Cooking diaries: Electric Pressure Cookers and LPG stoves in urban and peri-urban Zambia

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Working paper for comment

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Executive Summary

This report analyses cooking diary data from a study of 29 households in urban and peri-urban areas of Zambia. The Baseline and Transition phases, each around a month in duration, collected detailed information on cooking practices and energy consumption data on both the existing cooking context and a transition to cooking with modern energy. Participants were provided with Electric Pressure Cookers (EPCs) and LPG stoves for the Transition phase and training on how to use them.

The EPCs and LPG stoves were used extensively in the Transition phase, for 58% and 24% of dishes respectively, reducing charcoal usage from 71% of dishes in the Baseline phase to only 12%. Overall, the total charcoal usage across the households reduced from over 900 kg to just over 100 kg. In both phases, fuel stacking within meals was rare, occurring during only 5.5% and 3.7% of meals in the respective phases, showing that participants tended to cook entire meals with only one cooking fuel. The introduction of the EPCs reduced cooking energy consumption significantly, as evidenced by comparing the median per capita energy consumption of charcoal cooking in the Baseline phase of 1.06 MJ to that of EPC cooking in the Transition phase, which was 0.28 MJ. The EPCs also provided electrical energy consumption savings compared to hotplates, which were used for 42% of cooking in the Baseline phase and consumed 0.57 MJ per dish per capita on average.

The menu was similar across the study phases, with participants adapting their cooking practices to the new devices successfully, although there was a slight simplification in cooking as the mean number of dishes per meal fell slightly from 1.94 to 1.64. Commonly cooked dishes in both phases included Nshima, Tea, Rice, Rape leaves and Porridge, with Porridge and Tea usually prepared for breakfast. The EPC and LPG were used for most of the staple dishes in the Transition phase, the EPC especially, showing that most Zambian cuisine is compatible with EPCs. EPCs were particularly favoured over LPG for cooking Beans, and provided significant median dish energy (84%) and time (35%) savings for Beans compared to cooking with charcoal in the Baseline phase. Reheating provided energy and time savings in both phases but was rare at around only 6% of dishes in the Transition phase, reduced slightly from 11% in the Baseline phase.

Contents

1 Background

The Modern Energy Cooking Services (MECS) programme through its partner organization, the Centre for Energy Environment and Engineering Zambia (CEEEZ), undertook a cooking diary study in Lusaka to generate evidence to help reveal barriers and opportunities in adoption and scaling up of clean and energy efficient cooking technologies in Zambia. A number of activities were undertaken which included Control Cooking Tests (CCT), development of an eCookbook, Appliance Availability surveys, Cooking on mini-grid surveys, the Cooking Diary study, Clean Cooking policy review, Stakeholder mapping, and Clean Cooking awareness on TV and radio with a subsequent dissemination workshop. This report seeks to highlight the findings generated from the Cooking Diary study.

2 Methodology

A total of 29 households drawn from Kabangwe, Kanyama, Kasupe, Ng'ombe and John Laing townships took part in the Cooking Diary Study. Kanyama, Ng'ombe and John Laing are typically high-density population areas in Lusaka Urban. Kabangwe and Kasupe are emerging townships situated in Chibombo and Chilanga districts in Central Lusaka provinces, respectively. These two townships can best be described as peri-urban townships.

The Cooking Diary study activities involved two phases namely the Baseline and Transition phases, respectively. In the Baseline phase, which took place over participating households were to cook respective dishes and meals with their usual fuels and own appliances. In the Transition phase households switched to include MECS intervention cooking stoves/appliances in their cooking activities. These were the Electric Pressure Cookers (EPC) and the Liquified Petroleum Gas stoves (LPG). In the face of loadshedding either prior or during meal preparations, households were allowed to cook using Baseline appliances. The fieldwork in this study was conducted between June and October 2021. The length and timing of the phases varied across the households, with each phase lasting around 3-6 weeks, 5 weeks on average, and the Baseline phase taking place mostly across June and July 2021, while the Transition phase occurred across August and September 2021.

The aim of conducting this study under the MECS programme is to assess potential cooking practices using energy efficient appliances, such as EPCs, hotplates and LPG stoves, through cooking diaries to ascertain the cooking time, fuel stacking, appliance usage, and energy consumption in urban and peri-urban households.

The methodologies used in undertaking these activities were adopted from 'Cooking Diaries 3.0 Protocols'. The data were recorded on paper forms by household cooks and transferred to KoboCollect by the enumerators. The data was downloaded from the Kobo server in Excel for analysis in Excel and SPSS. The electrical energy of EPCs was recorded using smartmeters provided by A2EI. EPCs were plugged into the in-line meters, which stored consumption data and automatically uploaded to the A2EI server at regular intervals. A2EI provided the dataset in Excel compatible format.

In the survey design, it was intended that dish level electrical energy consumption data would be extracted from the smartmeter dataset. However, analysis showed that the smartmeter data did not align well with the manually recorded cooking diary data. Discrepancies include, for example:

- In the Cooking diaries dataset, individual dishes are recorded as separate records, but where dishes are cooked sequentially (e.g. as part of a meal), this can be registered as a single event in the smartmeter data.
- Smartmeter records exist for dates in which no cooking diary records exist, which may reflect incomplete recording of cooing events using the manual cooking diaries sheets.

The two datasets were aligned using a 15 minute 'window' based on cooking start times. Events in the smartmeter dataset were matched to dishes in the cooking diaries dataset if the manually recorded dish cooking start time (cooking diaries) was within 15 minutes of the event start time (smartmeter); from 5 minutes before to 10 minutes after the event start time in the smartmeter dataset. This approach meant that energy consumption readings were available for 22% of electric cooking records in the Transition phase cooking diaries dataset.

The original dataset was formatted by dish cooked i.e. each record represented a separate dish cooked. A single meal could comprise multiple dishes. In order to generate meal level data, the dataset was restructured into a wide format, in which each record represented a separate cooking event (typically breakfast, lunch, or dinner).

3 Data Overview

3.1 The dataset

An account of cooking events and meals across the study phases revealed that 57.5% and 42.5% of the total recorded dishes took place in the Baseline and Transition phases respectively, see Table 1.

Table 1 Cooking events distribution

Record type	**Baseline phase**		**Transition phase**		**Total**
	N	**%**	**N**	**%**	
Events (dishes)	4093	57.5	3029	42.5	7122
Meals	2104	53.4	1837	46.6	3941

All but one of the Baseline participants went on to take part in the Transition phase of the study (see Table 2). An additional household was recruited to take part in the Transition phase, but it was not possible to generate corresponding Baseline data. There is a wide range in the number of cooking events recorded by different participants.

The table also shows that although there are differences in the mean number of cooking events recorded per day in the two phases, there is a good deal of consistency. If the mean figures for each phase are averaged across all households, the average number of events per day in the Transition phase was 3.6, slightly higher than 3.3 in the Baseline phase.

Table 2 Number of cooking events by participant

	Baseline		Transition	
HHID	**Number of events**	**Events per day (mean)**	**Number of events**	**Events per day (mean)**
1	44	3.1	49	3.5
2	114	2.2	61	2.5
3	177	4.1	176	4.9
4	136	2.9	129	3.9
5	170	3.4	87	2.5
6	183	3.2	90	2.8
7	199	3.6	73	2.5
8	50	1.5	42	1.2
9	134	2.6	89	3.3
10	125	2.7	97	3.0
11	108	2.3	18	1.6
12			153	3.8
13	71	2.8	153	2.4
14	39	1.8		
15	125	3.5	131	3.9
16	211	4.2	162	4.9
17	283	5.7	245	7.9
18	123	2.9	84	3.2
19	165	3.2	150	3.8
20	213	4.3	88	2.8
21	134	3.0	108	4.3
22	166	3.6	149	4.7
23	104	2.3	48	3.4
24	158	3.2	76	2.7
25	226	4.6	209	6.1
26	248	4.9	118	3.9
27	212	4.2	81	3.2
28	175	3.6	163	4.7

3.2 Heating events

Figure 1 below shows that there was little change in the proportion of meal types across the phases.

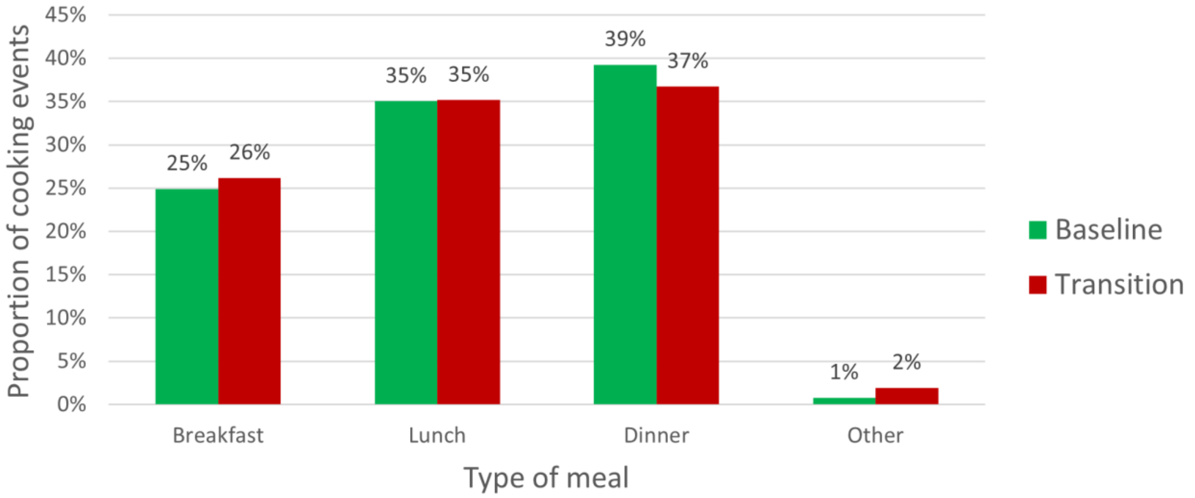

Figure 1 Share of meals during Baseline and Transition phases

The data revealed that almost all of the cooking events were either boiling or frying processes, with boiling dishes accounting for around 90% of events in each phase.

