Kenya

eCooking Market Assessment

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The MECS/EnDev eCooking Market Assessments

This study is one of a series of publications produced jointly by Energising Development (EnDev) and the Modern Energy Cooking Services (MECS) Programme. This series of market assessments offer strategic insight on the current state of electricity access and clean cooking in eight countries across sub-Saharan Africa and South Asia. These studies identify the key opportunities and challenges to the scale up of electric cooking in the coming decade and conclude with a series of recommendations for targeted interventions that could support the development of emerging eCooking sectors. The market assessments are structured according to the MECS transition theory of change (TToC), which consists of three interrelated dimensions: the enabling environment, consumer demand and the supply chain.

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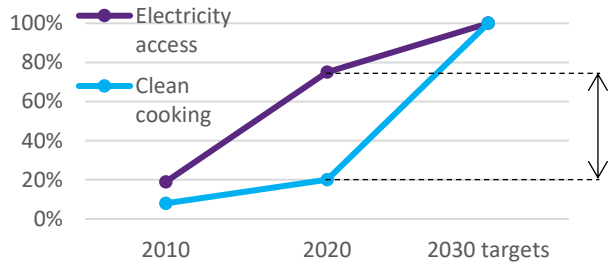
Executive Summary

Kenya is the birthplace of mobile money and a hotbed for innovation in the development sector [1]. Many of the new electric cooking technologies and business models developed by MECS are being piloted in Kenya [2], where they are able to leverage the ecosystem of actors and the strong enabling environments in the converging clean cooking and electrification sectors [3]. Kenya has made enormous progress on electrification with coverage increasing from 19% to 75% in just 10 years, and the majority of it's grid electricity is generated from renewable sources, mainly geothermal and hydro. However, most of the population still rely on polluting fuels such as firewood, charcoal and kerosene for cooking [4]. Currently 0% of Kenyans use electricity as their primary cooking fuel, meaning that there is an enormous untapped potential for electric cooking, which is increasingly drawing the interest of both the government and the private sector.

Kenya data snapshot from MECS eCooking Global Market Assessment:

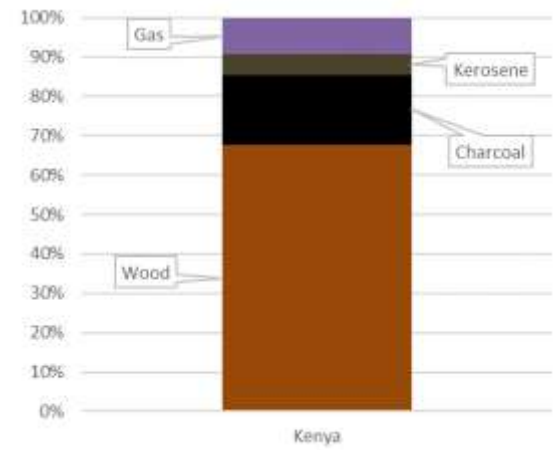


55% now connected to electricity, but still primarily cooking with polluting fuels

Cooking energy

Primary fuel use:

0% cook primarily with electricity



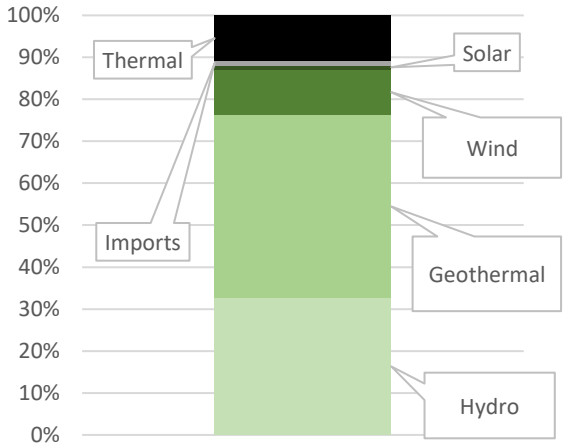
22% cook primarily with commercialized polluting fuels (charcoal & kerosene)

91% cook primarily with polluting fuels

Electricity generation

On-grid:

89% renewable



45% surplus power generation

High reliability: 99% power availability (SAIDI*SAIFI=83hrs/yr)

Off-grid:

World leading mini-grid & off-grid sectors: 0.1m mini-grid customers, 20 mini-grid developers, 13m off-grid lighting/appliance customers

eCooking GMA viability scores/rankings

Overall: **7th/130**	On-grid eCooking: **0.59 – 19th/130**	Mini-grid eCooking: **0.43 – 27th/130**	Off-grid eCooking: **0.55 - 2nd/130**

Key opportunities

- Rapid expansion of access to electricity in last 10 years
- Diversified mix of renewable electricity generation both on- and off-grid
- Market leader for SHS sales in SSA
- National utility actively stimulating demand growth for surplus electricity
- EPC highly compatible with popular 'heavy foods'
- Strong ecosystem for innovation and political will for change

Key challenges

- LPG already the aspirational fuel for many
- Electricity commonly perceived as 'too expensive for cooking', even though clean fuel stacks (LPG & EPC) often the most cost-effective solution
- Policy makers have identified need for integrated planning, but framework not yet in place

Potential impacts of scaled uptake in most viable market segment

If 40% of Kenya's grid-connected charcoal users (2.6m ppl, 0.7m HHs) switched to eCooking, the WHO's BAR-HAP tool suggests that:

- 1,203 DALYs/yr avoided
- 1.9m tonnes/yr CO2eq emissions reduced
- 0.4m tonnes/yr reduction in unsustainable wood harvest
- 191m hrs/yr of women's time saved (272hrs/HH/yr)
- 9 months payback for eCooking appliances ($80/HH upfront cost, $110/HH/yr savings on fuel energy costs)
- 422 GWh demand for electricity stimulated

For further detail, please see *Appendix E: Impact of Scaled Uptake*.

