -10% increase in consumption - 10x savings increase - 2x access to land and assets - 3x more hours for productive use (BRAC, n.d.)
Potential delivery partners	○ Chamber of Commerce ○ Kenyan Universities	○ Chamber of Commerce ○ Kenyan Universities	○ Kenyan Universities ○ Kitui vocational institutes

77 Based on 'personal initiative' entrepreneurial training evidence (Campos et al., 2017).

	○ Kitui vocational institutes ○ Local governments ○ MFIs and Commercial Banks ○ Ministry of Trade ○ Technoserve	○ Kitui vocational institutes ○ Local governments ○ MFIs and Commercial Banks ○ Ministry of Trade ○ Technoserve	○ Local governments ○ National Government ○ Chamber of Commerce ○ MFIs and Commercial Banks ○ BRAC or Village Enterprise: Development Impact Bond (DIB)

Table 34 Indicative training structure

Expand access to credit and affordable financing

As mentioned in the Table above, below are several activities for improving MSME financial skills and linkages with formal and informal financial institutions:

1. **Understand current finance needs and options for enterprises**
   - 1.1. Understand current financial needs of SMEs (of different types) and how they are met in practice
   - 1.2. Map the existing formal financial institution (FIs), their loan products and eligibility criteria for borrowers
   - 1.3. Collaborate with financiers such as TechnoServe who ae currently financing and supporting MSMEs in Kenya to link with Kitui MSMEs
2. **Improve credit access and availability from FIs**
   - 2.1. Determine the types of conditions that would be acceptable to small SMEs, based on their cash flow etc.
   - 2.2. Identify concessional sources of finance (youth funds, women funds, credit lines, donor funding) that can be used for SME financing- as risk guarantees/ collateral, lower interest rates, down-payment subsidies etc.
   - 2.3. Training programmes for FIs: Undertake training programmes for FIs and similar organizations to understand credit needs of SMEs
3. **Improve awareness about financial options**
   - 3.1. Explore the information channels to SMEs (Based on (1)), about existing financial products and how to access them
   - 3.2. Understand the current fears around borrowing from larger financial institutions and the cultural preferences for informal borrowing
   - 3.3. Explore examples where informal credit groups are linked to larger FIs (Groups can go to FSA etc.) or other formal channels (eg M-Shwari, M-Kopa cash loans etc.)

Key non-energy/supporting services components

Supporting services	Potential delivery partners/existing initiatives
Comprehensive MSME training programme to improve (1) better linkages and networking along value chains, between businesses and to customers; (2) basic business skills and business	○ Ministry of Trade ○ Chamber of Commerce, Kitui- offers training to its members on business development skills, which can be customised depending on business and group interest. ○ TechnoServe in Kenya ○ Sidai Network who provide training for livestock and crop farmers (see Livestock Solution) ○ Existing polytechnics and Vocational Training Centres in Kitui
Expand access to credit and affordable financing	○ Local Financial Services Associations (FSAs) ○ Formal financial channels- M-Shwari, M-Kopa cash loans ○ For livestock and crop farmer MSMEs- Kenya Crops and Dairy Market Systems Activity (KCDMS) programmes aims to support savings and lending for farmers by strengthening the capacities of Village Savings and Loans Associations (VSLAs). (See livestock solution for more details) ○ County and national level funds for youth, women, and other target groups ○ SACCOs in target areas

Table 35: Non-energy supporting services and potential delivery partners

1.39 Solution 7 - Cooking: improved access to cleaner, faster, reliable, and more affordable fuels and technologies for cooking for households in Kitui

Summary of problem and solution

The objective is to improve access to cooking fuels and technologies that are cleaner, reliable, affordable and faster for households in Kitui County. There is a need to develop solutions to address the following gap and barriers identified:

- Lack of alternative cooking fuels that are cleaner, cheaper, and faster
- Lack of well-established distribution channels for cleaner fuels and technologies to reach remote unserved communities.
- Lack of qualified technicians to provide quality installation, repair, and maintenance services for different cooking technologies in rural areas.
- Deep-rooted cultural cooking practices which impede adoption and usage of alternative cleaner cooking fuels and technologies by communities.
- Lack of awareness on negative impacts of continued use of traditional cooking solutions on their health, finances, and the natural environment. Similarly, lack of awareness on benefits of using clean cooking solutions.

Before moving to a discussion of solutions to address these gaps and meet the priority need, it is important to note that currently there is insufficient and disaggregated data on the drivers of cooking technology and fuel usage among different user groups in Kitui County, particularly the socio-cultural, behavioural factors underpinning cooking preferences and practices, to develop sustainable solutions. For this reason, what follows are to some extent topline solutions informed by the current state of knowledge on cooking fuel and technology use in the County. Further data gathering and analysis is critical to develop these into detailed solutions targeting specific end user groups.

Energy components

- Adopt and continually use improved cookstoves (for households relying on charcoal and firewood and are unlikely to change to other cleaner fuels in the foreseeable future)
- Adopt and continually use clean fuels and cooking appliances (for households currently using purchased kerosene and charcoal)
- Build technical capacity of local artisan to manufacture quality cook stoves, provide standardized installation of cooking appliances.
- Train local artisans/technician to provide repair and maintenance support services for different cooking appliances such as solar cookers, biogas systems and electric cookers.

Non-energy components

- Raise awareness of the negative impacts of continued use of traditional fuels and cooking appliance and the benefits of using clean cooking solutions
- Build business skills of cookstove artisans/dealers
- Establish effective distribution/supply channels for clean cooking solutions
- Undertake further research to understand socio-cultural practices that hinder and enable uptake of modern cooking fuels and technologies by communities in Kitui. This will guide in development of targeted solutions that address social barriers and enablers that need to be integrated into the existing solutions.

What problem is the solution addressing?

The priority need identified was greater access to cooking fuels and appliances that are cleaner, cheaper and faster to reduce the health impacts of using traditional technologies and solid fuels, especially on women and children, fuel costs, time and drudgery from repetitive collection of firewood by women and children (especially girls) and to allow more time for other social and productive activities.

According to KNBS (2019, Volume IV), households in Kitui can be classified into four broad categories based on their fuel usage, namely:

- Category I: Households using firewood
- Category II: Households using Charcoal
- Category III: Households using kerosene
- Category IV: Households using clean fuels and technologies (electricity, LGP, Solar and biogas)

Over 81.3% of all households in Kitui (235,371 households) use firewood to meet their cooking needs, while 8.6% (22,516 households) used charcoal. 2.7% (7,069 households) used kerosene and 6.7% liquified petroleum gas (LPG). Finally, 0.3% used biogas and 0.2% used solar and another 0.2% use electricity (KNBS, 2019, Volume IV).

Category I: Households using firewood

These households, totalling 235,371, who are distributed mostly in rural and peri-urban areas of Kitui County obtained firewood from three main source: farmlands, forests, and purchase from local markets according to Kitui County Energy Outlook (SEAF-K, 2017). Those who collect firewood from farmlands or forest are reported to do so for up to 8 times in a month depending on household size and cooking frequency. Those who purchase firewood spend between KES 200 to KES 500/-, dictated by location of the market and bundle size, and the fuel will last a household for two weeks to a month (SEAF-K, 2017). There is lack of data on households that purchase firewood and those who acquire them at no cost. However, study done by Groots Kenya in 2017 use the term 'majority of households' access firewood for free.

In terms of cooking technologies, around 67% of households relying on firewood use three stone open Fires (TSOF) to meet their cooking needs (GROOTS Kenya, 2017) and the rest use different forms of improved cookstoves (such as Jiko Kisasa and Rocket stoves).

There is also lack of data on (i) whether the households in this category use firewood exclusively, or they combine with other fuels (ii) the 33% of households who don't use TSOF, what other cooking technologies they are using.

Category II: Households using charcoal

Over 90% of charcoal in Kenya, including in Kitui county is produced using traditional earth Kilns which are inefficient (Kenya Forest Services, 2013). Worth noting that rural communities in Kitui County engage in charcoal production as a fall-back strategy for income generation especially during years of severe drought (Luvanda et al, 2016). However, in 2018, Kitui County Government effected a ban on charcoal production and transport within its borders as a measure to address the wanton degradation of forests in Kitui (Kitui County Government, 2018). Before 2018, most of the charcoal produced in the county was destined to major urban centres and cities outside Kitui county such as Thika and Nairobi. This implies that charcoal production in Kitui was driven mainly by external demand.

Discussions with MENR in Kitui, indicated that the county has put in place alternative measures to support the actors in the charcoal value chain by equipping them with skills and equipment to produce

fuel briquettes as an alternative to charcoal. At this point, we lack information on studies done to determine the viability of fuel briquettes as an alternative income generating venture for charcoal producers as well as substitute for charcoal to meet household cooking needs.

About 22,516 households in Kitui County use charcoal to meet their cooking needs. Consumption rate ranged between 10 to 35 Kgs per month. 20% of these households especially in rural areas produce their own charcoal, while 80% purchase the commodity. The price range for charcoal in Kitui in 2017 was between KES 20 to KES 30 per Kilogram (SEAF-K, 2017). This implies that a household would spend between KES 200 to KES 1050 per month.

For households that use charcoal, 35.4% use traditional charcoal stoves. About 64.6% of households use a certain form of improved charcoal stove (ICS) (SEAF-K, 2017). The most common one being Kenya ceramic Jiko (owned by 87.6% of households with ICS). It is important to note that majority of these households (82%) do not use their ICS on daily basis citing high price of charcoal as the main barrier to uptake (Groots Kenya, 2017).

Category III: Households using kerosene

Of all households in Kitui county in 2019, only 7,069 or 2.7% used kerosene for cooking (KNBS, 2019, Volume IV) and it is mostly used as a secondary fuel. Monthly consumption ranges between 3- 4 litres for majority of the households while few consume between 10 litres to 15 litres (SEAF-K, 2017). Therefore, majority of households spent KES231/- to KES 310/-per month while few spent KES 773/- to KES 1160/- during the same period if retail price of KES 77.29/litre78 is used. Important to take note that the monthly consumption data is not exclusive to cooking, but also include kerosene for lighting. There is no disaggregated data on cooking/lighting for Kitui county.

Households in this category use kerosene stoves for cooking. The stoves are either pressurised or have wicks. Several points of concern are noted from households using kerosene/stoves, i.e. change of colour and smell of kerosene which affects breathing, produces a lot of smoke/soot and at times burns with a pop sound (SEAF-K, 2017). We lack data on what type of kerosene stove is owned/used by households in Kitui

Category IV: Households using clean fuels and technologies (electricity, LGP, Solar and biogas)

About 7.4% of all households in Kitui County used different forms of clean fuels and cooking technologies, ie electricity- 0.2%, LPG-6.7%, biogas-0.3% and solar thermal-0.2% (KNBS, 2019, Volume IV). As with all categories of households in Kitui County, we lack data on usage of the clean cooking solutions and technologies - whether it is used exclusively or together with other forms of fuels/technologies.

Households in Category IV represent the desired direction for household cooking in Kitui County- i.e. access to cleaner, cheaper, and faster cooking fuels and appliances. However, there are barriers/gaps hindering these households in Kitui from accessing and continuously using clean cooking solutions, which are energy and non-energy related. It is imperative that the barriers/gaps identified by the community are addressed holistically. The section below discusses key barriers/gaps as identified by the stakeholders in Kitui county

Energy gaps/barriers

- **High costs of alternative cooking fuels and technologies making them unaffordable to most households**

78 Kerosene prices in Nairobi for the month of May-June in Nairobi according to EPRA. Important to note that EPRA review fuel prices every month

Stakeholders in Kitui cited high costs of alternative fuels and cooking appliances. For example, the cost of acquiring a filled 6 Kg LPG cylinder, burner and grill is KES 4790/- as the initial cost of investment and subsequent refilling of the cylinder cost KES 1000/- per re-fill. Similarly, the cost of acquiring factory made Improved cookstove ranges between KES 3800/- to KES 12000/- depending on the brand. The initial cost of investment for these appliances is considered too high and most of the household indicated that they cannot afford, especially the fact that they are sold at lumpsum price. Additional issue raised with LPG is how it is not available in small quantities like as compared to fuels such as charcoal or firewood which are normally sold in small quantities. The other cooking technology with high initial cost of investment cited by the stakeholders is biogas system.

Overall, the alternative cooking fuels and appliances which are cleaner and faster were considered expensive when compared with traditional cooking solutions. For example, households incur negligible initial cost of investment to install the traditional three stones fires for cooking. The same households, especially in the rural areas collect the firewood for free from their own farms or nearby forests at no cost. If these households were to switch to using improved cookstove like Jiko Kisasa, the initial cost of investment will be about KES 2500/- for single pot. The initial costs will be even higher if they were to use cleaner solutions like LPG which require initial investment of about KES 3010/- for 3 Kg Filled cylinder with accessories (Total Kenya, n.d).

- **Availability of alternative cooking fuels and technologies in rural areas is limited**

Cooking fuels such as LPG and branded cookstoves are mainly found in urban centres in Kitui County. Households living in far flank remote areas cited the need to cover long distances to access these fuels and cooking appliances as a barrier. Similarly, for fuels that require regular refill such as LPG, stakeholder indicated that the cost of transport to the refilling station was an extra expense, that would need to be incurred by households living far away from such stations.

- **Low quality of cooking appliances**

The quality of some of the cooking appliances, especially, artisanal stoves which are produced locally such as Kenya Ceramic Jiko (KCJ), Maendeleo Jiko and Rocket Stoves were considered wanting by the stakeholders. Examples were given where artisans were selling to unsuspecting buyers KCJ which have been assembled with ceramic liners that are not fired. These ceramic liners are then painted with Red Oxide to mimic firing. Stove made in this manner start developing cracks once they are put into use. They easily crumble when it gets into contact with liquid such as water during the cooking process. For Maendeleo Jiko and Rocket stove, stakeholders indicated poor installation of the stoves, resulting to poor performance.

Overall, it emerged from the stakeholder consultations that different types of improved cookstoves made by local artisans have quality challenges and do not meet the recommended standards[79]. This makes the stoves owners not to enjoy the intended benefits of such stoves, and a point of discouragement for others who would have liked to acquire stoves. The low quality of locally fabricated cooking appliances in Kitui County was attributed to low skill levels of local artisans. Only ten (10) artisans in the county (six male and four female) have been trained on production of quality cookstoves- cladding and assembly by Kitui

79 The recommended standards require the cladding material to be made from mild steel of 1 mm in thickness and the stop top to be 1.5 mm in thickness. Ceramic liners made from suitable pottery clay and pottery sand, which has been properly cured and properly fired at 700^{o}c- 900^{o}C are also required. While Local fabricators are using metal sheets of low gauge for cladding. In addition, they use ceramic liners which are not fired as insulators and assume that these will be fired when the stove is in use. Ceramic liners that are not properly fired crumble easily when they encounter any fluids during cooking process.

Energy Centre[80]. Similarly, Caritas Kitui has trained 125 local artisans (62 male & 63 female) on Rocket stove installation/construction, while Groots Kenya together with MENR trained 41 artisans (three male and 38 female) called 'clean cooking champions' on installation of Maendeleo Jiko. Despite these efforts, issues of appliance quality are still being raised by the stakeholders. Further, these number of trained artisans is low compared to the numbers of households currently using three stone fires over a large area.

However, in terms of the availability of materials to fabricate stoves of the correct quality, 16 sites were identified by Kitui Energy as ideal for extraction of pottery clay and sand.[81]

- **Lack of/ substandard repair and maintenance services for different cooking appliances**

Stakeholders in Kitui county including the community members highlighted the low number of trained and qualified local technicians to provide repair and maintenance services for cooking appliances. Regardless of the initiatives by Kitui Energy Centre, Caritas Kitui, Groots Kenya and MENR- Kitui County to train the local artisans on stove production, which includes repair and maintenance services, these trainings focused more on artisanal stoves, excluding other cooking appliances. As mentioned earlier, the trained artisans are few in comparison to vastness of Kitui county and are found in main urban centres, such as Kitui town, Mwingi, Kwa Vonza etc and unable to reach most of the remote rural households.

Non-energy gaps/barriers

- **Socio-cultural barriers**

Feedback from the needs assessment workshops held across the county revealed that householders were attached to the traditional stoves- three stone open fires (TSOF) cooking. This was attributed to inherent characteristics of TSOF, namely they are easy to use, both in terms of accommodating cooking pots of different sizes as they are adjustable, no intense processing of firewood is required, and its construction requires no investment. This attachment could act as barrier to the adoption of clean cooking solutions. The other issues closely linked to TSOF is on household routine cooking practices. Stakeholders mentioned that, sometimes food is prepared and kept next to the fireplace (smouldering or sometimes, ambers are covered with ash), for it to remain hot/warm for longer period. This practice helps to serve family members who may not be there during mealtime, with hot/warm food when they come back. This also demonstrates attachment to TSOF and could act as a barrier to adoption and continued use of clean cooking solutions, especially if they do not serve the same purpose as TSOF. Anecdotally, covering ambers or smouldering logs with ash to preserve fire is practiced in rural areas. The stakeholders also raised fears of burns and fires from use of certain types of fuels and cooking technologies. Examples of these included LPG and kerosene stoves, which they thought could easily explode. The fear of explosion could also be barrier to the adoption of clean cooking solutions.

- **Lack of Business Skills by cookstove artisans/dealers.**

It is important to note that cookstoves artisans and dealers in Kitui County operate micro and small enterprises formally or informally that deals in production and/or sale of different types of cook stoves. As was the case with lack of technical skills, cookstove artisans and dealers present during the consultative workshops revealed that they lacked basic business skills. For example, most of them indicated that they do not keep any business records as they did not see any value in doing so. This then raises the question

- **Lack of awareness on the impacts of continued use of traditional fuels and cooking appliance and the benefits of clean cooking solutions.**

80 15 groups in Kitui on liner production, totalling X artisans.

81 Kitui Energy Centre identified 13 sites suitable for ceramic liner production.

Research carried out by Groots Kenya (2017) showed that over 75% of households surveyed in Kitui were aware about clean cooking technologies. However, findings from the CEP needs assessment and stakeholder consultative workshops in Kitui between March and July 2019 appear to suggest that communities may not be familiar with the impacts of using solid fuels (firewood, charcoal) and inefficient cooking technologies on household health, social wellbeing, and the natural environment. Similarly, the benefits of adopting and continuously using clean cooking solutions appeared not to be well understood.

Solutions

As noted above, the proposed solutions below that will require further data gathering and analysis to inform the further development and optimisation of these proposed solutions.

Targets

The three categories of households described in Section II above who are currently not using clean fuels and technologies for cooking.

Energy Component

1. **Adoption and continual use of improved firewood stoves**

The targeted households will include those that are currently using firewood **(Category I)** together three stone open fires for cooking. Statically, 67% or 142614 households in Kitui county relying on firewood use three stone open fires (KNBS, 2019, Volume IV). Further, majority of these household's source firewood from their own farms or nearby forests at no cost, while few of them buy from nearby markets at very minimal cost (approximately KES 200 to KES500/- per month) (Groots Kenya, 2017).

