MECS
Modern Energy Cooking Services

Cooking with Electricity in Uganda: Barriers and Opportunities

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Executive Summary

According to the Uganda Bureau of Statistics (UBOS, 2017), 95 per cent of Ugandan households rely on charcoal, wood, or other forms of biomass for their household cooking needs while only 5 per cent rely on alternative and modern energy, i.e. electricity, gas or kerosene. In Uganda, the Modern Energy Cooking Services (MECS) programme seeks to promote and support households' transition to modern energy cooking services and technologies. As part of this objective, the Centre for Research in Energy and Energy Conservation (CREEC) in partnership with the MECS and Loughborough University has been carrying out research activities to understand domestic cooking energy use and compatibility of energy-efficient electric cooking appliances to Ugandan context.

This report presents findings from a Controlled Cooking Test (CCT) carried out in Kampala. The CCT, which we refer to as a 'kitchen lab CCT' here, involves a process where a local dish that is representative of domestic cooking practices is selected and cooked using different cooking fuels and devices to compare the performance. The stoves and fuels were tested for fuel/energy consumption and total time needed to prepare a typical meal. Furthermore, feedback was obtained from the cooks and observations were made on how they operated the stoves. In addition to devices and fuels commonly used by households, the CCT included an energy-efficient cooking device – electric pressure cooker (EPC) to observe its energy-saving potentials as well as compatibility in preparing local dishes (without compromising foods taste). The CCT was carried out with the help of everyday cooks cooking the different dishes as they would normally cook them at home. Data was captured by a research team with experience in stove testing. The CCT focused on three categories of local dishes: matooke, a traditional staple dish; beans and meat stews, and a vegetable dish - Sukuma wiki. The dishes were cooked using a charcoal stove, a Liquefied Petroleum Gas (LPG) stove, an Electric Hot Plate, and an EPC. The Kitchen lab CCT is complemented with and draws from two household surveys carried out in Kampala. The surveys aimed to capture households cooking practices, energy consumption patterns and preferences. Although this paper reports on findings on selected dishes, the research team also experimented with cooking a broader range of dishes including groundnut sauce, rice and posho.

Findings show that EPC is the most energy and time-efficient as well as the least expensive option to prepare the dishes, especially for preparing meals that take a long time and require much energy. When cooking staple foods such as matooke and beans stew, compared to the other cooking devices, an EPC uses three times less energy. The EPC can potentially save roughly half the time and 60-90% of the cost on dishes with a long boiling stage. The efficiency observed with the EPC can be attributed to the fact that the cooking chamber (the inner pot) is fully insulated and does not exert as much energy to heat up.

For vegetables or dishes that generally take a short time (and involve frying and sautéing cooking techniques), the EPC uses – more or less – the same amount of energy as the other cooking devices. This, again, is due to the fact that it is not possible to fully utilise its key attribute of the advantage of pressurised cooking. However, comparing with LPG, cooking with an EPC costs significantly less. LPG is the costliest option across all the cooking devices used. For example, steaming matooke using an LPG stove is seven times more expensive than steaming matooke using an EPC. A comparison between a charcoal stove, an LPG stove and an electric stove demonstrates that cooking with charcoal takes a lot of time and more expensive than cooking with an EPC. Energy-efficient modern technologies like EPC offer an opportunity for households to cook efficiently and at low cost. However, we observe an underdeveloped market for energy efficient modern cooking appliances and public perception of electricity as the most expensive cooking option are the two barriers to the uptake of cooking with electricity in Kampala.

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1. Introduction

The use of open fires and solid biomass fuels for cooking is one of the world's most pressing health and environmental problems, directly affecting millions of lives daily. According to the International Energy Agency (2014), a little under 80 per cent of households in Sub-Saharan Africa rely on solid fuels, such as biomass, as their primary energy source for cooking. Over the years, this percentage has not changed much due to several factors, including strong population growth (IEA, 2014). Furthermore, without any significant change or intervention, the number of people relying on traditional biomass fuels is expected to remain roughly the same in 2030.

Uganda's energy sector is dominated by biomass. According to the National Charcoal Survey (2016), released by the Ministry of Energy and Minerals Development, 9 out of 10 households use either firewood or charcoal for cooking. The Uganda Bureau of Statistics (UBOS, 2017) says 95 per cent of all households rely on charcoal, wood, or other forms of biomass for their household cooking needs. Global Alliance for Clean Cookstoves (GACC) (2017) report notes that the use of clean fuels, such as liquefied petroleum gas (LPG), biogas, and ethanol also remain under 1 per cent. A report by SNV, the Netherlands Development agency, also observes that despite more than three decades of interventions in the renewable energy sector in Uganda, currently, only 10 per cent of the population has access to clean energy for cooking (SNV, 2014). According to the National Charcoal Survey, charcoal is the primary source of fuel for people in urban areas, while firewood is preferred in rural areas.

Access to modern and clean fuels are limited due to relatively high prices and low demand. Therefore, while the benefits of modern energy are many - low emissions, speed, convenience, and controllability are substantial - overcoming barriers associated with cost, accessibility and awareness are essential. For the most part, access to modern energy fuels like LPG and electricity is limited due to issues of accessibility and affordability (high initial cost and expensive fuel) (National Charcoal Survey, 2016). However, to those that wish and can afford to cook with electricity, access to the grid is an important barrier. In Uganda, where only 26 per cent of the population currently has access to the national grid, cooking with electricity is not an option for many people. According to the Uganda national Population and Housing Census, 20.4 per cent of households use electricity as their main source of energy for lighting. The report notes electricity use for cooking is much lower at 2 per cent nationally, with 4.4 per cent in urban areas and 1.2 per cent in rural areas (UBS, 2016). Hence, the limited reach of the grid continues to contribute to the household's over-reliance on charcoal. However, households in urban and peri-urban areas and with access to electricity also continue to rely on charcoal, and perceive cooking with electricity as unaffordable (Scott et al., 2019). In the meanwhile, biomass fuels are also becoming expensive due to the increased pressure on limited resources, especially in urban areas (Muhumuza, 2019). Charcoal fuel in Kampala and surrounding urban areas does not only facilitate cooking meals and boing water for over 95 per cent of households but also a source of livelihood for many (Bamwesigye and Doli, 2019).

Furthermore, poor access to clean and modern cooking energy solutions also has national ramification at the macro and micro level. At the macro level, deforestation is a major concern. Uganda currently loses about two per cent of its forest annually, and firewood use is the second driver of this after land-clearing and agricultural expansion (Balder,

2019). The Biomass Energy Strategy (2014) estimates demand for firewood at 44 million tonnes per year, compared to a supply of 26 million tonnes per year. At the household level, traditional cookstoves and fuels continue to present a danger to human health. Inefficient and poorly vented stoves create a hazardous indoor environment and cause of premature deaths (WHO, 2016). Solid fuel use in Uganda contributes to 5 per cent of the national disease burden, and nearly 20,000 young children die of household air pollution-related pneumonia every year (WHO, 2007). A national survey data investigating the relationship between housing quality and occupant health in Uganda found that burning biomass for cooking was associated with morbidity more than any other physical housing attribute measured (Herrin et al., 2013).

In Kampala, the capital city of Uganda, over 70 per cent of the population has access to electricity. However, over 80 per cent of the households identify charcoal as their main (primary) cooking fuel (Scott et al., 2019). Furthermore, the survey carried out in Kampala by CREEC and Gamos Ltd (2019) notes that only 1 per cent said electricity is their primary cooking fuel. Hence, although Kampala with more concentrated grid connections relative to other parts of the country has considerable access to electricity, it is also one of the largest markets for the country's charcoal (Nabukalu and Giere, 2019).

1.1 Objectives and methodology

As part of the Modern Energy Cooking Services (MECS) programme, the overall purpose of this study is to assess the practicality of cooking with electricity in Uganda. The study, which was carried out in Kampala, aimed to understand households cooking cultures, preferences and other context-specific factors related to cooking. The report draws from three studies carried out in Kampala. In October 2019, CREEC and Gamos Ltd carried out a Discrete Choice Modelling survey (see Scott et al., 2019). In June-July 2020, researchers from MECS and CREEC carried out an online survey with residents in Kampala. This report also draws heavily from a Controlled Cooking Test (CCT) carried out from May to July 2020. CCT is a field test that measures stove performance in comparison to traditional cooking methods when a cook prepares a pre-determined local meal. The CCT is designed to assess stove performance in a controlled setting using local fuels, pots, and practice. It reveals what is possible in households under controlled conditions but not necessarily what is achieved by households during daily use (Clean Cooking Alliance, n.d). MECS approach to this process, which we refer to as "kitchen lab CCT' is slightly different. It blends ethnographic and engineering techniques to create a research methodology that can enable us to assess the compatibility of current and aspirational cooking practices in a context with different modern cooking devices. Thus, although CCTs are generally done in a lab, we carried out the testing in a real kitchen, using simple measurement equipment, allowing much more representative cooking in an environment in which the cook is accustomed to. The key output of the process is the identification of culturally-appropriate opportunities for transitioning to cooking with modern energy.