1 Introduction

The Kenya eCooking Market Assessment

This study is one of a series of publications from GIZ/EnDev and the Modern Energy Cooking Services (MECS) Programme. This series of market assessments offer strategic insight on the current state of electricity access and clean cooking in eight countries across sub-Saharan Africa and South Asia. This study identifies the key opportunities and challenges to the scale up of electric cooking in the coming decade and concludes with a series of recommendations for targeted interventions that could support the development of the eCooking sector. The market assessments are structured according to the MECS transition theory of change (TToC), which consists of three interrelated dimensions: the enabling environment, consumer demand and the supply chain.

Clean cooking and electricity access in Kenya

Kenya faces 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 initial acceptance (GoK, 2020). Recent evidence also shows that the health benefits of ICS are much more limited than previously thought (WHO, 2016).

eCooking presents a potentially transformative opportunity for Kenya's clean cooking sector to break out of this 'business as usual cycle. Currently, 0% of Kenyan's use electricity as their primary cooking fuel. This highlights the enormous untapped potential, as 75% of the population is now connected to some form of electricity, but doesn't yet use for the majority of their cooking needs. Meanwhile, Kenya Power is desperately trying to stimulate demand for its almost exclusively renewable electricity, as the Last Mile Electrification Programme has connected many new customers with very low demand.

Kenya has a rich history of progress in the energy sector, with a world-leading solar sector 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.

2 Enabling environment

eCooking policy outlook: Strong policy in place in both the electricity access and clean cooking sectors, with key policy makers starting to create an integrated policy framework that cuts across the two sectors

Key policy stakeholders: Ministry of Energy, Energy and Petroleum Regulatory Authority (EPRA), Renewable Energy and Rural Electrification Corporation (REREC), Kenya Power and Lighting Company (KPLC), County governments, Kenya Bureau of Standards (KEBS)

RISE (Regulatory Indicators for Sustainable Energy) scores:

76%	79%	59%	67%
Electricity Access	Clean Cooking	Renewable Energy	Energy Efficiency

Targets:

Electricity access	**Clean cooking**
100% electricity access by 2030 (grid/off-grid)	100% clean cooking access by 2028
100% renewable grid electricity by 2030	40% modern energy cooking access by 2028
	Specific eCooking targets under development

Key government/NGO programmes creating the enabling environment in which eCooking can scale:

- **Last mile connectivity programme –** increased electricity connectivity from 56% in 2016 to 74% in 2018 by extendng the national grid into rural areas and densifying the network to reach low-income households in slum areas.
- **National Electrification Strategy** - outlines the necessary policy direction, investments and collaborative environment required to achieve universal access to electricity in Kenya by 2022.
- **National eCooking Strategy –** Ministry of Energy currently preparing to develop a baseline study and strategic plan to support the scale up of eCooking in Kenya.
- **KOSAP** – eCooking in scope for GoK's RBF programme incentivising supply chain development for off-grid electricity and clean cooking devices in underserved counties.
- **CrossBoundary/CLASP/ESMAP/KPLC** - Appliance financing scoping study underway with eCooking one of several key appliance groups. Funding not yet secured for piloting designed during scoping study.
- **CLASP Global LEAP+RBF –** Global LEAP Awards identifies best in class energy-efficient appliances. 2020/21 EPC competition identified safe, durable, affordable and user-friendly models. Global LEAP Usability Testing empowered everyday cooks in Nairobi to select which models of EPC they prefer. CLASP/EnDev EPC RBF programme supported sale of 5,000 EPCs in 2020/2021, with follow on programme for 3,000 EPCs about to begin.
- **KPLC** – Pika na Power programme raising awareness and creating opportunities for eCooking appliance retailers to demonstrate and sell their products to KPLC's 7 million customers.
- **Strathmore University** – understanding the supply chain for eCooking appliances and developing scalable quality assurance and repair infrastructure.

Key barriers/drivers in the enabling environment:

- KPLC in financial difficulties as revenue per customer dramatically decreased after connecting many new customers, as the majority are rural households where electric demand is low, and costs of maintenance are very high due to long distribution lines. As a result, they are keen to stimulate demand for electricity, but unable to finance appliances themselves.
- Kenya's Ministry of Energy (MoE) is a vocal champion for clean cooking on the global stage and are now taking an integrated planning approach that can leverage the rapid progress in electrification to drive forward the clean cooking agenda.

For further detail, please see *Appendix B: Enabling Environment*.

3 Consumer demand

What's on the menu?

In an average week, a typical Kenyan household might prepare:

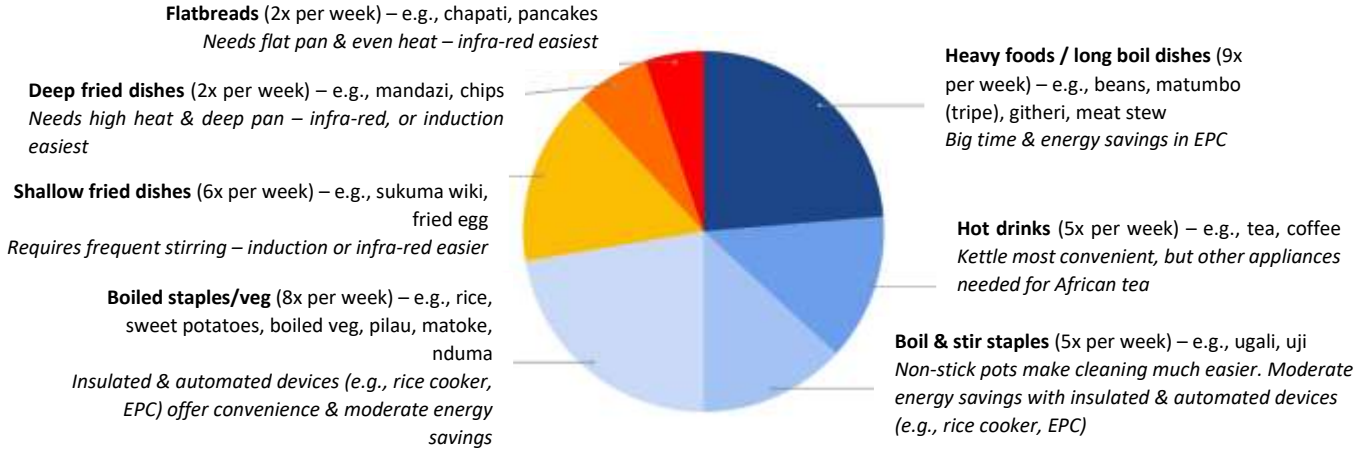


Figure 1: Visualisation of the results of a culinary analysis carried out during this market assessment by asking local team members to map out the dishes that a typical Kenyan household might prepare in an average week and assessing their compatibility with modern energy-efficient appliances.

