Techno-policy spaces for e-cooking in Kenya

Authored by:

Joanes Atela, Jon Leary, Tom Randa, Victoria Chengo, Joel Onyango, Syprose Ochieng, Mourine Chepkemoi, & Paul Osogo

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EXECUTIVE SUMMARY

This techno policy report is part of the Modern Energy Cooking Services (MECS) engagement in Kenya. It highlights key technology opportunities for clean energy transition and low carbon development in Kenya through electric cooking. Insights are based on the analysis of relevant documents and engagements with a range of stakeholders through consultative meetings, dialogues, and learning sessions.

The clean cooking challenge for Kenya

Cooking in Sub-Saharan Africa (SSA) provides a strategic entry point towards catalyzing the adoption of clean, affordable, and sustainable energy in line with the Sustainable Development Goals (SDG). A greater share of energy use in SSA is on residential usage (particularly cooking) (IEA, 2020). 4 billion people globally still have no access to modern cooking services with the majority in Sub-Saharan Africa (World Bank, 2020a). Attainment of modern energy cooking services for many populations in SSA remains a challenge.

Kenya is one of the many SSA countries facing a formidable clean cooking challenge. The majority of the population (81%) still relies on polluting fuels such as firewood (65%), charcoal (10%), and kerosene (6%) for their cooking needs (GoK, 2019). This has led to an array of interlinked development challenges: GoK (2019) estimates that in Kenya, 21,560 deaths/yr are caused by household in-door air pollution; 8-11Mton/yr. woody biomass is lost due to forest degradation, and 13.6 MtCO2e/yr is emitted. Women and girls are disproportionately affected, with greater exposure to cooking smoke, as well as the drudgery of collecting fuel and lighting/tending fires, which results in missed educational and economic opportunities. Historically, Improved Cookstoves (ICS) have been heavily promoted in Kenya through government and non-governmental initiatives to promoting clean cooking. However, sustainable uptake has been a major challenge characterized by high rates of abandonment after the initial acceptance (GoK, 2020). Recent evidence also shows that the health benefits of ICS are much more limited than previously thought (WHO, 2016).

At the Clean Cooking Forum in Nairobi, 2019, the Government of Kenya (GoK) announced its intention to enable universal access to clean cooking by 2028, 2 years ahead of the global SEforAll targets. Hon. Simon Kachapin, the Chief Administrative Secretary in the Ministry of Energy, told delegates at the close of the forum that: *"[This] means we have to do things differently, disrupt our way of thinking, as business as usual will not enable us to achieve our global and national aspirations."*

Progress with electrification in Kenya

Kenya has made enormous progress on electrification, with coverage increasing from 29% to 73% in just 5 years (KPLC, 2018). The Last Mile Electrification program has extended the national grid into rural areas and densified the network to reach low-income households. The majority of Kenya's grid electricity (over 70% is generated from renewable sources, with hydro and geothermal the most significant sources (GoK, 2021). Indeed, Kenya ranks 8th globally in geothermal production and with huge untapped potential signaling the country's opportunity to catalyze the clean energy transition through electrification. There is already surplus power available, with a total installed generating capacity of 2,700MW and peak demand of just

1,859MW (KPLC, 2018). In addition, Kenya hosts the world-leading mini-grid and off-grid solar industries, which are rapidly connecting households beyond the reaches of the national grid, with the support of strong enabling policy, such as KOSAP (the Kenya Off-grid Solar Access Project). Kenya has been a first-mover in the development and implementation of many innovative off-grid solutions and pro-poor financing models, and now sits in a commanding position at the forefront of the global drive towards the electrification of cooking in both grid-connected and off-grid regions.

The opportunity for e-cooking in Kenya

There is a potentially transformative opportunity for Kenya's clean cooking sector to break out of this 'business as usual cycle' with electric cooking. Currently, 0% of Kenyans use electricity as their primary cooking fuel. This highlights the enormous untapped potential, as three-quarters of the population is now connected to some form of electricity, but doesn't yet use it to meet the majority of their cooking needs. What is clear is that several domestic policies have successfully advocated for expanded access to electricity, but little is known about the expanded use of this electricity.

Electricity is beginning to enter into the fuel stack of some Kenyan households, with 3% now owning an electric cooking appliance and a 2 percentage point increase expected by end of 2021 (GoK, 2019). Kettles, microwaves, and other task-specific appliances are gaining popularity as a compliment to other fuels. Although they may not be able to meet all household cooking needs at once, they are very efficient and convenient at meeting certain parts of the cooking processes and can be stacked together to offer a fully electric solution.

Many of the Kenyan households who have already adopted e-cooking are stacking it with LPG (GoK, 2019). LPG has already seen substantial uptake and is now the aspirational fuel for many, with the latest survey data (KNBS, 2020) indicating that 24% now use it as their primary cooking fuel. Kenya seemed to be on track to meet its goal of 35% LPG primary use by 2030, with a strong policy framework creating a favorable enabling environment (GoK, 2019). However, this may take a different turn as the government reintroduced the 16% VAT on LPG in July 2021, reversing the 2016 exemption for clean cooking stoves and fuels. In Kenya, there are many LPG companies and business models that are ready for large-scale investment, as the supply chain is already well established and can be scaled up rapidly. The high upfront cost of the cylinder and stove is a substantial barrier, but new delivery model innovations, such as Pay-as-you-go (PAYG) LPG and the *Mwananchi* Gas Project are finding ways to overcome this challenge and extend access to lower-income households.

In addition to LPG, there are several other modern energy cooking options that have have found niches in Kenya and offer additional opportunities to complement e-cooking as part of a clean fuel stack. Biogas has developed a niche in agricultural contexts and ethanol as a drop-in replacement for kerosene in urban slums. However, to date, uptake beyond these niches has been limited. Biogas is as clean as LPG and has negligible running costs; however, the capital cost is much higher and there is a need for a reliable source of appropriate feedstock, which has substantially constrained uptake to date. Ethanol has a much lower upfront cost; however, uptake has been limited by challenges within the supply chain.

Evidence generated through MECS research shows that certain electric cooking appliances such as the Electric Pressure Cooker (EPC) can cook energy-intensive foods most efficiently, resulting

in substantial time and money savings for everyday cooks (Leary et al, 2019). The potential for EPCs in Kenya is increasingly being recognized by several private sector organizations, with conventional appliance and cookstove retailers (e.g. Hotpoint, Burn Manufacturing) and energy service providers (e.g. KPLC, PowerHive, SunCulture) already starting to exploit this potential in the market.

Reliability and access remain a challenge for some. However, a suite of new technologies and business models that can enable electric cooking for households connected to mini-grids, an unreliable grid, and off-grid systems are emerging. Many of these innovations are being pioneered in Kenya by MECS partners, including SCODE, MKopa, SunCulture and Strathmore University.

Challenges for e-cooking in Kenya

While there are clear technical and policy opportunities to leverage the gains in electrification to drive forward the clean cooking agenda, certain systemic challenges will need to be addressed to realize the emerging opportunities for e-cooking:

Consumer demand: Limited awareness of the range of the available modern energy-efficient electric cooking appliances and their compatibility with Kenyan cuisine; deep-rooted social-cultural perceptions built over histories of biomass dependency and widely-promoted intermediary technologies such as improved biomass cookstoves, as well as the perception that electricity is 'too expensive for cooking' and that food cooked with electricity doesn't taste the same.

Supply chain: Limited access to after-sales services for modern energy-efficient electric cooking appliances; high initial costs of energy-efficient appliances, which excludes poorer households; and unreliable supply of electricity at the fringes of the grid, with many regions still off-grid.

Enabling environment: Disconnected clean cooking and electrification policy. Electrification policy focusses mainly on lighting and productive applications, whilst clean cooking policy focusses on LPG and improved biomass.

Emerging policy interest in e-cooking in Kenya

Harnessing this substantial opportunity for e-cooking will require an enabling policy environment. Historically, the energy policy in Kenya has been disconnected, with clean cooking and electrification dealt with as two separate problems. For example, the Energy Act 2019, National Energy Policy 2019, and Kenya National Electrification Strategy 2018 have no mention of cooking. Meanwhile, Kenya's Bioenergy Strategy 2020-2027 directly addresses the clean cooking challenge yet omits the mention of the potentially transformative role of electric cooking. Some policies, such as the National Climate Change Action Plan (NCCAP) 2018-2022 and the Ministry of Energy's Gender Policy mention both clean cooking and electrification, but fail to link the two together.

However, there is a growing recognition that there is a need for a joined-up energy policy in Kenya that connects the clean cooking challenges with the new opportunities opened up by progress in electrification. In December 2020, Kenya updated its NDCs, clearly highlighting the

need to connect these two areas: "*While Kenya has abundant renewable energy resources such as geothermal, solar, wind and hydro for electricity generation, more than one-half of Kenya's households use wood fuel for cooking*" (Ministry of Environment and Natural Resources, 2020). The Government of Kenya is also taking on a leading role at global high-level political forums, including the new HEPA (Health and Energy Platform for Action) and the upcoming 26th Conference of Parties (COP 26), championing the clean cooking agenda and highlighting the need to drive forward progress by connecting with the electrification sector.

Indeed, the potential for electric cooking is already being recognized amongst high-level Kenyan decision-makers. On June 18th, 2019, Kenya's Minister for Energy stated that "*households should also utilize electricity for cooking especially with the more advanced energy-efficient cookers and other appliances available…Kenyans stand to benefit from cheaper electricity cost with more consumption of the commodity"* (GoK, 2019). The e-cooking ambition of the Kenyan Government and stakeholders is further reflected in the efforts by the parastatal Kenya Power and Lighting Company (KPLC) through its *Pika Na Power* program, which is already working with a wide range of stakeholders to create awareness and develop the market for e-cooking.

What then should be done to catalyze the adoption of ecooking in Kenya?

There is a window of opportunity opening up to support the GoK to build the enabling policy framework that can facilitate the rapid uptake of modern energy cooking services in Kenya, by unleashing the transformative potential of electric cooking and accelerating the uptake of electric cooking and other clean fuels such as LPG, ethanol, and biogas. By bringing together key actors from the clean cooking and electrification sectors through creating shared spaces and brokering of strategic partnerships, we can support their journey into the emerging e-cooking sector. Some of the key entry points identified by this techno-policy analysis are listed below in Table 1. A stakeholder engagement strategy is currently under development that aims to explore how the MECS Kenya team might facilitate the convergence of clean cooking and electrification sectors in Kenya by exploring each of these opportunities in greater detail.

Table 1: Strategic entry points to catalyse the development of the emerging e-cooking sector in Kenya. See section 5 for complete list.

Entry point	Challenge	Opportunity for strategic intervention
Clean cooking inter-ministerial committee	Lack of coordination between ministries on the cross-cutting issue of eCooking	Work with the existing inter-ministerial clean cooking committee and extend remit into the electricity sector. Develop a policy scenario analysis that could enable the committee to make evidence-based decisions on how to create an enabling policy framework for eCooking.
EPRA	Existing electricity tariff structure not designed around eCooking	Build the evidence base on electricity price sensitivity for eCooking, particularly in institutions to support the development of an off-peak tariff designed to stimulate demand for excess renewable electricity during the daytime.

SEforALL Kenya Action Agenda	e-cooking not yet included in the range of clean cooking solutions expected to contribute to the 2030 SE4All goals.	Offer a technical advisory service to the Kenyan SEforAll team at the Ministry of Energy to integrate e-cooking into new and updated policy instruments, such as the EEAP (Energy Efficiency Action Plan)
Food bloggers	The widespread perception that electricity is 'too expensive for cooking'	Work with social media influencers to produce content showing the real cost of cooking popular local dishes with electricity and position energy-efficient appliances as aspirational products for modern Kenyan cooks.
PayGo companies (e.g., Angaza, MKopa)	Additional hardware is required to enable innovative financing models such as PayGo	Engage with service providers to encourage the development of interoperable technology that can enable innovative financing mechanisms. Develop and pilot electric appliances with integrated energy metering, cloud-based communications, and locking mechanisms.
County Energy Plans	Lack of awareness of eCooking as a viable solution amongst county-level energy planners	Work with the Ministry of Energy on the development of the INEP (Integrated Energy Plan) framework and support specific counties (Kisumu, Nakuru, Kitui, Nairobi) to develop County Energy Plans inclusive of eCooking. The energy plans and centres (see below) provide opportunity/platform for local convening of different agencies and sectors in practice thus could aid in testing the inter-agency actions in practice and generate responses for national level inter-agency actions
KPLC's Pika na Power	Pika na Power program struggling to reach scale	Support KPLC to explore opportunities to scale up their Pika na Power program across the country by brokering strategic partnerships with external organisations. Explore the viability of utility-enabled financing, and/or extending the Stima Loan concept from connection fees to electric cooking appliances
KEBS, KRA	Energy-efficient eCooking appliances are currently subject to import and sales taxes	Develop national quality standards for energy-efficient eCooking appliances, building on Strathmore's work on quality standards and CLASP's work on the Global LEAP Awards for EPCs. Lobby for tax exemptions for the most energy-efficient products.

County Energy Centres & KPLC County Showrooms	KPLC eCooking sales and marketing focussed in Nairobi	Develop a modular framework that can enable KPLC to replicate its demonstration, retail, and after-sales service in other counties. Design a programme for empowering local champions to start up innovative new eCooking businesses in their local area.
Legislaure	Legislateive agenda on clean cooking still weak and mixed up.	There is an opportunity to use e-cooking discourse to strengthen/lead the legislative agenda for clean cooking. Discussion with Senate and Parliement Committees has yielded some interest by the Parliamentarians. These legislative agencies can be leveraged to strengthen the inter agency challenge given their oversight role across agencies and sectors.

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LIST OF ACRONYMS

BoP	Base of the Pyramid
CCA	Clean Cooking Alliance
CLASP	Collaborative Labelling and Appliance Standards Program
CoP	Conference of Parties
eCooking	Electric Cooking
EnDev	Energy Development
EPC	Electric Pressure Cooker
EPRA	Energy & Petroleum Regulatory Authority
ESMAP	Energy Sector Management Assistance Program
FCDO	Foreign, Commonwealth and Development Office
GDC	Geothermal Development Company
GOGLA	Global Off-Grid Solar Forum and Expo
GoK	Government of Kenya
HAP	Household Air Pollution
HEPA	Health and Energy Platform for Action
IEA	International Energy Agency
ICS	Improved Cookstoves
KEBS	Kenya Bureau of Standards
KEMP	Kenya Electrification Modernization Program
KenGen	Kenya Electricity Generating Company
KETRACO	Kenya Electricity Transmission Company
KIRDI	Kenya Industrial Research and Development Institute
KOSAP	Kenya Off-Grid Solar Access Project
KPLC	Kenya Power and Lighting Corporation
LPG	Liquefied Petroleum Gas
MECS	Modern energy Cooking Services
MOE	Ministry of Energy
NCCAP	National Climate Change Action Plan
NDC	Nationally Determined Contribution
RBF	Result Based Financing
REDD+	Reduced Emissions from Deforestation and Forest Degradation
RERAC	Renewable Energy Resource Advisory Committee
REREC	Rural Electrification and Renewable Energy Corporation
SCI	Solar Cookers International
SDG	Sustainable Development Goals
SEforAll	Sustainable Energy for All
SHS	Solar Home Systems
SSA	Sub-Saharan Africa
WHO	World Health Organization

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1 INTRODUCTION

Cooking in Sub-Saharan Africa (SSA) provides a strategic entry point towards catalyzing the adoption of clean, affordable, and sustainable energy in line with SDG 7. Residential energy consumption makes up the dominate share of energy use in SSA and for most poorer households, cooking is their primary energy need (IEA, 2020). Globally, 4 billion people lack access to modern energy cooking services (ESMAP, 2020). More than 95% of these people either reside in Sub-Saharan African (SSA) or developing countries in Asia, and 84% are of these are in rural areas (ESMAP, 2020). In SSA specifically, over 70% of the population still depends on biomass energy for cooking (ESMAP, 2020), with most of the fuels being burned in inefficient cook stoves, which in turn affects the health and wellbeing of the population through indoor air pollution. According to the World Health Organization (WHO) Household, Air Pollution (HAP) is a significant driver of premature death in Africa. For instance, in the East Africa region, poor indoor air quality is the second most important environmental driver of premature deaths after water contamination.

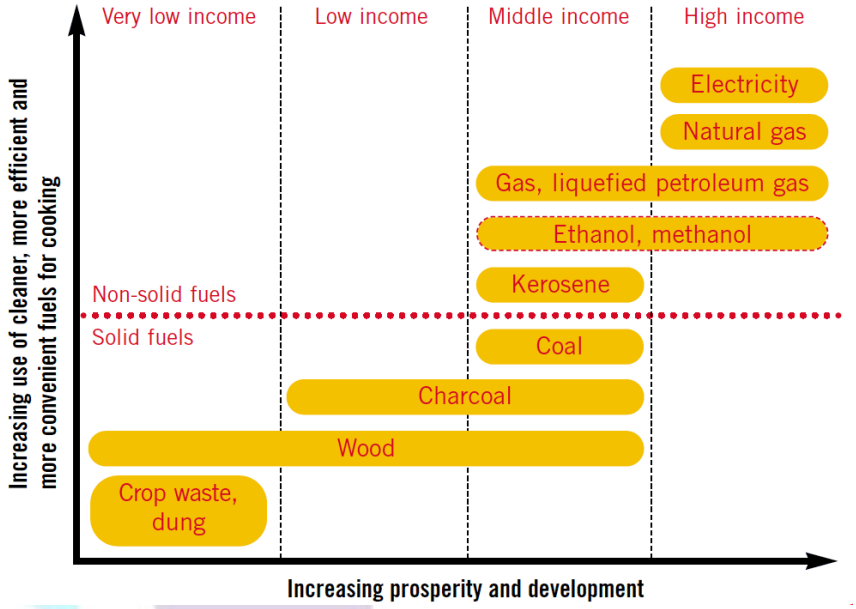

Figure 1: The energy ladder – the link between household energy and development – WHO (2014)

Kenya is one of the many SSA countries facing substantial clean cooking challenges. The majority of the population (81%) still relies on polluting fuels such as firewood (65%), charcoal (10%), and kerosene (6%) for their cooking needs (GoK, 2019). This has led to an array of interlinked development challenges: GoK (2019) estimates that in Kenya, 21,560 deaths/yr are caused by household in-door air pollution; 8-11Mton/yr. woody biomass is lost due to forest degradation, and 13.6 MtCO2e/yr is emitted. Women and girls are disproportionately affected, with greater exposure to cooking smoke, as well as the drudgery of collecting fuel and lighting/tending fires, which results in missed educational and economic opportunities.

Historically, Improved Cookstoves (ICS) have been heavily promoted in Kenya through government and Nongovernmental clean cooking initiatives. However, sustainable uptake has

been a major challenge characterized by high rates of abandonment after the initial acceptance (GoK, 2020). Recent evidence also shows that the health benefits of ICS are much more limited than previously thought (WHO, 2016).

At the Clean Cooking Forum in Nairobi, 2019, the Government of Kenya (GoK) announced its intention to enable universal access to clean cooking by 2028, 2 years ahead of the global SEforAll targets. Hon. Simon Kachapin, the Chief Administrative Secretary in the Ministry of Energy, told delegates at the close of the forum that: *"[This] means we have to do things differently, disrupt our way of thinking, as business as usual will not enable us to achieve our global and national aspirations."*

The ambition to achieve universal access to clean cooking in Kenya is developing at a time when the country is experiencing rapid expansion of electricity through renewable sources, promising a new pathway towards low carbon development. Through the last-mile connectivity program, Kenya has now achieved over 70% connectivity which is relatively higher compared to other countries in the East African region. There is a huge opportunity for Kenya to connect the clean cooking challenge to this rapid progress in electrification by promoting electric cooking. At a household level, there is already a high willingness to adopt energy-efficient appliances that are well-matched with local cuisine, offering an aspirational cooking experience (Leary et al.,2020; Lambe et al., 2020).

This opportunity has already been acknowledged by Kenya's Ministry of Energy, who have championed the need for an integrated approach to electrification and clean cooking planning on the global stage. They have on various occasions urged households to use electricity for cooking and take advantage of the expanding electricity connectivity and e-cooking technologies/appliances. Similarly, practical programs such as the KLPC-led *Pika na Power*, *Jikoni Magic's* social media platform and Mediae's *Shamba Shape Up* TV series have emerged to popularise e-cooking in various settings.

More broadly, e-cooking is also a cross-sectoral opportunity for low carbon development. Due to the health, environmental, and gender-related impacts of traditional cooking and the limited gains offered by many models of supposedly improved cookstoves, e-cooking is well-positioned to play a central role in promoting the objectives of various sectors including health, climate change, forestry, gender, housing, and other related sectors.

