eCook Kenya Cooking Diaries

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Executive Summary

This report presents the key learning points from the cooking diaries study to inform the future development of eCook (battery-supported electric cooking) within Kenya. The aim of this study is to gain a deeper understanding of how Kenyan households cook and how compatible this is with electricity. This mixed methods approach gathers data from various sources: cooking diary forms, energy measurements, a registration survey an exit survey.

Despite decades of work on improving the efficiencies of biomass stoves, there seems to be little available data on 'how' people cook. Modern fuels such as gas & electricity are more controllable & can be turned on/off in an instant. There are also a huge range of electric cooking appliances, each designed for specific processes (e.g. microwave for reheating). Therefore, it is important to know how often people are frying, boiling, reheating or doing something else entirely.

19 households (HHs) were asked to keep detailed cooking diaries, recording exactly what they cooked, when and how for six weeks. For the first two weeks they were asked to cook as they would normally, using their usual fuels and stoves. For the remaining four weeks, they were asked to transition to cooking with electricity, using a hotplates, rice cookers and Electric Pressure Cookers (EPCs), plus any electrical appliances they already owned. Fuel quantities were measured by weighing charcoal, kerosene or LPG cylinders before and after each "*cooking event*"; plug-in electricity meters were used for the electric cooking appliances.

The study samples were drawn from urban households in Nairobi and therefore represent an evolved mix of traditional and modern cuisine. A database of foods cooked; cooking time and duration; and energy used was assembled. The probability distributions for the energy required to cook each meal type were produced, and disaggregated as far as possible to explore the influence of a variety of parameters, including fuel, appliance and meal type.

The key findings are that cooking with electricity is compatible with Kenyan cuisine and that modern energy-efficient appliances are highly desirable to everyday Kenyan cooks. In particular, the Electric Pressure Cooker (EPC) as a prime candidate for future eCook products, as it can significantly reduce the energy demand for the biggest energy consumers: "long boiling" dishes. In fact, in many areas of Nairobi, the grid is already strong enough for direct AC cooking without a battery, meaning there is a considerable opportunity already on the table to promote off-the-shelf appliances, in particular, EPCs. LPG is already popular in Nairobi and while electric hotplates do not offer anything new for LPG users,

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the ability to cook faster and multi-task, whilst also saving money make a fuel stacking scenario with EPCs extremely attractive.

User preferences

Perhaps surprisingly to some, food cooked on electricity was rated as the tastiest, just ahead of LPG & charcoal. Wood & kerosene lagged far behind. Whist most respondents missed the smokey flavour in specific foods, many did not miss it at all.

The rice cooker & EPC have found a place in almost every participant's home, however the EPC is the most popular (Figure ES-1), as the ability to cook faster, cheaper & autonomously is highly valued. Being able to cook faster & keep the kitchen clean are both highly valued by these urban participants. However, priorities may well be different in rural areas. The automated control systems of the EPC & rice cooker make cooking easier, enabling multi-tasking & preventing food from burning.

If you could design your own completely new eCooker, what would it be like?

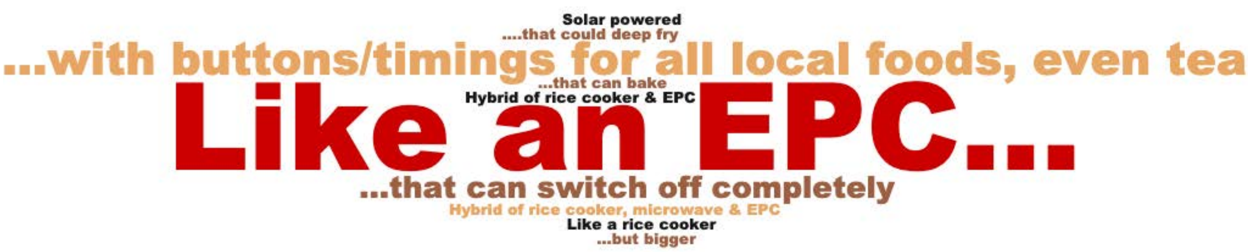

Figure ES-1: Word cloud indicating user preferences for electric cooking appliances based upon participants' responses on the exit survey.

Appliance choice

The fact that almost all meals were cooked on electricity during phase 2 suggests that the electric appliances selected for the study were highly compatible with Kenyan cooking practices. Cooking processes did not change significantly when transitioning to electricity, implying that the selected appliances were well matched with urban Kenyan cooking practices.

There is a clearly big opportunity to promote the use of off-the-shelf AC efficient electric cooking appliances in Nairobi & potentially other parts of Kenya. In middle and upper income areas, blackouts

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are infrequent enough that batteries are not really necessary, especially for households who already cook with LPG and can quickly swap the food over if a blackout does strike at meal time.

The EPC & rice cooker in particular are likely to be aspirational appliances, as evidenced by the exit survey, where participants reported that it looked good in their kitchens, food tasted better than usual & they could cook faster & multi-task. 'Heavy foods' such as beans or matumbo (tripe) that usually require boiling for an hour or more to soften are unsurprisingly rated as much easier to cook on the EPC than the hotplate. In contrast, foods such as chapati or mandazi that require manual heat control &/or a shallow pan are rated much easier on the hotplate.

EPCs were preferred for dishes that require boiling, however they were reportedly used for frying more often than pressure cooking. This is in contrast to stove-top pressure cookers, which are almost exclusively used for pressure cooking. Frying is done at a higher temperature than boiling and foods frequently dry out and burn if not stirred frequently. A shallow frying pan makes frequent stirring easier. Although the EPC can only operate with the deep sided pot it is supplied with, it seems that this was not a major restriction on participants' ability to fry.

Although 'heavy foods' can take several hours on other fuels, no food exceeded a recommended cooking time of 1 hour on an EPC. In controlled cooking tests, EPCs can cook 'heavy foods' like matumbo in half the time. The exit survey also revealed that participants highly valued the ability of electric cooking appliances to cook faster. However, the cooking diaries dataset showed little difference between cooking times with LPG & electricity. This could be because of unfamiliarity with the devices (e.g. depressurising too early & having to repressurise), however further investigation is needed to understand why.

Behavioural change barriers

Although often seen as a barrier to the adoption of new cooking technologies, in this case, participants reported not having to change their behaviour or that if they did, the change (e.g. cooking faster) was positive.

It seems the EPC & rice cooker are already well suited to user needs (Figure ES-1), but there are still minor tweaks, such as manual heat control, that could make them even more attractive. It appears that although there is a steep learning curve with EPCs, once this has been overcome, they are relatively easy to use. On the other hand, hotplates & rice cookers appear much more intuitive. If EPCs came with

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buttons for popular local foods, training requirements could be reduced significantly. However, safety would still be a strong concern amongst new users.

Insulation & automatic control are key safety features. Despite the general perception of stove-top pressure cookers as unsafe, the EPC was rated as even safer than the hotplate in the exit survey. As a result, there was not a single safety concern with the rice cooker.

Hotplates are the least popular appliance, with user feedback showing that they consume too much electricity compared to the insulated rice cooker & EPC. Their strength is being able to use different pots, but controlling heat levels is difficult compared to LPG, so most will not continue using them after the study.

Cost

eCooking was unanimously declared as affordable in the exit survey, with 2/3 of respondents reporting that it was cheaper than the fuels they used before the study. The registration survey revealed that mean electricity consumption for both cooking & other domestic applications before the study was appoximately 2,000KSh/month, which equates to 85kWh/month or 2.8kWh/day at KPLC's standard rate of 23ksh/kwh. Mean expenditure on cooking fuels before the study was roughly 1,700KSh/month or 57KSh/day.

The limited data available suggests that cooking with charcoal uses:

- 5x as much energy & costs 3x as much as kerosene
- 6x as much energy & costs 4x as much as LPG
- 13x as much as energy & costs 4x as much as electricity

However, it can be stated with more confidence that cooking with LPG uses twice as much energy, but costs the same as electricity.

Energy demand

Median daily energy consumptions for participating households cooking all their food with electricity were found to be 0.45 kWh per person (1.6MJ), or 1.4 kWh per HH (5.1MJ).

As expected, water heating is a significant energy demand & should not be underestimated in the design of an eCooking system – or users are likely to be disappointed when the batteries end up flat half way

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through a meal. Unlike cooking, which usually occurs at set mealtimes, water heating occurs throughout the day for a variety of purposes including bathing & purification, but mainly for tea/coffee.

One of the major challenges for eCook (especially PV-eCook) system designers will inevitably be coping with the variability in energy demand. LPG can easily cope with days of exceptionally high demand (e.g. cooking for visitors). In contrast, eCook systems will be limited to the size of the battery, which is the most expensive component, so will need to be sized very carefully.

The diaries dataset shows that EPCs use roughly half the energy of electric hotplates across the full range of dishes that they are able to cook. With minimal training, households would choose to use an EPC to cook half their menu if it were the only electric appliance available.

The Githeri eCooking Challenge shows that participants can cook very efficiently when they want to, achieving 80-90% savings on long boiling dishes are credible in real kitchen environments (Figure ES-2). Whilst bean variety & soaking can have a big influence on cooking time (& therefore cost) on a hotplate, most of the energy required for cooking with an EPC goes into getting the contents to pressure, i.e. the first 5-20 mins. Maintaining pressure for 1 hour doesn't use much more energy than maintaining it for 30 mins. Although re-pressurising after opening the EPC before the food is ready can almost double energy consumption, it is merely the difference between 'ultra-efficient' & 'very efficient', i.e. 70-80% savings over a hotplate, rather than 80-90%.

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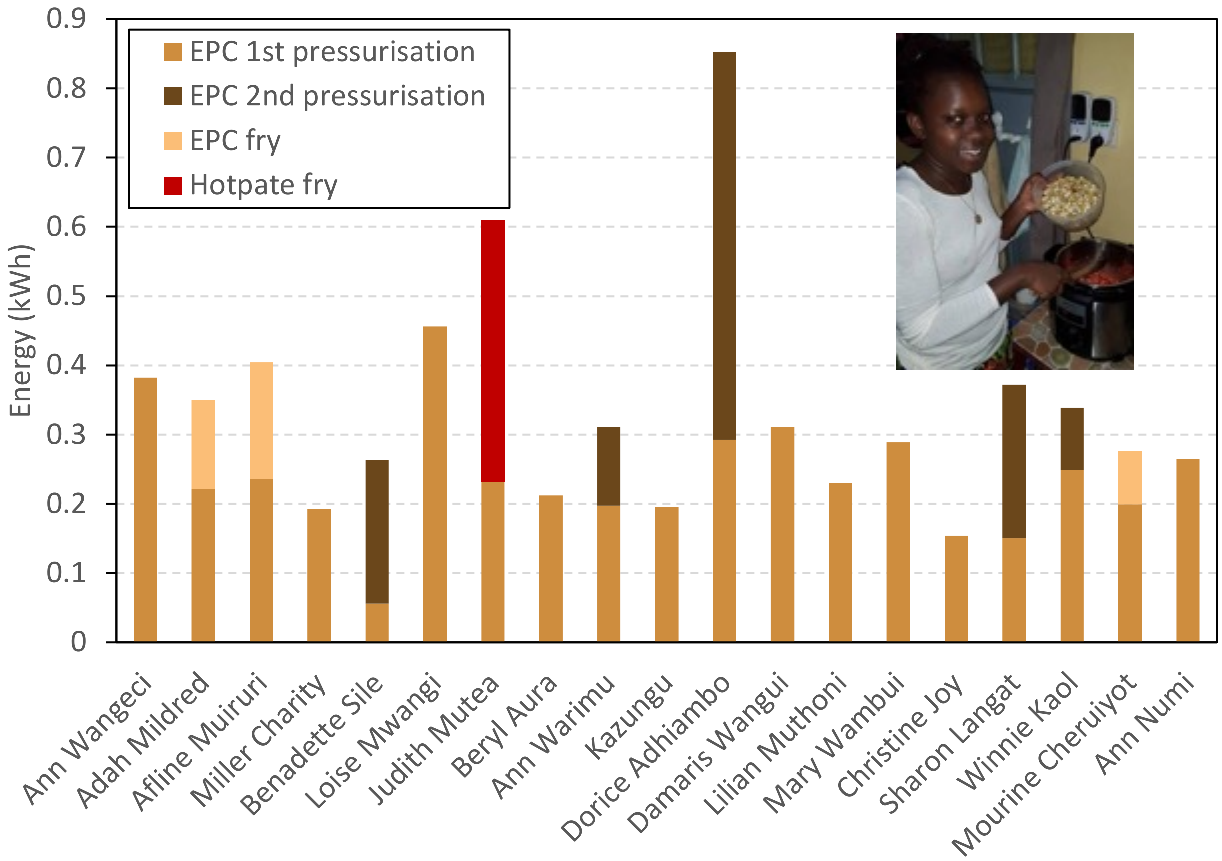

Figure ES-2: Energy consumption during the githeri eCooking challenge by participant, appliance and process.

1/4 of all meals are reheated, which has significant implications for energy demand, as reheating uses roughly half the energy of cooking from fresh. Lunches are the most commonly reheated meal, whilst dinner is the least likely to be reheated. Although many participants already owned electric cooking appliances before the study, they were rarely used. Microwaves were already popular among participants, as they offer a something above and beyond LPG – easy reheating.

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Load profiles

Dinners were found to be the most energy-intensive meal on the Kenyan menu – bad news for utilities, as this coincides with peak demand for electricity. The average load profile in Figure ES-3 shows that cooking can occur from 3am until midnight, but is concentrated into morning, midday & evening peaks, with the latter the most significant. Unfortunately this is also peak time for most utilities & mini-grids. Importantly for solar electric cooking, it is after the sun has set, however this may be earlier in a rural context, where daylight hours have more influence on daily routines.

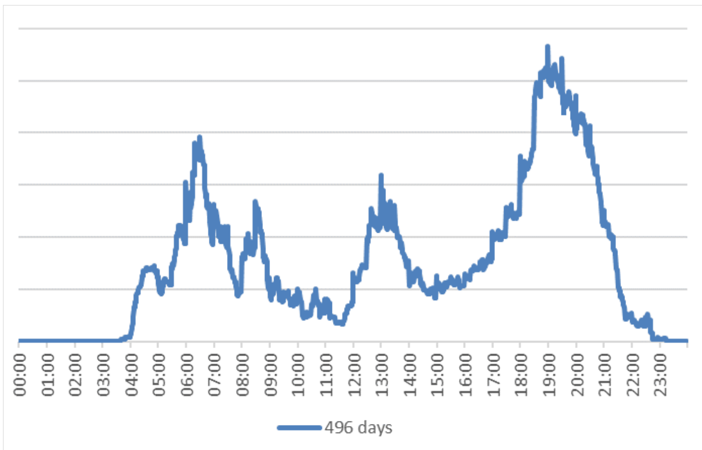

Figure ES-3: Average load profile for all complete days of data recorded during this study.

Automated energy-efficient electric cooking appliances have an important role to play in reducing and regularising electricity demand. Inter-daily variation was much higher in phase 1 (baseline) than phase 2 (electric cooking). This is likely partly due to the effect of the EPC, which significantly reduces the energy consumption of the biggest energy consumers (long boiling dishes). This effect is particularly important for eCook systems, where sizing the battery is much easier for a regular daily load.

Efficient Cooks use roughly the same amount of energy on LPG and electricity (0.4 MJ/event/person), whilst inefficient cooks use almost twice as much LPG (2.2 vs 1.2 MJ/event/person). This is likely because the EPC & rice cooker are automatically controlled appliances, as opposed to the hotplate & LPG, which are both manual.

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Fuel stacking

Fuel stacking is clearly part of everyday kitchen routines for Kenyan cooks: every HH reported using at least 2 fuels & 10% of heating events used multiple fuels. Surprisingly, the registration survey revealed that electric appliances were the most widely owned cooking devices, however they are almost all task specific appliances such as microwaves. For most participants, charcoal stoves are only used to prepare specific dishes, most notably those that require boiling for several hours, such as beans or matumbo (tripe). These 'heavy foods' are the dishes that EPCs offer the greatest energy and time savings on, which suggests that promoting EPCs could be an effective strategy to enable households stacking LPG and charcoal to transition to 100% clean cooking.

The motivations for transitioning to electricity are strong, however it seems likely that most participants will continue fuel stacking to some degree. Battery-supported appliances would directly address the strongest motivation to continue fuel stacking: blackouts. 80% of respondents reported having to use LPG during the eCooking portion of the study because of blackouts, showing that battery-supported appliances are likely to be a key enabler for electric cooking, especially in poorer neighbourhoods, where blackouts are more frequent.

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1 Introduction

This report presents one part of the detailed in-country research carried out to explore the market for eCook in Kenya. In particular, this in-country work aims to gain much greater insight into culturally distinct cooking practices and explore how compatible they are with battery-supported electric cooking. The report is rich with detail and is intended to provide decision makers, practitioners and researchers with new knowledge and evidence.

This report presents the key learning points from the cooking diaries study to inform the future development of eCook within Kenya. It is one component of a broader study designed to increase global understanding of the demand from various BoP segments with respect to low-cost energy-efficient technologies, and how such products can be sustainably developed and deployed in developing countries to have large-scale impact. *The Next Generation of Low Cost Energy Efficient Products for the 'Bottom Of The Pyramid'*, or *Low Cost Technologies* (*LCT*) project was funded by UK Aid, EPSRC, RCUK and DECC (now BEIS) via the USES (Understanding Sustainable Energy Solutions) programme: http://www.sussex.ac.uk/spru/research/projects/lct.

A much deeper analysis of the data collected during this project was supported by the Modern Energy Cooking Services (MECS) programme, which included the writing of this report. The overall aims of the LCT project, plus the series of interrelated projects that precede and follow on from it are summarised in in *Appendix A: Problem statement and background to LCT eCook project*.

1.1 Background

1.1.1 Context of the potential landscape change by eCook

The use of biomass and solid fuels for cooking is the everyday experience of nearly 3 billion people. This pervasive use of solid fuels and traditional cookstoves results in high levels of household air pollution with serious health impacts; extensive daily drudgery required to collect fuels, light and tend fires; and environmental degradation. Where households seek to use 'clean' fuels, they are often hindered by lack of access to affordable and reliable electricity and/or LPG. The enduring problem of biomass cooking is discussed further in *Appendix A: Problem statement and background to LCT eCook project*, which not only describes the scale of the problem, but also how changes in renewable energy technology and energy storage open up new possibilities for addressing it.

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1.1.2 Introducing 'eCook'

eCook is a potentially transformative battery-supported electric cooking concept designed to offer access to clean cooking and electricity to poorer households (HHs) currently cooking on charcoal or other polluting fuels (Batchelor, 2013, 2015a, 2015b). Enabling affordable electric cooking sourced from renewable energy technologies could also provide households with sustainable, reliable, modern energy for a variety of other purposes.

A series of initial feasibility studies were funded by DfID UK AID under the PEAKS mechanism (available from https://elstove.com/dfid-uk-aid-reports/). Slade (2015) investigated the technical viability of the proposition, highlighting the need for further work defining the performance of various battery chemistries under high discharge and elevated temperature. Leach & Oduro (2015) constructed an economic model, breaking down PV-eCook (Figure 1) into its component parts and tracking key price trends, concluding that by 2020, monthly repayments on PV-eCook were likely to be comparable with the cost of cooking on charcoal. Brown & Sumanik-Leary's (2015), review of behavioural change challenges highlighted two distinct opportunities, which open up very different markets for eCook:

- PV-eCook uses a PV array, charge controller and battery in a comparable configuration to the popular Solar Home System (SHS) and is best matched with rural, off-grid contexts.
- Grid-eCook uses a mains-fed AC charger and battery to create distributed HH storage for unreliable or unbalanced grids and is expected to best meet the needs of people living in urban slums or peri-urban areas at the fringes of the grid (or on a mini-grid) where blackouts are common.

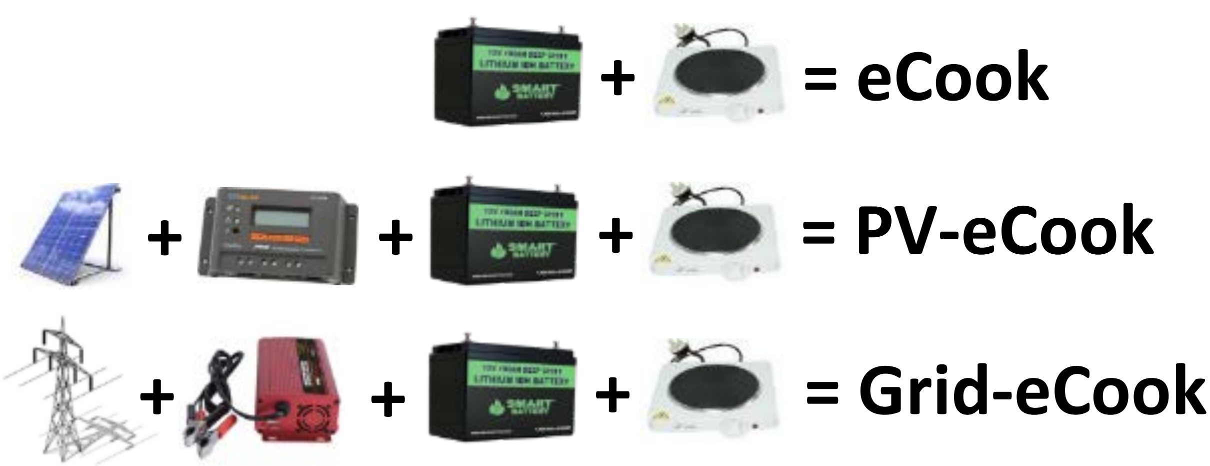

Figure 1: Pictorial definitions of 'eCook' terminology used in this report.

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1.1.3 eCook in Kenya

Given the technical and socio-economic feasibility of the systems in the near future, Gamos, ACTS, the University of Sussex and UIU have sought to identify where to focus initial marketing for eCook. Each country has unique market dynamics that must be understood in order to determine which market segments to target are and how best to reach them. Leary et al. (2018) carried out a global market assessment, which revealed Kenya as the most viable context for PV-eCook, as it has the highest mobile money penetration rate and the second largest market for pico-solar products and SHS in the world.

The accompanying reports from the other activities carried out under the LCT project in Kenya can be found at: http://www.sussex.ac.uk/spru/research/projects/lct.

1.2 Aim

The aim of this study is to gain a deeper understanding of how Kenyan households cook and how compatible this is with electricity.

In particular, the objectives of the study are:

- To find out what Kenyan households cook and how
- To assess the user acceptability of electricity for cooking popular Kenyan dishes
    - Can people cook the foods they want?
    - If so, which appliances are best matched with each food?
- To quantify the amount of energy Kenyan households need to cook
    - To make comparisons between electricity and popular fuels
    - To generate cooking load profiles for typical households

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2 Methodology

The cooking diary study is an innovative methodology that addresses limitations of the standard tests associated with improved cookstoves. To date, the standard international improved cookstove tests are the Water Boiling Test (WBT), Controlled Cooking Test (CCT) and the Kitchen Performance Test (KPT). None of these tests were designed to give key insights into 'how' a cook cooks, and whether, when they transition to a different fuel or appliance, their cooking practices change. Cooking is a deeply cultural experience, as the foods people cook and the practices they use to prepare them vary widely. To date studies of the 'how' people cook have been based on observational qualitative data.

DESPITE DECADES OF WORK ON IMPROVING THE EFFICIENCIES OF BIOMASS STOVES, THERE SEEMS TO BE LITTLE AVAILABLE DATA ON 'HOW' PEOPLE COOK.

MODERN FUELS SUCH AS GAS & ELECTRICITY ARE MORE CONTROLLABLE & CAN BE TURNED ON/OFF IN AN INSTANT. THERE ARE ALSO A HUGE RANGE OF ELECTRIC COOKING APPLIANCES, EACH DESIGNED FOR SPECIFIC PROCESSES (E.G. MICROWAVE FOR REHEATING).

THEREFORE, IT IS IMPORTANT TO KNOW HOW OFTEN PEOPLE ARE FRYING, BOILING, REHEATING OR DOING SOMETHING ELSE ENTIRELY.

The cooking diary study was applied in Kenya to offer a deeper exploration into the unique cooking practices of individual households, paired with quantitative measurements of energy consumption. 20 households were selected to participate in the study, based upon the fuels they cooked with and their willingness and ability to record high quality data for the duration of the study. This mixed methods approach gathers data from various sources:

- *Cooking diary forms*
    - Data on foods cooked, cooking processes and times, appliances used.
    - *Appendix C: Cooking diary form.*
- *Energy measurements*
    - Manual measurements of fuel use and electricity consumption taken by participants.
- *Registration surveys*
    - Simple demographic data on participants.
    -
    -
    -
    - *Appendix B:* Cooking diaries registration form.
- *Exit surveys*

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- Qualitative feedback from participants.
- *Appendix D: Cooking diaries exit survey.*

Data was recorded in two stages:

- *Baseline*: cooking as normal.
- *Transition*: cooking with electric appliances only.

Enumerators visited participating households throughout the research. The study began with a registration survey designed to capture basic information on who cooks are cooking for, the appliances they use and why (

Appendix B: Cooking diaries registration form). Enumerators explained the purpose of the research, obtained informed consent from participants and showed participants how to take energy measurements complete the diary forms (*Appendix C: Cooking diary form).*

Energy measurements were taken before and after each heating event to give '*meal-level resolution'* data (Table 1). Solid, liquid and gaseous fuels were measured using the difference in weight between before and after cooking from a hanging balance, whilst electricity consumption was measured using a plug-in electricity meter (Figure 2). Gas is the hardest fuel to measure by weight, as the weight of gas used in each meal is relatively small compared to the total weight of the cylinder. Cylinders above 6kg were too heavy for participants to lift every time they cooked, so 3kg cylinders with stove-top burner (pictured) was purchased, as there was no regulator to remove, so the whole assembly could simply be suspended from the hanging balance. It proved more convenient, but some households still struggled to get accurate measurements.