Popular meal combinations in Kenya include:

- *Ugali and sukuma wiki* – ugali is a maize meal porridge that is boiled and vigorously stirred. It's very easy to cook in an EPC or rice cooker and the non-stick pot is much easier to clean, although most people won't believe you until you show them. Sukuma wiki (kale) is usually fried and can also be cooked with an EPC, although many people may choose induction/infra-red so they can use a shallow pan that is easier to stir.
- *Beans and rice* – there are many varieties of beans, which are boiled from 30 mins to several hours and typically served with a tomato or coconut sauce. Rice is simply boiled, so an EPC and a rice cooker would be an ideal combination.
- *Githeri* – one pot meal, beans and maize stew boiled for several hours, usually served with a tomato and onion sauce. EPCs are the obvious choice, offering big time and energy savings.
- *Sweet potatoes or nduma (arrow roots) and tea* – boiled tubers and African tea (tea leaves boiled in milk) is a popular breakfast combination. EPCs are also an obvious choice for the tubers and although you can cook African tea very easily on an EPC (without pressurizing), many people will choose a sufuria (saucepan) on an infra-red/induction stove instead.

Most viable energy-efficient appliances: **EPCs, rice cookers, induction, infra-red, kettles**

Key marketing messages: **energy-efficient appliances offer substantial time and cost savings and enable multi-tasking. EPCs are the cheapest and most convenient way to cook heavy foods.**

Key demand side barriers/drivers:

- Rapid urbanization (4%/yr) driving broader changes in lifestyle: shifts towards purchasing cooking fuel and wider range of income generating activities driving demand for time savings.
- Mobile money widely adopted (78% penetration).
- Widespread perception that electricity is 'too expensive for cooking'

- Over 90% of the everyday Kenyan menu can be cooked in an EPC, with big time and energy savings on the most energy-intesive dishes (heavy foods), which make up around 25% of the weekly menu.
- 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, including the perception that food cooked with electricity doesn't taste the same and that electricity is 'too expensive for cooking'.
- Cooking with energy-efficient electric appliances such as an EPC can be much cheaper than popular cooking fuels, yet the the high upfront cost of energy-efficient appliances is prohibitive for the low- and middle-income households that would stand to benefit the most.

Key demand creation programmes:

- KPLC's Pika na Power promoting eCooking via bi-weekly cooking classes, social media and national TV.
- Influential food bloggers such as Jikoni Magic & Nimoh's Kitchen creating eCooking content on Instagram, YouTube & other popular platforms.
- Shamba Shape Up featuring EPCs on national TV.

Key market segments:

- *Charcoal users* – 7 million Kenyans use charcoal as their primary fuel and many more use it as part of their fuel stack. The majority of whom are located in urban areas and are now connected to the national grid. Unlike firewood, charcoal is almost always purchased, creating an attractive existing expenditure to convert into electricity units. Charcoal prices rose dramatically in 2019 with the enforcement of logging ban to protect the nation's dwindling forests. Charcoal is now the most expensive way to cook, leaving many looking for an alternative. Charcoal is typically preferred for heavy foods, as it burns slowly and many people still believe it is the cheapest way to cook them. The EPC offers a highly attractive modern alternative that can greatly reduce expenditures on cooking fuel, however the upfront cost is a substantial barrier for many who use charcoal, which can be purchased in small quantities.
- *LPG users* – Kenya's LPG market has expanded rapidly in recent years, positioning it as the aspirational fuel for many and over 5 million already using is as their primary fuel. Whilst the social impact of transitioning LPG users to electricity may be limited, many wealthier households who currently cook with LPG are starting to integrate task-specific eCooking appliances such as kettles and EPCs into their fuel stack. These early adopters have a vital role to play in building the supply chain for eCooking appliances as their liquidity is high enough to make cash purchases of appliances.

For further detail, please see *Appendix C: Consumer Demand*.

4 Supply chain

Key domestic eCooking appliance manufacturers: Burn Manufacturing (EPC Global LEAP Awards winner).

Key eCooking appliance distributors: Hotpoint Appliances (EPC Global LEAP Awards winner), Ramtons, ARMCO

Innovative eCooking pilot projects:

- Burn – Designing an EPC specifically for African cooks for manufacture in their modern cooking device factory in Nairobi.
- Bidhaa Sasa – Selling EPCs to rural women's savings groups through their network of leaders in Western Kenya.
- ATEC - Preparing to pilot PayGo induction stoves in the Kenyan market.
- SunCulture – Piloting EPCs as an additional appliance for their PayGo solar irrigation systems.
- SCODE – Piloting solar electric cooking systems and LPG/electric clean fuel stacks for off-grid and weak-grid customers.
- SNV – Preparing to pilot larger EPCs with off-grid institutions in Kakuma refugee camp.
- WFP – Preparing to pilot larger EPCs with schools in Nairobi and Isiolo.
- MKopa – Exploring the viability of adding eCooking to their portfolio of digitally financed assets.
- Jikoni Magic – Selling EPCs via social media, live cooking demonstrations and developing partnerships with financial institutions (SACCOs, chamas, etc.).
- Perybere Energy – Piloting EPCs with 100 newly electrified customers in Western Kenya.
- Caritas Kitui – Piloting EPCs, LPG and ICS as part of the Energy Delivery Models (EDM) framework to support evidence-based policy making in Kitui County.
- RVE Sol & PowerHive – Piloting EPCs with mini-grid customers and incentivizing usage with dedicated cooking tariffs.
- Biolite – Developing an interoperable DC EPC for off-grid solar systems.
- Fosera – Developing off-grid eCooking appliances with customized cooking algorithms to optimize energy-efficiency.