The opportunity provided by e-cooking however enters into the background of a strong attachment to traditional energy technologies such as biomass, with an array of improved cookstoves that have been systemically embedded through a variety of diffusion approaches. This implies that e-cooking requires more integrated economic, social, political, institutional, and technological approaches to break the cycles of biomass consumption and create impactful and widescale adoption. In other words, incorporating e-cooking into Kenya's clean cooking mix requires identification of specific niches within the current policy and technology settings, and building on those niches to support a transition. Such opportunities for transition further build on the existing willingness to adopt new cooking technologies as demonstrated in the adoption of improved cookstoves in Kenya, which has been much higher than most other SSA countries (KIPRA, 2010). Traditionally, emerging cooking technologies such as improved cookstoves have been promoted through massive technology deployment through government and NGO programs, and with the assumption that this will ensure sustained demand and use (Ockwell et

al., 2019). However, evidence shows that many users often revert to their traditional ways which they can understand and afford (Tigabu et al.2019; Ockwell et al., 2019). The market challenges are compounded by weak institutional and policy frameworks, mainly poor representation of cooking energy in the modern energy policy discussions and agendas. Instead, industrial electricity supply and household lighting often take precedence in electrification planning, while cooking remains a localized agenda mainly driven by the NGOs and various civic actors.

This study aims to highlight the key technology and policy opportunities to drive forward the emergence of the nascent electric cooking sector in Kenya. Insights are based on the analysis of available literature and engagements with a range of stakeholders through consultative meetings, policy dialogues, and learning sessions.

The specific objectives are to:

i. Understand the technology and policy landscapes for e-cooking in Kenya by highlighting the nexus between clean cooking and electrification policy systems
ii. To identify strategic entry points for catalyzing the transition to e-cooking.

Section 2 of this report details the approach taken by this study. Section 3 presents the findings on the clean cooking and electrification technology landscape, whilst Section 4 presents the accompanying policy landscape. Section 5 presents the strategic entry points for e-cooking and Section 6 draws final conclusions.

2 STUDY CONTEXT

2.1 ABOUT THE MECS PROGRAMME

The Modern Energy Cooking Services (MECS) programme is a £40 million ($50.5 million) UK Aid-supported initiative aimed at promoting modern energy cooking services in the Global South. The programme works through a multi-partner program of activities, led by Loughborough University in the UK, to catalyze the transformation of the clean cooking and electrification sectors that can enable widespread uptake of modern energy cooking services. This could generate inclusive environmental and development benefits for the poor by enabling technological, institutional, and market innovations.

The MECS programme is designed to leverage the enormous progress that has been made globally on access to electricity to drive forward the clean cooking sector. Electric cooking (eCooking) has long been considered 'inappropriate' for use in development programs. However, the landscape of electricity access has changed, with many more people now connected to both grid and off-grid electricity and the quality of supply becoming increasingly more reliable. What is more, an array of new energy-efficient electric cooking appliances is now available, opening a myriad of new opportunities for access to cost-effective and convenient modern energy cooking services.

The programme aims to generate and test new knowledge to break out of the 'business as usual' approach of treating clean cooking and electrification as two separate elements. The programme

intends to support the technological, business model, and institutional innovations that accelerate the transition from biomass to modern energy cooking services on a global scale to enable long-term inclusive environmental and developmental benefits for the poor (MECS, 2019). The program is enabled through multi-level partnerships, bringing key and experienced global players such as the Energy Sector Management Assistance Program (ESMAP) and key national governments and partners in the priority countries.

The programme targets 15 countries in the Global South: Bangladesh, Ethiopia, Ghana, Kenya, Malawi, Nepal, Rwanda, Tanzania, Uganda, Zambia, Cambodia, Cameroon, Gambia (the), Myanmar, and Nigeria. These are countries with biomass-dominated cooking landscapes with potential for transformation in the cooking sector, rich in renewable resources, and are prioritized by FCDO's support towards the alleviation of extreme poverty.

This study is part of the MECS work in Kenya led by the African Centre for Technology Studies (ACTS) and the Africa Research and Impact Network (ARIN). The Kenya work aims to identify local niches through which access to modern energy cooking services can be catalyzed by influencing policy, creating awareness, and building an enabling business environment that can feed into the wider global MECS movement for rapidly transitioning away from biomass for cooking.

2.2 Defining Modern Energy Cooking Services

While there is no consensus or clarity in the literature on what constitutes Modern Energy Cooking Services, ESMAP (2020:1) defines MECS as '*a household context that has met the standards of Tier 4 or higher across all six measurement attributes of the Multi-Tier Framework: convenience, (fuel) availability (a proxy for reliability), safety, affordability, efficiency, and exposure'* (see Figure 1). MECS are often identified in ways that contrast them with traditional energy services such as those derived from the burning of biomass in open fires (Watson et al., 2012:3). As such, the concept combines energy carriers, associated technologies, and benefits to users that these fuels and cooking technologies afford lighting, cooking, heating, transportation, and so forth (Watson et al., 2012: 3; UNDP, 2005). Electric cooking (both on-grid and off-grid) alongside other modern cooking fuels and technologies, such as LPG, biogas and ethanol are fundamental examples of emerging modern energy options (Watson et al., 2012:3).

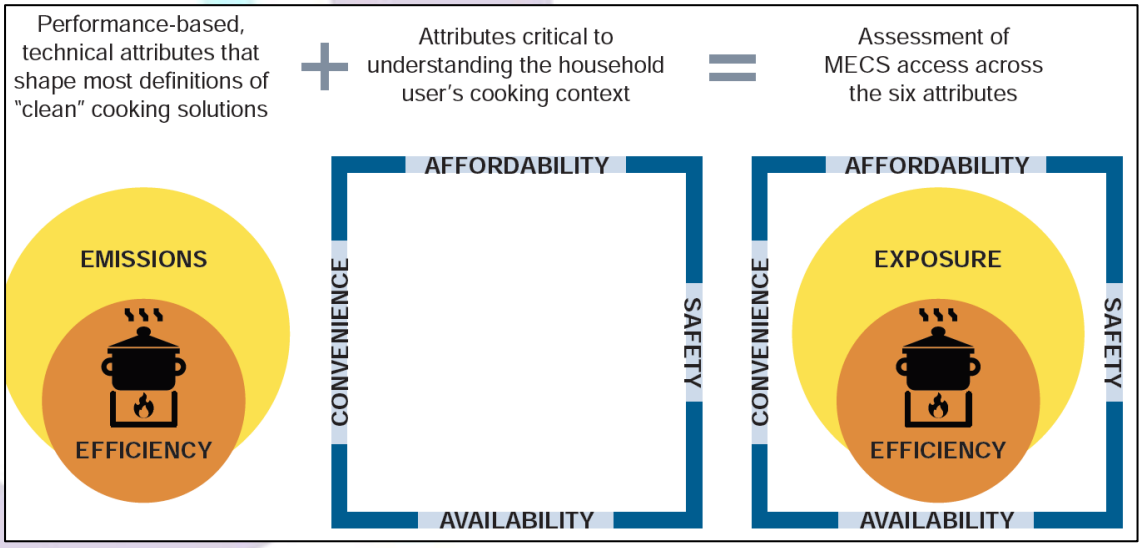

Figure 2: Multi-Tier Framework that defines access to Modern Energy Cooking Services (Source: ESMAP, 2020)

2.3 Data collection

The study employed a mix of desk reviews, stakeholder engagements and learning sessions (see **Error! Reference source not found.**). The study began with an exploratory desk-review to get an overview of relevant technologies and policies in the clean cooking and electrification sectors in Kenya, and the gaps and opportunities for e-cooking (see annex 1). This included both regulatory and fiscal policies (e.g. import taxes, exemptions, manufacturing standards, subsidies). Stakeholder consultations, mapping and engagements were co-produced with the Innovation System Histories (ISH) team from the University of Sussex (Byrne et al., 2020) with the aim of understanding the existing clean cooking and electricity access innovation systems, as well as the emerging e-cooking innovation system forming at their intersection.

Figure 3: Overview of the methodology used by the MECS Kenya team during this study.

3 The Clean Cooking and Electrification Policy Landscape in Kenya

This section provides an overview of clean cooking and electrification policy in Kenya, followed by an in-depth analysis of the potential outlook, gaps, and opportunities in the emerging spaces for e-cooking policy.

3.1 International policy spaces for e-cooking

The international policy agenda for e-cooking is developing fast in the context of the need to accelerate the attainment of SDG 7 which seeks to ensure access to affordable, reliable, sustainable, and modern energy for all. SDG 7 also requires that countries translate their energy commitments into concrete, implementable domestic policies and plans, financial support, improved monitoring of household energy use, among others (United Nations, 2018). Kenya has integrated the SDGs in its development strategies and mainstreamed SDG tracking in its Vision 2030 (GoK, 2017). In the context of the SDGs, various international strategies and commitments such as the Sustainable Energy for All (SE4ALL), the Paris agreement, among others, have given

the central focus on clean energy as a means to achieving the SDGs. This is centrally informed by the potential of the MECS agenda to catalyze the achievement of various multi-lateral ambitions related to climate change, energy, health, and natural resources, among others. While several MECS related options, such as LPG and ethanol fuels have been promoted actively through government programs (e.g., Mwananchi Gas Initiative), e-cooking presents a new and innovative option for utilizing emerging opportunities such as increasing access to electricity to potentially create a major transition towards clean energy in line with SDG 7.

SDG 7.1 specifically aims to achieve universal access to electricity, measured by the share of people with electricity access at the household level both from on and off-grid options (UN, 2015). The specific targets of SDG 7 aim to promote sustainable use of renewable energy through energy-efficient technologies that contribute to resolving multiple global challenges such as health, climate change, and poverty reduction among others, niches that e-cooking can feed directly into. It was reported that globally, the number of people with access to electricity between 2000-2016 increased from 78% to 87%, providing great hope towards achieving the 2030 goal.

However, SDG 7.1 also measures access to clean cooking, and during the same period, access increased from 50% to 60%. However, due to population growth, the total number of people without access remained almost stagnant at 3 billion. At this rate of progress, there will still be 2.9 billion people without access to clean cooking by 2030. While access to electricity as advocated by SDG 7.1 provides a global framework to drive the supply of clean energy through electricity connections, achieving the SDGs will require innovative use of the supplied electricity. In a world where the majority of the population in Low-Middle and Income Countries (LMICs) are still using biomass for cooking, there is a great opportunity to leverage the electricity connection advancement to transform clean cooking through affordable, convenient, and efficient e-cooking appliances and systems. Promoting e-cooking towards clean energy transition for SDG 7 will have huge positive effects on the other SGs (health SDG 3; Quality Education SDG 4; climate change SDG 13; gender equality SDG 5; and poverty reduction SDG 1). The multiple impacts of COVID-19 have demonstrated the role of innovative clean cooking on health and broader socio-economic spheres of society. COVID-19 has particularly demonstrated the urgency of new clean cooking options (such as e-cooking) that minimize respiratory effects (e.g., Batchelor and Brown, 2020; Zhang Y., and Li Z., 2021; UNDP, 2021).

When electricity is generated from predominantly renewable sources, as it is in Kenya, e-cooking also links centrally to the climate action enshrined in the Paris Agreement and highlighted under SDG 13 (climate action). The role of clean cooking in global climate change ambitions is central to the Paris Agreement adopted in 2015 as a global effort to address climate change and its concomitant impacts. The agreement seeks to reduce global greenhouse gas emissions to limit the global temperature rise to below 2°C above pre-industrial levels (UNFCCC, 2020). The Agreement underscores accelerated action through clean cooking. Evidence shows that over half of all wood harvested worldwide is used as fuel, resulting in deforestation and forest degradation, and greenhouse gasses (GHGs) emissions (carbon dioxide, methane among others). It is estimated that burning solid fuels (biomass) for cooking at the household level emits about 25% of global black carbon emissions.

The IPCC Sixth Assessment Report (IPCC, 2020) shows that deforestation and associated land-use changes have been identified to result from cooking. Deforestation creates major

developmental challenges across sectors including dimisnishing agricultural productity, loss of biodiversity and cultural heritage and most importantly, emission of GHGs. E-cooking provides an entry point through which these interconnected challenges can be tackled: In terms of tackling the deforestation challenge, e-cooking can help replace biomass usage especially charcoal. This is important because charcoal aspecifically is a major driver of deforestation and is predominantly used in urban centres than in rural setting -where three stones- firewood is dominant. E-cooking is building up in urban areas where charcoal demand is high. Historically in Kenya, deforestation is mainly associated with the rural settings where forests are hosted. However, evidence shows that surrounding towns and urban areas are major sources of pressure on forests through demand on charcoal thus the e-cooking momentum building in urban areas presents an opportunity to manage deforestation. From biomass loss assessment reports, a family using charcoal uses twice as much wood as a family using wood (even three stone fire).

Connecting this to GHGs emissions, e-cooking could help reduce the CO2 emmitted through the various pathways which through which deforestation emmists GHGs including - reducing GHGs from wood harvesting for biomass cooking, to deforestation associated with wood harvesting both from aboveground and below ground for biomass as well as preserving trees ac carbon sinks.

Sustainable Energy for All (SEforALL) further provides a platform through which the energy ambitions under the SDGs can be achieved. SEforALL is an international initiative aiming to catalyze major new investments in a bid to accelerate the transformation of the world's energy systems, pursue the elimination of energy poverty, and enhance prosperity. The main remit of SEforALL is to catalyse action through connecting networks and innovations in the energy arena (GoK, 2016: SEforALL, n.d). Kenya was among the first country to sign a SEforALL commitment and has since developed an Action Agenda and an Investment Prospectus detailing actions that the Government intends to carry out to ensure access to energy for all. Specifically, the 2016 action agenda on SEforALL has set long-term goals of having an 80% contribution of renewable energy resources to the country's overall energy mix, and 43% of households adopt modern energy cooking services such as LPG stoves, biogas systems, electric cookers, ethanol stoves, and solar stoves by 2030, in order to address the overreliance on inefficient cooking fuels and technologies (MoEP, 2015). Some of these actions include training and upgrading human resource capacity in the sector to keep up with the changing technological issues, developing a programme to identify, develop and implement renewable energy projects for heat and power, with particular emphasis in clean cooking and off-grid electricity services (MoEP, 2015). SE4All therefore offers a wide range of clean energy options and has given specific attention to clean cooking, as well as electricity access.

In summary, Kenya has committed to the major global energy access efforts including SEforAll and SDG7, however the clean cooking and electricity access dimensions are not yet connected. Kenya's policy direction around electrification and renewable energy in general lay an important foundation for the roll out of e-cooking (see Fig 1). In these international commitments, the role of clean cooking in general is significant, but the contribution that e-cooking in particular could make is still vague. The general commitments provide broader political goodwill, but there is still more work to be done to clearly define the contribution that e-cooking should make.

3.2 NATIONAL POLICY SPACES FOR E-COOKING

3.2.1 Kenya's energy policy phases - implications for e-cooking

The global policy frameworks are key to informing the national level policy measures that directly influence clean cooking and electrification in particular. Kenya has implemented a number of national policies and strategies to accelerate the development and adoption of clean cooking as part of a broader energy transition. The policy progress and institutional set-up for e-cooking is however not yet well understood. What is clear is that several domestic policies have successfully advocated for expanded access to electricity, but little is known about the expanded use of this electricity. As such, most of the national level policies, laws and programmes analysed are still representing the unexploited potential for e-cooking. To clearly understand the policy landscape and opportunities, **Error! Reference source not found.** below shows the various policy phases that could help define the main e-cooking niches. The fundamental basis for clean cooking is already broadly enshrined in Kenya's constitutional provisions (GoK, 2010).

The Constitution provides fundamental societal principles that encompass clean cooking and associated technologies such as e-cooking. This means that e-cooking as a technology is already enshrined in the main law of the country. The Constitution provides a basis upon which a number of laws have been enacted through the Parliament. The laws mainly provide spaces around energy governance including regulations, institutions, and agencies responsible for governing energy supply and demand. The main space for e-cooking in this case relates to the tariffs set on different energy options, as well as understanding the agencies with stronger and relevant mandates around e-cooking. The third policy phase is the plans and strategies which define specific action agendas and frameworks legitimising different energy options to the consumers, including households, institutions, and the private sector. Plans and strategies broadly define the energy action agenda, which are then specified in programmes and projects/initiatives. Programmes and initiatives provide the action phase where e-cooking is put in practice through various demonstrations, technology development, diffusion, financing, etc. Depending on where the e-cooking agenda is at a particular time, there is often the opportunity to link to new spaces in the next policy phase, or even feedback to various policy phases.

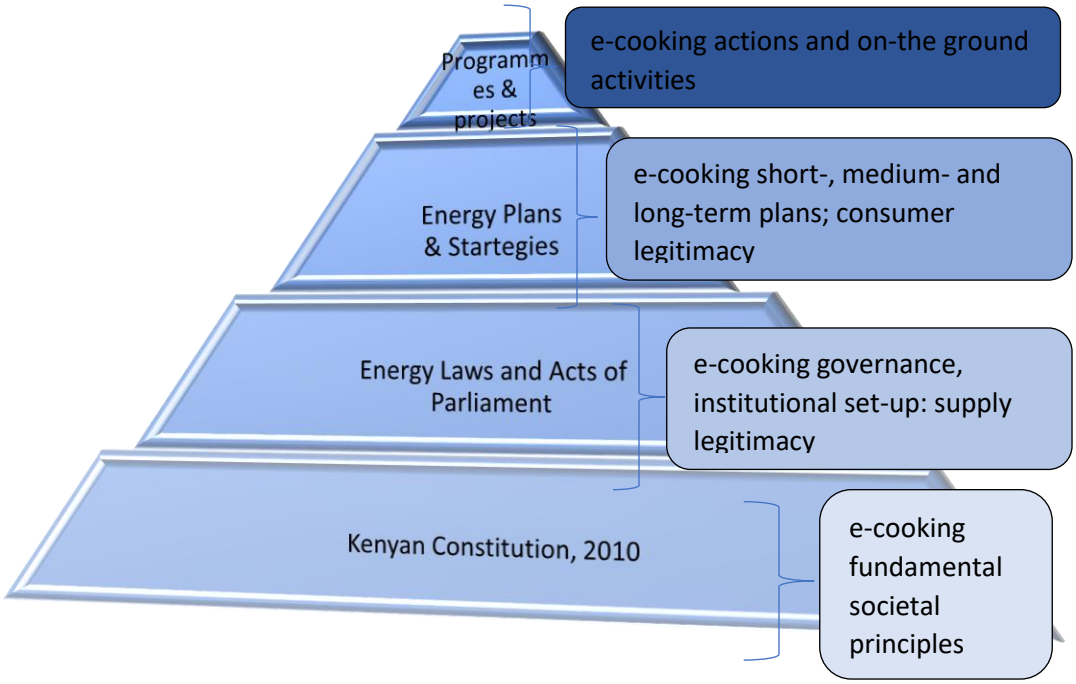

Figure 4: Kenya policy phases and the interlinkages of Kenya's policy spaces for e-cooking

In the following section, we look at the specific provisions both from the energy sector policies and programmes (largely regulating the energy supply and demand), and the wider non-energy policies that could benefit from the e-cooking agenda. Both these policy domains have missions and ambitions that align with the e-cooking technological, social, and economic innovations, thereby opening up opportunity spaces in different ways as discussed next.

Error! Reference source not found. shows that there is currently a disconnect between clean cooking and electrification policy in Kenya, as less than 10% of analysed policies/programmes have some direct focus on e-cooking. The diagram shows that many of the analysed policies have direct relevance to either the clean cooking (e.g., 2019 LPG regulations) or electrification (e.g., Last Mile Electrification Programme) sectors. Some are directly relevant to both sectors, but in separate capacities (e.g., the original NCCAP, which has separate sections for clean cooking and electricity access). However, a growing number have crossed the great divide between the two sectors and connected clean cooking and electrification together by directly focussing on e-cooking (e.g., Pika na Power). Others are venturing into this shared space (e.g., KOSAP clean cooking component, which has electric cooking appliances in scope).