Table 1: Measurement techniques for energy consumption during each heating event.

Technique	Equipment	Accuracy	Installation	Procedure
Weight	Hanging balance	5-10g	Fixed hanging point far from walls found to ensure hanging object does not touch when being weighed.	Hang bag of biomass, whole kerosene stove or whole LPG cylinder (detaching regulator) before cooking and again after cooking.

kWh metering	Plug-in meter	electric	0.001kWh	Plug-in meter plugged into socket, appliances plugged into meter.	Zero meter before cooking, read kWh value after cooking.

Figure 2: a) (left) Plug-in energy meters and b) hanging balance used to measure the total energy consumption of each heating event.

For the first 2 weeks of the study, baseline data was captured on how households currently cooked. Before cooking, the cook would record the time and an energy reading by weighing the fuels they planned to use. After cooking, they would again record time and energy, plus details of what they cooked and how they cooked it. Data was recorded on paper forms (*Appendix C: Cooking diary form)*, which were collected by the enumerators. The first day of data was validated by the enumerators, who described the meal that was recorded to the participant from the recorded data, noting and correcting any inconsistencies. Initially, participants were visited every day, however once they were recording good quality data, the visits gradually decreased to around once a week.

In the second part of the experiment, the households were asked to transition to using solely electricity for cooking. Each household was given a hotplate, a rice cooker and an electric pressure cooker and received basic training on how to use each appliance. The 3 appliances were plugged into an extension cable, which fed into a plug-in energy meter Figure 2. Participants were also able to continue using any electrical appliances that they already owned, as long as they were plugged into the plug-in meter so

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that energy consumption data could be captured. Data was recorded for a further 4 weeks, allowing participants time to adapt their cooking practices around the new appliances.

The study finished with an exit survey, asking participants about their experience with cooking with different electric appliances *(Appendix D: Cooking diaries exit survey*). Participants were also invited to share their energy-efficient cooking practices by participating in the Githeri eCooking Challenge. A prize was offered to the participant who could cook half kg of githeri using the least energy possible, whilst the enumerators observed and recorded their cooking practices to understand exactly where energy was being saved/wasted.

Paper records kept by participants were transcribed into digital form by the enumerators. An Excel worksheet was designed to mimic the paper form, with a macro to copy data from each 'sheet' into a separate column in the database. Subsequent analysis of the complete database was performed in both SPSS and Excel.

The cooking diaries protocols offer a more complete guide to this methodology for those looking to replicate the cooking diaries study: https://elstove.com/forward-looking-guidance/

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3 Results

3.1 Overview of data

3.1.1 Overview of participants

Analysis of the data from the registration surveys was used to develop a series of a priori user profiles based upon poverty status, HH size and fuel stacking behaviour (Table 2). A crude Multidimensional Poverty Indicator (MPI) was created based on 5 indicators: school attendance, HH overcrowding, HH construction, primary cooking fuel and access to electricity. HHs were classified as deprived if they did not meet the minimum criteria in a third or more of the indicators (Alkire and Jahan, 2018), however only 2 of the 19 HHs fell into this category.

THE CONVENIENCE SAMPLE OF 19 HHS ONLY INCLUDED 2 LIVING IN DEPRIVED CONDITIONS. FUTURE ITERATIONS OF THE COOKING DIARIES STUDY SHOULD PAY GREATER ATTENTION TO UNDERSTANDING HOW POORER PEOPLE COOK.

Figure 3 shows that LPG is the most widely used fuel amongst the cooking diary participants, however Figure 4 shows that electric appliances are the most widely owned cooking devices. Nevertheless, almost all of these are task-specific appliances, notably microwaves (reheating), kettles (water boiling), toaster/sandwich makers and deep fryers. As a result, no HHs cooked using solely electricity and only a single HH used it as their primary fuel. Charcoal was also never used an exclusive fuel by any of the participants. In contrast, three HHs cooked solely with LPG and one solely with kerosene. 16 of the 19 HHs also reported that their LPG stove is their primary cooking device.

SURPRISINGLY, ELECTRIC APPLIANCES ARE THE MOST WIDELY OWNED COOKING DEVICES, HOWEVER THEY ARE ALMOST ALL TASK SPECIFIC APPLIANCES SUCH AS MICROWAVES.

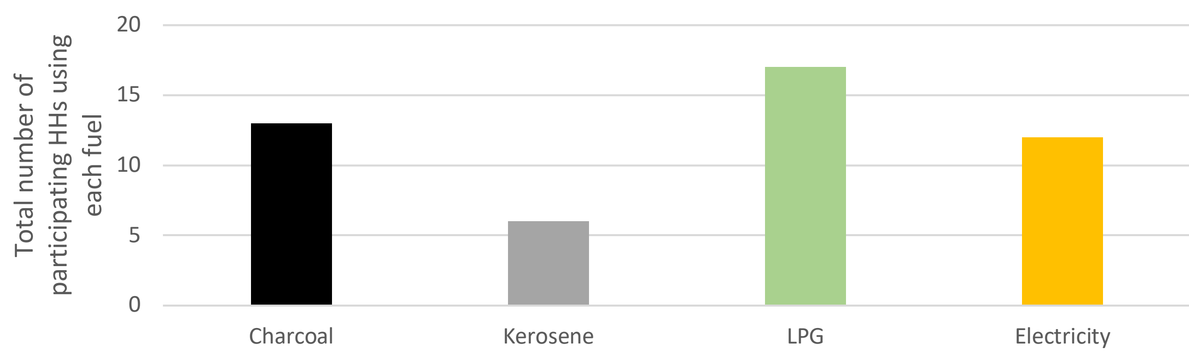

Figure 3: Total number of HHs reportedly using each fuel.

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Table 2: Summary of registration data used to create a priori user profile for each HH.

■ Charcoal ■ Kerosene ■ LPG ■ Electricity

HH ID	MDPI (/5)	No. ppl in HH	Appliance ownership: Biomass stove	Improved biomass stove	Kerosene stove	LPG cylinder top	LPG 2 burner countertop	LPG 4 burner countertop	LPG/oven 4 burners	LPG/electric oven 4 burners	Electric hotplate	Kettle	Microwave	Toaster/sandwich toaster	Deep fryer	Reported baseline cooking fuel & electricity expenditure (KSh/month): Charcoal	Kerosene	LPG	Total fuels	Electricity (all HH appliances)	Total fuels + electricity	A priori user profile
1	0	2	1						1			1	1		1	200		900	1100	2250	3350	Small modern/charcoal stacker
2	0	1		1		1						1				107		213	320	1000	1320	Small modern/charcoal stacker
3	0	7		1					1			1				429		1900	2329	4000	6329	Big modern/charcoal stacker
4	0	4						1										300	300	2000	2300	Small LPG purist
5	0	2						1	1				1					1000	1000	1050	2050	Small modern stacker
6	0	3		1	1		1					1	1	1		210	50	600	860	1250	2110	Small modern/kero/charcoal stacker
7	0	4		1			1					1	1			1500		2000	3500	2000	5500	Med modern/charcoal stacker
8	4 - deprived	5		1	1											3000	2100		5100	500	5600	Poor medium kero/charcoal stacker
9	1	4			1												3000		3000	1500	4500	Med kero purist
10	0	4				1					1	1						500	500	5000	5500	Med modern stacker
11	0	2	1		1		1		1			1	1	1		180	210	975	1365	1500	2865	Small modern/kero/charcoal stacker
12	4 - deprived			1	1	1										1500	600	320	2420	500	2920	Poor medium modern/kero/charcoal stacker
13	0	3		1			1					1	1			771		800	1571	1900	3471	Small modern/charcoal stacker
14	0	6	1							1						1667		900	2567	4750	7317	Medium modern/charcoal stacker
15	0	3					1											1750	1750	1500	3250	Medium modern/charcoal stacker
16	0	4		1				1								429		900	1329	1400	2729	Medium LPG purist
17	0	4					1											800	800	2100	2900	Small LPG purist
18	0	3	1		1		1					1				250	200	773	1223	1000	2223	Small modern/kero/charcoal stacker
19	0	4		1				1					1			200		750	950	2000	2950	Medium modern/charcoal stacker

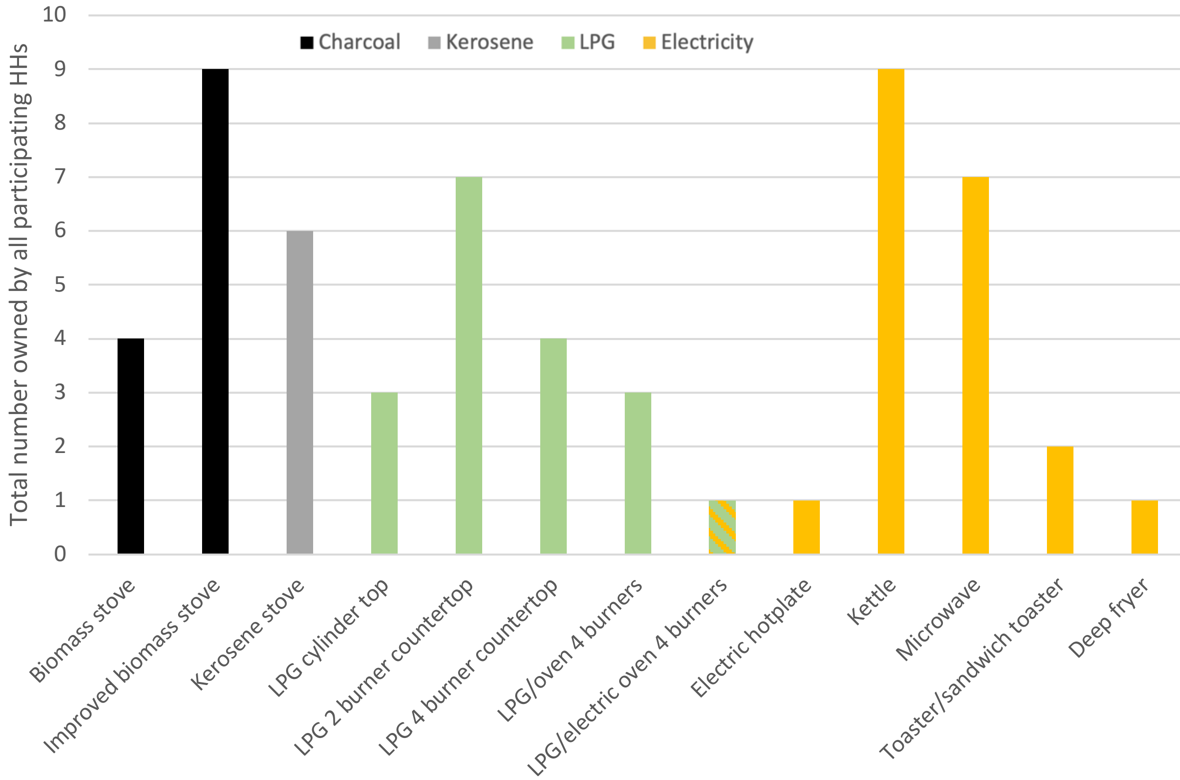

Figure 4: Total number of cooking stoves and appliances owned by all participating households.

FOR MOST PARTICIPANTS, CHARCOAL STOVES ARE ONLY USED TO PREPARE SPECIFIC DISHES, MOST NOTABLY THOSE THAT REQUIRE BOILING FOR SEVERAL HOURS, SUCH AS BEANS OR MATUMBO (TRIPE).

Charcoal stoves are generally used as secondary stoves for specific dishes, most notably long boiling dishes such as cereals, matumbo or kienyeji chicken. However, some participants also use their charcoal stoves for other foods, such as chapati (pan fried flat bread) and mandazi (deep fried dough). Presumably this is because it heats the pan very evenly, and nyama choma (grilled meat), presumably because of the crispy texture and smokey flavour. Only two HHs reported using charcoal as their primary fuel; however, Figure 5 shows that it makes up a significant portion of fuel expenditure (>20%) for ten HHs. Unsurprisingly for the urban setting, all 19 HHs reported that their kitchen area was outside; however, Figure 6 shows that over half (7/12) of the charcoal users always take their jiko outside to light. Significantly more smoke is generated when lighting the stove, so taking it outside for this stage is likely to reduce the health impacts from indoor air pollution for these participants and their families. However, 5/12 participating HHs still sometimes and one always light their charcoal stove inside.

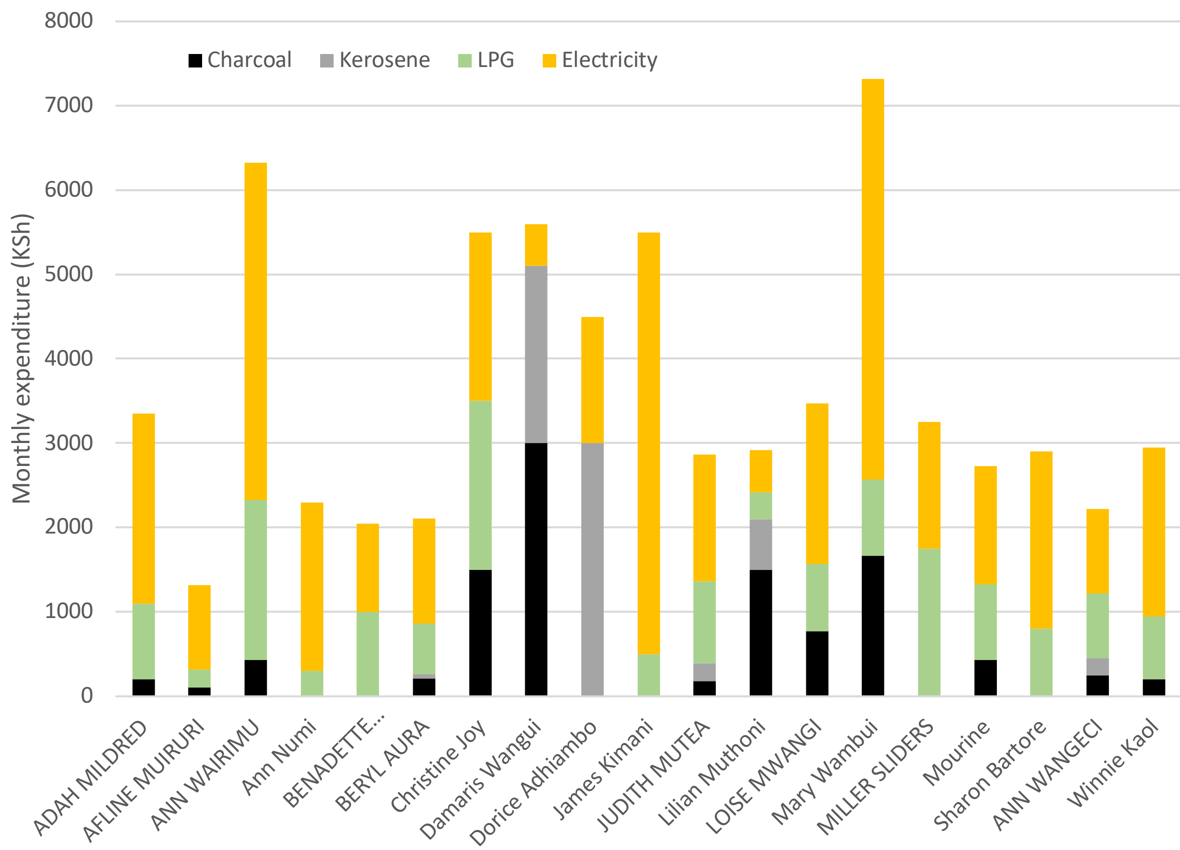

Figure 5: Reported baseline fuel & electricity expenditures per HH. Note: Electricity expenditures are for all domestic appliances, not just cooking.

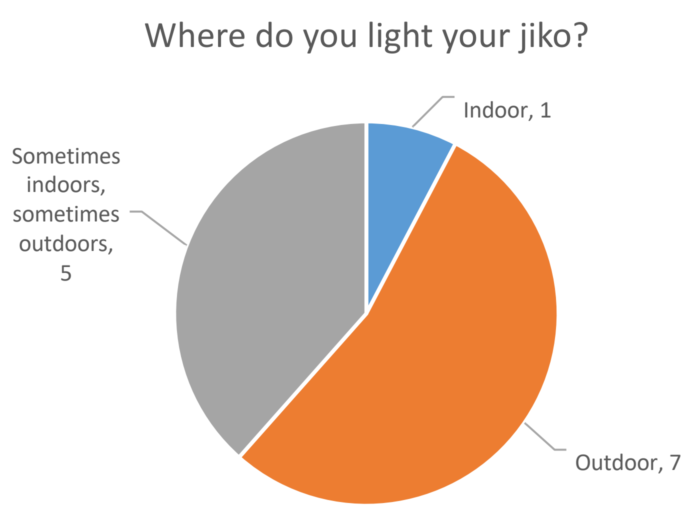

Figure 6: Stove lighting practices amongst charcoal users.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

It is difficult to draw firm conclusions from Figure 5 regarding the comparative costs of cooking on electricity and other fuels, as HH electricity bills are inclusive of all domestic appliances, not just cooking devices. The average monthly expenditure on electricity is 1,958 KSh, which equates to 85 kWh at KPLC's standard domestic rate of 23 KSh/kWh. The highest monthly electricity bill is unsurprisingly from the only household using electricity as their primary fuel (HH 10), who is also the owner of the only electric hotplate.

MEAN ELECTRICITY CONSUMPTION FOR BOTH COOKING & OTHER DOMESTIC APPLICATIONS IS APPOX. 2,000KSH/MONTH, WHICH EQUATES TO 85KWH/MONTH OR 2.8KWH/DAY AT KPLC'S STANDARD RATE OF

MEAN EXPENDITURE ON COOKING FUELS IS ROUGHLY 1,700KSH/MONTH OR 57KSH/DAY.

In comparison,

Table 3 shows that the average monthly expenditure on cooking fuel is 1,683KSh. The average monthly expenditure on LPG is 905KSh, with an average cost of 139KSh/kg, equating to an average consumption of 6.5kg/month. Gas users refill their cylinders on average once every 2 months and the 13kg cylinder is more popular than the 6kg – average retail prices are 1,7880KSh and 863KSh respectively. Even though kerosene and charcoal are generally used as secondary fuels by this set of participants, average expenditures on kerosene (1,027KSh/month) are actually higher than both LPG (905 KSh/month) and charcoal (803KSh/month). In fact, the highest monthly expenditure on any single fuel is 3,000KSh (both kerosene and charcoal equally) and the highest total monthly fuel expenditure of 5,100KSh is HH8, who stacks charcoal and kerosene. The average prices of kerosene and charcoal are 94KSh/litre and 55KSh/kg respectively, which implies average consumptions of 10.9litres/month and 14.6kg/month respectively. Kerosene is most commonly bought daily, in 1 litre quantities, whilst charcoal is most commonly bought monthly, in 2kg paint tins.

Table 3: Selected fuel purchasing pattern statistics.

	Charcoal	Kerosene	LPG	Total
Max expenditure (KSh/month)	**3,000**	**3,000**	**2,000**	**5,100**
Mean expenditure (KSh/month)	**803**	**1027**	**905**	**1,683**
Mean consumption (kg/ or litres/month)	**14.6 (kg)**	**10.9 (l)**	**6.5 (kg)**	
Mean unit cost (KSH/kg or /litre)	**55 (kg)**	**94 (l)**	**139 (kg)**	
Mode purchase quantity (kg or litres)	**2 (kg)**	**1 (l)**	**13 (kg)**	
Mode purchase frequency (days)	**30**	**1**	**60**	

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 4 summarises the sizes of the utensils owned by participants. For comparison, the average dimensions of the rice cookers and electric pressure cookers used in this study are 23x14cm and 23x16cm respectively, which makes them deeper than most pots, but towards the smaller end of the range in terms of diameter.

EPC & RICE COOKER POTS ARE DEEPER THAN MOST SUFARIAS OWNED BY PARTICIPANTS, BUT A LITTLE SLIMMER THAN AVERAGE, SO THEY MAY FEEL A LITTLE SMALL FOR BIGGER FAMILIES OR ON SPECIAL OCCASIONS WITH LOTS OF VISITORS.

Table 4: Average number and size of pots and pans owned by participants.

	Mean no. owned	Mean diameter (cm)	Mean height (cm)
Small sufaria (pot)	**3**	**21**	**8**
Med sufaria (pot)	**3**	**25**	**10**
Big sufaria (pot)	**2**	**29**	**12**
Frying pan	**1**	**24**	**4**

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

3.1.2 Typical Kenyan foods

An overview of typical preparation techniques for popular Kenyan foods is given below, based upon observations made of Kenyan cooks during the cooking diaries study and accompanying kitchen laboratory experiments for the eCookBook. Dishes are categorised into 4 groups according to their compatibility with efficient electric cooking appliances and the potential energy and time savings available: 'heavy', 'staple', 'quick fry' and 'long fry and deep fry' foods.

'*Heavy*' foods like beans, meat stew or makande/githeri generally require boiling for 60 minutes or more. They are easy to cook on an EPC, which can offer significant energy & time savings over electric hotplates, or a rice cooker with moderate energy savings.

- **Githeri/mokimo** - beans & maize stew, usually wet fried/mashed potatoes with maize/beans/peas/pumpkin leaves. Many people will pre-cook (boil) githeri in bulk and wet fry portions throughout the week.
- **Beans/peas/kamande/ndengu** - beans/peas/lentils/green grams, usually stewed. Typically dry, so require rehydrating as well as cooking - some people soak before cooking, others just cook for longer. Many people will pre-cook (boil) in bulk and wet fry portions throughout the week.
- **Chicken, meat** - In Kenya, wet fry and dry fry were separated out, so stew does not appear as an option in the dishes column, but would be represented as a combination of these items and 'wet fry' from the process column . Many people will pre-cook (boil) meat in bulk and wet fry portions throughout the week.
- **Matumbo** - Tripe, usually wet fried

'***Staple'*** foods and water that require boiling for 15 minutes or more can also be cooked on an EPC, with moderate energy & time savings or rice cooker with moderate energy savings.

- **Heating water** - for tea/coffee, bathing, drinking etc.
- **Pasta/noodles** - Boiled and then often wet fried.
- **Porridge** - Requires regular stirring, but perhaps not in the electric pressure cooker. Need to do more experimentation on this.
- **Potatoes/pumpkin/nduma/muhogo** - Nduma=arrow roots, muhogo=cassava. Usually boiled, sometimes wet fried. Will need to check process to differentiate boiled and stewed.
- **Matoke** - Bananas. Usually wet fried, sometimes boiled. Will need to check process to differentiate boiled and stewed.
- **Rice** - Just boiled.
- **Pilau -** A combination of meat stew and rice. May use meat stew/stock pre-cooked on a previous occasion, or may cook the meat especially for this dish. May involve some frying of onions too. Sometimes potato is even thrown in!
- **Ugali** - Kenyans usually bring water to the boil, turn down the heat, add maize flour, stir, repeating a few times, then leaving to simmer until the mixture has reached the desired consistency.

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'Quick fry' foods can also be cooked on an EPC or rice cooker, but some households may be reluctant to try and/or there are limited energy savings.

- **Eggs** - Could be boiled, fried or omlette. If omlette, can often be combined with potatoes (chips mayai), which may need deep frying first.
- **Fish** - Typically wet or dry fried fried whole or in fillets.
- **Leafy veg** - Sukuma wiki, spinach, etc. Typically dry fried, sometimes with onions.
- **Sausages** – Typically shallow fried.

'Long fry and deep fry' foods are very difficult to cook on an EPC or rice cooker, as they require precise temperature control.

- ***Pancakes/Chapati*** - Shallow fried one by one in a shallow pan, as they must be flipped and swapped over many times. Requires low heat evenly distributed throughout the pan.
- ***Chips*** - Deep fried. If oil too hot, they burn, if too cold, they go soggy.
- ***Mandazi*** - Donuts. As above.

3.1.3 Overview of diaries data

The cooking diaries recording system meant that each record could cover multiple heating events e.g. an early morning record could include breakfast, preparing food for a baby, and heating water (3 events). However, 94% of data records covered only a single heating event (see Table 5).

AS EXPECTED, WATER HEATING IS A SIGNIFICANT ENERGY DEMAND & SHOULD NOT BE UNDERESTIMATED IN THE DESIGN OF AN ECOOKING SYSTEM – OR USERS ARE LIKELY TO BE DISAPPOINTED WHEN THE BATTERIES END UP FLAT HALF WAY THROUGH A MEAL.