Key supply side barriers/drivers:

- Strong supply chains for importation of appliances from China in place, with many companies now expanding product range into energy-efficient eCooking appliances.
- Rapidly growing demand for EPCs with over 10 models now available through a variety of retail channels.
- Early piloting of innovative consumer financing mechanisms underway to enable low-income households to unlock low-cost cooking with energy-efficient appliances.
- Limited access to after-sales services for modern energy-efficient electric cooking appliances.
- Reliability of electricity now high in major cities, but still a challenge at the fringes of the grid (slums, rural areas) and many regions still off-grid.

Popular appliances in Kenya today:

- Oven/cookers using electricity only or a mixture of electricity and LPG are currently the best selling appliances in Kenya, mainly to wealthy households.
- Task-specific appliances such as rice cookers and kettles are popular amongst a wider range of income brackets.

- Stove-top pressure cookers are popular in Kenya, but EPCs have only recently broken into the market. In 2018, only 1 high end model was available in any substantial quantity, however in 2021 over 10 different models are now on sale through a variety of retail channels.
- Hotplates are the most popular counter-top appliance and are particularly popular amongst students and low-income households who share an electricity meter with their landlords as they either pay a fixed rate for electricity or nothing at all.
- Induction and infra-red stoves have yet to see substantial uptake, as LPG is already widely adopted, but their popularity is slowly growing.

Table 1: Import volumes and typical retail prices for selected eCooking appliances in Kenya.

Appliance	**Sales volumes (Jul-Dec 2019 import data)**	**Typical retail price (MECS Appliance Availability Survey – online retailers in Nairobi)**
Oven/cooker (elec & elec/gas)	68,859	5k-23k KES (50-230 USD)
Hotplate	21,401	900-5k KES (9-50 USD)
Rice Cooker	14,780	3k-10k KES (30-100 USD)
Kettle	18,465	700-6k KES (7-60 USD)
Electric Pressure Cooker (EPC)	6,500[1]	5k-15k KES (50-150 USD)
Microwave	313[2]	5k-200k KES (50-200 USD)
Induction/infra-red stoves	138	3k-180k KES (30-180 USD)

Relative cost of eCooking vs. popular cooking fuels:

- In urban grid connected areas, cooking heavy foods with EPCs is over 5x cheaper than charcoal, LPG or kerosene (Leary, Fodio Todd et al, 2019).
- A clean fuel stack of LPG and an EPC is usually the cheapest way to cook (except collected firewood) (ESMAP, 2020).
- Cooking all your food with grid electricity is cost comparable to LPG or kerosene and cheaper than purchased biomass (ESMAP, 2020).

Grid electricity tariffs:

- **Regular: 23 KES/kWh** (0.23 USD/kWh)
- **Lifeline: 17 KES/kWh** (0.17 USD/kWh) **< 100kWh/mnth**

Mini-grid tariffs:

- Private sector avg.: 56 KES/kWh (0.56 USD/kWh); KPLC mini-grids = grid tariff

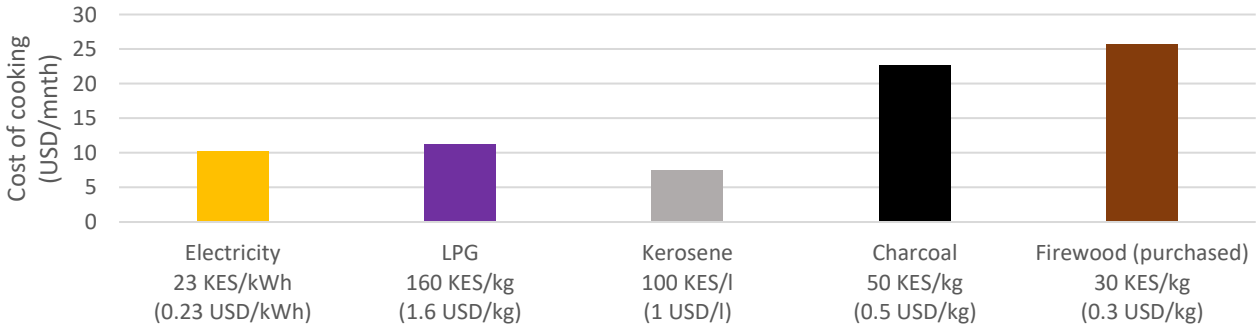


Figure 2: Cost comparison of different cooking fuels based on international averages for cooking energy demand from ESMAP (2020) and local electricity/fuel prices from GoK (2019).

For further detail, please see *Appendix D: Supply chain & delivery models*.

[1] No. EPCs actually lower as this includes some conventional stove top pressure cookers.
[2] No. microwives actually higher, as the majority are captured under a different import classification (HS code).

5 Recommendations for interventions

Table 2: Decision matrix/board highlighting key factors and viability of specific interventions.