3.3 Number of people cooked for

During both the Baseline and Transition phases, cooking for 5 people was the most common pattern (Figure 2). Overall, the mean number of people cooked for in each phase was similar at 5.7 and 5.6 in the Baseline and Transition phases respectively.

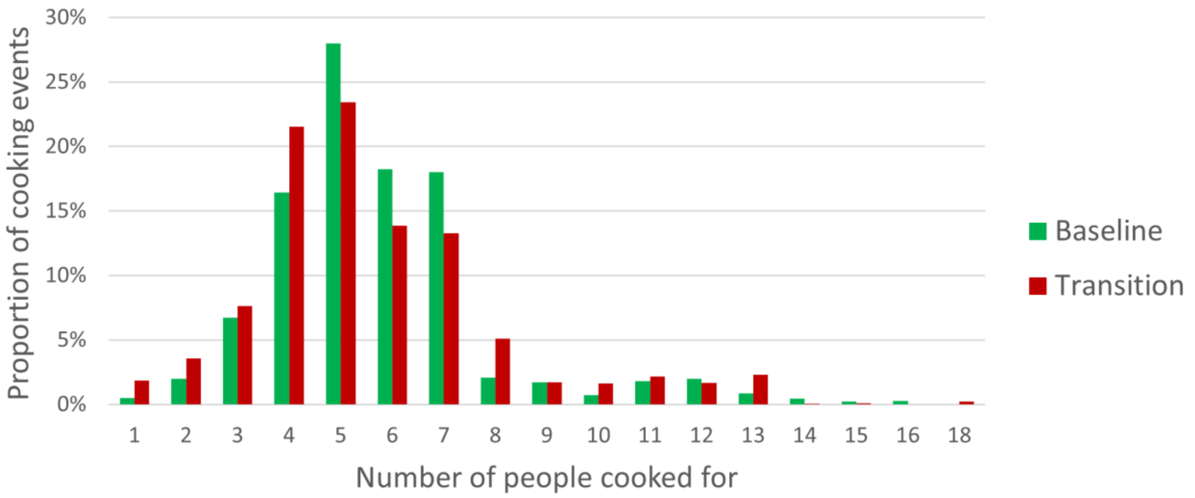

Figure 2 Number of people for reported by Baseline and Transition phases

Table 3 below shows that there are only modest variations in the number of people cooked for in each type of meal, with dinner generally had by the highest number of household members.

Table 3 Number of people cooked for by type of meal (means)

Type of meal	Baseline	Transition
Breakfast	5.52	5.02
Lunch	5.60	5.59
Dinner	6.01	6.22
Total	5.74	5.63

4 Data Overview Cooking Devices and Fuels used

4.1 Changes in usage

As indicated in Figure 3, seven types of cooking devices were recorded. EPCs and LPG stoves were deployed as MECS intervention appliances. A switch to intervention stoves triggered a sharp decline in the use of the mbaula (charcoal) stove for meal preparation from 58% in the Baseline phase to 8% in the Transition phase. The four hotplate cookers were significantly used in the Baseline phase (22%), however households with both four hotplate and two hotplate cookers reduced their usage rates to 5% and 1% respectively in the Transition phase. There was significant usage of EPCs, as clean and energy efficient appliances, across the households. A similar pattern was equally observed across LPG stove users where substantial usage was recorded at 24%.

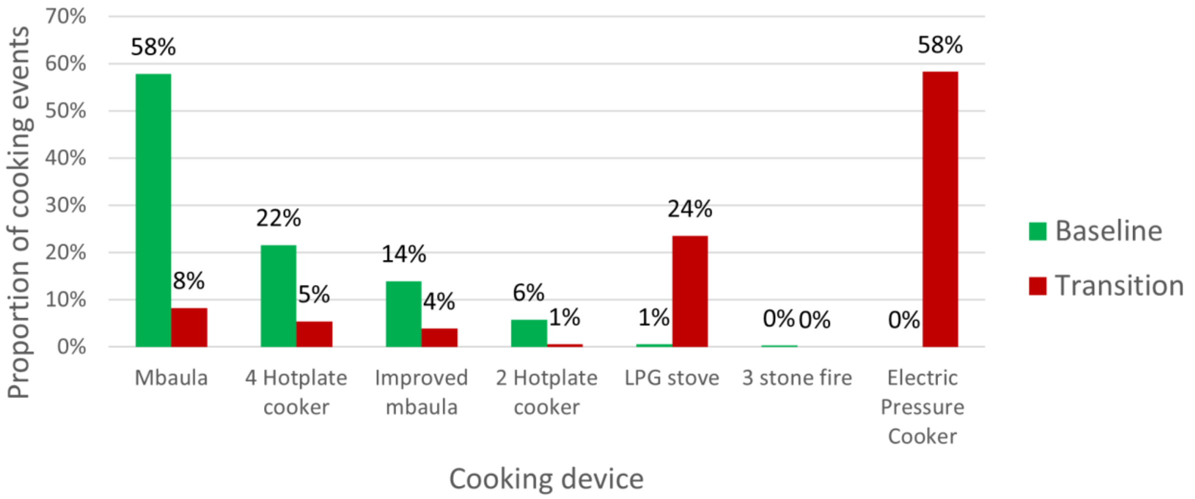

Figure 3 Cooking devices used during Baseline and Transition Phases

The cooking fuel mix reflects the cooking devices used. During the Baseline phase, charcoal was the fuel most often used for dish preparation across breakfast, lunch and dinner, followed by electricity. However, the pattern changed during transition. Electricity became the main fuel followed by LPG with charcoal being the least used fuel, apart from firewood, as presented in Figure 4, which depicts the proportion of dishes cooked with each fuel in each of the study phases.

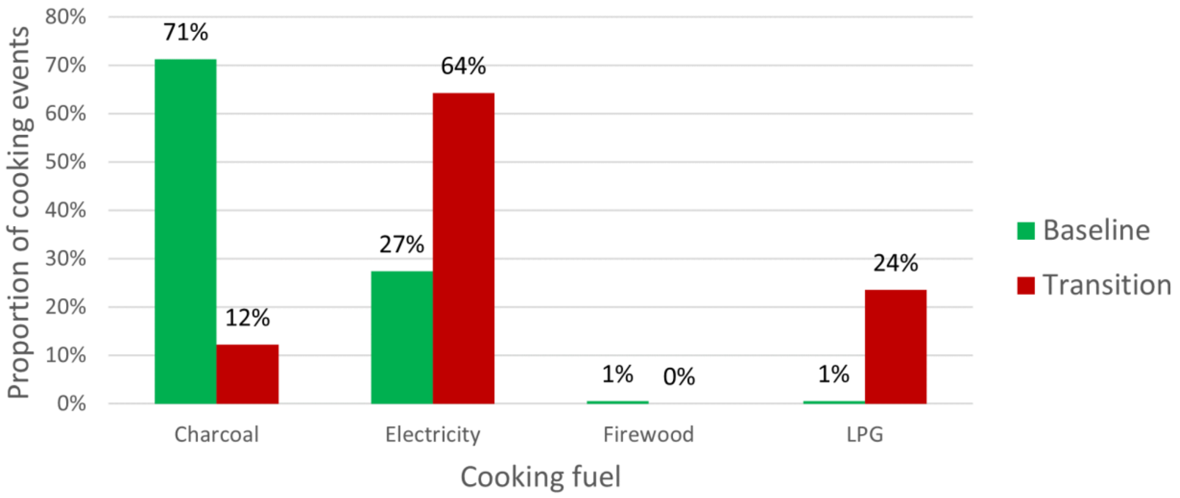

Figure 4 Cooking fuels used during Baseline and Transition phases

4.2 Devices and fuels by event purpose

The proportions of each meal type that were cooked using the different appliances are presented in Table 4. These figures show that the extent of this substitution was consistent across the three different types of main meals. Use of the mbaula to cook breakfasts dropped from 56% to 6%; for lunches the reduction was from 65% to 10%, and for dinners 64% to 11%.

