MECS Kitchen Laboratory – Zambia

Initial Testing for the Zambian eCookBook

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Executive Summary

The Zambian government are committed to a '20-40-20-20' cooking scenario, that would see electric cooking reduce from 34.5% to 20% by 2030 and see the nascent LPG sector grow to meet 40% of cooking needs in urban areas[1]. Charcoal, a polluting fuel that is responsible for 59% of cooking in urban areas, would be reduced to 20% by 2030, and the final 20% of the market is filled by firewood.

If these objectives are met, modern and clean energy cooking will increase in Zambia over the next decade. The government also aim for all Zambian households to have *access* to clean and modern energy cooking solutions, and in this respect a reduction in electric cooking must be challenged. Load shedding, outages, and tariff hikes in recent years have shifted the focus away from electricity and electrification as part of the solution, despite the fact that:

- The cost of 100% renewable electricity is reducing year-on-year[2]
- Zambia may be producing surplus electricity by 2022[3]
- Significant gains have been made in terms of energy efficiency and battery storage[4].

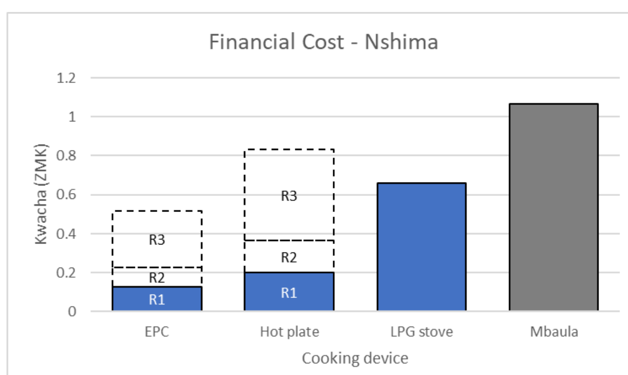
This report provides much-needed insight into the role that **energy-efficient cooking devices** can play in Zambia's clean energy future. Kitchen laboratory tests have been developed by the Modern Energy Cooking Services (MECS) Programme to investigate the potential energy, time, and cost savings from using more efficient cooking devices, as well as the suitability of the devices for local cuisines. This is a mixed-methods approach, combining Controlled Cooking Tests (CCTs) with qualitative data that takes account of the cooking experience as well as the quality of the dish from an eating perspective. This report focuses on the results concerning four cooking devices: two that are commonly used in Zambia today (a charcoal mbaula stove and an electric

[1] https://rise.esmap.org/data/files/library/zambia/Documents/Energy%20Efficiency/Zambia_SEforALL%20AA.pdf
[2] https://www.irena.org/newsroom/articles/2020/Jun/How-Falling-Costs-Make-Renewables-a-Cost-effective-Investment
[3] https://www.afrik21.africa/en/zambia-towards-surplus-electricity-production-from-renewable-energies/
[4] http://documents1.worldbank.org/curated/en/920661600750772102/pdf/Cooking-with-Electricity-A-Cost-Perspective.pdf

hotplate) and two modern, clean and energy-efficient devices (an electric pressure cooker (EPC) and an LPG stove). Tests were completed on five dishes that are regularly prepared in a typical Zambian household. The fives dishes are: nshima, bean stew, chicken stew, porridge (with groundnut powder) and rape.

Data was obtained by weighing the fuel (charcoal, LPG) using scales (spring and flat top); and taking electricity consumption readings from a plug-in energy meter. Overall, the EPC was observed to be the most efficient in terms of time and cost for preparation of the selected dishes. This was followed by LPG and the electric hotplate, while the mbaula was the least efficient. The efficient devices were found to be extremely well suited to Zambian cuisine from both a cooking and taste perspective.

The cost and time savings of the electric pressure cooker show that electric cooking can play a significant role in Zambia's clean cooking transition without overloading the national grid. In fact, if inefficient electric appliances such as hotplates and ovens were phased out and replaced by EPCs, Zambia's reliance on charcoal and wood could be significantly reduced below the 40% target for urban areas by 2030. Currently, LPG appears to also be a better alternative than the inefficient electric hotplate at the highest electricity tariff. Despite charcoal stoves being extremely affordable without the need for consumer finance solutions, the cost of cooking with charcoal tends to be higher than the cost of cooking with modern energy alternatives.



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Introduction

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The five type of foods selected for this activity were based on commonality in Zambian households, cultural ties and also because the foods represent different preparation categories, that is long, medium and short cooking events. The foods/dishes include nshima, chicken, beans, porridge and rape.

The main objective of conducting the kitchen lab or controlled cooking tests was to generate data on time taken and cost to prepare five selected dishes on different fuels and/or devices for a Zambian eCookbook, which will be published later this year. The data generated has also been used to simulate evidence-based fuel stacking matrix/pathways that would speak to efficiency in the context of time taken to cook, energy consumption and cost of meal preparation. These are presented towards the end of the paper.

This report consists of an overview of energy and cooking in Zambia, the scope and methodology, devices used, foods/dishes, results and conclusions/recommendations.

Energy and Cooking: an overview

The conversion process of raw ingredients into fully-fledged meals (dishes) cuts across cultural diversity and further down to household dynamics, demographics and geographical contexts.

Although the context of food choices and taste preferences can be perceived as evolving dynamics across cultures and households, energy remains central and an independent parameter in the meal preparation processes.

Except for a few, most raw foods such as cereals, vegetables and meat resources are typically subjected to heat to produce palatable meals for human consumption.

The energy needed to prepare a dish can be generated from different sources. Biomass, fossils, hydro and solar resources are amongst the notable sources of energy. However, fuel use varies between localities and households due to factors ranging from availability, accessibility and affordability dynamics to energy generation and cooking device technologies.

Unfortunately, certain cooking fuels are derived from inefficient and carbon emitting biomass resources (e.g., firewood and charcoal).

In instances where clean energy like electricity is consistently available and used for cooking, it is likely that cooking activities are characterized by inefficient energy consumption due to the use of certain inefficient modern cooking appliances, such as ovens and hotplates.

Figure 1 [Top] – Mbaula stove;
Figure 2 [Bottom] – firewood stove.
Credit: CEEEZ

Although no official study has been conducted, day to day interactions with urban populations reveal that many households who own electric hotplates sporadically use these appliances for typical meal preparation processes. When used, fast to prepare dishes (such as tea, fried eggs, rice etc.) are most often prepared on these appliances. Charcoal-powered stoves have dominated cooking practices in the majority of households and are often the preferred alternative to electric hotplates. Medium- and long-cook dishes (nshima, bean stew, game meat, etc.) are frequently cooked this way.