		Current status (inc. summary of key opportunities & challenges)	Recommended interventions (highlight most important in bold)
Market segments	**On-grid**	Majority of population now grid-connected, but uptake of eCooking very limited. Utility keen to stimulate demand for surplus electricity.	Support KPLC to expand their cooking with electricity demand stimulation programme to low-income households by funding the eCooking component of the consumer finance piloting designed by CrossBoundary/CLASP/ESMAP.
	Mini-grid	Pilots carried out on solar-hybrid MGs with encouraging results, but high tariffs are major barrier. Innovative developers experimenting with price signaling to encourage off-peak eCooking.	Leverage new Gold Standard methodology for streamlined verification of eCooking projects with smart metering to subsidised dedicated cooking tariffs.
	Off-grid (SHS)	Several SHS companies piloting solar eCooking, but high import tariffs for battery storage and DC eCooking appliances increasing price point above commercial viability.	Lobby government to reduce import tariffs on DC eCooking appliances and battery storage sized for cooking.
TToC dimensions	**Supply chain**	Product/market fit of EPCs established with early studies, Global LEAP+RBF EPC pilot programmes have enable distributors to explore the market, but sales volumes still measured in thousands.	Build upon the EPC RBF pilots to design and implement a much larger EPC RBF programme. Connect with EnDev electrification RBFs to offer EPCs with new grid/mini-grid connections to ensure sufficient demand for electricity to justify connection costs.
	Consumer demand	Consumer awareness campaigns carried out to raise profile of energy-efficient appliances (in particular EPCs) involving a blend of live cooking demonstrations, TV and social media.	Support KPLC to expand their network of demonstration centres and retail outlets outside of Nairobi by connecting with GIZ local offices and other local champions who can establish local retail outlets and carry out cooking demonstrations with local dishes.
	Enabling environment	Strong policy framework for clean cooking & electrification in place and Ministry of Energy about to start work on National eCooking Strategy.	Support Ministry of Energy to integrate lessons learned from previous GIZ/EnDev clean cooking & electrification interventions in Kenya (e.g. EPC RBF) into the development of the National eCooking Strategy.

Appendices

These appendices present further detail on each of the three dimensions explored in this market assessment from the African Centre for Technology Studies' (ACTS) *Techno-policy Analysis of eCooking in Kenya*. Please see the full techno-policy analysis for further analysis and references.

Appendix A: Electricity Access and Clean Cooking in Kenya

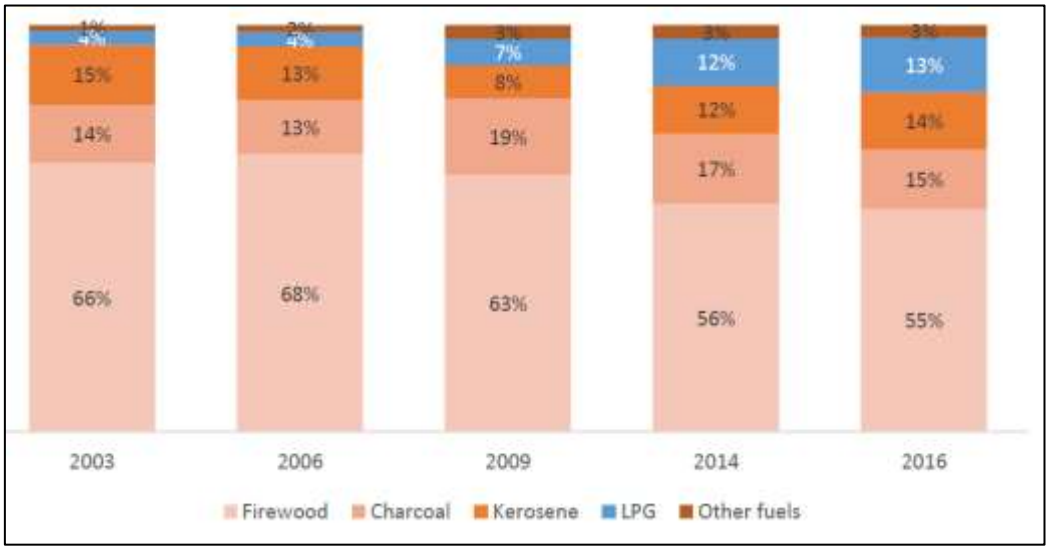


Figure 3: Trends in primary fuel use in Kenyan households (2003-2016). (Source: GLPGP, 2019): Trends in primary fuel use in Kenyan households (2003-2016). (Source: GLPGP, 2019)

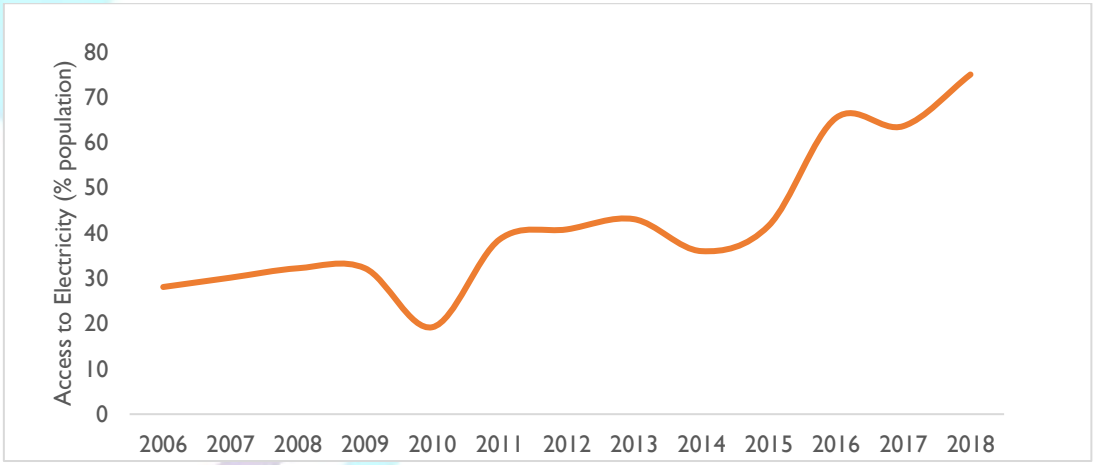


Figure 4: Trends of access to electricity in Kenya. Source: (World Bank, 2020b)

Appendix B: Enabling Environment

Historically, 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 upcoming COP 26 (Conference of Parties), championing the clean cooking agenda and highlighting the need to drive forward progress by connecting with the electrification sector (see *Stories* section below).

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, accelerating uptake of clean fuels such as LPG, ethanol, and biogas, and unleashing the transformative potential of electric cooking in Kenya.

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.

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.