Table 4 Proportion of cooking events prepared on appliances – by meal type: comparison of Baseline and Transition

Appliance	**Breakfast**		**Lunch**		**Dinner**		**Other**	
	BL	T	BL	T	BL	T	BL	T
3 stone firewood-stove	0%	0%	0.5%	0%	0.3%	0%	6%	0%
Charcoal mbaula stove	56%	6%	65%	10%	64%	11%	20%	0%
Improved charcoal mbaula	16%	4%	19%	6%	17%	3%	10%	11%
LPG stove	0.5%	24%	0.2%	25%	0.8%	26%	8%	13%
1 Hotplate cooker	0.4%	0.0%	0.1%	0.1%	0.2%	0.3%	0%	0%
2 Hotplate cooker	6%	2%	4%	1%	3%	0.3%	29%	0%
4 Hotplate cooker	21%	8%	11%	5%	14%	5%	27%	0%
Electric Pressure Cooker	-	56%	-	53%	-	54%	-	76%
Total	100%	100%	100%	100%	100%	100%	100%	100%

BL- Baseline; T - Transition

If these figures are expressed in terms of the proportion of each meal type that is cooked using different fuels, as in Table 5, the ratio of these two dominant fuels was slightly different for breakfasts in the Baseline phase; the proportion of breakfasts cooked using electricity was higher (32%), and the proportion using charcoal was lower (67%) – this compares with 24% and 75% of lunches cooked with electricity and charcoal respectively. In the Transition phase, these variations were more modest, although there was still a trend for a higher proportion of breakfasts to be cooked using electricity.

Table 5 Proportion of cooking events prepared with each cooking fuel - by meal type: Compare Baseline and Transition

Fuel	Breakfast		Lunch		Dinner		Other	
	BL	T	BL	T	BL	T	BL	T
Charcoal	67%	10%	75%	14%	72%	12%	25%	10%
Electricity	32%	67%	24%	63%	27%	63%	53%	76%
Pellets	0.6%		0.1%		0.2%		0%	
Firewood	0.4%		0.4%		0.5%		13%	
LPG	0.4%	23%	0.3%	23%	0.7%	25%	9%	14%
Total	100%	100%	100%	100%	100%	100%	100%	100%

4.3 Multiple devices per dish

When cooking individual dishes, participants occasionally resorted to using more than one device; this was the case in around 5% of records in each phase, as shown in Figure 5.

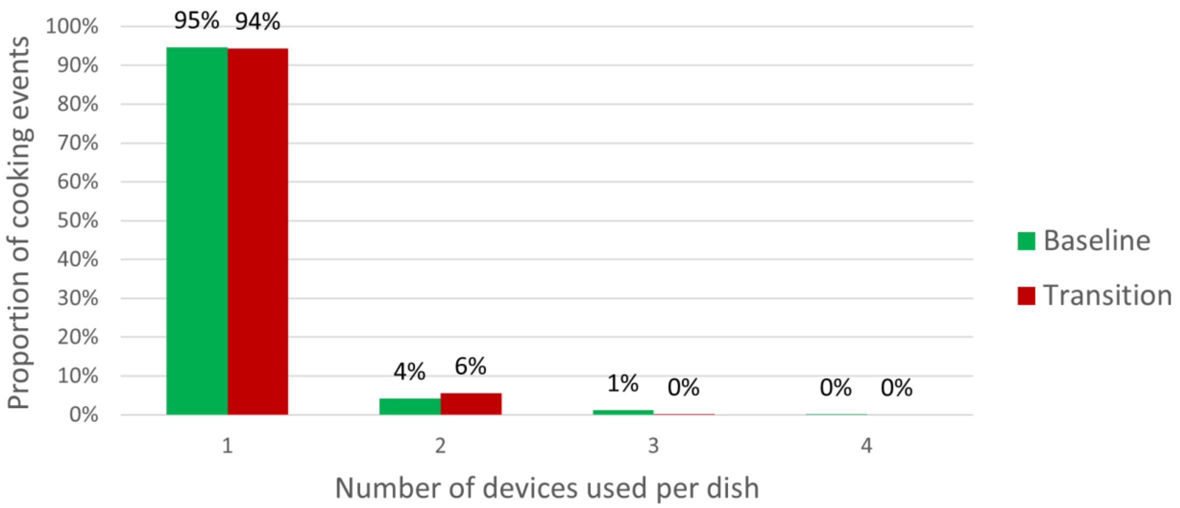

Figure 5 Breakdown of the number of devices used to cook dishes in each phase

In the Transition phase participants were asked why they used appliances other than the EPC and LPG stove, both during dish cooking and in a general sense. Load shedding, preventing the usage of the EPC, and running out of LPG, were two common reasons for reverting to other stoves. Many other reasons were provided, including, for reverting from the EPC to another device:

- moving to an unelectrified household.
- wanting to cook faster.
- running out of units of electricity.
- needing to roast food in the oven.
- and a lack of confidence in the EPC with certain foods, such as Okra.

4.4 Fuels used within meals

The mix of fuels used to prepare a single meal have been calculated by aggregating together the fuels used in all of the cooking event records that pertain to a given meal. Table 6 shows that fuel stacking, within a given meal, was rare and that this was true of both phases.

Table 6 Number of fuels used in preparing a single meal

Number of fuels per meal	Baseline		Transition	
	N	percent	N	percent
1	1985	94.5%	1734	96.3%
2	115	5.5%	67	3.7%
Total	2100	100.0%	1801	100.0%

For those few meals where two fuels were used, the dominant combination was charcoal and electricity, and this was true for both phases (see Table 7).

Table 7 Fuel choices (for a given meal)

Fuel choice	Baseline		Transition	
	N	percent	N	percent
LPG, electricity			5	0.3%
Charcoal, electricity	95	4.5%	46	2.6%
Wood, electricity	7	0.3%		
Charcoal, LPG	9	0.4%	16	0.9%
Wood, charcoal	4	0.2%		
Electricity	533	25.4%	1077	59.8%
LPG	5	0.2%	471	26.2%
Charcoal	1435	68.3%	186	10.3%
Wood	12	0.6%		
Total	2100	100%	1801	100%

5 Energy consumption and cooking durations

5.1 Energy content of fuels

Consumption of firewood, charcoal and LPG fuels was measured by weighing the amount of fuel before and after cooking. The energy content of the fuel used has been calculated by multiplying the weight of fuel used by the calorific value of the fuel (given in Table 8).

Electricity consumptions were recorded automatically by smart meters provided by A2EI. Dishes cooked using electricity that were recorded in the Cooking Diaries were aligned with cooking events recorded on the smart meters; a detailed explanation is given in Section 2. The two datasets did not align well, and only 22% of electric cooking events had a corresponding meter reading. The valid readings were used to understand EPC electrical energy usage as far as possible.

Table 8 Calorific values and conversion efficiencies

Fuel	Calorific value
Wood	16.0 MJ/kg
Charcoal	31.8 MJ/kg
LPG	49.0 MJ/kg
Electricity	3.6 MJ/kWh

5.2 Summary of fuel and energy consumption and cooking durations

Firstly, the total cooking fuel quantities used in each phase were investigated to understand how the introduction of EPCs and LPG stoves affected fuel consumption. Table 9, which also provides the number of valid records for each value, shows that charcoal consumption reduced drastically across the study from over 900 kg to just over 100 kg, due to its displacement by electric and LPG cooking. The electrical energy consumption, given here in kWh, increased by only around 25% for double the number of records. This was due to relatively inefficient hotplate usage in the Baseline phase, which was mostly displaced by highly efficient EPC usage, consuming significantly less energy per dish.

Table 9 Total fuel consumption in each phase

Fuel	Baseline count (N)	Baseline total fuel consumption	Transition count (N)	Transition total fuel consumption
Firewood	28	45 kg	0	0 kg
Charcoal	2899	930 kg	364	120 kg
LPG	22	2.5 kg	702	63 kg
Electricity	215	200 kWh	441	250 kWh

Table 10 presents the key energy consumption statistics from each phase. Energy values are presented for the fuels that were regularly used. EPC dish energy is presented for the Transition phase as the majority of electric cooking was done using EPCs in that phase. Dish energies consider only dishes which were cooked with a single device, while meal energies summarise records for which a single fuel was used to cook the entire meal. Daily energies also considered only days during which all cooking was conducted using a single fuel. Generally, median values are lower than means due to reheated dishes consuming much less energy, as explored in Section 7.

Average charcoal energy consumptions were similar in each phase, as would be expected. LPG cooking consumes less energy than charcoal but still a lot more than electricity. Per capita electrical energy consumption reduced with the introduction of the EPCs. EPC meal energy consumption is very similar to dish energy consumption, as the low data coverage of EPC electrical energy meant that there were very few multiple dish meals cooked entirely on EPCs with full valid energy data, meaning that single dish EPC meals dominate. Daily energy consumptions reflect the described trends and provide useful datasets, although the low data coverage of EPC energy readings meant that very few days of entirely electric cooking were available, and those identified were often single dish days, reducing the usefulness of the Daily electrical energy consumption data obtained.

Dish and meal cooking time durations reduced from Baseline to Transition phases (see Table 11), reflecting the faster cooking enabled by the EPC and LPG stove, compared to charcoal stoves and hotplates. Note that meal time figures have been calculated as the sum of the time taken to cook each of the dishes that made up the meal. Therefore, this does not necessarily represent the total time that the cook spends in the kitchen preparing the meal.