In the past 5 to 6 years, Zambia has experienced significant load shedding[5] with the worst episode in 2019 and lasting up to 15 hours/day. In 2014, Zambia had the lowest tariffs in sub-Saharan Africa, with the average Zambian tariff only 38% of the median[6]. In 2019, ZESCO applied to the Energy Regulation Board

[5] Demand-side intervention measure to manage a power supply deficit
[6] https://openknowledge.worldbank.org/handle/10986/24869

for a tariff increase which was later approved in January 2020. Appendix 1 shows details of residential tariff plan which was approved in 2020.

The alluded scenarios justify a perception held by many grid-connected Zambian households that cooking with electricity is expensive. This narrative leveraged by continued load shedding continues to validate urban household's reliance on charcoal, and a spike in usage drives increased indiscriminate charcoal production from the supply side. The load shedding problem in 2015 also lead to a spike in LPG usage as a clean fuel for cooking, although some households abandoned LPG when load shedding hours were subsequently reduced by ZESCO[7].

Currently, the level of adoption and use of smart efficient electric cooking appliances such as electric pressure cookers across Zambian households remains low. LPG use for cooking also remains low and, like electricity, is perceived by many households to be expensive.

Kitchen Lab Scope and Methodology

The scope of the kitchen lab tests revolved around the generation of relevant quantitative data for the purpose of analysing the efficiency, cooking time and cost of cooking a variety of dishes on different cooking appliances and stoves. This process allows us to make evidence-based comparisons and conclusions about modern energy cooking in the Zambian context, providing valuable information for stakeholders and policy makers in the energy and clean cooking sectors.

Five dishes were prepared in an electric pressure cooker (EPC), the ordinary charcoal stove (mbaula), the LPG stove and the electric hotplate.

The parameters of interest in the lab tests were (i) fuel/energy consumption, (ii) cooking duration and (iii) these variables relate to cost of cooking a dish on respective appliances.

In order to validate the results, the tests were repeated multiple times for every dish and every stove/device. In total, 60 cooking tests were performed. A small number of tests were deemed to be outliers and have been omitted from the test results presented below. Outliers were usually the result of challenges in obtaining accurate LPG and charcoal measurements for a given dish.

[7] Permissions at the following:
https://www.researchgate.net/publication/343007468_THE_DEMAND_AND_MARKET_STRUCTURE_FOR_LIQUEFIED_PETROLEUM_GAS_LPG_IN_ZAMBIA_ENERGY_REGULATION_BOARD

Dishes

Five dishes were selected for the lab tests on the basis of commonality, nutritional value, seasonality, cultural attachment and geographical inclusiveness. These were nshima, bean stew, chicken stew, porridge (with groundnuts) and fried rape vegetables. These dishes also vary in cooking time and cooking process (boiling/simmering, frying, or combination) and therefore the selection allows us to test the performance of the cooking devices in relation to this diversity. It is expected that fried dishes will be cooked best by devices that allow for a quick and high transfer of heat, without increasing the risk of burning or over-cooking the food. Dishes that require long periods of boiling or simmering will be cooked best by devices that successfully retain heat and can keep the cooking liquid at a high heat throughout the cooking process. This will be particularly important for 'hard food' dishes like beans, for instance, which take hours to cook.

a. Nshima

Nshima is a major dish widely consumed across Zambian households both in rural and urban areas. Typically, its main ingredient constitutes maize meal, a derivative of a starch-rich maize grain which accounts for the biggest share of grain yield in the country.

The 2019/2020 agricultural season saw 3,387,469 metric tons of maize grain produced countrywide[8].

Figure 3 – Nshima cooked in an EPC, Chitandika, Eastern Province. Credit: CEEEZ

The maize meal is readily available and accessible in all 3 seasons of the year. In the case of rural households, many do not buy maize grain as they grow enough for domestic consumption and they sell the surplus.

In a typical Zambian household, nshima is consumed at least twice a day (usually in the afternoons and evenings) and commonly served with either protein rich dishes (e.g., chicken, beef, beans etc.) or

[8] https://www.iapri.org.zm/wp-content/uploads/2020/12/2020_asr.pdf

vitamin/mineral-rich vegetables (rape, cabbage, okra, pumpkin leaves etc.). The choice and combination of relish to accompany nshima is mainly driven by microeconomic factors (i.e., income).

Nshima is rich in carbohydrates hence mainly consumed for body energy needs. It is also so deeply embedded into the Zambian cultures that almost all cultural/traditional related events (i.e., Kitchen Parties[9], traditional ceremonies and funerals) have a component of nshima cooking and eating.

Figure 4 – Nshima cooked on an electric stove. Credit: CEEEZ

The ingredients:

- maize meal
- water

The process:

Typically, nshima preparation is a continuous boiling process from start to finish. However, the process can further be subdivided into 3 main sessions namely water warming, simmering process and finally the stirring process. Worth mentioning is that the time involved in the boiling pathways depends on the type of fuel and appliance used.

- Water warming: Desired quantities of water are poured into a pot and subjected to heating until it is warm enough to add maize meal. The outcome of this stage in the cooking process is porridge.
- Boiling and stirring phase: Let the porridge boil until the texture changes and the porridge has a fresh corn aroma. The cook begins to add maize meal in small quantities while stirring with a cooking stick until a desired thick nshima paste is formed.
- Simmering: The thick formed nshima paste is further subjected to heat while a lid is tightly closed to simmer for a few minutes. Remove the lid and stir again to ensure that the maize meal powder is well mixed into the paste and the paste is smooth. Reduce the temperature and let it simmer

[9] Kitchen parties are held for women before their wedding, and one of the rituals is to prepare nshima in a large pot with the help of the bridal party

for two to three minutes and eventually remove from the cooking appliance as a complete dish ready to be served.

b. Bean Stew

Figure 5 [Top] – Raw beans; Figure 6 [Bottom] – soaked beans. Credit: CEEEZ

Although over 60% of beans come from northern Zambia, they are consumed in both urban and rural households across the country.

What makes beans attractive to many households is that approximately 500 grams (which is equivalent to 20 Kwacha, or $2 USD) can feed a family of six for two meals. Just like the other selected foods, beans are equally accessible in all seasons on demand. In simplicity, it is an affordable source of protein and starch which has an attribute of expanding during the cooking process.

Ingredients:

- Beans
- Cooking oil
- Tomato
- Onion
- Salt
- Spices (optional)
- Green pepper (optional)

The Process:

Typical of hard foods, the preparation process consists only of boiling, from start to finish. The boiling process can be separated into two sessions. The first session is an intensive continuous boiling process that ensures that cooks and softens the beans. The second session involves a few minutes of boiling after adding of tomato, cooking oil, onion and salt.

c. Chicken Stew

Records at the ministry of Fisheries and Livestock indicate that poultry is currently the main meat consumed by Zambian households accounting for an estimated 50% of the total meat consumption in the country.