Key stakeholders

- Rural Electrification And Renewable Energy Corporation (REREC) - Already supporting access to electricity for household and institutions and are advocating for diverse electricity uses to match the supply.
- EPRA - Recognizes electricity use more generally but no specificity on e-cooking yet – current electricity tariff structure not designed around eCooking
- County Government Energy Planners - Clean cooking and electrification planning currently disconnected - e-cooking not prominent. Electricity connectivity is identified in planning as an opportunity but usage remains unclear beyond lighting.
- Ministry of Energy - Vocal champion for clean cooking and e-cooking specifically at high level global events. Leading Integrated Energy Planning which considers diversifying electricity market through alternative uses including cooking.

- Clean cooking inter-ministerial committee - Aware of the transformational potential of e-cooking and are interested in solutions with multi-sectoral benefits, but still lack evidence on how e-cooking could promote such multi-sectoral benefits.
- KPLC - Already promoting e-cooking with the Pika na Power programme. Looking to expand beyond Nairobi hub and expand range of financing options beyond KPLC employees.

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."*

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).

The Kenya National Electrification Strategy 2018 outline the necessary policy direction, investments and collaborative environment required to achieve universal access to electricity in Kenya by 2022.

Appendix C: Consumer Demand

The Global LEAP Awards Usability Testing sought to determine **which models of EPC are most attractive to everyday cooks in Kenya and why?** The testing was carried out in Nairobi with 14 cooks testing the EPCs that had been entered into the competition. The study was implemented by CLASP, with participants from MKopa, Jikoni Magic and KPLC, including Agnes Kalyonge (Director of Jikoni Magic) and Wairimu Njehia (Manager of KPLC's Pika na Power programme). The results showed that safety, size (cooking capacity) and service delivery (frying, pressure cooking and additional functionality) were the most important attributes from the cook's perspective. 9 models of EPC achieved finalist status, with 3 models standing out above the rest and receiving innovation prizes. Burn's MY-8001 won the Best Value Prize for balancing user experience with upfront and running costs. It was specifically designed for Kenyan cooks, with local foods on the menu buttons and a larger (8l) capacity. The Instant Pot Duo 80 and Von VSCP60MMX shared the Best User Experience Prize, with well-designed products that really make cooking easy. The Instant Pot has a much higher price tag, which will likely put it out of reach for most consumers in Kenya. However, the Von is already one of the best (if not the best) selling EPCs in Kenya right now, as it delivers a similar cooking experience for a much more affordable price. The competition resulted in the production of a Buyer's Guide and a set of Impact Stories - see Story section below for further details.

ESMAP's *Cooking with Electricity: A Cost Perspective (Report Summary, Video)* sought to determine **whether electricity really is 'too expensive' for cooking?** This report included 2 case studies from Kenya (KPLC and SCODE), exploring how much it really costs to cook with electricity from both the national grid and off-grid systems. The report highlighted the fact that for many Kenyans who are still cooking with biomass, it is already cost-effective for them to switch to electricity for cooking. Charcoal users in Nairobi could already save over 75% every time they cook heavy foods such as beans if they were to switch to an EPC. However, the cheapest solution for cooking the whole menu was found to be a clean fuel stack of LPG and an EPC in almost all scenarios. The price of biomass fuels in Kenya is now so high that even in some rural communities, it would already be cost-

effective to switch from charcoal to a solar home system sized to power an EPC paired with LPG. However, the report highlighted the need for consumer financing models to help lower income households overcome the high upfront cost of energy-efficient appliances, and where necessary accompanying energy storage, which can enable them to save money in the longer term, as the relative cots of cooking with energy-efficient appliances are much lower than biomass.

Mediae, Jikoni Magic, Nimoh's Kitchen and KPLC have explored the question '**which messages are most effective in persuading Kenyan consumers to adopt electric cooking?**' These actors have focussed heavily on showcasing the core messages from the Kenya eCookBook of how everyday cooks can save time and money in the kitchen by cooking heavy foods with an EPC. Mediae tailored the messaging of their eCooking features on the latest season their prime-time TV show, Shamba Shape Up, to specifically target men as cooks and offer solutions to overcome the upfront cost challenge (see *Story 1* below). Kenyan food blogger Jikoni Magic has reached out to other social media icons, such as Nimoh's Kitchen, resulting in a much broader selection of content showcasing how easy it can be to cook popular local foods with an EPC. Kenya Power's Pika na Power (Cook with Electricity) programme aims to encourage its seven million customers to cook with electricity as a means to stimulate demand for surplus power on the national grid. However, they are aware that many of their customers see this as simply a ploy to increase their bills. As a result, they now always use plug-in energy meters to measure exactly how much electricity has been consumed as they cook each dish so that they can show the audience how much it really costs, emphasises the key message of cost savings versus biomass and other popular fuels.

The report Beyond Fire: Backcasting a pathway to fully electric cooking in rural Kenya by 2030 shows that working together with communities and investing in their social capacity are key to success in the transition to 100% electric cooking. It calls for a better understanding of the socio-cultural impacts on households who are involved in this energy transition.

The Forgotten Half: Men's Influence Over Cookstove Adoption Decisions in Northern Kenya highlighted the need to equally target men with clean cooking messaging, bundle cookstoves with other products that men value, and take advantage of women's groups as a source of collective bargaining power for women in the acquisition of clean cooking devices.

Appendix D: Supply chain & delivery models

Whilst in 2018, obtaining an EPC in Nairobi was almost impossible, there are now a diversity of models available through a range of retail outlets and several consumer financing models are being piloted to facilitate uptake amongst low- and middle-income households. E-cooking is still very much in its infancy in Kenya, with less than 3% of the population owning an electric cooking appliance. However, several Kenyan suppliers have recently started selling EPCs, with promising results and a Results Based Financing (RBF) has further accelerated the market. There is also increasing interest in other electrical appliances, such as kettles and induction stoves, which can complement the EPC and electrify a greater proportion of cooking.