Table 10 Key energy statistics (single fuels only) – comparing Baseline and Transition

	Baseline				Transition			
Energy (MJ)	**Records (N)**	**Mean**	**Median**	**Std**	**Records (N)**	**Mean**	**Median**	**Std**
Charcoal Dish energy per capita	2863	1.93	1.06	2.65	364	2.29	1.03	3.26
Charcoal Meal energy per capita	1434	3.48	2.02	4.44	186	3.84	1.48	6.18
Charcoal Daily energy per capita	498	8.39	5.52	10.23	57	8.88	4.19	13.04
Elec Dish energy per capita	168	0.57	0.47	0.42				
EPC Dish energy per capita					405	0.38	0.28	0.37
Elec Meal energy per capita	142	0.85	0.65	0.76	160	0.37	0.28	0.31
Elec Daily energy per capita	10	5.67	3.47	6.01	14	2.58	2.02	1.72
LPG Dish energy per capita					631	0.87	0.54	1.41
LPG Meal energy per capita					470	1.15	0.74	1.67
LPG Daily energy per capita					180	2.51	1.99	2.65

Table 11 Cooking times (all records) – comparing Baseline and Transition phases

	Baseline				Transition			
	Records (N)	**Mean**	**Median**	**Std**	**Records (N)**	**Mean**	**Median**	**Std**
People	3854	5.80	5	2.23	2813	5.57	5	2.39
Dish time (hh:mm)	3821	0:41	0:35	0:38	2780	0:34	0:29	0:28
Meal time (hh:mm)	1975	1:15	1:00	0:55	1722	0:54	0:41	0:44

Figure 6 and Figure 7 present dish and meal energy data graphically, showing charcoal and electricity consumption in the Baseline phase, and charcoal, EPC and LPG consumption in the Transition phase, providing valuable data sources on dish and meal energy requirements and reflecting the trends seen in Table 10.

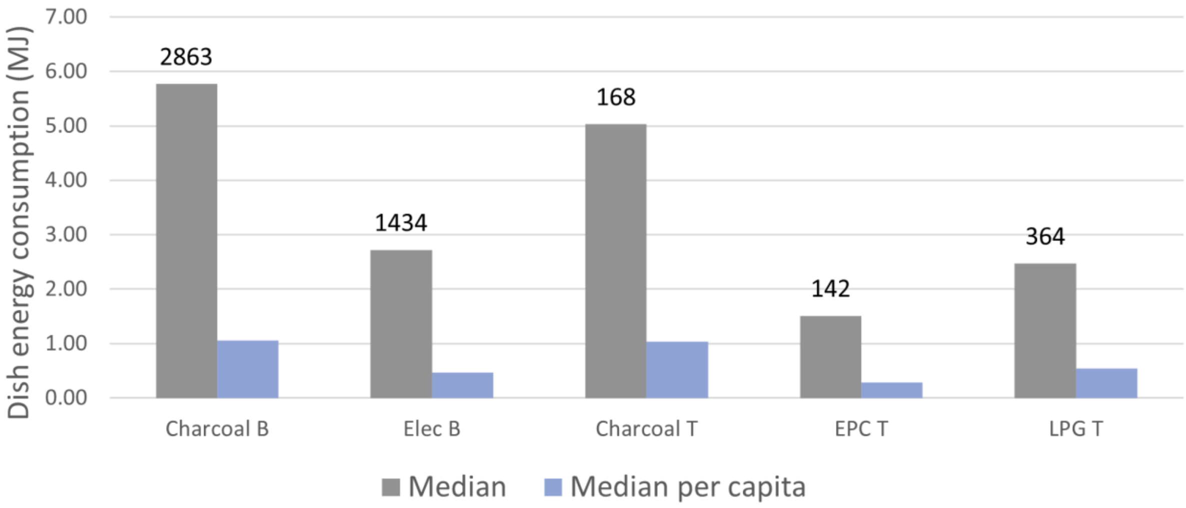

Figure 6 Median dish energy consumption for commonly used fuels/devices in each phase with frequencies shown above

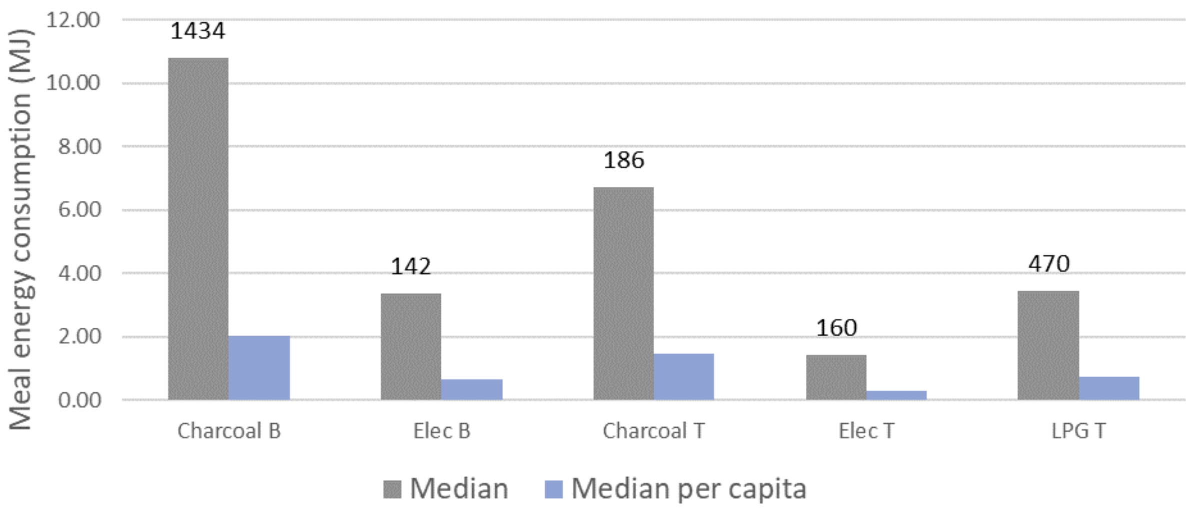

Figure 7 Median meal energy consumption for commonly used fuels in each phase with frequencies shown above

6 Dishes cooked

6.1 Popular dishes

Over 30 different dishes were cooked during the cooking diary study. As indicated in Figure 8, which presents the ten most commonly cooked dishes in the Transition phase, Nshima was the most commonly cooked dish, prepared over 1,000 times in each phase. The chart confirms that the participants were able to cook their preferred menus when cooking with EPCs and LPG stoves in the Transition phase. Water was mostly heated for tea, although it was also heated for bathing 20 and 65 times in each phase respectively. Annex 1 presents a full breakdown of dishes cooked during the study.

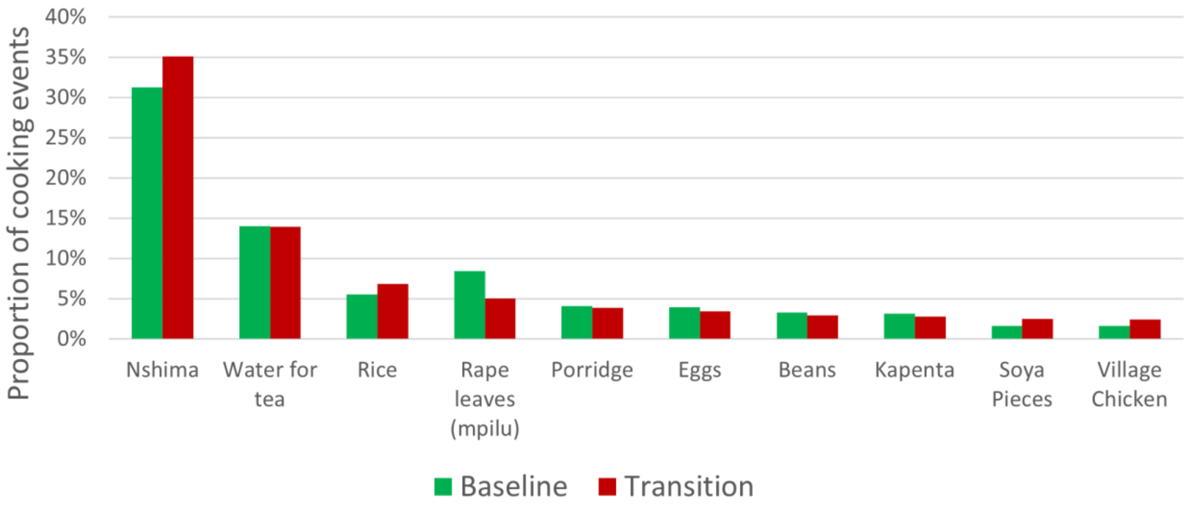

Figure 8 Breakdown of dishes cooked in each phase

The results further revealed that Nshima was mostly cooked as part of lunch and dinner meals while heating water for tea and cooking porridge dominated the breakfast meals. Comparing Figure 9 and Figure 10 confirms that this trend was consistent across both phases.