Over 1 million small and medium scale farmers across the country have ventured into poultry farming hence available and accessible on demand. Chicken is a rich source of protein and animal fats.

Because it carries a prestige status from the context of Zambia's diverse cultures, chicken always features on special occasions such as marriage negotiations in rural areas, Kitchen Parties, weddings events and funerals.

Ingredients:

- Pieces of chicken meat
- Cooking oil
- Tomato
- Onion
- Salt

Figure 7 [Left] – Frying chicken on a hotplate; Figure 8 [Right] – Preparing the sauce. Credit: CEEEZ

The process:

Preparation of chicken stew has two major processes namely the boiling and the frying processes. Initially, chicken meat is boiled in water on a high heat. The meat is later transferred to a pan with cooking oil and fried until brown. Finally, the used oil is them combined with onions and tomatoes to make the sauce.

d. Porridge (with Groundnut Flour)

Groundnuts are one of the major high-value crops in Zambia with 2020 production reported at 127,172 metric tons[10]. Groundnuts are a source of cholesterol-free fats. Versatile products such as peanut butter are produced from groundnuts, but groundnut flour is typically used by Zambian households and for a variety of dishes. Here, it is used to prepare a nutritious groundnut blended porridge, a recipe that is representative of rural and urban households.

Figure 9 – Preparing porridge on a gas stove.

Credit: CEEEZ

Ingredients:

- Maize meal
- Powdered groundnuts
- Sugar
- Salt

Similar to nshima cooking, porridge preparation is a typical continuous boiling process with the initial phase being water heating. When the water is warm enough, mealie meal is added in stages until the required level of porridge thickness is reached.

The porridge is left to boil and simmer for a desired interval of time, which may vary from kitchen to kitchen. Halfway into the boiling process, groundnut powder is added to the porridge by sprinkling it over while stirring, to avoid the formation of lumps. The porridge is then left to further boil until it is deemed ready to serve.

Sugar can be added 3 minutes before the end, or when a pot is removed from the heat.

[10] https://www.iapri.org.zm/wp-content/uploads/2020/12/2020_asr.pdf

e. Rape vegetable

Figure 10 – fried rape vegetables. Credit: CEEEZ

Rape is a vegetable which is grown commercially and in backyards throughout the year across the country. It is readily available, affordable, and rich in vitamins and minerals. It is consumed in rural and urban households as an accompaniment to nshima.

Ingredients:

- Leaves of rape vegetable
- Cooking oil
- Tomato
- Onion
- Salt

The Process:

The Cooking process is stirring and fry. Typically, rape is cut into small sizes and placed in a pot with cooking oil at the base to heat. Onion, salt and tomato are equally added to the frying vegetables. Depending on cook preferences, all the ingredients can be added at the same time or at intervals. To retain the original green color, rape is cooked without a lid on top.

Cooking Devices

Electric Pressure Cooker

Figure 11 – Midea Electric Pressure Cooker. Credit: CEEEZ

An electric pressure cooker is a modern cooking appliance fitted with an in-built heating element, a microprocessor, sensors, and a control panel to generate and retain heat energy, monitor and regulate pressure and temperature in order to give users a smart and efficient cooking experience (see images below). Midea was the brand used in the controlled cooking tests and the notable features are listed below.

- o Power rating: 1000W, 220V
- o Capacity: 6.0L

- 15 In-built pre-programmed cooking menus.
- Current Price: 1,795.00 Kwacha ($180 USD) (at the time of writing this report)

Figure 12 [Top] – Two-burner gas stove and LPG cylinder; Figure 13 [Middle] – Single electric hotplate; Figure 14 [Bottom] – Charcoal Mbaula stove.

Credit: CEEEZ

LPG Stove

A gas stove unit consists of a stove, a gas cylinder, a hose, and a gas flow regulator. The image represents a setup of a 2-burner stove powered by a 5kg gas cylinder. The brand name for the unit used was Cadac. This particular LPG combo had a market price of 1,815 Zambian kwacha (approx. $180 USD) at the time of writing this report.

Hotplate

Essentials JB-3108 is the brand used for the kitchen lab experiments. As seen in the image below, it is a single spiral hotplate with power rating at 230V /50Hz and wattage at 1000W. It is mostly sold in Shoprite retail chain stores and was priced between 150-180 Zambian kwacha ($15-18 USD) at the time of writing this report.

Charcoal Mbaula Stove

The mbaula stoves are made from scrap metals by local blacksmiths/artisan. As seen in the image below, the base and walls are perforated to facilitate air circulation. The mbaula vary in sizes. The one used in the laboratory tests can take up to approximately 400 grams of charcoal at any one time. This size of mbaula costs between 15 and 25 kwacha (approx. $2 USD) depending on the location it is sold.

Test Results

This section discusses the findings from the kitchen lab experiments for each individual dish. We compare the devices according to the energy consumed and time taken to cook the dishes, and we can apply a range of different cost scenarios to understand the cost of using these devices in different contexts.

The results below focus on the Lusaka context, taking the national grid tariffs for the price of electricity, and the actual prices paid for charcoal and LPG by the team between November 2020 and January 2021. The cost of cooking using the electrical appliances are calculated for all three price points, to show the costs according to different household energy consumption patterns and cooking at different times of the month.

- Tariff Structure:
    - Lifeline Tariff: 0.56 (ZMK/kWh)
    - R2 Tariff: 1.01 (ZMK/kWh)
    - R3 Tariff: 2.31 (ZMK/kWh)
- Cost of LPG: 17.8 (ZMK/kg, converted from 9.09 ZMK/L)
- Cost of Charcoal: 5 (ZMK/kg)

Each dish was cooked multiple times on each device, and the data presented below reflect the mean cooking time, cost, and energy consumption across the valid tests. Towards the end of this section, a number of scenarios are presented that capture different cooking contexts in Zambia and how they would be implicated by a transition towards modern, energy-efficient cooking practices. Finally, the chef that administered the majority of tests gives his insight into the performance of each of the appliances for this specific selection of dishes.

Nshima

Energy consumption

Nshima is traditionally cooked using biomass, which proves to be more energy intensive, more laborious, and more expensive than modern energy equivalents.