In Kampala, the kitchen lab CCT aimed to address questions such as: on average, how much energy is consumed to prepare a typical (most commonly cooked) meal using electricity, LPG and charcoal? On average, how much time did

it take the cook to prepare the meal on each cooking device? What is the average cost of preparing each meal using the different fuels? And is the finished product as tasty as people would expect? The research team then cooked selected (most commonly cooked) dishes in Kampala households. Meals were chosen not only for their popularity but also because they represent different categories of cooking time and techniques. In this regard, the study focused on three varieties of meals:

- Meals that take a long time to cook and require applying traditional cooking techniques (matooke / Amanyige).
- Meals that take a medium length of time but require applying a mixture of techniques (boiling, sautéing, simmering) (beans stew, meat stew).
- Dishes that are relatively quick to prepare (shallow frying or sautéing) (Sukuma wiki - kale).

Why electric pressure cooker: Testing was carried out using a ceramic charcoal stove, an electric hot plate, an LPG gas, and an electric pressure cooker (EPC). For charcoal and LPG, the team converted the energy consumption to MJ and an equivalent kWh. Based on the success in other countries in the region, the Electric Pressure Cooker (EPC) was introduced in the study as one energy-efficient cooking technology. EPCs are attractive for their energy saving capability, convenience and speed. The features of automatic control, insulation and pressurisation enable EPC to save energy, therefore money. The insulation also allows it to continue cooking during short blackouts and keep food warm after cooking has finished. The highly insulated cooking feature makes an EPC similar to rice cookers and thermo pots (Bachelor et al., 2019). Furthermore, the option to pressurise enables the food to cook faster. For example, studies in Kenya have shown that by using the EPC, households can save over half the amount of money/power, especially when cooking heavy staples like beans (Kenya eCookbook, 2019). In Kampala, the EPC was tested for its energy-saving potentials and to assess its compatibility with and adaptability to Ugandan dishes that are mostly cherished by households in Kampala.

The selection of meals to sample and our understanding of households cooking practices and preferences is based on the two surveys the team carried out as well as a desk review of literature available on the subject matter. The primary purpose of the Discrete Choice Modelling Survey was to explore households' preferences regarding the various aspects of the design and functionality of cooking devices. The survey has also been used to enhance our understanding of households cooking practices, cooking energy consumption patterns, and expenditure on cooking fuels. The DCM was carried out by a team of enumerators who conducted interviews with randomly selected households in Kampala and surrounding districts – in total 315. The DCM survey was also augmented with an online survey. The online survey, which used snowball sampling and received a response from 84 participants, focused on capturing the meals people eat, the fuels they use, their views on electricity service, what cooking fuel they use and when among other things; this gave us a deeper understanding of the context. Initially, the survey plan was to carry out the survey face to face along with focus group discussions. In June 2020, the research team had to move the survey online due to state-imposed movement restrictions in effect due to COVID-19. The online survey offered critical insight on households eating habits and domestic cooking fuel consumption patterns. However, although the team used 'exponential non-discriminative snowball sampling' one limitation of snowball sampling is that the research team had little control over the representation of the sample. Thus, the sampling for the survey was skewed in a way that 86 per cent of the survey participants were between the age of 19 and 39; and 60 per cent of those surveyed have a first university degree (Bachelors), and 31 per cent have a Master's degree.

2. Food culture and dietary patterns in Uganda

Ugandan diet is primarily based around plant-based foods, and most of the energy in people's daily meals comes from plantains and roots or tubers. Intake of pulses and nuts is also relatively high, while, for the most part, intake of meat, fish and poultry is limited but conventional. The main dishes are mainly composed of plantain, starchy roots such as cassava and sweet potatoes and cereals including maize, millet and sorghum. Uganda is self-sufficient in terms of staple food production and plays a significant role in regional food supply and trade (FEWS NET, 2017). Staple foods are exported to neighbouring countries (Kenya, South Sudan, and the Democratic Republic of the Congo (DRC)).

Dishes consist of traditional and modern cooking styles. Cooking practices and types of foods regularly consumed vary from one region to another depending on factors like climate and land cover as well as by ecological zone and ethnic group. Households in Central and Western Uganda heavily rely on matooke and sweet potatoes as their staple food. In the Northern parts of the country, the primary food crops include ground cassava millet, sorghum, and simsim (sesame). A wide variety of dry beans are produced predominantly in the Western and Northern regions. Depending on the season, beans flow between Uganda and neighbouring countries. Beans are cooked and served as a compliment ("sauce") to other staples.

Figure 1 Cooked matooke served with meat stew

Figure 2 Cooked groundnut paste sauce (below)

With more than 30 ethnic groups, Uganda does not have a single national dish that is universally eaten by all. However, matooke, a mashed green banana or plantain meal is popular among many households, especially in the central and southern part of the country. It is either boiled or steamed and then mashed and cooked in or served with a sauce of peanuts, beans, fresh fish or meat. Katogo is another dish like matooke, but the bananas are left whole and un-mashed. Posho (aka, ugali) is another popular staple dish mainly made from maize flour though cassava flour can also be used. It is prepared by mingling maize flour with water until it becomes a solid lump similar to mashed potato and is commonly served with beans or meat stew as well as groundnut paste sauce. Posho is said to be cheaper than matooke and a good substitute staple food.

Eastern and Northern Uganda contribute about two-thirds of total cassava production (FEWS NET, 2017). Both leaves and tubers are eaten. The tuber is eaten fresh, dried, or processed into chips or flour, which is used to prepare posho and bread. Its tolerance to drought and the possibility of the harvest throughout the year make cassava an important food security crop. In terms of sauces and stews, groundnut paste sauce is an essential flavouring in Ugandan dishes. It is eaten plain or mixed with smoked fish, smoked meat or mushrooms, and can also be mixed with greens. A sauce is commonly made with groundnut flour, onions and tomatoes, a leafy green vegetable, beans, and meat or fish. Beans or peas stew is also a common source of protein.

2.1 Food culture and dietary patterns in Kampala

Because of its broader ethnic diversity, higher income and status as the capital city, the food scene in Kampala offers and represents a greater variety of dishes. As a commercial hub, Kampala gets its food from the central, eastern, and western regions. However, food production in Uganda takes place at the smallholder and subsistence level, under rain-fed conditions, thus the food market in Kampala is affected by food availability and fluctuating prices. Matooke is central to the Kampala diet and is abundant from mid-January until the end of June, after which the availability goes down and the price increases. Maize flour, which is sourced from all over Uganda, is available in abundance from July until February.

Fresh beans are available in abundance from October to April, while there is relatively regular supply of cassava and no known significant price hikes or scarcity period (Pottier, 2015). Rice is not a traditional staple food in Uganda, however, it is becoming increasingly popular, particularly in urban areas. Pottier (2015) observes that in Kampala seasonal dietary change revolves and has to do with the availability and cost of matooke, which, when expensive, is first replaced with rice, and ultimately with posho (made from maize flour). Green leafy dishes (kale, cabbage, spinach) are generally considered affordable and accessible. (Fig. matooke plant)

On average, households in Kampala cook 2.4 meals per day and spend four hours preparing it (Scott et al., 2019). A typical breakfast mainly consists of eggs with bread and tea. Porridge, a posho flour or millet flour mixed with water and boiled, is also quite common. Some people, especially workers who may be out for most of the day also eat elaborated and filling meals such as Katogo for breakfast. Most households prepare breakfast between the hours of 6:00AM and 10:00AM. In Kampala, we found difference in what people say they consume for lunch and dinner. Lunch meals essentially consist of staples (rice, posho and matooke), beans/peas or meat stews along with groundnut paste sauce. Our online survey shows rice, matooke and posho are respectively the most consumed staple dishes people consume several times in a week. (The survey defined frequency as “three times or more per week”). For stews, beans stew was identified as the most common lunch and dinner meal, followed by meat. Most respondents also indicated that they are likely to have vegetable for dinner than for lunch. Similarly, more people said they are likely to eat posho for lunch than for dinner. Finally, pasta is the least preferred and cooked meal across different age and income groups. Regarding the dietary pattern of households in Kampala, similar observations were made by Namugumya (2011).