Cooking dinner is the most common single heating event (Table 6). Most households appear to cook breakfast and dinner, and only around one half cook lunches. The breakdown of heating events represented by those records relating to only a single heating event was similar (see Table 7). N.B. of the 2029 cases with a single heating event (in which the heating event is identified), 55% included a water heating event (n=1114). Only 126 of these were allocated to 'Heating water' as the heating event, which means that 988 single heating events actually included some 'hidden' water heating. These have been filtered out of most calculations in order not to inflate energy consumption figures.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 5 Number of heating events captured in each case

		Frequency	Percent
Valid	1.00	2029	93.9
	2.00	71	3.3
	3.00	3	.1
	Total	2103	97.3
Missing	System	58	2.7
Total		2161	100.0

Table 6 Number of heating events[1]

Heating event	Frequency	Percent
Breakfast	735	34.0
Lunch	397	18.4
Dinner	774	35.8
Snack	48	2.2
Baby food	44	2.0
Heat water	177	8.2
Other	4	0.2

[1] N.B. multiple heating events in each record means that total sums to more than 100%.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 7 Breakdown of heating events (single heating event records only)

Heating event	Frequency	Valid Percent
Breakfast	691	34.1
Lunch	377	18.6
Dinner	759	37.4
Heat water	126	6.2
Snack	44	2.2
Baby food	29	1.4
Other	3	.1
Total	2029	100.0

ONE OF THE MAJOR CHALLENGES FOR ECOOK (ESPECIALLY PV-ECOOK) SYSTEM DESIGNERS WILL INEVITABLY BE COPING WITH THE VARIABILITY IN ENERGY DEMAND. LPG CAN EASILY COPE WITH DAYS OF EXCEPTIONALLY HIGH DEMAND (E.G. IF COOKING FOR VISITORS). IN CONTRAST, ECOOK SYSTEMS WILL BE LIMITED TO THE SIZE OF THE BATTERY, WHICH IS THE MOST EXPENSIVE COMPONENT, SO WILL NEED TO BE SIZED VERY CAREFULLY.

Table 9 shows both the number of heating events per day recorded by each participant, and the allocation of days to Phase 1 (cooking as normal) and Phase 2 (cooking with electricity). Overall, 37% of heating events fell into Phase 1, and 63% into Phase 2. Note that for any given participant, the number of heating events recorded in a day varies. This reflects variations in heating behaviour e.g. water may not be heated every day, lunches may only be prepared at weekends, and certain meals may not be prepared if the household eats out. However, there are some inconsistencies in the date stamping of data. The survey was designed to capture all heating events during days on which records were kept, in order to reflect the variance of cooking patterns of behaviour. Table 8 shows that the mix of heating events was similar in the two phases of the survey.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 8 Breakdown of heating events by Phase (single heating event records only)

Heating event	**Phase 1**		**Phase 2**	
	Frequency	**Valid Percent**	**Frequency**	**Valid Percent**
Breakfast	260	33.4	431	34.5
Lunch	143	18.4	234	18.7
Dinner	278	35.7	481	38.5
Heat water	62	8.0	64	5.1
Snack	18	2.3	26	2.1
Baby food	17	2.2	12	1.0
Other	1	0.1	2	0.2
Total	779	100.0	1250	100.0

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 9 Number of heating events per day by participant

					21/05/2018							28/05/2018							04/06/2018						
	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
Adah				2	2	2	2	3	3	1	1	3	1	2	3	3	2	2							
Afline					6	4	6	6	8	2	4		4	4	6	6	2		4	2					
Ann							3	3	4	3	3	3	3	3	2					1	3	2	2	3	3
Ann Numi				1	2	2	2	2	1	1	2	1	1	1					1			2		2	1
Bernadette								2	3	2	3	3	3	4	4	5	3	4	4	6	4		4	4	3
Beryl				2	2	3	1	1	3	4	4	2	2	2	3		2	1	1		1	1	2	2	1
Christine Joy	1		2			2	3	2	3				1		3	2	3	2	3	1	4	1	3	3	3
Damaris						1	4	3	3	3	3	3	2	3		3	4	3	3	3					
Dorice					2	2	2	4	4			2	2	2	2	2	3	1	2	5	1	6		5	2
James				3		3	2	2	2	3	4	3	2	2	4	1				2	2	3	2		1
Judy				3	2	3	1	1	4	3	3	3	3	3	2	2	2	3	2	1	2	3	2	3	2
Lilian					2	1	2	2	2	2	1	2	1	2	2	2	2	2	2	2	2				
Louise							3	4	3	2	1	2							2	1	4	2	2	3	2
Mary					1	3	1	3	5	3	4	3	3	3	2	1	1	2	2	2	1	1	3	3	5
Miller											1	3	1	2	4		3	2	2	2	2	2	1	1	1
Mourine					2	1	4	3	3	3	3	4	3	6	2	3	3	4	3	4	4	3	1	3	3
Sharon							3	4	2	3	4	4	4	5	3	4	4	5	4	3	3	5	3	3	3
Wangeci												1	2	1	1	4	3	1	1	2	2	3	5	3	2
Winnie						6	5	2	3	3	3	3	2	2	2	3	4	2	1		2	3	1	3	2

	11/06/2018							18/06/2018							25/06/2018						
	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
Adah				3	2	1	3	2	2	2				1	3	3	3	3	3	2	3
Afline										6	4	6	4	2		4	2				
Ann	1			2	2			3	3	3	3	3	1			2	3	3	3	3	4
Ann Numi	3	2	2	1	1	2	2	1	1	1	1	1		1			1			2	2
Bernadette	4	4	3	3	3	2	4		3	5	3	3	4	3	4	2	2	4	1		3
Beryl	2	2	1	2	2	3	1	1		1	1	1	3	1	1	2	1	1	2	1	1
Christine Joy	3	3	4	2	3	3	3	4	2	3	3	2	3	3	2	2	3	2	2	3	3
Damaris	4	5	5	5	4	4	3	3	3	4	3	1	4	2	1	4	4	4	3	2	4
Dorice	4	2	2	2	2	2	2	2	2	2	2	2	3	1	2	2	4	2	2	1	2
James	2	2	2	2	2	2	3	3	3	2	3	1			2	3	3	2	1	1	1
Judy	1	1	3		3	2		2	2	4	3	2	2	3	3	2	3	2			
Lilian						2	2	2	2	2	2	2	2	1	2	2	4	4	2	2	2
Louise	4																	2	4	3	3
Mary	2	3	2	3	2	2	2	5	2	2	2	2	2		3	3	3	2	3	3	2
Miller	1	1	4	2	2	3		2		1			2	2	2	1	1	2	1	1	1
Mourine	3	3	3	4	2	2	6	3	6	4	4	4	5	7	1	3	4	4	4	4	3
Sharon	4	3	3	3	3	3	3	1	2	2	2	1	2	2	2	2	2	3	3	2	3
Wangeci	3	3	2	3	3	1	2	4	3	3	4	2	2	2	2	2	3	3	3	2	2
Winnie	2	3	2	3	1		1	2	3	2	2	3	3	4	3	2	4		3	2	1

	02/07/2018							09/07/2018							16/07/2018		
	M	T	W	T	F	S	S	M	T	W	T	F	S	S			
Adah	3	1	3	3	3	3	2	3	4	3	4	2	1	3			
Afline	6	2			6		2	6	6	4	4	6	4				
Ann	4	4	4	3	3	2	3	5	1								
Ann Numi	1		2	2	2				1		2						
Bernadette	2	2	3	4	3	3											
Beryl	1	1						1	1	2	2						
Christine Joy	3	3	2	2	2								2	2	2		1
Damaris	3	4	4	3	3	2	3	3	3	3	1						
Dorice	2	2	2	1		1	2	2	2	2	2						
James	1	2	2	3	2	2		2	3	2							
Judy	2	3	2	3	3	3	2	2	3	2	3	4	2				
Lilian	2	2	2	2	2	1	4	3	1	2	3	2	4	1			
Louise	3	2	4	3	3	5	4	1	5	3	2	2	5	5	4	1	
Mary	2	3	3	2	2	2	2	2	2								
Miller	1	2	1	1	2				2								
Mourine	3	3	4	3	3	2	4	4	4	2	4	1					
Sharon	2	2		2		2			2	2		1			1		
Wangeci	2	2	2	2	2	3	2	3	2	3	2	1		1	3		
Winnie	2	2	1	2	3	2	2	2	4	1	3						

Key:

- Phase 1
- Phase 2

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Energy consumption is proportional to the number of people being cooked for. Overall, the mean number of adults per heating event was 2.3, and the mean number of children was 1.4. If children are weighted the same as adults, then the mean number of persons per heating event was 3.1. The distribution was quite evenly split across events cooking for 1 to 4 persons (Figure 7).

THE MEAN OF 3.1 PPL PER HEATING EVENT INDICATES THAT OUR SAMPLE REPRESENTS SMALLER HHS THAN THE NATIONAL AVERAGE OF 4.4 PPL PER HH (KNBS, 2009).

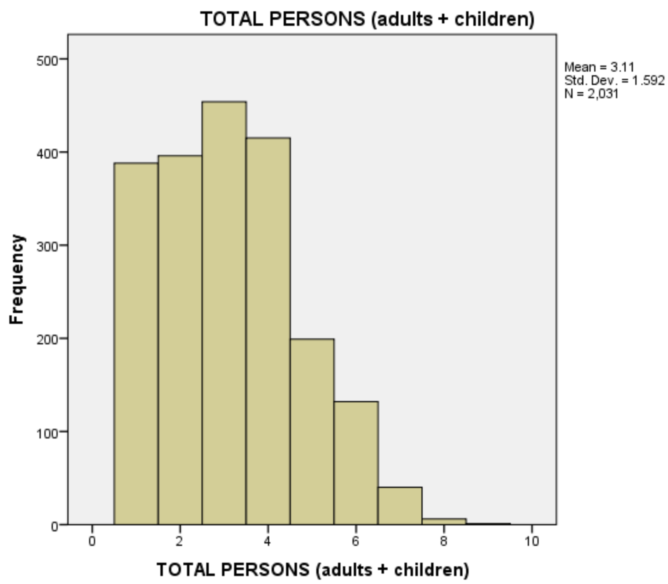

Figure 7 Distribution of persons per heating event

3.2 Energy consumptions

For each of the five dominant fuels, energy consumptions have been calculated from deduced fuel consumptions (based on the before and after readings e.g. weight of wood (kg)) and the calorific values given in Table 10.

Table 10 Calorific values and conversion efficiencies[2]

Fuel	Calorific value	Density
Wood	15.9 MJ/kg	
Charcoal	29.9 MJ/kg	
Kerosene	34.9 MJ/ltr	0.8 kg/ltr
LPG	44.8 MJ/kg	
Electricity	3.6 MJ/kWh	

3.2.1 Mix of fuels

The mix of fuels used in Phase 1 is presented in Figure 8. This shows that LPG accounts for the majority of energy consumed (63%). During Phase 2, electricity was the dominant fuel used for all heating events, as was intended in the design of the experiment (see Figure 9). Note that only 5% of the total energy consumed during phase 2 was non-electrical energy, indicating two things:

- the grid supply was reliable enough for participants to do almost all of their cooking using electricity. In only one event was electricity not used because of a power cut.
- participants were able to cook using electricity, so either electric devices were compatible with their cooking practices, or participants were able to adapt their cooking practices. In only one event was charcoal used because the electric pressure cooker was too small.

[2] Source: World Bank (BLG14 Cooking Costs by Fuel Type.xlsx)

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

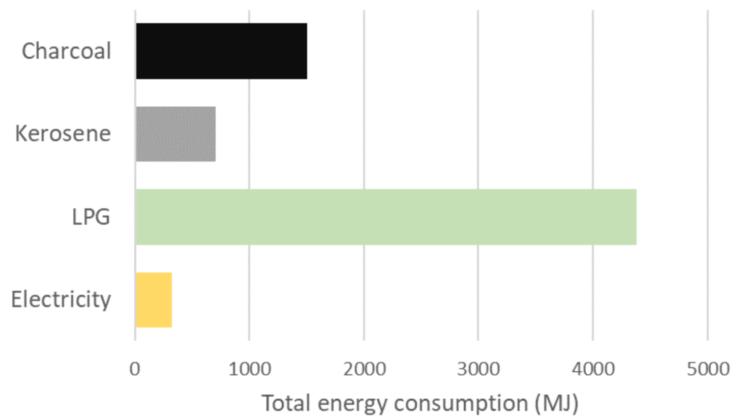

Figure 8 Energy content of fuels used in Phase 1

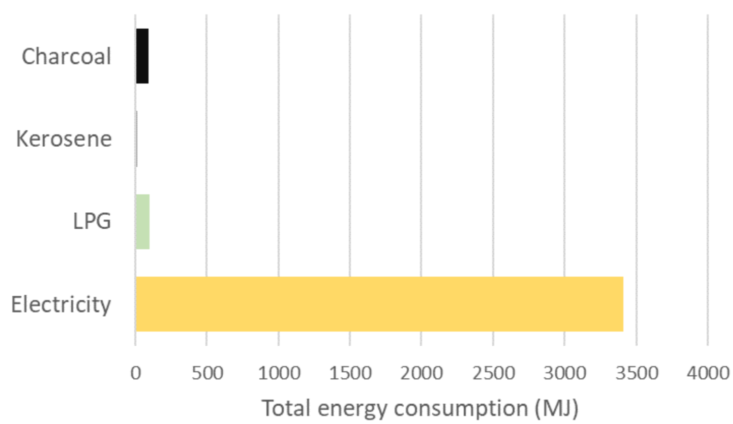

Figure 9 Energy content of fuels used in Phase 2

THE FACT THAT ALMOST ALL MEALS WERE COOKED ON ELECTRICITY DURING PHASE 2 SUGGESTS THAT THE ELECTRIC APPLIANCES SELECTED FOR THE STUDY WERE COMPATIBLE WITH KENYAN COOKING PRACTICES & THAT BATTERIES MAY NOT BE NECESSARY FOR MANY NAIROBI RESIDENTS. SEEMINGLY THERE IS ALSO A BIG OPPORTUNITY TO PROMOTE THE USE OF OFF-THE-SHELF AC EFFICIENT ELECTRIC COOKING APPLIANCES IN NAIROBI & POTENTIALLY OTHER PARTS OF KENYA.

Table 11 shows that participants used multiple fuels in 10% of heating events in Phase 1, but in only 1% of heating events in Phase 2. Table 12 shows that almost all participants used LPG. None used fuelwood.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 11 Number of fuels used in single heating event

	Phase 1		Phase 2	
	Frequency	Percent	Frequency	Percent
0	8	1.0	23	1.7
1	724	88.9	1312	97.4
2	81	10.0	12	0.9
3	1	0.1	0	0.0
Total	814	100.0	1347	100.0

FUEL STACKING IS CLEARLY PART OF THE KITCKEN ROUTINE FOR KENYAN COOKS: EVERY HHS REPORTED USING AT LEAST 2 FUELS & 10% OF HEATING EVENTS USED MULTIPLE FUELS.

Table 12 Use of fuels by participants (both phases)

	Electricity	LPG	Kerosene	Charcoal
HH1	x	x		
HH2	x	x		
HH3	x	x		x
HH$	x	x		
HH5	x	x		
HH6	x	x	x	
HH7	x	x		
HH8	x		x	x
HH9	x		x	
HH10	x	x		
HH11	x	x	x	
HH12	x	x	x	x
HH13	x	x		
HH14	x	x		
HH15	x	x		
HH16	x	x		x
HH17	x	x		
HH18	x	x		
HH19	x	x		

ALTHOUGH 13 PARTICPANTS REPORTED USING CHARCOAL IN THE REGISTRATION SURVEY, ONLY 4 ACTUALLY DID DURING THE STUDY. THIS IS LIKELY DUE TO THE LOGGING BAN INTRODUCED JUST BEFORE THE STUDY BEGAN, WHICH CAUSED CHARCOAL PRICES TO DOUBLE.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

3.2.2 Per capita consumptions

As noted above, energy consumption depends on the number of people being cooked for. Per capita energy consumptions have been calculated simply by dividing the energy consumption for the heating event by the number of people that the meal was cooked for. Note that adults and children have been given an equal weighting when calculating per capita consumptions.

During Phase 1, different participants used different fuels, so per capita energy consumption values will depend on the fuel being used. A single fuel was used in most heating events (Table 11), so per capita consumptions for heating events using a single fuel only have been calculated (Table 13). This table presents data from 553 out of 814 heating events in Phase 1. Totals indicate that cooking with charcoal uses five times as much energy as cooking with kerosene, six times as much energy as cooking with LPG, and thirteen times as much energy as cooking with electricity (in Phase 2). These figures should be treated with caution as, given the small number of records for charcoal and kerosene use, it cannot be assumed that all fuels are used for similar purposes. It can be stated with more confidence that LPG uses twice as much energy as electricity.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 13 Per capita energy consumptions and number of people cooked for – single fuels only, results shown only for participants with 5 or more cases.

	PHASE 1 (LPG)			PHASE 1 (Charcoal)			PHASE 1 (Kerosene)			PHASE 2 (Electricity)		
	Median	PPL (mean)	N	Median	PPL (mean)	N	Median	PPL (mean)	N	Median	PPL (mean)	N
HH1	0.39	2.2	18							0.38	2.8	65
HH2	1.14	1.5	42							1.19	1.1	72
HH3	1.17	5.3	18							0.35	4.8	55
HH$	1.01	1.0	10							0.64	1.0	35
HH5	2.17	1.9	43							1.09	1.8	67
HH6	0.95	2.4	26							1.43	1.9	30
HH7	1.03	3.9	27							1.02	4.4	70
HH8				9.60	5.2	18	4.10	4.7	23	0.52	4.2	96
HH9							1.16	3.5	31	0.72	3.2	70
HH10										1.20	3.7	60
HH11	1.68	1.8	12							1.51	1.9	55
HH12	0.43	4.0	12	9.47	5.6	9	1.56	4.8	8	0.41	4.0	62
HH13	1.19	2.9	30							0.44	3.0	47
HH14	1.64	5.8	26							0.58	4.5	81
HH15	0.86	2.4	26							0.91	1.9	30
HH16	1.69	4.2	32							0.55	3.2	116
HH17	6.38	3.2	66							0.83	3.5	62
HH18	0.90	3.0	37							0.74	2.7	70
HH19	3.53	3.4	38							0.83	3.1	75
Total	1.49	3.1	464	9.47	5.3	27	2.03	4.1	62	0.72	3.1	1218

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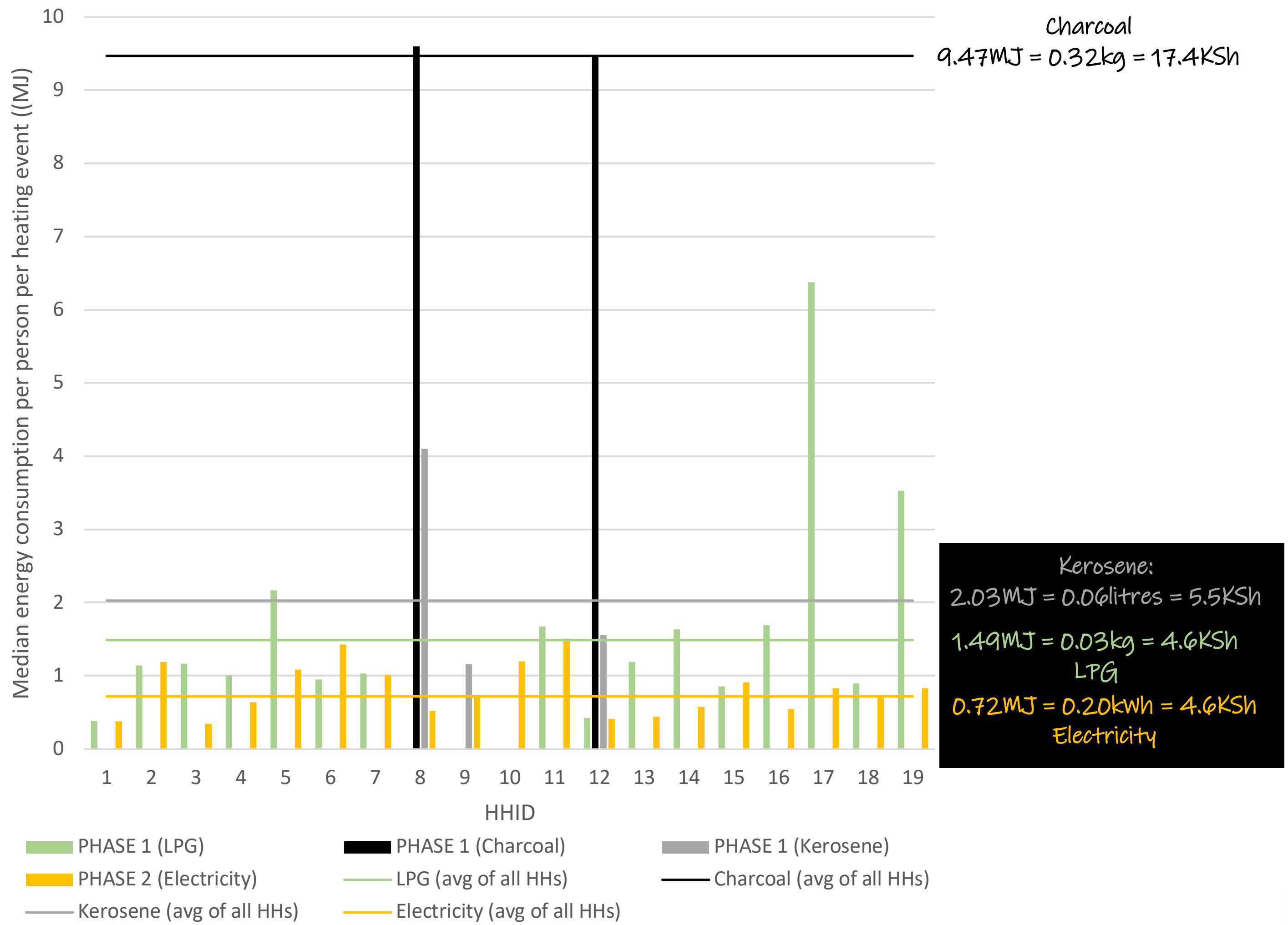

Figure 10: Per capita energy consumptions for single fuel heating events by household.

THE LIMITED DATA AVAILABLE SUGGESTS THAT COOKING WITH CHARCOAL USES:

- 5x AS MUCH ENERGY & COSTS 3x AS MUCH AS KEROSENE
- 6x AS MUCH ENERGY & COSTS 4x AS MUCH AS LPG
- 13x AS MUCH AS ENERGY & COSTS 4x AS MUCH AS ELECTRICITY

HOWEVER, IT CAN BE STATED WITH MORE CONFIDENCE THAT COOKING WITH LPG USES TWICE AS MUCH ENERGY, BUT COSTS THE SAME AS ELECTRICITY.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

The main fuel used in Phase 1 was LPG and Figure 11 plots median per capita energy used against the mean number of people, but only for heating events where only LPG was used. Sharon seems to be a bit of an outlier, and inspection of the data suggests that her house girl had trouble weighing the LPG cylinder. Similarly, Winnie had trouble weighing the cylinder. There was no evidence that the per capital energy consumption was linked to the number of people cooked for.

WEIGHING THE LPG CYLINDERS WAS CHALLENGING & NEEDS TO BE ADDRESSED TO IMPROVE THE QUALITY OF THE DATA & THE EXPERIENCE OF THE PARTICICPANTS.

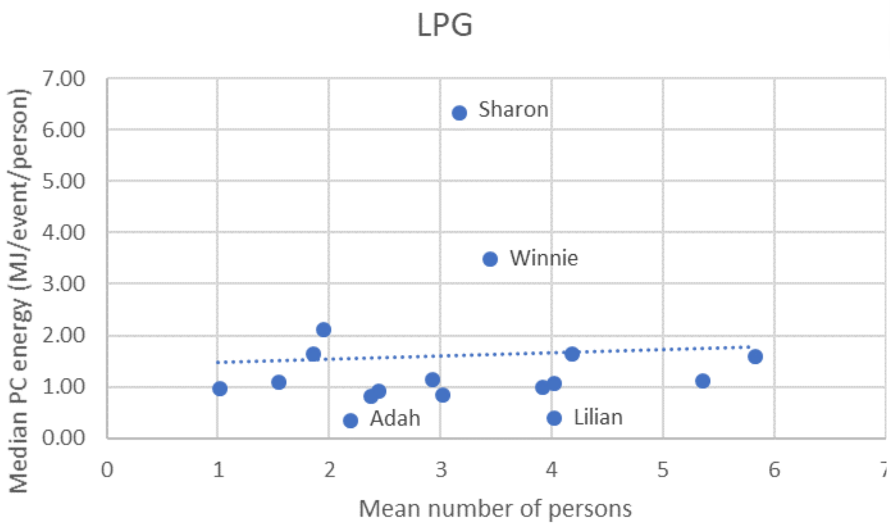

Figure 11 Relationship between per capita energy consumption and number of people – Phase 1 LPG

Figure 12 presents consumption data for Phase 2, but only those heating events where just electricity was used. Note the difference in scales between Figure 11 and Figure 12. A regression analysis shows that per capita electrical energy consumption goes down when cooking for larger numbers of people ($\beta = -0.145$, $p < 0.001$).

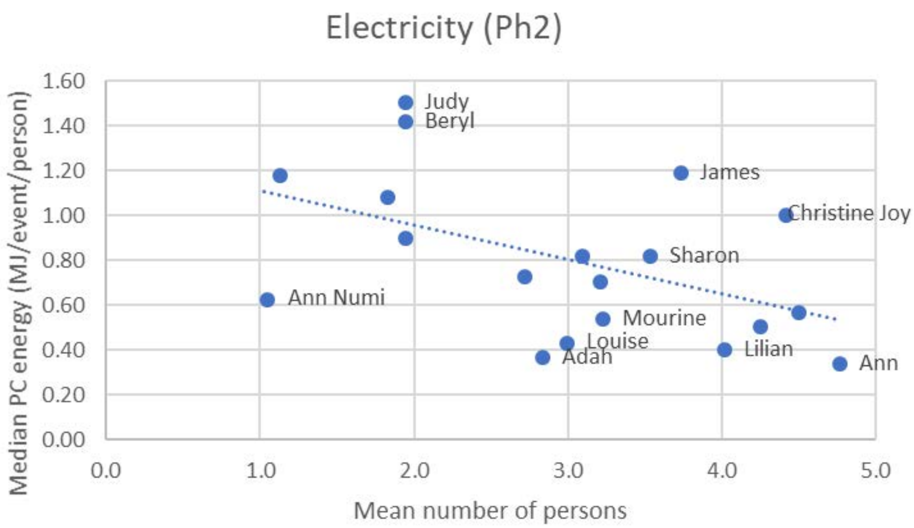

Figure 12 Relationship between per capita energy consumption and number of people – Phase 2

These findings indicate that economies of scale can be achieved when using electricity, suggesting that participants had not mastered controlling cooking. LPG, in contrast, can be turned down and switched off instantly, and did not exhibit any economies of scale.