The mbaula stove requires more than 3 times the energy of an LPG stove to cook and prepare nshima, and more than 7 times the energy used by an EPC. The EPC cooks nshima

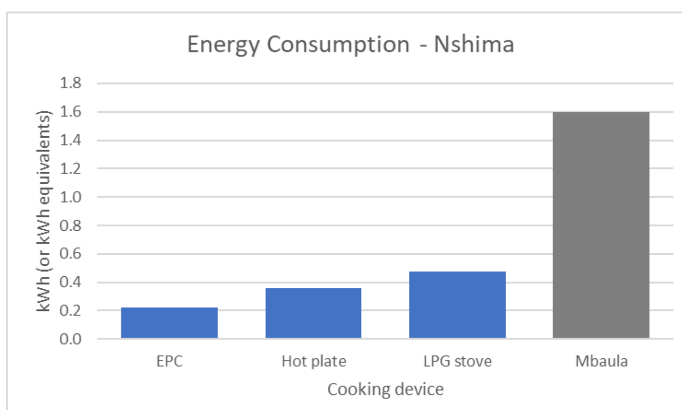

Figure 15 – Average energy consumed cooking nshima (kWh).

using half the energy needed for the LPG stove, which also uses more energy than an electric hotplate.

Cooking time

On average, nshima took 44 minutes to prepare on the mbaula, while only half the time is needed when cooking with LPG. Due to the increased efficiency and insulation of the EPC, nshima (25mins) was prepared in less time than on the hotplate (34mins) and on the Mbaula (44mins). The two more efficient appliances save time for those responsible for cooking meals at home.

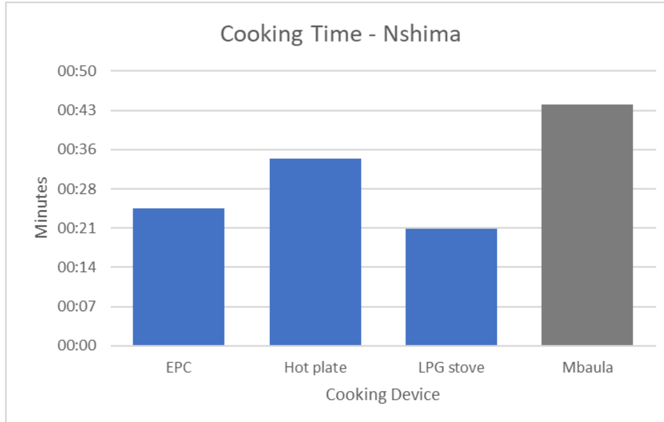

Figure 16 – Average cooking time for nshima (mins).

Cooking cost

Even when cooking at the highest electricity tariff (R3), which requires the household to have used 300 units in the month, the EPC is still the cheapest way to cook nshima (0.5 kwacha) – it is half the cost of the charcoal used to prepare the very same dish. At this tariff, LPG is a cheaper way of preparing nshima compared to an electric hotplate. At the lower tariffs, both the EPC and the hotplate are much cheaper than the two alternatives.

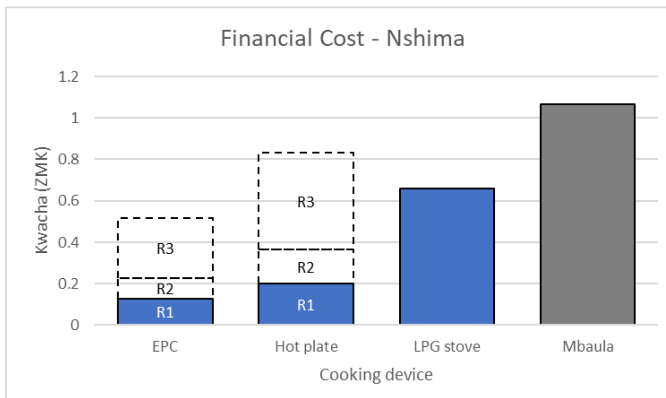

Figure 17 – Average cost of cooking nshima (ZMK). R1 = cheapest tariff, R2 – middle tariff; R3 – highest tariff.

"Preparing nshima in the EPC has been an exciting experience. The insulation from this pot creates a moist but firm textured nshima; it is very tasty with a nice aroma… and most of all the crust comes out as you remove the nshima, making it easy to clean the pot."

Bean Stew

Energy and Time

This dish requires a much longer cooking time than any other dish included in the tests, taking more than 6 hours on a mbaula and 3-4 hours on an LPG stove and a hotplate.

The EPC out-performs the other devices considerably, due to its increased efficiency and ability to cook under pressure. In an EPC, beans take less than an hour and a half, and uses 20% of the energy needed for a hotplate, 10% of the energy of an LPG stove, and less than 5% of an mbaula stove.

The 'EPC*' column denotes a test where there was a break in the electricity supply and the device lost pressure. Despite this interruption, the cooking still took a much shorter time to complete when compared to the LPG stove (70mins quicker), hotplate (100mins) and the mbaula (260mins). This shows the significant benefits of energy-efficient electric cooking even in cases where the electricity supply is not 100% reliable.

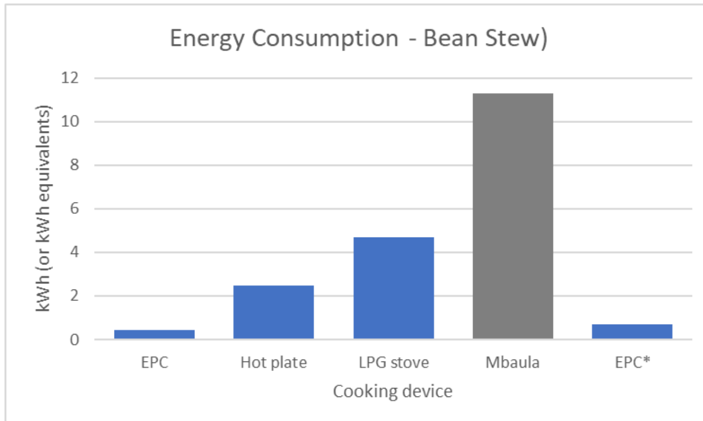

Figure 18 – Average energy consumption for cooking bean stew (kWh). EPC denotes a short blackout that increased the cooking time and energy consumed.*