Assumptions

- Most households currently using firewood for cooking will continue with the same usage in the foreseeable future.
- Households are willing to adopt improved firewood stove and to incur some costs to acquire the stoves

Table 36 below summarises the options for improved firewood stoves.

Improved Firewood Stoves	
Energy delivery system	Two varieties of improved firewood stoves are available in Kitui County: 1) improved firewood stoves produced by local artisans 2) improved firewood stoves that are factory-made and branded (including imported stoves) The solution considers two types of improved firewood stoves produced by local artisans: Jiko kisasa (fixed & portable) and Rocket stoves. It also considers factory-made improved firewood stoves: Kuni Okoa, Jiko Dura "24 cm", Jiko Dura "28 cm", Model 2-M2, SmartSaver Wood, and SuperSaver wood.

a) Jiko Kisasa fixed

Figure 34 Jiko Kisasa-double pot

b) Jiko Kisasa portable

Figure 35. Jiko Kisasa-Portable

c) Rocket stove (i)

Figure 36: Rocket Stove with Insert

d) Rocket stove (ii)

Figure 37 Rocket stove made from bricks & mortar

Cost

Capex for Jiko Kisasa Fixed

○ Single cooking pot	○ Cost range: KES 2500/ (wholesale)- KES 3000/- (retail
○ Double cooking pot	○ Cost range: KES 4200/-(wholesale)- KES 5000/- (retail)

Capex for Jiko Kisasa Portable

Jiko Kisasa Portable	Cost range: KES 800- 2300/- (depending on size)

Capex for Rocket Stoves

○ Rocket stove with ceramic insert	○ Cost range KES: 3000/ (wholesale) & 3500/- (retail)
○ Rocket stove from bricks and mortar	○ KES 5000 (retail)

Opex

	Firewood (103.6 kg per month, EED Advisory, 2019). o KES 500/-
Revenues	**Environmental savings** (based on The World Bank and ESMAP, 2019). Jiko Kisasa are 40% more efficient than three stone open fires- lifespan of more than three years. **This implies 40 kgs of firewood is saved for every 100Kgs that would have been consumed on TSOF.** The Rocket Stove is 20% more efficient than the Jiko Kisasa stove and has a lifespan of five years. Both types are produced locally, use firewood, and have no chimneys but provide good combustion. **This implies savings of 20kg of firewood over the 100kg of firewood used in Jiko kisasa**
Key points to note	o If households have the skills to install Jiko Kisasa (fixed) using local materials, the cost will reduce to about KES 500/- to KES 800/- for the single pot (i.e the cost of insert only). Hence the economic benefits from training households in Kitui on stove installation. o Households need to be encouraged to continuously use the ICS as the primary cooking technology if any environmental and health benefits are to be realised. o The socio-cultural issues that inform decision-making by householders on which stove and fuel to use must be better understood to develop demand creation strategies. o There is need to increase the availability of improved firewood stoves closer to unserved households. This is to be achieved through interrelated interventions. o There is a need to improve local production of improved firewood stoves in Kitui County. Kitui Energy Centre has the required infrastructure (kiln, moulds, source of pottery clay and sand, and production space) that needs to be tapped into to produce cheap and quality firewood stoves. Similarly, there are 15 groups that have been trained by Kitui Energy centre on ceramic liner/stove production, that can also contribute in the production of cheap and quality stoves. o Train households on quality installation and use of improved firewood stoves. Key entry points for engaging households will be existing groups, development programmes and networks. CSOs including Caritas Kitui, Anglican Development Services, Groots Kenya in collaboration with Kitui Energy Centre and MENR could provide customised trainings on installation of fixed firewood stoves such as Jiko Kisasa and Rocket Stoves. Linkages could be created between producers of improved firewood stoves in the county and the trained households. o Support businesses to develop distribution chains for different varieties of firewood stoves in remote rural areas of Kitui. o To address the issue of affordability of improved firewood stoves, the MENR could consider providing a subsidy for purchase of ceramic

	liners/insert. CSOs could also consider providing subsidies for the costs of artisans and cooking technologies. Similar issues were raised by Kitui Energy Centre personnel who mentioned that some of the groups trained by Kitui Energy Centre on production of ceramic liners were reported to charge high prices for their ceramic liners, sometimes four times higher than the price of similar ceramic liners in the markets. Similarly, the artisans indicated that they did not engage in marketing activities for their cookstoves. Some mentioned that customers will come looking for them in their outlets, which act as both the production centres and selling points. Overall, it was evident that majority of the local artisans had minimal knowledge of the basic skills needed to run their business.

Table 36: Options of improved firewood stoves for household currently using firewood together with TSO fires for cooking

2. **Adopt and continually use improved charcoal stoves**

The solution targets households that are currently using charcoal (Category II) and the traditional-metallic stoves, which waste a lot of heat. Among this category, a specific sub-category of households who purchase charcoal, majority of who are found in towns and urban centres of Kitui County.

Working assumptions

- Households currently using the traditional metallic charcoal stoves can pay for improved charcoal stoves.
- Households currently purchasing charcoal (urban households who are unable to produce charcoal for own consumption) want to reduce cost through efficient use of the fuel.
- The solution is aimed at displacing the use of metallic/traditional charcoal stoves which are inefficient since they lack insulators and any other components that could improve fuel and thermal efficiency.

Table 37 provides a summary of the options for charcoal stoves. Several types are available in Kitui county. These include stoves made locally by artisans including Kitui Energy Centre such as Kenya Ceramic Jiko, and those that are factory-made and branded (including Jiko koa).

Improved Charcoal Stove Options			
Energy delivery system	There are two types of charcoal stoves available in Kitui County: 1. Locally fabricated by artisans including Kitui Energy Centre 2. Factory-made and branded		
	Artisanal- Kenya Ceramic Jiko 	Ecozoom- Jiko bora 	Envirofit- Super Saver 

	Burn- Jikokoa 
Cost	
	Capex for Improved charcoal stoves a) Branded stoves (Jikokoa, Jikobora, Supersaver etc.) — Cost range: KES 3800/- - KES 12000/- (depending on brand and cookstove size) b) Quality Artisanal Stoves (e.g. KCJ) — Cost range: KES 450/- KES 2500/- (depending on make and size) **Opex** **Charcoal** (1 sack of about 30.4kgs[82]) KES 900-1300/ in Kitui. — KES 900/- to KES 1950/ per month (consumption of 1 to 1.5 bags per household)
Revenues	**Environmental and financial savings[83]** **Artisanal ICS** saves between 25% to 50% of charcoal compared to traditional metallic charcoal stoves and reduce toxic emissions (for improved artisanal stoves that meet quality standards) **Factory-made ICS (Jikokoa, Jikobora and Supersaver)** have thermal efficiency ranging from 30%-70%, allowing for higher fuel savings than traditional charcoal stoves.
Key points to note	○ Monthly operating cost for these stoves will vary depending on stove efficiency, cooking habits of households and the amount and number of meals cooked per day. Therefore, some households will use more charcoal than others.

Improved Charcoal Stove Options	
Energy delivery system	There are twyo types of charcoal stoves available in Kitui County: 3. Locally fabricated by artisans including Kitui Energy Centre 4. Factory-made and branded

82 Nationally, around 7.6 kg of charcoal is consumed per household in a week. A month is considered to have four weeks, giving a monthly consumption of 30.4 kg (including use of both a traditional charcoal stove and ICS) (EED Advisory, 2019).

83 The environmental and financial savings are implied i.e., with improved stove efficiency, less charcoal would be required, which reduces pressure on trees. Since the majority of household who use charcoal purchase their fuel, it means lower expenditure.

	Artisanal- Kenya Ceramic Jiko  Burn- Jikokoa 	Ecozoom- Jiko bora 	Envirofit- Super Saver 
Cost			
	Capex for Improved charcoal stoves c) Branded stoves (Jikokoa, Jikobora, Supersaver etc.) — Cost range: KES 3800/- - KES 12000/- (depending on brand and cookstove size) d) Quality Artisanal Stoves (KCJ, — Cost range: KES 450/- KES 2500/- (depending on make and size) **Opex** **Charcoal** (1 sack of about 30.4kgs[84]) KES 900-1300/ in Kitui. — KES 900/- to KES 1950/ per month (consumption of 1 to 1.5 bags per household)		
Revenues	**Environmental and financial savings** **Artisanal ICS** saves between 25% to 50% of charcoal compared to traditional charcoal stoves and reduce toxic emissions (for improved artisanal stoves that meet quality standards) **Factory-made ICS (Jikokoa, Jikobora and Supersaver)** have thermal efficiency ranging from 30%-70%, allowing for higher fuel savings than traditional charcoal stoves.		
Other costs/revenues			
Key points to note	○ Monthly operating cost for these stoves will vary depending on stove efficiency, cooking habits of households and the amount and number of meals cooked per day. Therefore, some households will use more charcoal than others.		

84 Nationally, around 7.6 kg of charcoal is consumed per household in a week. A month is considered to have four weeks, giving a monthly consumption of 30.4 kg (including use of both a traditional charcoal stove and ICS) (EED Advisory, 2019).

Table 37: Options for households currently purchasing charcoal and using traditional-metallic charcoal stoves for cooking

3. Adopt/switch to cleaner cooking solutions: LPG

This solution targets households currently using charcoal (**Category II**), specifically those who purchase and those that use kerosene for cooking (**Category III**). The shared characteristic of this target group is that they purchase the fuels either on daily, weekly, or monthly basis. For example, a household in urban areas in Kenya consumes an average of 30.4 Kg (equivalent to one sack) of charcoal per month (EED, 2019). Anecdotally, a sack of charcoal in Kitui County costs averagely KES 950/-. Similarly, a household uses about 8.8 litres (national average) of kerosene per month, according to EED Advisory (2019), costing about KES 89.64/per litre, hence the mean monthly expenditure is KES 790/-.[85]

Working assumptions

- Households in this category are willing to invest to acquire alternative cooking solutions that are cleaner than charcoal or kerosene such as LPG.
- Since the majority of households in these categories are found in urban centres, they have easy access to alternative clean fuels such as LPG.

The options for these households will be to use other fuels and associated cooking technologies that are cleaner than charcoal and kerosene but are within their expenditure limits. For example, households in urban areas in Kenya consume about 5.2 Kgs of LPG per month (EED Advisory 2019). The average cost of refilling 6 kg LPG cylinder is KES 1000, and about KES 500/- for 3Kg Cylinder (Total Kenya, n.d). These prices, however, vary depending on the brand. It then appears that it is beneficial for households to use LPG which is cleaner than charcoal or kerosene as the monthly costs of these of fuels do not vary significantly. However, there are underlying barriers regarding access to LPG which will need to be addressed separately, such as the initial cost of investment, distances to refilling centres and consistency of supply. Important to note that LPG is currently Zero rated and is still expensive to majority of the poor households. Kitui County Government need to consider a subsidy programme, that will make LPG more affordable.

Kenya standardized the capacities of LPG cylinders at 1kg, 3kg, 6kg and 13kg and the valves used, making it easier to replace used-up gas from retail outlets such as Service stations, Supermarkets, Kiosks etc

LPG cooking solutions	
Energy delivery system	The delivery system for LPG includes the following components: ○ LPG cylinder- common sizes used by household are 3kg, 6Kg and 13 Kg ○ Grill and burner (applicable for 3 kg and 6Kg cylinders) ○ Pressure regulators (High or low), gas pipes and cookers- mostly used in the 13 kg cylinders 

85 The average value for kerosene for 02-March to 08- June 2020 for Kenya was KES 89.64/- per litre with a minimum of KES 79.59/- Kenyan Shilling on 20-Apr-2020 and a maximum of KES 104.87/- on 02-Mar-2020. Note that the price of kerosene is reviewed on monthly basis.
Available at https://www.globalpetrolprices.com/Kenya/kerosene_prices/. Accessed on 15th June 2020.

Cost	
	Capex (options provided for households on cylinder sizes and the associated accessories). i. 3 Kg LPG + Cylinder & accessories[86] KES 3010/- ii. 6Kg LPG + Cylinder & accessories KES 4790/- iii. 13 Kg LPG + Cylinder & accessories[87] KES 11980/- **Opex** Costs are mainly for refilling LGP 3Kg LPG KES 500/- 6 KG LPG KES 1000/- 13 Kg LPG KES 2170/- **Note:** all cylinder and fuel costs are obtained from Total Kenya (n.d) There is a small variation in fuel costs depending on the brand of ± KES 250. Fuel costs exclude transport costs.
Other costs/benefits	Transitioning to use of LPG which burns cleaner, there will be reduced indoor air pollution.
Key points to note	There are other alternative fuel and technologies that households in these categories can adopt including: o Ethanol gel and liquid which are mostly available in supermarkets o Biogas especially for farmers who have animals under zero grazing and enough water ◦ Electric cookers

Table 38: Options for households currently purchasing Charcoal and kerosene for cooking in Kitui

4. Build technical capacity of local stove producers.

This solution targets untrained stove artisans currently operating in Kitui County as a priority. On rolling basis, the solution will also target new entrants to stove production space. Worth mentioning that we lack data on the number of untrained stove producers in Kitui hence the need for MENR to undertake mapping exercise to identify the number and spread of the artisans and undertake training needs assessment. The findings of this exercise will be used to customise the training approach articulated below.

Working Assumptions

- Untrained stove artisans are willing to undertake the training
- The untrained stove artisans have some of the basic production tools and hence will not require full set of tools
- The targeted artisans have/own production yards (working space and storage area)

Two general approaches are considered as part of the solution. The first is to address equipment needs. The following basic equipment is required for stove production: a set of hand tools (eg pliers, hammer),

86 Accessories here refer to the grill and burner for both 3 kg and 6 Kg tanks
87 Accessories for 13 kg cylinder refers to low pressure regulator, low pressure hose pipe and twin pot cooker

manual machines (eg roller, jenny, cutting machine), electric machines (eg welding machine, compressor for spray painting), and safety gears.

Secondly, enhancing the technical skills of the artisans. A lean but comprehensive technical skills training programme could train selected clusters of stove artisans/dealers across the eight sub-counties on essential technical skills in quality stove production and in repair and maintenance of different cooking appliances, coupled with a mentorship programme to help stove artisan/dealers retain and apply the skills. As discussed in relation to Solution Six on MSMEs, evidence shows that training are only effective in the long-term if followed up with coaching or mentoring, which supports stove artisans/dealers to implement and solidify the acquired skills (Robb et al., 2014).

Next Steps

1. **Gather detailed information from artisans.** For effective technical training of stove artisans in Kitui County, more data on artisan locations to select, optimise, and cluster the training sessions and mentorship support for the artisans more accurately. Further, data is needed for artisans needs, constraints, priorities and so on, which will be used to tailor the curriculum, training methods, and mentorship activities appropriately.
2. **Design training programme, implement, and iterate.** The programme uses phases to 'learn by doing' and to apply best practices for Kitui in subsequent programme phases. Experimentation and iteration should be built into the programmes design, so called 'adaptive management'.
3. **Champions to demonstrate skills.** The initial participants would also be trained to become 'Champions'/trainers within their community, demonstrating techniques and highlighting best practices to other artisans in the area. There is evidence that with the right incentives, 'Champions'/trainers can help popularize the skills and techniques.[88]

Technical skills capacity building	
Target	○ 280 Cookstove Artisans- 35 per cluster. ○ 8 clusters. Each sub-county in Kitui represent a cluster
Artisan selection criteria	○ 'Growth Artisans/stove entrepreneur'[89]
	○ Gender Balance
	○ Target Artisans in remote and rural areas
	○ In production of stoves > two years[90]
	○ Artisans operating formally, (Licenced), informally (unlicensed) and members of Associations and those who are not members
Recommended Modules	❖ Training on metal cladding for portable stoves
	❖ Training on assembly of portable stoves
	❖ Training on installation of non-portable stoves

88 As discussed in the MSME's solution, IIED's work with the Energy Change Lab in Tanzania shows that properly incentivised rural 'champions' can have tangible on their communities.

89 Evidence shows that it is important to distinguish between 'subsistence entrepreneurship' versus 'growth entrepreneurship', where subsistence entrepreneurs do not actively seek to grow their businesses beyond simply hiring family members. Nurturing growth entrepreneurs has the potential to spur innovation and competition and build local economies (see: Valerio et al., 2014).

90 According to KNBS 2016, MSMEs that have been in operation less than two years are more vulnerable to closure than those that have been operating for more than two years. If targeted, these MSMEs have a better chance of using the skills they learn to strengthen their business practices to survive and thrive following the programmes.

	❖ Repair and maintenance of different cooking appliances
Activities	❖ Hands on Training (36 contact hours)
	❖ Mentorship (4 visits over 4 months)
Approximate costs	Quotation from Kitui Energy Centre in 2019 showed that it costs Ksh 16030/- to train one artisan on stove fabrication- cladding and assembly. The mentorship of Ksh 12,000/[91]-
Expected return on investment	The potential business model and financing option 1. Artisans acquire production equipment at own cost. 2. Untrained artisans pay for the training 3. MENR allocating resource to Kitui Energy Centre to provide training to selected Artisans as Trainers on condition that they will provide hands-on training to 4 artisans each as a pay back, while they benefit from the labour of the trainees. With both MENR and Kitui Energy Centre following up on enforcement and quality assurance. 4. CSOs to finance training of artisans through development programmes.
Potential delivery partners	○ Kitui Energy Centre ○ Caritas Kitui ◦ Groots Kenya

Table 39 : Technical skills capacity building

Non-energy component/supporting services

The most cost-effective and sustainable way of delivering the suggested interventions below would be through deepening cross-ministerial collaboration between the MENR, the Ministry of Agriculture and farmer groups and the Ministry of Health (to identify linkages with programmes that address indoor air pollution), and Ministry of Education (school feeding programmes).

1. **Undertake further research on how socio-cultural practices in Kitui hinder/enable uptake of clean cooking solutions**

It is important to note that rate of uptake of clean cooking solutions have remained significantly low (about 15%) nationally (IEA et al, 2020), and this situation is also the case in Kitui County. Evidently a lot of interventions have been implemented by different stakeholders for several decades in the country (Republic of Kenya, 2019c). The commonality of the interventions has been their focus on business and financing models to support dealers of fuels and technologies, and on cooking technology designs.

However, there is gap in terms of data on, and understanding of, the behavioural drivers of cooking fuel and technology use in Kitui County – that is, the cooking and eating practices and preferences of households, especially at a disaggregated level (by types of end user, different locations, etc) – and most initiatives do not appear to be informed by such analysis, which could be a contributor to low uptake for clean cooking solutions, especially in rural areas.