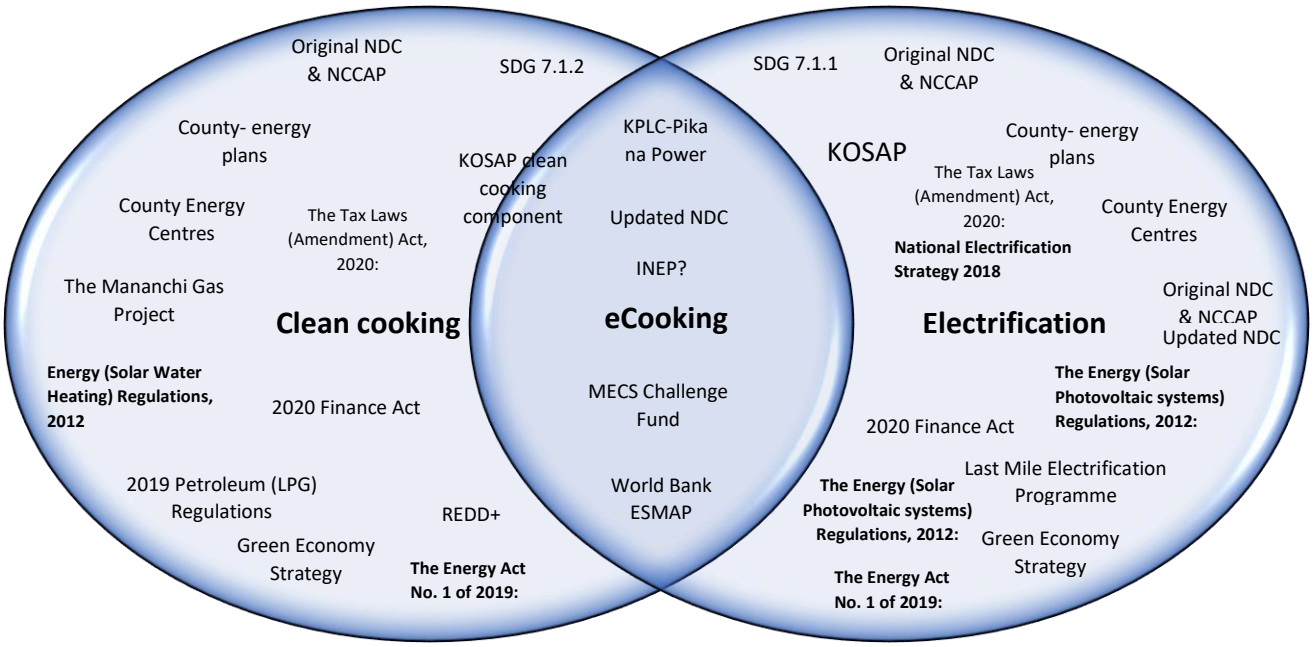

Figure 5: General placing of policies and programmes by their relevance to Kenya's established clean cooking and electrification sectors and emerging e-cooking sector.

3.2.2 The energy sector (regulatory) policy spaces

The regulatory policies in this case are defined as programmes, strategies, laws and plans that have direct mandate to govern the supply and use of energy in Kenya. These mainly occur within the energy sector where the direct mandate for energy governance lies. As a starting point, the Kenyan Constitution of 2010 provides a fundamental basis for energy governance. Promulgated on 27th August 2010, the constitution provides some fundamental societal principles supportive to e-cooking and opens up spaces for innovative natural resource governance that enables innovations in the energy and other sectors of the economy. More specifically, the constitution provided for the establishment of autonomous County Governments (sub-national governments) within different contexts, entities which are closer to energy resources and the consumers. The potential role of county governments is creating strategic linkages between people and the resources; facilitating actual implementation of new clean energy techniques such as e-cooking. More broadly, Article 42 of the constitution grants every individual the right to a clean and healthy environment, thus establishing a legal frame for clean energy taking into account, for instance, the destruction of forests for fuel wood.

The opportunity provided by the constitution has catalyzed a raft of policies, programmes, and projects within the energy regulatory policy space. These energy laws and policies are critical to setting up enabling governance structures and establishing legitimacy for clean cooking, and potentially e-cooking. The established laws range from the Sessional Paper on Energy No.4 of 2004 which forms the basis for the policies and strategies for the country's energy development. The law encourages energy sustainability more broadly through renewables and the development of associated technologies. The law recognizes the energy opportunities and provides

governance options to catalyse utility. For instance, it recognized the low rates of electric energy access in the country especially within the rural areas and established the Rural Electrification Authority (REA) to accelerate the pace of rural electrification through grid extension and off-grid projects. Since its establishment, the Authority has provided electricity in off-grid areas through extension of powerlines from off-grid towns, with diesel stations to other towns within the off-grid areas such as the Turkwel-Lokichar Line, and the implementation of solar mini-grids such as the 26 solar mini-grid projects which the authority is currently implementing in the off-grid counties of Wajir, Turkana, Marsabit, Mandera and Garissa. Upon completion, the projects are expected to serve more than 4000 households (REA, 2020).

As part of enhancing the utility of increased electricity generation resources, the law already recognizes and encourages diverse use of electricity especially for heating and other options that might emerge. This provides a strategic opportunity towards e-cooking as a means to contributing to this mission. The development of fiscal and regulatory frameworks to create enabling environments to accelerate the development and utilization of the technology in the country provides leeway for the various innovations and accounted actors to get into the opportunity spaces created by increased electricity connectivity. While the law also promotes other clean cooking technologies, the expanded electricity connection provides an opportunity to transition from the traditional and resource intensive cooking options such as biomass, to modern options such as e-cooking. As part of promoting technology development and technical support within the space, institutions such as KIRDI have helped develop and support clean energy technologies and innovations.

It is worth noting that the Sessional Paper No.4 has enabled the construction of clean cooking infrastructure, which e-cooking could build upon. For instance, there are sixteen County Energy Centres in the country whose functions include: development of Renewable Energy (RE) & Energy Efficiency (EE) county energy plans; training, demonstration, and extension on RE & EE technologies; dissemination of RE & EE technologies; establishment and maintenance of databases on renewable energy technologies in the country; and undertaking Research and Development activities (Ministry of Energy, 2018). These institutions are promoting adoption of MECS technologies by developing prototypes, business development and incubation, training, and awareness creation on the use of different cooking technologies and lobbying for suitable policies. KIRDI specifically developed a state-of-the-art energy laboratory and stove testing centre to conduct research and development on clean fuels and technologies (KIRDI, 2019). Such centres are spaces within which e-cooking could be demonstrated and compared with other modern options such as LPG. Similarly, the law has promoted the establishment of the LPG import handling, and construction of storage and filling facilities in Nairobi, Kisumu, Nakuru, Eldoret and Sagana, with plans to expand. In addition, the construction of a US$75m LPG storage and filing facility that began in April 2018 in Liwatoni Mombasa is ongoing, and a down-stream infrastructure in Kisumu, Rift Valley, Nairobi and Western at a cost of US$15m with a potential to move 12,500tonnes monthly once completed (Pumps Africa, 2019).

The Sessional Paper No. 4 has informed a number of more specific legislations that also embed enabling nodes of energy governance. The Energy Act No. 1 of 2019 came into effect in March 2019 and repealed the Energy Act No. 12 of 2006. The Act has established a number of institutions governing energy supply and demand (see section 5). The Act obligates the Authorities (Energy Cabinet Secretary) to develop strategies for developing the renewable energy share of the country's energy mix (including distribution and markets). The distribution and

marketing of renewable energy such as solar, wind, and small-scale hydropower promotes international co-operation on programmes focusing on renewable energy sources.

The Energy Act is complimented by several regulations that aim to ensure quality appliances and consumer safety through market standardization as regulation of LPG cylinder refilling procedures, getting rid of illegal refilling and illegal rebranding of cylinders (i.e., unlicensed refilling and rebranding options). This is important for e-cooking as many studies have identified safety as a key concern in the adoption of e-cooking (Parikh et al., 2019; Leary, Fodio Todd et al, 2019).

The Petroleum (Liquefied Petroleum Gas) regulations of 2019, otherwise referred to as LN 100 of 2019, replaced ''The Energy (Liquefied Petroleum Gas) Regulations of 2009 (LN 121 0f 2009). The LN 121 created regulations around Standardized cylinder sizes (0.5kg, 1kg, 3kg, 6kg and 13kg fitted with unified valves), Standardized cylinder valves, license requirements for all players in the domestic LPG space (LPG importers, exporters, transporters, wholesalers, retailers and storage facilities) and the LPG Cylinder Exchange Pool ('The Pool), where marketers were obliged to accept each other's brands when selling refills, and then hand over the empty cylinders to the brand owners. However, the LN 100 came into effect following the enactment of the Energy Act, 2019 which has maintained the rules around standardized cylinder sizes and valves in addition to safety measures and powers of inspection of business vehicles or facilities by the ERC/EPRA, as well as requirements to adhere to standards of the Kenya Bureau of Standards for cylinder specifications and handling, storage, and distribution of LPG. The LN 100 however dismantled ''The Pool'' due to perceived abuse. In this, the cylinder exchange is now mutual rather than compulsory as in the 2009 regulation compulsory for LPG cylinder marketing companies to accept competitor cylinders (GOK, 2019). With the mutual exchange system in place, brand owners now have the choice to allow exchange of their gas cylinders with competitor brands or opt out of the pool thereby restricting cylinder exchange to their own brands (Oimeke, 2020). The regulations outlaw refilling, rebranding, defacing or even submitting a gas cylinder for maintenance without prior written authority by the brand owner (GOK, 2019; Omoike, 2020), thereby eliminating unfair competition practices. A six-month transition period was set in place under Schedule 7 on LN 100 to allow players sufficient time before these changes. The implementation of the LPG strategy is however faced with financial challenges that have resulted in the stalling of the planned 5,000 metric tonnes LPG distribution and filling depot in Eldoret (Mwita, 2019). Finally, besides the LPG purchase subsidy to the low-income bracket by the government through the Mwananchi Gas Project, the government is yet to launch any loan program to assist with up-front cost of cookers and cylinders.

The implications of these changes remain unclear even though there are concerns that some of the measures such as restricting the pool might impede market innovations for expanded access and convenience of LPGs. This impedes the MECS access framework especially with regards to convenience and to some extent affordability due to a more regulated market system and higher costs that could lock out alternatives for the poor. The diversity of standardized cylinder regulators for each brand of cylinder available at home has, however, facilitated adoption of LPG in Kenya.

Nonetheless, the case of LPG safety and consumer protection regulations shows some critical lessons for e-cooking. The market and regulatory failures and efforts to manage such mirror what

the e-cooking market is likely to face in its market coverage. Nonetheless, programmes promoting e-cooking should take note of such lessons.

The existing laws have also usefully developed some opportunities for off-grid e-cooking especially in off-grid remote areas. The Energy Regulations 2012 (Solar Photovoltaic Systems and Solar Water Heating) are specific to enhancing solar development and distribution. The solar PV regulations provide a licensing framework for the solar PV value chain and facilitate proper design, installation and use of solar PV systems while avoiding the supply of substandard components and installations. Meanwhile, the Solar Water Heating Regulations promote use of solar, requiring all premises with hot water requirements of a capacity exceeding one hundred litres per day to install and use solar heating systems. While the solar-based regulatory interventions promote off-grid technologies, the focus on the heating and cooking arena lays the foundation for solar electric cooking. Further, expanding the range of electricity options is critical for e-cooking where initial costs have been identified as a key impediment. This expanded option was reflected recently where consumers in Kenya were beginning to use solar-generated electricity especially in situations where they felt that the on-grid electricity cost was relatively high.[1]

While the Tax Laws (Amendment) Act 2020 provides fiscal incentives for expanding solar electricity options, the Feed-In Tariffs (FIT) 2008 enable expanded on-grid supply through independent power producers who are permitted to sell renewably-generated electricity to an off-taker at a pre-determined tariff for a given period of time (20-year period) (GoK, 2012). The first FIT was enacted in 2008 and covered wind, small hydro, and biomass energies. The 2008 tariff was revised in 2010 and 2012 to include solar and geothermal into the FIT policy. The current FIT policy provides for payment of power supplied at a rate not exceeding US Cents 20 per Kilowatt-hour for renewable projects of up to 10MW of installed capacity, and a rate not exceeding US cents 12 per kWh for renewable projects above 10MW of installed capacity (Republic of Kenya, 2012).

[1] https://www.businessdailyafrica.com/bd/corporate/companies/kenya-power-raises-alarm-over-clients-solar-switch--3204410

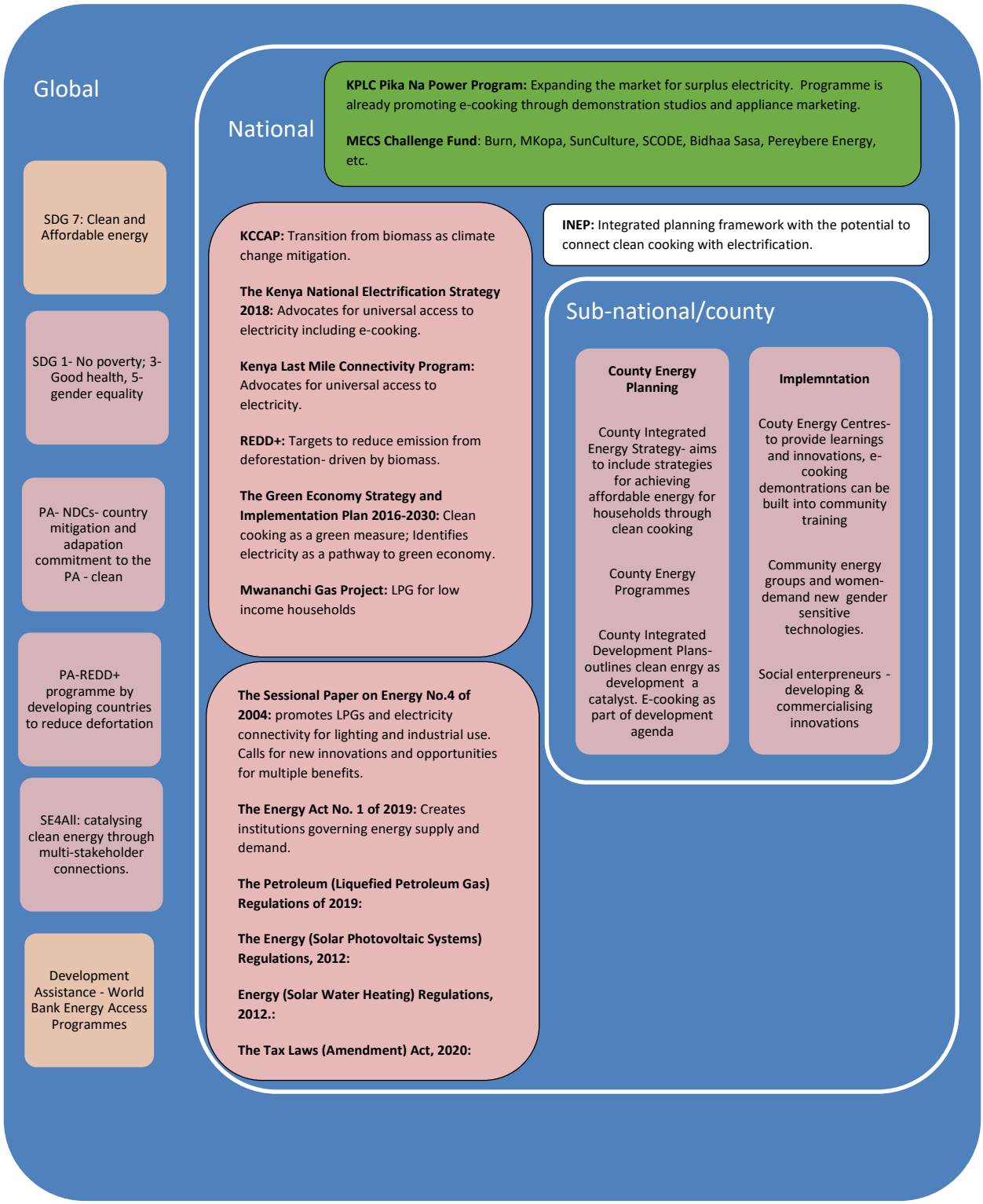

Figure 6: Illustration Illustration of the various policies, programs and strategies at the international, national and sub-national levels. Green indicates policies, programs and strategies that specifically mention e-cooking.

Kenya has a number of regulatory policy spaces with enormous potential to transition clean cooking to modern energy cooking options. However, few polices, programs or strategies specifically mention e-cooking. The regulations, as shown in **Error! Reference source not found.**, show the broad range of relevant policies that govern the energy supply chain. In this, most of the regulations highlight the potential for e-cooking to connect into a broad range of policy spaces, including the stimulation of demand for surplus grid electricity, access to off-grid renewable electricity, and general clean cooking. However, there is still lack of specific direction on e-cooking and the supply of energy-efficient appliances.

At the time of writing, the Ministry of Energy's Integrated Energy Planning (INEP) process, had just begun. This is a key example of energy policy with an aspiration to create an integrated framework that connects the counties to the national government, but with the right support, it could also address the electricity and clean cooking challenges via e-cooking.

3.2.3 Policy spaces outside the energy sector

The potential impact of e-cooking can be viewed beyond the energy sector into other sectors such as health, environment and socio-economics. As already described above, the climate change policy prescribed under the Paris Agreement and its associated national policies such as the **Kenya National Climate Change Action Plan (KNCCAP; 2018-2022)**, the NDCs, REDD+ readiness, among others aligns clearly to the e-cooking mission. In other words, e-cooking presents a new and innovative low carbon pathway that can significantly contribute to the goals of emission reduction advocated by these climate policies, given the significant contribution of biomass to the GHGs either through direct emissions during burning or indirectly through deforestation and forest degradation. The KNCCAP specifically promotes the transition to clean cooking with a range of fuels, such as LPG, ethanol and other clean fuels in urban areas, and estimates that this move would contribute to GHG emission reductions of 0.8 MtCO2e per year by 2022 (GOK, 2018). Some of the actions that the plan proposes to accelerate towards the uptake of these clean cooking technologies include development of a depot with LPG storage tanks, bottling machines and stock cylinders of various sizes; instituting loan programs through micro-finance institutions to assist with up-front cost of cookers and cylinders; and providing incentives (e.g., tax-relief for manufacturers) to promote local manufacturing and servicing of clean cookers (GOK, 2018).

Similarly, Kenya's NDCs and NCCAP presents measures and actions that a country can implement to reduce national emissions and adapt to the impacts of climate change. Kenya submitted its first NDC on 28th December 2016, which largely promoted the adoption of clean energy technologies as the main climate mitigation option. The NDC prioritised clean energy as the main mitigation pathway (Liti et al. 2016). It includes the promotion and implementation of renewable energy (hydropower, geothermal, solar options, which accounts for over 70% of energy investments). Given that the Kenyan NDC keenly promotes electricity as a central vector of renewable energy, the utility space for electricity presents a huge opportunity for Kenya's enhanced mitigation ambition under the Paris Agreement. Additionally, evidence (Pauw & Klein, 2020) shows that most NDCs of developing countries including Kenya are still characterized by general statements on intent, and that there is real need to develop tangible implementable programmes/projects to realize the ambitions. E-cooking is strategically placed as one of those tangible actions towards realizing the Kenyan NDC. Additionally, the NCCAP is updated every 4

years, and the NDC was just updated at the end of the year 2020. Thus, the key entry point would be to build e-cooking into the next iteration of the NCCAP.

The wider policies on climate change and energy are a central part of the green growth aspect of sustainable development. Kenya's **Green Economy Strategy** 2016-2030 provides a roadmap for moving Kenya to a globally competitive green economy by 2030, by creating green jobs, green energy, etc. (GoK, 2016). However, the strategy does not explicitly articulate how this should be accomplished. The strategy has also emphasized the need to increase the share of solar energy, among other renewables, in the national grid. Nonetheless, a key value of the strategy is that it highlights key challenges that could also apply to e-cooking including inadequate compliance and weak enforcement of standards, gaps in skills and capabilities on green technologies, financial constraints, among others. These gaps were also highlighted by practitioners (i.e., MECS Challenge Fund winners) during the MECS-Kenya policy dialogues. These gaps include the need to develop supportive and action-oriented policy measures around developing and adopting e-cooking.

The opportunity space provided by the regulations and associated plans would enable e-cooking to posit positive knock-on effects on the missions and activities of multiple sectors including forestry, health, and housing, among others. For instance, as discussed, e-cooking is central to reducing deforestation and promoting forest cover in line with the ambitions of the Kenya Forestry Service to promote 10% forest cover by 2030. The steering of the REDD+ readiness programme supported by the World Bank through the Kenya Forests Services (KFS) targets to minimise dependence on wood-fuel for cooking at households and institutional level, an opportunity that e-cooking could promote. Similarly, the impact of COVID-19 on health and health systems has made countries to re-focus on promoting respiratory-friendly fuels that could include e-cooking. The rising housing designs through the real estate investments and emerging modern kitchen designs are key opportunities for e-cooking.