		Freq.	%			Freq.	%			Freq.	%
Breakfast	Eggs	70	83	**Lunch**	Rice	70	83	**Dinner**	Rice	66	79
	Tea or coffee	66	79		Matooke	60	71		Matooke	61	73
	Porridge	54	64		Posho	53	63		Posho	37	44
	Katogo	34	40		Beans Stew	68	81		Beans Stew	55	65
	Chapati	33	39		Meat Stew	49	58		Meat Stew	50	60
	Mendazi	16	19		G-nut Sauce	47	56		Vegetables	49	58
	Cereal (cornflakes)	14	16		Vegetables	43	51		Pasta	15	18
	Others	5	6		Pasta	18	21				

2.2 Cooking Ugandan popular dishes: techniques and processes

Most popular dishes in Uganda are prepared by boiling and steaming. Steaming is often used in daily life and has a high cultural value (Sato, 2012). Wrapping foods in banana leaves to steam is also a popular method used with an aim to enhance the flavour of the dish. This involves using banana leaves and banana stalks. If and where banana leaves are used, the cut stalks are placed in a pan and water is poured over them and then the ingredients (food item) is wrapped in banana leaves and placed on the top. Dishes prepared with such method include matooke, cassava, sweet potato, posho and luwombo.

Boiling is also a popular method of cooking in Uganda. This mainly involves a cooking technique where water is added to food and cooked to boiling point. Some of the dishes that require boiling are matooke, potato, rice, cassava, and beans. Beans or peas and meat or fish stew are part of Ugandan's daily dish. Stewing is a cooking method where every food is cooked together at the same time in one pot. The ingredients are placed in at different times as the sauce cooks and finally thickens. Hence, the process involves a mixture of techniques. For instance, preparing beans stew involves boiling of the beans, sautéing of basic ingredients (onions, tomato and green papers), and simmering of all ingredients including the boiled beans. No special utensils are required to prepare most of Ugandan dishes. However, given most meals in Uganda require steaming, pressure pots and steamers are potentially practical and useful.

In low income households, food preparation is strongly linked to cost-saving ideas which more often override notions of taste. Hence, one study notes that the decision of what to cook becomes a matter of which meal takes much time to cook (Balder, 2018). In this regard, the study notes, when the price of charcoal and other cooking fuels increase, cheaper and fast-cooking food such as greens and posho replace more expensive and slow-cooking foods such as matooke. Other techniques (to reduce cooking time, therefore save energy) include removing edible stalks from greens; or cook cassava porridge, which prepares in a short time, instead of maize porridge, which takes a longer time (Balder, 2019). Another study notes, that in Kampala, typical cooking practices include pre-soaking of hard grains and dry beans as well as preference for boiled matooke (katogo) to the traditionally steamed and mashed matooke (Mukwaya, 2016).

There is also a noticeable shift in how food is prepared – mainly from steaming to frying foods. The other notable change is the emergence of new foods like 'Rolex' and 'tv chicken', or a mix of traditional foods with new ways of food preparation such as 'fried cassava'. Rolex is a rolled chapatti filled with egg omelette and vegetables such as cabbage while TV chicken is chicken roasted in a make-shift rotisserie oven that to the locals, resembles a television and served with salad and fries. These new trends include an element of convenience, time and cost-saving as well as the emergence of new tastes and food styles. The introduction of favourite foods like rolex and tv-chicken can be attributed to the appearance and rapid growth of street vending. As in other urban areas, street food is attractive to people who do not have the money, space, or time to cook for themselves. (Figure showing a Katogo dish in an EPC).

Box 1. How to prepare a steamed matooke

No meal in Uganda would be complete without matooke. To be invited to somebody's home in Buganda (including Kampala) or western Uganda and be served pasta, rice and irish potato as a staple is downright frowned upon and considered near unorthodox. To prepare matooke for steaming as opposed to braising, one has to have Endagala (banana leaves), usually sold in bunches or singularly. Then once the matooke is peeled and washed, it is neatly wrapped with the banana leaves and secured with banana fibers. Then, the cook proceeds to prepare the saucepan. For this, the cook will place a couple of banana stalks crosswise at the bottom of the saucepan and place the matooke (wrapped with banana leaves) on top of the stalks. Then pour a small amount of water to the bottom of the saucepan, but without submerging the matooke.

The process of cooking matooke is via steaming. Then place the saucepan on high heat and allow for the water to boil for an hour or so. Then reduce the heat, but always make sure that the matooke has enough water and that at all times it is boiling. Allow a minimum of two hours of cooking, the longer the better. When the banana leaves have turned brown, this is an indication that the matooke is ready to be mashed. Safely remove it from the fire and set it aside. At this juncture, you will need to have some used banana leaves where you can place the wrapped banana and begin mashing. Gingerly press the matooke until it is mashed to the consistency of mashed potatoes. Wrap the mashed matooke in banana leaves and return to the saucepan adding more water making sure that the water does not touch the matooke. Then, return the saucepan to the stove and bring it to boil before reducing the heat and allow it to gently simmer. The simmering duration can vary from minutes to several hours depending on user or consumer preference; for die-hard matooke lovers, the longer the food is allowed to simmer, the better. Without adequate heat you will get poor and dismal results as the matooke will stay hard and blacken instead of softening and proper yellowing.

3. Cooking fuels and devices

As already stated elsewhere in this document, in Uganda biomass serves as the main source of cooking energy. In Kampala, Scott et al. (2019) find that 88 per cent of the households that participated in the survey rely on charcoal as their primary fuel for cooking and water heating. LPG and electricity are used less prominently, 8 percent and 1 percent, respectively. Fuel stacking is an almost universal practice in Kampala. For those that can afford to do so, LPG in conjuncture with charcoal is the most common combination of fuels used. However, charcoal is always chosen as the main fuel. Where people say they cook with electricity or own an electric appliance, for the most part it is used as a backup or for preparing quick dishes. When fuelwood and charcoal are used together, there is no clear preference to use one or the other as the main fuel (Scott et al., 2019).

The online survey carried also confirms this finding. Among households that use single fuel, charcoal is the most often and frequently used fuel, followed by LPG. For households that use more than one fuel, charcoal and LPG is the most prominent combination, followed by charcoal and electricity. The study further disaggregates fuel choice by meal type and time (see table below). For breakfast, which tends to be a quick dish (mostly frying of eggs and heating water for tea) households that rely on a single fuel mostly use LPG, while those that rely on more than one fuel use charcoal and LPG. For lunch, (or meals that tend to require boiling and steaming) households that rely on a single fuel mostly use charcoal, while those that rely on more than one fuel use charcoal and LPG. Similarly, for dinner, those that rely on single fuel use charcoal, while those that rely on two fuels use charcoal and LPG. On the other hand, although 24 percent of the study participants said they own an electric stove and cooking appliance, it appears electricity is rarely used on its own and it is often used along with charcoal.

	Charcoal	Electric	Kerosene	LPG	Char+LPG	Char+Elec	Elec+LPG
Breakfast	20%	5%	2%	31%	25%	2%	6%
Lunch	25%	5%	1%	27%	26%	10%	0%
Dinner	32%	6%	1%	15%	37%	11%	0%

In the subsequent sub-sections, we briefly discuss the different cooking fuels and devices households in Kampala use.

Charcoal: Charcoal is widely used and accessible cooking fuel in Kampala. It is available throughout the year and easily purchased at the local markets, from roadside vendors, it can even be delivered to customers' doorsteps. The cost of charcoal will vary depending on the season, however it is generally considered widely available. Households can buy charcoal at different prices and sizes. Affluent households can buy one or several sacks of charcoal at once and store it, while households with lower income can lower amounts and on daily basis for around 1000 or 2000 UGX (£0.20 to £0.40). A sack of charcoal can sell for 60,000 to 100,000 UGX (£13 - £21), depending on the season. Scott et al., (2019) find that while many households in Kampala purchase charcoal in sacks, 36 percent of charcoal users also say they buy charcoal in small amounts (5kg or less). With a tin of charcoal purchased at 1000 UGX, this is often enough for daily use, hence accessible for lower income households. Various types of charcoal stoves are also available in the local market at different price ranges. The cheap metallic stoves cost around 4000 UGX, while an improved cookstove costs as much as 25,000 UGX (1GBP to 5GBP where 1GBP=4,804UGX). Charcoal fuel in Kampala and surrounding urban

areas does not only facilitate cooking meals and boiling water for over 95% of households but is also a source of livelihood for many (Nexus, 2019). The importance of charcoal can be gauged by its nickname, “black gold”, as it is referred to by some traders in Kampala (UNDP, 2013). Over the past few decades, efforts to promote improved cooking stoves (ICS) have failed to deliver substantial result. ICS use in Uganda remains low at around one percent (Energising Finance, 2019). The charcoal sector provides employment to semi-skilled and unskilled labourers at different stages of production, transportation and distribution. However, the sector also suffers from inadequate enforcement of regulation, poor organisation, use of inefficient technologies and unsustainable production practices.