The EnDev/CLASP EPC Results Based Financing (RBF) programme launched in Kenya in 2020 was the first-ever RBF solely focussed on electric cooking. In contrast to the other components of the EnDev RBF Facility in Kenya, which was mainly focused on improved cookstoves and SHS, the Kenya EPC RBF was solely dedicated to the

promotion of EPCs and was of much smaller scale. The $226,000 programme aimed to support the sale of 5,000 EPCs and followed an ambitious timeline, allocating just four months for the programme launch plus six months for the implementation. The EPC models eligible for the RBF were originally intended to be those appearing in the EPC Global LEAP Buyer's Guide. However, the timeline of the competition and the RBF did not align, so eligibility was decided based upon existing quality standards (e.g., Conformitè Europëenne (CE) for importing into Europe) and/or safety and performance testing carried out by CREST. MECS research showing the compatibility of Kenyan cooking practices with EPCs was a key driver for the selection of Kenya as a pilot country for the e-cooking RBF.

Stritzke et al (2021) concluded that this RBF was successful in drawing together actors from the electricity access and clean cooking sectors, who would previously have participated in separate RBFs. It enabled mini-grid developers to explore adding e-cooking to the array of energy services they offer to their customers, whilst simultaneously allowing cookstove manufacturers to venture into the world of electric appliances. One programme participant reported that his business would probably not have moved into the EPC space without the RBF programme, while another participant confirmed that the RBF significantly supported the uptake of EPCs among consumers. As a consequence, both companies reported that as a result of the programme, EPCs became a central future business component.

Distributors mainly targeted grid-connected consumers at medium to higher income levels as the EPCs were distributed mainly as a one-off cash purchase, however participants stated that PAYG—or 'pay as you cook' (PAYC)—models could further enhance the uptake of EPCs as one-off purchases are a challenge for many. Interestingly women showed a higher ability for purchasing EPCs through one-off payments, while men preferred to purchase the EPCs through a credit option.

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.

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.

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 needsat 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.

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.

State of the on- & off-grid electricity sectors

National grid

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).

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).

Mini-grid and off-grid

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 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.

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.

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.

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 - cross-subsidized from customers connected to the national grid), meaning that eCooking is likely to already be cost-effective for many of their customers.

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 (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[3])	Part way through a field trial of DC EPCs as an additional 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

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. 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

[3] Payment schedule developed around harvests.

existing customers to make use of surplus power available when the sun is shining, and sufficient water has already been pumped.

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.

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.

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.

Appendix E: Impact of Scaled Uptake

This section explores the likely costs and benefits for one simple illustrative scenario of scale-up of eCooking in selected key segments. The World Health Organisation (WHO) revised "Benefits of Action to Reduce Household Air Pollution" (BAR-HAP) tool[4] has been applied to quantify the expected financial costs, health and environmental benefits of the scale-up.

The scenario modelled is chosen to reflect the first part of the MECS programme's suggested "40, 60, by 2030" goals: a target of 40% for all households connected to grid or off-grid electricity in Low and Middle Income Countries to be using it for cooking by 2030, and a target of 60% of households utilising modern energy for cooking to be utilising energy generated from low carbon sources by 2030 (low carbon interpreted here to include electricity coming from relatively low carbon fuel mix, and excluding fossil-derived LPG). For this illustrative analysis of costs and benefits, the focus is just on urban households that are grid connected, but currently cooking primarily with charcoal. While specific data are not available for this demographic, an estimate was made based on the evidence earlier in the report about different categories of users, suggesting approximately 1.8 million households. Consistent with the MECS 40% goal, the scenario models transition of 40% of those, so 730,000 households. Details are in the first part of the table. BAR-HAP models a ramp-up of transitioning households over the first 5 years to 2025 and then a further 5 years operation.

[4] https://www.who.int/tools/benefits-of-action-to-reduce-household-air-pollution-tool

BAR-HAP has been implemented here using its policy option of a ban on charcoal use, which comes in gradually from 2020 to 2030. This is clearly not a realistic policy and is simply used here to effect the transition wanted for this illustration, with clarity about the impacts and where costs fall; it can be regarded as a proxy for other specific actions used to mobilise a major transition from charcoal to eCooking. The assumption is that transitioning households are fuel stacking, with 20% of cooking still delivered using charcoal. The full costs of the new MECS devices have been assumed to be paid for by the Government, as a convenient simplification for this illustration. Other policy options that could have been modelled would see a different distribution of stove and fuel costs and savings between parties. eCook devices are assumed to cost $80 and to have an average efficiency of 75% (MJ input to MJ useful heat output). eCooking is assumed to save 30% of the typical 2.6 hours cooking per day. Kenya's grid electricity generation mix is dominated by geothermal (44%) with most of the balance from hydro (33%) and approximately 10% from each of wind and thermal generation. So generation is already 90% renewable, with a policy aim for 100% by 2030. The Kenyan electricity emission factors built in to BAR-HAP look to be out of date, and alternative factors have been used for this analysis based on data for Iceland, which has a similar generation mix.

The lower part of the table shows the outputs of BAR-HAP for the modelled scenario. The figure shows the structure of costs and benefits.