3.2.4 Climate finance

There is potential to finance eCooking technologies through the Green Climate Fund under the Paris Agreement (UN, 2015). The GCF is currently the key fund supporting climate actions under the Paris Agreement (PA). Under the PA, developed countries committed to mobilize USD 100 billion per year between 2015-2020, and this is to be partly channeled through the GCF to support mitigation and adaptation programs in developing countries. The fund became operational in 2013 and commits 50% of its portfolio to adaptation. The fund's actual portfolio currently stands at USD 10.3 billion in pledges and USD 9.9 billion in signed contributions, and with a readiness support fund for up to USD 50 million for projects preparation. E-cooking could become an integral part of climate change mitigation. Developing consolidated eCooking proposals with a clear mitigation contribution either from direct emission reduction in clean cooking or through avoidance of emissions from deforestation from biomass cooking are key fundable areas under the GCF. Furthermore, clean cooking has been highlighted in Kenya's NDC as one of the key areas of achieving mitigation, however, e-cooking is not specifically mentioned.

The process of engaging with GCF is well set out, and most countries including Kenya have adhered to these processes. The GCF is especially linked and managed through a National Designated Authority (NDA) who recommends a proposal to the GCF board upon reviewing its relevance to the country's low carbon development pathways. There are also national

accredited/implementing entities (NIEs) that provide a technical and institutional review of proposals. The NIEs receive proposals on behalf of the NDA, undertakes the initial technical assessment, and submits it to the GCF subject to clearance from the NDA.

Access to the GCF is mainly through developing competitive bankable project proposals aligned to six investment criteria: impact potential; paradigm shift potential; sustainable development potential; responsive to recipient's needs; promote country's ownership as well as showing efficiency and effectiveness. E-cooking meets all these investment criteria. There have been concerns, about the capacity of key stakeholders in Kenya to develop bankable projects, thus the need to embrace targeted capacity building initiatives aimed at promoting technical innovations for bankable eCooking GCF proposals will be critical.

3.2.1 International development assistance

In addition to FCDO's support to Kenya through the MECS programme, international development assistance continues to give priority to clean cooking as part of the commitment to the SDG 7, as well as the Paris Agreement. Recently, the US government, through their renewed commitment to climate change, announced clean cooking as a priority area of their development support targeted at meeting their climate obligation, but also achieving a raft of SDGs.[2] There are multiple other development partner programs e.g., World Bank's ESMAP and others that either directly promote eCooking through technology and market development, or indirectly through enhancing supply through expanded connectivity. EnDev funded the first eCooking RBF in Kenya in 2020, supporting the sale of 5,000 Solar Home Systems (SHS) (further details below), and GIZ is preparing to implement a range of eCooking interventions in 2021 in several of their country offices, including Kenya.

3.3 INSTITUTIONAL SPACES FOR E-COOKING

The national policies discussed in section 4 have created a number of institutions which are relevant to e-cooking. These agencies are important for e-cooking because they either govern or facilitate the energy agenda and potentially e-cooking. Figure 7 below shows the range of Government Agencies/Ministries that have a stake in energy regulations in order of their influence on overall energy decisions, and thus e-cooking. The analysis of roles and responsibilities shows that the Ministry of energy has the very direct responsibility to influence the energy options and related policies and incentives in the country. The Ministry of Energy constitutes a wide range of agencies with different mandates.

A key challenge for e-cooking is that there is no particular agency taxed to manage clean cooking, and although an inter-ministerial committee was established to address this issue, it does not yet connect into the electrification sector. The committee is chaired by key collaborators within the MECS-Kenya programme, which could be a key entry point. During one of the MECS-Kenya policy dialogues on cooking diaries, it was suggested that the MECS programme could develop a policy

[2] https://www.cleancookingalliance.org/news/04-22-2021-u-s-government-announces-major-re-commitment-to-clean-cooking-and-the-clean-cooking-alliance.html

scenario analysis comparing the potential impact of the different types of e-cooking policies the ministry could implement.

Most of the existing agencies are largely managing the supply side of energy including electricity supply and connections (e.g., Kengen, KPLC etc), petroleum (e.g., Ministry of Petroleum and Mining) and other renewable energy sources (e.g., Renewable Energy Resource Advisory Committee), and with relative focus on industrial, transport and lighting energy usage. The management of energy demand and consumption is relatively weak and largely limited to price regulations. The Energy and Petroleum Regulatory Authority (EPRA) is tasked to manage energy consumption, but its role has largely remained around price regulations and less on managing, guiding, and expanding energy usages, associated innovations, and their consequences. The implication here is that whereas the Ministry influences key energy supply and demand decisions, clean cooking and e-cooking in particular remains a secondary focus in those decisions. Nonetheless, during a MECS-Kenya policy dialogue, a representative from the Energy and Petroleum Regulatory Commission (EPRA) noted the potential for developing an off-peak electricity tariff that could encourage schools, restaurants, and other institutions to cook with surplus renewably generated electricity.

Despite the weak institutional set-up for clean cooking, a key opportunity lies in the relatively strong institutionalisation of electricity as a mainstream source of energy for the country. The Ministry of Energy has established various agencies to manage different elements of electricity supply and use. Key among them is the Kenya Electricity Generating Company (KenGen), which is the country's largest electricity producer accounting for 72% of the electricity consumed in the country. It largely produces electricity from renewable sources including hydropower and geothermal, thus signalling sustainable supply in line with the MECS framework and an opportunity to explore e-cooking as one of the pathways to utilising the electric supply to attain clean energy transition. As already highlighted, Kenya has one of the world highest potential for renewable electricity through geothermal.

Building on the strong electricity generation potential in Kenya, the Ministry has established institutional arrangements to enhance distribution and use through the Kenya Power and Lighting Company (KPLC) and Kenya Electricity Transmission Company (KETRACO) which plans, designs, builds, operates, and maintains transmissions. These agencies have a clear understanding of the electricity demand and supply and have been able to identify the existing gaps.

KPLC has developed an electric cooking program known as **Pika na Power** (which translates as 'cooking with electricity') to stimulate demand for the surplus power now available on the national grid. The program has been promoting electric cooking with the aim of ushering KPLC's 7 million customers towards cooking with electricity. The program works closely with other initiatives such as Jikoni Magic, Hotpoint Appliances Ltd and the MECS programme to bring Electric Pressure Cookers (EPCs), induction cookers, infrared cookers and other efficient electric cooking solutions to the masses (Jon, Agnes and Monica, 2019). Although initially focussed on induction stoves, Pika na Power now recognise that EPCs offer the ability to cook the most energy intensive foods with a fraction of the cost of other fuels. A key challenge to the program however is the lack of awareness and availability of EPCs. Efforts to create awareness through influential Kenyan bloggers as well as social and mainstream media continue to pay off. A Television program,

'Shamba Shape Up'[3], aired in one of the leading Television Station in Kenya (Citizen TV), now features e-cooking. As part of promoting greater outreach, the MECS-Kenya partners (ACTS) are currently negotiating a Memorandum of Understanding (MoU) with the KPLC with the aim of upscaling awareness and demonstration on e-cooking across Kenya. '*There is increasing supply of electricity and Pika na Power program is already implementing e-cooking studios where many consumers are coming to learn about cooking with electricity. As KPLC, we believe that electric cooking using new technologies such as the Electric Pressure Cookers (EPCs) is an opportunity for many people to diversify their use of power in a clean way.*'' Wairimu Njehia, Manager, Pika na Power program.

Other agencies within the Ministry include the Rural Electrification and Renewable Energy Corporation (REREC), charged with spearheading rural electrification projects in Kenya and strengthening the renewable energy drive. REREC also implements the electrification of public facilities through grid extension within the grid network and installation of solar PVs for facilities in off-grid areas. The corporation also promotes (in collaboration with other agencies) the development and use of appropriate local capacity for the manufacture, installation, maintenance, and operation of renewable technologies such as bio-digesters and solar systems. The roles around electrification and capacity support in private and public facilities provide a huge opportunity to integrate e-cooking innovations in the expansion programme.

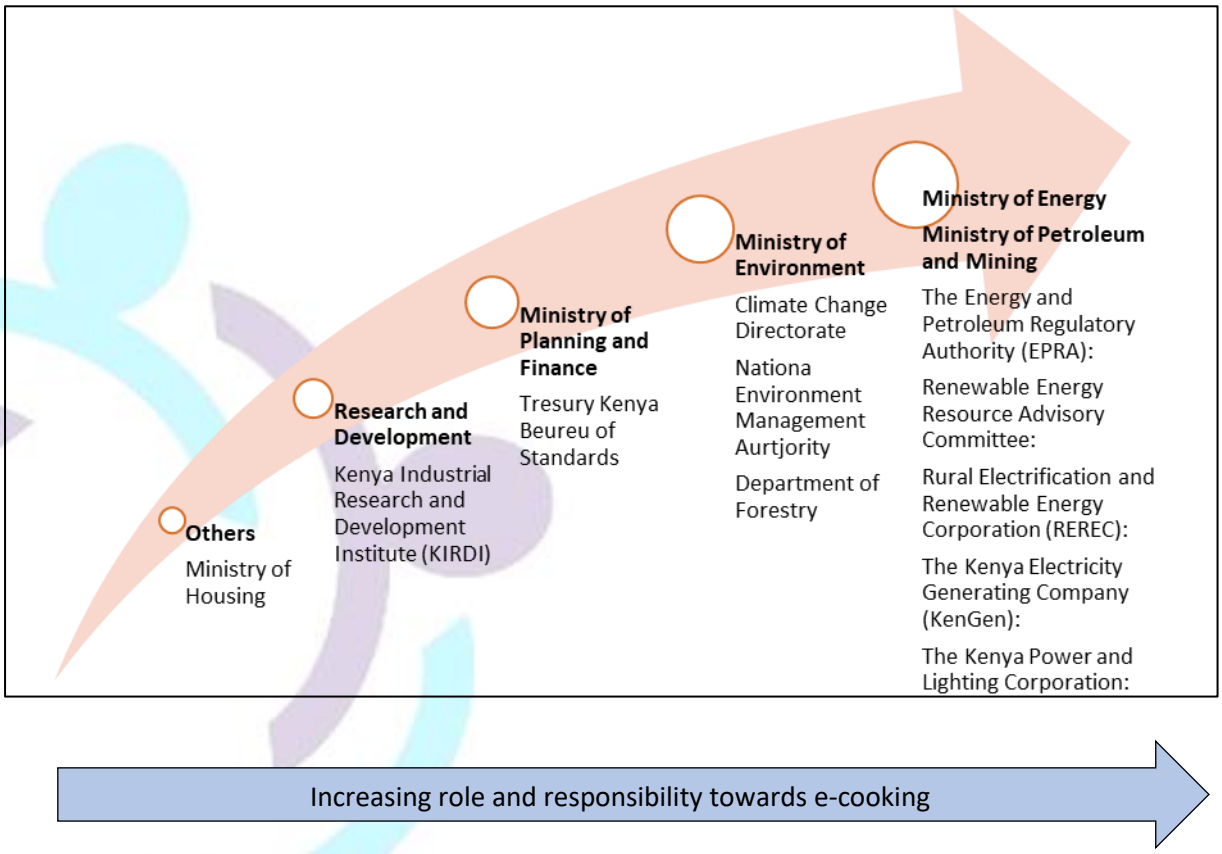

Figure 7: Government Agencies/Ministries that have a stake in energy regulations in order of their influence on overall energy decisions.

[3] https://shambashapeup.com/

While the Ministry of Energy has a more strategic role in promoting e-cooking, there are other important Ministries and agencies outside the energy docket. These agencies do not have much direct role in governing the energy supply and demand but are important in facilitating the implementation of measures as well as innovations. The Ministry of Environment for instance is responsible for promoting sustainable management of natural resources including those used in generating electricity. The Ministry hosts the climate change directorate which is responsible for preparing and implementing the country's climate action plan. As already highlighted, e-cooking presents new and innovative options to reduce GHGs resulting from burning solid biomass. Kenya's climate plan and the NDCs submitted to the Paris Agreement recognise modern cooking options for both climate mitigation and adaptation through income generation.

There is an opportunity to engage and mainstream e-cooking in the climate action planning and revised NDCs. E-cooking can be part of funded climate change programmes and projects including those supported through the Green Climate Fund. In this regard, the Ministry of Finance and Planning and associated agencies such as the Treasury are key in setting the fiscal policies including taxation and incentives on e-cooking appliances. Other than taxation, there are technology agencies such as the Kenya Industrial Research and Development Institute (KIRDI) which undertakes multidisciplinary research and development in industrial and allied technologies, develops prototypes of different cooking technologies, and lobbies for the development of standards for such technologies in line with the_Kenya Bureau of Standards (KEBS). KEBS is responsible for the provision of Standards, Metrology, and Conformity Assessment. It ensures standards of the energy appliances such as cookers.

At the sub-national level, the role of county governments in preparing and supporting energy planning and implementation is increasingly becoming important. The county government is central in supporting energy governance at the local level where a lot of action takes place (GoK, 2011). The counties have been mandated to establish energy centers for demonstration, and extension on renewable energy technologies and innovations including capacity building. This provides a special opportunity to strengthen, demonstrate, and integrate e-cooking in various counties.

Overall, modern energy cooking services and e-cooking in particular is **a multi-agency agenda**. Strategies that leverage the strengths and influence of these agencies are critical as part of promoting e-cooking as an innovative pathway to clean energy transition, building on existing electricity infrastructure. One key challenge however, highlighted during the policy dialogues is the lack of proper coordination among the agencies even within the Ministry of Energy itself. There are general overlaps that might remain an impediment to promoting e-cooking. For instance, while KPLC is keen on promoting electricity consumption, there is a very strong push for other agencies to promote a wide range of energy technologies, including improved cookstoves. The lack of harmony is further inspired by a lack of an integrated understanding of the opportunities associated with the various energy uses and the consequences of such. For instance, while KPLC is already aware of e-cooking as an opportunity, this awareness probably needs to be appreciated across the various relevant agencies. The development of the Integrated Energy Plan (IEP) is an opportunity towards such direction. As part of promoting e-cooking, MECS-Kenya will engage closely with the IEP development process to facilitate **inter-agency dialogues** around e-cooking. Such dialogues will also require active integration of the civil society organizations as well and the private sector who are key players in the policy and market influence.

3.4 INSTITUTIONAL AND POLICY INNOVATIONS

The analysis has shown that policies and institutions around e-cooking are still disintegrated, with a lack of clear policy messaging around e-cooking. Whilst there are many policies in the clean cooking sector and even more in the electrification sector, very few connect between the two. Additionally, the institutional arrangements around energy governance are very rich but relatively unclear with respect to e-cooking specifically. Key elements to consider include:

i. **Institutional engagements and arrangement**: Identifying optimal institutional and stakeholder arrangements focused on e-cooking, enabling business models and engaging these as change agents and nodes for advocacy.

ii. **Evidence for decision making**: From policy to business models, the development of policy specifically focused on e-cooking will require the continuous generation of evidence around supply, demand, capacity gaps, market opportunities, among others.

iii. Establishing **institutions that span the clean cooking and electrification sectors** e.g. departments and **inter-agency/cross-sectoral committees and dialogues** would make e-cooking messaging clearer in the policy domain and enable it to scale out through the policy action arena, i.e., programs.

iv. **Institutional cooking**: Institutions play a key role in disseminating technologies and have much higher cooking demand than households, thus require different electric cooking solutions with much higher capacity.

v. Finally, **partnerships** to upscale e-cooking are critical. While KPLC has initiated the Pika Na Power program, they are hoping to broaden partnerships with external retailers, distributors, and financing institutions to scale up the adoption of the appliances. Moreover, the rate of adoption of e-cooking especially in the rural areas is still quite marginal due to the limited distribution channels targeting these areas.

3.4.1 Transitioning from policy to action - programmes relevant for e-cooking

As will be seen in the subsequent section, e-cooking enjoys more direct and clear alignment at the programme and action level, where a number of initiatives directly support e-cooking options. This section has shown that there is relative vagueness in the lower policy phases around legislations and policy plans. This creates some loss of momentum at the action level. Thus, there is need to rejuvenate e-cooking through more clear alignment with the base policies and legislation as a foundation for up-scaling and out-scaling e-cooking.

4 THE CLEAN COOKING AND ELECTRIFICATION TECHNOLOGY LANDSCAPE IN KENYA

This section aims to identify key niches for e-cooking technology in the Kenyan market and how these could be enhanced moving forward, building on a rich landscape of clean cooking and electrification technology in Kenya.

Wood fuel and charcoal cooking technologies still dominate the Kenyan cooking market. The GoK (2019) report highlights that approximately 67% of households rely on biomass (firewood/charcoal) for cooking, with a much higher proportion in rural areas (92%) than urban (27%). Although firewood use has been slowly declining, the trends show that charcoal use has remained relatively constant, with LPG displacing firewood use over the last two decades (see Figure 8).

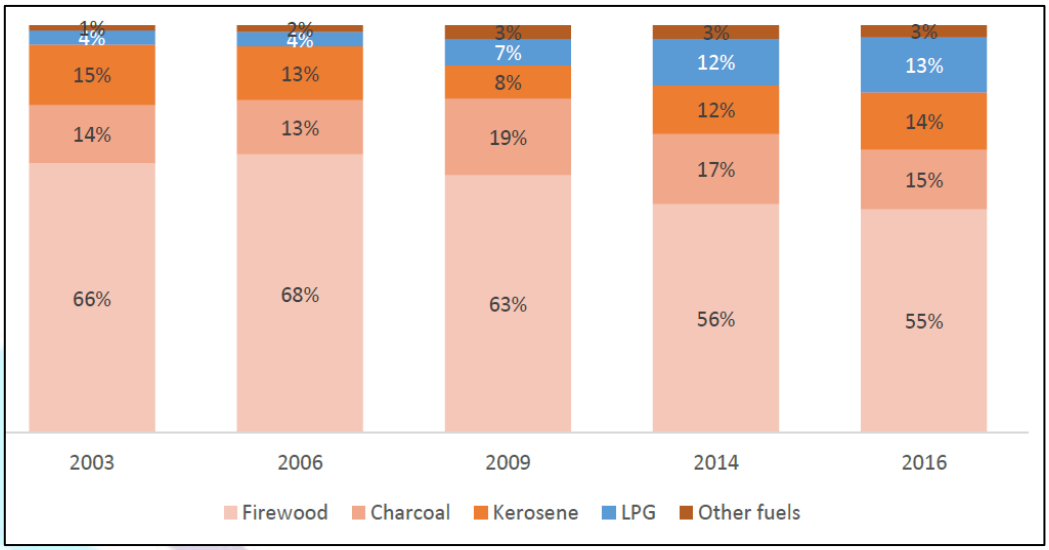

Figure 8: Trends in primary fuel use in Kenyan households (2003-2016). (Source: GLPGP, 2019): *Trends in primary fuel use in Kenyan households (2003-2016). (Source: GLPGP, 2019)*

Figure 8 shows that the Three Stone Open Fire (TSOF) remained the most used wood-based cooking technology since 2003, with about 66% usage in 2016 and down to 55-58% between 2016 and 2019. The Kenyan Ceramic Jiko (KCJ) dominates Kenya's charcoal stoves, with an estimated 4.2 million households (33.8%) reporting owning at least one during the same period (GOK, 2019). To address this overreliance on inefficient cooking fuels and technologies, the government of Kenya has set a long-term goal of having 43% of households adopt modern energy cooking services by 2030 (Van den Berg, 2018) and associated technologies, which include biogas systems, liquefied petroleum gas (LPG) stoves, electric cookers, ethanol stoves, among others.

Electric cooking has traditionally been viewed as cooking with grid electricity. However, with the falling cost of energy storage and growing availability of DC electric cooking appliance, the range of options is now expanding. A suite of new technologies and business models are emerging that can enable electric cooking for households connected to mini-grids, unreliable grids, and off-grid systems (**Error! Reference source not found.**9). Many of these innovations are being pioneered in Kenya by MECS partners, including SCODE, MKopa, SunCulture and Strathmore University.

USE OF BATTERY	GRID OR MINI GRID	SOLAR HOME SYSTEM
Without battery	**Strong grid** AC grid eCooking	**Off-grid** DC solar eCooking
Battery-supported	**Weak grid** DC grid battery-powered eCooking	**Off-grid** DC solar battery–powered eCooking

Figure 9: Typologies of electric cooking technologies. (Source: ESMAP, 2020)

4.1 E-COOKING WITH GRID ELECTRICITY

In Kenya, the adoption of electric cooking technology is still quite low. The GoK (2019) reported that only 3% of households in Kenya own an electric cooking appliance, such as a dual LPG-electricity stove, electric induction stove, electric coil stove or a microwave. The study attributed this to the high purchase costs of electric cooking appliances, highlighting the mixed LPG-electricity stoves[4] which retail at an average price of KES. 28,920 and KES. 39,250 for urban and rural users, respectively. However, this fails to recognize the fact that there is now a wide range of much more affordable and energy-efficient electric appliances available, from a simple hotplate (typically KES 2,000-4,000) to the much more efficient Electric Pressure Cooker (EPC) (typically KES 6,000-15,000). Moreover, the perceived high cost of electricity as a cooking fuel does little to help this situation (ibid), despite the fact that Kenya's electricity tariff is relatively moderate for SSA, and the relative costs of cooking with energy-efficient appliances can actually be much lower than other options (ESMAP, 2020).