3.2.3 Energy consumption by heating event

Summing the energy consumed in all Phase 1 records shows that dinners consumed the most energy, closely followed by breakfasts and lunches. Figure 13 shows that charcoal was only used for lunches and dinners, and it is interesting to note that less LPG is used in preparing lunches. The mix of fuels used for different events in Phase 1 is also illustrated in Figure 14. Note that this chart presents the number of occasions (or cases) in which fuels were used – it does not reflect the amount of energy used, which is presented in Figure 13. It shows that:

- LPG was the fuel of choice for all types of event;
- kerosene and electricity were used an equal number of times for breakfasts and dinners; and
- electricity was used almost as much as LPG for heating water.

DINNERS WERE FOUND TO BE THE MOST ENERGY-INTENSIVE MEAL ON THE KENYAN MENU – BAD NEWS FOR UTILITIES, AS THIS COINCIDES WITH PEAK DEMAND FOR ELECTRICITY.

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The median per capita energy consumptions for each type of heating event illustrate differences in the overall conversion efficiencies associated with different fuels (Figure 15). Figures in Table 14 to Table 18 show that for most fuels, heating water was the most energy intensive heating event (on a per capita basis). The next most energy intensive event was lunch (LPG) and dinner (electric).

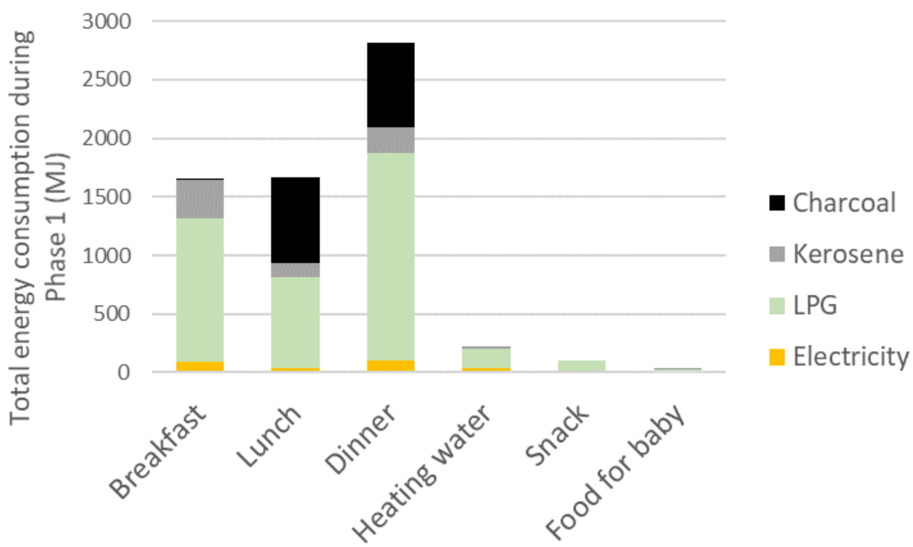

Figure 13 Total energy consumption by heating event (Phase 1)

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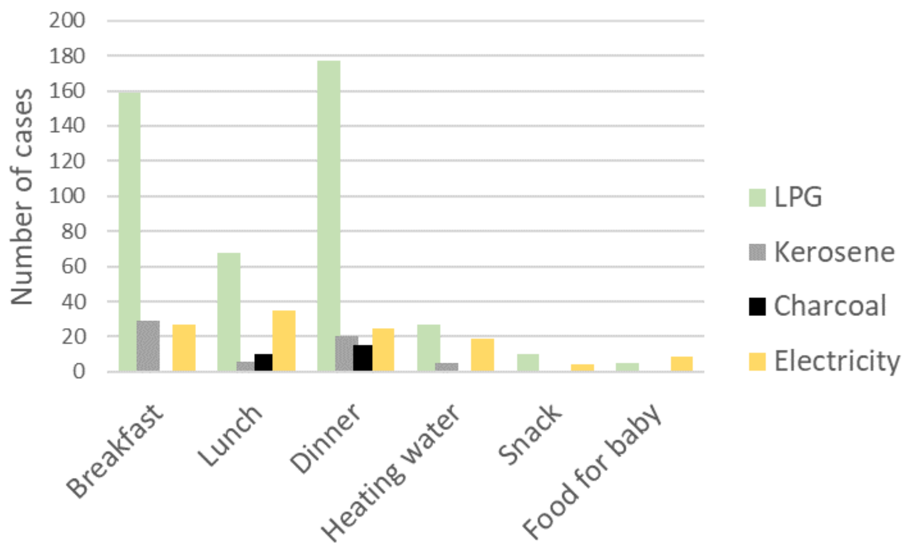

Figure 14 Choice of fuels for heating events (Phase 1)

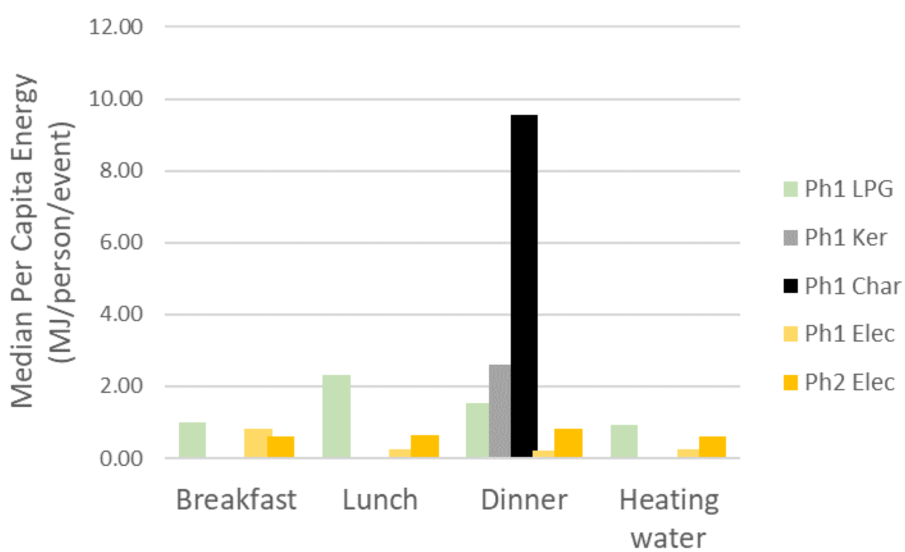

Figure 15 Per capita energy consumptions for different heating events

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Table 14 Per capita energy consumption by heating event – Phase 1 Electricity only

Heating event	Frequency	Mean (MJ/pers/event)	Median (MJ/pers/event)	Std.dev.	25% Quartile	75% Quartile
Breakfast	2	0.83	0.83	1.15	0.01	.
Lunch	29	0.39	0.23	0.48	0.13	0.47
Dinner	11	0.60	0.23	0.65	0.09	1.16
Heating water	19	1.48	**1.06**	0.97	1.02	1.44
Food for baby	3	0.60	0.24	0.63	0.23	.

Table 15 Per capita energy consumption by heating event – Phase 1 LPG only

Heating event	Frequency	Mean (MJ/pers/event)	Median (MJ/pers/event)	Std.dev.	25% Quartile	75% Quartile
Breakfast	17	1.10	1.01	1.01	0.33	1.59
Lunch	60	4.64	2.33	4.97	1.13	7.56
Dinner	132	2.43	1.55	2.43	0.97	3.15
Heating water	27	4.92	**2.17**	5.48	0.90	5.38
Snack	6	1.04	0.92	0.63	0.43	1.79
Food for baby	4	2.07	1.12	2.22	0.73	4.37

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 16 Per capita energy consumption by heating event – Phase 1 Kerosene only

Heating event	**Frequency**	**Mean (MJ/pers/event)**	**Median (MJ/pers/event)**	**Std.dev.**	**25% Quartile**	**75% Quartile**
Dinner	9	2.12	2.62	0.85	1.13	2.87
Heating water	5	2.62	0.76	3.72	0.49	5.67

Table 17 Per capita energy consumption by heating event – Phase 1 Charcoal only

Heating event	**Frequency**	**Mean (MJ/pers/event)**	**Median (MJ/pers/event)**	**Std.dev.**	**25% Quartile**	**75% Quartile**
Dinner	6	9.01	9.55	2.21	8.12	10.24

Table 18 Per capita energy consumption by heating event – Phase 2 Electricity only

Heating event	**Frequency**	**Mean (MJ/pers/event)**	**Median (MJ/pers/event)**	**Std.dev.**	**25% Quartile**	**75% Quartile**
Breakfast	33	0.76	0.59	0.52	0.39	1.12
Lunch	185	0.86	0.65	0.82	0.33	1.10
Dinner	319	1.12	0.81	1.11	0.48	1.30
Heating water	45	1.03	**1.12**	0.44	0.84	1.26
Snack	6	0.65	0.61	0.37	0.34	0.91
Food for baby	2	3.25	3.25	0.09	3.18	.

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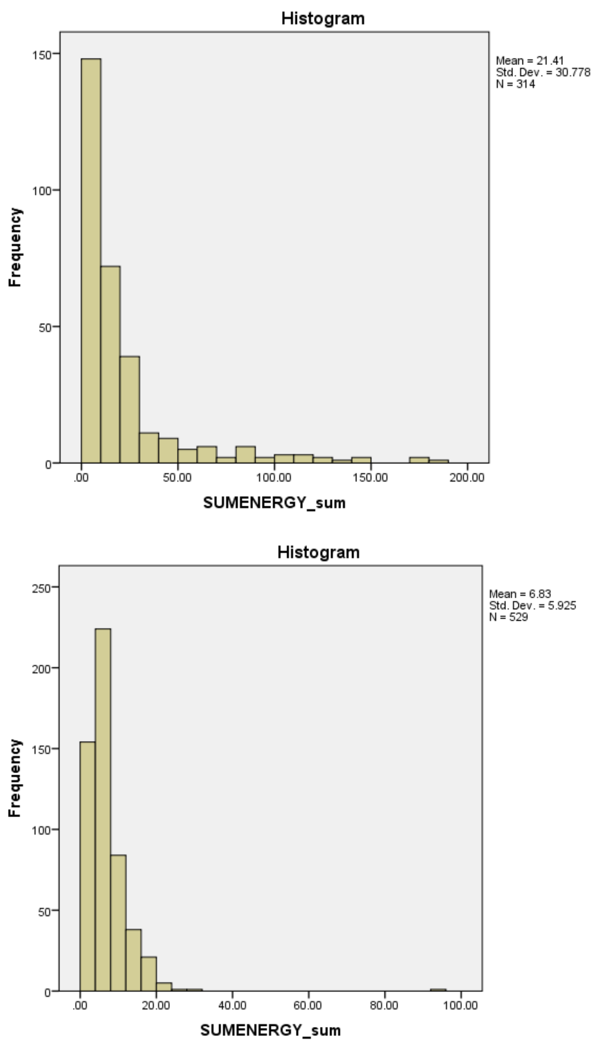
3.2.4 Energy consumption per day

The total energy consumed per day has been calculated as the sum of the energy consumption of all heating events on a given date. Data has been calculated for 314 person-days in Phase 1 and 529 person-days in Phase 2. The distributions of daily energy consumption in Phase 1 and Phase 2 are presented in Figure 16 respectively. Note that both of these charts include multiple sources of energy used in any given day.



EFFICIENT COOKS USE ROUGHLY THE SAME AMOUNT OF ENERGY ON LPG AND ELECTRICITY (0.4MJ/EVENT/PERSON), WHILST INEFFICIENT COOKS USE ALMOST TWICE AS MUCH LPG (2.2 VS 1.2 MJ/EVENT/PERSON). THIS IS LIKELY BECAUSE THE EPC & RICE COOKER ARE AUTOMATICALLY CONTROLLED APPLIANCES, AS OPPOSED TO THE HOTPLATE & LPG, WHICH ARE BOTH MANUAL.

Figure 16 Distribution of daily energy consumption (MJ/day) - Phase 1, baseline fuels (left); Phase 2, electricity with occasional other fuel use (right).

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Daily energy consumptions for three participants in Phase 1 have been plotted in Figure 17. These three have been chosen as they represent a range of LPG cooking efficiencies (drawn from Table 13):

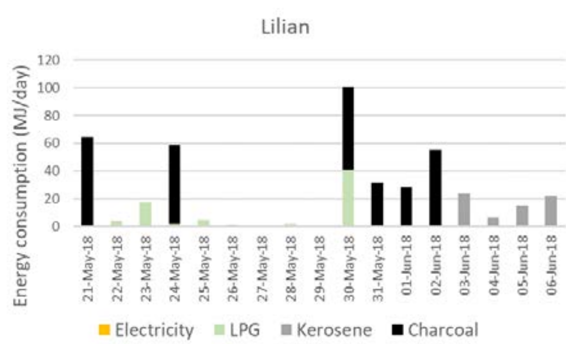
- Lilian – efficient: 0.4 MJ/event/person (median); mean of 4.0 persons/event.
- Louise – average: 1.2 MJ/event/person (median); mean of 2.9 persons/event.
- Bernadette – inefficient: 2.2 MJ/event/person (median); mean of 1.9 persons/event.

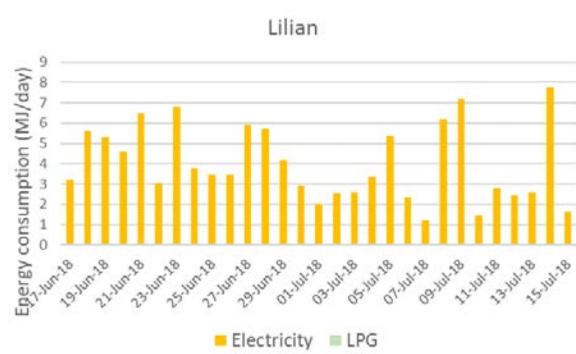
Figure 17 shows a similar set of charts for Phase 2, again drawn from Table 13:

- Lilian – efficient: 0.4 MJ/event/person (median); mean of 4.0 persons/event.
- Winnie – average: 0.8 MJ/event/person (median); mean of 3.1 persons/event.
- James – inefficient:1.2 MJ/event/person (median); mean of 3.7 persons/event.

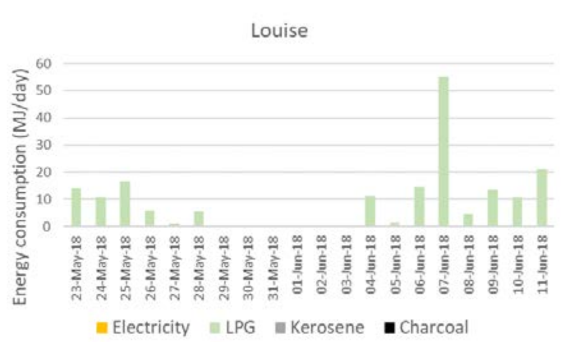
Phase 1	Phase 2

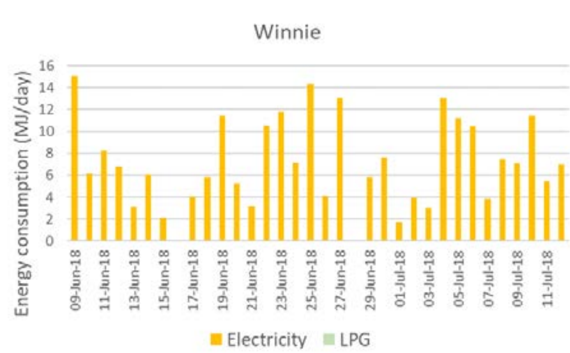
Efficient





Average





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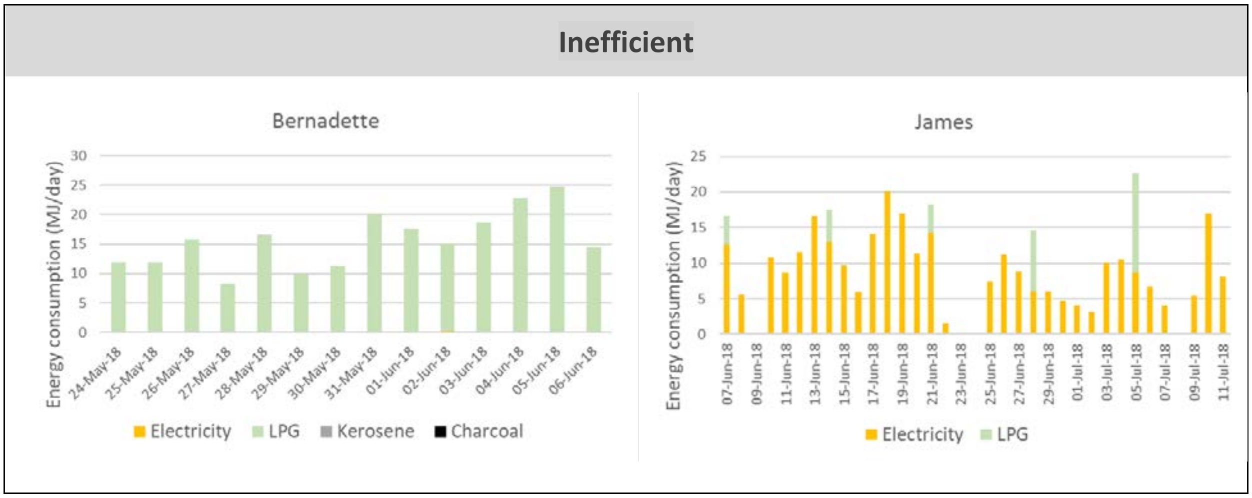
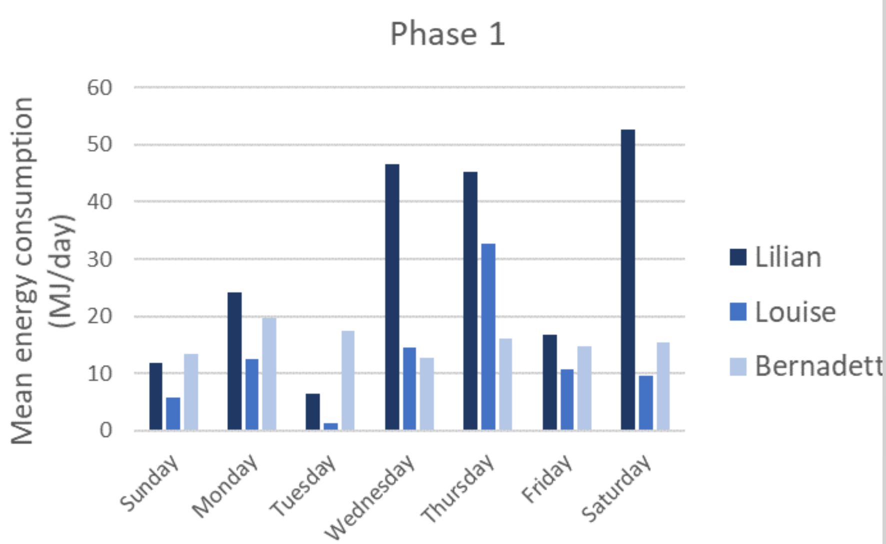


Figure 17 Daily energy consumption - time series (example participants) – Phase 1 (left), Phase 2 (right).

Several of the charts in Figure 17 suggest consistent daily energy consumption, with odd anomalies (or spikes), representing special occasions of some sort. An analysis of mean energy consumption by day of the week shows little consistency between the three example participants, nor between Phase 1 and Phase 2. There does appear to be a vague trend in Phase 1 that Lilian and Louise used less energy on Sundays and Tuesdays. Note that these figures typically represent the means of only 2 to 5 days.

INTER-DAILY VARIATION WAS MUCH HIGHER IN PHASE 1 THAN PHASE 2. THIS IS LIKELY PARTLY DUE TO THE EFFECT OF THE EPC, WHICH SIGNIFICANTLY REDUCES THE ENERGY CONSUMPTION OF THE BIGGEST ENERGY CONSUMERS (LONG BOILING DISHES). THIS EFFECT IS PARTICULARLY IMPORTANT FOR ECOOK SYSTEMS, WHERE SIZING THE BATTERY IS MUCH EASIER FOR A REGULAR DAILY LOAD.



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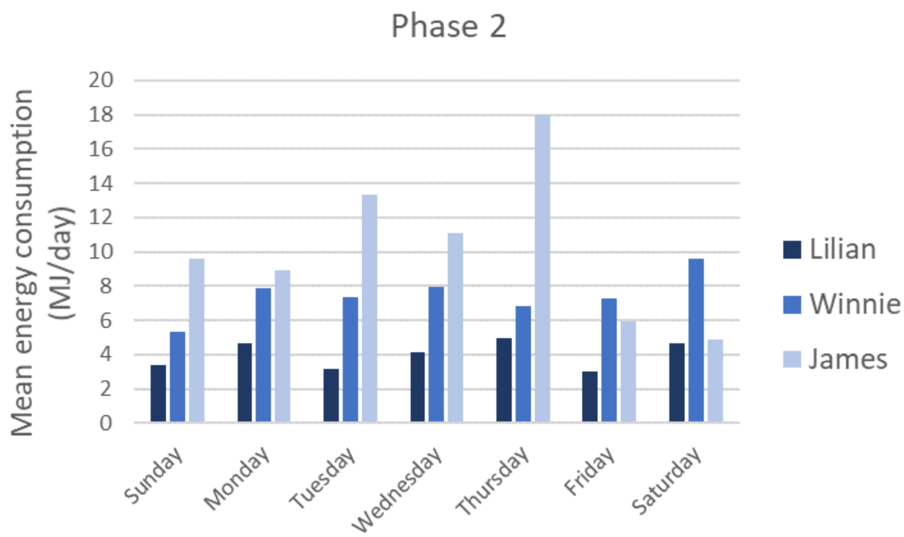

Figure 18 Mean daily energy consumption by day of the week

In order to compare the energy required by different fuels to meet daily household needs, an analysis has been conducted on only those days in which a single fuel was used for all heating events recorded in a day. Among the small number of participants who used charcoal (see Table 12), they tend to mix it with other fuels throughout the day. This means that only 3 days can be identified where a participant used only charcoal for heating – unfortunately not enough to conduct any meaningful analysis.

Not all meals are prepared each and every day (and neither are other heating events). Table 19 shows that dinners are prepared most days (over 80%), and that people most commonly skip lunches (or at least the meal requires no cooking).

Daily household energy consumptions, based on these daily patterns of heating events, are also presented in Table 19. Note that these values have not been normalised for the number of people catered for – rather, they show the range of total daily energy consumptions at the household level, which is dependent on the number of people that each meal was prepared for. The mean number of household members catered for has been calculated for each day (across however many meals were prepared), and the table presents the mean of these means. This indicates that LPG energy consumption is roughly 50% higher than the electrical energy required (and the number of people catered for is similar).

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Table 19 Total daily energy consumption (MJ/household/day) – use of single fuel in a day

	Daily energy consumption (MJ/household/day)					Proportion of days with heating event				Household members (mean of means)
	n	Mean	Q1	Median	Q3	Breakfast	Lunch	Dinner	Water heating	
Charcoal (Phase 1)	3									
Kerosene (Phase 1)	17	16.5	6.3	10.0	21.4	82.4%	11.8%	94.1%	17.6%	4.0
LPG (Phase 1)	129	18.5	3.5	8.1	19.0	76.0%	37.2%	77.5%	20.9%	3.2
Electricity (Phase 2)	431	6.1	3.4	5.1	7.8	79.8%	42.9%	83.8%	13.5%	3.1

3.2.5 24 hour electricity load profiles

The energy consumption for any given day has been estimated from records for multiple heating events (e.g. breakfast, lunch, dinner, heating water) – see Table 19. For each heating event, average power consumption has been calculated for the time period during which the meal was prepared by dividing the energy consumption by the time duration of the heating event (both start and end times for the preparation of the meal were recorded for each heating event). Load patterns have been added together for multiple heating events occurring on the same date to create a 24 hour load profile for each day, for each household.

MEDIAN DAILY ENERGY CONSUMPTIONS FOR PARTICIPATING HOUSEHOLDS COOKING ALL THEIR FOOD WITH ELECTRICITY WERE FOUND TO BE 0.45 KWH PER PERSON (1.6MJ), OR 1.4 KWH PER HH (5.1MJ).

Two types of chart have been created:

- A multiple line chart showing 24 hour profiles for seven days (not necessarily consecutive days making up a week); this illustrates how much the shape of daily load profiles changes from day to day;
- A single line chart in which all daily load profiles have been aggregated together to give a smoother 'average' profile.

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While these load profiles give a good idea of the overall patterns of consumption, they are conservative, in that they do not include all electricity consumed. There are several reasons for this:

- Some records were omitted because they had incomplete (or nonsensical) electricity meter readings.
- Many records had incomplete start/end times for the heating event
- Some combinations of energy consumption and event duration give unreasonably high power levels, so a filter has been used to include only those records with an average power of 2.5 kW or less.

Load profiles for each household are presented in Figure 19, and an aggregated profile based on all daily profiles calculated for all households is presented in Figure 20. Three categories of profile can be seen in Figure 19:

- 3 peaks – morning, midday, and evening e.g. Household ID 8, 17;
- 2 peaks – morning and evening e.g. Household ID 9, 10, 14;
- 1 peak in the evening e.g. Household ID 6, 18.