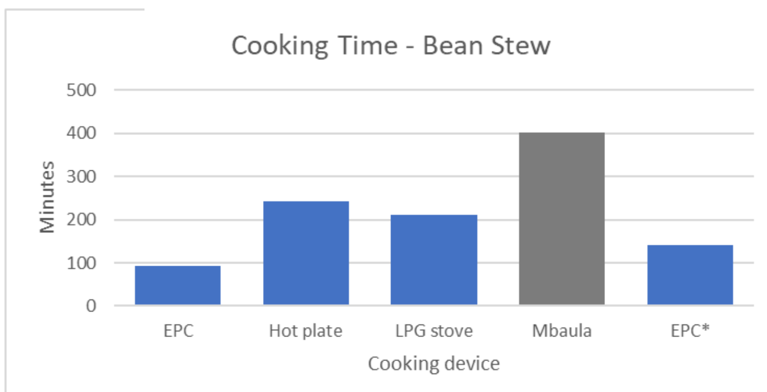

Figure 19 – Average cooking time for bean stew (mins). EPC denotes a short blackout that increased the cooking time and energy consumed.*

Cooking Cost

It might be expected that a dish that requires a long cooking process will be much cheaper on charcoal than on LPG. However, since the LPG stove cooks the beans in almost half the time of the mbaula, the cost of the cooking process is marginally cheaper using LPG than using charcoal. If a household is cooking on the R3 tariff, an inefficient appliance like a hotplate is almost as expensive as cooking with LPG. Even at the highest tariff, the cost of cooking beans in an EPC is just 1 kwacha, almost 7 times cheaper than the cost of charcoal for the very same dish.

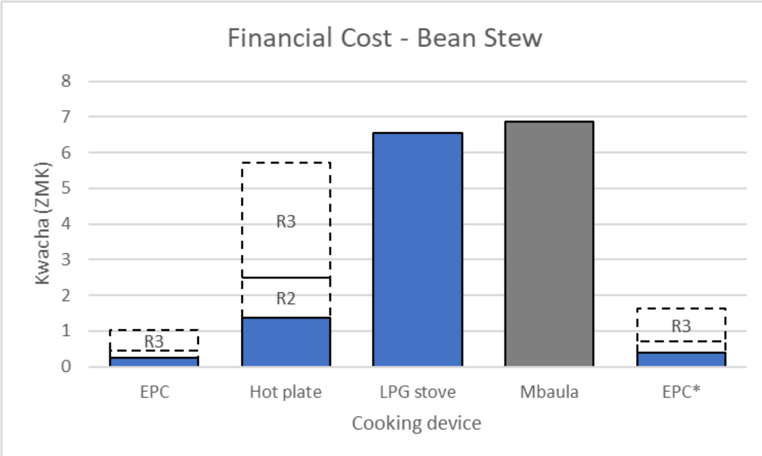

Figure 20 – Average cost of cooking bean stew (ZMK). R1 = cheapest tariff, R2 – middle tariff; R3 – highest tariff. EPC denotes a short blackout that increased the cooking time and energy consumed*

Chicken Stew

Energy Consumption and Time

The mbaula stove by far requires the highest use of energy to cook chicken, 2-3 times more than each of the modern energy equivalents.

The dish takes between 25 and 35 minutes to cook, and the EPC and LPG stove were shown to shorten the cooking time in comparison to the two less efficient stoves/devices. For the electric cooking tests that took measurements for the boiling and frying stages separately, it becomes clear that the energy saving of the EPC is concentrated in the frying process, rather than for the short boiling period.

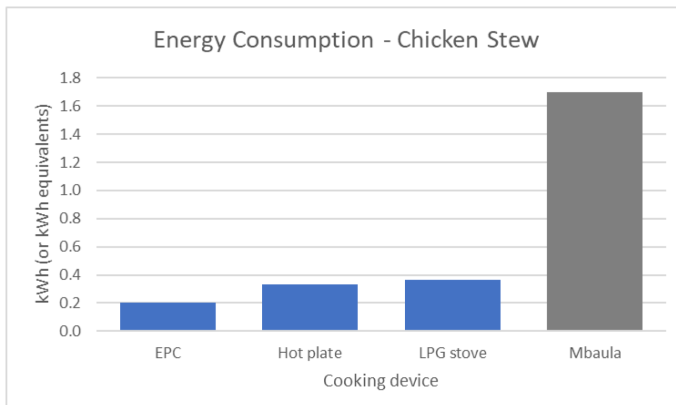

Figure 21 – Average energy consumption for cooking chicken stew (kWh).

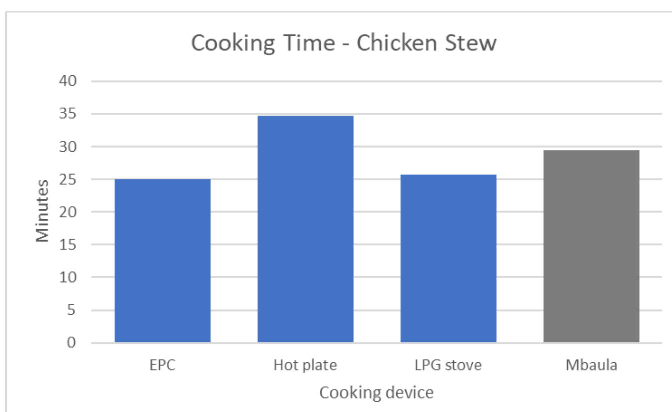

Figure 22 – Average cooking time for chicken stew (mins).

Cooking Cost

The inefficiency of the hotplate is important in terms of the cost of cooking. Although it is cheap to cook chicken on a hotplate on the lowest two tariffs, the hotplate is no longer cost competitive at R3. The EPC remains the cheapest option regardless of the tariff, although the difference is minimal at R3 in comparison to the LPG stove. These findings suggest that the benefits of an EPC are less pronounced for Zambian foods that require different cooking processes consecutively.

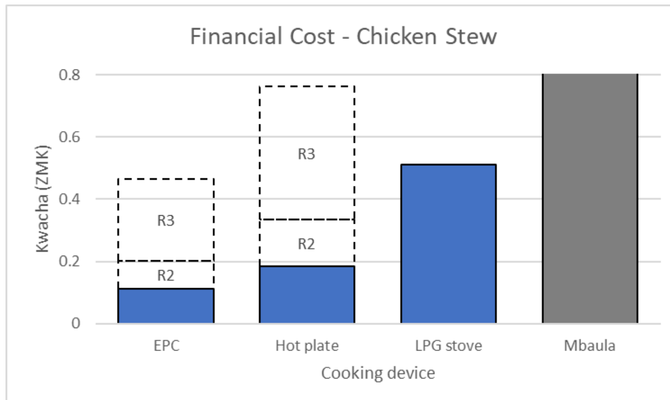

Figure 23 – Average cost of cooking chicken stew (ZMK). R1 = cheapest tariff, R2 – middle tariff; R3 – highest tariff.