[4] Mixed LPG-electricity stoves have LPG powered burners and electricity powered hot plates.

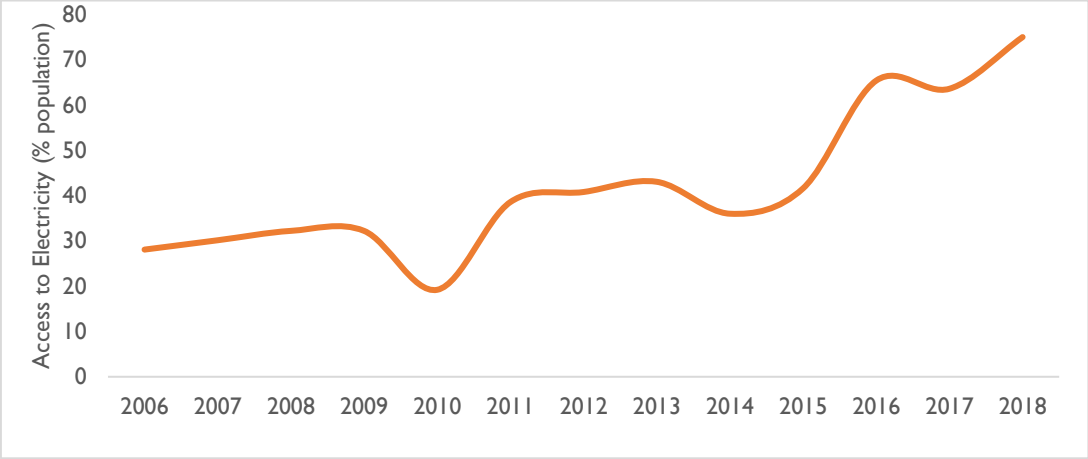

Figure 10: Trends of access to electricity in Kenya. Source: (World Bank, 2020b)

Various interventions are being implemented by the government and the private sector to stimulate electricity demand. Kenya has a total installed electricity generating capacity of approximately 2,700MW against a peak demand of roughly 1,859MW, thereby leaving 900MW of unutilized capacity (Fazal, 2019).

The **Kenya Last Mile Connectivity Program**, launched in 2015 has been pursuing universal access to electricity by 2020, primarily targeting informal settlements in urban areas and low-income households in rural areas. The program has led to an increase in electricity connectivity in the country from 56% in 2016 to 74% at the end of April 2018 (Global Infrastructure Hub, 2019). The government launched the fourth and final phase of the Last Mile Connectivity Program, which targeted 280,475 new customers in 32 counties across the country over a period of three years (Mbabazi, 2019). Although the Kenya Last Mile Connectivity Program has led to an increase in the number of electrified customers from 2.3 million in 2013 to 7.5 million as at June 2020, the majority of these connections involve rural households where electric demand is low, and costs of maintenance are very high due to extensive distribution lines. For example, as Okoth (2020a) notes, the number of electrified rural households increased by 5.8% to 1,409,256 in 2018/19 from 1,332,209 in 2017/18, but the revenue realized over the same period declined by 9.1% from KES 11.84 billion to KES 10.77 billion due to low demand by the new customers. While this paradox could be a complex combination of institutional and technical gaps, instability persists in most of these areas where power outages occur often and longer. KPLC's financial situation is further worsened by the power purchase agreements signed with Independent Power Producers who compel KPLC to pay for electricity generated even if it has nowhere to sell it to (Okoth, 2020a). As a result, there is now a strong drive, for example through the Pika Na Power Program which was re-launched in 2017, to stimulate demand for electricity to increase the revenue per customer and bring KPLC's financial performance back on track.

The Kenya National Electrification Strategy 2018 further builds on the progress made under the Last Mile Connectivity which increased connection from 56% access in 2016 to 74% access in 2018, a key milestone in the country's energy transformation but with certain challenges faced. The challenges faced include high connection costs, lack of appropriate incentives to attract private sector investments, among others. This strategy therefore broadly outlines the necessary policy direction, investments and collaborative environment required to achieve universal access to electricity in Kenya by 2022.

These programmes have increased electricity connection, with the World Bank projecting that Kenya's generating capacity will double between 2015 and 2020. Kenya now has a total installed electricity generating capacity of about 2,700MW, yet the nation's peak demand is roughly 1,859MW, creating about 900MW of unutilised capacity. This further underscores the need to diversify the innovative use of electricity through emerging options such as e-cooking.

In 2017, KPLC, the national power utility, started to promote the use of electric appliances such as induction cookers to increase electricity demand. The company initiated a television cookery show, '***Pika Na Power' (Cook with Electricity)*** to create awareness on the use of electrical appliances for cooking (KPLC, 2017). They began with a focus on induction cookers, which were retailing at KES 9,500 at KPLC's demonstration kitchen at Electricity House in Nairobi (GoK, 2019). To enhance market uptake of induction cookers in Kenya, KPLC strategically established a purchase option through monthly installments for its employees, which total over 10,000 (Leary, Kalyonge A & Kalyonge M, 2020).

KPLC's current lifeline tariff for the first 100kWh/month is already sufficient to enable poorer households to cook with electricity, as the 2019 Kenya Cooking Diaries study showed that the average 4-person household in Kenya consumes around 40kWh/month to cook with electric appliances (Leary et al., 2019). However, the discounts that they give on the tariff of 17KES/kWh are not very substantial as opposed to the regular tariff of 23KES/kWh. Moreover, there are plans to increase the consumption charge for usage of fewer than 100 kilowatts per month to KES12.50 a unit, up from the current KES10 and that above 100 units from KES15.80 to KES19.53 a unit (Okoth, 2020d). Cooking with electricity could be made much more attractive for poorer households by offering clear price signal with a bigger discount on the first 100kWh/month.

Induction cookers are highly responsive to adjustments in heat levels, just like LPG, and can use any shape pan thus they can fry foods very efficiently. However, one of the weaknesses of these induction cookers is their inefficiency in cooking dishes that require boiling for a long time, such as beans and tripe (popularly known as Matumbo) (Leary, Kalyonge A & Kalyonge M, 2020). To counter this, many Kenyan stakeholders are now promoting the use of the Electric Pressure Cooker (EPC), which can cook most energy-intensive foods with less than a fifth of the energy of the electric hotplate and at a fraction of the cost of any other fuel (Leary et.al, 2019).

To popularize EPCs in Kenya, the MECS program funded a number of technology development and awareness programmes in Kenya to promote e-cooking. These include Jikoni Magic (selling EPCs via social media), BURN Manufacturing (developing an EPC for Kenyan cooks to be produced in their modern factory in Nairobi), SunCulture (piloting a DC EPC with their solar irrigation systems), SCODE (piloting DC EPCs with solar home systems), BioLite (developing an EPC for the off-grid sector), Pereybere Energy (trialing EPCs with newly electrified consumers), Bidhaa Sasa (selling EPCs through women's savings groups in rural areas), and awareness creation efforts through leading Kenyan Food Bloggers who are also helping to create awareness on the EPC smart cooking practices through social media (Leary, Kalyonge A. & Kalyonge M., 2020).

CLASP and EnDev ran a Results Based Financing (RBF) pilot in Kenya that facilitated the procurement of 4,800 EPCs in Kenya. The RBF programme aimed to develop supply chains for EPCs in Kenya and enabled appliance distributors, manufactuers and energy service companies to make bulk purchases and expand their customer base. Additionally, a strategic alliance has

since been formed between Jikoni Magic, Hotpoint Appliances (producers of Von-branded EPC) and KPLC's Pika na Power Initiative, to promote EPCs among a broader range of electric cooking solutions in the country (ibid).

It remains to be seen whether these recently launched promotional programs will enhance the adoption of the electricity and associated technologies for cooking amidst various challenges:

- The ***perceived high cost of electricity*** is a major barrier that needs to be overcome with targeted awareness raising campaigns (ROK, 2019). MECS research has shown that the relative cost of cooking with electricity in Kenya is similar to other cooking fuels and can be much lower for specific foods with energy-efficient appliances (ESMAP, 2020b, Leary et al, 2019, Leary, Fodio Todd et al., 2019).
- Ultimately, the ***high upfront cost of electric cooking appliances, in particular energy-efficient appliances*** are substantial barriers. Currently, electric appliances are primarily marketed to wealthy households, who are not so concerned with the number of units they consume. There is a need for ***deliberate efforts to target the masses*** at the bottom of the pyramid with affordable and accessible energy-efficient appliances. There is a need to develop consumer financing mechanisms that can break down the high upfront cost of appliances and enable it to be repaid over time with the savings made on cooking fuels.
- There is ***limited awareness of modern energy-efficient electric cooking appliances,*** such as induction cookers, Electric Pressure Cookers (EPC), insulated electric frying pans, electric rice cookers, and infra-red stoves. There is therefore a need for nationwide consumer awareness campaigns targeting convenience, cost savings and safety.
- ***Limited distribution points*** for the technology is also another hindrance to their adoption (ROK, 2019). For instance, KPLC currently only retails electric cooking appliances at Electricity House in Nairobi (although plans are underway to extend this to other county offices). However, many potential customers may not be in a position to access KPLC's main offices and hubs.

While these challenges impede the adoption of e-cooking technologies, they also open spaces for strategic interventions.

4.2 E-COOKING WITH MINI-GRIDS

4.2.1 The opportunity in the mini-grid sector

The previous sections have highlighted the enormous progress that has been made by extending the national grid across Kenya over the past 10 years. However, many places still remain out of reach. In these remote regions, off-grid solutions such as mini-grids and solar home systems have played a vital role in extending electricity access to rural and peri-urban households. Decentralized mini-grids have played a key role in Kenya's electrification for many years, with some communities still using mini-grids that were first developed over 50 years ago (USAID, 2019).

The National Electrification Strategy (KNES) projects that to meet the goal of universal access to electricity by 2022, Kenya will require an additional 2.2 million and 38,661 Solar Home Systems (SHS) and mini-grid connections, respectively, which represent a significant opportunity to

integrate cooking into off-grid electricity provision (USAID, 2019). KPLC (2016) reported that just 61,000 households were connected to mini-grids, whilst 13 million were connected to the national grid. However, the Kenya Off-grid Solar Project (KOSAP) estimates that mini-grids and off-grid solutions are expected to be the most viable solution for 10% of the population (MoE, 2017), many of whom are scheduled to be connected by the 120 mini-grids that the project intends to build.

ESMAP (2017) presented a case study of the Kenyan mini-grid sector, which was regarded as a center for innovation on mini grids across the continent and beyond. A strong private sector emerged, based on the ability to charge cost-reflective tariffs. The regulatory environment set technical standards to follow but was loose enough to attract a variety of business models. Kenyans have relatively high purchasing power, so mini-grid developers have also been able to sell value-added services to mini grid customers, a model which has recently been extended to eCooking. However, uncertainty over the future regulatory environment caused the industry "to stall." USAID (2018) noted that Kenya has also developed numerous new public mini-grids and has recently started implementing the Kenya Electrification Modernization Program (KEMP) and Kenya Off-grid Solar Access Project (KOSAP) that include tender-based opportunities for new mini-grid development. With successful implementation, these recent initiatives, projects and changes are likely to revive the Kenyan mini-grid sector (USAID, 2019).

Value-added services offered by private mini-grid developers include agricultural processing, internet access, and more recently, eCooking. The close relationship that mini-grid developers have with their customers means that they can rapidly develop and pilot innovative new services by adapting tariffs, setting up new supply chains, developing repayment plans, and designing training programmes as needed. These are all critical elements to enable a successful roll-out of eCooking, where the high upfront cost and lack of availability of energy-efficient appliances and the need to adapt cooking techniques pose significant barriers to uptake.

Several Kenyan private mini-grid developers have recently started to experiment with electric cooking. Private mini-grids charge cost-reflective tariffs and need to actively stimulate demand for their power to bring in enough revenue to cover their costs. PowerHive and RVE Sol have both received financing from EnDev's pilot RBF programme for EPCs, allowing them to make bulk purchases of several hundred EPCs. These appliances are sold to their customers as demand stimulation tools, with the intention of making a profit on the additional revenue brought in through the sale of electricity units.

PowerGen has trialed EPCs on several of their mini-grids in neighboring Tanzania in partnership with CLASP, A2EI and MECS, which could lead to the implementation of eCooking on their Kenyan mini-grids. Initial results suggest that EPCs could be an effective tool for demand stimulation if the high tariffs can be reduced. A2EI (2021) reported that although EPC usage was initially encouraging amongst the 100 households participating in their trial, it dropped off several months later after the 'honeymoon period' ended. As in Kenya, private mini-grids in Tanzania were also able to charge cost-reflective tariffs. However, part-way through the study, the Government of Tanzania mandated that all private mini-grids must charge the same tariff as the national grid (but without offering subsidies to cover the cost gap). When the new tariffs were implemented, usage of the EPCs returned to the levels seen during the 'honeymoon period.' In Kenya, there is concern that the government could also enact similar regulations. However,

without offering subsidies to cover the gap between cost-reflective tariffs and the national tariff (in line with how KPLC's mini-grid tariffs are cross-subsidized by national grid customers), this would likely result in severe challenges to the viability of the private mini-grid sector.

However, there are other options for reducing tariffs to more affordable levels that could facilitate eCooking uptake. Many private mini-grid developers already use smart metering to monitor customer demand and, in some cases, control the tariff. Smart metering can enable greater accountability of energy consumption, which could be used to leverage new funding sources, such as carbon financing. It can also be used to send price signals to customers to encourage them to cook when excess renewable energy capacity is available. On their solar mini-grids, Power Hive already have separate daytime and night-time tariff to encourage greater use of surplus solar electricity which then does not require storing in expensive battery banks. Whilst it may not be possible for customers to do all their cooking in the daytime, the night-time tariff is 50% higher than daytime, which could offer sufficient incentive for customers to make greater use of their EPCs during the day.

4.2.2 Ownership Models

Kenya has public, private and community-owned mini-grids (ESMAP, 2017). Public mini-grids are developed by REREC (formerly REA) and operated by KPLC. Most of the older public mini-grids were diesel-based. However, these are slowly being hybridized by adding renewable generation (predominantly solar and wind) and new public mini-grids that are renewable with diesel backup. Some mini-grids are community-owned (these are mainly smaller systems), including micro-hydro systems. Although there are some commonalities between these community systems, each is unique and so little is known about this sector. In the last decade, private mini-grid developers such as PowerGen, PowerHive, and RVE Sol have entered the market, supplying villages with power, and generating further revenue through the sale of value-added services. Today, the private sector is expanding rapidly. However, the Kenya Off-grid Solar Access Project (KOSAP) is shifting the boundaries between public and private sectors to extend access into the least electrified Counties. Figure 11 shows the relationship between the public and private sectors and their key areas of operation, whilst Table 1 summarises the key developers and their emerging role in the e-cooking sector.

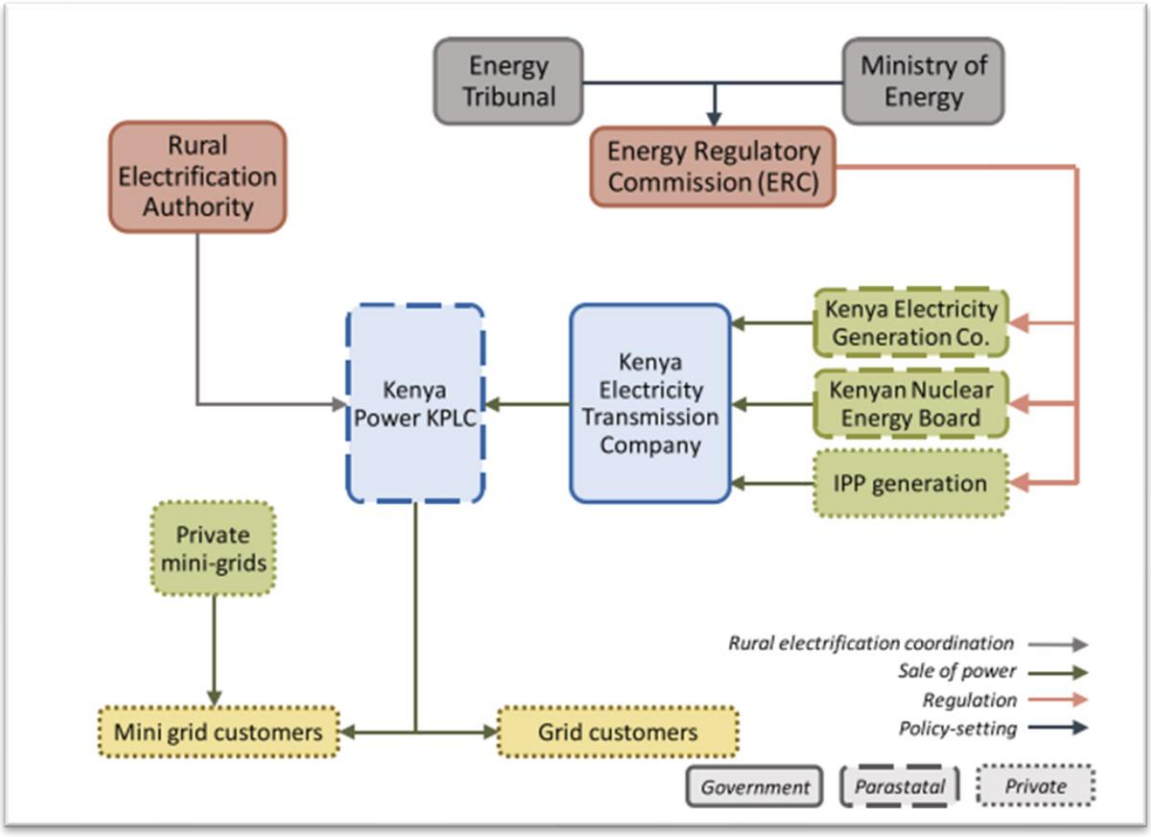

Figure 11: The complimentary approaches of the public and private sectors to mini-grid development in Kenya ESMAP, 2017). The Kenyan power sector structure

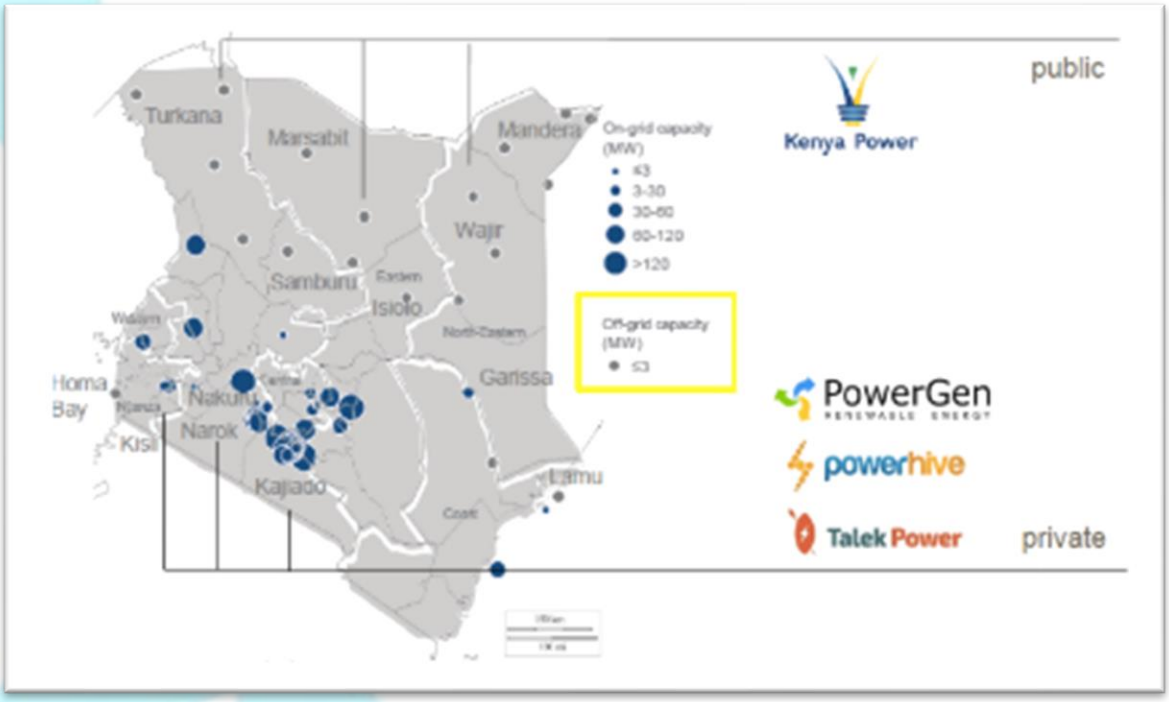

Figure 12: The location of key mini-grids

Table 2: Key mini-grid developers/operators in Kenya. Adapted from ESMAP (2017)

Company	Technology	Business model	Location	No. mini-grids & customers[5]	Experience with eCooking
PowerHive	Solar with diesel backup	Village-scale MGs selling power & value-added services	Kisii	20 MGs	Piloting EPCs supported by EnDev RBF
RVE Sol	Solar with diesel backup	Village-scale MGs selling power & value-added services	Busia	1 MG, 7MW	Piloting EPCs supported by EnDev RBF
Talek Power Company[6]	Solar with diesel backup		Narok	1 MG, 50MW	
PowerGen	Solar/wind with diesel backup	Village-scale MGs selling power & value-added services			EPC pilots in Tanzania
REREC/KPLC	Diesel (some hybridised with solar/wind)			19 MGs (11 under construction), 25 MW	Pika na Power programme nationwide, but no local supply chain development or cooking demonstrations
Agricultural estates - flower farms, tea estates, etc.[7]		Generation for self-consumption selling excess to KPLC & supplying HHs on site		9 MGs, >65MW	

4.2.3 Mini-grid Tariffs

In 2017, the average tariff on private mini-grids in Kenya was 0.56 $/kWh, whilst mini-grids operated by KPLC were obligated to charge the same tariff as the national grid, approximately 0.20 $kWh (ESMAP, 2017). Private mini-grid developers are allowed to charge cost-reflective tariffs, whilst the lower tariffs on KPLC-operated mini-grids are cross-subsidized from customers connected to the national grid.