Figure 3 Locally made improved stoves in Uganda

Liquefied Petroleum Gas (LPG) is a readily available clean cooking fuel. LPG consumption increased from 1000 metric tons in 1998 to 5000 metric tons. With the recent discovery of oil and gas resources, it is expected that Uganda will soon start to produce its own LPG for domestic supplies. However, until then and currently, all the LPG being consumed in the country is imported through Mombasa port in Kenya and Dar Es Salaam port in Tanzania, hence making it one of the most expensive cooking option. Furthermore, as a landlocked country, any upheaval in the supply chain has a significant impact on Uganda’s domestic market supplies. LPG is also an expensive option for the consumer. The commonly sold LPG cylinders for household use on the market are the 6kg and 12 kg cylinders and the commonest stove used is the cylinder-top burner. In our online survey, 74% of the participants said they own an LPG stove. Of those, 53% said they use cylinders within the category of 9kg to 15kg and 35% said 6kg or less. The initial cost of the 6kg cylinder filled with gas is about UGX 200,000 (GBP 44), while the re-filling cost is about UGX 57,000 (GPB 12) (different suppliers have a slightly different price range). Hence, on average a bottled kg of gas goes for about UGX 9,500, a price relatively high for the average household.

Cylinders are readily available at the many of the well-known fuel service stations in Kampala. As stated earlier, LPG is the most commonly used fuel in combination with charcoal. Uganda plans to convert its natural gas reserves to LPG for domestic consumption and electricity generation. The country plans to produce 60,000 tonnes of LPG per year

from associated gas alone. The government sees LPG as an environmental mitigation and way to end households' dependence on firewood. The 2014/2015 ministry of Energy and Mineral Development Sector review report notes that the country's recoverable gas reserves are estimated at 672 billion cubic feet, of which 499 billion is non-associated gas and 173 billion is associated gas (The Observer,2016).

Electricity: The majority of households in Kampala are connected to the national grid and many rate the service and their experience with the provision of service as satisfactory. According to our online survey, 70% of the respondents rated their service as satisfactory. On the other hand, 80% of those who rated the service unsatisfactory stated their reason as 'too expensive.' Since the government removed subsidies on electricity in 2012, the cost of electricity per unit has been on the rise. Consumers pay 750 UGX per unit (£0.15 or $0.17/kWh). Cost is the main reason why many say they are not cooking meals with electric-powered stoves. Although, households enjoy a lower rate (lifeline tariffs), the scheme only applies to the first 15 units/month, one of the lowest lifeline thresholds in the region (Kenya and Ethiopia lifeline tariff threshold is at 50 kWh/month).

4. Cooking with electricity: the kitchen lab CCT

The CCTs carried out in Kampala aimed to measure the relative rate of fuel consumed by different cooking devices as they are used in the normal household environment. The tests were done with the help of everyday cooks cooking the different dishes as they would normally cook them at home. The team tested a range of typical dishes (most common) using a range of cooking fuels and cooking devices including Electric Pressure Cooker (EPC). In the subsequent pages, the report outlines and discusses the KPT findings.

Dishes cooked: As noted earlier, the testing focused on three categories of dishes: staple foods are meals that are most commonly consumed and take a relatively long time to prepare; stews that generally take medium length of time to prepare but also require applying a mixture of cooking techniques; then finally, Sukuma wiki (a leafy vegetable dish) that is rather a quick dish. The dishes were selected based on feedback from the online survey as well as the CREEC team unique understanding and insider knowledge of the context.

Cooking appliances and devices used for the kitchen lab CCT

Appliance / device	Specifications
	**Electric hot plate** ○ Make: Logik ○ Model No: LGK-002 ○ Freq: ~50Hz ○ Watts: 2600W ○ Amps: 11.3A ○ 7 litre flat bottomed aluminium pot was used
	**LPG stove** ○ 6 kg cylinder with a regulator ○ 7 liter flat bottomed aluminum pot was used
	**EPC** ○ Make: Tower with a 5L pot ○ Model: T16004 ○ 220-240V ○ 50Hz ○ 1000W
	**Ceramic Charcoal stove** ○ combustion chamber diameter, 19cm ○ combustion chamber height, 9.3 cm ○ cooking power, 0.6 kW ○ thermal efficiency, 43.3% ○ 7 litre flat bottomed aluminum pot was used ○ Cooks food for family size of 4-7 people
	**Plugin energy meter** ○ UK Plug Power Meter AC 230V~250V 13A Max ○ Operating voltage: 230V AC ○ Frequency display: 50Hz ○ Wide voltage range: 230V - 250V Operating current: max 10A

Figure 4 Cooking appliances and devices used

Parameters measured: The following parameters were measured during the test using different equipment;

Table 1 Parameters measured and Equipment used

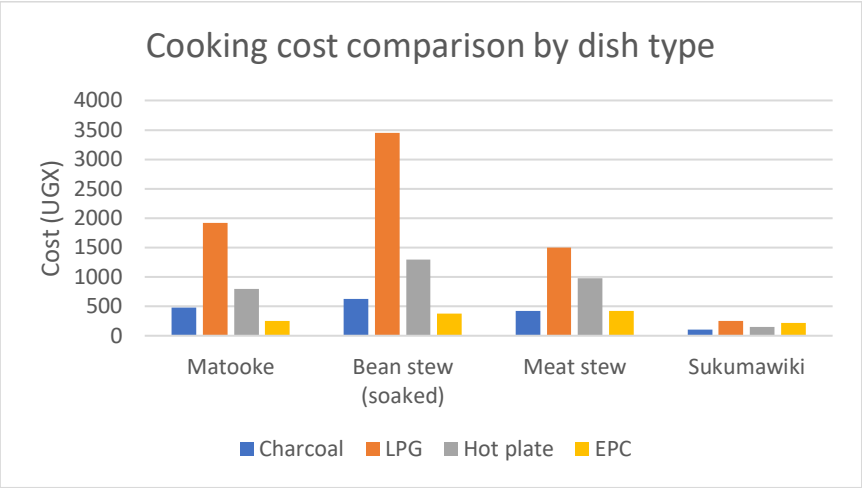
Parameter	Equipment used	Other tools used
Energy consumed (kWh)	Plug in energy meter (UK Plug Power Meter AC 230V~250V 13A Max)	○ 5 liter pot used for cooking on EPC ○ 7 liter flat bottomed used on the other devices ○ Data entry forms for raw data capture
Fuel used (kg)	30 kg digital weigh scale	
Time to prepare the meal (minutes)	Clock	
Cost of fuel to prepare the meal (UGX)	None	

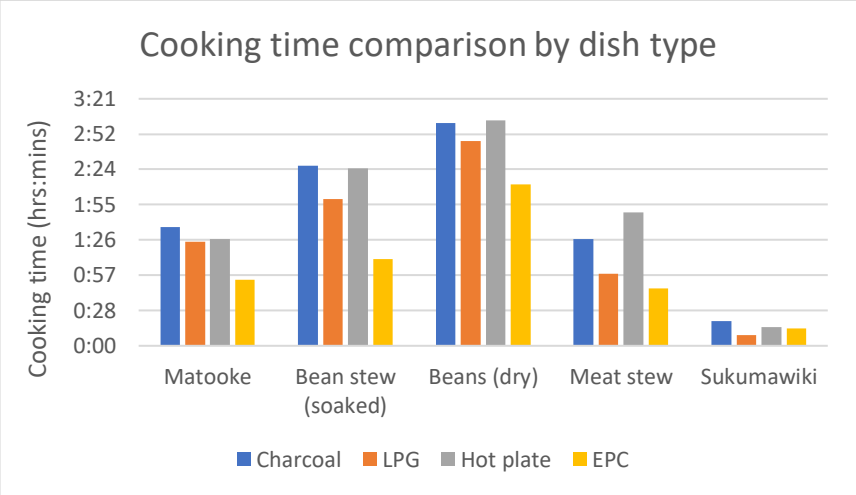
Assumptions and cost calculations

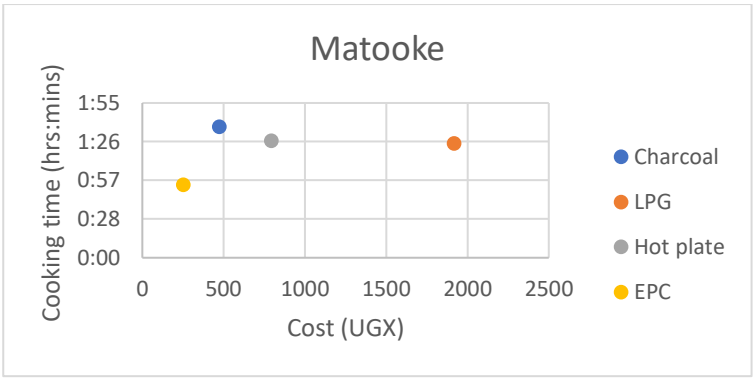
Table 2 Assumptions for data calculation