Therefore, to ensure the cooking solutions in the CEP are responsive to these issues to have a higher chance of successful and sustainable uptake and are tailored to different groups of target end users, it is

[91] One mentorship visit is estimated to cost Ksh 3000/-

imperative that more in-depth research is carried out on the socio-cultural practices in Kitui that can hinder or enable uptake of clean and improved cooking fuels and technologies by households. The findings can refine the general solutions articulated in the solutions section (energy and non-energy components)

2. Build business skills for cookstove artisans and dealers

Generally, cookstove artisans and dealers can benefit from strengthened business skills, improved market linkages along the value chain, moving towards formalisation such as securing licenses and membership in business associations, and promoting graduates or 'champions' from training programmes.

The recommendation would be to develop a lean but comprehensive skills development and market linkages programme to train selected clusters of stove artisans/dealers across the eight Kitui sub-counties on essential skills, coupled with a mentorship programme to help stove artisan/dealers retain and apply the skills in their individual enterprises. As discussed in relation to the MSME solution (Solution Six above), research shows that trainings are only effective in the long-term if followed up with coaching or mentoring. (Valerio, et al., 2014). Any programme for stove artisans/dealers should be built to respond to the complexity of needs that differ across individuals, men and women, and teach entrepreneurial skills (Campos et al., 2017). Any training and mentoring programme should also promote a gender balance into the design and implementation of activities, such as by targeting women. The next steps for this programme would be the same as for the MSME training component outlined under Solution Six (Section 6: 10).

A. **Gathering more detailed information from stove artisans/dealers.** Data on specific locations of stove artisans/dealers is needed in order to more accurately select, optimise, and cluster the training sessions, mentorship, and identify market linkages. Data will also be collected on needs, constraints, and priorities, which will be used to tailor the curriculum, training methods, and mentorship activities appropriately.

B. **Design programme, implement, and iterate.** The programme uses a 'learn by doing' approach. Experimentation and iteration should be built into the programmes design, so called 'adaptive management'.

C. **Identify champions to demonstrate skills.** The initial stove artisans/dealers would be trained to become 'champions'/trainers within their community, demonstrating techniques and highlighting best practices to customers and other artisans/dealers in the area. There is evidence that with the right incentives, champions can help popularize the skills and techniques among their wider community.

Table 40 below summarises how the programme could be implemented.

Enterprise development training	
Target	○ 280 Artisans/dealers (35 per cluster) ○ 8 clusters. Each sub-county in Kitui represent a cluster
Entrepreneur selection criteria	○ Growth stove artisans/dealers
	○ High proportion of participants should be women
	○ Target stove artisans/dealers majorly in rural and remote areas.
	○ Artisans/dealers who have been in operation > two years
	○ Licensed and unlicensed stove artisans/dealer. ○ Artisans/dealers who are members/not members of Associations.
Recommended Modules	❖ Business operations and management

	❖ Linkages along cookstove and fuels value chains
	❖ Marketing
	❖ Business associations
	❖ Financial skills
	❖ Incorporating ICT
Activities	❖ Training (36 contact hours)
	❖ Mentorship (4 visits over 4 months)
Approximate cost	
Expected return on investment	Programme pays for itself within one year[92]
Potential delivery partners	○ South Eastern Kenya University ○ Kitui vocational institutes ○ Kitui Chamber of Commerce ○ MFIs and Commercial Banks ○ Ministry of Trade ◦ Technoserve
Note: Both business and technical skills training programmes are to be implemented as one programme. This will save on resources required to effectively roll out the programmes in all eight sub-counties	

Table 40: Enterprise development training

3. **Raise Awareness of the negative impacts of continued use of traditional fuels and cooking appliance and the benefits of using clean cooking solutions**

These interventions target households currently using firewood, charcoal, and kerosene (Categories I, II, & III) in traditional cooking appliances. To encourage more of these householders to use clean cooking solutions, a proposal is made to carry out sensitisation on:

- The various types of benefits of using cooking fuels and technologies that are cleaner, cheaper and faster
- The impacts of continued use of rudimentary cooking fuels and technologies-forest degradation and deforestation, indoor air pollution (causing respiratory infections), drudgery among women and girls due to the need to collect large quantities of fuels repeatedly), financial loses in terms of household budgets spent to address illnesses stemming from indoor air pollution and drudgery.

Targeted awareness raising needs to be done at village level (as the smallest unit of administration within the county). This approach requires close collaboration between MENR and county administrators. MENR should also explore close collaboration with CSOs and religious leaderships to act as messengers to the congregants considering that these actors are involved in delivering development programmes and are trusted by community members.

4. **Establish effective distribution/supply channels for clean cooking solutions.**

Closely interrelated to awareness raising is to ensure availability of clean cooking solutions through well established distribution channels. Basing on a study done by SNV (2015) of successful cook stoves distributions models, two models are proposed that have potential of boosting access to clean cooking solutions, namely:

92 Based on 'personal initiative' entrepreneurial training evidence (see: Campos et al., 2017).

A. Use of **village level entrepreneurs** (VLE). A proposal is made to use local entrepreneurs and artisans through various incentive structures to distribute selected clean cooking solutions within their communities in Kitui County. This is to take advantage of their direct knowledge of the communities to distribute products at limited costs. The MENR working with other actors (CSOs and social enterprises) to remunerate women and youths to do door-to-door marketing/sale of different cooking solutions. This model works well where demand for the cooking solutions is high.

B. **Piggyback model**: this takes advantage of the existing structures within Kitui County, namely women groups, faith-based groups, farmer groups, cookstove producers/dealers, SACCOs, and MFIs. By focusing on existing networks rather than individuals, the model aims to open a wide range of possibilities for partnerships and pooling of customers. Therefore, MENR and other actors in Kitui are encouraged to leverage on these structures to enhance access to clean cooking solutions.

Synergies between solutions

The EDM planning process aims to identify potential synergies between different solutions: or solution components: that means the solution or specific components could deliver on more than one of the priority needs, across different sectors. The benefits are two-fold: first, solutions can deliver increased development impact and, second, synergies can result in more efficient use of resources. Synergies can also relate both the energy service component of a solution (where this exists) and to non-energy components (supporting services).

Table 41 outlines the indicative synergies identified between the seven solutions developed during the CEP development process. Further analysis and cross-sectoral engagement with stakeholders will be required as part of the solutions demonstration and implementation planning phases to further develop detailed synergies between solution components and also to explore any potential trade-offs between solutions.

Better quality, reliable lighting for households (HH)

Energy components

- Synergies exist across most of the solutions, namely water, health, agriculture, MSMEs, livestock and irrigated agriculture, on the need for improved operation, repair and maintenance supporting services for energy infrastructure, particularly off-grid systems such as SHSs and stand-alone, customised systems.
- This requires increased numbers of local technicians with the appropriate skills to install, maintain and repair off-grid energy systems. This could be achieved by:
  - Training existing KPLC electricians plus technicians and staff at healthcare facilities to carry out basic SHS maintenance.
  - Developing additional, targeted and high-quality training courses at Vocational and Technical Centres (VCTs). This could be a cost-effective way to build networks of technicians to provide cross-sectoral maintenance/repair support.
- There is a need for better distribution channels and linkages between off-grid suppliers of energy systems and components with existing retailers to increase availability of spare parts for energy systems (and appliances) across the sectors identified above. This should include one reliable distribution outlet per sub-county. For instance, MSMEs that do general trading would benefit from improved access to lighting solutions like SHS.

- Ensuring quality standards for energy systems and putting in place enabling policies to build the market for efficient appliance will benefit **all the sectoral solutions**.
- These synergies can be supported through the following policy actions by the county government:
    - Creating a standard for testing and rating equipment suppliers
    - Developing criteria for selecting approved suppliers of energy systems and appliances who will be eligible to win public procurement contracts, and install systems for public institutions (in collaboration with key ministries such as health)
    - Establishing supplier requirements for servicing and maintenance, including having a local presence within the county
    - Introducing enabling policies to strengthen & build the market for efficient appliances and support appliance repair

Non-energy components

- Access to financing for supporting services will be important to ensure that technician business models are workable, and that linkages between providers and services in the energy the value chain, to build up distribution channels and trust, are properly incentivised.

Improved HH access to clean, affordable, and reliable water for drinking and general-purpose needs

Energy components

- Synergies with the above solutions in terms of need for sustainable maintenance and repair function for water pumping and purification facilities.

Non-energy components

- Synergies with agriculture and livestock solutions in terms of provision of better-quality data on water resource availability and usage, and improved user understanding of the need for sustainable water consumption. For instance, there is a lack of data on water supply across seasons, including current and projected climate change impacts on this, and data on water quality (impurities, salinity issues etc.) as poor or no data on these issues can lead to poor and unsustainable investments.
- This includes the immediate next step of auditing water quality, resource levels and usage (who is using which water points) for better design of water solutions.
- There may be specific synergies in terms of a co-benefit of provision of clean water to health facilities depending on the location of water points targeted under the water solution. See also synergies identified under the health solution.
- Access to clean water will require accurate revenue models (either business modelling or government budgeting, dependent on usage) so that the required services can be financially viable, with linkages to appropriate financing.

Improved provision of health services at Level two (dispensary) and Level three facilities (health centres) for communities in remote and poorly served areas

Energy components

- Synergies between the business models for funding sustainable operation and maintenance (O&M) costs for energy services for health facilities (beyond grant support and warranty periods) with this component of the MSMEs solution (general trading). One such model is to

cover these O&M costs including component replacement via a revenue generation activity using the facility's PV system.

Non-energy components

- Synergy with delivering improved HH water access by setting up a community water point for health facility use and generating revenue by selling water to local communities.
- One risk identified is poor governance/weak financial management skills which could impact on ensuring sufficient allocation for future O&M by the health facility staff. Another risk is that this revenue is diverted to finance core operations rather than O & M of energy systems.

Improved yield and productivity of small-scale livestock (poultry and dairy) farmers across Kitui County

Energy components

- Synergy with access to HH lighting & other solutions from HH having increased income from improving livestock yields**.**
- Synergy with agriculture solution: a component of the livestock farmer's business model can include use and sales of livestock manure for meeting fertiliser needs. It should be noted that this is usually a very small part of the farm revenue.

Improved income of smallholder farmers from irrigated and rain-fed crops

Non-energy components

- Integrating solutions on the non-energy side of agriculture: specifically, delivery of concrete GAP activities (including provision of mentoring and ongoing support, as well as financing this) and market literacy (and resourcing this). There are synergies with improving conservation and management of water resources (and more widely with climate adaptation planning).

Improved business capacities to deliver quality products and services for communities in remote and poorly served areas, and increased revenue of existing MSMEs

Energy components

- There are synergies between MSME capacity building programmes and the multiple income generation components of most solutions, including livestock and agriculture. Farmers require business skills training to build and manage their businesses, access finance, and access markets for their products.
- This includes synergies with improving the business skills of energy repair and maintenance businesses required for most solutions (one model here is Fundifix), for example through mentoring, basic entrepreneurship training, links to business financing, and so on.

Table 41: Synergies between solutions

Recommended priority investments

1.40 Identifying priority investments

This section presents an **indicative list of priority investments** for Kitui County based on the solutions presented in Section Six. Each sectoral solution has its specific rationale and criteria for prioritisation, based on the needs assessment and solution development, based on the available data at the planning stage. In most cases, further information and analysis are required before finalising the priority investments list and developing an implementation plan.

A critical next step towards finalising priority investments is obtaining further feedback from the Technical Committee and reaching consensus with the relevant sectoral ministries and wider stakeholders who will lead their implementation. This review process is also crucial given the potential changes to development priorities, programmes and funding due to Covid-19 related economic and social shocks and impacts, and to take account of any additional socio-economic or environmental changes since the CEP process began.

Below are suggested criteria to assist prioritisation of investments across all the sectoral solutions, as well as key next steps to move to final selection of investments. Decision-making criteria should include:

1. Clear linkages between the selected investments and county development objectives and programming, including the current CIDP and any needs assessment or analysis defining the goals and activities of the next CIDP (2023-28), and the ADPs. Priority investments should align with, optimise and build on the County's wider development plans and programming.
2. Identifying target groups/ locations where the priority investments can maximise development impact and meet community needs. This should also ensure equitable distribution of investments and inclusion of marginal and vulnerable groups.
3. Identifying potential suppliers, delivery partners and (co)funding for the priority investments. This includes exploring synergies with the following sources of (co)finance and delivery partnerships:

    i. Kitui County Government budget allocation through sectoral ministries as well as the MENR (ADPs or other financing secured or planned).

    ii. National energy sector initiatives and funds: mapping opportunities for integrating energy infrastructure and supporting service investments into existing initiatives and programmes, to both leverage and strengthen those initiatives. This requires outreach and further discussion with key national energy service providers (such as KPLC and REREC) and the Ministry of Energy.

    iii. National sectoral initiatives and funds (secured or planned): these can support investment in energy and/or non-energy supporting services to ensure holistic solution delivery (eg water or health sector initiatives). This also requires targeted engagement with national-level sectoral ministries and state agencies.

    iv. Development partner (cross)-sectoral and energy programmes and funds (secured or planned). Building on the existing CEP partnership mapping to identify potential co-financing for specific investments in both energy infrastructure and energy/ non-energy supporting services.

1.41 Household lighting/least cost electrification priority investments

Desired impact: better quality, reliable household lighting to ensure cooking, lighting, educational and general-purpose activities can be carried out more safely and effectively.

The energy gaps identified include:

- No access to grid in remote areas
- Unaffordability of connection and wiring costs in areas with the grid
- Low reliability of the grid due to infrastructure breakdown and power rationing
- Little access to off-grid solar systems
- Lack of access to solar home systems (SHS) due to limited supplier availability
- Unaffordability of off-grid systems, both SHS & generators, (purchase of systems and fuel; maintenance)
- Poor management of SHS due to lack of technicians and supporting services at the local level
- Lack of enabling policies and financing options for off-grid systems and more efficient appliances
- Low consumer knowledge and awareness of off-grid lighting options and how they can improve lighting quality

Rationale for prioritisation

The suggested criterion for prioritisation is to target un-electrified households (HH) via different types of infrastructure depending on their proximity to the existing grid infrastructure. Three categories of HH have been identified and the following investments for each group identified. However, the level of access (Tier One to Three1-3) for these groups needs to be determined before the mix of solutions and the costs of investment can be calculated.

1. HHs within 600 meters from existing grid transformers not connected to the main grid. This group should be targeted with grid connection, requiring engagement with KPLC to expedite the connection process.
2. HHs living in remote areas beyond 15KM from existing grid transformers where there are currently no plans to extend the grid to reach these areas before 2022. These HH should be targeted with investments in solar mini grids.
3. HH living in remote areas with no access to grid electricity, no plans to extend the grid to these areas and no economic and technical rationale for the installation of mini grids. These HH should be targeted with SHS.

Next steps

Before a final decision is taken on the priority investments, the following steps should be taken:

1. Decide which level of access (Tiers 1-3) investments are to target.
2. Carry out an affordability mapping of households for each of the proposed solutions and develop a strategy to address this.
3. Map agencies/initiatives offering end-user financing for SHS and research the best financing models to enable HH to purchase different sizes of SHS.
4. Develop a strategy to increase the presence of good quality SHS suppliers across the county
5. Develop an outreach strategy to raise community awareness of the different solutions to HH electrification
6. Identify potential priority investment locations based on clear criteria (including synergies with other CEP solutions, geographical spread across sub-counties, inclusivity and equitable use of resources, presence/willingness of suppliers to serve the location etc.

Energy infrastructure	Tier of access	Number of investments	Investment per energy system **Note:** costings do not include labour costs (except where indicated).
Capital funds			
HH living 600m from existing grid	TBD	X HH (TBD)	○ KES 35,000 for single phase connection ○ KES 20-KES 30,000 for internal wiring (includes all costs) ○ Total = KES 55-65,000 Note: Under LMCP, connection costs were KES 15,000 deposit plus monthly instalment of KES 1,000 for 24 months Total = KES 39,000 total (excluding cost of internal wiring).
Solar mini grids for HH living 15 KM beyond grid	TBD	XX HH	○ KES 103,000 capital cost per connection (EED, 2017) ○ KES 6, 600– 9, 500 connection cost (GMG Kenya). ◦ Total = 109,600-112,500 per HH
SHS	TBD	XX HH	○ *Tier 1 (6-40 W):* KES 10,500- 35,600 cash payment. Potential for paygo model. ○ *Tier 2 (50-120W):* KES 45-60,000 cash payment. Potential for paygo model. ○ *Tier 3 (200-500W):* KES 95-179,000 cash payment. Potential for paygo model.

Additional technical assistance funds are needed to support with the prioritisation and to integrate various supporting services as noted below.

Technical assistance funds for supporting services
Energy infrastructure

Training of technicians for maintenance and repair of electricity systems	Lack of technician support is a critical issue that affect sustainability of electricity systems. Initiatives that can already train technicians to establish a network of trained technicians are critical for implementation of solutions and are not costed as part of this CEP.
Financing models	Grid connection or off-grid system purchase costs are the biggest barrier to entry. Financing mechanisms/payment models to address the range of affordability gaps for end users in terms of the various options for grid/off-grid electrification will need to be developed.
Other supporting services	
Supplier standards & enabling policies	The County Government could develop standards for suppliers for public equipment procurement to push up system and product standards. There may be a need for other enabling policies to attract reliable suppliers of off-grid systems, and maintenance
Consumer awareness of off-grid solutions & their benefits	Map current/develop new initiatives to promote consumer understanding of: (a) enabling functions/benefits of electricity access; (b) types of off-grid systems available; (c) use and maintenance of SHS; (d) financing options for HE electricity (focus on SHS for end users).

1.42 Water sector priority investments

Desired impact: improved access to clean, affordable, and reliable water for drinking and general-purpose needs in households

The priority need identified was improved access to clean water for drinking and to meet other general-purpose needs of communities.

The key energy gaps identified are:

- Lack of reliable and affordable electricity for water pumping
- High number of non or partially functioning water points due to either poor design, poor maintenance, and lack of repair services

The critical non-energy barriers to be addressed are:

- Poor governance and operation of community Water Management Committees (WMCs)
- Lack of data on community water demand, and ground and surface water availability
- Impurities in water
- Lack of community and wide stakeholder awareness on water resources

Rationale for prioritisation

The proposed priority investment is electrification (solar and/or grid) and equipping non-functional and non-hybridised water points that have a high demand.

Analysis for the CEP based on data from the County Government and the Water Infrastructure Audit of Kitui County in 2017 conducted under REACH programme shows that there are around 380 non-functional water points that do not currently fall under the Hybridization Plans of the Water Department. This provides a new investment opportunity for the government and other financiers to engage.

Next steps

Before a final decision is taken on the priority investments, the following steps should be taken:

1. Collect water demand and supply data for existing water points to design energy systems and supporting services such as water purification.
2. Map new water points in areas with supply gaps to design energy systems for new water points- Identify supply issues to meet the water demand and identify the most suitable energy source based on capacity and distance to grid.
3. Conduct county wide water sector climate risk assessment.
4. Understand capacity and financing needs for management of water points by doing a survey on existing water points and their management structures and challenges.