[5] Data from 2017
[6] set up by GIZ, operated by Narok County
[7] e.g. Oserian Development Company, Virunga Power, Kenya Tea Development Agency Power Ltd.

Globally, the solar hybrid mini grid sector is developing rapidly, driving down costs and opening up further opportunities for affordable eCooking. ESMAP's (2019) analysis of the mini grid sector showed that in 2018, solar hybrid mini grid tariffs typically ranged from $0.55–$0.85/kWh. With a combination of increased load factor, streamlined planning, further declines in component costs, and other measures, tariffs are projected to fall by 55% to $0.25–$0.38/kWh by 2025. As tariffs decline, cooking with electricity is becoming an increasingly affordable option for households connected to solar hybrid mini grids.

ESMAP (2020b) conducted a sensitivity analysis to explore the forms of eCooking that become cost-effective at typical tariffs, and those that could become so with time. The analysis showed that in 2018, cooking part of the everyday East African menu with an energy-efficient eCooking appliance such an EPC could be cost effective for some peri-urban charcoal users. However, by 2025, it is likely to become cost-effective for most peri-urban charcoal users, and even 100% eCooking with a mixture of inefficient (e.g., hotplate) and efficient (e.g., EPC) may become cost effective for some.

In 2017, average tariffs in Kenya (0.56 $/kWh) were already at the lower end of ESMAP's (2019) range (0.55-0.85 $/kWh), indicating that the opportunities for cost-effective eCooking are likely to open up faster in Kenya than in other contexts. What is more, the mini grids operated by KPLC are mandated to charge the national tariff (0.20 $/kWh), meaning that eCooking is likely to already be cost-effective for many of their customers.

4.3 E-COOKING WITH SOLAR HOME SYSTEMS

Kenya is the market leader in solar home system (SHS) sales in Africa (USAID, 2019). This success is attributed to a largely favorable regulatory environment, government support, and the adoption of business models such as pay as you go (PAYGO). Reported sales of off-grid solar products in Kenya since July 2014 have exceeded five million units (USAID, 2019).

USAID (2019) reports that the GoK has taken a relatively hands-off approach to the off-grid sector, which has allowed the sector to grow without unnecessary impediments and allowed the country to maintain its status as a leader in SHS. KNES projects 2.2 million SHS installations by 2023 to be mainly driven by the private sector. To support this, the GoK is adopting conducive regulations that enable the private sector to operate and grow, such as favorable taxes, and facilitating duty exemption requests during procurement and delivery cycles (USAID, 2019). The SHS market has enjoyed a favorable taxation framework. Current exemptions under the VAT Act, 2013, VAT (Amendment) Act, 2014, and Finance Act include exemption from VAT and import duties for supplies imported or bought for the construction of a power-generating plant.

The Energy (Solar Photovoltaic Systems) Regulations, 2012 are specific to enhancing solar development and distribution. The solar PV regulations provide a licensing framework for the solar PV value chain and facilitate proper design, installation and use of solar PV systems while avoiding the supply of substandard components and installations. KEBS is the government agency responsible for the development of standards and certification services. However, the

enforcement of its standards has been weak given the insufficient institutional capacity at the customs level and slow implementation of regulations.

4.3.1 Production and distribution of SHS

USAID (2018) noted that the SHS sector in Kenya has attracted many diverse and active players, including Azuri, Barefoot Power, BBOXX, Bidhaa Sasa, BioLite, Bright, d.light, Fosera, Givewatts, and Greenlight Planet. Additional companies include Mibawa, M-Kopa, Mobisol, Mwezi Energy, Orb Energy, Pawame, Solar Kiosk, Solar Panda, Solinc, Sollatek, and Spark Possibilities. **Error! Reference source not found.**3 shows that many of these organizations are now experimenting with off-grid eCooking, primarily facilitated by grant funding via the MECS Challenge Funds.

Table 3: Kenyan SHS players already experimenting with eCooking

	Product range	Business models	Experience with eCooking
BBOXX	SHS, LPG	PayGo	Exploring eCooking as a compliment to PayGo LPG via MECS research on the drivers of fuel stacking
Bidhaa Sasa	Wide range of products including SHS, clean cookstoves & LPG	Peer-to-peer women-led enterprises with revolving funds	Successful experience marketing EPCs to rural women's savings groups under MECS TRIID Challenge Fund. Demand for EPCs exceeded available supply at that time
BioLite	SHS, clean cookstoves	PayGo, B2B	About to begin design work on a DC EPC designed for off-grid solar supported by MECS/EforA Challenge Fund
Fosera	SHS	PayGo, B2B	About to complete design and field testing of a customized DC rice cooker supported by MECS/EforA Challenge Fund
MKopa	SHS	PayGo	About to complete initial market scoping study on the viability of adding eCooking appliances to their portfolio of PayGo financed appliances supported by MECS/EforA Challenge Fund
SunCulture	SHS, solar water pumps	PayGo (PayGrow[8])	Part way through a field trial of DC EPCs as an additional

[8] Payment schedule developed around harvests.

			appliance for their solar water pumping systems supported by MECS/EforA Challenge Fund
SCODE	SHS, clean cookstoves	Micro-credit, PayGo	About to complete a field trial of DC EPCs powered by SHS & hybridized with LPG supported by MECS EforA Challenge Fund

USAID (2018) highlighted that most first-generation SHS companies in Kenya have vertically integrated out of necessity, as the value chain did not exist yet. However, as SHS manufacturers such as Green Light Planet, BioLite, and d-light and other service providers like Angaza have developed, companies no longer needed to do everything themselves.

Whilst powering an eCooking appliance would be a stretch for most existing SHS available in Kenya, the size of systems is gradually increasing, and most companies have larger systems that could support an energy-efficient DC appliance in the pipeline. Figure 13 shows that whilst the market used to be dominated by pico solar systems (often just a single light), larger SHS (>11W) are becoming increasingly popular in the Kenyan market. USAID's (2019) report noted that with the sheer number of systems already sold and companies operating in the country, some have questioned whether the market is saturated, with little potential for companies looking to enter the market. However, in addition to SHS sales, the sector has experienced growth in the sales of appliances, with a record of almost 70,000 appliances reported during the second half of 2018 (most of which were televisions). SHS companies have been able to offer an expanding range of both SHS and non-SHS products (insurance, agriculture products, small loans for school fees, etc.) to their existing customers by using the assets that have already been repaid as collateral.

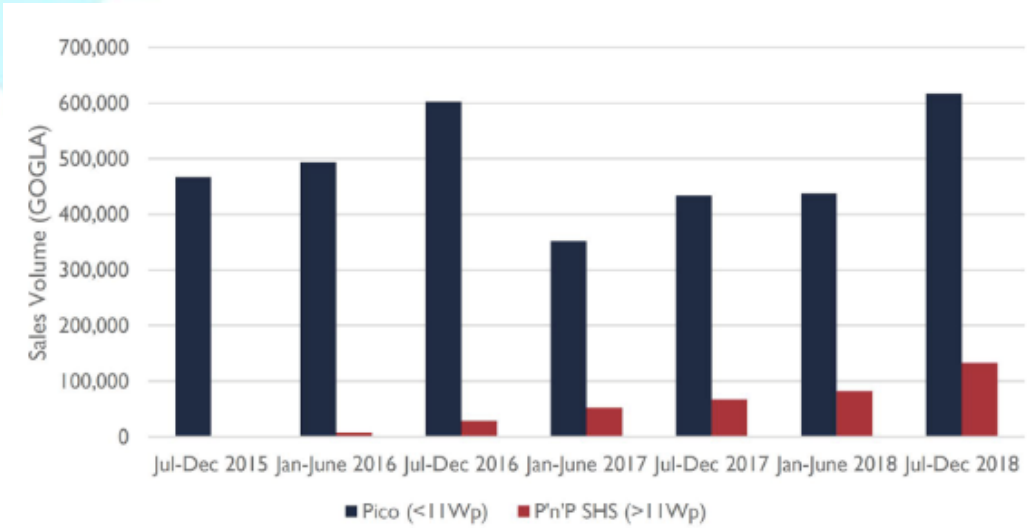

Figure 13: Pico solar and SHS sales volumes for Kenya (GOGLA data depicted in USAID, 2019)

Several SHS designed for productive uses of energy that are large enough to support eCooking is already available in the Kenyan market. A prime example is SunCulture, which sells a 300Wp SHS designed to power a DC irrigation pump. Early piloting has shown the potential for DC EPCs as an additional appliance that could be sold to their existing customers to make use of surplus

power available when the sun is shining, and sufficient water has already been pumped. USAID (2019) noted that productive use of energy is a much less mature sector of off-grid energy than either solar home systems or mini-grids, but the sector holds significant potential for clearly attributable economic impact among rural populations. It requires nurturing and support to flourish. Kenya has been a first-mover and leader in the development and implementation of other off-grid solutions, therefore there is a great opportunity for the productive use of off-grid energy technology (USAID, 2019). The same applies to eCooking, which has both the potential to displace existing fuel expenditures and to be used productively in restaurants, institutions, and amongst street vendors.

The PayGo business model has played a crucial role in unlocking demand for SHS in Kenya. USAID (2019) notes that mobile money started in Kenya and provided an ideal platform to facilitate the growth of PAYGO, which is the primary method for collecting payments among SHS companies. While PAYGO is certainly the dominant method for sales among GOGLA associates in Kenya, cash sales still play an important role. Numerous companies have reported that cash sales are stronger in lesser developed regions, and it will be interesting to see the balance of cash versus PAYGO or other consumer financing options in the underserved counties under KOSAP (see below). Micro-finance institutions (MFIs) provide customer financing of SHS systems in Kenya but play a much smaller role than PAYGO.

4.3.2 KOSAP

The Kenya Off-grid Solar Access Project (KOSAP) is a flagship initiative of the Ministry of Energy designed to fill in the gaps around the Last Mile Connectivity Programme (LMCP), which had focussed on the central corridor from Mombasa through Nairobi and across to Lake Victoria (SNV, 2020). KOSAP focuses on 14 under-served counties, predominantly in Northern Kenya, and is designed to incentivize the development of electricity infrastructure in regions not yet attractive to the private sector. The $150m project is financed by the World Bank and offers both RBF and debt facilities to incentivize solar energy service companies (mini-grid developers, solar home system developers, etc.) to expand their infrastructure into these less developed regions. The incentives are offered for both the supply of electricity itself and appliances that can deliver energy services.

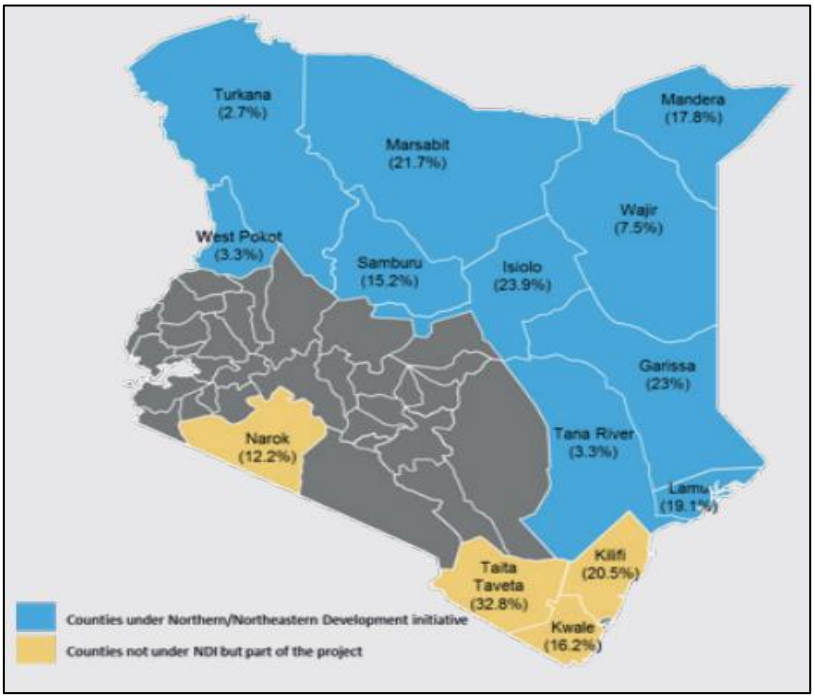

Figure 14: KOSAP Counties (Lighting Africa, 2018)

$40m of the KOSAP budget will be used to develop and establish 120 mini-grids under a public-private partnership (PPP) model, jointly implemented by REREC and KPLC (ESMAP, 2017). Figure 14 illustrates how private companies will build the generation and distribution network, operate, and maintain those assets for up to 10 years. However, the mini-grid customers will be charged a regulated national tariff, paid to KPLC, who will send monthly payments to the private companies for services provided under the Power Purchase Agreement (PPA).

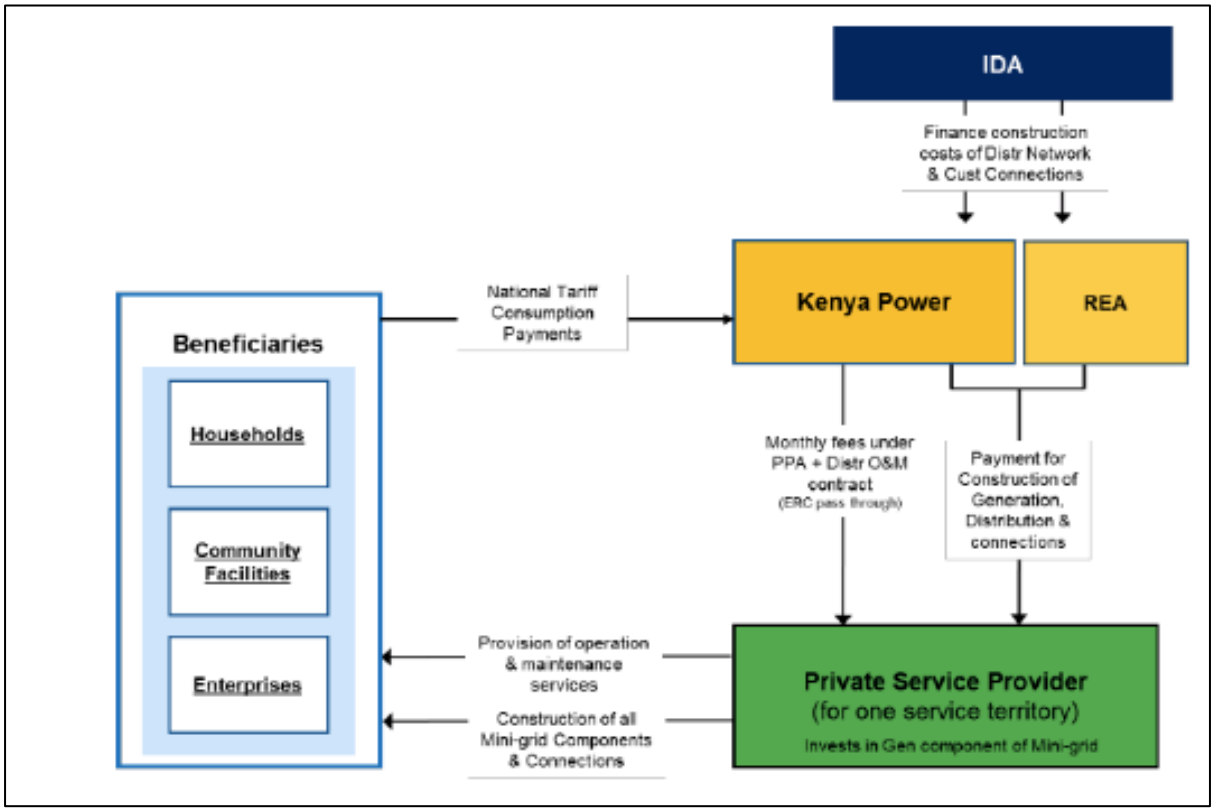

Figure 15: KOSAP Implementation Plan (World Bank, 2017, adapted by ESMAP, 2017)

However, ESMAP (2017) warned that several Kenyan mini-grid players were concerned that the program would make KPLC more powerful and force them out of the market, as customers will have a contract with KPLC, who will manage retail and billing using its system and tariffs. Private mini-grid developers expressed concern that KOSAP could standardize PPAs between the private sector and KPLC, and only allow for generation business. Many of the already proven and implemented models would then no longer be feasible. Programs such as KOSAP are seen by some to be hindering innovation and additional revenue streams, putting control back with KPLC that already enjoys a quasi-monopoly. Private sector mini-grid operators often see direct access to the customer as essential for enabling the sale of value-added services, of which eCooking may become a key component.

KOSAP also includes a clean cooking component valued at $6m (SNV, 2020), which could provide a strategic entry point for MECS. Electric cooking appliances are already in scope for the KOSAP clean cooking RBF, however, there will be opportunities to link the much larger electricity access component of KOSAP with the clean cooking component more directly. RBFs in the cooking sector typically only cover the purchase of the cooking device, whilst RBFs in the electrification sector typically only incentivize connection. However, by linking the two together and incentivizing companies to provide an electrical connection with an energy-efficient cooking appliance, the challenge of stimulating demand for electricity via these new connections can be addressed from the beginning.

4.4 Consumer Financing for e-Cooking Appliances

The high upfront costs of e-cooking appliances and perceived high cost of electricity for cooking is a source of hesitancy for many (CCAK, 2019), highlighting the need for innovative financial instruments to support access to e-cooking. Innovative financing mechanisms that have already been proven in the Kenyan market are already being extended to eCooking. These include **revolving funds** that allow particular households to receive credit for purchasing e-appliances from their neighbors, friends, and/or colleagues. Revolving funds have been explored by Bidhaa Sasa and Jikoni Magic and showcased by Shamba Shape Up. Further, the **PAYGO** system of financing clean energy has proven relatively successful in Kenya with solar home systems and MECS Challenge Fund winners such as M-KOPA are already exploring how this model could be extended to eCooking, both off-grid and on-grid.

4.5 Other Clean Cooking Technologies

4.5.1 Solar Thermal Cookers

The first noticeable effort to promote solar cooker technology in Kenya was in 1995 when Solar Cookers International (SCI) introduced a large-scale solar cooking project in the Kakuma refugee camp (SCI, 2020). The project aimed to promote clean cooking while reducing the amounts and cost burden of firewood used by the households within the refugee camp (GoK, 2019). The SCI project reached over 15,000 families by the time the project ended in 2004 (SCI, 2020). An ongoing initiative in promoting solar cookers is steered by Farmers with a Vision, a community-based organization of 32 members, based in Busia County. The CBO has actively engaged with schools, churches, and communities in teaching about solar cooking. It is reported that as of 2017, barely four years into the project, 1,500 households were already using solar cookers in the county (GoK, 2019; Wanzala, 2017). While there are several types of solar cookers such as Haines Solar Cookers, Minimum Solar Box Cooker, CooKit, and Windshield Solar Cookers, the Solar Cookers International's "CooKit" is the most widely used panel cooker with tens of thousands of this technology in use in various refugee camps around the world including Kakuma Refugee Camp in Kenya (SCI, 2019). CooKit was first developed and produced in 1994 by a volunteer group of engineers and solar cooks associated with Solar Cookers International (SCI). CooKit is made of cardboard and foil shaped to reflect maximum sunlight onto a black cooking pot that converts sunlight into thermal (heat) energy (SCI, 2020). A heat-resistant bag (or similar transparent cover) surrounds the pot, acting as a greenhouse by allowing sunlight to hit the pot and preventing heat from escaping. It weighs half 0.5 kg (1.1 lbs) and folds to the size of a large book for easy transport (SCI, 2020).