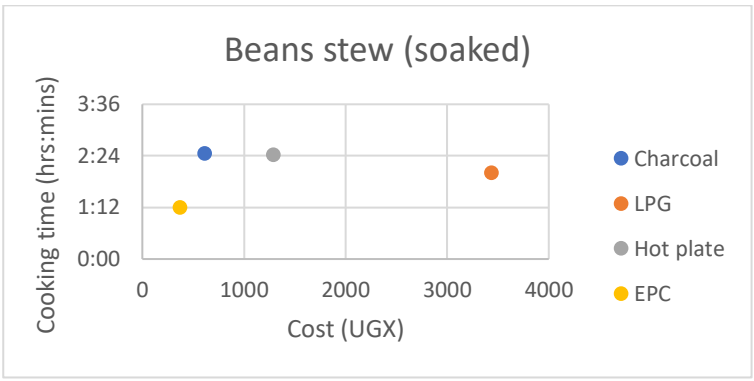
Assumptions	Unit	Source
1 Unit of electricity	750.9 UGX	ERA quarterly report
1 litre of gas	9,500 UGX	Market price
1 kg of charcoal	1,000 UGX	Market price, *based on selling price*
Energy content of charcoal (MJ)	31 MJ	
LPG default energy content (MJ)	46.1 MJ	
MJ conversion to kWh	0.2778	
kWh conversion to MJ	3.6	

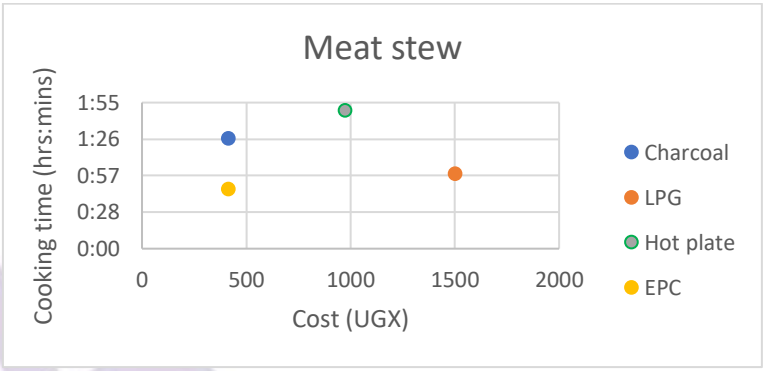
Test Results: The section below presents the findings of the kitchen lab test across devices for the different types of dishes cooked. These results represent the average of multiple testing. Tests were carried out in three rounds. Two cooks participated at each round and cooked each meal three to four times on each device. Results at each round were compared with results from the previous round to ensure consistency and identify anomalies. The data here represents an average of multiple tests from round three.

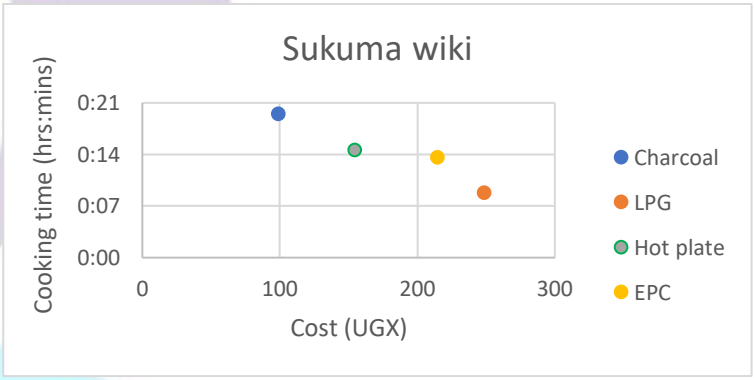





Matooke
Cooking time (hrs:mins)
1:55
1:26
0:57
0:28
0:00
0
500
1000
1500
2000
2500
Cost (UGX)
Charcoal
LPG
Hot plate
EPC


Beans stew (soaked)
Cooking time (hrs:mins)
3:36
2:24
1:12
0:00
0
1000
2000
3000
4000
Cost (UGX)
Charcoal
LPG
Hot plate
EPC


Meat stew
Cooking time (hrs:mins)
1:55
1:26
0:57
0:28
0:00
0
500
1000
1500
2000
Cost (UGX)
Charcoal
LPG
Hot plate
EPC


Sukuma wiki
Cooking time (hrs:mins)
0:21
0:14
0:07
0:00
0
100
200
300
Cost (UGX)
Charcoal
LPG
Hot plate
EPC

4.1 Staple Dish: Matooke

In Uganda, there are many ways to prepare and eat matooke in Uganda. Matooke is a variety of banana (plantain) indigenous to Uganda. It is often cooked when it is still green and unripe. The most common ways to cook a matooke are boiling, steaming, or roasting. For the purpose of the kitchen lab test, the team cooked steamed matooke (locally termed as *'amatooke amayinge'*). Overall the process involves, peeling, washing and wrapping the matooke in banana leaves and then placing it in a saucepan for steaming. After it has steamed (cooked to readiness), it is removed from fire and pressed or mashed. It is then wrapped again and placed back on the fire for further steaming. For the test, steamed Matooke was cooked on ceramic charcoal stove, electric hotplate, LPG and EPC. As readers may note from the description on how to prepare matooke (Box 1), steaming matooke is a time-consuming process.

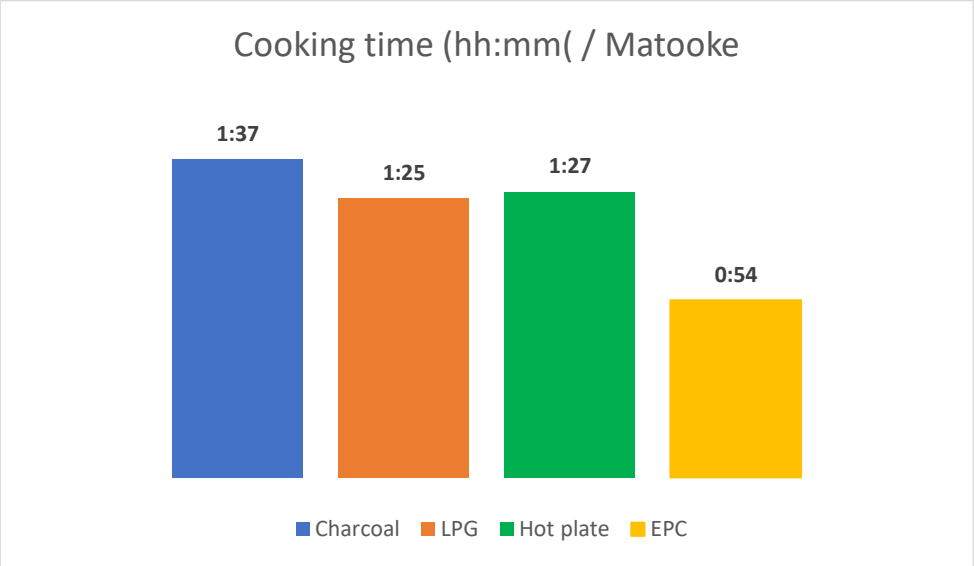


Figure 5 Cooking time (hh:mm) / Matooke

In terms of **electricity consumption**, a comparison between an EPC and electric hotplate demonstrates a significant energy-saving opportunity. An electric hotplate consumes almost three times more electricity compared to an EPC.

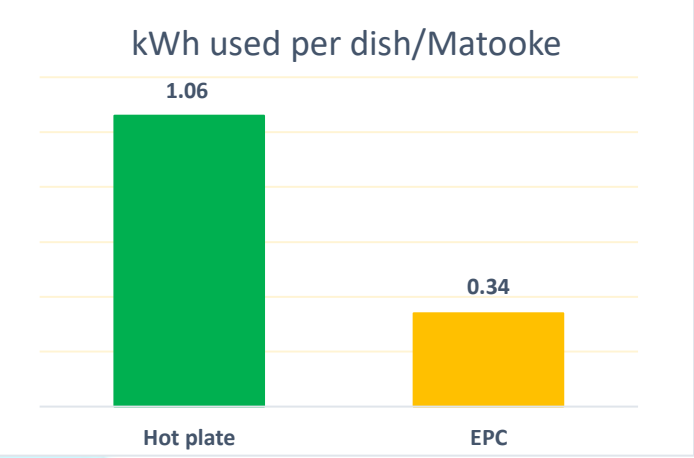


Figure 6 Energy Consumption (kWh) / matooke

An appraisal of cost also reveals an incredibly wide difference between the different devices. The first to note is how expensive it is to prepare this dish with an LPG. This confirms the finding that most households use LPG as a backup. Considering the cost here, it is unlikely that households are using LPG to prepare this staple dish. On the other hand, although significantly lower than LPG, the electric hot plate is also not an option possible for most households (at least not on a regular basis). Hence, in terms of cost, the competition is between an EPC and charcoal, even then an EPC is half the price to what it costs cooking matooke with charcoal.