Porridge (with Groundnut Flour)

Energy Consumption and Time

The CCT results show that the mbaula once again requires significantly more energy than modern energy equivalents: almost 9 times the energy consumed when cooking porridge with the EPC. The EPC is much more efficient than the LPG stove, but the differences between LPG and the hotplate are marginal.

In terms of cooking time, the LPG stove cooks the porridge in the shortest time when compared with the other devices. The difference in time between the LPG stove and the EPC is minimal (26mins vs 27.5mins), and this is also true of the hotplate and mbaula (35mins vs 38mins).

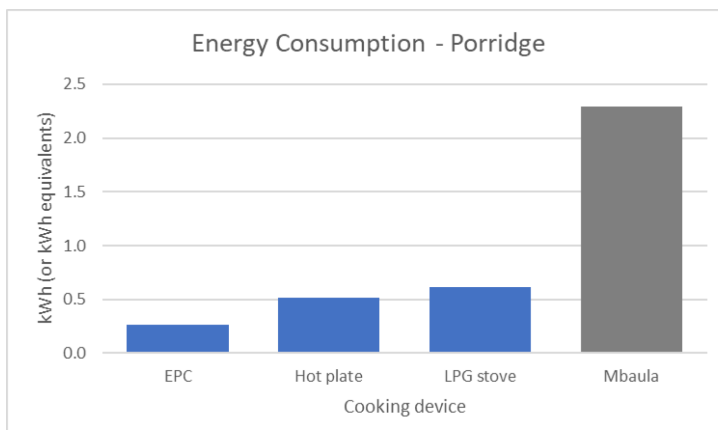

Figure 24 – Average energy consumption for cooking porridge (kWh).

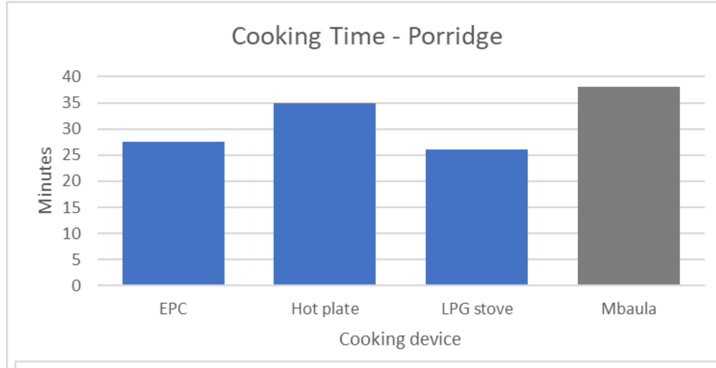

Figure 25 – Average cooking time for porridge (mins).

Cooking Cost

The EPC is the cheapest cooking option at all three tariffs, although the LPG stove remains cheaper than the hotplate at R3. The mbaula stove is once again the most expensive.

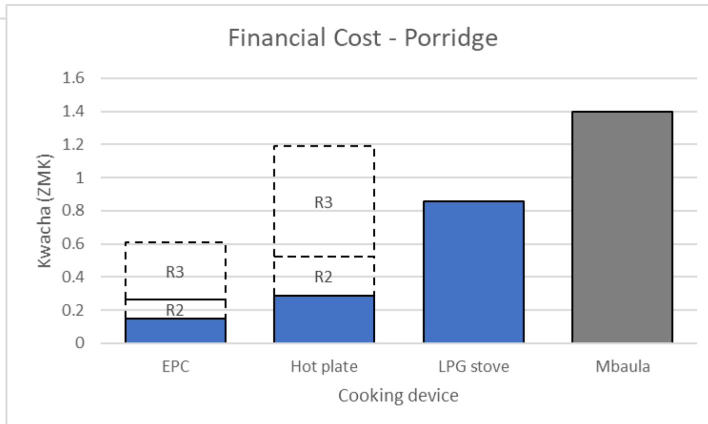

Figure 26 – Average cost of cooking porridge (ZMK); R1 = cheapest tariff, R2 – middle tariff; R3 – highest tariff.

Rape Vegetable

Energy Consumption and Time

Of all the dishes selected for testing, the rape dish is the quickest and consists of a short frying process. For this dish, the hotplate requires slightly less electricity than the EPC, but the difference is marginal. The energy required for both devices remain 4 times less than the energy needed for the LPG and charcoal devices.

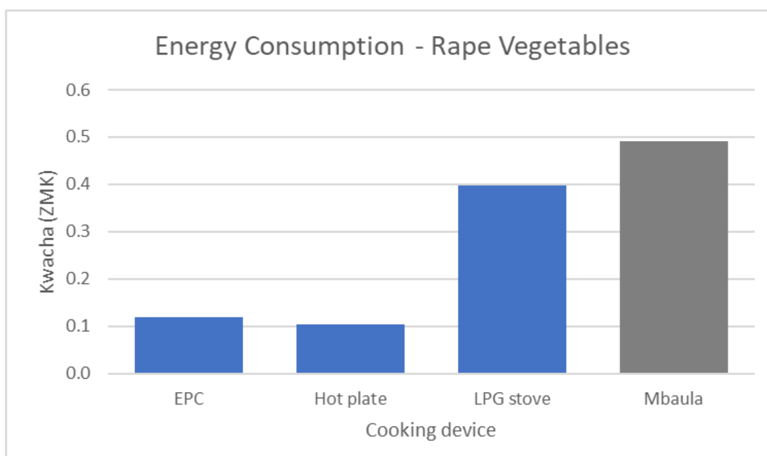

Figure 27 – Average energy consumption for cooking rape (kWh).

All three modern energy devices take 8-9 minutes to cook rape, whereas the mbaula stove takes over 20 minutes. This longer cooking time was likely the result of a poorer quality of charcoal and difficulties in maintaining a high enough temperature. The consistency that comes with modern energy devices are an advantage, in addition to increased efficiency and a lack of fuel pollution.

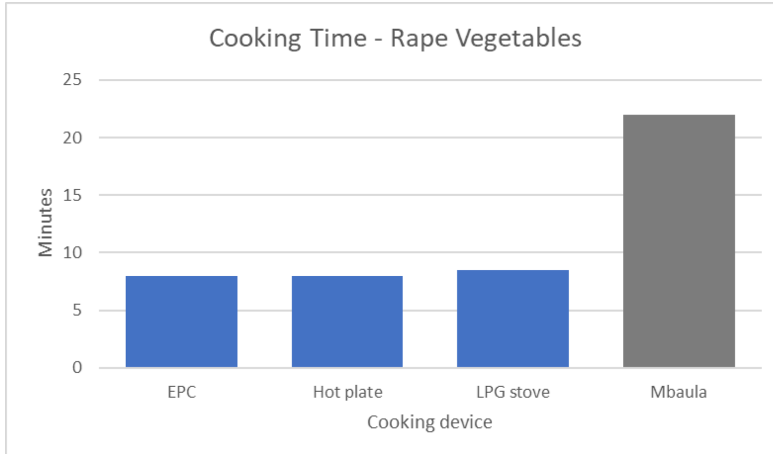

Figure 28 – Average cooking time for rape vegetables (mins).