Priority options: energy infrastructure	**Number of investments**	**Investment per energy system and pumps** **Note:** costings do not include labour costs or crucial ancillary component costs (piping, tank, fencing etc.)
Capital funds for infrastructure		
Solar powered pumping systems for boreholes more than 600m from the grid	Total- 277 To be prioritised for each sub-county based on a demand survey	80-150m depth: KES 556,000 80-100m depth: KES 489,000
Grid powered pumping system with solar back-up for boreholes withing 600m from the grid	Total- 102 To be prioritised for each sub-county based on a demand survey	80-150m depth: KES 626,000 80-100m depth: KES 559,000 In addition, grid three-phase connection costs

Additional technical assistance funds are needed to support with the prioritisation and to integrate various supporting services as noted below.

Technical assistance funds for planning and supporting services for delivery model	
Water demand and supply surveys for the non-functional and non-hybridised systems including climate risk assessments	Water supply and demand surveys will help to, • identify locations that need prioritisation and can be aggregated/ bundled to increase access to clean water by the communities • identify water quality issues in specific locations and integrate water purification solutions or changing locations of water pumps • identify location specific climate risks that need addressing as part of the investment This is not costed as part of this CEP- to engage with Department of Water and Irrigation for further details.

Training for water management committees	Survey of existing water points and their management structures to develop a complete delivery model for each water point can help address current management challenges, including identify the best revenue generation options. There are several initiatives promoted by the Department of Water and Irrigation that focus on training of water management committees- however targeted funds are needed to deliver these training and sale-up in an effective manner. One opportunity is to piggy-back on an initiative by SNV to pilot and assess different management models. Lessons from these need to be captured and integrated into the CEP implementation plans related to water.
Training of technicians for maintenance and repair	Lack of technician support is a critical issue that affect sustainability of water points. Initiatives that can already train technicians to establish a network of trained technicians and support scaling up of enterprise models such as FundiFix are critical when CEP solutions are being implemented. Engagement with the Water Department and Fundi-fix to identify the costs expanding support to other counties (not costed)

1.43 Health sector priority investments

Desired impact: improved provision of health services through level two (dispensaries) and level three (health centres) facilities for communities in remote and poorly served areas.

The priority need identified was access to better quality basic health service by communities living in remote or poorly served areas of Kitui County. The services involved include maternal and child health, family planning, outpatient services, HIV care and treatment and immunization services.

The energy gaps identified are:

- Lack of reliable electricity to deliver basic health services in the targeted levels of health facilities
- Lack of long-term operation, maintenance and repair services
- Challenges in provision of critical appliances to deliver services

The critical non-energy barriers to be addressed are:

- Access to clean water
- Lack of medicines and medical supplies in remote facilities
- Difficulties in recruiting and retaining qualified staff.

Rationale for prioritisation

Prioritization of investments is based on targeting those facilities that are currently unelectrified. Based on the available data, only three level three facilities are unelectrified. The caveat is that there may be more unelectrified level three facilities in the following three sub-counties: Kitui Central, Kitui West and Mwingi North

Sixty level two facilities are unelectrified, with a coverage of all sub-counties. Prioritization of investment in these facilities should be based on which facilities have the largest number of patients, using the criteria of population density and remoteness from other health facilities (for instance, Mwingi North).

In addition to investment in electrification, for the overall solution to be sustainable, funding for supporting services for the target facilities and for additional investments in non-energy supporting services is critical.

Next steps

Before a final decision is taken on the priority investments, the following steps should be taken:

1. Confirm whether any of the targeted facilities (levels two and three) have been reclassified by the County Government.
2. Develop a standard specification for service delivery by a level two and a level three facility, and identify the appliances required to deliver these services.
3. Audit all level two and three facilities to confirm
    a. their current level of electrification (including the reliability of the service).
    b. estimated current and future demand.[93]
    c. level of access to clean water.
    d. current provisions for heating water and cooking.

Energy infrastructure	**Number of investments**	**Investment per energy system** **Note:** costings do not include labour
Capital funds		
Grid connection with grid battery or solar back-up	2 level 3 facilities	KES 15,000 for connection under LMCP** Grid-battery back-up: KES 332, 000 Solar-battery back-up: KES 438, 0000
Solar home system (SHS)	1 level 3 facility	KES 1,146,000
Grid connection with grid battery or solar back-up	33 level 2 facilities	KES 15,000 for connection under LMCP[94] Grid-battery back-up: KES 332, 000 Solar-battery back-up: KES 438, 0000
SHS	27 level 2 facilities	KES 658,000

Additional technical assistance funds are needed to support with the prioritisation and to integrate various supporting services as noted below.

[93] The KOSAP initiative is undertaking analysis of electricity demand for level two and three health facilities, with systems required estimated to be in the range of 1.2 to 3.6 Wp. However, there is currently no information on standardisation of systems for different levels of facilities by the Ministry of Energy and KPLC.
[94] If the Last Mile Connectivity Programme (LMCP) is no longer operable, these costs will need to be recalculated.

Technical assistance funds for supporting services	
Energy infrastructure	
Training of technicians for maintenance and repair of electricity systems	Lack of technician support is a critical issue that affect sustainability of electricity systems. Initiatives that can already train technicians to establish a network of trained technicians are critical for implementation of solutions and are not costed as part of this CEP.
Non-energy supporting services	
Adequate provision of medical supplies & equipment	Ministry of Health to work with other national agencies (KEMSA) and partners (eg USAID Afya Halisi and Afya Kamilisha programmes) both to audit the current level of supplies and identify critical gaps, and develop initiatives to ensure adequate provision
Improved access to clean water	Ministry of Health to work with Department of Water & Irrigation and other key stakeholders to audit clean water access. Non/ partially functional water points near target health facilities could be prioritised for repair or for hybridization (with maintenance and repair functions and effective management systems, see Water solution; Section 6:6). Rainwater harvesting is also an option that should be explored, along with water purification/treatment systems.
Staff recruitment and retention	The Ministry of Health should work with partners to further analyse and develop initiatives on staff welfare and training issues (eg Afya Halisi

1.44 Agriculture sector priority investments

Desired impact: Improved income of smallholder farmers from high-value crops on farms with reliable access to water through improved irrigation and better market linkages

The main energy and non-energy gaps are:

- **Electricity:** Lack of access to affordable and reliable electricity to run irrigation equipment
- **Equipment**: Lack of access to and knowledge of reliable irrigation equipment.
- **Finance:** Lack of finance for irrigation equipment and agricultural inputs
- **Good Agricultural Practices (GAP):** Lack of knowledge of irrigation farming techniques, especially for new crops & preference for flood irrigation, even where water is scarce
- **Socio-cultural:** reluctance to work together for collective marketing (aggregation), to continue to carry out GAP (after training), and to share equipment at farm level. Security issues for equipment left on the farm
- **Market linkages:** Lack of access to market information and inability to link with more reliable buyers

Rationale for prioritisation

The proposed priority investment is to develop a proof-of-concept demonstration for high-value horticulture using powered irrigation focusing on a small number of farmers to build learning and confidence in this sector for Kitui. Importantly this demonstration will establish sustainable business models, and an enabling environment with government and other partners for future scale-up.

Kitui is classified as a semi-arid county and is generally perceived, including by local farmers, as having water scarcity issues and very limited rainfall between the two main wet seasons (the long rains from

March-May and short rains from late October to December). In recent years, the rains have been variable and are being impacted by climate change. Kitui's CIDP 2018-2022 also states Kitui's topography is suitable for irrigated crop production although only 1,850 Ha (1.3 percent) of arable land is currently utilised for irrigated production against a potential land area of 11,095 Ha.

Kitui has an existing network of sand dams which capture river water during rainy seasons for use in the dry seasons: which have potential to be used for irrigation. Analysis in developing the CEP shows farmland considered a reasonable distance for water pumping: less than 300 metres from a permanent river, major river or a sand dam covering around 61,400 Ha (614 km2 or 152,000 acres) (Nyago, 2019). This is around 4% of the total farmland in the county.

The CIDP also notes that the potential for exploitable irrigation can be expanded even up to 500,000 Ha through the development of the Tana and Athi River basins. The county's whole land mass lies within the Tana River drainage basin except a narrow strip along the south and southwest border draining into the Athi River. These two rivers form the northern, western, and southern boundaries of the County.

Yet use of irrigation for high-value horticultural crops in Kitui is nascent. Developing proof of concept solutions appropriate for local farmers which consider the value chain for various crops would build confidence in how to scale-up, potentially catalysing further development of irrigation.

Prioritising a demonstration programme across Kitui can support poorer farmers understand the technology and develop interest. Some specific criteria for selection of farmer groups are noted below:

- **Existing cooperatives or clusters:** Select small-scale farmer groups that are currently registered as cooperatives or hare clustered together. These should have existing experience of irrigated agriculture.
- **Water sustainability:** Only select locations where there will be reliable supply of water for irrigation with no resource conflicts (for sand-dams, ensure adequate supply and no conflict with other uses)
- **Prioritise areas:** In addition to water sustainability consider a spread locations across the county where other projects such as poultry and rainfed agriculture are not taking place

Priority activities	**No of investments**	**Energy system investment**
1. Stand-alone solar for drip irrigation	30 of each type of system (or a larger number of solar powered drip irrigation systems to experiment with improved	○ Energy system and pump (pump, panels, structure, cabling, panel security) KES 543K ○ Irrigation system (drip irrigation tank and lines, security fencing and concrete housing for the pump) KES 561K ○ Farmer savings with loan & 30% deposit KES 500K

2. Standalone petrol pump system for drip irrigation	environmental techniques). Site surveys to be used to target and refine these options.	○ Energy system and pump (pump, piping, cabling) KES 80k ○ Irrigation system (drip irrigation tank and lines, security fencing and concrete housing for the pump KES 532k ○ Farmer savings with loan & 30% deposit KES 300K
3. Standalone petrol pump system for furrow-based irrigation		○ Energy system and pump (pump, panels, structure, cabling, panel security) ○ Farmer savings with loan & 30% deposit KES 110K
4. Grid connected system for drip-based irrigation		○ Energy system and pump (pump, panels, structure, cabling, panel security KES182k ○ Irrigation system (drip irrigation tank and lines, security fencing and concrete housing for the pump KES 561k# ○ Farmer savings with loan & 30% deposit KES 350K

Additional technical assistance funds are needed to support various activities alongside the investments on energy system and appliances.

Technical assistance funds for planning and supporting services for delivery model	
Designing the demonstration programme by identifying the needs better	The design elements of the pilot program would include: ○ **Cost:** Re-visit costing and edit based on energy needs. Test a range of the irrigation solution options as part of the demonstration ○ **Suppliers:** Work with good suppliers to develop a supported system based on the solution design ○ **Targeted subsidies and financing:** Undertake detailed needs assessment and target subsidies based on affordability of the farmers. Consider a revolving fund to finance the initial high costs of equipment for farmers. ○ **Non-energy inputs:** The business model requires farmers to have improved access to recommended agricultural inputs, provision of Good Agricultural Practice (GAP), and improving knowledge on markets. Consider linkages to stakeholders who can help provide these (training needs to be more than a one-off)
GAP and market literacy training for farmers	The business model will need farmers to improve GAP (including integrated Pest Management and improving accessibility to quality/certified seeds), and improving farmer "market literacy",

	access to market information and promoting linkages to more reliable buyers for farm produce.
Enabling environment analysis and improvement	Working with Kitui government and other local partners to establish what changes are needed to support the business and finance models. This may include changes to the 'business as usual' process for government to support revolving funds or other forms of loans through a third party for farmer financing. The government and other partners may also be able to facilitate access to good quality inputs for farmers and broker market linkages

Next steps

1. **Mapping sand dams that can be used for irrigation.** This should focus initially on sand dams that were identified in the Water Infrastructure Audit in 2017
2. **Conduct analysis of annual quantity of supply versus demand for farming and other uses.** Collaborate with the Department of Water and Irrigation on their plans for identifying various water consumption sectors, demand and the available water sources and the associated challenges better. Map the supply and demand on a per water source basis for each planned irrigation location.
3. **Validate data on water requirements** for different types of horticulture crops by engaging with the Agriculture and Livestock Department who provide farmers with seed varieties and other extension services
4. **Refine solutions and bundle/aggregate:** given the above and the results of the demonstration project priority investment, refine solution options and financing options and detailed delivery models

1.45 Livestock sector priority investment

Desired impact: Improved yield and productivity of small-scale livestock (poultry and dairy) farmers across Kitui County

The priority need identified was improving income of small-scale livestock farmers in Kitui County. The most common livestock sectors in Kitui include poultry, cattle, and goat.

The key energy gaps identified are:
- Lack affordable and reliable power for operating appliances
- Lack of access to good quality appliances

The critical non-energy barriers to be addressed are:
- Lack of access to affordable inputs
- Lack of access to timely veterinary care services
- Lack of local livestock extension officers
- Lack of access to market information and links

Rationale for prioritisation

The proposed priority investment is to support a group of indigenous poultry farmers from each sub-county to use electric appliances (incubators, brooders, and lighting), and training on production and market links.

While use of incubators has the potential to increase income from improved poultry production there are several gaps that needs addressing prior to scaling up with large scale interventions:

- Increase interest and poultry farmer awareness on incubator technology including the requirements for reliable energy sources: incubators connected to unreliable grid often cause business model failures, leading to mistrust in the technology and financial difficulties.
- Provide a package of support which helps to operate and manage incubators, knowledge on managing poultry to meet good quality standards and linking with buyers/ markets in Kitui and outside to ensure revenue streams for the farmers.

Prioritising a demonstration programme across Kitui can support poorer farmers understand the technology and develop interest. Some specific criteria for selection of farmer groups are noted below:

- **Existing cooperatives:** Select small-scale poultry groups that are currently registered as cooperatives and selling produce. This provides a strong basis to start with as the farmers are already working together to some extent and may have trusted relationships.
- **Geographical coverage**: Select at least 2 groups for each sub-county, with around 15 members in each group. 16 groups minimum- allowing to have 2 groups per sub-county, In addition, prioritise dry areas where agriculture potential is limited.
- **Prioritise women:** Select at least 80% of the groups to be women poultry farmers given poultry is more popular among women.

Next steps

Before a final decision is taken on the priority investments, the following steps should be taken:

- Map of market for different livestock products
- Mapping of livestock farmers across the county and their level of energy us
- Map target groups and identify their characteristic and identify capacity and financing needs

Priority options- energy infrastructure	**No of investments**	**Energy system and appliance investment**
Stand-alone solar and appliances for off-grid farmers- beyond 600m from the grid)	16 poultry groups minimum	○ Energy system (including panels, batteries, inverter, controller and installation fee)- KES 317, 000 ○ Appliance costs: 300 eggs incubator and LED bulb- KES 55,850
Battery back-up and appliances for farmers near the grid or grid connected		○ Energy system (batteries, controller and installation fee) KES 116,650 ○ Appliance costs: 300 eggs incubator and LED bulb- KES 55,850 ○ In addition to above costs grid connection fee: KES 15,000

Additional **technical assistance funds are needed** to support various activities alongside the investments on energy system and appliances.

Technical assistance funds for planning and supporting services for delivery model	
Designing the pilot programme by identifying the needs better	The design elements of the pilot program would include: ○ **Review of investment:** Re-visit costing and edit based on energy needs of the selected groups. Some may require grid back-up (if living near grids) and some may require off-grid solar incubators. ○ **Identifying and linking with appliance suppliers:** Identify good quality suppliers for incubators, lighting and brooders who would be willing to build supply chains to Kitui. In addition, identify their warranties and support for maintenance of appliances. ○ **Targeted subsidies and financing:** Undertake detailed needs assessment and target subsidies based on affordability of the farmers. Not all groups will need the same subsidy amount. ○ **Non-energy inputs:** The business model requires farmers to increase flock-size. Therefore, the farmer require links to recognised input suppliers (eg Sidai Network).
Integrating and delivering supporting services and training for farmers	This business model require support on building skills such as book-keeping and planning to ensure each farmer get an opportunity to incubate. Identify links to programmes (eg Kenya Crops and Dairy Market Systems Activity (KCDMS)) and organisations already providing such support (eg KDC, Caritas Kitui, GROOTS).
Assessments for understanding the poultry market	A market mapping exercise should be carried out to validate market availability and identify potential market channels for different poultry products. This would provide a basis for obtaining interest and buy-in from existing and new farmers for investing in energy systems to improve their production rates.

1.46 Micro, Small and Medium Enterprises (MSMEs) sector priority investments

Desired impact: improved business capacity to deliver quality products and services for communities in remote and poorly served areas, and increased revenue of existing MSMEs.

The priority need was to strengthen enterprises' ability to source and deliver quality products and offer better services, especially for remote or poorly served communities.

The key energy gaps identified are:

- Lack of reliable electricity services for both on-grid and off-grid MSMEs
- Limited access to efficient appliances/equipment

The critical non-energy barriers to be addressed are:

- Lack of supporting services including enterprise linkages along value chain actors, business management and financial skills, and enterprise financing

Rationale for prioritisation

The proposed priority investment is to work with key enterprise focused stakeholders to develop and pilot a comprehensive training programme for MSMEs and package bank financial products with

reputable energy delivery company systems and appliance companies to MSMEs that fit the programme criteria.

By packaging both energy and non-energy need, the program will help simplify, streamline, and popularise energy options for MSMEs. In this initial investment it can look at enterprises who are already using energy for their businesses and identify ways to improve their energy use by supporting improvements to business delivery including upskilling on business operations and management, finance, business planning, customer service, shop layout/design, stronger value chain linkages (eg through contracts), etc.

Next steps

Before a final decision is taken on the priority investments, the following steps should be taken:

1. Liaise with KNBS to access and better understand what Kitui specific data is available from the KNBS 2016 MSME Survey, which interviewed a total of 454 Kitui MSMEs across Kenya. Some Kitui specific, and statistically significant data is available in the report, but only for select variables. While the data itself is publicly available, statistically significant data analysis for more variables in the Kitui dataset would require that specific dataset, and more resources for full analysis. Worth noting is that MSMEs have a low survival rate, so this data from 5 years ago may not be statistically significant anymore but is an available resource that should be explored.
2. Better understand the types of MSMEs and their energy needs by undertaking a county wide survey (samples across sub-counties) on MSMEs to collect more detailed data on energy usage and energy needs. More recent data (than the KNBS 2016 Survey) will help design and direct interventions, financial support, and supporting policies that are required to grow and improve existing MSMEs in Kitui. This will include establishing delivery models that are suitable for improving access to energy in these MSMEs. This data would feed into better targeting the energy components (grid or off-grid) and the comprehensive training programme.