However, The adoption of solar cooking technology is still marginal among households in Kenya mainly due to three main factors:

- First, the mismatch in the cooking needs and the utility offered by solar cooking technologies. Solar cooking is restricted by the availability of solar energy and therefore without energy storage options, its ability to displace other forms of energy remains limited (GoK, 2019).
- Second, there are various types and designs of solar thermal cookers which pose a great challenge when it comes to standardization, a situation that may lead to the proliferation of

poor-quality technologies, thereby distorting the market. This situation is exacerbated by the lack of capacity in the country to develop and maintain the technology.

- Third, adoption is constrained by a lack of awareness in terms of its availability, efficiency, costs, and distribution points. There are no noticeable efforts to promote this technology through mainstream media or on social media platforms. Another constraint is the lack of policy and regulatory framework specific to solar cooking technology.

4.5.2 Liquefied Petroleum Gas (LPG)

The number of households using LPG in Kenya has increased steadily over the last two decades from an estimated 0.6 million in 1999 to 3.7 million in 2018 (GoK, 2019; Kairu, 2019). A total of 151,900 MT of LPG was consumed in 2016, rising to 222,300 MT in 2018 (Kairu, 2019; GLPGP, 2019). However, the actual average annual consumption of the product, which stands at approximately 170 kilotons (KT), is still lower than the demand, which stands at approximately 300 KT per annum (GLPGP, 2019; Gakii, 2019). This is attributed in part to the lack of sufficient LPG storage infrastructure. For instance, the total storage capacity in early 2019 stood at a paltry 6 KT against a consumption demand of 300 KT per annum (Gakii, 2019). Demand is expected to rise to 392-550 KT by 2030 (GLPGP, 2019). The Kenyan government has set an ambitious target of achieving per capita consumption of 15kg of LPG per year by 2030. However, this target is far from being met with the country's LPG consumption standing at an average of 3.1kgs with 0.8 Kgs from rural areas, and 3.1 Kgs in urban settings relatively above Africa's average of 3kg per capita (GLPGP, 2019). This consumption rate is also lower than Ghana's 5kg per capita, South Africa's 6kg per capita, Ivory Coast's 9kg per capita, and Senegal's 10kg per capita (Table 3) (Gakii, 2019).

The country's LPG distribution chain is licensed and regulated by the Energy and Petroleum Regulatory Authority (EPRA). This distribution chain consists of importers, exporters, and bulk wholesalers of LPG; LPG bulk transporters; storage facility operators; wholesalers of LPG in cylinders; storage facility operators of LPG in cylinders; and LPG retail stations (GoK, 2019). As of May 1st, 2020, EPRA had issued licenses to 66 import, export, and wholesale LPG operators in bulk, 34 exporters and wholesalers of LPG in bulk, 63 storage and filling facility operators (cylinder), 98 bulk transporters, 305 transporters in the cylinder, 5672 retailers in cylinders, and 204 storage and wholesale of LPG operators (cylinder) (EPRA, 2020).

The top twenty of Kenya's licensed LPG dealers account for over 80% of the market. The Petroleum (Liquefied Petroleum Gas) regulations of 2019 standardized the 0.5kg, 1kg, 3kg, 6kg, and 13kg LPG cylinders and unified their valves, which are the commonly used cylinder sizes at the household level. LPG cylinders are also available in additional capacities including 35kgs by K-gas, 22.5kgs and 50kgs by Total, and 25kgs and 50kgs by Gulf Energy (ROK, 2019). The 1kg, 3kg, and 6kg cylinders are used together with a cooking grill, a burner, and a regulator to form a complete cooking system. The cylinders may also be attached to a separate LPG stove or dual LPG and electric stove. On the other hand, the 13 kg cylinders are strictly attached to a separate LPG stove or dual LPG and electric stove.

The demand for the 6kg cylinders is very high at 70% of the current demand compared to 20% for the 13-kilogram cylinders (Van den Berg, 2018). The 6 Kg cylinders are relatively cheaper and are fitted with inexpensive burners relative to the 13kg cylinders, which are more expensive and require large and expensive stoves. Innovations such as double burner stoves could nonetheless allow multiple cooking at the same time and support more exclusive use of clean

cooking fuel. The 6kg complete LPG cylinder is the commonly used LPG cooking solution, with 72% of the 3.7 million households that have LPG based cooking solution reporting owning at least one compared to 21% who own LPG multiple burners and 7% who own Mixed LPG electricity (**Error! Reference source not found.**) (GOK, 2019).

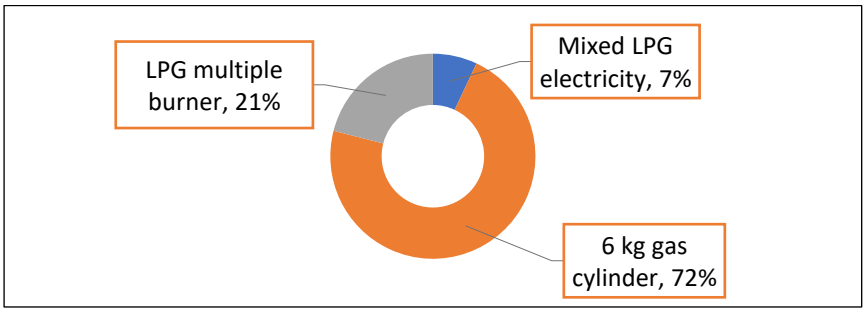

Figure 16: Distribution of types of LPG devices (ROK, 2019)

The consumption of LPG in Kenya has been constrained by high costs and low supply rather than the market. The price of LPG in Kenya is high for the BoP (Base of the Pyramid) communities (who are the majority) with some of the expensive brands e.g., K-gas costing KES 175 per kg (US$ 1.5) per kilo, as compared to the global average of $0.6 (KES 60.69) per kilo in 2019 (GLPGP, 2019). There are other cheaper options such as the Lake Gas prices LPG, retailing aggressively at KES 105/kg (about 1US$) to the end-user. The product cost is also relatively higher than the cost of competing fuels (such as charcoal, kerosene, and firewood) in Kenya (Table 4). For instance, kerosene (per liter) (inclusive of VAT) was still cheaper than LPG (which was by then exempt from VAT) in 2017 (van den Berg, 2018). This suggests that the VAT exemption has not helped in lowering the LPG prices to effectively compete with other alternative cooking fuels and technologies even though there is an increase in LPG adoption, so this statement is also not supported by user behavior. The prices of different fuels as compared to the LPG are presented in Table 4. While these prices indicate trends in terms of what has been done, they do not necessarily depict the ultimate costs given the different levels of efficiency and other variables.

Table 4: The 2018 retail prices of various cooking fuels (Source; GLPGP, 2019)

Fuel	DR/Retailers 2018: Average price in Ksh	KIHBS/Consumers 2016: Average Price in Ksh
LPG (per kg)	141	230
In 6kg cylinder (per kg)	*143*	*N/A*
In 12kg cylinder (per kg)	*139*	*N/A*
Charcoal (per kg)	103	15
Kerosene (per litre)	93	83
Purchased firewood (per kg)	13	5

The **Mwananchi Gas Project** was initiated by the Government through the National Oil Corporation aimed to increase the consumption of LPG in the country from 10% currently to 70% from 2016, even though the programme duration remains unclear. Under the project, 6Kg complete cylinders (gas, burner & grill), trading under the brand name "Gas Yetu", was distributed at a discounted

price of KES 2,000 to households which would otherwise not afford the system (ROK, 2019). The program which initially targeted to distribute more than three million cylinders has revised the target downwards by 84% to just 200,000 cylinders (Okoth, 2020b) due to technical and institutional challenges such as budget cuts from the government. It is expected that full implementation of these interventions will contribute to an increase in LPG consumption from the present 200,000 tons to more than 1 million tons by 2030 (Toyota Tsusho Corporation, 2019). Several finance and micro-finance institutions also support the clean cooking technologies by providing loan facilities for their adoption. For instance, Equity Bank in partnership with Hashi Energy and Pro Gas launched a credit facility that allows their customers to purchase Pro Gas and Hashi Gas cylinders[9]. With regards to the microfinance sector, Kenya Women Microfinance Trust (KWFT) has a credit facility for stoves and biogas systems, while Musomoni Microfinance provides asset financing loans for clean energy products GoK, 2019).

However, the situation on the affordability of LPG is fast changing, with additional entrants into the LPG market such as Proto Energy, PIMA 10, and Pay-as-you-Go (PAYG) smart-meter technology companies such as Paygo Energy and M-Gas. These new entrants are now providing affordable LPG in small quantities to accelerate wider adoption especially among the masses who cannot afford mainstream gas technologies. For example, Pima Gas allows consumers to refill their gas cylinders for as low as KES 50, or around KES 300 per one-kilogram cylinders (Rubadiri, 2012). Barely one year after its launch, Pima Gas had attracted more than 8,000 new Liquid Petroleum Gas (LPG) users, thereby transitioning from the exclusive use of biomass and kerosene (Wahito, 2013). Though still in the market, Pima gas has nonetheless struggled to maintain an upward trajectory in its market acquisition (Kamau, 2019). This has been attributed in part, to the inability of the product to guarantee safety to its consumers (Kamau, 2019).

On the other hand, PayGo Energy which has been operational since March 2017, and M-Gas (linked to Safaricom which started operations in January 2020) have developed cylinder smart metering, which allows for the payment of gas in small amounts on a pay-as-you-go basis through mobile payments. The cylinder smart meter allows for monitoring of LPG consumption volumes by consumers and retailers, thereby optimizing the supply of gas including home delivery and mobile payment options. Since 2020, PayGo Energy has partnered with Safari Supa Gas to leverage its growing distribution network and the operational expertise required to scale across Kenya (Kimuyu, 2020). A similar approach has been adopted by the M-Gas linked to Safaricom, among others.

Other factors that are constraining the uptake of LPG especially outside the core markets of Nairobi and Mombasa include limited storage, distribution, and retail capacity across the country (Dalberg, 2018). As already mentioned, the total LPG storage infrastructure available in Kenya stands at about 6,000 metric tonnes against a consumption demand projected at 300,000 metric tonnes per annum. Further, the LPG market is replete with illegal operators who are estimated to constitute 30-50% of the market (Dalberg, 2018). Some of these illegal operators import cooking gas through porous border points and distort the market through unfavorable pricing, thereby out-competing genuine ones (Okoth, 2020c). Moreover, the illegally imported cooking gas largely

[9] https://equitygroupholdings.com/ke/uploads/Equity-News-Issue-15.pdf
[10] They entered several years ago (in fact your reference is from 2012) and their model now is not largely used as proven unsafe, as you point out later.

does not meet the legitimacy standards set by the LR 100 2019 regulations, and sometimes results in safety risks that reduce consumer trust in LPG, hence poor uptake in LPG as a clean cooking option. The illegal LPG operations and substandard LPG products are exacerbated by a lack of capacity by the relevant authorities to ensure compliance with some of the LPG regulatory provisions such as provision on standards.

Despite the recent increase in adoption of LPG in Kenya, the technology still faces several challenges that might stagger this adoption in the coming years:

- High initial capital costs for acquiring the consumer LPG equipment. Additionally, the refill cost of LPG is relatively high for several consumers especially for the low-income earners who are often forced to revert to biomass fuels. Moreover, and recently, the Kenyan Government announced a 16% VAT on LPG to be imposed with effect from July 1st, 2021. This is likely to make LPG unfordable to many households who would then be looking for alternatives and are likely to revert to biomass unless alternative solutions such as e-cooking could be quickly upscaled to cover the potential gap.
- Weak enforcement of regulations including quality standards and markets in line with the international standards could impede the scalability of LPG.
- There are considerable access concerns especially for certain parts of the country. While the Kenyan Government has invested considerably in LPG distribution chains, these chains are more concentrated in major towns and peri-urban areas. There is still a lack of availability in most rural areas and small towns with potential consumers.
- Other than the cooking benefits, there is still very low awareness among consumers on the full range of benefits of LPG including environmental, social, and health benefits. This has meant the loss of full-scale adoption and utility.
- Finally, there are relatively moderate concerns around the safety of LPG especially fear of gas leaks and potential hazards associated which such.

4.5.3 Ethanol-based fuels.

Ethanol fuel is produced from the fermentation of sugars and starch from various crops, such as maize, sorghum, wheat, cassava, and sugarcane, and is utilized for both domestic and industrial purposes. There are three major producers of ethanol in Kenya: Spectre International, Agro Chemicals and Food Corporation, and Mumias Sugar Company (Afrinol n.d). These companies produce approximately 64,000 m^3/year, out of which over 20,000 m^3 of ethanol is exported yearly to Uganda, Tanzania, the Democratic Republic of Congo, and other East African countries to produce beverages (Afrinol n.d). Table 5 shows the annual production of ethanol by the three main producers.

Table 5: Major producers of ethanol in Kenya. Adopted from Afrinol n.d.

Company	Amount of ethanol produced per year (m^3)
Spectre International	30,000
Agro Chemicals and Food Corporation	18,000
Mumias Sugar Company	16,000

The ethanol produced by the above three companies mainly targets the industrial production of beverages and little attention has been paid to bioethanol as a clean and easy-to-use cooking fuel for the Kenyan population (Darlberg, 2018). However, in 2011, the United Nations Development Program (UNDP) supported a pilot study on bioethanol as an alternative cooking fuel in western Kenya. The study sought to test the viability of ethanol as a clean, affordable, and easily accessible household fuel and to stimulate its demand in the country (UNDP, 2020). As a result, ethanol is now emerging as a fuel option for domestic consumption with the potential of substituting or reducing the use of kerosene, and is currently available in liquid and gel form for cooking (ROK, 2019).

Emerging players in the ethanol market include KOKO Networks, Leocome, Prosol Limited, IR&D Africa Limited, and Giraffe Bioenergy. Ethanol cooking fuel for these emerging players is sourced both locally and internationally. For example, an interview with Agro Chemicals and Food Corporation established that 5% of their ethanol production is dedicated to the domestic cooking sector. Koko Networks, which is a relatively prominent player in the market, has a cooking system that comprises a smart canister and the KOKO cooker, which is a modern, high-power 2-burner ethanol stove that delivers affordable cooking energy, safely and conveniently. The complete KOKO system (a 2-burner KOKO Cooker and the smart canisters) retails at KES 6,999, an amount which a consumer can pay in deposits and collect the cooking unit upon completion (Jefwa, 2019). The KOKO technology uses mobile money (Mpesa) to purchase KOKO fuels which are dispensed from KOKO point Smart Fuel ATMs located in over 700 shops across Nairobi city. This KOKO point Smart Fuel ATMs are supplied by a fleet of "Smart Micro Tankers", which obtain the KOKO fuels from dedicated storage tanks at petrol stations (Jefwa, 2019).

To this end, KOKO fuels have partnered with Vivo Energy Kenya, the company that owns and operates Shell-branded fuels distribution infrastructure in Kenya, to ensure a reliable supply of high-quality fuel (Ibid). KOKO fuel prides itself in appealing to the masses by offering affordable fuel in quantities ranging from between KES 35 to KES 200 (which fills up the canister and can last for a week when being used consistently for three cooking events (breakfast, lunch, and dinner per day (Jefwa, 2019). These fuel prices are at par with LPG but are still slightly more expensive than kerosene and charcoal (Dalberg, 2018). According to Dalberg (2018), the costs of ethanol-based cooking solutions have the potential to be the lowest in the cooking sector if bioethanol tax and tariff regimes are harmonized with other fuels.

4.5.4 Biogas Cooking Solutions

Biogas has a long history in Kenya and has developed a niche in the agricultural sector where reliable feedstocks are available. The first biogas system in Kenya is believed to have been installed in 1957 by Tim Hutchinson, a coffee farmer, to provide gas and fertilizers that his coffee farm needed (Biogas for a Better Life Initiative, 2007). Based on the success of the bio-slurry in improving yields in his coffee farm, he started Tunnel Engineering Company Ltd to steer commercial installation of biogas systems for the production of bio-slurry and biogas (as a by-product for household energy needs). The company sold more than 130 small biogas units and 30 larger units all over the country between 1960 and 1986 (ibid).

Subsequent installations have been through several promotional efforts by the Ministry of Energy (today Ministry of Energy and Petroleum), development partners, and private stakeholders. For instance, the then Ministry of Energy and GTZ's (now GIZ) Special Energy Programme which

marked the first rigorous intervention to promote biogas, and which was implemented between 1987 and 1992 led to the construction of 800 biogas systems largely in Meru county (GoK, 2019). Other initiatives include the Kenya National Domestic Biogas Programme (KNBP) which was funded by the Directorate-General for International Cooperation (DGIS) under the Netherlands Ministry of Foreign Affairs and installed over 16,000 bio-digesters across the country between 2009 and 2015 (Kenya Biogas Program, 2020). Phase 1 of the KNBP (2009-2013) provided KES 25,000 subsidy and achieved 12,000 installations against a target of 8,000 (MoEP, 2018). About 2,000 digesters have also been installed by private domestic biogas entrepreneurs, including Takamoto, Sustainable Energy Strategies, and Afrisol, among others (MoE, 2018). Three main types of biogas technologies can be distinguished in Kenya; (i) the floating drum technology which consists of a digester and a moving gas holder (the drum); (ii) the fixed dome technology, which has most of its components built underground with the gas piping, feedstock inlet, and gas outlet being the only visible hardware; and (iii) plastic tubular digester which consists of a plastic tube where the gas is generated and piped for use (GoK, 2019).

The marginal adoption of biogas technology in the country can be attributed to several factors:

- First, affordability of the technologies is the main hindrance to their adoption with the installation costs ranging from KES 50,000 to 100,000 depending on the technology and size of the system. This cost is unaffordable for most consumers. Moreover, the delivery model of most installation companies is largely based on upfront cash payment, which further prohibits potential users from embracing the technology. However, this is changing as the innovative pay-as-you-go model has been tested and is being implemented by Takamoto gas (ibid). This mode of payment is designed with mobile money-integrated meters, which allows customers to pay a small fee to install the system and then pay for the biogas as they use it (Enegy4Impact, 2014).
- Second, most bio-digesters fail because of shortages of water and feedstock to "feed" the digester (Biogas for Better Life Initiative, 2007). The systems require a consistent supply of suitable biodegradable feedstock, a situation that hinders their adoption by the urban low-income citizens (ROK, 2019).
- Lack of awareness is the third factor constraining the adoption of biogas technology in Kenya. Most potential users have not even seen the technology, and those have remain ignorant of how it operates and its potential benefits (Biogas for Better Life Initiative, 2007).
- A final constraint is the high rate of failures of most biogas plants. This is as a result of poor standards and poor maintenance of the systems. According to the feasibility study 'Promoting Biogas Systems in Kenya', a high proportion of the biogas digesters operated below capacity and were dormant or completely abandoned after construction. The report further indicated that only 30% of the 2,000 biogas plants earlier constructed were fully operational at the time of the study (MoE, 2018; Biogas for Better Life Initiative, 2007). This has heavily damaged the reputation of biogas technology in the country. This situation has been exacerbated by a lack of capacity to install high-volume biogas plants (Biogas for Better Life Initiative, 2007), as well as a lack of biogas regulations to enforce standards in the country.

5 ENTRY POINTS FOR E-COOKING: TECHNO-POLICY SPACES EMERGING AT THE INTERSECTION OF THE CLEAN COOKING AND ELECTRIFICATION SECTORS

With a clear picture of both the current state of the technology and policy landscapes for the clean cooking and electrification sectors in Kenya, it is now possible to identify the spaces emerging in the crossover space they are beginning to intersect. These spaces represent entry points for e-cooking, so this section explores some of the potential opportunities for strategic interventions that could catalyze the transition to e-cooking in Kenya. This section looks forward and draws together many of the MECS programme's ongoing activities to connect them into the spaces identified earlier in this report.

The spaces are grouped together into:

- Institutional and policy spaces;
- Financial and market spaces;
- Technology and manufacturingspaces; and
- Capacity and awareness spaces.