Cooking Cost

The relatively short cooking time means that only small amount of charcoal is needed (0.06kg), which makes this dish cheaper on the mbaula than on the LPG stove. This is the only dish included in the CCTs where charcoal is not the most expensive of the three cooking fuels. However, the difference is only 0.25 ZMK ($0.02c USD). Even at the highest tariffs, both the EPC and hotplate remain cheaper than the mbaula for cooking rape, and due to the short cooking time, there is little difference in the cost of cooking between the two electrical appliances.

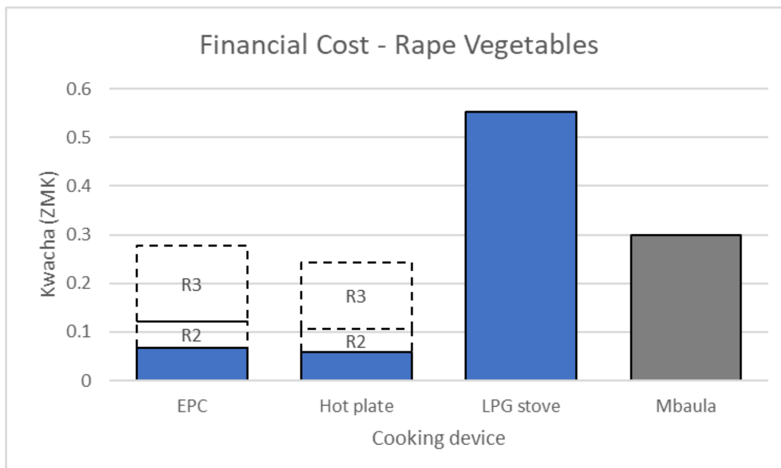

Figure 29 – Average cost of cooking rape (ZMK); R1 = cheapest tariff, R2 – middle tariff; R3 – highest tariff.

Modelling Household Cooking Practices

Fuel stacking is prevalent across urban households. Typically, fuels are chosen based on their availability, food type and personal preference. In the face of load shedding, households revert to alternative fuels to either start a new cooking process or finish up what was started on electric cooking appliances. In instances where all fuels are readily available, the practice of multi-tasking where respective dishes are simultaneously cooked on specific cooking devices is common. For example, nshima would be cooked on a charcoal mbaula stove, vegetables on a hotplate and perhaps warming of beans on the other hotplate. To reflect these kinds of practices, this section of the report models the cost of cooking different foods different ways, often in combination with one another.

Table 1 highlights CCT energy, cost and savings outcomes as a result of replacing the charcoal mbaula for nshima preparation. Even at the highest electricity tariff (2.31 ZMW/kWh), a Zambian household would save 27.38 ZMW/month if it adopted an EPC to prepare nshima twice a day instead of the mbaula.

Table 1: Energy consumption and Cost implications: Cooking nshima twice a day

Dish	**Cooking Device**	**Daily energy consumption (kWh or kWh equivalent)**	**Cost/Day (ZMW)**	**Weekly cost (ZMW)**	**Monthly Cost (ZMW)**
Nshima	EPC	0.45	1.04	7.26	31.12
	Hotplate	0.72	1.66	11.65	49.92
	LPG	0.95	1.32	9.23	39.55
	Charcoal	3.2	1.95	13.65	58.50
Average net savings (Mbaula to EPC)		**2.75**	**0.91**	**6.39**	**27.38**

If a household phases out a charcoal mbaula stove in preference for an LPG stove, ZMW 18.95 would be its average monthly savings as a result of transitioning. The amount saved could be used towards the next LPG gas refill. Transitioning to modern energy cooking for nshima will displace 0.39kg of charcoal per day, equivalent to 11.7kg per month. This saving will have a positive impact on household air pollution and carbon emissions, as well as on forest degradation that is caused by charcoal production.

In a typical Zambian urban household, starchy enriched nshima, protein rich meat products (e.g., Chicken, beef, fish etc.) and vitamins rich vegetables make up a complete meal for either lunch or dinner. Multi-tasking is common. Below are tables highlighting different pathways. In table 2, our simulation reflects existing cooking practices common in urban areas: the use of the charcoal mbaula stove and an inefficient electric hotplate (cooked once per day).

Table 2: Inefficient meal preparation pathways

1st Pathway – Charcoal-orientated					**2nd Pathway – Electricity-orientated**				
Dish	Appliance	Cost /Day	Cost /Week	Cost /Month	**Dish**	Appliance	Cost /Day	Cost /Week	Cost /Month
Nshima	Charcoal stove	0.98	6.83	29.25	Nshima	Charcoal stove	0.98	6.83	29.25
Chicken stew	Charcoal stove	1.04	7.26	31.13	Chicken stew	Hotplate	0.76	5.34	22.87
Rape Veg	Hotplate	0.25	3.86	16.57	Rape Veg	Hotplate	0.25	3.86	16.57
Cumulative Cost		**2.27**	**17.95**	**76.95**	**Cumulative Cost**		**1.99**	**16.03**	**68.69**

In these two inefficient scenarios, a marginal saving of ZMW 8/month can be made by making a small adjustment in favouring the hotplate over the Mbaula for one dish. Where the electricity supply is unreliable, this does not provide enough of an incentive on its own to transition households from charcoal to electricity.

In table 3, two ideal EPC-LPG simulations were generated. As shown, the 1st simulation outlook is the most efficient fuel stacking pathway with average monthly cost of ZMW 46.06, which represents a cost saving of ZMW 30/month when compared to a typical, inefficient stacking scenario from Table 2. The 2nd simulation outlook remained very attractive and competitive compared to pathway 1 and 2 in table 2. Households would save significantly if they transition to EPC and LPG gas stove for cooking a complete meal. On assumptions that suppliers of EPCs and LPG stoves introduce pay-as you go payment models, households can use the saving generated to help finance the purchase of clean cooking appliances.