Option I: Initial intervention	
Target	○ 160 Entrepreneurs ○ 8 sub-counties, 8 clustered cohorts ◦ 20 entrepreneurs per cohort
Entrepreneur selection criteria	○ 'Growth entrepreneurs'*
	○ High proportion of participants should be women
	○ Target MSMEs outside of major urban areas of Kitui and Mwingi
	○ In operation > two years
	○ Licensed and unlicensed MSMEs, and members of Associations and those who are not members
Categorization**	○ Low-powered energy grouping
	○ High-powered energy grouping
Recommended Modules for Training***	❖ Business operations and management
	❖ Linkages along value chains
	❖ Marketing
	❖ Business associations
	❖ Financial skills and linkages
	❖ Incorporating ICT

Activities****	• Training (36 contact hours)
	• Mentorship (4 visits over 4 months)
Approximate investment for the training	**~KES 5,356,800**

* Evidence shows that it is important to distinguish between 'subsistence entrepreneurship' versus 'growth entrepreneurship', where subsistence entrepreneurs do not actively seek to grow their businesses beyond simply hiring family members. Nurturing growth entrepreneurs has the potential to spur innovation and competition and build local economies (see: Valerio et al., 2014).

**Important to note is that men are more likely to own businesses that require higher amounts of energy (high-powered MSMEs), so any additional provision of energy services is likely to benefit men more than women entrepreneurs by default. Consequently, implementation of any energy access activities must be careful not to reinforce existing power dynamics and reduce the additional barriers for entry to programmes or running businesses that women face.

***The modules should be designed with a gender and intersectional lens and aim to be as inclusive as possible.

****Similarly, to the above, activities should aim to be gender transformative, with women mentors mentoring women entrepreneurs, visit times should consider the additional domestic burdens that women are typically responsible for, and so on.

Additional technical assistance funds are needed to support various activities alongside the investments on energy systems and appliances.

Technical assistance funds for planning and supporting services for delivery model	
Survey of MSMEs to better understand types of MSMEs in Kitui and their needs	This could link with existing surveys that partners are carrying out- for examples linking to KNBS MSMES most recent datasets and identifying specific gaps that can be embedded into a statistically significant, Kitui-specific dataset.
The Comprehensive training would require technical assistance funds to design and implement them	The partnership for this technical assistance funds could include: ○ Ministry of Trade ○ Chamber of Commerce, Kitui- offers training to its members on business development skills, which can be customised depending on business and group interest. ○ TechnoServe in Kenya ○ Sidai Network who provide training for livestock and crop farmers (see Livestock Solution) ◦ Existing polytechnics and Vocational Training Centres in Kitui

1.47 Cooking priority investments

Desired impact: Increased adoption and use of clean cooking solutions for households in Kitui County.

The priority need identified was improved access to cleaner, more efficient and affordable fuels and technologies for cooking for households in Kitui. The following gaps/barriers were identified during the needs assessment and consultation with stakeholders:

- Lack of alternative cooking fuels that are cleaner, cheaper, and faster

- Lack of well-established distribution channels for cleaner fuels and technologies to reach remote unserved communities.
- Lack of qualified technicians to provide quality installation, repair, and maintenance services for different cooking technologies in rural areas.
- Deep-rooted cultural cooking practices which impede adoption and usage of alternative cleaner cooking fuels and technologies by communities.
- Lack of awareness on negative impacts of continued use of traditional cooking solutions on their health, finances, and the natural environment. Similarly, lack of awareness on benefits of using clean cooking solutions.

The priority investment aims to address the critical lack of data to build understanding of the current drivers of cooking fuel and technology use, including disaggregating use by different groups of end users in Kitui County (grouped at present into the four categories of households outlined in Section 6:11), particularly the socio-cultural behavioural factors underpinning cooking and eating practices and preferences. This data will then inform the development of financially, socially and environmentally sustainable solutions.

Rationale for Prioritisation

Business-as-usual approach which assumes a ''one-size fits all'' type of solution appears not to be working in Kitui. This is demonstrated by a high number of households without clean cooking solutions. A different approach is required based on deeper understanding of the socio-cultural, behavioural as well as the economic issues which inform households' decisions to adopt and use certain cooking solutions. There is a critical lack of data that would allow for sustainable cooking solutions to be developed to address these barriers/gaps and identify enablers, including:

- Lack of disaggregated data on cooking needs of different categories of households
- Lack of disaggregated data on use of cooking technology and fuel use (exclusivity or stacking) by different user groups.
- Lack of disaggregated data on specific drivers for use of different cooking solution by end users including the socio-cultural and behavioural factors and affordability issues (eg free access to firewood).

Next steps

1. Carry out additional research to fill the data gaps and address the following set of questions:

    - What are the current patterns of fuels and cooking technologies usage by end-user group (exclusive usage or practice stacking)?
    - How do cooking practices influence the use of different cooking solutions by the end-users?
    - What are the consumption patterns for different cooking fuels by end-user in Kitui?
    - What factors influence the preference for certain fuels and cooking technologies by end-users in Kitui looking at urban, peri-urban and rural set-up?
    - Business models used currently in Kitui County: what are the successes, and the challenges?
    - What are the current distribution models for various clean cooking fuels and technologies, in terms of the strengths, and weakness of these models as well as the actors involved?

An initial piece of research currently being undertaken in a small number of sub-counties by the project team and other partners (see Box 2) could provide a model and methodology for more extensive research across all the sub-counties of Kitui County.

Box 2: Cooking research in Kitui County

IIED in collaboration with Caritas Kitui, African Centre for Technology Studies (ACTS) and Access to Energy Institute (A2EI) are undertaking action research on access and use of cooking fuels and technologies in Kitui County with a sample of different types of poor end user groups across three Sub-counties (Mwingi Central, Kitui Central and Kitui Rural) to identify the drivers of their usage of cooking fuels and technologies and the gaps that are hindering uptake of cleaner cooking solutions.

The study methodology follows the following steps

Literature review and key informant interviews

- Phase 1: Household selection
- Phase 1: Data collection: Household Survey, cooking-diaries, and automated monitoring
- Phase 1: Participatory analysis
- Phase 2: Testing of new appliances technologies, cooking diaries and supporting activities
- Data entry, analysis and interpretation
- Reporting

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From Planning to Implementation

1.48 Overview

The CEP considered the priority sectors and activities outlined in the 2017-2202 CIDP and also the development priorities identified by community members and sectoral stakeholders during an in-depth and inclusive needs assessment process. This offers the opportunity for each of the sectoral ministries to consider the synergies of the solutions proposed with existing sectoral programmes and projects, as well as to form the basis of, or contribute to, new programmes developed under the next CIDP (2023-2028).

1.49 Integration of solutions into County Development Planning

Kitui County has a robust CEP Technical Committee that draws its memberships from all sectors and that can drive a cross-sectoral implementation process. The initial steps to be undertaken will be to carry out the demonstration phase for the solutions, followed by optimisation and detailed implementation planning.

Republic of Kenya (2012) states that no funds should be appropriated in the budget unless planned for. Therefore, for ease of budgetary allocation and sustained resourcing of the CEP solutions beyond the year 2022, the solutions should be integrated into the forthcoming CIDP (2023-2028). The implementation of the solutions will be operationalised through the ADPs (as provided for under Section 126 of the Public Finance Management Act). The ADP is a yearly plan drawn from the CIDP and allowing for more detailed planning and for any changes required in response to emerging issues in the county.

The Technical Committee can play a leading role in this phase, by engaging the different sectoral Ministries and Departments on integrating (the various components of) different solutions and priority investments into the new county integrated development planning process. The MENR will undertake socialisation activities targeting different sectors and internal and external stakeholders, including members of the County Executive and the wider public, with aim of enhancing their understanding on contents of the CEP and the need for the integrated approach to its implementation.

The ADP is supposed to be presented to the County Assembly by the 1st of September each year. This means different sectoral ministries in Kitui, led by MENR, can present the CEP solutions to members of the county assembly to allocate commensurate budgets to (components of) the proposed solutions in each of the sectors, as well as for aggregation of solutions (or solution components).

It is important to note that counties have diverse sources of revenues that could be used to finance the CEP. They include:

1. Equitable Share: funds which parliament share vertically between national and county governments. Which the senate then allocates horizontally in 47 counties. The money is the ordinary tax collected by the national government across the country.
2. Own sources of revenue: Article 209 (3) of the Kenyan Constitution empowers the county governments to impose two types of taxes and charges; property rates and entertainment taxes.
3. Conditional Grants: Counties can receive additional revenue from the national government under conditional grants. Comes with restriction on how they are to be spent.
4. Loans: These could be from external sources or private lenders. This is applicable if the national government guarantees the loans and also, the amounts to be borrowed must be approved by the county assembly.

5. Donor funding: involves aid from international donors or development partners. International donors or development partners provide aid in the form of loans and grants (see 6.15 below).
6. Investments: Counties can receive returns or profits from undertaking investments (return on investments

1.50 Partnerships and Co-financing

There are also potential synergies/opportunities on the level of aligning (components of) solutions with existing projects and initiatives being undertaken by the national government, other development partners, either donor agencies or NGOs, and the private sector and develop partnerships for solution delivery. This could add value in terms of learning from, and leveraging, existing good practice and stakeholder relationships in different sectors, and help to maximize available resources.

In addition to mapping of such potential delivery partners/co-implementers undertaken during the solutions development, the project team undertook an initial mapping of potential sources of co-financing in different sectors. The projects and initiatives that were mapped in relation to the different sectoral solutions are listed both in the description of the individual solutions and summarised in the Annexes. Project collaborator WRI carried out mapping focussed on the energy, health, agriculture and livestock sectors (see Annex 3) and the project team carried out a further mapping of off-grid energy suppliers (see Annex 2).

There is potential to develop specific financing mechanisms to support delivery of several of the solutions, and to address affordability gaps and ensure social inclusion in target groups (for instance to ensure poorer farmers can participate in the agriculture and livestock solutions). One example would be a revolving fund managed by the County Government to provide cross-sectoral financing for the capital costs of energy systems or equipment components of solutions. Further research and analysis will be needed during the demonstration phase to develop the detailed modalities of the financing and payment models required to meet individual or cross-sectoral financing needs.

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Annex 1: Relevant national and county legislation relating to energy planning

- County Government Act, 2012 that provides for the regulation required to implement the provisions relating to devolved government and to give effect to Chapter 11 of the Constitution, to provide for county government powers, functions and responsibilities to deliver services and for connected purposes
- The Consumer Protection Act No. 46 of 2012 that provides for consumer protection and prevention of unfair trade practices in consumer transactions.
- The National Government Loans Guarantee Act No. 18 of 2011 that provides for the transparent, prudent and equitable management of the authority to guarantee loans conferred on the National Government.
- The Standards Act, Chapter 496 of the Laws of Kenya that provides for establishment of minimum quality specifications, mode, materials and apparatus used in the country.
- The Environmental Management and Co-ordination Act, 1999, which regulates the environmental issues including those relating to the energy sector.
- The Physical Planning Act, Chapter 286 of the Laws of Kenya that provides for zoning of areas for storage, distribution and retailing of petroleum products and construction of electric power sub-stations and other infrastructure
- The Weights and Measures Act, Chapter 513 of the Laws of Kenya under which storage tanks and dispensing equipment for sale of petroleum products are calibrated and regulated for accuracy.
- The Public Procurement and Asset Disposal Act No. 33 of 2015 that establishes procedures for efficient public procurement and for the disposal of unserviceable, obsolete or surplus, stores, assets and equipment by public entities.
- The Anti-Corruption and Economic Crimes Act No. 3 of 2003 which provides for prevention, investigation and punishment of corruption, economic crime and related offences.
- The Public Officer Ethics Act No. 4 of 2003 which provides for code of conduct and ethics for public officers.
- The Ethics and Anti-Corruption Commission Act No. 22 of 2011 which establishes the Ethics and Anti-Corruption Commission.
- The Land Act 2012 No. 6 of 2012 which provide for matters relating to public, private and community land.
- The Land Registration Act, No. 3 of 2012 which provides for registration of titles to land and the objects of devolved government in land registration.
- The National Land Commission Act 5 of 2012 that provides for the establishment of the National Land Commission.
- The Environment and Land Court Act No. 19 of 2011 that provide for the establishment of the Environment and Land Court.
- The Urban Areas and Cities Act No. 13 of 2011 that provide for the, classification, governance and management of urban areas and cities.

Annex 2: List of suppliers of renewable energy systems

	Entrepreneur	Contacts	Products/Services	Core Business
1	Altener Energy Technologies Ltd	Charles Oloo +254 721 727 830 info@altenersolar.co.ke www.altenersolar.co.ke	Design, supply, installation of solar water heating (SWH), solar cooking, solar PV systems. designs and locally assembles solar water heating & solar cooking systems.	Solar PV products supplier.
2	Africa Solar Designs Ltd	Karin Sosis +254 707 823 166 ksosis@africasolardesigns.com www.africasolardesigns.com	Renewable energy consultants, design, installation and servicing of solar PV projects including mini grids and captive systems	Re consultants and solar PV systems installers.
3	Center for Alternative Technology	Nawir Ibrahim +254 722 512 004 nawir@cat.co.ke www.cat.co.ke	Supplier of good quality RE equipment to entrepreneurs and installers of solar PV systems.	Solar PV products supplier.
4	Craftskills East Africa Limited	Simon Guyo +254 724 324 273 simon@craftskillseastafrica.com www.craftskillseastafrica.com	Long standing entrepreneur in local design, assembly, installation, training and maintenance of wind turbines &installer of solar PV systems. established his business in his backyard in the 1980s.	Wind energy products supplier and installer.
5	Mibawa Suppliers Ltd	Michael Wanyonyi +254 712 455 714 wanyonyi@mibawa.com www.mibawa.co.ke	Solar PV pico and solar water pumping systems, design, sales, installation, training & maintenance.	Solar PV products supplier.
6	Off grid Energy Alternative	Maina Mumbi +254 728 781 690 elecsolar@gmail.com No website	Installer, trainer, sales and service of solar PV systems based in Naivasha.	Solar PV system installers.

7	PowerGen Renewable Energy	Sam Slaughter +254 718 015 737 sslaughter@powergen-re.com www.powergen-re.com	Solar PV/wind system design & engineering; procurement; system implementation & integration; operations & maintenance; advisory & consulting. installation and management of micro grid systems in Zambia, Kenya and Tanzania.	Solar mini and micro grid developer.
8	Powerpoint Systems (EA) Ltd	Cosmas Kilili +254 722 155 534 musyoki@powerpoint.co.ke www.powerpoint.co.ke	Solar PV systems imports, sales, supply, design & installation and distribution. also supply mains power control equipment.	Solar PV products supplier.
9	SolarWorks	Dickson Muchiri +254 722 525 455 mthagichu@solarworksealtd.co.ke www.solarworksealtd.co.ke	Solar PV equipment importer, sales, supply, design & installation of domestic and institutional mini grids.	Solar PV products supplier.
10	Solinc EA Ltd	Ismael Abisai +254 715 255 025 abisai@ubbink.co.ke www.solinc.co.ke	Manufacturer of solar PV modules in based in Naivasha, they recently changed the name from Ubbink EA to solinc EA.	Solar products manufacturer.
11	Sollatek Electronics (K) Ltd	Saleem Abdulla +254 703 673 243 sales@sollatek.co.ke www.sollatek.co.ke	Importer and local assembly of solar lanterns, pico systems and power protection/control equipment. equipment supply and service with a unique 5-year warranty period for power control equipment.	Solar PV products supplier.
12	Sun culture	Sammy Ibrahim +254 700 327 002 sales@sunculture.com www.sunculture.com	Supply, training, installation & maintenance of solar PV water irrigation systems in kenya,	Solar PV water irrigation products supplier.
13	Sun Transfer (K) Ltd	Gathu Kirubi +254 710 100 059 kirubi@suntransfer.com www.suntransfer.com	Importer, sales, supply, design & installation of solar PV systems for domestic, institutional and mini grid and grid connect systems. work in Kenya, Ethiopia and the Philippines. currently establishing a network of solar centres in of Kenya.	Solar PV products supplier.

14	Sunny Money Kenya)	Sharleen Muthoni +254 726 313 900 sharleen.muthoni@sunnymoney.org www.sunnymoney.org	Social enterprise that designs, supplies, sells & maintains solar PV payGo pico systems through school campaigns; agents and shops.	Solar PV products supplier.
15	RVE Sol	Vivian Vendeirinho No phone number vivian@rvesol.com www.rvesol.com	Both off-grid and on grid mini/micro-grid developers - domestic and institutional	Solar mini and micro grid developer.
16	Powerhive	Rik Wuts Phone number N/A rik@powerhive.com www.powerhive.com	Both off-grid and on grid mini/micro-grid developers - domestic and institutional	Solar mini and micro grid developer.
17	Virunga Power	Brian Kelly Phone number N/A brian.kelly@virungapower.com www.virungapower.com	Both off-grid and on grid mini/micro-grid developers - domestic and institutional.	Hydro powered mini and micro grid developer.
18	Wind for Prosperity (Kenya)	Bernard Osawa Phone number N/A bos@frontier.dk www.frontier.dk	Off-grid mini/micro grid developer.	Wind powered mini and micro grid developer.
19	Solarkiosk	Andreas Spiess Phone number N/A spiess@solarkiosk.eu www.solarkiosk.eu	Standalone solar hub for powering businesses institutions.	Solar PV products supplier.
20	Biashara Energy Solutions Ltd	Shadrack K. Kamau Phone number N/A biasharaenergy@gmail.com www.biasharaenergy.webs.com	Design, feasibility studies of renewable energy solutions. high efficiency products/appliances.	Solar mini and micro grid developer.

21	Africa Power Ltd	Alastair Livesey +44 7401 910251 alivesey@africapowerltd.com www.africapowerltd.com	Solar water pumping solutions, high efficiency solar products.	Supplier of solar pumping products.
22	Husk Power Systems	Phone number N/A info@huskpowersystems.com www.huskpowersystems.com	Off-grid mini/micro grid developer.	Solar mini and micro grid developer.
23	Rafiki Power	Phone number N/A info@rafikipower.com www.rafikipower.com	Off-grid mini/micro grid developer.	Solar mini and micro grid developer.
24	Rift Valley Energy	Mike Gratwicke Phone number N/A info.rvetz@riftvalley.com www.riftvalleyenergy.com	Hydro, thermal and wind mini grid projects.	Hydro, thermal and wind powered mini grids.
25	Steamaco	Phone number N/A contact@steama.co www.steama.co	Off-grid mini/micro grid developer.	Solar mini and micro grid developer.
26	RE-DAVIA Rental Solar Power	Erwin Spolders Phone number N/A hello@redaviasolar.com www.redaviasolar.com	Both off-grid and on grid mini/micro-grid developers - domestic and institutional.	Solar mini and micro grid developer.
27	JUMEME	+255 769 486 844 info@jumeme.com www.jumeme.com	Off-grid mini/micro grid developer.	Solar mini and micro grid developer.
28	Rubitec Solar	Bolade Soremekun B.Pharm +234 903 2600 077 www.rubitecsolar.com	Solar and inverter, backup systems, small hydro power, biomass energy systems, waste to energy plant, land-fill gas plants and wind energy.	Solar PV products supplier.
29	Havenhill Synergy	+234 706 380 388 info@havenhillsynergy.com www.havenhillsynergy.com	Mini grids or solar & power backup systems.	Solar mini and micro grid developer.