Although preparing three meals a day appears to be the norm (amongst this limited sample), it is proposed that modern urban lifestyles tend to disrupt this trend. Table 20 shows that participants whose household exhibited only a single peak in load in the evening tended to be younger and lived in smaller households. The load profiles suggest that these participants rarely prepared a cooked meal in the morning before going to work, and then cooked only a single meal in the evening after returning from work.

Table 20 Characteristics of households in categories of load profiles

Household ID	Age	Number of household members
3 peaks		
8	42	5
17	28	4
2 peaks		
9	54	4

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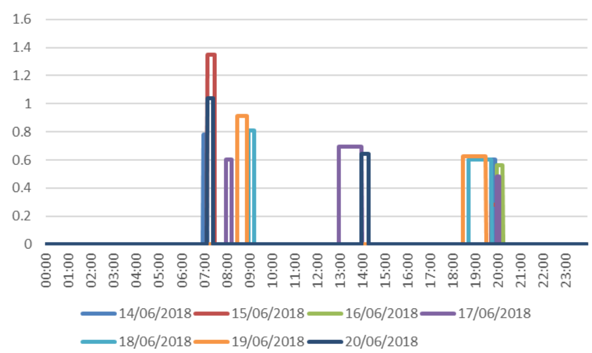
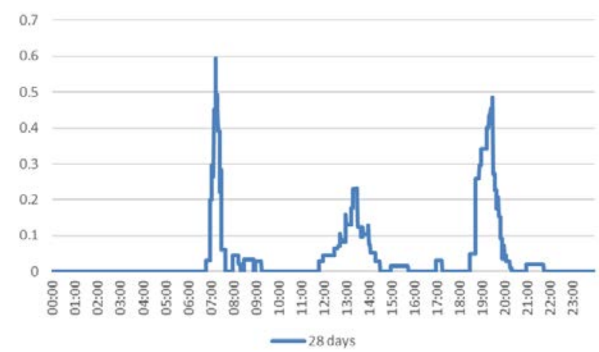
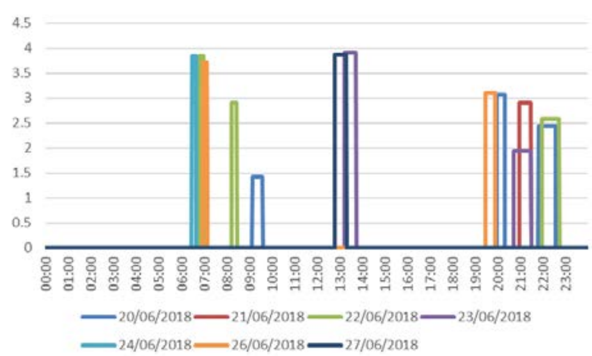
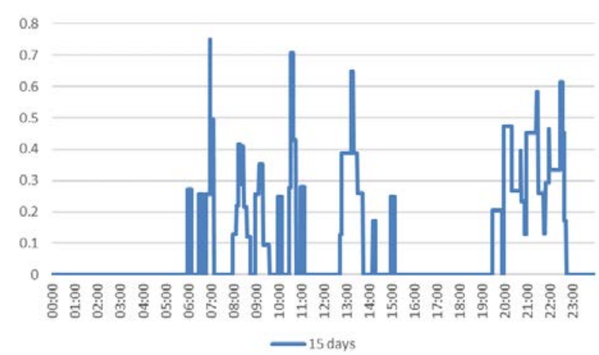
10	40	4
14	52	6
1 peak		
6	24	3
18	25	3

Because of the variation in load profiles found among participants' households, the aggregated load profile is relatively smooth, although it still exhibits three distinct peaks (Figure 20).

ID	7 day chart	Aggregate chart (all records)
1		
2		

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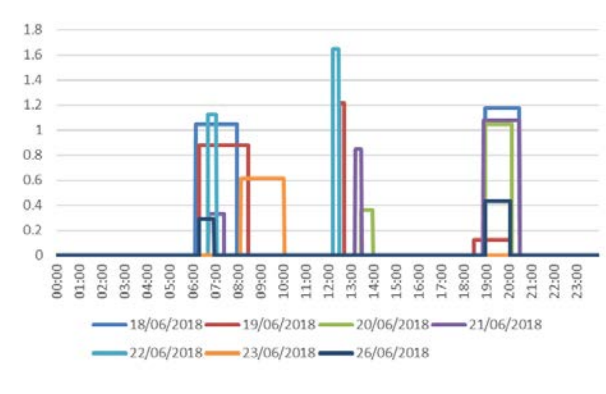

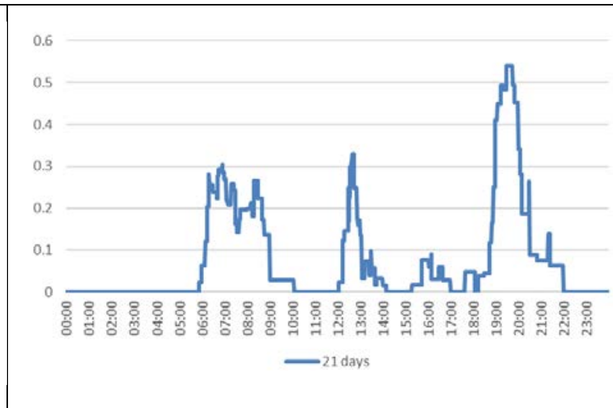

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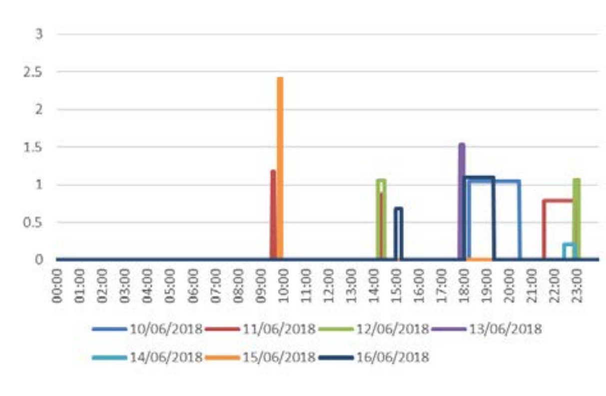

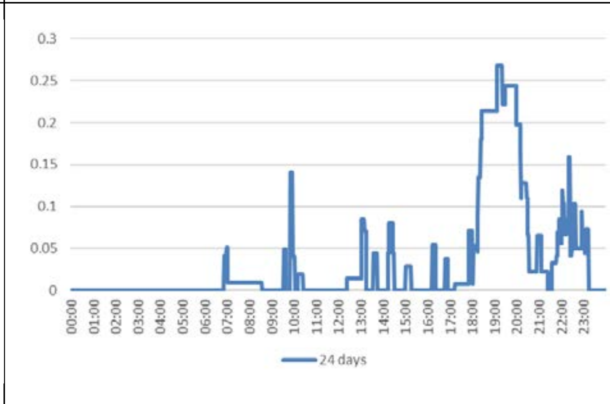

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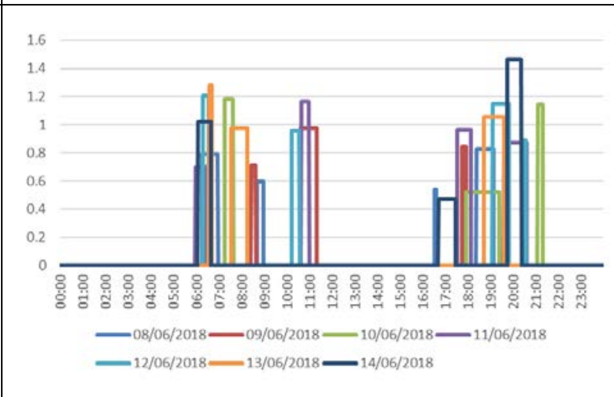

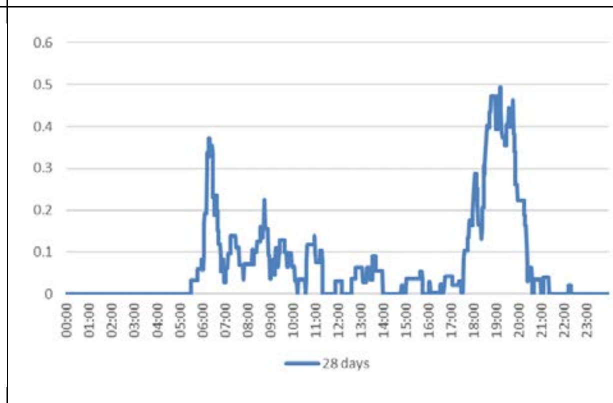

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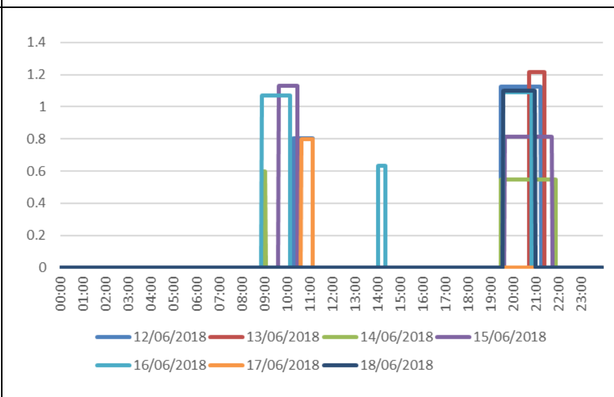

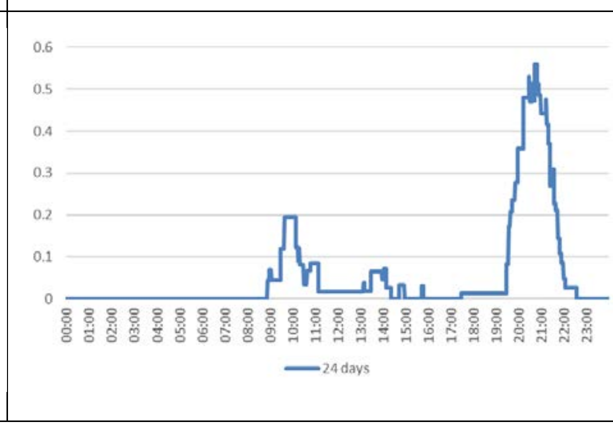

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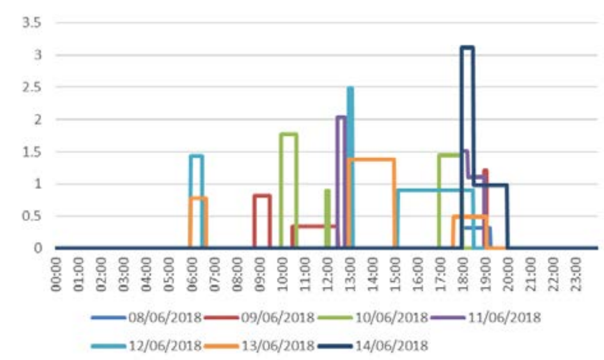

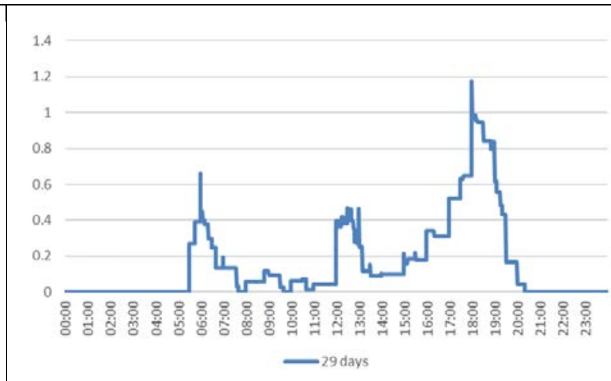

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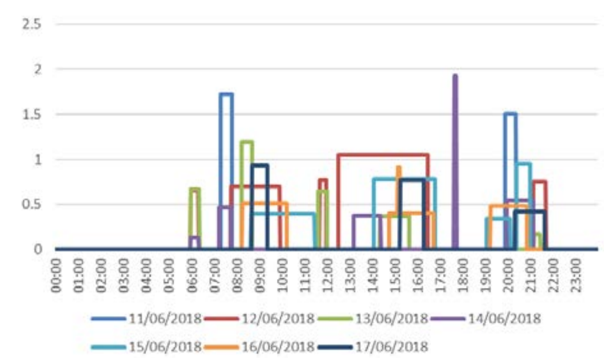

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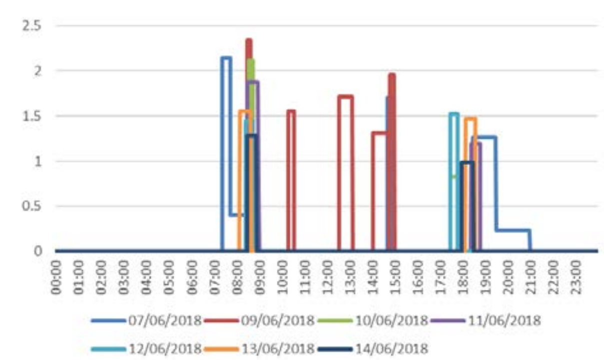

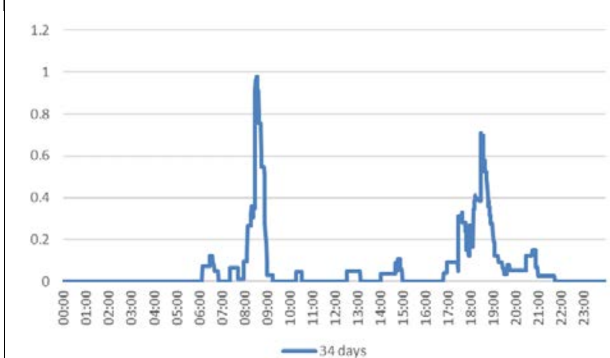

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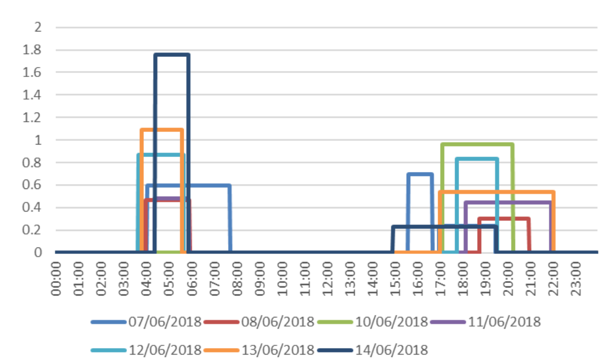

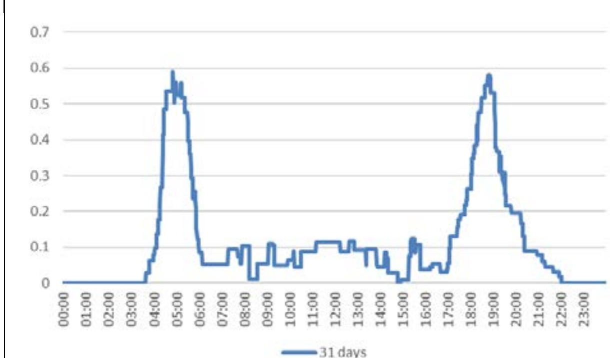

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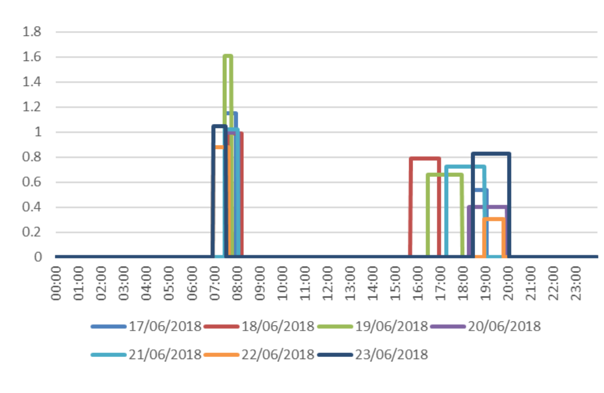

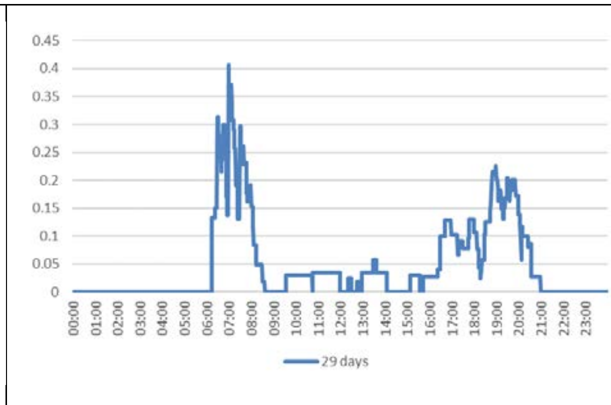

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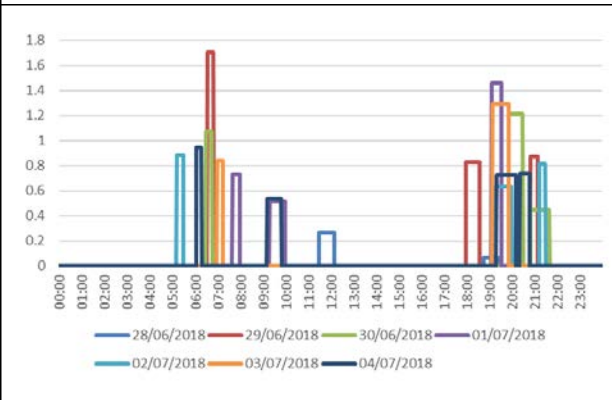

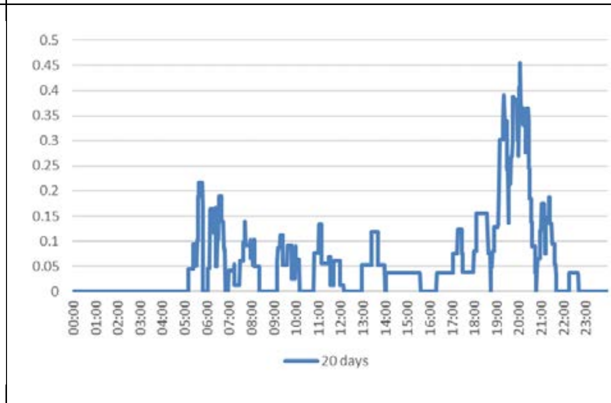

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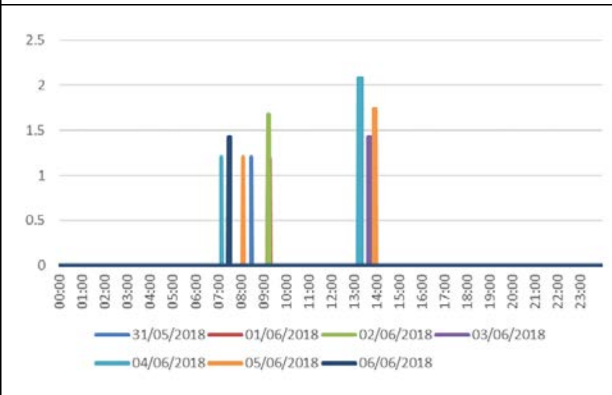

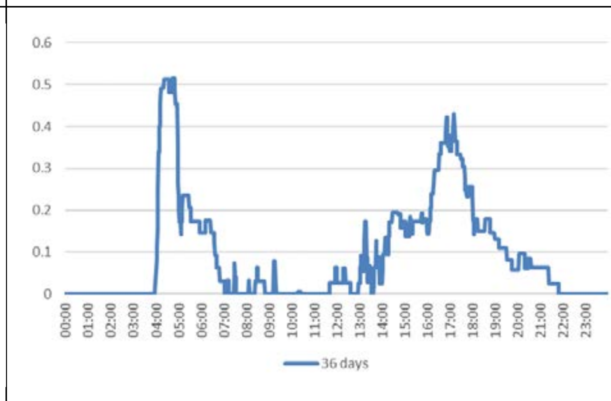

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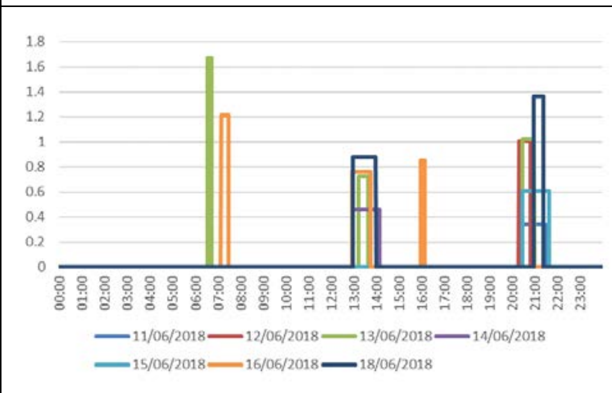

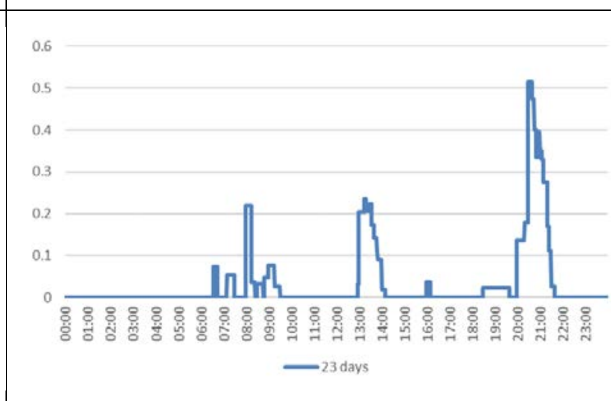

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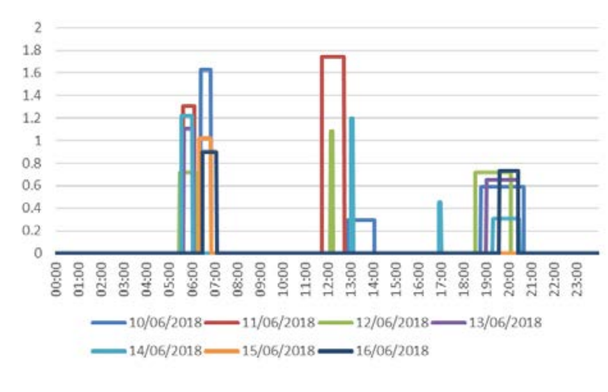

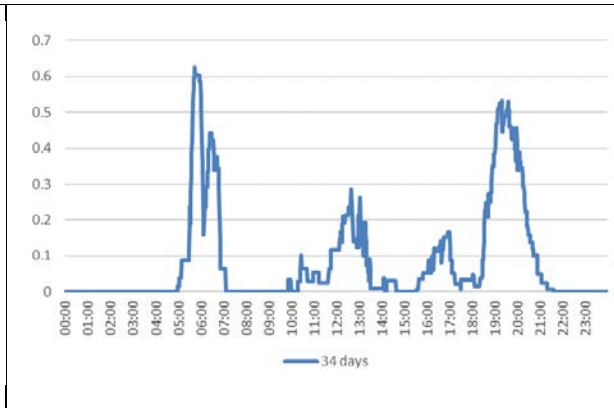

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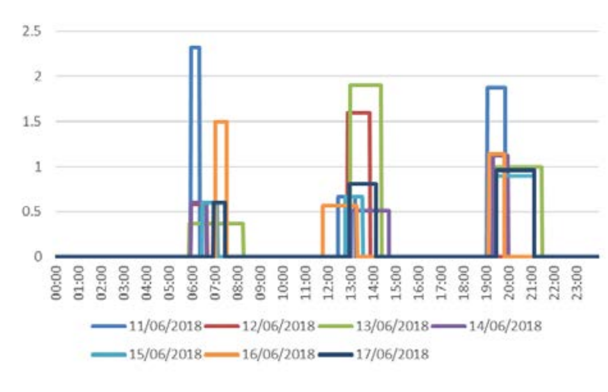

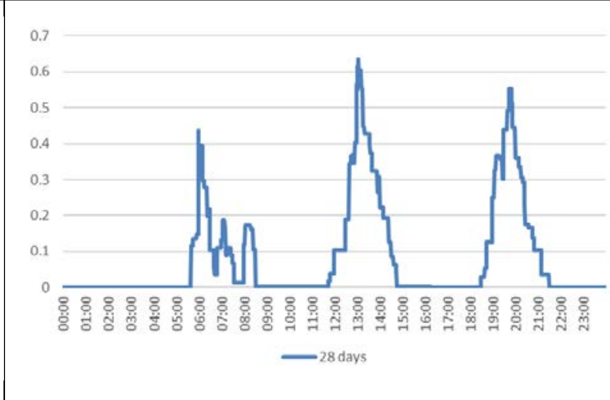

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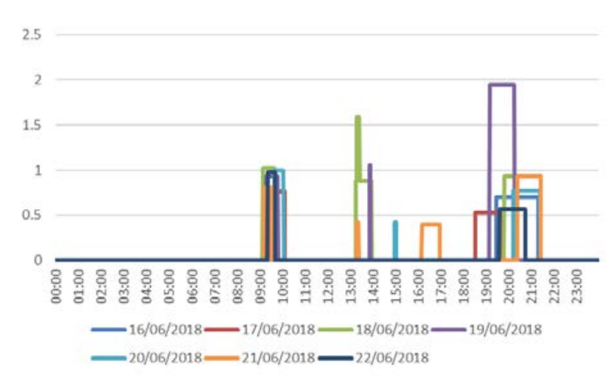

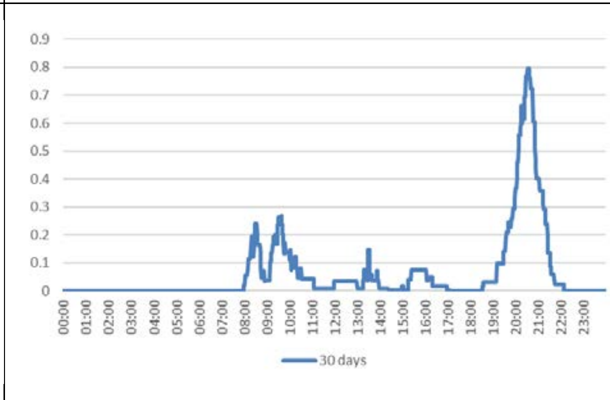

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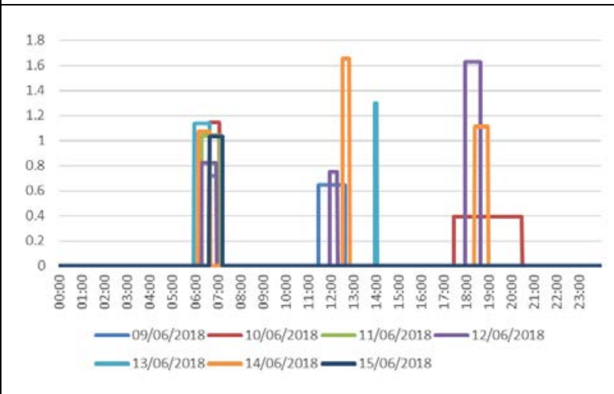

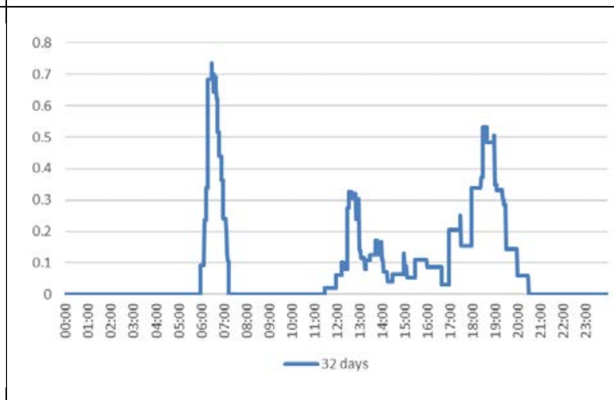

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Figure 19 24 hour load profiles (all households)

Figure 20 24 hour load profile – aggregated from all households

THE AVERAGE LOAD PROFILE SHOWS THAT COOKING CAN OCCUR FROM 3AM UNTIL MIDNIGHT, BUT IS CONCENTRATED INTO MORNING, MIDDAY & EVENING PEAKS, WITH THE LATTER THE MOST SIGNIFICANT. UNFORTUNATELY THIS IS ALSO PEAK TIME FOR MOST UTILITIES & MINI-GRIDS. IMPORTANTLY FOR SOLAR ELECTRIC COOKING, IT IS AFTER THE SUN HAS SET, HOWEVER THIS MAY BE EARLIER IN A RURAL CONTEXT, WHERE DAYLIGHT HOURS HAVE MORE INFLUENCE ON DAILY ROUTINES.