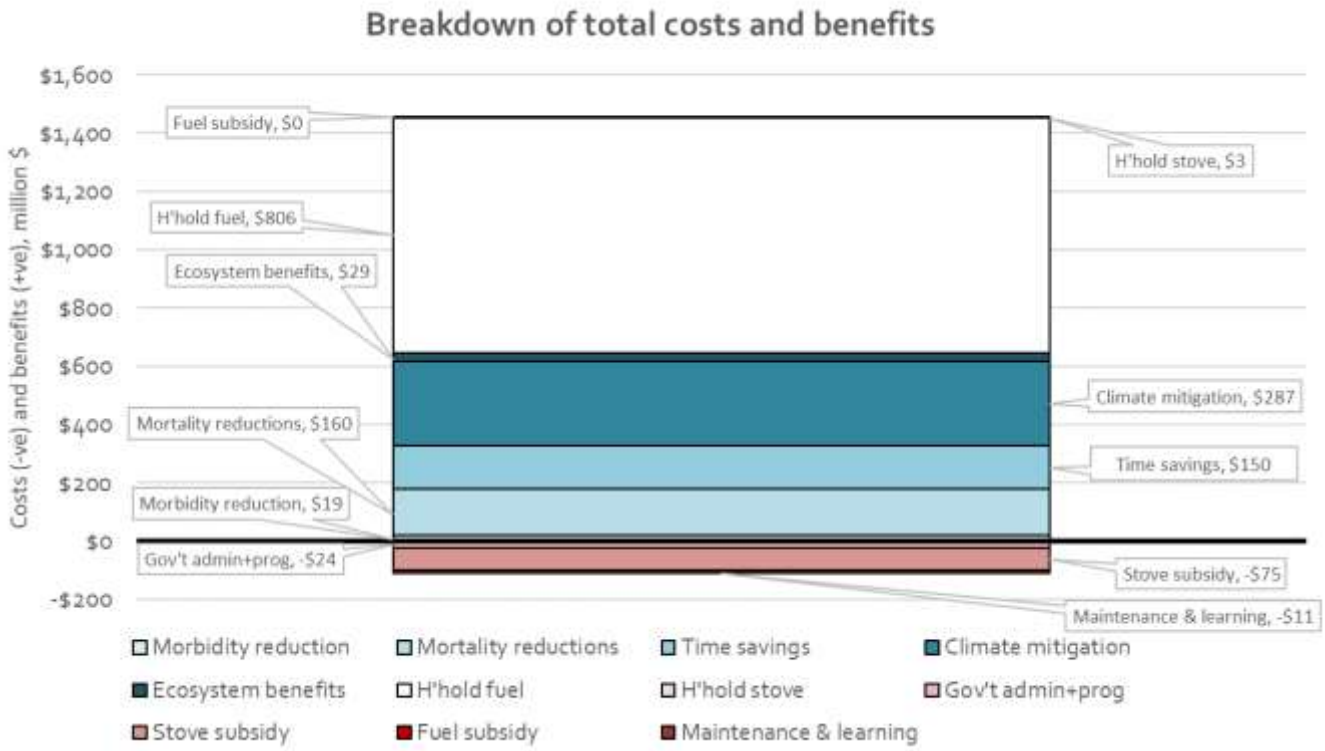
Grid connections projections and eCook target		Population (million)	housholds (million)	% grid connected			
National population, 2020		53.60	14.73				
Grid connections, 2020		38.80	10.66	72%			
Of which, using charcoal as main fuel		6.60	1.81				
Scenario modelled							
Transition from charcoal to eCooking		2.64	0.73				

Costing (costs are -ve, benefits are +ve)				$/yr	$/yr per household transitioning	$M total for 10yrs	$total per household
Total present value (ie net social benefits of the transition)				**134,472,360**	**181**	**1,345**	**1810**
Total costs of transition, government+private				**69,992,112**	**94**	**700**	**942**
Private cost to housholds: total				79,851,732	**107**	799	1075
Stove				*298,533*	**0**	3	4
Fuel				*80,639,294*	**109**	806	1085
Maintenance				*-1,086,094*	**-1**	-11	-15
Costs to government: total				-9,859,620	**-13**	-99	-133
Stove				*-7,463,329*	**-10**	-75	-100
Fuel				*0*	**0**		
Admin+Programme				*-2,396,291*	**-3**	-24	-32
Health, Time, and Environmental Benefits: total		Physical: change/yr	Physical: % of national cooking total	**64,480,248**	**87**	**645**	**868**
Health impacts total: DALYs avoided	DALYs	1,203		17,843,232	**24**	178	240
Mortality reduction	*YLL*	*622*	0.1%	*15,969,893*	**21**	*160*	215
Mortality reduction	*Lives*	*54*	0.2%				
Morbidity reduction	*YLD*	*581*	0.3%	*1,873,339*	**3**	*19*	25
Morbidity reduction	*Cases*	*2,975*	0.3%				
Time savings	Hours	191,929,679	3.2%	15,006,624	**20**	150	202
Time savings per adopting household	*Hours/HH*	*258*					
Electricity use	*MWh*	*422,448*					
CO2-eq reduction (CO2,CH4,N2O)	Tonnes	1,878,668	6.0%	28,684,766	**39**	287	386
Unsustainable wood harvest reduction	Tonnes	355,555	2.5%	2,945,625	**4**	29	40

Note: costs are discounted across programme period.
Totals are Net Present values; costs/year are NPV divided by the ten years of the programme

The table shows that while this transition would cost government some $130 per household for equipment and programme costs, it would save households 8 times that in reduced energy bills over the ten years of the programme: electricity tariffs are relatively high, but charcoal prices are very high. Furthermore, health benefits

would include more than 50 lives saved per year. Some 2.5% of current unsustainable wood harvesting would be avoided. These impacts may seem modest but this scenario is targeting only 5% of the total population. The transition from charcoal to electric cooking would make a significant reduction in greenhouse gas emissions, due to the very low carbon generation mix.



The chart summaries the various physical and financial impacts of the transition in monetary terms. The social benefits from avoided time spent cooking are significant, reflecting mainly time savings using an EPC, and the opportunity cost for peoples' time, as used in BAR-HAP. However this saving is not as large as for some countries: it is assumed here that average cooking time before transition is 2.6 hours/day, which is lower than suggested for some others. Health benefits are also considerable, mainly associated with the lives saved. By far the largest benefit though comes from reduced fuel costs to households. Charcoal prices in urban areas were assumed to be $0.55/kg, and even with electricity tariffs at $0.2/kWh, combined with cooking energy savings from use of more efficient electric devices this leads households to save around $9 per month. The largest element of cost is from the purchase of modern stoves by government.

This is an impact analysis for one simple scenario for just one particular segment (grid connected charcoal users) of Kenya's population. The scenario has very significant net social benefit overall, based on the WHO's physical impact and impact monetisation methodologies.