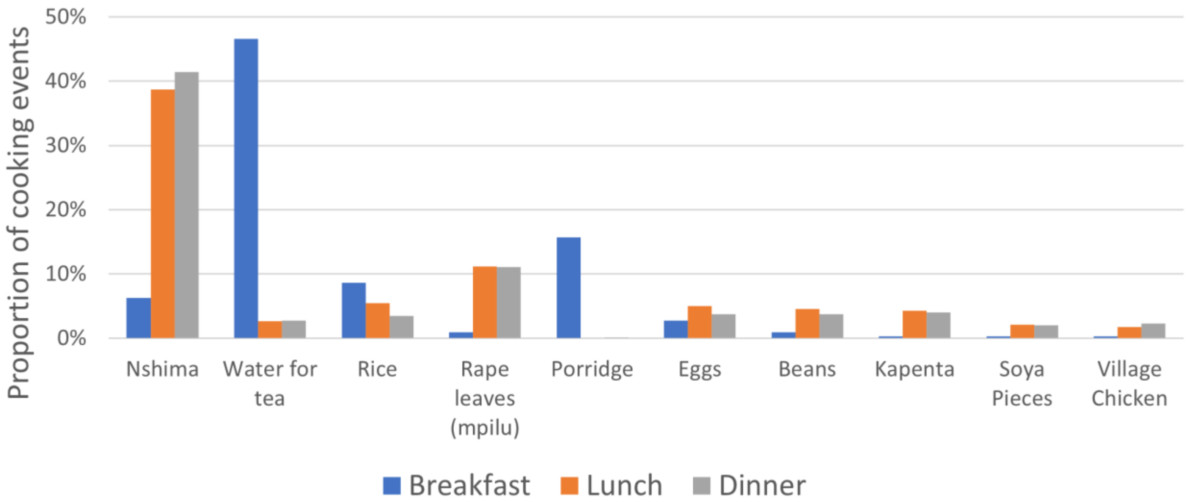

Figure 9 Breakdown of dishes by meal type in the Baseline phase

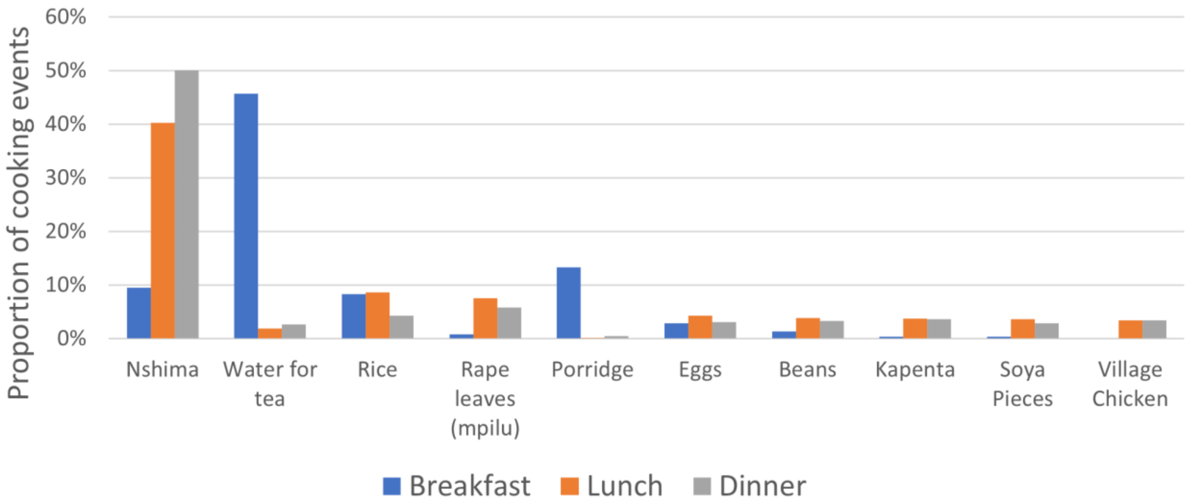

Figure 10 Breakdown of dishes by meal type in the Transition phase

As presented in Figure 11, the number of dishes per meal generally decreased across the phases, with the overall mean reducing from 1.94 to 1.64 dishes per meal. This simplification in menu reflects two issues: firstly, it is difficult to cook multiple dishes in an EPC and, secondly, it will take time for participants to adapt recipes and cooking practices to fit the new cooking devices.

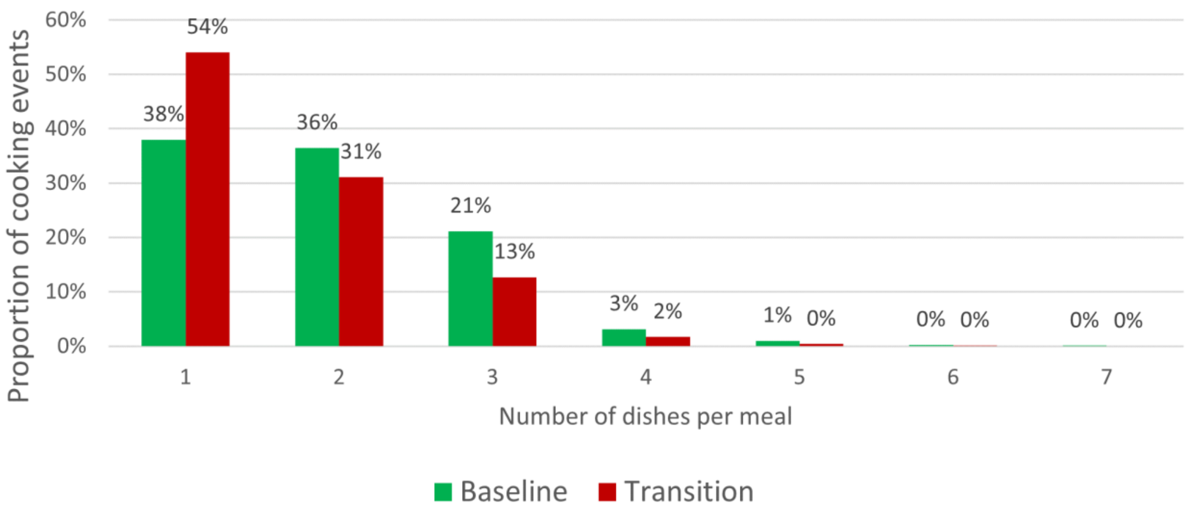

Figure 11 Breakdown of number of dishes per meal by type in each phase

6.2 Fuels used to cook common dishes

As indicated in Figure 12, charcoal was the dominant fuel of choice for cooking all dishes during the Baseline phase. Electricity was second choice. It was used less for long cooking dishes such as Beans, and was more commonly used for cooking village chicken and heating water. LPG usage was almost zero. Figure 13 reveals extensive use of electricity and a significant use of LPG in the Transition phase, across all of the commonly cooked dishes. LPG was used less often for Beans while the EPC was used for every common dish to a similar degree.