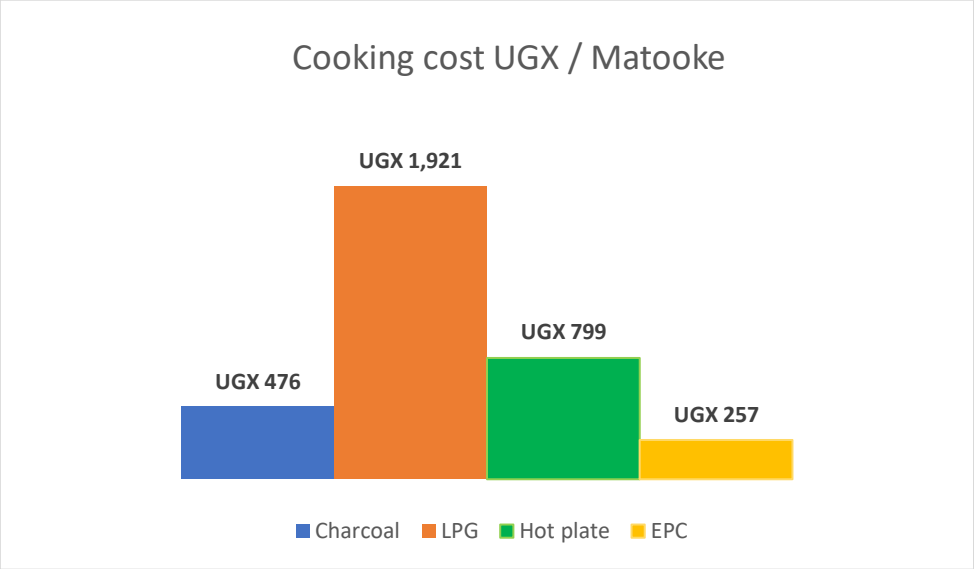


Figure 7 Energy cost (UGX) / Matooke

4.2 Stew Dish: Beans stew

The team prepared beans stew using two methods: dry and soaked. Dry beans refer to cooking of beans as purchased from the market and soaked means beans were soaked for twelve hours prior to cooking. Soaking of beans is a method known and used by many to soften the beans and cut the cooking time and energy needed. In this case the beans were soaked for 12 hours. To prepare beans stew, the (dry and soaked) beans were first boiled until soft and nice. Once the beans are cooked to the cook's preference, it was put aside while the other ingredients (onion, tomato, carrots and peppers) are sautéed together until soft. Then, the cooked beans are added to the ingredients and mixed well. Then a bit of water is added to allow for the beans and ingredients to simmer.

The team found that the EPC uses much less energy as compared to the electric hot plate. And clearly, soaking the beans prior to cooking is a good practice in improving device efficiency. Cooking beans with the EPC is a time saver as compared to other devices, almost an hour saved. Furthermore, a comparison of EPC cooking time for dry beans versus soaked beans shows that a cook can save another one hour just by soaking beans prior to cooking (see Figure 9). In terms of cost, once again, an EPC is the cheapest option for cooking beans stew (whether it is soaked or dry). However, charcoal is in close competition, whilst LPG once again appears to be the most expensive option by far (see figure 10).

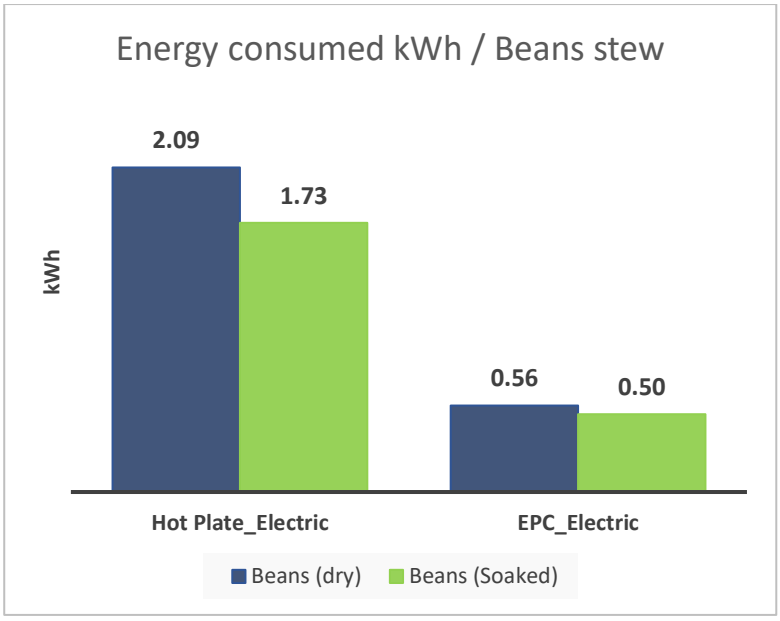


Figure 8 Energy consumption (kWh) / bean stew

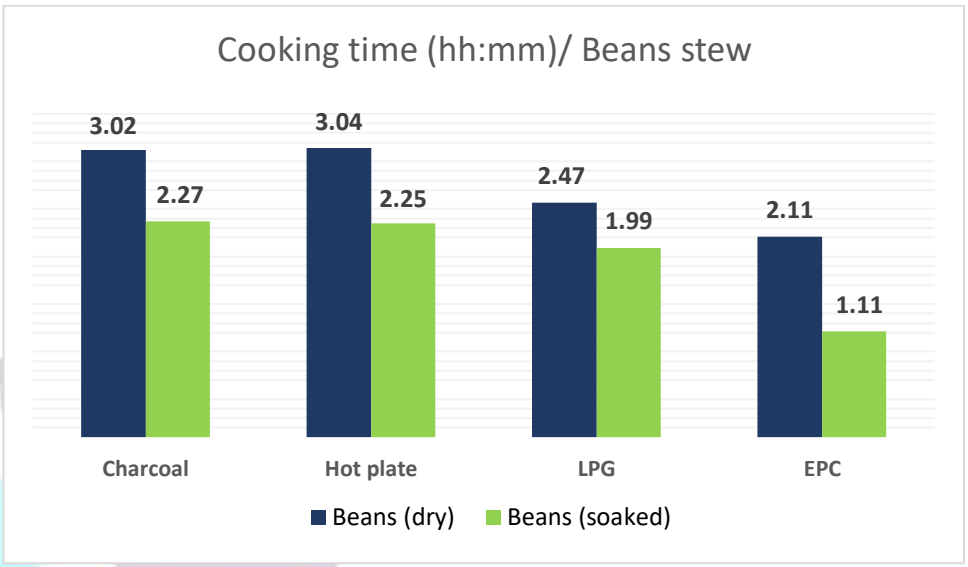


Figure 9 Cooking time (hh:mm)/ bean stew

A breakdown of energy use at various stages of the cooking process (boiling, sautéing and simmering) also demonstrates that the energy and cost-saving potential of EPC rests particularly at the boiling phase. For example, cooking beans stew (soaked) overall consumes 0.50kWh energy, of this total 0.29 kWh goes to boiling, while 0.21kWh goes to sautéing the ingredients and the final simmering task. Similarly preparing beans stew (soaked) using an electric hot plate consumes 1.73 kWh, of which 1.4 kWh goes to boiling and 0.21 kWh goes to sautéing the ingredients and the final simmering task. As such, a breakdown of the different cooking tasks involved in preparing the dish shows (see Figure 10) much of the energy consumed is attributed to boiling.

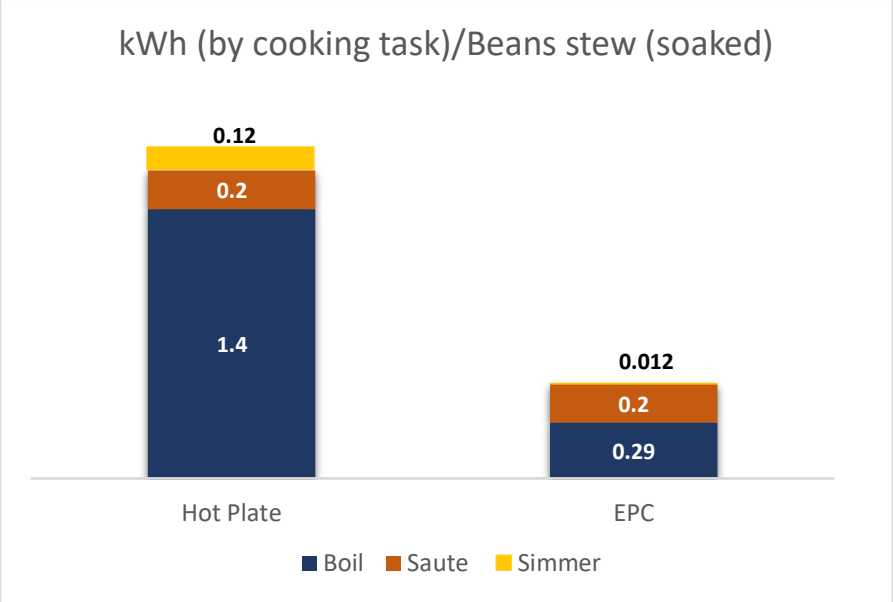


Figure 10 Energy (kWh) consumed disaggregated by cooking task

4.3 Stew Dish: Meat Stew

Preparing meat stew is like preparing beans stew. It starts with the cook chopping the meat ready for boiling. While the meat is boiling, the cook starts to prepare the ingredients for sautéing. This part of the cooking process starts with the frying of the onion and garlic until soft. Then, the cook adds the other ingredients (tomato, carrot, and peppers). Once the vegetables start to get soft, the boiled meat is added. Then, the cook adds a bit of water and lowers the heat for simmering until it is ready for serving. Cooking meat stew on EPC takes slightly less time than it does on LPG (12 minutes). However, there is a significant difference in cooking time comparing to cooking it on a charcoal stove (a difference of 40 minutes.)