30	ACOB Lighting Technology Limited	+234 80 3290 2825 info@acoblighting.com www.acoblighting.com	Installation and maintenance of renewable energy products.	Solar mini and micro grid developer.
31	Nayo Tropical Technology	+234 08093745193 info@nayotechnology.com www.nayotechnology.com	Solar home system installer, mini grid developer, and standalone solar powerhouses.	Installation of shss and standalone solar powerhouses.
32	Nirav Agencies	Savan Shah Phone number N/A savan@nal.co.ke No website	Both off-grid and on grid mini/micro-grid developers - domestic and institutional	Solar mini and micro grid developer.
33	Strauss Energy	+254 020 440 9938 info@straussenergy.com www.straussenergy.com	Mini grids and solar PV solutions.	Solar mini and micro grid developer.
34	Dream EP	+254 20 780 370 info@dream-kenya.com www.dream-kenya.com	Mini grids and solar PV solutions incluing SHSs, captive power solutions and street lighting solutions.	Solar mini and micro grid developer.
35	Renewvia Energy	+254 730 112 158 Contact email N/A www.renewvia.com	Mini grids and solar PV design and installtion, captive power solutions and street lighting solutions, consultation and financing.	Solar mini and micro grid developer.
36	AEG international	Phone number N/A Contact email N/A www.aeginternational.us	Solar lantern kits, firefly, pico solar home power station, solar streetlights, and multi-MW solar farms.	Solar PV products manufacturer.
37	All solar lights	Harold de Rijck Phone number N/A info@allsolarworld.com No website	Complete home-use lighting kit containing high efficiency patented led bulbs and a USB socket.	Solar PV products manufacturer.
38	Nadji.Bi Group	Phone number N/A group@nadjibi.com www.nadjibi.com/en_US	Solar lighting systems, solar hybrid home systems, solar home systems, solar streetlights, solar water pumps, solar cold solutions, inverters and controllers.	Solar PV products manufacturer.

39	Poly Solar Technologies Co. Ltd	Phone number N/A info@polysolar.cn www.en.polysolar.com.cn	Solar PV panels, solar lighting systems.	Solar PV products manufacturer.
40	Speed tech Energy	Phone number N/A Contact email N/A www.speedtechenergy.com.tw	Solar lighting systems, solar hybrid home systems, solar mini home systems, solar streetlights, solar water pumps, high efficiency solar products.	Solar PV products manufacturer.
41	True Solar USA Inc.	+65 9487 1142 sales@truesolarusa.com www.truesolarusa.com.sg	Solar lanterns, solar lighting system, solar home systems.	Solar PV products manufacturer.
42	Village boom GmbH	Thomas Ricke Phone number N/A ricke@villageboom.com www.villageboom.com	Solar lanterns, solar lighting systems.	Solar PV products manufacturer.
43	Azuri Technologies Ltd	Nigel Preston Phone number N/A info@azuri-technologies.com www.azuri-technologies.com	PayGo solar systems .	Solar PV products manufacturer.
44	Anji DaSol Solar Energy Science & Technology Co, Ltd	Mabel Wang Phone number N/A mabel@dasol.cn www.dasol.cn	Solar lighting systems, solar water pumping.	Solar PV products manufacturer.
45	Barefoot Power Ltd	Anthony Lenthen Phone number N/A info@barefootpower.com www.barefootpower.com	Micro-solar lighting and phone charging products.	Solar PV products manufacturer.
46	D. light design	Rainbow Huang Phone number N/A testing@dlight.com www.dlight.com	Solar lanterns and solar lighting systems.	Solar PV products manufacturer.

47	Fosera Group	Guzman Zotes Phone number N/A info@fosera.com www.fosera.com	Solar home systems.	Solar PV products manufacturer.
48	Freeplay Energy	Viv Jenkins Phone number N/A vjenkins@freeplayenergy.com www.freeplayenergy.com	Solar lanterns and solar lighting systems.	Solar PV products manufacturer.
49	Futura	Patrick O'Leary Phone number N/A admin@futurasolar.com www.futurasolar.com	Captive solar systems.	Solar PV products manufacturer.
50	Greenlight Planet	Ben Matthew Phone number N/A sales@greenlightplanet.com www.greenlightplanet.com	Solar lanterns, solar lighting system and solar home systems.	Solar PV products manufacturer.
51	JUA Energy	Hill Ren Phone number N/A hill.ren@juaenergy.com www.juaenergy.com	Solar lanterns, solar lighting system and solar home systems.	Solar PV products manufacturer.
52	Little sun	Mason Huffine Phone number N/A mason@littlesun.com www.littlesun.com	Solar lanterns and solar lighting systems.	Solar PV products manufacturer.
53	M-KOPA Solar	Manish Sharma Phone number N/A manish.sharma@m-kopa.com www.m-kopa.com	PayGo solar systems.	Solar PV products manufacturer.

54	Mibawa Suppliers Ltd	Michael Wanyonyi '+254 772 707 800 info@mibawa.co.ke www.mibawa.co.ke	Solar lighting systems.	Solar PV products manufacturer.
55	Mobisol	Jens Hohne Phone number N/A communications@plugintheworld .com www.plugintheworld.com	Solar home systems.	Solar PV products manufacturer
56	Niwa Next Energy Products Ltd	Ti el Attar Phone number N/A sales@niwasolar.com www.niwasolar.com	PayGo solar systems (solar lighting systems, home systems), high efficiency appliances.	Solar PV products manufacturer.
57	Nokero International Ltd	1-303-991-9871 salessupport@nokero.com www.nokero.com	High efficiency solar lights.	Solar PV products manufacturer.
58	Nuru Energy	Simon Treemer Phone number N/A stremeer@nuruenergy.com www.nuruenergy.org	Solar lanterns, high efficiency appliances, solar panels.	Solar PV products manufacturer.
59	Off-Grid Sun	+39 049 5979802 info@offgridsun.com www.offgridsun.com	Solar lanterns, solar lighting system, solar home systems, solar street lighting, solar pumping kits.	Solar PV products manufacturer.
60	Omnivoltaic Power Co., Ltd	Alpha Guo Phone number N/A sales@omnivoltaic.com www.omnivoltaic.com	High efficiency solar appliances, solar lanterns.	Solar PV products manufacturer.
61	Orb Energy	Ramin Nadimi Phone number N/A ramin.nadimi@orbenergy.com www.orbenergy.com	Solar home systems, captive power solutions, solar water heating.	Solar PV products manufacturer.

62	Renewit Solar Limited	Richard Atwal Phone number N/A richard@renewit.com www.renewit.com	Solar home systems, solar lighting systems, commercial solar systems.	Solar PV products manufacturer.
63	Sinoware Technology Co., Ltd	Tommy Huang Phone number N/A tommyhuang@sinoware.com.cn www.sinoware.com.cn	Solar home system and solar lanterns.	Solar PV products manufacturer.
64	SolarWorks!	Thomas de Wijn Phone number N/A info@solarworks.nl www.solar-works.co.za	High efficiency appliances.	Solar PV products manufacturer.
65	Zimpertec	Antonn Zimmermann Phone number N/A info@zimpertec.com www.zimpertec.com	LED-lighting, prepayment systems, solar home system and solar charge controller.	Solar PV products manufacturer.
66	Mpowerd	Phone number N/A support@mpowerd.com www.mpowerd.com	Solar lanterns	Solar PV products manufacturer
67	Shenzhen LEMI Technology Development Co	Wendy Chen Phone number N/A info@lemi88.com www.enfsolar.com	Solar home system and solar street lights.	Solar PV products manufacturer.
68	Sollatek Electronics	Robert Kairo +254 725 546 865 robert.kairo@sollatek.co.ke www.sollatek.co.ke	Distributor of D.light products.	Solar PV products manufacturer.
69	Total Kenya Ltd	Jeremia Kithae Phone number N/A jeremia.kithae@total.co.ke www.total.co.ke	Distributor of D.light products.	Solar PV products manufacturer.

70	D.light Africa Office	David Small Phone number N/A david.small@dlightdesign.com www.dlight.com	Distributor of D.light products.	Solar PV products manufacturer.
71	Smart Solar (K) Ltd	Jackson Machuhi '+254 733 822 988 Jacksonm@barefootpower.com No website	Distributor of Barefoot Power products.	Solar PV products manufacturer.
72	Barefoot Power Kenya offices	Boldewijn Sloet Phone number N/A boldewijns@barefootpower.com www.barefootpower.com	Distributor of Barefoot Power products.	Solar PV products manufacturer.
73	Power Technics Limited	Kamal Gupta Phone number N/A kamal_gupta@powertechnics.com No website	Distributor of Schneier Electric products.	Solar PV products manufacturer.
74	Greenlight Planet Kenya Offices	Radhika Thakkar +254 737 135 570 radhika@greenlightplanet.com www.greenlightplanet.com	Distributor of Greenlight Planet products.	Solar PV products manufacturer.
75	Sola Taa	Deepali Gohil +254 722 228 888 deepali.gohil@solataa.co.ke www.solataa.co.ke	Distributor of Greenlight Planet products.	Solar PV products manufacturer.
76	Radbone Clark	James Wanyande +254 722 206 310 james_wanyande@radboneclark.com No website	Distributor of Greenlight Planet products.	Solar PV products manufacturer.

77	Ezylife Kenya	Mathew Kimolo Phone number N/A mkimolo@ezylife.co.ke www.ezylife.com	Distributor of Greenlight Planet products.	Solar PV products manufacturer.
78	Renewable Energy Ventures (K) Ltd.	Carol Wacera +254 737 135 570 cwacera@africarenewables.com www.energy-kenya.com	Distributor of Greenlight Planet products.	Solar PV products manufacturer.
79	Trony East Africa Ltd	Scott Hua +254 706 100 100 hua.shengkun@trony.com www.trony.com	Distributor of Trony Sofar Holdings products.	Solar PV products manufacturer.
80	Omnivoltaic Africa Limited	Dennis Maiyo +254 720 780 803 dennis.maiyo@omnivoltaic.com www.omnivoltaic.com	Distributor of Omnivoltaic products.	Solar PV products manufacturer.
81	One Degree	Paul Okech Onyango +254 721 584 684 paul@onedegreesolar.com www.onedegreesolar.com	Distributor of One Degree products.	Solar PV products manufacturer.
82	Pulse Experiential Ltd	Craig Inda +254 723 421 111 craig@nokero.com No website	Distributor of Nokero products.	Solar PV products manufacturer.
83	Sidian Bank	Esther Daudi +254 711 058 146 talktous@sidianbank.co.ke www.sidianbank.co.ke	Distributor of Orb Energy products.	Solar PV products manufacturer.

84	Deutrex 818 Ltd	Gladys Cliff +254 722 880 666 murungi@deutrex818.com No website	Distributor of NIMH Technolinks products.	Solar PV products manufacturer.
85	Hensolex	Kamau wa Njeri +254 722 323 168 kamauwanjeri@yahoo.com www.hensolex.co.ke	Distributor of Solux products.	Solar PV products manufacturer
86	Solar Green Africa	Aleksandra Zakrzewska +254 734 640 823 alex@solargreenafrica.com No website	Distributor of Pharos products.	Solar PV products manufacturer.
87	Nuru East Africa Ltd	Bernard Kinyanjui Phone number N/A bkinyanjui@nurulight.com www.nuruenergy.org	Distributor of Nuru Energy products.	Solar PV products manufacturer.
88	Suntransfer (K) Ltd	Gathu Kirubi Phone number N/A mailkenya@suntransfer.com www.suntransferkenya.com	Distributor of Niwa-Next Energy products.	Solar PV products manufacturer.
89	Mark Holdings	Sanjay Verma +254 729 110 901 markholdings.africa@gmail.com www.markholdingskenya.com	Distributor of Mark Holdings products.	Solar PV products manufacturer.
90	Kingfisher Consultants Ltd	Derek Steel +254 717 639 620 info@sunlite.co.ke No website	Distributor of Sunlite products.	Solar PV products manufacturer.

Annex 3: Mapping of funders and projects focussed on the energy, health, agriculture and livestock sectors

Name	Agency Type	Targeted Sector	Funding Mechanism	Target County	Project /Programme Title	Project Description	Committed Amount (USD/GBP/Euro)	Current Project Y/N	End Date	Implementing Agency/Partner(s)	Link
IDA	DFI	Agriculture & Livelihoods	Grants (To Implementing Partners)	Cluster (Turkana, Makueni, Meru, Kitui, Embu, Kilifi, Kwale, Narok, Kirinyaga, Kiambu, Murang'a & Nakuru)	National Ag. & Rural Inclusive Growth	This project will be implemented in 24 counties, including **Turkana, Makueni, Meru, Kitui, Embu, Kilifi, Kwale, Narok, Kirinyaga, Kiambu, Murang'a and Nakuru.** Its development objectives are to increase agricultural productivity and profitability of targeted rural communities. It has 4 major components including: Component 1 - Supporting Community-Driven development and aims to strengthen: (a) community-level institutions' ability to identify and implement investments that improve their agricultural productivity, food security, and nutritional status and (b) linkages to selected Value chains (VCs) and Producer Organizations (POs). Component 2 - Strengthening Producer Organizations and Value Chain Development, aims to build POs' capacity to support member Common Interest Groups (CIGs) and Vulnerable and marginalized groups (VMGs) to develop selected priority VCs in targeted	US$ 200 M		Dec. 2021	Ministry of Agriculture, Livestock, Fisheries and Irrigation;The National Treasury and Ministry of Planning	http://projects.worldbank.org/P153349/?lang=en&tab=details

						rural communities. Component 3 - Supporting County Community-Led Development, aims to strengthen the capacity of county governments to support community-led development initiatives identified under Components 1 and 2. It has two subcomponents as follows: (a) Capacity Building of Counties; and (b) County Investment and Employment Programs. Component 4 - Project Coordination and Management, finances activities related to national and county-level project coordination					
IDA	DFI	Energy	Loans/Debts (To GoK)	All	KE Electricity Modernization Project	Its objectives are: (a) to increase access to electricity; (b) to improve reliability of electricity service; and (c) to strengthen KPLC's financial situation. The project has four components. **Component 1** - improvement in service delivery and reliability; **Component 2** - revenue protection programmes aimed at permanently protecting the revenues that KPLC receives from sales to large and medium customers, ensuring that all users in that high value segment are systematically billed according to accurately metered consumption and thus reduce non-technical losses through (i)	US$ 250 M	2015	2020	KPLC & REA	http://projects.worldbank.org/P120014/electricity-modernization-project?lang=en&tab=details

						creation of one or more Metering Control Centers (MCCs) and investments in IT infrastructure needed to operate them; (ii) incorporation of state-of-the-art Meter Data Management software and training of staff in the MCCs in its proper use; and (iii) supply and installation. **Component 3** - electrification programmes, will support the government's objective of 70% HHs connectivity by 2018 by providing grant financing for the connection of new households					
IDA	DFI	Energy	Grants (To Implementing Partners)	Cluster (Garissa, Isiolo, Kilifi, Kwale, Lamu, Mandera, Marsabit, Narok, Samburu, Taita Taveta, Tana River, Turkana, Wajir, & West Pokot)	Kenya Off-Grid Solar Access Project (KOSAP)	Its objective is to increase access to modern energy services in underserved counties of Kenya which include Garissa, Isiolo, Kilifi, Kwale, Lamu, Mandera, Marsabit, Narok, Samburu, Taita Taveta, Tana River, Turkana, Wajir and West Pokot. The project has 4 components. **Component 1** - mini grids for community facilities, enterprises, and households. **Component 2 -** stand-alone solar systems and clean cooking solutions for households. **Component 3** - stand-alone solar systems and solar water pumps for community facilities. **Component 4** - implementation support and capacity building, which includes two subcomponents: consumer education and citizen	US$ 150 million	2017	2023	Kenya Power & Lighting Company Limited (KPLC) & Rural Electrifiction Authority (EA)	http://www.worldbank.org/en/news/press-release/2017/07/26/world-bank-approves-150-million-for-kenya-to-provide-solar-energy-in-underserved-northeastern-counties

						engagement, and implementation support and capacity building.					
IDA	DFI	Health	Grants (To GoK)	All	Tranforming Health Systems	The objective of this project is to improve utilization and quality of primary health care (PHC) services with a focus on reproductive, maternal, newborn, child, and adolescent health (RMNCAH) services. The project comprises of three components. **Component 1** - improving PHC results aims to improve the delivery, utilization, and quality of PHC services at the county level with a focus on RMNCAH. **Component 2** - strengthening institutional capacity aims to strengthen institutional capacity to better deliver quality PHC services under component one. Three sub-components include: (i) improving quality of care; (ii) strengthening M&E and civil registration and vital statistics (CRVS); and (iii) supporting health financing reforms towards universal health coverage (UHC). **Component 3** - cross-county & intergovernmental collaboration, and project management aims	US$ 191 M	2016	2021	Ministry of Health	http://projects.worldbank.org/P152394/?lang=en&tab=details

						to enhance cross-county and intergovernmental collaboration as well as facilitate and coordinate project implementation.					
IDA	DFI	Agriculture & Livelihoods	Loans/Debts (To GoK)	Cluster (Mombasa, Trans Nzoia)	Kenya Water Security and Climate Resilence project	The project's development objectives are to (i) increase availability and productivity of irrigation water for project beneficiaries; and (ii) enhance the institutional framework and strengthen capacity for water security and climate resilience for the country. The project has three components. Component 1 - water resources development aimed at supporting climate resilience and water security for economic growth by financing water investments and by progressively building a longer-term investment pipeline. Component 2 - effective water sector institutions. It will support the current sector institutions, as well as the preparation, implementation and full functioning of the new; legal and institutional framework resulting from alignments with the Constitution of Kenya 2010.	US$ 182.67 M	2013	2022	Ministry of Environment, Water & Natural Resources	http://projects.worldbank.org/P117635/kenya-enhancing-water-security-climate-resilience?lang=en&tab=details

						Component 3 - support for project implementation.					
IDA	DFI	Agriculture & Livelihoods	Loans/Debts (To GoK)	All	Kenya Social and Economic Inclusion Project (KSEIP)	The objective of the KSEIP is to strengthen delivery systems for enhanced access to social and economic inclusion services and shock-responsive safety nets for poor and vulnerable households. It has three components: ***Component 1***: Strengthening Social Protection Delivery Systems; ***Component 2***: Increasing Access to Social and Economic Inclusion Interventions; & ***Component 3:*** Improving the Shock Responsiveness of Safety Net System	US$ 250 M	2018	2023	State Department for Social Protection (SDSP) & National Drought Management Authority (NDMA)	http://projects.worldbank.org/P164654?lang=en