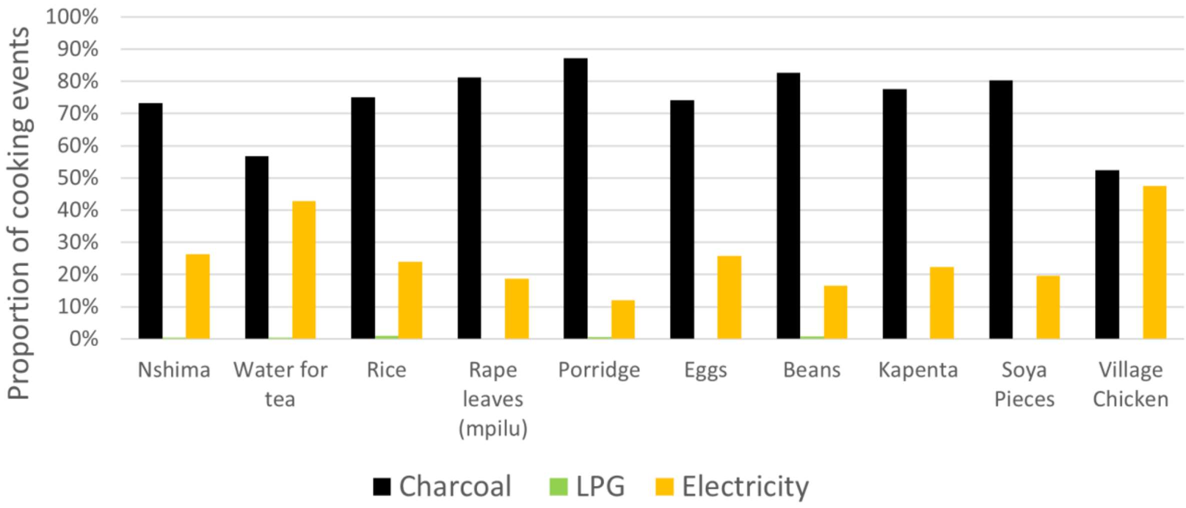

Figure 12 Breakdown of common dishes by cooking fuel in the Baseline phase

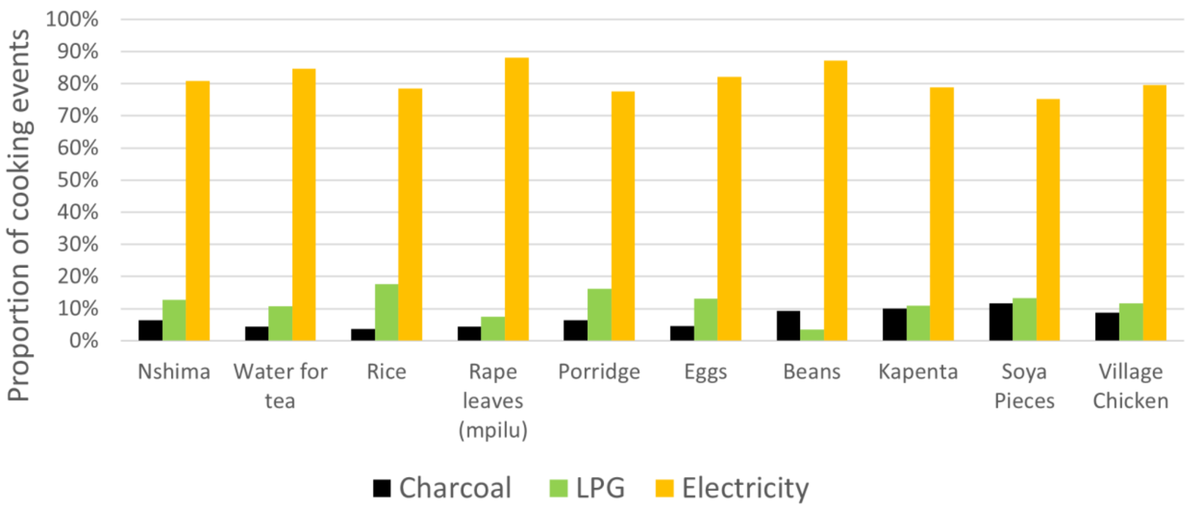

Figure 13 Breakdown of common dishes by cooking fuel in the Transition phase

6.3 Dish energy consumption

This section explores differences in specific energy consumption (using median per capita dish energy consumption) when cooking dishes using different fuels. Figure 14 compares charcoal usage in the Baseline phase with EPC energy consumption in the Transition phase across the 10 most commonly cooked dishes; the associated numbers of valid records are presented as data labels. Figure 15 compares EPC and LPG energy consumption when cooking each of the same dishes, both in the Transition phase.

The study generated valuable datasets on dish energy consumption for different fuels. The graphs show that EPC cooking provides energy savings on all dishes compared to charcoal, and uses less energy than LPG when cooking most dishes. When compared with charcoal (Figure 14), energy savings are highest for staple dishes such as Nshima, Rice, Porridge, Beans and Village Chicken. The savings for long cooking dishes such as Beans with the EPC are particularly striking, e.g. the saving compared to charcoal is highest at 84%. Although only three data points were available for cooking Beans with LPG, Figure 15 also illustrates how savings from using EPCs are greatest when cooking long cooking dishes.

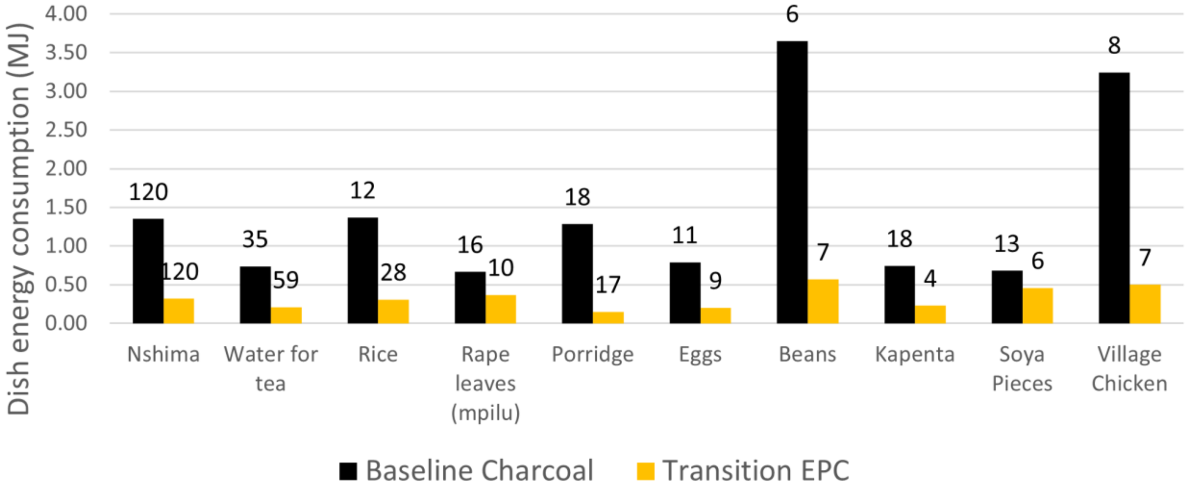

Figure 14 Median per capita energy consumption of common dishes cooked with charcoal in the Baseline phase and EPCs in the Transition phase (fresh only)

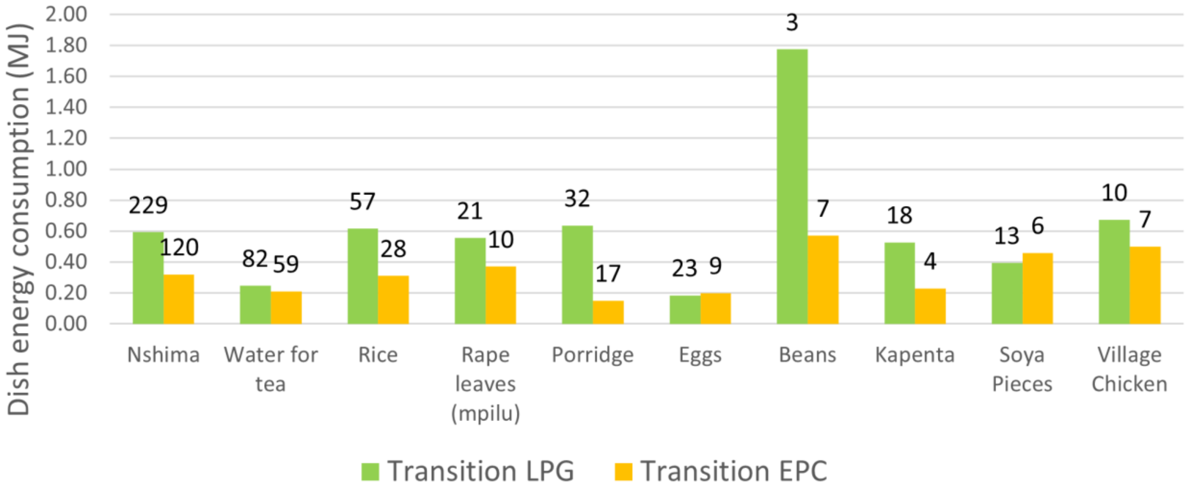

Figure 15 Median per capita energy consumption of common dishes cooked with LPG and EPCs in the Transition phase (fresh only)

6.4 Dish cooking durations

Figure 16 and Figure 17 present median cooking durations for the most common dishes for the same phases and fuels as specified in Section 6.3. The graphs show that EPCs provided time savings for most of the main dishes cooked, compared to both charcoal and LPG. In particular, Beans were much quicker to cook with the EPC than charcoal, with a time saving of 35%, and other useful time savings evident for Rice, Porridge and Village Chicken. EPC and LPG cooking led to similar cooking durations for the common dishes, with only marginal time savings when using EPCs.

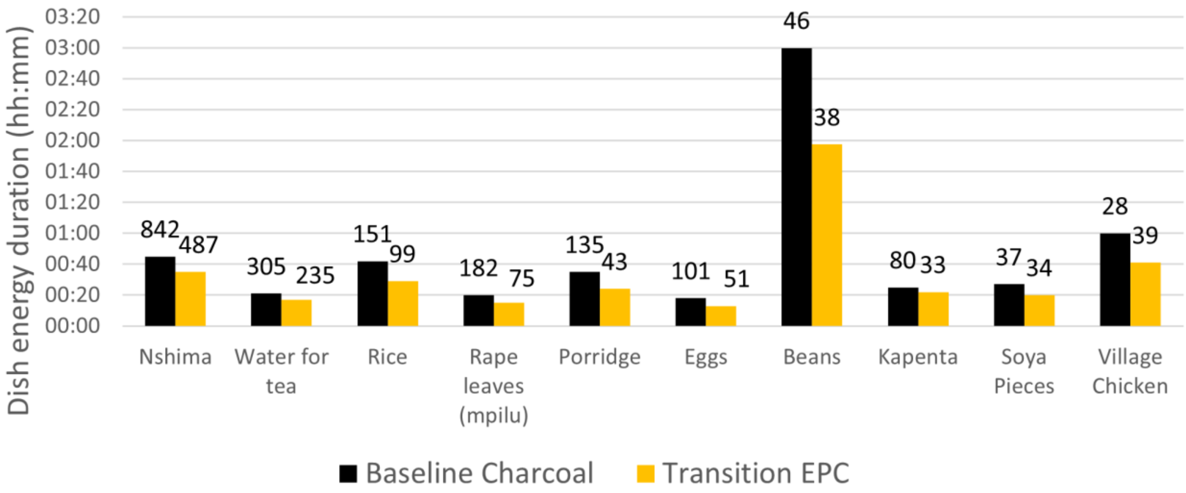

Figure 16 Median cooking durations of common dishes with charcoal in the Baseline phase and EPCs in the Transition phase (fresh only)