Table 3: EPC-EPG Stove Matrix

1st Pathway – EPC-orientated					**2nd Pathway – LPG-orientated**				
Dish	Device	Cost /Day	Cost /Week	Cost /Month	**Dish**	Device	Cost /Day	Cost /Week	Cost /Month
Nshima	EPC	0.52	3.63	15.56	Nshima	LPG stove	0.66	4.61	19.78
Chicken stew	EPC	0.46	3.25	13.93	Chicken stew	EPC	0.46	3.25	13.93
Rape Veg	LPG stove	0.55	3.87	16.57	Rape Veg	LPG stove	0.55	3.87	16.57
Cumulative Cost		**1.53**	**10.75**	**46.06**	**Cumulative Cost**		**1.67**	**11.73**	**50.28**

As observed in Table 4, load shedding makes cooking a more costly activity if charcoal stove is the only options. A complete switch to LPG without any electric cooking for this meal would lead to a monthly saving of ZMW 17.71.

Table 4: Simulation under load shedding/disconnected scenario

100% meal preparation using the mbaula				**100% meal preparation using the LPG stove**			
Dish	Cost /Day	Cost /Week	Cost /Month	**Dish**	Cost /Day	Cost /Week	Cost /Month
Nshima	0.98	6.83	29.25	Nshima	0.66	4.61	19.78
Chicken stew	1.04	7.26	31.13	Chicken stew	0.51	3.58	15.32
Rape Veg	0.30	2.10	9.00	Rape Veg	0.55	3.87	16.57
Cumulative Cost	**2.32**	**16.19**	**69.38**	**Cumulative Cost**	**1.73**	**12.06**	**51.67**

These tables above focus on lunch/dinner rather than on cooking practices over an entire day. This is because many households in Zambia will limit cooking to these mealtimes and rely on purchased bread and tea/coffee for breakfast. At weekends, households are more likely to cook for all three meals. Based on the five dishes included in the study, Table 5 below provides two hypothetical scenarios for breakfast, lunch and dinner, based on a modern fuel stack (1st pathway) and a kitchen using Mbaula for 100% of their cooking (2nd pathway). If a household were to cook all three meals every day for a month, the cost saving for the modern fuel stack would be ZMW 229.80 ($23 USD/month).

LPG/EPC stack				**100% meal preparation using the mbaula**			
Dish	Cost /Day	Cost /Week	Cost /Month	Dish	Cost /Day	Cost /Week	Cost /Month
Breakfast				**Breakfast**			
Porridge (EPC)	0.61	4.24	18.19	Porridge	1.40	9.80	42.00
Lunch				**Lunch**			
Nshima (EPC)	0.52	3.63	15.56	Nshima	0.98	6.83	29.25
Chicken stew (EPC)	0.46	3.25	13.93	Chicken stew	1.04	7.26	31.13
Rape Veg (LPG)	0.55	3.87	16.57	Rape Veg	0.30	2.10	9.00
Dinner				**Dinner**			
Nshima (EPC)	0.52	3.63	15.56	Nshima	0.98	6.83	29.25
Bean Stew (EPC)	1.01	7.08	30.33	Bean Stew	6.88	48.14	206.30
Rape Veg (LPG)	0.55	3.87	16.57	Rape Veg	0.30	2.10	9.00
Cumulative Cost	**4.22**	**29.54**	**126.60**	**Cumulative Cost**	**11.88**	**83.16**	**356.40**

The Chef's Perspective

1. Mbaula charcoal stove

Except for brownish appearance it gives chicken pieces, cooking on charcoal was more time consuming for all five selected dishes. It was worse if it was fresh fire (from scratch) where it took me roughly 15 minutes if good charcoal was used and at least 20 minutes for poor quality charcoal for fire to spread across mbaula stove.

2. LPG Stove

I loved the fact that I was able to ignite the fire Instantly and regulate heat output each time I needed to. I enjoyed preparing Nshima and rape vegetables more so during the times of load shedding in the evenings. My observations on chicken stew preparations, it is suitable for boiling chicken and making soup but frying can be done on the EPC. On the other side, heat spread across the pot and heat the handle which was unpleasant experience.

3. Electric Pressure Cooker I found it more convenient to boil beans, boil and fry chicken, boil porridge and cook nshima with the EPC. Both pre-set and manual settings made cooking more exciting as I was able to plan and schedule cooking time. It was also easy to clean the EPC pot after cooking (roughly 3 minutes).

4. Hotplate Cooking on hotplate was exciting especially when preparing nshima and vegetables although I needed to be alert to avoid burning and spending more energy and time.

Figure 30 [Top] – Lighting the mbaula stove; Figure 31 [Bottom] – Preparing nshima in the EPC. Credit: CEEEZ

Conclusions

This report provides clear evidence of the important role electricity and LPG can play in Zambian households' choice of cooking fuels and practices in the future. Energy efficient appliances provide a cheaper, quicker, and more convenient way of cooking Zambian dishes, in comparison to using the traditional Mbaula stove. Although energy efficient appliances are currently too expensive for many Zambian households, consumer financing and public support can help to overcome these barriers. While the costs of modern appliances are likely to fall in the coming years, the cost of charcoal is only set to increase, as forests are depleted and national and international organisations remain deeply committed to reducing charcoal consumption and production in the country.

The kitchen laboratory tests have been very useful in the generation of quantitative data on energy consumed, time taken and cost to prepare food/dishes on different fuels/appliances. Nshima, chicken stew, bean stew, porridge (with groundnut powder) and rape were prepared on the hotplate, mbaula, EPC and gas stove, and the tests provide evidence of the significant advantages of modern cooking appliances in Zambia. This data will play an important role in demonstrating the cost-effectiveness of appliances and devices that are also designed to reduce household air pollution and carbon emissions.

The results show that the EPC consumed the least energy when preparing the five dishes. Converting the energy into cost also reveals low amounts at three price points/tariffs on the grid (refer to Appendix 1). The LPG stove scored second for the majority of dishes, while the most expensive device was the mbaula. Recent tariff increases have made less efficient electrical appliances, like the hotplate, no longer cost-competitive, and future investment, regulation, and policy should focus on incentivising the purchase of efficient electrical appliances more suited to both strong and weak grid contexts.

It can be concluded from the experiences gained while conducting the tests that the EPC is not only efficient (in terms of cost and time) but safe, easy-to-use and clean, and is capable of cooking most, if not all, Zambian dishes.

The LPG stove is a fast cooker and can also be used efficiently. Charcoal is an expensive fuel to use, and the cost and time decreases or increases depending on the quality of the fuel.

It is therefore our recommendation that appliances like EPC and gas stove be encouraged because of their efficiency. These appliances are clean to work with and will enable users to save on energy for cooking. Based on the stacking modelling matrix, a combination of EPC and gas stove would be most effective in contexts where load shedding or other issues with the electricity supply are present. That said, innovations relating to battery storage may make 100% electric cooking viable even in these contexts.

Appendix 1

Residential tariffs explained