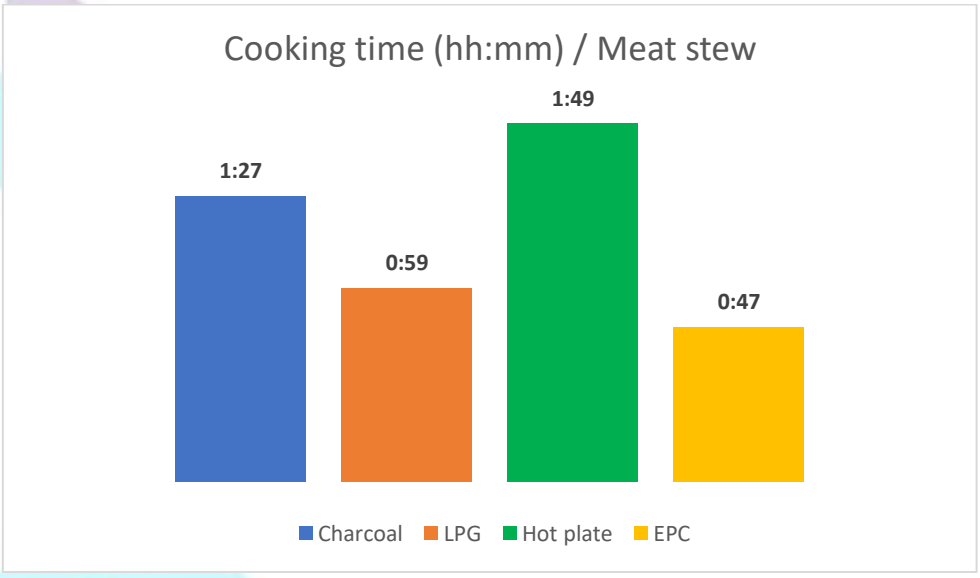


Figure 11 Cooking time (hh:mm)/ meat stew

With regards to electricity consumption, cooking meat stew with electric hot plate consumes three times the amount of electricity needed to cook the same dish with an EPC. Similar to the beans stew, a breakdown of the energy use by different processes shows that with electric hot plate most of the energy consumed goes to the boiling. See Figure 13 for a breakdown of energy used per cooking task (boil, sauté, simmer).

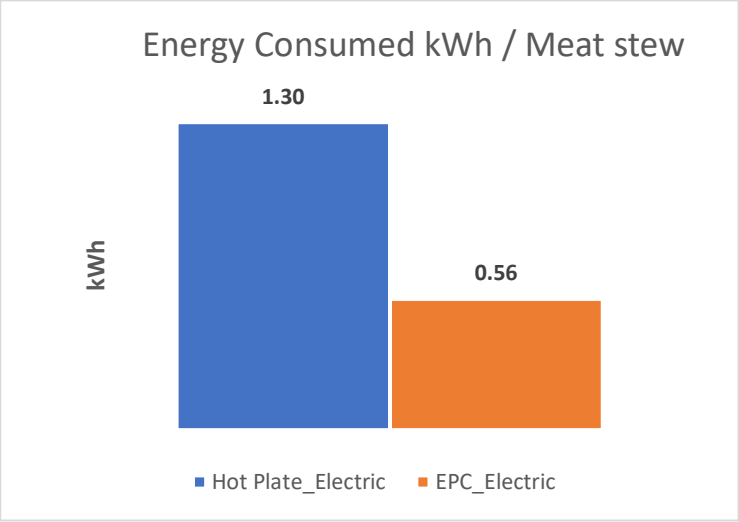


Figure 12 Energy consumption (kWh) / meat stew

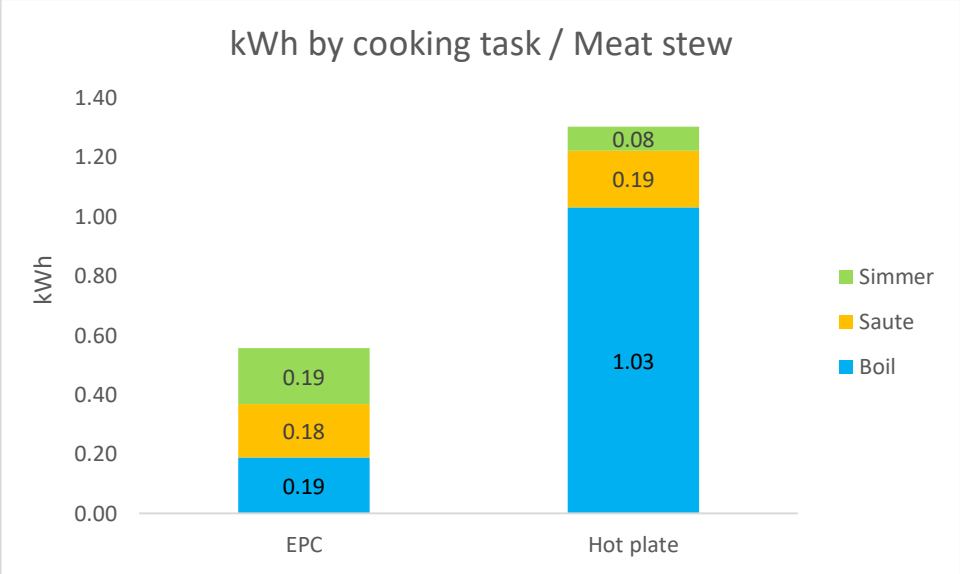


Figure 13Energy (kWh) consumed disaggregated by cooking task

4.4 Side Dish: Sukuma wiki

To prepare vegetables, ingredients (onion, tomato and other spices) are first sautéed. Then the leafy vegetable (i.e. Sukumawiki / kale) is added. Then, the pan is covered to allow for the vegetables to cook at medium heat. The dish is

relatively easy and quick to make and takes about 20 minutes from start to finish. As Fig. 14 shows the dish is cooked faster with LPG and takes longer when cooked with charcoal.

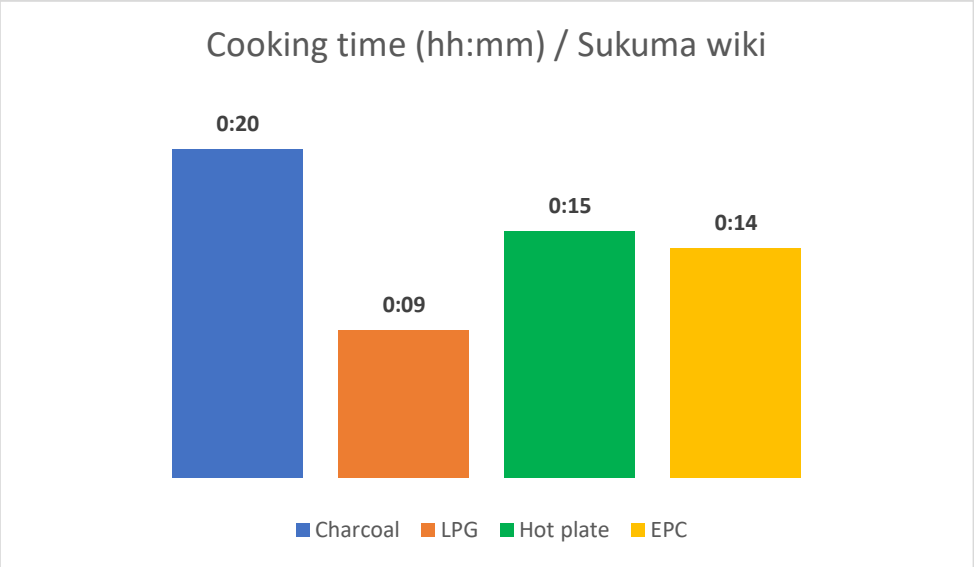


Figure 14 Cooking time (hh:mm) / Sukuma wiki

However, in terms of cost, it is significantly cheaper to cook Sukuma wiki with charcoal than any other appliances. Followed by the hot plate, then EPC and LPG.