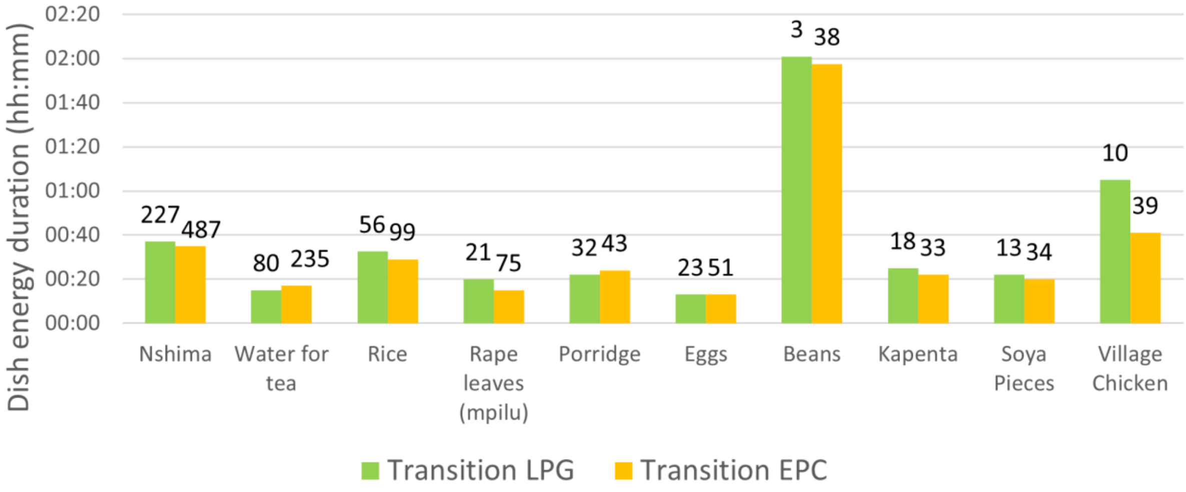

Figure 17 Median cooking durations of common dishes with LPG and EPCs in the Transition phase (fresh only)

7 Fresh cooking versus reheating

Table 12 presents key outputs for dishes cooked both fresh and reheated. The data shows that most dishes were cooked fresh in both phases, but for reheated dishes the median dish cooking duration and median energy consumptions reduced drastically for all fuels used.

Table 12 Key data outputs for fresh versus reheated dishes

Prep	Baseline frequency	%	Transition frequency	%	Dish duration (hh:mm)	Charcoal energy per cap (MJ)	LPG energy per cap (MJ)	Elec energy per cap (MJ)
Fresh	3644	89	2803	94	33:00 (6366)	1.18 (2844)	0.56 (678)	0.35 (614)
Reheated	441	11	186	6	10:00 (619)	0.36 (379)	0.06 (46)	0.15 (41)

Figure 16 and Figure 17 present the proportions of fresh cooking and reheating for the most common dishes. Rape leaves and Beans were most commonly reheated in both phases.

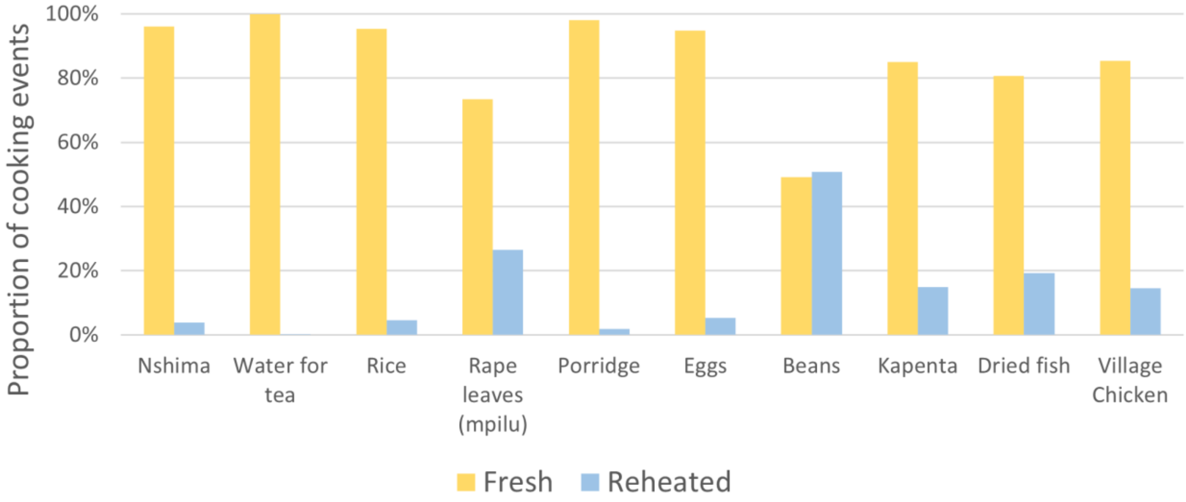

Figure 16 Proportions of fresh versus reheated cooking for the most common dishes in the Baseline phase

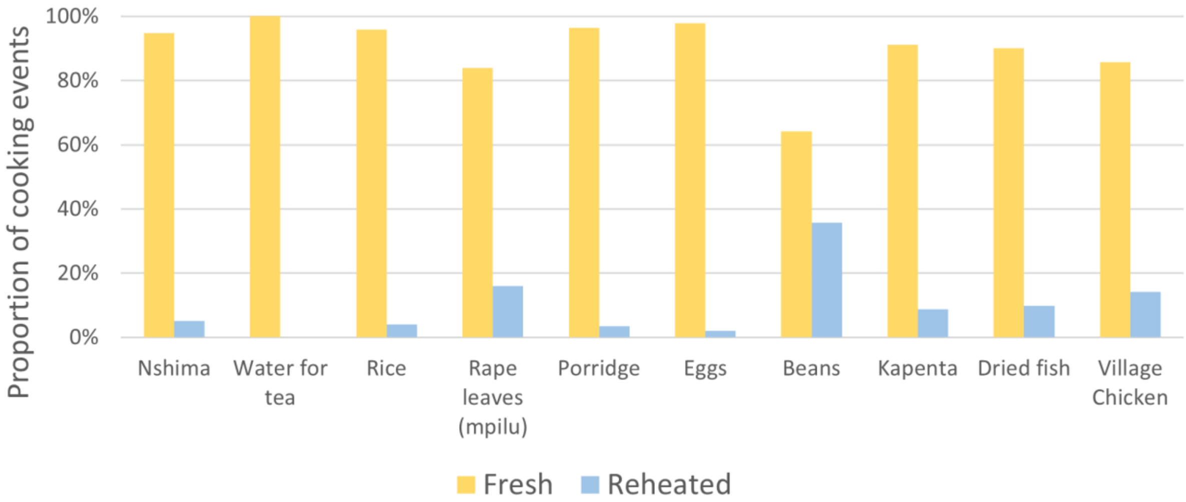

Figure 17 Proportions of fresh versus reheated cooking for the most common dishes in the Transition phase

Reheating was more common when cooking with charcoal than electricity in the Baseline phase (Figure 18), but equally common when cooking with each of the three prevalent cooking fuels in the Transition phase (Figure 19), showing that reheating is possible with each of the commonly used cooking fuels.