3.3 Meals cooked

3.3.1 Food types cooked

Separating out foods cooked for breakfast, lunch or dinner only, Table 21 shows a high degree of consistency in the mix of foods cooked in both phases i.e. cooking with electricity did not cause participants to change what they cooked. There are a couple of exceptions e.g. when cooking with electricity, participants were less likely to cook leafy vegetables in particular, but also beans/peas, githeri/mokimo and chapatis/pancakes. Chapatis and pancakes require a medium temperature frying, with evenly distributed heat across the pan, otherwise parts of the chapati/pancake will burn and others will remain uncooked. They also require frequent access to the pan with a hand or spatula, so the utensil must be shallow. Therefore the hotplate is the only one of the 3 appliances that could cook these dishes, however the heat it produced was concentrated in the centre of the pan, especially for lower power levels, where only part of the spiral heats up.

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Leafy vegetables are very easy and quick to cook on almost any fuel, so it could be that participants decided to cook tougher foods that usually take a long time, but are much quicker on the EPC. This is supported by the increase in meat-based dishes, however, it is contradicted by the decrease in the frequency of githeri/mokimo and beans/peas. It could be that as electricity consumption was subsidised for participants during phase 2, they decided to spend their savings on meat, which is certainly one of the most expensive ingredients and may be considered by many as a luxury.

N.B. food information was not submitted in all records. 80% of breakfast/lunch/dinner records in Phase 1 and 76% of records in Phase 2 contained details of types of food prepared.

THE MINIMAL CHANGE IN THE MENU WHEN TRIALING ECOOKING IN PHASE 2 SHOWS THAT THE ELECTRIC APPLIANCES ON TRIAL WERE ABLE TO COOK ALL POPULAR DISHES & SUGGESTS THAT KENYAN CUISINE IS HIGHLY COMPATIBLE WITH ECOOKING.

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Table 21 Number of meals containing food types (Breakfast, lunch and dinner heating events only).

	Phase 1 N = 559		Phase 2 N = 913		
	Frequency	Percent	Frequency	Percent	% change
Eggs	60	10.70%	96	10.50%	-0.2%
Meat	105	18.80%	193	21.10%	2.3%
Ugali	140	25.00%	231	25.30%	0.3%
Fish	24	4.30%	45	4.90%	0.6%
Chapati/pancake	53	9.50%	68	7.40%	-2.1%
Githeri/mokimo	47	8.40%	62	6.80%	-1.6%
Pasta/noodles	30	5.40%	62	6.80%	1.4%
Mandazi	1	0.20%	10	1.10%	0.9%
Porridge	41	7.30%	61	6.70%	-0.6%
Pilau	10	1.80%	15	1.60%	-0.2%
Chips	14	2.50%	12	1.30%	-1.2%
Rice	156	27.90%	257	28.10%	0.2%
Sausages	9	1.60%	14	1.50%	-0.1%
Matumbo	12	2.10%	12	1.30%	-0.8%
Matoke	7	1.30%	26	2.80%	1.5%
Chicken	20	3.60%	32	3.50%	-0.1%
Leafy veg	162	29.00%	229	25.10%	-3.9%
Beans/peas	160	28.60%	247	27.10%	-1.5%
Potatoes/pumpkin	55	9.80%	100	11.00%	1.2%
Other	25	4.50%	49	5.40%	0.9%

Table 22 shows that participants were just as likely to prepare complex meals with multiple dishes in Phase 2. It can be seen from Table 23 that some foods tend to be eaten on their own, such as eggs, githeri, and porridge. Others, such as meat, and leafy vegetables, tend to be eaten in complex meals (3 food types).

Table 22 Number of foods included in a heating event (Breakfast, lunch and dinner heating events only)

Number of food types in meal	Phase 1		Phase 2		Total
	Frequency	Percent	Frequency	Percent	
1	160	29%	272	30%	432
2	231	41%	381	42%	612
3	163	29%	254	28%	417

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4	5	1%	5	1%	10
5	0	0%	1	0%	1
Total	559	100%	913	100%	1472

Table 23 Occurrence of foods in meals by number of foods in the meal (all heating events, Phase 1 and 2)

Food type	Number of food types in meal				
	1	2	3	4	5
Eggs	66	35	53	1	1
Meat	9	100	182	6	1
Ugali	14	171	183	3	
Fish	3	26	40		
Chapati/pancake	35	55	29	1	1
Githeri/mokimo	51	22	36		
Pasta/noodles	19	35	38		
Mandazi	3	4	4		
Porridge	64	29	9		
Pilau	17	5	3		
Chips	7	17	2		
Rice	22	239	145	7	
Sausages	10	10	2	1	
Matumbo	2	6	14	2	
Matoke	16	8	8	1	
Chicken	3	31	18		
Leafy veg	7	132	247	5	
Beans/peas	36	214	149	7	1
Potatoes/pumpkin	31	53	64	6	1
Other	17	32	25		

1/4 OF ALL MEALS ARE REHEATED, WHICH HAS SIGNIFICANT IMPLICATIONS FOR ENERGY DEMAND, AS REHEATING USES ROUGHLY HALF THE ENERGY OF COOKING FROM FRESH. LUNCHES ARE THE MOST COMMONLY REHEATED MEAL (2/5), WHILST DINNER IS THE LEAST LIKELY TO BE REHEATED (1/7).

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3.3.2 Reheating food

For each food item prepared, participants were asked if the dish was fresh, reheated, or partially cooked. Results for all those records that contained only a single heating event are presented in Table 24. This shows that dinners are almost always cooked fresh, but nearly one half of breakfasts and lunches are reheated. Overall, 24% of meals were reheated (25% in Phase 1 and 23% in Phase 2). Note also that these patterns were not altered when cooking with electricity in Phase 2.

Table 24 Number of meals fresh or reheated (single heating event records only)

Phase 1								
	Fresh		Reheated		Partially cooked		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Breakfast	74	61%	46	38%	2	2%	122	100%
Lunch	77	56%	58	42%	3	2%	138	100%
Dinner	237	87%	25	9%	10	4%	272	100%
Snack	11	73%	4	27%	0	0%	15	100%
Food for baby	8	53%	7	47%	0	0%	15	100%
Phase 2								
	Fresh		Reheated		Partially cooked		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Breakfast	119	63%	70	37%	0	0%	189	100%
Lunch	129	57%	93	41%	6	3%	228	100%
Dinner	412	87%	42	9%	17	4%	471	100%
Snack	2	25%	6	75%	0	0%	8	100%
Food for baby	2	100%	0	0%	0	0%	2	100%

To find out which foods were most commonly reheated, cases in which a food was cooked in a meal were tagged as either fresh or reheated (where information was available). Results collated across all three dishes are presented in Table 25 and show that pilau, fish, beans, and githeri were most commonly reheated (in terms of proportion of times they were cooked). In absolute terms, it was rice and beans that were most often reheated.

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Table 25 Food types most commonly reheated (individual dishes, cooked as part of meals).

	Fresh	Reheated	Total
Eggs	**156 (96%)**	**7 (4%)**	**163**
Meat	**209 (70%)**	**89 (30%)**	**298**
Ugali	**340 (90%)**	**36 (10%)**	**376**
Fish	**35 (58%)**	**25 (42%)**	**60**
Chapati/pancake	**83 (68%)**	**39 (32%)**	**122**
Githeri/mokimo	**59 (60%)**	**40 (40%)**	**99**
Pasta/noodles	**70 (75%)**	**23 (25%)**	**93**
Mandazi	**7 (64%)**	**4 (36%)**	**11**
Porridge	**74 (63%)**	**44 (37%)**	**118**
Pilau	**12 (48%)**	**13 (52%)**	**25**
Chips	**20 (69%)**	**9 (31%)**	**29**
Rice	**263 (62%)**	**161 (38%)**	**424**
Sausages	**25 (100%)**		**25**
Matumbo	**24 (96%)**	**1 (4%)**	**25**
Matoke	**29 (81%)**	**7 (19%)**	**36**
Chicken	**39 (70%)**	**17 (30%)**	**56**
Leafy veg	**310 (79%)**	**83 (21%)**	**393**
Beans/peas	**236 (60%)**	**160 (40%)**	**396**
Potatoes/pumpkin	**123 (73%)**	**46 (27%)**	**169**
Other	**75 (84%)**	**14 (16%)**	**89**

Reheating food might be expected to take less energy than preparing a meal from scratch (fresh), and indeed this can be seen to be the case both for meals prepared using only LPG in Phase 1 (Table 26) and meals prepared using only electricity in Phase 2 (Table 27). These tables show that reheating lunches and dinners uses roughly half of the energy taken to cook a fresh meal. Reheating breakfasts seemingly saves less energy, but there are too few data points to make a valid comparison.

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Table 26 Per capita energy consumption by heating event and reheating (MJ/pers/event) – Phase 1 LPG only.

Heating event	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast						
Fresh	10	1.30	1.01	1.21	0.34	1.87
Reheated	6	0.88	0.80	0.64	0.27	1.54
Lunch						
Fresh	43	4.83	2.61	5.02	1.12	7.84
Reheated	14	4.66	1.40	5.37	0.77	10.36
Dinner						
Fresh	121	2.52	1.57	2.50	0.97	3.34
Reheated	5	1.13	0.67	1.33	0.22	2.26

Table 27 Per capita energy consumption by heating event and reheating (MJ/pers/event) – Phase 2 electricity only.

Heating event	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast						
Fresh	23	0.81	0.59	0.53	0.40	1.12
Reheated	6	0.37	0.27	0.40	0.08	0.60
Lunch						
Fresh	104	1.09	0.90	0.86	0.54	1.34
Reheated	74	0.58	0.40	0.67	0.24	0.80
Dinner						
Fresh	277	1.18	0.88	1.14	0.57	1.33
Reheated	30	0.48	0.35	0.44	0.21	0.64

Food can only be reheated if it has been cooked in advance. In an urban context such as this, cooked food is often available to purchase, with certain dishes such as chapati and githeri readily available from street vendors. As a result, reheated food may or may not originally have been cooked in the household. Participants were asked to what extent food prepared in each heating event was then available for consumption at a later time. Overall, roughly 40% of heating events produced some food that could be

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eaten later (mostly leftovers). Table 28 shows the breakdown of precooking of food for each type of meal, across the two phases of the survey. This shows:

- Leftovers are most commonly left from dinners, but only in Phase 1.
- No leftovers were saved from dinners when cooking with electric (Phase 2).
- It appears that fewer meals were prepared in advance when cooking with electricity.

The precooking option was intended to capture the practice of partially cooking batches of foods that require long boiling times, such as githeri, beans or tougher meats. Portions of precooked food are stored and a final stage involving reheating and preparing a fresh sauce would take place up to a week later. However, this option was rarely used, so it is suspected that there was confusion between ‘precooking’ and ‘saving leftovers’, as often the first portion of precooked food Is consumed at the time.

Table 28 Number of heating events that produce food that can be eaten later

	No		Saved leftovers		Precooking		Prepared in advance		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Phase 1										
Breakfast	94	78%	21	18%	2	2%	3	3%	120	100%
Lunch	90	67%	37	28%	1	1%	6	4%	134	100%
Dinner	122	48%	125	49%	4	2%	5	2%	256	100%
Snack	9	69%	4	31%	0	0%	0	0%	13	100%
Food for baby	10	67%	4	27%	0	0%	1	7%	15	100%
Phase 2										
Breakfast	155	82%	32	17%	2	1%	0	0%	189	100%
Lunch	163	42%	216	55%	11	3%	1	0%	391	100%
Dinner	228	98%	0	0%	0	0%	5	2%	233	100%
Snack	7	70%	1	10%	0	0%	2	20%	10	100%
Food for baby	6	67%	0	0%	2	22%	1	11%	9	100%

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3.3.3 Energy to cook food types

In this section we identify the energy required to cook various food types and meal combinations. In Phase 1 participants may have used multiple fuels. In order to meaningfully compare the specific energy used to cook different foods and combinations, only records using a single fuel have been included in Table 29 to Table 31. Furthermore, records in which food was reheated have been omitted from the results, as have records in which food was prepared in advance for eating later.

Electrical energy consumption is broken down further in Section 3.4.4 where the efficiency of different electrical devices is discussed.

Table 29 Specific energy consumptions (MJ/pers/event) - single food meals

Food	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Phase 1 LPG						
Beans/peas	3	1.53	1.49	1.25	0.30	.
Chapati/pancake	4	0.77	1.01	0.49	0.28	1.01
Githeri/mokimo	2	6.87	6.87	8.24	1.05	.
Matumbo	2	5.71	5.71	3.01	3.58	.
Other	2	0.58	0.58	0.19	0.45	.
Pasta/noodles	6	2.28	1.92	1.74	1.02	3.36
Pilau	2	4.16	4.16	0.29	3.96	.
Porridge	10	2.36	1.79	2.56	0.85	2.52
Potatoes/pumpkin	3	2.02	0.90	2.14	0.67	.
Phase 2 Electricity						
Beans/peas	8	0.59	0.58	0.32	0.41	0.90
Chapati/pancake	3	1.19	1.12	0.22	1.01	.
Chips	2	1.00	1.00	0.42	0.70	.
Githeri/mokimo	11	1.02	0.71	0.55	0.61	1.44
Matoke	7	2.11	3.49	1.75	0.08	3.51
Meat	8	1.04	0.85	0.55	0.58	1.69
Other	4	0.50	0.32	0.42	0.25	0.93
Pasta/noodles	4	1.13	0.72	1.22	0.29	2.39
Pilau	3	0.58	0.55	0.09	0.50	.
Porridge	8	1.00	0.58	0.95	0.47	1.26

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Potatoes/pumpkin	7	0.75	0.45	0.84	0.29	0.72
Rice	5	1.02	0.61	0.83	0.38	1.88
Ugali	2	0.23	0.23	0.08	0.18	.
Eggs	11	0.76	1.08	0.41	0.35	1.12

Table 30 Specific energy consumptions (MJ/pers/event) - two food meals

Food	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Phase 1 LPG						
Chapati/pancake Beans/peas	2	0.95	0.95	0.08	0.90	.
Chips Chicken	2	2.86	2.86	1.50	1.79	.
Meat Pasta/noodles	4	4.79	5.66	2.64	1.99	6.72
Meat Rice	2	1.96	1.96	0.24	1.79	.
Meat Ugali	5	2.03	0.82	1.83	0.63	4.03
Rice Beans/peas	23	3.84	2.35	3.39	1.96	6.50
Rice Chicken	3	2.01	1.68	1.88	0.31	.
Rice Leafy veg	3	0.83	1.01	0.54	0.22	.
Rice Potatoes/pumpkin	4	7.55	6.65	7.03	1.31	14.70
Ugali Fish	5	1.30	0.90	1.56	0.34	2.46
Ugali Leafy veg	19	4.17	1.34	5.66	1.01	6.61
Phase 2 Electricity						
Chapati/pancake Beans/peas	5	1.41	1.40	0.60	0.83	1.99
Chips Sausages	3	0.92	0.86	0.11	0.86	.
Githeri/mokimo Potatoes/pumpkin	4	0.39	0.27	0.25	0.24	0.64
Meat Chapati/pancake	2	0.95	0.95	0.09	0.89	.
Meat Other	2	1.38	1.38	0.87	0.76	.
Meat Pasta/noodles	3	2.40	1.58	2.35	0.58	.
Meat Pilau	2	1.08	1.08	0.49	0.74	.
Meat Rice	15	1.56	1.19	1.04	0.96	2.70
Meat Ugali	8	2.01	1.93	1.46	0.65	3.49

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Pasta/noodles Beans/peas	5	0.97	1.11	0.36	0.66	1.22
Rice Beans/peas	41	0.95	0.84	0.63	0.56	1.12
Rice Chicken	5	1.81	1.30	0.73	1.26	2.61
Rice Leafy veg	3	0.58	0.38	0.44	0.27	.
Rice Potatoes/pumpkin	8	1.00	0.80	0.96	0.28	1.32
Ugali Beans/peas	3	0.74	0.80	0.30	0.41	.
Ugali Chicken	7	2.14	2.61	0.60	1.65	2.61
Ugali Fish	10	0.93	0.63	0.67	0.41	1.62
Ugali Leafy veg	33	0.81	0.62	0.68	0.42	0.91
Ugali Other	2	1.86	1.86	0.93	1.20	.
Eggs Other	2	1.10	1.10	0.53	0.72	.
Eggs Ugali	2	1.19	1.19	0.86	0.59	.

Table 31 Specific energy consumptions (MJ/pers/event) - three food meals

Food	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Phase 1 LPG						
Fish Rice Beans/peas	2	4.82	4.82	5.86	0.67	.
Meat Rice Beans/peas	4	3.56	2.41	3.65	0.84	7.42
Meat Ugali Leafy veg	16	1.92	1.25	2.29	0.75	2.12
Rice Leafy veg Beans/peas	3	1.56	0.90	1.24	0.78	.
Ugali Chicken Leafy veg	5	6.17	8.06	3.98	1.88	9.52
Ugali Fish Leafy veg	6	2.24	1.46	2.03	0.89	3.85
Eggs Ugali Leafy veg	7	2.35	1.12	3.22	0.82	2.44
Phase 2 Electricity						
Meat Githeri/mokimo Leafy veg	5	0.55	0.54	0.19	0.37	0.73
Meat Leafy veg Beans/peas	2	0.82	0.82	0.21	0.67	.
Meat Pasta/noodles Beans/peas	4	1.42	1.38	0.91	0.56	2.32
Meat Rice Beans/peas	6	1.92	0.76	3.15	0.40	2.85
Meat Rice Leafy veg	4	0.43	0.34	0.20	0.33	0.64

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Meat Rice Other	4	0.86	0.81	0.27	0.63	1.14
Meat Rice Potatoes/pumpkin	3	0.98	1.03	0.20	0.76	.
Meat Ugali Leafy veg	25	1.01	0.76	0.56	0.64	1.39
Rice Beans/peas Potatoes/pumpkin	9	1.17	0.37	2.11	0.27	0.89
Rice Leafy veg Beans/peas	5	0.96	0.87	0.25	0.74	1.23
Ugali Chicken Leafy veg	2	1.11	1.11	0.12	1.03	.
Ugali Fish Leafy veg	8	1.05	0.95	0.48	0.75	1.35
Ugali Leafy veg Other	2	0.74	0.74	0.34	0.50	.
Ugali Matumbo Leafy veg	4	2.20	1.51	1.67	1.18	3.92
Eggs Ugali Leafy veg	15	1.06	0.99	0.59	0.75	1.35

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

The meals (food combinations) most commonly cooked are presented in Table 32[3]

Table 32 Most commonly prepared meals

	Frequency	Percent	Single fuel only Frequency	Electricity only Frequency	LPG only Frequency	Charcoal only Frequency	Median per capita electricity
Rice Beans/peas	110		106	69	32	4	0.67
Ugali Leafy veg	69		65	41	19	1	0.67
Porridge	22		22	9	12	0	0.51
Meat Ugali Leafy veg	48		48	30	16	1	0.76
Eggs	14		14	13	1	0	0.81
Githeri/mokimo	34		31	25	5	1	0.59
Beans/peas	21		21	15	6	0	0.50
Meat Rice	26		25	19	5	0	0.97

3.4 Cooking devices

3.4.1 Detail on how participants cook

Participants were asked to record the following information on how they cooked:

- Cooking device used i.e. what type of stove.
- Type of cooking pot / utensil.
- How they used the lid.
- Cooking process used e.g. fry, boil, bake etc.

> DO EGGS REALLY NEED TWICE AS MUCH ENERGY TO COOK THAN BEANS & GITHERI?
>
> PERHAPS IF EACH PERSON HAS THEIR OWN OMLETTE COOKED ON A HOTPLATE WHISLT EVERYONE'S BEANS/GITHERI IS COOKED ON AN EPC.
>
> FIGURES FOR THE ENERGY INTENSITY OF EACH MEAL COMBINATION ARE DIFFICULT TO INTERPRET, AS A SINGLE ENERGY METER MEASURED ALL APPLIANCES, GIVING A SINGLE VALUE FOR THE MEAL, RATHER THAN FOR EACH COMPONENT DISH. APPLIANCE DATA IS AVAILABLE, HOWEVER MOST MEALS USED MULTIPLE APPLIANCES & SINCE MOST MEALS ALREADY HAD LESS THAN 5 DATA POINTS, IT WAS NOT POSSIBLE TO MAKE ANY MEANINGFUL FURTHER DISAGREGATION.

[3] >=1.9% of all meals (breakfast, lunch, dinner, or snack).

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The cooking appliances used to cook individual foods are presented in Table 33. Note that any single record (or meal) can contain information on up to three foods, so the table includes each separate food–appliance combination. This shows that 17% of foods were cooked with electricity in Phase 1. Table 34 shows that boiling is by far the most commonly used cooking process. Changing to cooking with electricity in Phase 2 does not appear to have caused participants to change the mix of cooking processes used. Electric pressure cookers and rice cookers substituted for normal pots (sufurias) in Table 35. Participants were more likely to use lids when cooking electricity only (see Table 36), which may partly reflect the use of devices with integral lids such as pressure cookers and rice cookers.

Table 33 Appliances used to cook foods (frequencies)

	Phase 1	Phase 2 (electric only)
Rice cooker	6	359
Microwave	103	113
Electric kettle	1	3
Gas stove	792	4
Wood stove	1	0
Electric pressure cooker	1	362
Electric hotplate	87	782
Kerosene stove	87	1
Charcoal Stove	68	0
Other	7	18
Total	1153	1642

COOKING PROCESSES DID NOT CHANGE SIGNIFICANTLY WHEN TRANSITIONING TO ELECTRICITY, IMPLYING THAT THE SELECTED APPLIANCES WERE WELL MATCHED WITH URBAN KENYAN COOKING PRACTICES.

Table 34 Cooking processes used to cook foods (frequencies)

	Phase 1	Phase 2 (electric only)
Boil	458	636
Dry fry	174	247
Grill	0	0

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Bake	0	3
Wet fry	271	392
Deep fry	24	41
Steam	72	76
Microwave	93	141
Pressure cook	5	61
Other	4	0
Total	1101	1597

Table 35 Utensils used to cook foods (frequencies)

	Phase 1	Phase 2 (electric only)
Sufuria big	37	15
Sufuria medium	507	323
Sufuria small	360	298
Kettle	1	0
Frying pan	127	167
Bowl/plate	103	151
Pressure cooker	4	346
Other	3	225[4]
Total	1142	1525

Table 36 Use of lid when cooking foods (frequencies)

	Phase 1	Phase 2 (electric only)
No	442	514
Some	94	147
Yes	612	1018

[4] Mostly rice cookers

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Total	1148	1679

3.4.2 Characteristics of different cooking devices

ALTHOUGH MANY PARTICIPANTS ALREADY OWNED ELECTRIC COOKING APPLIANCES BEFORE THE STUDY, THEY WERE RARELY USED.