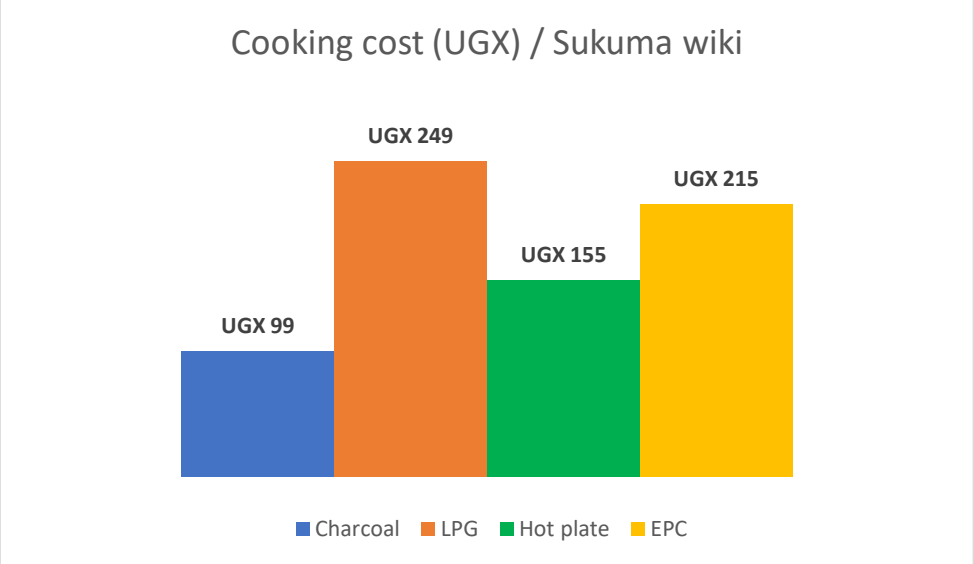
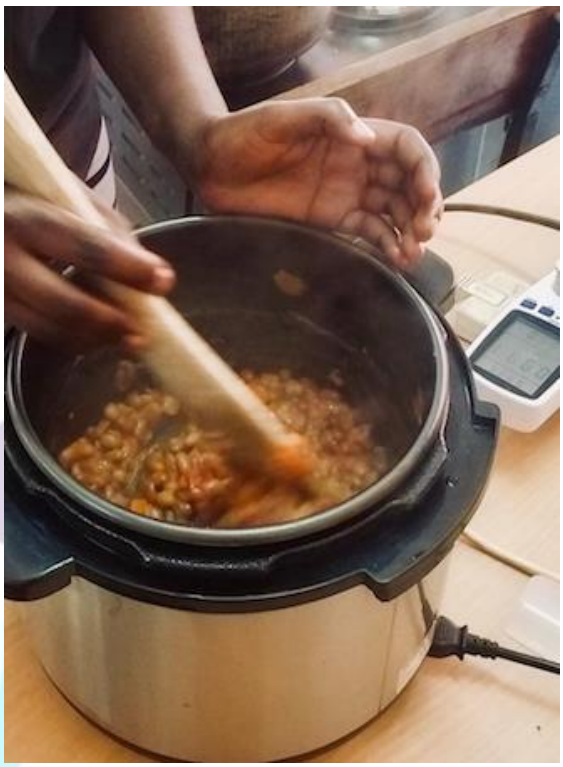


Figure 15 Energy cost (UGX) / Sukuma wiki

4.5. Cooks observation and feedback: cooking with EPC

Cathy and Lucie, the cooks that helped with the project, were pleasantly surprised and impressed by the efficiency of the electric pressure cooker. After the initial learning phase and after some trials, the cooks said that they were eventually comfortable operating the EPC and that with every round of testing, they found it easy and convenient to use. They also reported that the taste was good with little to no difference comparing to the other appliances. Not only the taste, but the cooks also commented that they felt safe using the EPC in terms of the actual cooking. Cathy and Lucie noted that the EPC generally requires less water as compared to the other devices. This has to do with the fact that the food is cooked in a sealed pot and under pressure, thus less evaporation.

One key limitation Lucie and Cathy reported was the fact the EPC's can only cater for a limited number of people in a household. [editor's note: the project used 5-litre pots, which are typically enough for 4 to 6 people. Other sizes available in the market include up to 12 litres]. Other challenges cooks reported whilst using the EPC include that at times the lid is tight and difficult to close and that it takes time to learn how to use the EPC effectively to produce a tasty meal. They also expressed concern about the cooking process being disrupted during and in case of power interruption or cuts. They also cautioned about the importance of being careful when releasing the pressure to avoid getting burned.



5. Conclusion

In low- and middle-income countries like Uganda clean cooking technologies like the EPC offer enormous promise to advance at least five of the UN Sustainable Development Goals (SDGs): Good health and well-being (SDG 3); gender equality (SDG 5); affordable and clean energy (SDG7); climate action (SDG 13); and life and land (SDG 15). Cleaner and modern fuels and energy sources, such as LPG and electricity, have impacts on social and environmental factors, including limiting rates of deforestation, improving health, reducing the costs of cooking, time savings, and cleaner kitchens and cooking vessels. However, in Uganda, empirical evidence of the impact of modern cooking technologies remains limited. Thus, despite these numerous and tangibles benefits, access to modern energy services remains either inaccessible or unaffordable. The study, part of the MECS programme, is one attempt to understand the context and address this gap.

The findings of the CCT, from which this report draws from, demonstrates that energy-efficient modern cooking technologies like the EPC are not only compatible but also offer the most efficient (both financial and energy) solution to households. Findings show that EPC is the least time consuming, the most efficient and the cheapest option. More specifically, when preparing dishes that generally take more time and require steaming or boiling, which, as stated earlier, includes most of the local dishes. The time, energy and cost-saving qualities of EPC are particularly apparent with regards to dishes that take a long time to prepare (matooke, beans and meat stews). For vegetables or short cooking dishes, the EPC uses more energy to cook, most possibly due to the fact that it is not possible to fully utilise its key attribute of the advantage of pressurised cooking. Although, for some dishes (e.g. Sukuma wiki), LPG is the faster option, but also the most expensive option across the board. For example, steaming matooke using an LPG stove is seven times more expensive to use an EPC.

A comparison between charcoal, LPG and electric hotplate shows that cooking with charcoal consumes a lot of time, but currently it is also the least expensive option for cooking any meal. For example, on average, preparing a lunch of matooke and meat stew on LPG would take about two hours and a half to prepare and costs 3,426 UGX. On the other hand, preparing the same dish (matooke and meat stew) on a ceramic charcoal stove takes about three hours and costs 892 UGX altogether. As noted elsewhere in this report, charcoal is also the most accessible and reliable cooking fuel in Kampala. Demand for charcoal is high primarily because it remains the cheapest option for lower- and middle-income households. However, the fact that households are using LPG suggests that there is demand and willingness to include cleaner and modern sources of energy for cooking. However, considering the cost of LPG and the polluting effect of charcoal, efficient and convenient modern cooking technologies like the EPC offer a better option particularly when cooking meals that take a long time and require a lot of energy without compromising on the taste as well as with savings on cost. At the moment, cooking with electricity is not seen as an option by households due to the overall cost of electricity and because the market for efficient domestic electric cooking technologies is not well developed. Increasing awareness and creating a conducive environment for the development of the market for energy-efficient domestic cooking appliances is going to be critical.

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7. Annex 1: Kitchen Lab CCT results

		Boil	Steam	Sauté	Simmer	Fuel /device	Time on stove (hh:mm)	Energy used (kWh)	Energy Used (MJ)	Energy Used (kg)	Cost / dish (UGX)
Staple foods	Matooke		✓			Charcoal	1:37		14.88	0.48	476
						LPG	1:25		9.22	0.2	1921
						Hot plate	1:27	1.06			799
						EPC	0:54	0.34			257
Stews	Beans (soaked)	✓		✓	✓	Charcoal	2:27		19.22	0.62	622
						LPG	2:00		16.60	0.36	3444
						Hot plate	2:25	1.73			1298
						EPC	1:11	0.50			376
	Meat	✓		✓	✓	Charcoal	1:27		13.02	0.42	417
						LPG	0:59		7.38	0.16	1504
						Hot plate	1:49	1.3			978
						EPC	0:47	0.56			418
Vegetables	Sukuma wiki		✓		✓	Charcoal	0:20		3.07	0.099	99
						LPG	0:09		1.20	0.026	249
						Hot plate	0:15	0.21			155
						EPC	0:14	0.29			215