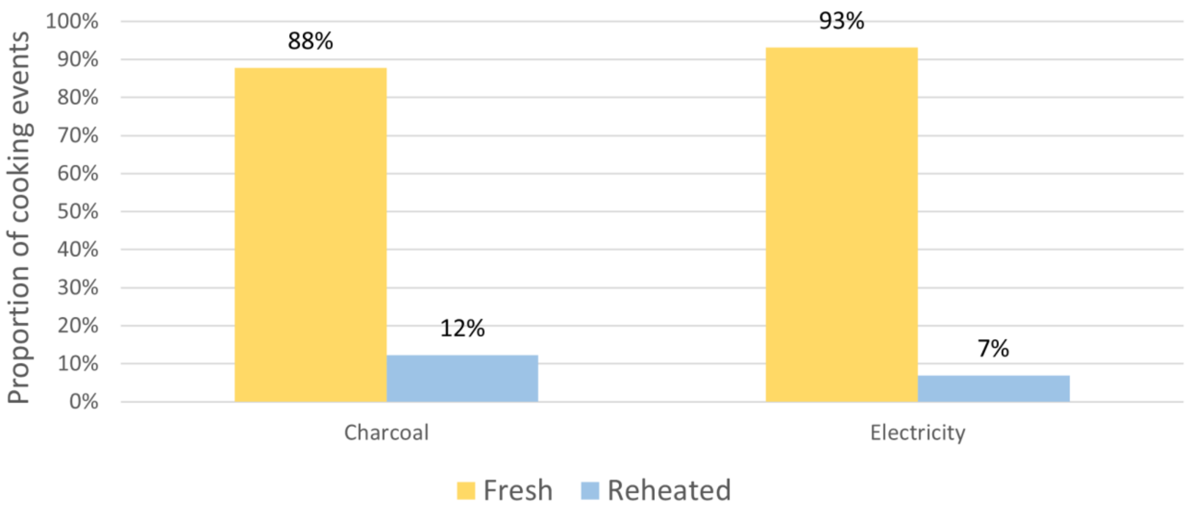

Figure 18 Fresh versus reheated cooking by fuel in the Baseline phase

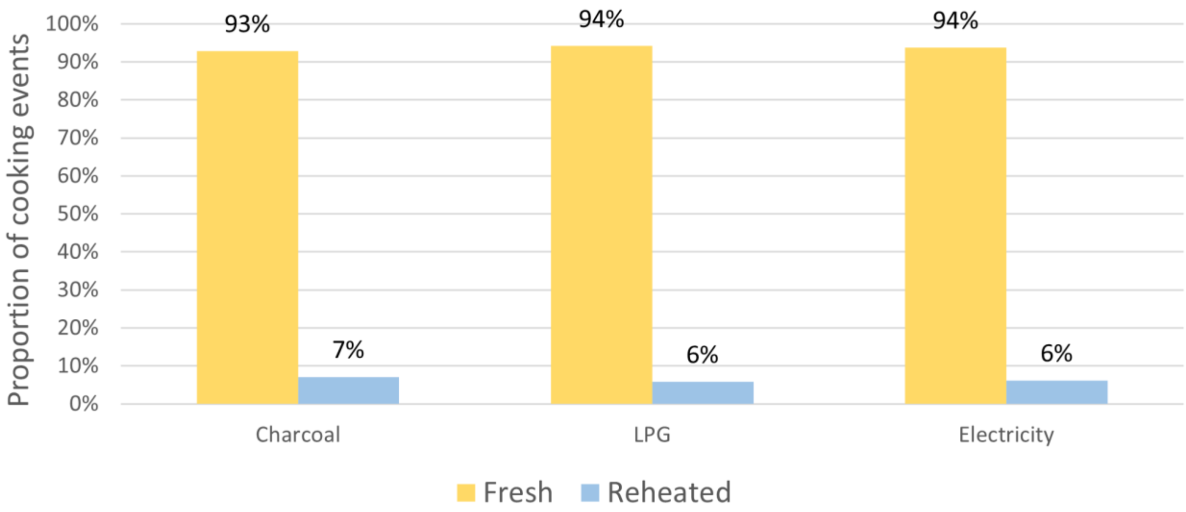

Figure 19 Fresh versus reheated cooking by fuel in the Transition phase

Regarding specific dishes, Nshima was the only dish reheated enough times in the EPC to merit examination, with a ratio of 137 to 23 of fresh preparation to reheating. The resulting median EPC energy per capita reduced from 0.32 MJ to 0.12 MJ, by 63%, illustrating the savings that are possible through reheating.

Charcoal was more commonly used for reheating across the phases. Figure 20 presents ten dishes reheated over ten times using charcoal, showing that the median per capita dish energy consumption reduced significantly for most dishes, with the overall median charcoal dish energy per capita reducing by 69% (see Table 12).

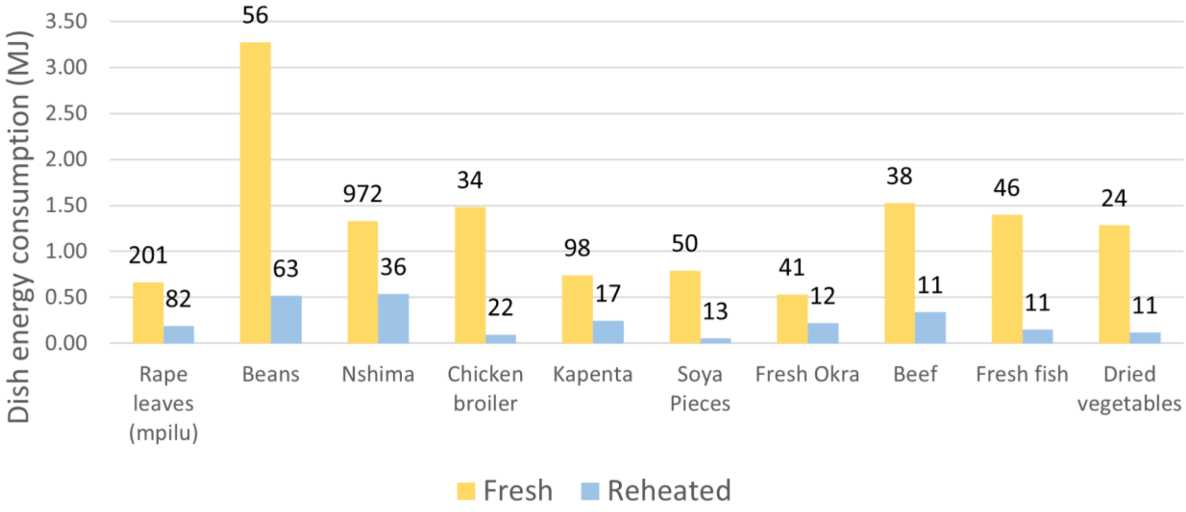

Figure 20 Fresh versus reheated median per capita dish energy consumption for both phases, cooking with charcoal (frequencies of valid records presented above bars)

8 Conclusions

The study showed that EPCs and LPG stoves were well accepted by Zambian cooks and compatible with Zambian cuisine. EPCs were used to cook a high proportion of dishes (58% of all dishes recorded in the Transition phase). EPCs were also successfully used to cook all of the most commonly prepared dishes in these Zambian households. The study provided insights into typical Zambian menus. For example, Nshima was the most commonly cooked dish, mostly as part of lunch and dinner meals, while heating water for tea and cooking porridge dominated breakfast meals. The menu changed minimally across the study phases, illustrating how modern energy cooking fuels are well suited to Zambian cuisine. There was a slight simplification in meal composition in the Transition phase, as the mean number of dishes per meal reduced slightly from 1.9 to 1.6 dishes per meal. This reflects two issues: firstly, it is difficult to cook multiple dishes in an EPC and, secondly, it will take time for participants to fully adapt recipes and cooking practices to fit the new cooking devices. Fuel stacking was rare in both phases at 5.5% and 3.7% respectively, with meals generally cooked using one fuel. It was also found that 90% of dishes cooked required boiling (as opposed to other cooking processes, such as frying or baking), meaning that the Zambian cuisine is well suited to EPCs. Reheating was another characteristic of Zambian cooking practice, given that 11% of dishes prepared in the Baseline phase were reheated. Although EPCs are capable of reheating food, they would not necessarily be any more efficient than other devices.

The energy efficiency of EPCs was evident in reduced cooking energy consumption. The per capita energy consumption when using EPCs was 0.28 MJ (median), compared with 1.06 MJ when using charcoal. The impact of modern, energy efficient electric cooking devices such as the EPC was illustrated by the finding that EPCs used 50% of the energy used by traditional hotplates.

In the Transition phase, EPCs and LPG stoves were used to cook 58% and 24% of dishes respectively. LPG stoves were most commonly used to cook rice and porridge, but the use of EPCs was consistent across all dishes cooked. Having said that, the impact of EPCs was greatest for cooking long cooking dishes such as Beans, for which the EPC can enable significant energy and time savings, calculated as 84% and 25% respectively compared with cooking with charcoal.

The study showed substantial reductions in biomass energy consumption. Introduction of the new devices reduced charcoal usage from 71% of dishes to only 12%, and firewood usage was eliminated. Even though firewood use was low in the Baseline phase, this still suggests that firewood was the fuel that participants were most keen to transition away from. EPCs use much less energy than charcoal (across all dishes), but only a little less energy than the LPG stoves. Total charcoal consumption reduced from 900 kg in the Baseline phase to 100 kg in the Transition phase.

Annex 1 Full breakdown of dishes cooked

Table 13 Full breakdown of dishes cooked in each phase

Dish	Baseline Frequency	Baseline %	Transition Frequency	Transition %
Nshima	1216	31%	1012	35%
Water for tea	545	14%	402	14%
Rape leaves (mpilu)	328	8%	144	5%
Rice	214	6%	197	7%
Porridge	158	4%	112	4%
Sweet Potato (Kandolo)	155	4%	33	1%
Eggs	153	4%	98	3%
Beans	128	3%	84	3%
Kapenta	121	3%	80	3%
Cabbage	75	2%	38	1%
Beef	70	2%	58	2%
Fresh fish	70	2%	30	1%
Chicken broiler	64	2%	2	0%
Sampo	63	2%	56	2%
Village Chicken	62	2%	70	2%
Soya Pieces	62	2%	71	2%
Fresh Okra	57	1%	24	1%
Dried fish	46	1%	18	1%
Dried Vegetables	44	1%	43	1%
Dried vegetables with groundnuts	39	1%	17	1%
Sausage	38	1%	25	1%
Potato (Irish)	35	1%	53	2%
Spaghetti	23	1%	23	1%
Soup	22	1%	21	1%
Water for bathing	20	1%	65	2%
Pork	18	0%	13	0%
Mince	18	0%	11	0%
Egg plant	16	0%	8	0%
Kalembula	12	0%	10	0%
Noodles	11	0%	14	0%
Water	4	0%	53	2%
Total	**3887**	**100%**	**2885**	**100%**