Given that most participants had access to both LPG and electricity (Table 12), it can be assumed that the dominant use of LPG in Phase 1 reflects an overwhelming preference for LPG (Table 37).

Table 38 shows that simple hotplates were most commonly used for all foods, but this may reflect appliances provided rather than preferences. Rice was most commonly cooked in rice cookers but interestingly, so was ugali. Electric pressure cookers were used to prepare many foods but not those that required frying (e.g. eggs, chapati, mandazi), plus some other including pasta and porridge.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 37 Cooking devices used to cook different food types - Phase 1 (frequencies)

	Rice cooker	Microwave	Electric kettle	Gas stove	Wood stove	Electric pressure cooker	Electric hotplate	Kerosene stove	Charcoal Stove	Other
Eggs	0	0	1	44	0	0	6	5	3	1
Meat	0	4	0	61	0	0	9	8	4	0
Ugali	3	4	0	103	1	0	5	15	8	0
Fish	0	0	0	17	0	0	2	2	1	0
Chapati/pancake	0	9	0	28	0	0	5	4	4	0
Githeri/mokimo	1	6	0	26	0	0	6	4	3	0
Pasta/noodles	0	1	0	23	0	0	4	3	1	0
Mandazi	0	0	0	1	0	0	0	0	0	0
Porridge	0	3	0	45	0	0	1	2	0	0
Pilau	0	3	0	4	0	0	3	0	0	0
Chips	0	4	0	7	0	0	0	1	0	2
Rice	1	14	0	96	0	0	11	6	9	0
Sausages	0	0	0	8	0	0	0	0	0	0
Matumbo	0	0	0	10	0	0	0	1	0	0
Matoke	0	0	0	6	0	0	0	1	0	0
Chicken	0	3	0	16	0	1	1	0	0	0
Leafy veg	1	2	0	111	0	0	8	17	15	0
Beans/peas	0	14	0	96	0	0	15	8	13	0
Potatoes/pumpkin	0	9	0	36	0	0	3	9	6	1
Other	0	4	0	17	0	0	6	1	0	3

Table 38 Cooking devices used to cook different food types - Phase 2 (frequencies)

	Rice cooker	Microwave	Electric kettle	Gas stove	Wood stove	Electric pressure cooker	Electric hotplate	Kerosene stove	Charcoal Stove	Other

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Eggs	1	3	1	1	0	1	86	0	0	1
Meat	9	6	0	0	0	80	50	0	0	0
Ugali	105	5	0	2	0	11	102	0	0	1
Fish	8	1	0	0	0	11	23	0	0	0
Chapati/pancake	2	10	0	1	0	2	43	0	0	0
Githeri/mokimo	8	9	1	0	0	13	24	0	0	0
Pasta/noodles	17	5	0	0	0	1	25	0	0	0
Mandazi	0	2	0	0	0	0	9	0	0	0
Porridge	2	5	0	0	0	1	57	0	0	0
Pilau	4	4	0	0	0	2	4	0	0	0
Chips	1	1	0	0	0	0	7	0	0	4
Rice	127	28	0	0	0	11	36	0	0	0
Sausages	0	0	0	0	0	0	10	0	0	5
Matumbo	0	0	0	0	0	8	3	0	0	0
Matoke	0	0	0	0	0	17	6	0	0	0
Chicken	2	0	0	0	0	19	9	0	0	0
Leafy veg	33	12	0	0	0	45	110	1	0	0
Beans/peas	6	18	0	0	0	87	80	0	0	0
Potatoes/pumpkin	6	10	1	0	0	14	30	0	0	0
Other	2	5	0	0	0	9	31	0	0	7

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 39 shows that all of the main cooking processes are carried out using gas stoves.

The equivalent table for Phase 2 highlights a few anomalies. For example, rice cookers used for frying, and electric pressure cookers most commonly used for frying (see Table 40).

Table 39 Cooking processes used with different cooking devices - Phase 1 (frequencies)

	Boil	Dry fry	Grill	Bake	Wet fry	Deep fry	Steam	Microwave	Pressure cook	Other
Rice cooker	3	1	0	0	1	0	1	0	0	0
Microwave	8	1	0	0	2	0	1	89	1	0
Electric kettle	1	0	0	0	0	0	0	0	0	0
Gas stove	352	133	11	0	187	18	55	4	2	3
Wood stove	1	0	0	0	0	0	0	0	0	0
Electric pressure cooker	0	0	0	0	1	0	0	0	0	0
Electric hotplate	29	17	2	0	33	1	2	0	2	0
Kerosene stove	32	12	4	0	29	1	6	0	0	0
Charcoal Stove	30	10	3	0	16	0	7	0	0	0
Other	1	0	0	0	0	4	0	0	0	1

EPCS WERE PREFERED FOR DISHES THAT REQUIRE BOILING, HOWEVER THEY WERE REPORTEDLY USED FOR FRYING MORE OFTEN THAN PRESSURE COOKING. THIS IS IN CONTRAST TO STOVE-TOP PRESSURE COOKERS, WHICH ARE ALMOST EXCLUSIVELY USED FOR BOILING. FRYING IS DONE AT A HIGHER TEMPERATURE THAN BOILING AND FOODS FREQUENTLY DRY OUT AND BURN IF NOT STIRRED FREQUENTLY. A SHALLOW FRYING PAN MAKES FREQUENT STIRRING EASIER. ALTHOUGH THE EPC CAN ONLY OPERATE WITH THE DEEP SIDED POT IT IS SUPPLIED WITH, IT SEEMS THAT THIS WAS NOT A MAJOR RESTRICTION ON PARTICIPANTS' ABILITY TO FRY.

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Table 40 Cooking processes used with different cooking devices - Phase 2 (frequencies)

	Boil	Dry fry	Grill	Bake	Wet fry	Deep fry	Steam	Microwave	Pressure cook	Other
Rice cooker	252	35	0	2	45	1	14	0	0	0
Microwave	10	3	1	0	2	0	0	138	0	0
Electric kettle	0	1	0	0	1	0	0	0	0	0
Gas stove	1	2	1	0	0	0	0	0	0	0
Wood stove	0	0	0	0	0	0	0	0	0	0
Electric pressure cooker	70	43	1	0	142	0	11	0	59	0
Electric hotplate	297	158	21	1	199	31	50	2	2	0
Kerosene stove	0	1	0	0	0	0	0	0	0	0
Charcoal Stove	0	0	0	0	0	0	0	0	0	0
Other	3	3	0	0	0	8	0	1	0	0

3.4.3 Fuel stacking

The number of cooking appliances used in preparing each meal (or case) in Phase 1 is presented in Table 41. In 7% of cases more than one cooking device was used. The mix of devices used to prepare these meals is given in Table 42, and suggests that participants are mixing LPG with electric microwaves and hotplates.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 41 Number of cooking devices used in preparing meals - Phase 1

Number of cooking devices	Frequency	Valid percent
1	568	93.4
2	38	6.3
3	2	0.3
Total	608	100.0

Table 42 Cooking devices used by participants who use multiple devices preparing single meal

Cooking device	**Frequency**
Rice cooker	3
Microwave	22
Electric kettle	1
Gas stove	35
Wood stove	1
Electric pressure cooker	1
Electric hotplate	10
Kerosene stove	2
Charcoal Stove	3
Other	4

MICROWAVES WERE ALREADY POPULAR AMONG PARTICIPANTS, AS THEY OFFER A SOMETHING ABOVE AND BEYOND LPG – EASY REHEATING.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

3.4.4 Energy used by different electrical appliances (Phase 2)

Per capita electrical energy figures in Table 43 indicate that 'efficient' electrical devices such as rice cookers and microwaves use less than half as much energy as a simple hotplate. However, both rice cookers and microwaves were mostly used to cook rice, whereas pressure cookers and hotplates were used to cook a range of foods (see Table 38). In order to make more meaningful comparisons, the specific energy consumption for different foods and combinations are presented in Table 44. An illustrative sample of foods cooked on most appliances are compared in Figure 21 (only data points where n>=5). This figure does not show consistent trends.

Table 43 Per capita energy consumption (MJ/pers/event) of meals cooked using single electrical device (Phase 2)

Cooking device	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Rice cooker	46	0.44	0.32	0.32	0.24	0.59
Microwave	53	0.43	0.32	0.55	0.12	0.44
Electric pressure cooker	59	1.01	0.63	1.04	0.29	1.44
Electric hotplate	119	0.97	0.83	0.67	0.52	1.16

Table 44 Detail of per capita energy consumption (MJ/pers/event) of meals cooked using single electrical device (Phase 2)

Food(s)	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Rice cooker						
Pilau	2	0.53	0.53	0.03	0.50	.
Rice	4	0.72	0.50	0.54	0.37	1.29
Ugali	3	0.33	0.29	0.17	0.18	.
Leafy veg Potatoes/pumpkin	2	0.17	0.17	0.01	0.17	.
Rice Beans/peas	4	0.31	0.32	0.06	0.25	0.35
Rice Potatoes/pumpkin	2	0.30	0.30	0.04	0.27	.
Ugali Leafy veg	10	0.52	0.59	0.28	0.19	0.81

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Meat Pasta/noodles Beans/peas	2	0.21	0.21	0.02	0.19	.
Rice Beans/peas Potatoes/pumpkin	4	0.30	0.29	0.04	0.27	0.35
Microwave						
Beans/peas	3	0.28	0.22	0.20	0.13	.
Githeri/mokimo	7	0.42	0.41	0.22	0.32	0.50
Potatoes/pumpkin	2	0.26	0.26	0.24	0.09	.
Rice	5	0.29	0.30	0.13	0.19	0.39
Rice Beans/peas	17	0.59	0.42	0.76	0.12	0.80
Rice Potatoes/pumpkin	2	0.31	0.31	0.09	0.25	.
Ugali Leafy veg	2	0.48	0.48	0.63	0.03	.
Pressure cooker						
Beans/peas	5	0.42	0.50	0.23	0.21	0.60
Githeri/mokimo	7	1.31	1.44	0.50	0.78	1.84
Matoke	8	1.85	2.06	1.78	0.06	3.51
Meat	4	1.37	1.55	0.61	0.73	1.84
Potatoes/pumpkin	3	0.37	0.38	0.08	0.29	.
Githeri/mokimo Potatoes/pumpkin	4	0.39	0.27	0.25	0.24	0.64
Rice Beans/peas Potatoes/pumpkin	2	0.60	0.60	0.48	0.26	.
Electric hotplate						
Beans/peas	3	0.86	1.00	0.25	0.58	.
Chapati/pancake	3	1.19	1.12	0.22	1.01	.
Githeri/mokimo	5	0.51	0.49	0.14	0.38	0.65
Leafy veg	2	0.85	0.85	0.79	0.29	.
Meat	4	0.71	0.69	0.20	0.53	0.92
Pasta/noodles	3	1.31	0.83	1.43	0.18	.
Pilau	3	0.49	0.44	0.17	0.36	.
Porridge	7	1.51	1.16	1.22	0.51	3.18
Potatoes/pumpkin	4	0.97	0.62	1.14	0.15	2.15
Rice	2	1.27	1.27	1.38	0.29	.
Eggs	11	0.76	1.08	0.41	0.35	1.12
Chapati/pancake Beans/peas	2	1.26	1.26	0.76	0.72	.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Meat Ugali	2	1.11	1.11	0.13	1.02	.
Rice Beans/peas	4	0.70	0.66	0.16	0.57	0.86
Ugali Fish	3	1.07	1.16	0.61	0.41	.
Ugali Leafy veg	7	1.34	1.00	0.88	0.91	1.53
Meat Leafy veg Beans/peas	2	0.82	0.82	0.21	0.67	.
Meat Pasta/noodles Beans/peas	2	0.30	0.30	0.12	0.22	.
Meat Rice Beans/peas	3	0.82	0.73	0.23	0.64	.
Ugali Fish Leafy veg	3	1.02	0.88	0.38	0.73	.
Eggs Rice Beans/peas	3	0.76	0.70	0.17	0.63	.
Eggs Ugali Leafy veg	4	0.89	0.90	0.41	0.49	1.27

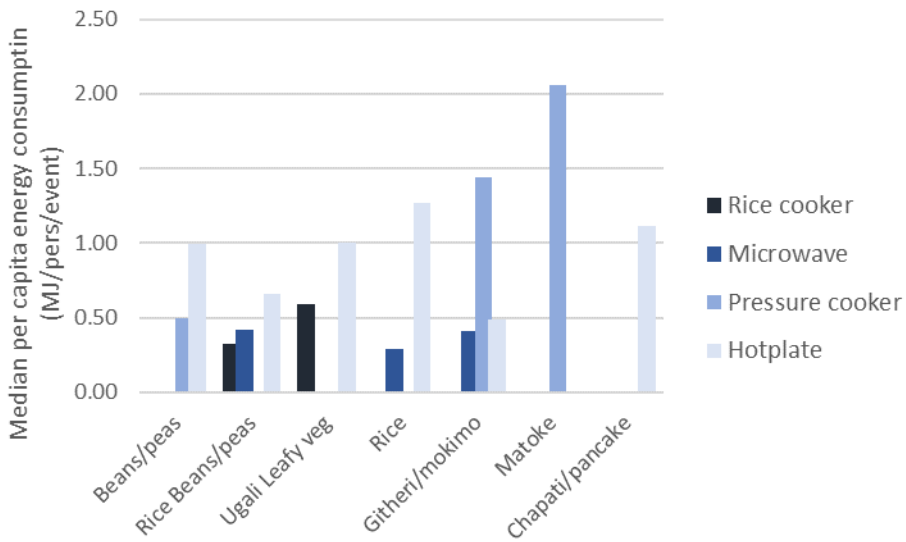


Figure 21 Specific energy consumptions of different electrical cooking appliances (n>=5).

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

However, Table 43 allows us to deduce that EPCs use roughly half the energy of electric hotplates across the full range of dishes that they are able to cook. On average, rice cookers used 39% (median of 0.09 kWh/person/event, n=46) and EPCs used 76% (0.18 MJ/person/event, n=49) of the energy of a hotplate (0.23 MJ/person/event, n=119). However, Figure 22 reveals that EPCs were chosen to cook 'heavier' (and therefore more energy intensive) dishes, when in fact they can also be used for the lighter staples (e.g. rice), which had been cooked in the rice cooker. As all participants in the Kenya cooking diaries had an electric hotplate, a rice cooker and an EPC, it can be assumed that all the dishes that were cooked in a rice cooker could also have been cooked in the EPC with the same energy consumption. Averaging the per capita, per heating event energy consumption figures for rice cookers and EPCs comes to just under half (45%) that of the electric hotplate.

EPCS USE ROUGHLY HALF THE ENERGY OF ELECTRIC HOTPLATES ACROSS THE FULL RANGE OF DISHES THAT THEY ARE ABLE TO COOK. WITH MINIMAL TRAINING, HOUSEHOLDS WOULD CHOOSE TO USE AN EPC TO COOK HALF THEIR MENU IF IT WERE THE ONLY ELECTRIC APPLIANCE AVAILABLE

Further analysis of the Kenya cooking diaries dataset suggests that with minimal training, households would choose to use an EPC to cook half their menu if it were the only electric appliance available. Figure 22 shows that a total of 645 dishes were cooked on EPCs and rice cookers. Ignoring all other appliances (which totalled only 150 dishes and were mainly microwaves) and comparing directly to the 739 dishes cooked on a hotplate, roughly half (47%), of a total of 1,387 dishes were cooked by choice on an EPC or rice cooker. We can therefore conclude that without additional training or design modifications, households with an EPC as their efficient appliance are likely to choose to cook roughly half their menu with it.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

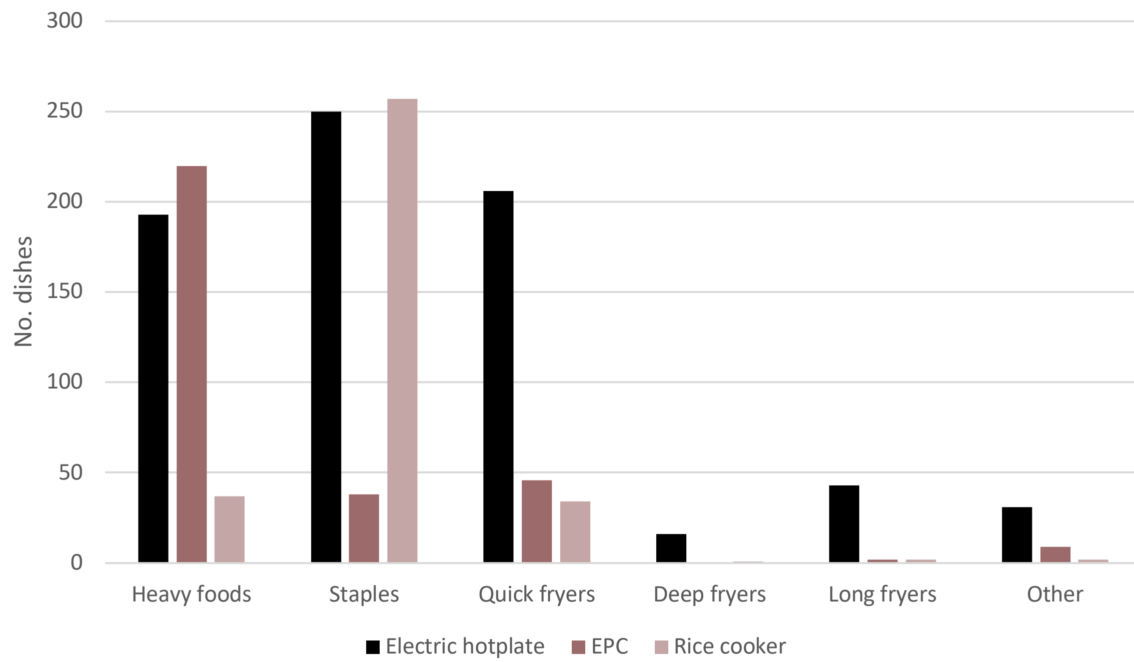


Figure 22: Number of each category of dish cooked on inefficient (hotplate) and efficient (rice cooker and EPC) appliances during the Kenya cooking diaries[5].

3.5 Time taken

3.5.1 Time taken to cook food types

The times taken to cook individual food types using only LPG in Phase 1 are presented in Table 45 (ranked by median). Note that this includes times taken to cook individual foods when prepared as part of a multi-dish meal. This suggests four groups of foods:

- Quick – eggs, other veg
- About 20 mins – fish, sausages, ugali, pasta, chips, rice
- About 30 mins – matumbo, potatoes, meat, githeri, chicken
- Longer – chapati.

[5] 127 records for dishes cooked on microwaves and kettles already owned by some participants have been omitted.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 46 presents times taken to cook using electricity (in Phase 2). When comparing the most common food types (ugali, rice, leafy vegetables, beans and meat), there is little difference in cooking times using LPG and electricity.

IN CONTROLLED COOKING TESTS, EPCS CAN COOK 'HEAVY FOODS' LIKE MATUMBO IN HALF THE TIME. HOWEVER, THE COOKING DIARIES DATASET SHOWED LITTLE DIFFERENCE BETWEEN COOKING TIMES WITH LPG & ELECTRICITY. THIS COULD BE BECAUSE OF UNFAMILIARITY WITH THE DEVICES (E.G. DEPRESSURISING TOO EARLY & HAVING TO REPRESSURISE), HOWEVER FURTHER INVESTIGATION IS NEEDED TO UNDERSTAND WHY.

Table 45 Time taken to cook food types using LPG only – Phase 1 (minutes)

Food	N	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Mandazi	*0*	*0.0*	*0.0*	*0.0*	*0*	*0*
Eggs	22	8.2	7.5	4.2	5	10.5
Leafy veg	88	10.7	10.0	7.2	5	15
Fish	15	17.9	15.0	8.8	10	25
Porridge	33	17.1	15.0	13.6	7	20
Sausages	8	15.0	15.0	7.1	10	22.5
Ugali	83	20.5	19.0	9.1	15	25
Pasta/noodles	17	24.5	20.0	16.3	11.5	34
Chips	6	35.2	20.0	35.4	7.75	80
Rice	73	22.3	20.0	13.6	14	30
Beans/peas/kamande/ndengu	70	27.7	20.0	26.9	11	32.75
Matumbo	7	33.6	30.0	14.4	20	40
Matoke	*2*	*32.5*	*32.5*	*3.5*	*30*	.
Potatoes/pumpkin/nduma/muhogo	20	32.4	32.5	23.4	10	56.25
Meat	47	42.1	35.0	35.1	19	60
Githeri/mokimo	13	39.0	35.0	23.9	30	42.5
Chicken	14	43.4	35.0	31.7	17.5	78.75
Pilau	*4*	*57.3*	*51.5*	*50.2*	*12*	*108.25*
Pancakes/Chapati	21	46.5	55.0	31.1	14	62

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 46 Time taken to cook food types using electricity only – Phase 2 (minutes)

Food	N	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Eggs	82	10.2	10.0	7.0	5.0	10.8
Pilau	13	20.2	10.0	18.9	6.0	40.0
Sausages	16	12.2	10.0	5.2	10.0	15.0
Leafy veg	184	12.9	10.0	9.7	6.0	15.0
Fish	43	18.7	15.0	19.4	6.0	30.0
Pasta/noodles	41	15.9	15.0	10.1	7.0	22.0
Porridge	59	16.4	15.0	10.3	10.0	20.0
Ugali	210	22.7	20.0	10.9	15.0	30.0
Rice	190	20.4	20.0	11.8	9.5	30.0
Matoke	21	22.7	20.0	12.1	15.0	30.0
Beans/peas/kamande/ndengu	170	29.5	20.0	28.0	10.0	40.0
Potatoes/pumpkin/nduma/muhogo	55	24.7	20.0	15.6	10.0	35.0
Meat	138	31.6	30.0	21.8	15.0	45.0
Mandazi	6	25.3	30.0	13.6	9.3	36.3
Chips	13	44.2	30.0	41.4	22.5	45.0
Chicken	32	31.8	30.0	19.8	12.8	47.8
Githeri/mokimo	44	36.7	32.5	30.1	6.3	60.0
Pancakes/Chapati	47	43.0	40.0	34.7	7.0	75.0
Matumbo	11	45.5	50.0	16.5	30.0	60.0

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

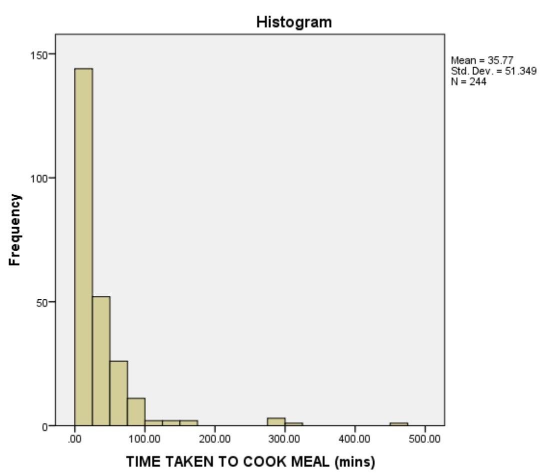
3.5.2 Time taken to prepare meal

The time taken to prepare lunches was almost half the time to prepare dinners, and breakfasts were quicker still (Table 47). 90% of dinners were prepared within 2 hours and 90% of lunches were prepared within 1.5 hours – see Figure 23.

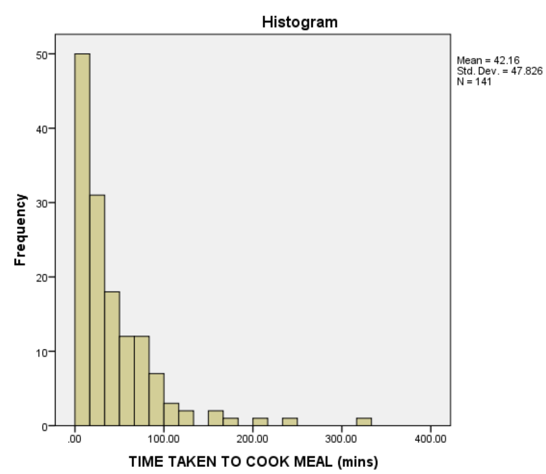
Table 47 Duration of heating events Time taken to cook food types – Phase 1 (minutes)

Heating event	N	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast	244	36	20	51.3	10	40.8
Lunch	141	42	27	47.8	10	60
Dinner	256	69	55	53.2	32	94
Water heating	77	26	13	42.0	10	21

Breakfast



Lunch



Dinner

Heating water

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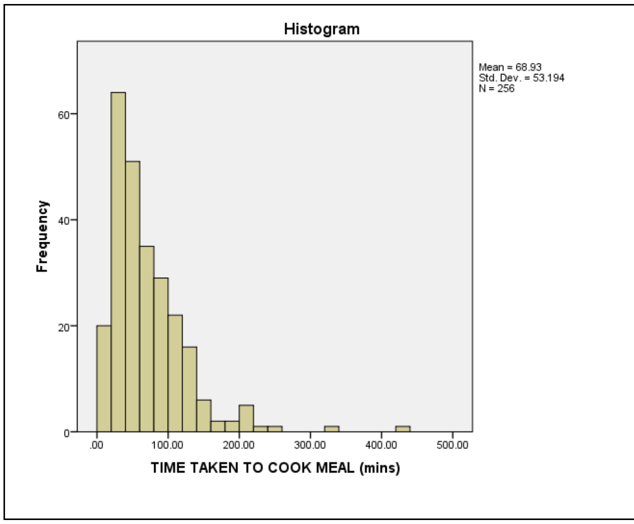

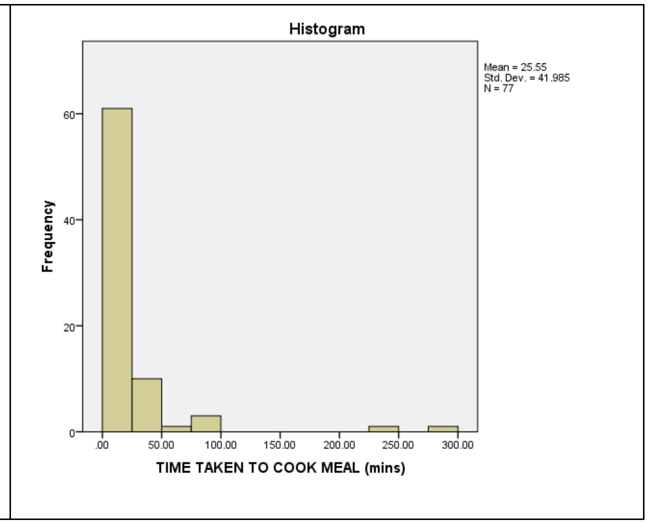

Figure 23 Distributions of durations of heating events (minutes) – Phase 1

In the same way that there is little difference in cooking times using LPG and electricity, there is little difference in the time taken to prepare meals between Phase1 and Phase 2 (see Table 48).