5.1 INSTITUTIONAL AND POLICY SPACES FOR E-COOKING

Secttion 3 explored the institutional and policy landscape for both clean cooking and electrification in Kenya. Whilst many of Kenya's institutions and policies span both domains, very few connect their work together, presenting a series of strategic entry points where e-cooking could facilitate more joined up thinking by connecting both elements together. The Ministry of Energy's Integrated Energy Planning (INEP) process, which at the time of writing has just begun, is a key example of energy policy with an aspiration to create an integrated framework that not only connects the counties to the national government, but also the electricity and clean cooking challenges.

The 2010 Kenyan constitution provided for the establishment of autonomous County Governments within different contexts, and these entities are closer to energy resources and the consumers. For instance, there are sixteen County Energy Centres in the country whose functions include: development of Renewable Energy (RE) & Energy Efficiency (EE) county energy plans; training, demonstration, and extension on RE & EE technologies; dissemination of RE & EE technologies; establishment and maintenance of databases on renewable energy technologies in the country; undertaking Research and Development activities (Ministry of Energy, 2018).

Table 6: Opportunities for MECS to make strategic interventions to facilitate innovation in the institutional and policy space.

Entry point	Challenge	Opportunity for strategic intervention
Clean cooking inter-ministerial committee	Lack of coordination between ministries on the cross-cutting issue of eCooking	Work with the existing inter-ministerial clean cooking committee and extend remit into the electricity sector. Develop a policy scenario analysis that could enable the committee to make evidence-based decisions on how to create an enabling policy framework for eCooking.
EPRA	Existing electricity tariff structure not designed around eCooking	Build the evidence base on electricity price sensitivity for eCooking, in particular in institutions to support the development of an off-peak tariff designed to stimulate demand for excess renewable electricity during the daytime.
County Energy Plans	Lack of awareness of eCooking as a viable solution amongst county-level energy planners	Work with the Ministry of Energy on the development of the INEP (Integrated Energy Plan) framework and support specific counties (Kisumu, Nakuru, Kitui, Nairobi) to develop County Energy Plans inclusive of eCooking.
KPLC's Pika na Power	Pika na Power program struggling to reach scale and KPLC is reluctant to take on further financial risk	Support KPLC to explore opportunities to scale up their Pika na Power program by brokering new partnerships with appliance distributors and financiers.
KOSAP (Ministry of Energy or SNV)	Electricity access and clean cooking components disconnected	Explore the viability of incentivizing the supply of eCooking appliances to newly connected households
REREC	Unaware of the potential role of eCooking in stimulating demand for electricity in rural areas	Explore the viability of incentivizing the supply of eCooking appliances to newly connected households
KEBS, KRA	Energy-efficient eCooking appliances are currently subject to import and sales taxes	Develop national quality standards for energy-efficient eCooking appliances, building on Strathmore's work on quality standards and CLASP's work on the Global LEAP Awards for EPCs. Lobby for tax exemptions for the most energy-efficient products.
CCAK	Consumers are unaware of which	Extend the recently launched consumer labeling scheme for improved cookstoves to electric cooking appliances.

	appliances are most efficient	
WFP (World Food Programme)	eCooking in institutions would require much larger appliances	Pilot larger eCooking appliances with WFP as part of MECS' Institutional Cooking workstream.
SEfor ALL Kenya Action Agenda	e-cooking not yet included in the range of clean cooking solutions expected to contribute to the 2030 SE4All goals.	Offer a technical advisory service to the Kenyan SEforAll team at the Ministry of Energy to integrate e-cooking into new and updated policy instruments, such as the EEAP (Energy Efficiency Action Plan)
Quality and Standards, Safety Policies (Energy Act)	Loose ends on governance structures and management of quality and standards of appliances. Lessons are drawn from LPG cylinders and refilling standards management.	Development and manage quality and standards policies for electric cooking appliances through capacity building, partnerships and strategic convenings.
The Energy Regulations 2012 (Solar Photovoltaic Systems and Solar Water Heating)	Commercial e-cooking options are currently limited to on-grid users despite the numerous off-grid electric users in Kenya.	Support off-grid e-cooking pilots and networking between partners to facilitate the development of commercially viable off-grid e-cooking services in Kenya.
NCCAP	Current NCCAP completely separates clean cooking and electrification, but NDC makes the link between them.	Build e-cooking into the next iteration of the NCCAP. The NCCAP is updated every 4 years, and the NDC was just updated at the end of 2020.

5.2 FINANCIAL AND MARKET SPACES FOR E-COOKING

The high upfront costs of e-cooking appliances and the perceived high cost of electricity for cooking is a source of hesitancy for many (GoK m& CCAK, 2019), highlighting the need for innovative financial instruments to support access to e-cooking. Innovative financing mechanisms that have already been proven in the Kenyan market are already being extended to eCooking. These include **revolving funds** that allow particular households to receive credit for purchasing e-appliances from their neighbors, friends, and/or colleagues. Reducing the upfront cost of appliances through RBF programs, in particular carbon financing, could also enhance access to

and affordability of e-cooking. Further, the **PAYGO** system of financing clean energy has proven relatively successful in Kenya with solar home systems and MECS Challenge Fund winners such as M-KOPA already exploring how this model could be extended to eCooking. Further, exploring carbon markets through the GCF and other climate funds could help fund e-cooking access and operations.

Table 7: Opportunities for MECS to make strategic interventions to facilitate innovation in the financial and market space.

Entry point	Challenge	Opportunity
AMDA (African Mini-grid Developers Association)	Energy-efficient appliances such as EPCs currently procured in small quantities with no guarantee of quality	Facilitate bulk-purchasing of quality-assured EPCs featured in the Global LEAP Buyer's Guide by aggregating demand across several mini-grid developers
Climate Care and KCIC	Cost-reflective tariffs charged by private sector developers are substantially higher than national tariff	Leverage streamlined Gold Standard methodology for appraisal of eCooking projects under development by MECS to enable mini-grid developers to pilot dedicated cooking tariffs subsidized with carbon finance
Climate Care and KCIC	High upfront costs of appliances exclude low and middle-income households	Leverage streamlined Gold Standard methodology to enable eCooking appliance manufacturers and distributors to subsidis appliance costs
GCF and KCIC	Limited capacity of key stakeholders in Kenya to develop bankable projects	Implement targeted capacity building and partnership brokerage with the aim of developing bankable eCooking GCF proposals.
KPLC	Pika na Power program centralized in Nairobi and other major cities	Enable Pika na Power program to reach into rural areas by enabling local sales of eCooking appliances, cooking demonstrations, and after-sales service
KPLC	Consumer financing for eCooking appliances promoted by Pika na Power is only available for KPLC employees	Explore the viability of utility-enabled financing, and/or extending the Stima Loan concept from connection fees to electric cooking appliances
MECS Challenge Fund Winners (Burn, MKopa, Bidhaa Sasa, Jikoni Magic)	Lack of consumer financing for eCooking appliances	Support development and trialing of PayGo and micro-finance (chamas, SACCOs, etc.) for eCooking appliances.
RBF adminstrators & funders (CLASP, EnDev, SNV, etc.)	High upfront costs & limited availability of appliances	Support the development of new RBF programs for eCooking and the incorporation of eCooking into existing clean cooking or electrification RBFs

Kenya Women Microfinance Trust (KWFT)	Has a credit facility for improved biomass stoves and biogas systems.	Extend credit facility to electric cooking appliances.

5.3 TECHNOLOGY AND MANUFACTURING SPACES FOR E-COOKING

Kenya has a rapidly developing industrial sector that is now capable of producing modern electric cooking appliances in modern factories. Although energy-efficient appliances save money in the long term by reducing electricity consumption, the initial costs are often higher. Producing low-cost quality assured energy-efficient appliances in Kenya could address this challenge.

An emerging trend and aspiration among Kenya's population is the aspiration around modern kitchens, which presents a strategic opportunity for installing modern electric cooking appliances. Strengthened by the new housing schemes and real estates that embrace innovative architectural kitchen design, there is a huge opportunity for positioning e-cooking in the context of modern kitchens by integrating e-cooking innovations into emerging housing plans and designs.

Empirical assessments of MECS opportunities in the target counties show a strong existence of different forms of renewable energies and clean cooking mechanisms. The emergence of e-cooking amidst some of the strongly embedded cooking options means that e-cooking is unlikely to fully replace the existing options but could instead complement them. There is a need for developing and testing e-cooking stacking models that allow for complementary strengths of e-cooking and to be integrated within a mix of clean cooking options. For instance, many wealthier households reportedly own task-specific electric cooking appliances such as kettles or microwaves but rely on LPG for the bulk of their cooking. To date, stacking models are yet to be developed for Kenya's consumers, even though this provides a strategic entry point to progressively grow e-cooking into the country's clean cooking mix.

Table 8: Opportunities for MECS to make strategic interventions to facilitate innovation in the technology space.

Entry point	Challenge	Opportunity for strategic intervention
Innovation labs (e.g., UoN FabLab, Gearbox, Mideva)	Difficulty translating new technologies into desirable energy services	Hack-a-thons to prototype innovative new eCooking products, services, and marketing strategies that could tap into the emerging modern cooking concept.
Kenyan cookstove or appliance manufacturers (e.g., Burn)	eCooking appliances typically produced in China	Kenya's manufacturing sector is developing rapidly and has been identified as a priority area for further development by the government. Raising awareness of the emerging opportunities for manufacturing appliances in Kenya amongst modern manufacturers.

PayGo companies (e.g., Angaza, MKopa)	Additional hardware is required to enable innovative financing models such as PayGo	Engage with service providers to encourage the development of interoperable technology that can enable innovative financing mechanisms. Develop and pilot electric appliances with integrated energy metering, cloud-based communications, and locking mechanisms.
Mini-grid and smart-meter developers	Simultaneous operation of eCooking appliances may overload mini-grids	Smart technologies can enable the implementation of variable tariffs to send price signals to consumers to encourage them to cook at off-peak times and prevent simultaneous operation of multiple eCooking appliances which could overload the mini-grid.
Cooking diaries	eCooking appliances are often very task-specific	Develop and pilot different models for fuel stacking via the cooking diaries, synthesising and disseminating the experiences.

5.4 Capacity and Awareness Spaces for E-Cooking

The analysis shows that despite the very promising electrification programs that have successfully expanded access to electricity, much attention has mainly been given to electrification for lighting and industrial purpose, with little shown to cooking. As a result, there is relatively weak technical capacity and awareness around e-cooking. There is therefore a need for capacity strengthening across the e-cooking value chain including the capacity of the consumers to drive demand and catalyse change in their kitchens. Further, there is generally weak awareness around e-cooking appliances and how to operate them and cook local foods successfully and safely. Scaling up cooking demonstrations through TV, radio, social media, and live demonstration centers is a critical way of creating awareness and building capacity. Further, Kenya is a large and diverse country, so empowering e-cooking champions to customize these demonstrations to local foods and local languages to catalyze demand in their local areas can play a critical role in driving uptake. These individuals play a key role in "last mile connections" once the necessary foundations of community awareness and the infrastructure have been put in place. Community-based organizations will also play a vital role in establishing local supply chains for retail and after-sales service in rural areas.

Table 9: Opportunities for MECS to make strategic interventions to facilitate innovation in the capacity and awareness space.

Entry point	Challenge	Opportunity
Food bloggers & TV/radio producers	The widespread perception that electricity is 'too expensive for cooking'	Work with social media influencers & producers of popular TV/radio programs to produce content showing the real cost of cooking popular local dishes with electricity and position energy-efficient appliances as aspirational products for modern Kenyan cooks.
Mini-grid & SHS sector knowledge platforms (e.g. GMG Facility, SNV, AMDA, CrossBoundary)	Knowledge gained from pilot projects often concentrated in specific organizations	Facilitate knowledge sharing on eCooking between mini-grid developers in Kenya (and internationally) on the viability of eCooking as a tool for stimulating demand & enhancing social impact
County Energy Centres & KPLC County Showrooms	KPLC eCooking sales and marketing focussed in Nairobi	Develop a modular framework that can enable KPLC to replicate its demonstration, retail, and after-sales service in other counties. Design a programme for empowering local champions to start up innovative new eCooking businesses in their local area.
Industry associations (GOGLA, CCAK, AMDA, etc.)	The electrification sector lacks capacity in clean cooking and vice versa	Set up opportunities for knowledge exchange and collaboration through workshops, staff exchange programs, collaborative projects, and the development of a community of practice on eCooking.

6 CONCLUSION

This report has explored the landscape for clean cooking and electrification technology, in particular the growing shared space between them. It has identified a series of spaces where the growth of the emerging e-cooking market could be catalysed.

Kenya has oriented its policy to several global efforts which advocate for clean and sustainable energy. Such global initiatives include *inter alia* the Sustainable Development Goals (SDGs), Sustainable Energy for All (SE4ALL), and the Paris Agreement on Climate Change. At the national level, The Constitution of Kenya 2010, The Energy Policy 2004, The Energy Act 2019, The Environment Policy 1999, and various Regulations under the Energy Act, 2019 are some of the policies and laws relevant to MECS. This policy, legislative, and regulatory frameworks aim to accelerate the development and adoption of MECS in line with the above global efforts.

Kenya also has well developed grid, mini-grid and off-grid electricity sectors and one of the most active clean cooking sectors globally. As a result, solar home systems, solar-hybrid mini-grids and a range of modern energy cooking technologies such as LPG, biogas and ethanol, are already mainstream solutions.

However, this analysis has revealed a disconnect between clean cooking and electrification technology and policy in Kenya. Whilst Kenya has a myriad of policies, programmes and strategies in both the clean cooking and electrification sectors, most address either clean cooking or electrification. Some address both, but in separate sections (e.g. NCCAP). However, a few (e.g. Pika na Power) have already crossed the great divide and ventured into the intersectional space between them where the nascent eCooking sector is growing.

Kenya has a rich history of progress in the energy sector, with the majority of the population now connected to electricity and modern energy cooking technologies such as LPG already seeing widespread adoption. These transitions have laid the groundwork for Kenya to take the next step towards its goal of achieving universal access to energy ahead of the 2030 SDG targets, by leveraging the progress it has made in electrification to drive forward the clean cooking agenda. To make this happen, there is a need for joined up thinking that connects actors in these two previously separate sectors together, and an enabling policy framework that effectively integrates the planning for electricity access and clean cooking with a single investment strategy. To support the achievement of this goal, the report identifies a series of strategic interventions that could support the growth of the nascent e-cooking sector by bringing together the clean cooking and electricity access communities.

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8 ANNEXES

Annex 1: List of Policies Reviewed and their linkages with e-cooking

Law/Regulation	Provision	Opportunities for e-cooking
The Constitution of Kenya 2010	▪ Grants every individual, right to a clean and healthy environment.	▪ Enables e-cooking by granting every individual the right to clean and healthy environments
The Sessional Paper on Energy No.4 of 2004	▪ Encourages wider adoption and use of renewable energy technologies. ▪ Promotes wider use of LPG in households as a strategy to reduce biomass consumption. ▪ Promotes the development of fiscal and regulatory frameworks to create enabling environments to accelerate the development and utilization of solar technology ▪ Promotes development of domestic and institutional biogas technology. ▪ Promotes increase electricity connectivity in the country especially within the rural areas.	▪ The Policy explicitly recognizes and promotes LPG and biogas technologies (enablers). It also mentions solar for heating and drying. However, it is not explicit on solar cooking technologies and does not mention bioethanol fuels and technology hence constraining their development and adoption.
The Energy Act No. 1 of 2019	▪ Establishes institutions relevant to MECS such as EPRA, REREC Renewable Energy Resource Advisory Committee ▪ Obligates the cabinet secretary to provide an enabling framework for the efficient and sustainable production, distribution and marketing of renewable such as solar, wind, small hydro.	▪ Creates relevant institutions to enable the development and adoption of MECS including enabling entrepreneurship and household access
The Petroleum (Liquefied Petroleum Gas) Regulations of 2019	▪ Maintains provisions of LN 121 around the LPG value chain. ▪ Standardizes LPG cylinders, and licensing requirements ▪ Establishes a 'mutual' cylinder exchange system rather than a free exchange pool. ▪ Outlaws unauthorized refilling and rebranding of cylinders and introduces stiff penalties for such illegal (i.e. unlicensed activities)	▪ Enables trade in LPG and ensures safety to consumers through standards. However, implementation of some of its provision such as strong market regulations and is still weak and might impede market innovations and lockout the poor from affording and accessing LPG.
The Energy (Solar Photovoltaic	▪ Licenses the solar PV value chain. ▪ Facilitates proper design, installation, and use of solar PV systems.	▪ The provisions mainly focus on lighting and operating electric appliances such as TV and radio. There is a focus on

Systems) Regulations, 2012		solar heating but not a clear focus on cooking.
Energy (Solar Water Heating) Regulations, 2012.	▪ Requires all premises (with hot water requirements of a capacity exceeding one hundred liters per day) to install and use solar heating systems.	▪ There is focus on solar heating but not clear focus on cooking though it indicates a good trajectory for technological advancement for solar cooking possibilities.
The Tax Laws (Amendment) Act, 2020	▪ Has provided tax incentives for biogas, clean cook stove manufactures and cooking appliances, sand plate warmers	▪ Enables through provision of tax incentives to MECS. Electric cooking appliances such as plate warmers could promote electric cooking. It does not offer same incentives for bioethanol technology
2020 Finance Act	▪ Removal of tax incentives	▪ Removal of tax exemption and zero taxation on LPG and renewable energy including wind and solar effective Jan and June 2021 could drain the gains already achieved in terms of affordability.

Annex 2: List of programs and strategies and their linkages with e-cooking

Program/ strategy/plan	Provision.
The Green Economy Strategy and Implementation Plan 2016-2030	The strategy promotes the development and use of bioenergy in households, public institutions, and commercial enterprises.
The Special Energy Programmes	The program was implemented between 1987 and 1992 and led to the construction of 800 biogas systems largely in Meru County
The Kenya National Climate Change Action Plan	Promotes the transition to clean cooking with alternative fuels such as LPG, ethanol, and other clean fuels
The Kenya Electrification Strategy	Addresses the broad spectrum of the necessary policy direction, investments, and collaborative environment required to achieve universal access to electricity in Kenya by 2022.
The Kenya National Domestic Biogas Programme	The program started rolling out bio-digester technology in Kenya in 2009, with over 16,000 bio-digesters installed across the country between 2009 and 2015.
National Climate Change Response Strategy	Promotes development of sugarcane, sweet sorghum, Jatropha, and other non-food crops suitable for producing biofuels.
The Mwananchi Gas Project	The aim is to distribute the 6 kg complete LPG cylinder (gas, burner, and grill), at a discounted price of Ksh 2000 and initially targeted to distribute more than three million cylinders. However, the government has revised the target downwards by 84% to just 200,000 cylinders.
The Kenya Last Mile Connectivity Program	Launch to provide universal access to electricity by 2020. It is credited with increasing electricity coverage to 70% of the population
KPLC Pika Na Power Program	Relaunched in 2017 with the strategic aim of utilising surplus power on the national grid by stimulating electricity demand for cooking.

Kenya Off-Grid Solar Access Initiative (KOSAP)	Aimed at electricity access for Kenyans in areas that are not connected to the national grid with a target of 277,000 households by 2023.

Annex 3: Agencies responsible for energy governance

Institutions/Regulations	Role
Energy and Petroleum Regulatory Authority (EPRA).	Licensing and regulating the energy sector, formulate, set, enforce safety and quality standards for the energy sector in coordination with other statutory authorities
Kenya Bureau of Standards (KEBS)	Ensure standards of the energy appliances such as cookers
Renewable Energy Resource Advisory Committee (RERAC)	Advises the Cabinet Secretary on licensing of renewable energy resource areas, advises (upon request) county governments on renewable energy resources.
Kenya Industrial Research and Development Institute (KIRDI)	Undertake multidisciplinary research and development in industrial and allied technologies, develops prototypes of different cooking technologies, and lobby for the development of standards for such technologies.
Energy Centers	Training, demonstration, and extension on renewable energy technologies; dissemination of renewable energy technologies; establishment and maintenance of a database on renewable energy technologies in the country; undertaking Research and Development activities
Kenya Power and Lighting Company (KPLC)	Responsible for power transmission and distribution as well as supplies to consumers.
Geothermal Development Company (GDC)	Responsible for the exploration of geothermal fields, exploration and production drilling, development of steam fields, and concluding contracts for the off-take of steam by power plant operators
Kenya Electricity Transmission Company (KETRACO)	KETRACO plans, designs, builds, operates, and maintains all-new transmission lines above 132 kV
The Kenya Electricity Generating Company (KenGen)	KenGen operates hydro, geothermal, and gas- and diesel-fired power plants.
Rural Electrification and Renewable Energy Corporation (REREC):	REREC is charged with spearheading Kenya's renewable energy drive, in addition to implementing rural electrification projects. Steers the development and promotion of the use of these renewable energy technologies