USAID	Donor	Agriculture & Livelihoods	Grants (To Implementing Partners)	Cluster (Busia, Kakamega, Kisumu, Kitui, Makueni, Migori, Nairobi, Nyamira, and Siaya)	Kenya Integrated Water Sanitation and Hygiene (KIWASH)	KIWASH is implementing activities which contribute to six distinct objectives: Scale up market-based WASH service delivery models, Increase and sustain access to finance/credit for WASH, Improved access to integrated WASH and Nutrition services, Increased production and consumption of nutrient-dense, diverse foods, Increased environmental sustainability of WASH services, Strengthen governance of WASH services and water resources institutions and Support targeted policy reforms advanced which stimulate and improve access improvements. By doing this, KIWASH aims to enable more than 1 million Kenyans to gain access to improved WASH services and assist households in gaining access to irrigation and nutrition services. KIWASH will partner with water and sanitation service providers to develop bankable business plans, improve operations, and facilitate access to financing.	US$ 50 M	N/A	N/A	DAI	https://explorer.usaid.gov/query?country_name=Kenya&fiscal_year=2017&transaction_type_name=Obligations

USAID	Donor	Agriculture & Livelihoods	Grants (To Implementing Partners)	Cluster (Kisumu, Kisii, Homa Bay, Migori, Siaya, Vihiga, Kakamega, Busia, Bungoma, Kitui, Makueni, Taita Taveta, Turkana, Marsabit, Isiolo, Garissa, Wajir)	Feed the Future (FTF)	FTF Kenya supports innovative, private-sector-led solutions and government policies to strengthen value chains for dairy, horticulture, livestock, and staple crops to increase incomes of smallholder farmers, including women and youth. FTF aligns with and contributes to the US government's Global Food Security Strategy objectives to foster: 1) inclusive and sustainable agricultural-led economic growth; 2) strengthened resilience among people and systems; and 3) a well-nourished population, especially women and children. Via strategic partnerships, the FTF private sector-led market systems approach promotes the commercialization of agriculture that includes producers, off-takers, finance, end markets, and service provision along the entire value chain—one that incentives households and smallholders to move into higher value and commercialized value chains, as well as diversifying into higher-return commodities and non-farm activities	US$ 190 M	N/A	N/A	RTI InternationalACDI/VOCAPalladiumInternational Livestock Research Institute UN Food and Agriculture OrganizationUnited States Department of AgricultureAlliance for a Green Revolution in AfricaKenya Agricultural and Livestock Research OrganizationKenya Plant Health Inspectorate ServiceMillennium Water Alliance	https://explorer.usaid.gov/query?country_name=Kenya&fiscal_year=2017&transaction_type_name=Obligations
USAID	Donor	Agriculture & Livelihoods	Grants (To Implementing Partners)	Cluster (Kitui, Machakos, Makueni, Taita	Improving Smallholder Productivity and Profitability (ISPP)	ISPP aims to strengthen capacities of smallholder farmers to increase agricultural productivity, marketing and utilization of high value food	US$ 7 M	2016	2019	United Nations Food & Agricultural Organization (FAO)	https://www.usaid.gov/sites/default/files/documents/1860/I

				Taveta Tharaka Nithi)		crops in the semi-arid area of Kenya. The project is being implemented in 5 counties, namely Kitui, Machakos, Makueni, Taita Taveta Tharaka Nithi					SPP_Fact_Sheet_March_2019.pdf
USAID	Donor	Agriculture & Livelihoods	Grants (To Implementing Partners)	All	Integrated Agricultural Research for Development (IARD) Programmes	The overall goal of the IARD project is to contribute to increased household income, food and nutritional security through generation and promotion of knowledge, information and technologies that respond to clients' demands and opportunities. The research agenda under the IARD Project seeks to address the identified constraints through targeted interventions in the three selected value chains (staple food crops, dairy & horticulture) in twenty two Counties, underpinned by biotechnology, NRM, socio economics and other cross-cutting arrangements. The approach is based on transfer of ready-to-go technologies which are matched with farmer and/or end-user needs aimed at upgrading the value chains and moving towards commercialization. (Targeted counties not listed)	US$ 7.9 M	2016	2029	Kenya Agricultural & Livestock Research Oganization (KALRO)	https://www.usaid.gov/sites/default/files/documents/1860/Integrated_Agricultural_Research_for_Development_IARD_fact_sheet_2019.pdf

USAID	Donor	Agriculture & Livelihoods	Grants (To Implementing Partners)	Cluster (Kitui, Makueni, Taita Taveta; Homa Bay, Migori, Kisii, Kisumu, Kakamega, Bungoma, Busia, Vihiga & Siaya)	Kenya Crops & Dairy Market Systems Development Activities (KCDMSD)	KCDMSD works to support five priority areas: (i) A competitive, inclusive, and resilient agricultural market system; (ii) Diverse agricultural production and improved productivity; (iii) An improved policy environment for market systems development; (iv) Integration of women and youth into agricultural market systems; and (v) Collaborative action and learning for market systems change and technology adoption. Targeted counties include (SA-2: Eastern) - Kitui, Makueni, Taita Taveta; (HR-1: South West) - Homa Bay, Migori, Kisii, Kisumu & (HR-1: North West) - Kakamega, Bungoma, Busia, Vihiga, Siaya	N/A	Oct. 2017	Sep. 2022	RTI International	https://www.rti.org/news/rti-international-and-usaid-improve-agricultural-market-systems-and-reduce-poverty-and
DfID	Donor	Agriculture & Livelihoods	Blended (Debt, Grants, Equity)	All	Kenya Market Assistance Programme (MAP)	To reduce poverty in Kenya by enabling poor people to benefit from better functioning markets, and by building greater awareness among influential decision makers of how markets can work better for the poor. This will increase household incomes of 148,000 small scale farmers and entrepreneurs - of whom 33% are women - by an average of over 20% by 2018. 36,000 jobs for women and 73,000 for men and male youth will also be created.	GBP 30M (US$ 38M)	Aug. 2012	Mar. 2020	Kenya Markets Trust (lead partner), Agri-Experience, Mercy Corps, TechnoServe and SNV Kenya.	https://devtracker.dfid.gov.uk/projects/GB-1-202698

DfID and EU's Union African Infrastructure Trust Fund (EU-AITF)	Donor	Energy	Grants (To Implementing Partners)	All	Green Mini grids Kenya	The Green Mini Grid Facility Kenya (GMG Facility) avails funds and supports green and sustainable mini grid electrification in Kenya. The GMG Facility provides technical assistance, investment grants and output-based grants to catalyse investment in this sector while providing support to the Kenyan National Electrification strategy.	Euro 30M (US$ 34M)	N/A	N/A	AFD (French Development Agency)	https://www.gmgfacilitykenya.org/
DfID	Donor	Energy & Livelihoods	Grants (To GoK)	Cluster (Undefined)	Sustainable Urban Economic Development (SUED) Programme	DFID is supporting emerging urban centres in Kenya to put in place sustainable urban economic plans; improve the investment climate and draw in investment for key climate-resilient infrastructure and value chain projects. This will include integrating digital technologies to build 'smart' towns/cities that improve the quality and performance of urban services and enable a better quality of life.	GBP 60M (US$ 76M)	N/A	N/A	Coffey in collaboration with Atkins	https://www.suedkenya.org/
Bill & Melinda Gates Foundation	Foundation	Agriculture & Livelihoods	Grants (To Implementing Partners)	Cluster (Undefined)	East Africa Dairy Development Phase II	To enable smallholder dairy farmers to increase their dairy productivity and income through the dairy hub approach, and achieve replication of the approach through private sector and government investment	US$ 25M	Open	Open	Heifer Internatioanl	https://www.heifer.org/ending-hunger/our-work/programs/eadd/index.html

EU/EC	Donor	Energy	Grants (To Implementing Partners)	All	Power Kiosk: Scaling-up Rural Electrification in Kenya, Ethiopia and Madagascar	The overall objective of the POWER KIOSK project partners is to address the needs of remote rural off-grid communities, households and SMEs, in 3 countries for access to clean energy. The project aims at supplying solar energy to 160 selected villages in order to help reduce their dependence on biomass and bio-fuels, decrease air pollution in homes, promote new types of commerce, and improve certain social areas (health, gender) in the area with all their associated impacts.	Euros 9.5M (US$ 11M)	N/A	N/A	Solar Kiosks Kenya Limited	
IDA	DFI	Energy	Loans/Debts (To GoK)	All	Eastern Electricity Highway Project under First Phase of the Eastern Africa Power Integration Programmes	The project sought to contribute to the improvement of reliability of electricity supply in the East Africa region by improving the Eastern Corridor: (a) transfer electricity between Ethiopia and Kenya; and (b) facilitate the integration of the power grids of the East African countries.	US$ 1,262M	2012	2020	Kenya Power & Lighting Company Limited	http://projects.worldbank.org/P126579/regional-eastern-africa-power-pool-project-apl1?lang=en
DfID	Donor	All	Blended (Debt, Grants, Equity)	All	Global Innovation Fund (GIF)	GIF provides funding at 3 stages: pilot, test and scale: and is open to ideas from any sector and any country provided that the innovation targets those living on under $5, or preferably, under $2 a day. GIF encourages applications from anyone and anywhere, including from social enterprises, researchers, governments and corporate organizations with an idea to deliver development results more effectively, quicker or	Open	Open	Open	Self	https://globalinnovation.fund/apply/about/

						cheaper than standard practice. GIF offers grants, loans (including convertible debt), and equity investments ranging from £30,000 to £10 million. Applicants are asked to indicate their preferred capital type and amount on their application.					
Berkely Energy	Fund Manager	Energy	Equity	All	Commercial & Industrial	This is a portfolio of renewable power projects with a primary focus on solar PV located on the premises of and selling power to, highly creditworthy commercial and industrial (C&I) consumers including multinational companies and national conglomerates	US$ 200M	Open	Open	Self	https://www.berkeley-energy.com/africa-renewable-energy-fund/
Energy & Environment Partnership (EEP)	Public	Energy	Blended (Debt, Grants, Equity)	All	N/A	EEP Africa is a multi-donor fund providing early stage grant and catalytic financing to innovative clean energy projects, technologies and business models.Applicants can apply for early-stage grants and repayable grants between EUR 200,000 — 500,000. The minimum required co-financing is 30% of the total project budget.	Euro 200K - 500K Euros	Open	Open	Self	

Africa Enterprise Challenge Fund (AECF)	Impact Investor	Energy	Grants (Repayable)	All	REACT SSA	Eligible techonologies include Renewable technologies such as hydro-power, solar energy, biomass and wind energy, household level solar home systems, comprising of basic lighting, phone charging systems and radios, made available to large numbers of households through pay-as-you-go (PAYGo) systems; Large solar power stand-alone systems for productive use, comprising of phone charging systems, radio etc. and that can be used at small scale rural based business premises to provide the required power. Larger solar power systems that meet the full range of household needs and are still affordable for low income individuals Larger centralised renewable power systems (mini grids/ micro grids)/ utility models, with distribution network that meet the full range of household/ business needs and are affordable for low income individuals. Production and/or distribution of cleaner fuels (eg ethanol) and energy efficient cook stoves. Distribution models that support local entrepreneurship and growth of SMEs within a renewable energy product demand and supply chain. Innovative ideas that stimulate "next generation"	US$ 61M		Open	Africa Entreprise Challenge Fund (AECF)	http://aecfafrica.org/index.php/portfolio/renewable_energy/react_ssa#118

						approaches in renewable energy sector					
Renewable Energy Performance Platform (REPP)		Energy	Blended (Debt, Grants, Equity)	All	N/A	REPP works to mobilise private sector development activity: and investment: in small to medium-sized projects (typically up to 25MW), and is supported with £148m funding from the UK's Department for Business, Energy and Industrial Strategy (BEIS) and the International Climate Finance initiative. Since inception, REPP has supported projects typically ranging from 1MW to 25MW, and employing technologies as diverse as solar home systems to utility-scale run-of-river hydropower. Eligible techonologies include Renewables such as hydro-power, solar energy, biomass and wind energy; Small, household level SHS comprising of basic lighting, phone charging	US$ 148M	Open	Open	Self	https://repp.energy/support/

						systems and radios made available to large numbers of households through PAYG systems. Other technologies include large solar power stand-alone systems for productive use, comprising of phone charging systems, radio etc. and that can be used at small scale rural based business premises to provide the required power; Larger solar power systems that meet the full range of household needs and are still affordable for low income individuals; Larger centralised renewable power systems (mini grids/ micro grids)/ utility models, with distribution network that meet the full range of household/ business needs and are affordable for low income individuals; Production and/or distribution of cleaner fuels (eg ethanol) and energy efficient cook stoves; Distribution models that support local entrepreneurship and growth of SMEs within a renewable energy product demand and supply chain; Innovative ideas that stimulate "next generation" approaches in RE sector					
KIVA	NGO	All	Loans/Debts (To Investors)	All	N/A	Kiva is an international nonprofit, founded in 2005 in San Francisco, with a mission to expand financial access to help underserved communities thrive. KIVA does this by crowdfunding loans and unlocking capital for	Open	Open	Open	VisionFund Kenya	https://www.kiva.org/about/where-kiva-works/partners/133

						the underserved, improving the quality and cost of financial services, and addressing the underlying barriers to financial access around the world.					
SunFunder	Private	Energy	Loans/Debts (To Investors)	All	N/A	SunFunder is the leading specialist **debt financing** partner for solar companies active in off-grid residential, commercial & industrial and other solar opportunities in emerging and frontier markets, with a ticket size of between US$250k - US$5 million. SunFunder provides scalable inventory, working capital, receivables and other structured debt financing from $250k to $5m+ for solar companies in emerging and frontier markets	Open	Open	Open	Self	https://sunfunder.com/contact
BMZ - International Climate Initiatives (ICI)	Donor	Energy & Livelihoods	Grants (Repayable)	All	Climate Partnership Programme (CPP)	The objective of the CPP is to mobilize the **private sector** to become a partner in climate protection and to channel private sector investments into climate-friendly developments. The programme focuses on promoting technology and knowledge transfer and developing capacities for climate-friendly technologies, particularly in the IKI priority countries. Development relevant projects of private enterprises are promoted which demonstrate the application of climate-friendly technologies, support the introduction and dissemination of innovative	Euro 4.9M (US$ 5.5M)	Jun-17	May-21		https://www.international-climate-initiative.com/en/project-funding/information-for-applicants/thematic-oriented-selection-procedure/#c10300

						climate protection technologies or adapt proven technologies for greenhouse gas reduction to specific framework conditions in the target countries. Currently, there is an ongoing call for proposal which is open until July 2019					
BMZ - International Climate Initiatives (ICI)	Donor	Agriculture & Livelihoods	Grants (To Implementing Partners)	All	Supporting developing countries to integrate the agricultural sectors into National Adaptation Plans (NAPs)	The project integrates agriculture in NAPs and supports partner countries in identifying and integrating climate adaptation measures for the agricultural sector into relevant national planning and budgeting processes. It is a multi-year initiative and responds to country-driven needs.	Euro 15M (US$ 17M)	2014	2020	Food and Agriculture Organization of the United Nations (FAO)	https://www.international-climate-initiative.com/en/nc/details/project/supporting-developing-countries-to-integrate-the-agricultural-sectors-into-national-adaptation-plans-naps-14_II_118-431/?cookieName=search_results&source=single
EKOenergy	NGO	Energy	Grants (To Implementing Partners)	All	Climate Fund	EKOenergy is an international non-profit ecolabel for energy (renewable electricity and renewable gas). In addition to being renewable, the energy sold with the EKOenergy label fulfills additional sustainability criteria and finances projects that combat energy poverty. EKOenergy does not set up its own projects, but donates to	Open ticket	2014	ongoing	Open	https://www.ekoenergy.org/our-results/climate-fund/

						projects managed by experienced organisations. Most importantly, the organisations work in close cooperation with local partners. The selected projects are also a part of larger, long lasting and ambitious projects.					
Oak Foundation	Foundation	Energy	Grants (To Implementing Partners)	All	Under Climate Change Strategy	OAK Foundation supports organisations which: (1) partner with governments in their work to build a clean and safe energy future; (2) advocate for improved policies, financial support of clean energy projects and innovations that increase energy efficiency; (3) help integrate clean energy solutions into poverty-reduction programmes; and (4) support grassroots community-led campaigns.	N/A	2016	2020	Open	http://oakfnd.org/env-strategies---climate.html
Zayed Sustainability Prize	Foundation	Energy	Grants (To Implementing Partners)	All	Calling Global Sustainability Pioneers	The Zayed Sustainability Prize is among the world's largest annual prize funds in renewable energy and sustainability.The Energy Prize has five categories: 1. Large corporations; 2. Small and medium enterprises (SMEs); 3. Non-governmental organizations (NGOs); 4. Individuals (for lifetime achievement); and 5. Global high schools (awards to one high school in each of the Americas, Europe, Africa, Oceania, and Asia).The prize amounts are US$600 thousand	N/A	N/A	open annually	Open	https://zayedsustainabilityprize.com/en/

						in each category. Application deadline is open until May 2019					
WISIONS	Donor	Energy	Grants (To Implementing Partners)	All	Sustainable Energy Project Support (SEPS)	Through the supporting scheme SEPS - Sustainable Energy Project Support - WISIONS nurtures innovative energy projects that are environmentally, economically and socially sound and fosters knowledge exchanges between practitioners. To date, SEPS has supported 129 projects and exchange activities across the world, illustrating the lessons learned in the field.	N/A			WISIONS	http://www.wisions.net/projects
Renewable energy and energy efficiency Partnership (REEEP)	Public	Energy	Grants (To Implementing Partners)	All	N/A	REEEP funds entrepreneurial projects for clean energy; supports business training, mentoring and best-practices in energy projects and markets; promotes improved energy laws, policies, standards, and regulations; and offers tools and support for knowledge sharing about clean energy.	N/A				
Private Financing Advisory Networ	Public	Energy & Livelihoods	Grants (To Implementing Partners)	All	N/A	PFAN funds entrepreneurs wishing to launch or scale up a climate adaptation or clean energy project in low- or middle-income countries, and looking for investment of up to USD 50	US$ 50M	Open	Open	PFAN	https://www.reeep.org/private-financing-advisory-network

k (PFAN)						million. Calls for Proposals are always open, meaning that proposals could be submitted at any time. Proposals must be submitted online, through PFAN's custom-built project management system					
William and Flora Hewlett Foundation	Foundation	Energy	Grants (To Implementing Partners)	All	Climate & Energy Programme	The Foundation has been investing in grants focused on cleaning up power production, using less oil, using energy more efficiently, preserving forests, addressing non-CO2 greenhouse gases, and financing climate-friendly investments. Grantmaking is focused in developed countries with high energy demand and developing countries with fast-growing energy demand or high deforestation rates.	Open ticket	Open	Open		https://hewlett.org/strategy/climate-and-energy/
United Nations Industrial Development Organization (UNIDO) + RE & EE Partnership	Public	Energy	Grants (To Implementing Partners)	All	Project Development & Financing Initiative (PDFI) SSA	The selected programmes will receive coaching from professional experts to create a financially, socially and environmentally viable business plan. The projects will also have the opportunity to present the business plans to investors at a financing forum. Best project will be awarded the PFAN Awards.	N/A	Open	Open	Private Financing Advisory Network (PFAN)	http://pfan.net/wp/wp-content/uploads/2018/01/Prospectus-OPEN-RfP-PDFI-Sub-Saharan-Africa.pdf

Agence Française de Développement (AFD)	DFI	Energy	Loans/Debts (To Investors)	All	N/A	Agence Française de Development (AFD) is a financial institution and the main implementing agency for France's official development assistance to developing countries & overseas territories. In the energy secto, AFD Kenya supports the development of a low-carbon energy mix, particularly geothermalenergy; supports access to electricity in rural and remote areas; reinforcing the power transmission and distribution grids; and regional integration of the electricity market in East Africa	Open	Open	Open		
Willow Impact Investors	Impact Investor	All	Grants (To Implementing Partners)	All	N/A	Willow Impact supports early-stage growth companies with strong business fundamentals and that are designed to generate social and/or environmental impact. We provide business development, management and entrepreneurship expertise and we work to realise the full potential of businesses through our networks, best practices and focus on value creation. We assist businesses with impact creation, assessment, measurement and reporting.	Open	Open	Open		
GIZ	Donor	Agriculture & Livelihoods	Grants (To Implementing Partners)	All	Green innovation centres for the agriculture and food sector	The GICA&FS aids smallholder farmers in sustainably increasing their agricultural production and income. It is also focused on aiding them to generate new jobs in the area of food	N/A	2015	2021	Open	agrarinnovation@giz.de

						processing, ensuring that a greater portion of the value added from agricultural production remains in the local area, especially within rural regions.					
Total, ENEA Consulting, SEforAll and Acumen	Private	Energy	Grants (To Implementing Partners)	All	Energy Access Booster	The Energy Access Booster supports entrepreneurs in the field of energy access in Africa focusing on green mini grids, sustainable mobility, refrigeration (cooling or cold storage) or energy for drinking water and agriculture. Up to five selected entrepreneurs will benefit from a selection of the following support, depending of their needs and the support capacity of each partner: 1. A strategic advisory consulting mission 2. A financial contribution of maximum $ 50,000 per selected entrepreneur 3. Operational support and potentially local support 4. Visibility of the project					
EDP (A global Energy Company)	Private	Energy	Grants (To Implementing Partners)	All	EDP Access to Energy Fund Programmes	The A2E CSR FUND Programmes is aimed at alleviating energy poverty by supporting sustainable and clean energy projects in developing countries. The fund will focus on five major themes for which energy makes a key contribution: education, health, water and agriculture, business and community. For its 1st edition (2018-2019), EDP will support projects in Kenya, Malawi, Mozambique and	Euros 450K (US$ 500K)	2018	Open	EDP	https://www.edp.com/en/aboutedp

						Tanzania. The 1st edition of this programmes has an endowment of 450.000€. Projects may apply for values between € 25,000 and € 100,000. The Fund covers: (a) upto 75% of the total project costs, for non-profit entities; (b) up to 50% of the total project costs, for for-profit entities.					
DfID	Donor	Energy	Grants (To Implementing Partners)	All	Energy Entrepreneurs Fund (EEF)	Energy Entrepreneurs Fund (EEF) is a competitive funding scheme to support the development and demonstration of state of the art technologies, products and processes in the areas of energy efficiency, power generation, as well as heating & electricity storage. The EEF seeks the best ideas, irrespective of source, across these energy technology areas from the public and private sector. The scheme particularly aims to assist small and medium-sized enterprises, including start-ups, and those companies that are selected will receive additional funding for incubation support. Currently in its 7th phase, UK£10 million is available for projects, with up to £1 million available for projects.	GBP 10M (US$13M)	annual	Annual		http://ow.ly/s5gv30lI9G4

DfID & Engineering and Physical Sciences Research Council (EPSRC).	Donor	Energy	Grants (To Implementing Partners)	All	Energy Catalyst Funding Programme	Innovate UK has a £10 million to invest in innovative, market-focused energy technologies through the Energy Catalyst funding programme. The different competitive rounds of the Energy Catalyst support energy innovations across all technologies, sectors and international markets to help address the global need for reliable energy. Organisations interested must address the World Energy Council's 'Energy Trilemma' and its 3 pillars, namely: (1) C**ost**: reducing prices to make energy accessible to everyone; (2) E**missions**: generating cleaner energy with lower emissions to protect the environment; (3) **Security of supply**: putting reliable infrastructure in place to keep energy flowing without disruption or shortage. Early stage projects can have total costs of £50,000 to £300,000 and last 6 to 12 months. Mid stage: £50,000 to £1.5 million, 12 to 24 months. Late stage: £50,000 to £3 million, 12 to 30 months. Projects must start by 1 April 2019 and end by 30 Sept 2021.	N/A		2021	Innovate UK	https://apply-for-innovation-funding.service.gov.uk/competition/221/overview

Google	Private	All	Grants (To Implementing Partners)	All	Google Impact Challenge	The aim of the challenge is to support Kenyan non-profits and social enterprises with game-changing ideas to create economic opportunities in their communities. Applicant's should meet the following criteria: (1) ***Community Impact -*** proposed project must create economic opportunity whilst improving the lives of people in Kenya; (2) ***Innovation*** - project project must present unexpected solutions to unmet needs; (3) ***Reach*** - proposed project must have the potential to scale directly or to serve as a model for other communities; (4) ***Feasibility***- the project plan (or business plan) must be well thought-out, and the team well-equipped to execute it	N/A	Open	Open	Google	https://impactchallenge.withgoogle.com/kenya2018#41
DFID UK and DST Government of India	Donor	Energy	Equity	All	POWERED Accelerator	POWERED Accelerator is an entrepreneurship development programme, globally, focusing on women-led businesses in the energy value chain. POWERED aims to build a multi-level ecosystem comprising of grand challenges, bootcamps, workshops, accelerator programmes, and seed investments. The objective of the Accelerator Programme is to support the selected ventures by helping them expand their innovative and consumer-responsive services, products and financing: with an ultimate goal to increase economic	N/A	Open	Open	Shell Foundation & Zone Start-Ups	http://powered.org.in/

						empowerment of women-owned businesses in the energy space.					
Lundin Foundation	Foundation	All	Blended (Debt, Grants, Equity)	All	N/A	Lundin Foundation develops and supports initiatives in the following strategic areas: (1) Resource Governance; (2) Education & skills training; (3) Local procurement; (4) Economic diversification; (5) Social & environmental innovation.	N/A	Open	Open	Lundin Foundation	http://www.lundinfoundation.org/
AHL Venture Partners	Impact Investor	Agriculture, Livelihoods & Energy	Blended (Debt, Grants, Equity)	All	N/A	AHL Venture Partners is an investment management company domiciled in Mauritius. One of the largest and most successful impact-focused venture capital firms in Africa, AHL has experienced investment professionals across West, East and Southern Africa. **Focus areas include:** (1) Energy Access; (2) Financial Inclusion; (3) Agriculture; (4) Human Capital; (5) Frontier Markets.					http://www.ahlventurepartners.com/welcome
WISIONS (Wuppertal Institute for Climate, Enviro	Donor	Energy	Grants (To Implementing Partners)	All	Wisions of Sustainability	WISIONS explores and develops models, strategies, and instruments to support sustainable development at local, national, and international levels. WISIONS of Sustainability is a grantmaking initiative of the Institute. WISIONS makes grants for energy-related basic	N/A	N/A	Annual	Sustainable Energy Project Support (SEPS)	http://www.wisions.net/

nment, and Energy)						needs in developing countries through SEPS (ie, Sustainable Energy Project Support). Thematic interests in SEPS include solar energy, biomass, biofuels, biogas, hydro power, wind power, and other topics of renewable energy and energy efficiency. WISIONS provides both investor and grant funding opportunities					
Vulcan Impact Investing (VI2)	Impact Investor	All	Equity	All	N/A	Vulcan Impact Investing (VI2) identifies and invests in market-based solutions that have the potential to transform lives through sustainable, scalable approaches to development. Vulcan Impact Investing support projects and businesses which accelerate access to infrastructure and services designed to meaningfully improve quality of life. VI2 bridges the gap between founder and venture capital funding. VI2 is specifically interested in projects or companies: (1) Based in Sub-Saharan Africa with a focus on Botswana, Kenya, Tanzania and Zambia; (2) focused on enabling infrastructure: mainly last mile off-grid electrification, connectivity, sustainable heating and cooking, and fresh water access; (3) with the potential for scalable and enduring impact (+1 million lives touched); 4. with a clear, compelling business plan and demonstrated proof of	N/A	N/A	Ongoing	Self	http://www.vulcan.com/Areas-of-Practice/Philanthropy/Key-Initiatives/Impact-Investing

						concept. VI2 invests through Investor & Equity Investing					
Vital Capital Fund	Impact Investor	All	Equity	All	N/A	Vital Capital Fund is a $350 million private equity fund that invests in opportunities which simultaneously enhance the quality of life of communities in rapidly developing nations, primarily in Sub-Saharan Africa, while also delivering attractive financial returns for investors. **SECTORS:** Urban community housing solution, Agriculture, Healthcare, Renewable Energy, Water and Education. Funding opportunities are provided through either Investor, Equity Investing or Fund	US$ 350M	N/A	Open	Self	http://www.vital-capital.com/
Venture South International (VSI)	Private	Energy	Loans/Debts (To Investors)	All	N/A	VSI is a lending company, which focuses on the niche above microfinance and below bank loan sizes (USD 2,000: 50,000 range). The company provides funding for Solar financing & purchase of receivables by providing **Debt of between USD 2,000: 50,000,** & Fixed Asset Acquisition, Purchase Order Loans, Lines of Credit.	US$ 2,000 - 50,000 plus supplies acquisition	N/A	Open	Self	http://venturesouth.net/

U.S. African Development Foundation (USDAF)	Foundation	Energy	Grants (To Implementing Partners)	All	USADF Off-Grid Energy Challenge	The Off-Grid Energy Challenge awards grants of up to $100,000 each to African companies and organizations providing off-grid solutions that deploy renewable resources and power local economic activities. Challenge winners receive near-term solutions to power the needs of productive and commercial activities, including agriculture production and processing, off-farm businesses, and commercial enterprises. Application is by annual competition that s usually posted on the website	Open	annual	Annual		https://www.usadf.gov/off-grid/
Small Enterprise Assistance Funds (SEAF)	Impact Investor	All	Blended (Debt, Grants, Equity)	All	N/A	SEAF provides growth capital and business support to small and medium-sized enterprises around the world. SEAF has an extensive track record of establishing local fund management capacity, and in investing in SMEs in emerging markets, in areas such as agriculture, food processing, health, technology, education, tourism, retail and infrastructure. SEAF provides funding in the form of Equity, Mezzanine & Debt	N/A	N/A	Open	N/A	http://seaf.com/
United Nations Environment Programme (UNEP)	Public	All	Blended (Debt, Grants, Equity)	All	Seed Capital Assistance Facility (SCAF)	SCAF co-finances: with private equity and venture capital fund managers, and project development companies: the development of new investment vehicles and, once operational, the origination, development	N/A	N/A	Open	Frankfurt School FS-UNEP Collaborating Centre for Climate & Sustainable Energy Finance	https://www.scaf-energy.org/about

						and seed financing of early-stage, low-carbon projects.					
Climate Investment Fund (CIF)	Public	Energy	Blended (Debt, Grants, Equity)	All	Scaling Up Renewable Energy Programmes (SREP)	SREP is a targeted programmes of the Strategic Climate Fund (SCF), which is one of two funds within the framework of the Climate Investment Funds (CIF). The SREP was established to scale up the deployment of renewable energy solutions and expand renewables markets in the world's poorest countries. It aims to pilot and demonstrate the economic, social, and environmental viability of low carbon development pathways. Around 20-50 M USD per country - though funding is determined on a project level. (Usually 2-3 projects/country).	U$20 - 50M per country	N/A	Annual		https://www.climateinvestmentfunds.org/fund/scaling-renewable-energy-programmes
IDA	DFI	All	Grants (To Implementing Partners)	Cluster (Turkana, Makueni, Meru, Kitui, Embu, Kilifi, Kwale, Narok, Kirinyaga, Kiambu, Murang'a & Nakuru)	Kenya Development Response to Displacement Impact (KDRDIP) Project	The Project Development Objective (PDO) is ***to improve access to basic social services, expand economic opportunities, and enhance environmental management for communities hosting refugees in the target areas of Kenya***. The Project has five components, but the critical ones that are linked to our work include: **Component 1**: ***Social and Economic Infrastructure and Services***, which has two subcomponents: 1(a) community investment funds; and 1(b)	US$ 108M	2019	2024		

						capacity support for local planning and decentralized service delivery; **Component 2:** ***Environmental and Natural Resource Management*** is divided into two: 2(a): integrated natural resources management; and 2(b): access to energy. **Component 3:** ***Livelihoods Programmes*** has two subcomponents: 3(a): support to traditional and non-traditional livelihoods; and 3(b): capacity building of CBOs for livelihoods.					
United Nations Conference on Trade & Development (UNCTAD)	Public	Agriculture, Livelihoods & Energy	Blended (Debt, Grants, Equity)	All	Common Fund for Commodities (CFC)	CFC supports activities which promote the contribution of the commodity sector to achieving the SDGs in CFC member countries including the following aspects: (i) ***Social:*** Create employment (particularly for youth and women), provide sustained increase in household incomes, reduce poverty, and enhance food security; (ii) ***Economic:*** Enhance production and productivity, achieve higher local value addition; improve competitiveness of producers, producer organisations and small and medium sized industries, support the financial sector development; (iii) ***Environmental:*** Enhance production taking into account the environment and its long-term possibilities for the same, or increased use of productive	Open	Open	15th Oct 2019		http://www.common-fund.org/call-for-proposals/

						resources while maintaining or reducing the impact on the environment. CFC provides financing in both grants (not exceeting $250,000); as well as loans, equity and quasi equity of between Euro 250K - Euro 1.5K					
International Fund for Agricultural Development (IFAD)	DFI	Agriculture & Livelihoods	Loans/Debts (To GoK)	Cluster (Meru, Tharaka Nithi, Embu, Kirinyaga, Murag'a & Nyeri)	Upper Tana Catchment Natural Resource Management Project	The goal of this project is to contribute to the reduction of rural poverty in the Upper Tana River catchment through increased sustainable food production and incomes for poor rural households, as well as sustainable management of natural resources. The project has three main components: (1) Empowering communities to sustainably manage natural resources by building their capacity to develop resource management plans while also improving their livelihoods; (2) Sustainably improving the incomes and living standards of the target group through interventions that are beneficial to the management of the natural resource base; (3) Improving the sustainable management and use of water and other natural resources.	US$ 82.45M				https://www.ifad.org/en/web/operations/country/id/kenya

IFAD	DFI	Agriculture & Livelihoods	Loans/Debts (To GoK)	Cluster (Embu, Tharaka Nithi, Kitui, Machakos, Makueni, Taita Taveta, Kwale, Kilifi)	Kenya Cereal Enhancement Programme Climate Resilient Agricultural Livelihoods Window	The overall development goal of the KCEP-CRAL is to reduce rural poverty & food insecurity among smallholders in Kenya's ASALs by developing their economic potential, while improving their natural resource management capacity and resilience to climate changein an increasingly fragile ecosystem. This goal will be pursued through: (i) graduation of smallholder farmers to commercially oriented,climate-resilient agricultural practices through improvements in productivity, post-production management practices and market linkages for targeted value chains;and (ii) empowerment of county governments and communities to sustainably & consensually manage their natural resources and buildresilience to climate change. The project is being implemeneted within three components namely: (1) Capacity-building for climate-resilient productivity enhancement & natural resource management, (2) Post-production management & market linkages & (3) Financialservices.	US$ 118M	2015	2022	State Department ofthe Ministry of Agriculture,Livestock & Fisheries	https://www.ifad.org/en/web/operations/project/id/1651/country/kenya
County Government of Kitui	Public	Health	Government Implementation	Kitui	Upgrading and Equipping of County Hospitals	These are 3 curative projects under the broader health programme. Under the programme, the county government will target to upgrade a number of public	KES. 4.9B (US$ 49M)	2018	2022	County Government	CIDP

						hospitals to a level they can offer specialized diagnostic services (KES. 1.2B); support county hospitals to equip their facilities with modern drug stores (KES. 1.4B) as well as establish and operationalize new health facilities UKES. 2.38B)					
County Government of Kitui	Public	Health	Government Implementation	Kitui	County Healthcare Flagship Projects	These are healthcare flagship projects that have been earmarked by CGK to be implemented over the 5 years period of the current administration. These include: (1) Construction and upgrading of model level three health centres in each ward (To facilitate provision of affordable and quality health services (KES. 175M); (2) Promotion of community Based Health Care Services (To improve health services to house hold level) (KES. 100M); & (3) Upgrading Kwa Vonza dispensary to an ultra-modern health facility (To improve provision of health services) (KES. 100M)	KES. 375M (US$ 3.75M)	2018	2022	County Government	CIDP
County Government of Kitui	Public	Health	Government Implementation	Kitui	Modernization of markets	These are projects under the Trade, Cooperatives & Investment Sector that CGK has identified for implementation over the 5 year period between 2018 - 2022. They include: (1) Renovation of modern markets and market sheds (KES. 100M); Construction of modern kiosks (KES. 120M); & Construction of modern markets (KES. 300M)	KES. 520M (US$ 5.2M)	2018	2022	County Government	CIDP

County Government of Kitui	Public	Agriculture & Livelihoods	Government Implementation	Kitui	Promotion of local industries	This is dedicated for promotion of local industries through a number of interventions including: (1) Construction and equiping of honey processing industries and products from honey (KES. 50M); Production of locally made wine (KES. 100M); construction of arbattoirs (KES. 200M); Construction of Jua kali sheds (KES. 570M); Construction of fruit processing factories (KES. 50M); Construction of soap making factories (KES. 10M); & construction of dairy factories (KES. 50M)	KES. 5.1B (US$ 513M	2018	2022	County Government	CIDP
County Government of Kitui	Public	Agriculture & Livelihoods	Government Implementation	Kitui	Irrigation Schemes Development & Maintenance	This will involve drilling & equipping of boreholes (KES. 3B); as well as construction and operationalization of irrigation schemes (KES. 5B)	KES. 8B (KES. 80M)	2018	2022	County Government	CIDP
County Government of Kitui	Public	Energy	Government Implementation	Kitui	Promotion & adoption of RE Technologies	CGK seeks to promote the adoption & use of RE technologies through a number of interventions including (1) Establishment of energy centers for alternative energy technologies (KES. 100M); (2) Installation of Solar powered water pumps at community level boreholes and irrigation schemes (KES. 1B); (3) ; (4) Electrification of off-grid village polytechnics, health centres with solar PV systems/mini grids (in collaboration with Development Agencies) (KES. 500M)	KES. 1.1B			County Government	CIDP

LOOOP Inc. Japan	Private	Energy	Loan/Debt (To GoK)	Kitui	40MW Solar Power Plant	Establishment of a 40 MW Solar power plant in partnership with County Government of Kitui	KES. 40B	2018	2022	County Government	CIDP