Table 48 Duration of heating events Time taken to cook food types – Phase 2 (minutes)

Heating event	N	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast	427	41	30	52.2	18	44
Lunch	217	36	30	33.4	10	55
Dinner	450	67	55	52.0	35	86
Water heating	91	27	23	23.9	13	30

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

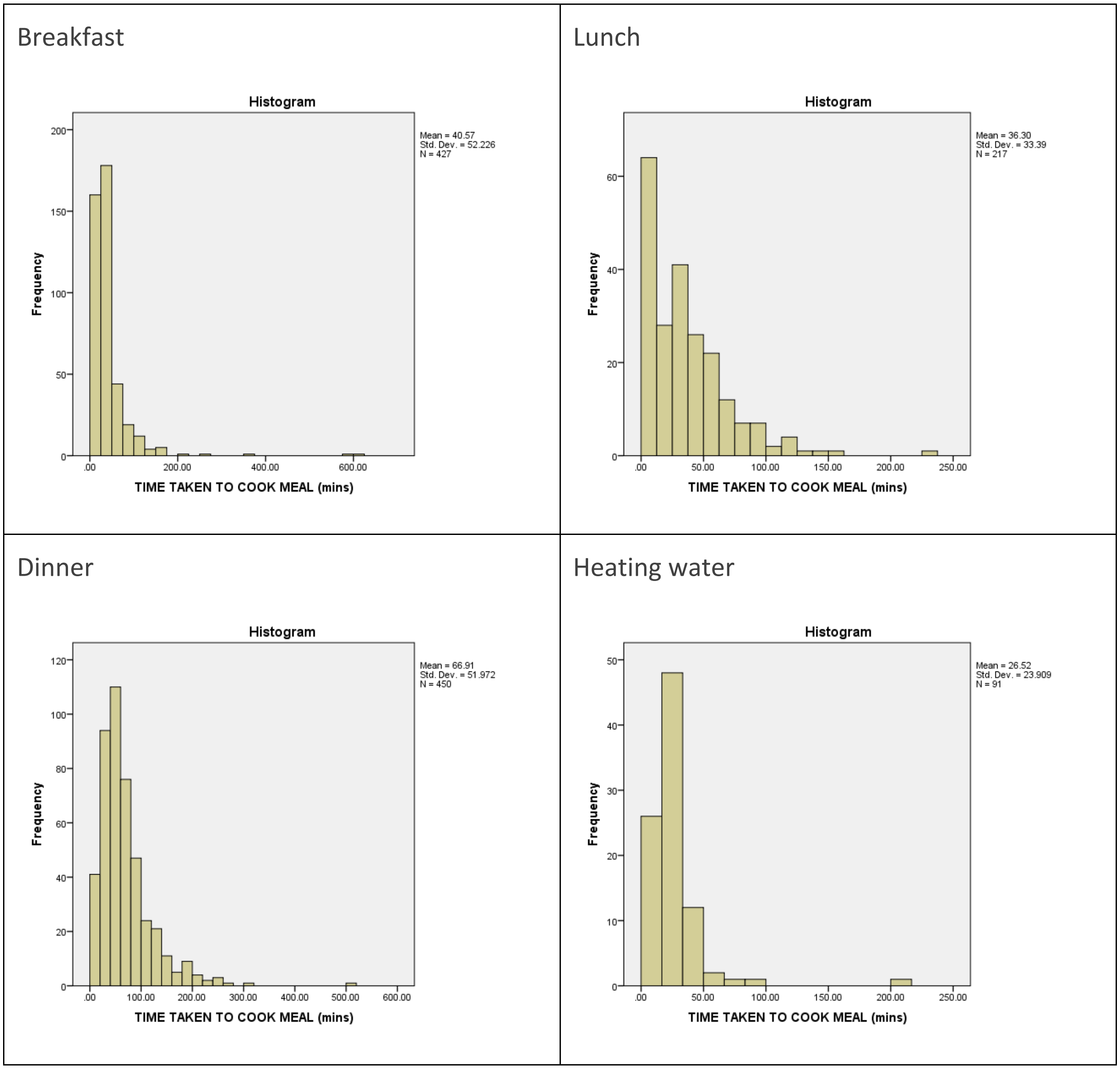

Figure 24 Distributions of durations of heating events (minutes) – Phase 2

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

3.5.3 Time of day

Table 49 Time of day to start preparing meal –Phase 1 (multiple fuels)

Heating event	N	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast	244	7.15	6.30	2.15	6.00	8.28
Lunch	141	12.34	12.45	1.33	12.02	13.23
Dinner	258	18.42	18.52	1.46	18.00	19.45

Table 50 Time of day to start preparing meal –Phase 2 (electricity only)

Heating event	N	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast	427	7.13	7.00	2.08	6.00	8.15
Lunch	217	13.12	13.00	1.27	12.30	13.36
Dinner	449	18.37	18.50	2.01	18.00	20.00

Water heating is done mostly from the morning (no particular peak time) through to mid afternoon – see Figure 25.

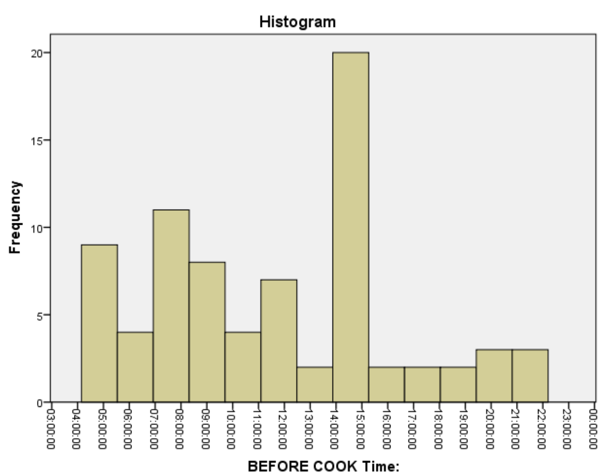

Figure 25 Time of day to start water heating (Phase 1)

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3.6 Water heating

In 73% of cases in which a water heating event was recorded, water was heated for a single purpose only. Water was most commonly heated in order to make tea or other hot drinks (Table 51). Although the majority of water heating events were recorded in cases with a single heating event (see Table 52), that heating event was usually something other than a 'water heating' event i.e. water was usually heated as part of preparing a breakfast, lunch etc. rather than being heated on its own. Table 53 shows that water was most commonly heated as part of preparing breakfasts, and that at breakfasts, it was used mainly for hot drinks.

UNLIKE COOKING, WHICH USUALLY OCCURS AT SET MEALTIMES, WATER HEATING OCCURS THROUGHOUT THE DAY FOR A VARIETY OF PURPOSES INCLUDING BATHING & PURIFICATION, BUT MAINLY FOR TEA/COFFEE.

Table 51 Purposes for heated water (all records)

Purpose of heating water	Frequency	Percent (n=1196[6])
Purifying drinking water	170	14.2
Bathing	370	30.9
Tea / coffee	804	67.2
Other	176	14.7

[6] Number of cases in which water heating event was recorded.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 52 Purposes of heating water (all records)

Purpose of heating water	Number of heating events in record			Total
	1	2	3	
Purifying drinking water	162	6		168
Bathing	322	40	2	364
Tea / coffee	748	35	3	786
Other	170	4		174
Total	1403	87	5	1492

Table 53 Purpose of water heating by heating events (single heating events only)

Heating event	Purify drinking	Bathing	Hot drinks	Other	
Breakfast	76	113	583	64	836
Lunch	21	25	38	10	94
Dinner	54	73	73	85	285
Snack	1	2	27	5	35
Food for baby/child	0	1	16	4	21
Heating water	10	108	11	2	131
	162	322	748	170	1402

The energy consumption for heating water for different purposes can only be deduced from those records that deal with a single heating event only, and pertain only to the heating of water for a single purpose. This restricts the analysis to a small sub-set of cases making it difficult to compare energy consumptions between Phase 1 and Phase 2. Per capita energy consumptions for heating bathing water are presented in Table 54 (where n>=5), and suggest that electrical energy consumption is lower than LPG energy consumption, but also that electrical energy consumption is much less variable.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 54 Per capita energy consumed by heating water for different purposes (MJ/pers/event) - Phase 2 and 3 (single use of water in water heating events only)

	Frequency	Mean (MJ/event)	Median	Std.dev.	25% Quartile	75% Quartile
Bathing						
Phase 1 LPG	22	4.35	2.17	5.35	0.90	5.10
Phase 2 Electricity	39	1.10	1.23	0.40	0.92	1.26

As with food, the majority of water in Phase 1 was heated using LPG (Table 55). However, 23% of water heating events used electric appliances, mostly electric kettles. In Phase 2, most water was heated on hotplates, but this probably reflects the devices provided to participants i.e. not all participants were given electric kettles.

Table 55 Devices used to heat water (single use of water in water heating events only)

	Phase 1	Phase 2 (electric only)
Rice cooker	0	3
Microwave	24	30
Electric kettle	43	48
Gas stove	230	0
Electric pressure cooker	0	39
Electric hotplate	15	344
Kerosene stove	30	0
Charcoal stove	10	0
Total	352	464

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

The utensils used to heat water for different purposes are presented in Table 56. It is interesting to note that kettles are rarely used for making hot drinks, which are mostly prepared using pots.

Table 56 Utensils used to heat water (all water heating events).

	Purify drinking water	Bathing	Tea / hot drinks	Other	Total
Sufuria big	18	186	10	12	226
Sufuria medium	53	46	374	54	527
Sufuria small	19	18	299	56	392
Kettle	67	63	30	15	175
Bowl/plate	1	0	11	8	20
Pressure cooker	6	46	26	0	78
Other	3	0	35	23	61
Total	167	359	785	168	1479

The majority of utensils are mostly filled or half filled with water for heating (Table 57).

Table 57 How much water is heated (all water heating events)

	Sufuria big	Sufuria medium	Sufuria small	Kettle	Bowl/plate	Pressure cooker	Other	Total
Quarter full	1	36	77	16	1	14	1	146
Half full	35	90	131	7	8	10	22	303
3/4 full	6	77	37	0	1	21	9	151
Full	136	179	105	86	5	21	24	556
Two utensils full	18	8	6	27	0	17	1	77
Four utensils full	10	59	4	8	0	1	0	82
Total	206	449	360	144	15	84	57	1315

Big pots are usually used with a lid but, interestingly, small and medium pots are usually used without lids (Table 58).

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Table 58 Use of lids (all water heating events)

	Sufuria big	Sufuria medium	Sufuria small	Kettle	Bowl/plate	Pressure cooker	Other	Total
No	81	313	209	13	17	26	37	696
Some	27	20	65	0	0	2	1	115
Yes	116	192	110	161	3	56	23	661
	224	525	384	174	20	84	61	1472

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

In 7% of water heating events, warm water is reheated (Table 59).

Table 59 Reheating of warm water (all water heating events)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fresh	1392	32.2	93.3	93.3
	Warm	100	2.3	6.7	100.0
	Total	1492	34.5	100.0	
Missing	System	2830	65.5		
Total		4322	100.0		

In 34% of water heating events, an insulated flask is used to keep water hot (assumed to be for use at a later time) - Table 60. The use of flasks is most common when water is heated using gas stoves, electric hotplates and electric pressure cookers (Table 61).

Table 60 Storing heated water in a flask (all water heating events)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	966	22.4	66.3	66.3
	Some	318	7.4	21.8	88.1
	Yes	173	4.0	11.9	100.0
	Total	1457	33.7	100.0	
Missing	System	2865	66.3		
Total		4322	100.0		

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Table 61 Use of flask by type of water heating device (all water heating events)

		USE OF FLASK - HEATING WATER			Total
		No	Some	Yes	
DEVICE USED TO HEAT WATER	Rice cooker	1	1	3	5
	Microwave	70	6	0	76
	Electric kettle	163	5	0	168
	Gas stove	178	101	35	314
	Electric pressure cooker	45	6	30	81
	Electric hotplate	429	181	94	704
	Kerosene stove	54	15	7	76
	Charcoal Stove	23	1	3	27
Total		963	316	172	1451

In 65% of water heating events, water is boiled (Table 62). Boiled water is most often used for hot drinks, but it is interesting to find water is often boiled for bathing (which may reflect inefficient practice). Table 63 shows that microwaves are only used to warm water, and stoves, electric pressure cookers, and hotplates are used to heat 'hot' water.

Table 62 Temperature of water used for different purposes

		TEMPERATURE OF WATER - HEATING WATER			Total
		Warm	Hot	Boiling	
WATER HEATING PURPOSE (single uses only)	Purify drinking water	12	18	134	164
	Bathing	17	228	114	359
	Tea / hot drinks	53	104	624	781
	Other	35	41	91	167
Total		117	391	963	1471

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 63 Temperature of water by type of water heating devices (all water heating events)

		TEMPERATURE OF WATER - HEATING WATER			
		Warm	Hot	Boiling	Total
DEVICE USED TO HEAT WATER	Rice cooker	0	2	4	6
	Microwave	40	34	4	78
	Electric kettle	4	7	158	169
	Gas stove	19	56	254	329
	Electric pressure cooker	1	46	44	91
	Electric hotplate	47	202	456	705
	Kerosene stove	2	38	36	76
	Charcoal Stove	2	13	12	27
Total		115	398	968	1481

Heating water for bathing takes longest (Table 64). The electric kettle is quickest (Table 65), except for the microwave, which is usually only used to warm up small quantities of water. N.B. these times will depend not only on the device but also on the amount of water heated, and the temperature to which it is heated.

Table 64 Time taken to heat water for different purposes (minutes)

WATER HEATING PURPOSE (single uses only)	Mean	N	Std. Deviation	Median
Purify drinking water	15.6	154	12.47766	13.0
Bathing	22.0	287	17.98241	20.0
Tea / hot drinks	15.7	664	9.46565	15.0
Other	14.3	126	11.15998	10.5
Total	17.2	1231	12.85951	15.0

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Table 65 Time taken to heat water using different devices (minutes)

DEVICE USED TO HEAT WATER	Mean	N	Std. Deviation	Median
Rice cooker	18.00	6	9.654	17.50
Microwave	2.81	45	4.827	1.00
Electric kettle	8.82	141	7.023	5.00
Gas stove	16.14	264	10.996	15.00
Electric pressure cooker	19.46	81	10.361	17.00
Electric hotplate	20.53	594	13.888	20.00
Kerosene stove	16.30	80	10.473	12.50
Charcoal Stove	20.15	26	14.215	20.00
Total	17.25	1237	12.837	15.00

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

3.7 User experience of electric cooking

User experiences of transitioning to cooking solely with electricity were captured with the exit survey, which took place shortly after completing the 4 weeks of electric cooking. The following section begins with a presentation of the responses to each question on the exit survey and concludes with the results of the Githeri eCooking Challenge.

3.7.1 Responses to exit survey questions

eCookers, in particular the EPC and rice cooker seem to be a good fit with how urban Kenyans cook. Figure 26 shows that despite the reputation of stove-top pressure cookers as being unsafe, the many automated control and safety features of the EPC seem to be more than sufficient to convince everyday cooks that they are safe to operate in their home, scoring even higher than the hotplate. Having the pot integrated into appliance (EPC and rice cooker) and avoiding the use of naked flames keep the pot clean and add extra stability, which is likely to be particularly useful for dishes such as ugali, where vigorous stirring is required. Perhaps surprisingly, although it was inconclusive as to whether participants missed the smokey flavour of food (3/5), most agreed that food tasted better than usual on the electric appliances (4/5). This could well be due to the increased control, especially by the appliances that are automatically controlled (rice cooker & EPC), which most participants strongly disagreed with the suggestion that it burned the food (1.5/5). In contrast, there was some agreement (3.5/5) that the hotplate burned the food. Interestingly, the automatically controlled appliances actually scored higher (4/5) than the hotplate (3.5/5) for ease of controlling heat. Unsurprisingly, they far exceeded the hotplate in terms of the ability to multi-task (5/5 versus 2.5/5).

THE EPC & RICE COOKER IN PARTICULAR ARE LIKELY TO BE ASPIRATIONAL APPLIANCES, AS EVIDENCED BY THE HIGH SCORES FOR LOOKING GOOD IN PARTICIPANTS' KITCHENS (4.5/5), FOOD TASTING BETTER THAN USUAL (4/5) & THE ABILITY TO COOK FASTER (4.5/5) & MULTI-TASK (5/5).

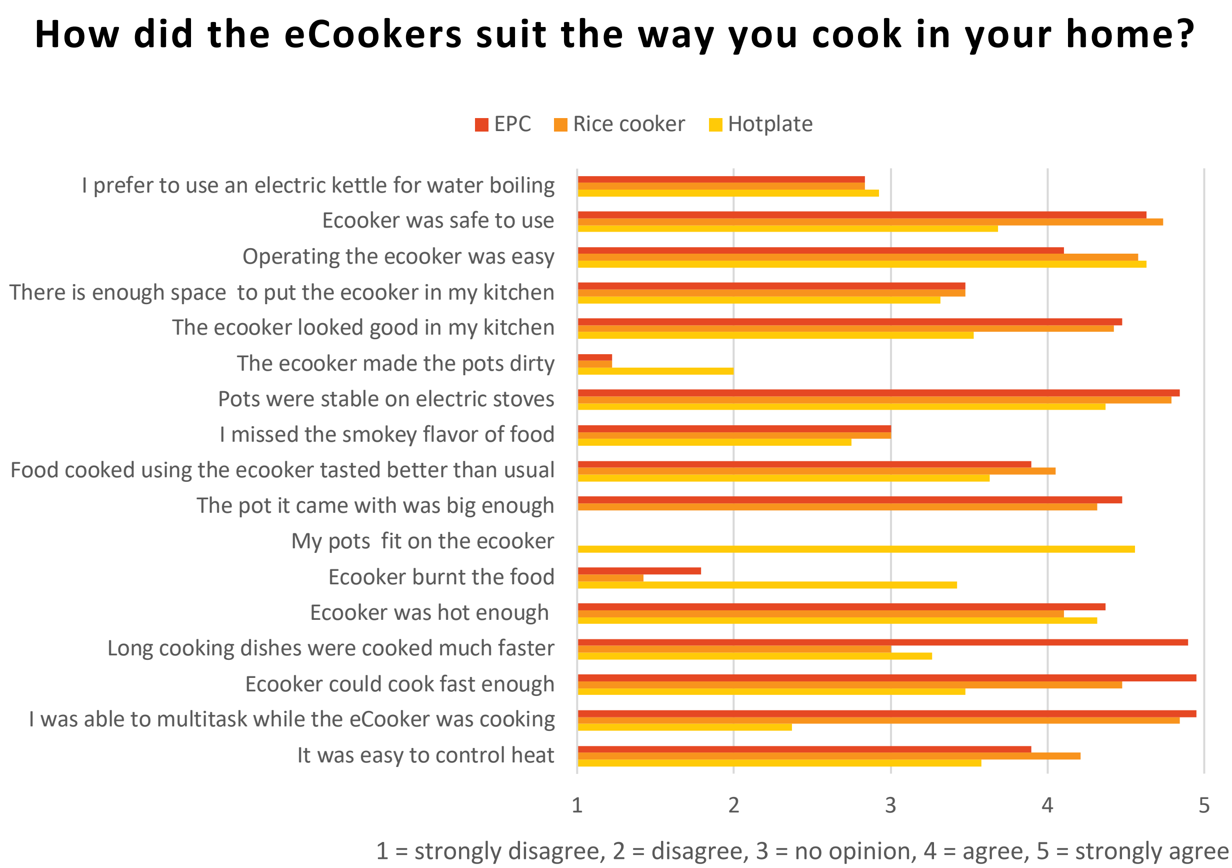

Figure 26: Overall user experiences of eCooking.

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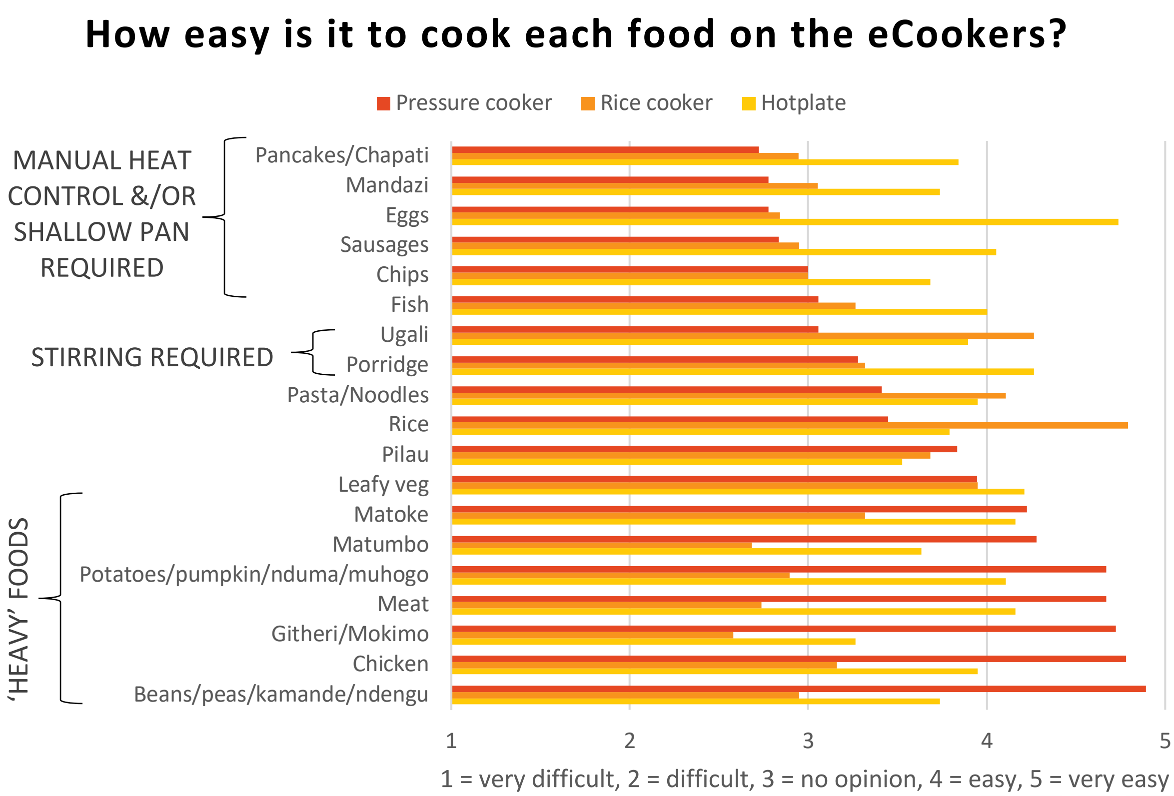

Figure 27: Ease of cooking each dish on each electric cooking appliance. Ranked by ease of cooking on an EPC.

'HEAVY FOODS' SUCH AS BEANS OR MATUMBO (TRIPE) THAT USUALLY REQUIRE BOILING FOR AN HOUR OR MORE TO SOFTEN ARE UNSURPRISINGLY RATED AS MUCH EASIER TO COOK ON THE E.P.C. THAN THE HOTPLATE. IN CONTRAST, FOODS SUCH AS CHAPATI OR MANDAZI THAT REQUIRE MANUAL HEAT CONTROL &/OR A SHALLOW PAN ARE RATED MUCH EASIER ON THE HOTPLATE.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Do you miss the smokey flavour of food? If so, for which dishes in particular?

PERHAPS SURPRISINGLY TO SOME, FOOD COOKED ON ELECTRICITY WAS RATED AS THE TASTIEST, JUST AHEAD OF LPG & CHARCOAL. WOOD & KEROSENE LAG FAR BEHIND. WHIST MOST RESPONDENTS MISSED THE SMOKEY FLAVOUR IN SPECIFIC FOODS, MANY DID NOT MISS IT AT ALL.

Do foods taste different when cooked on different fuels? If so, please rank each fuel for each food.

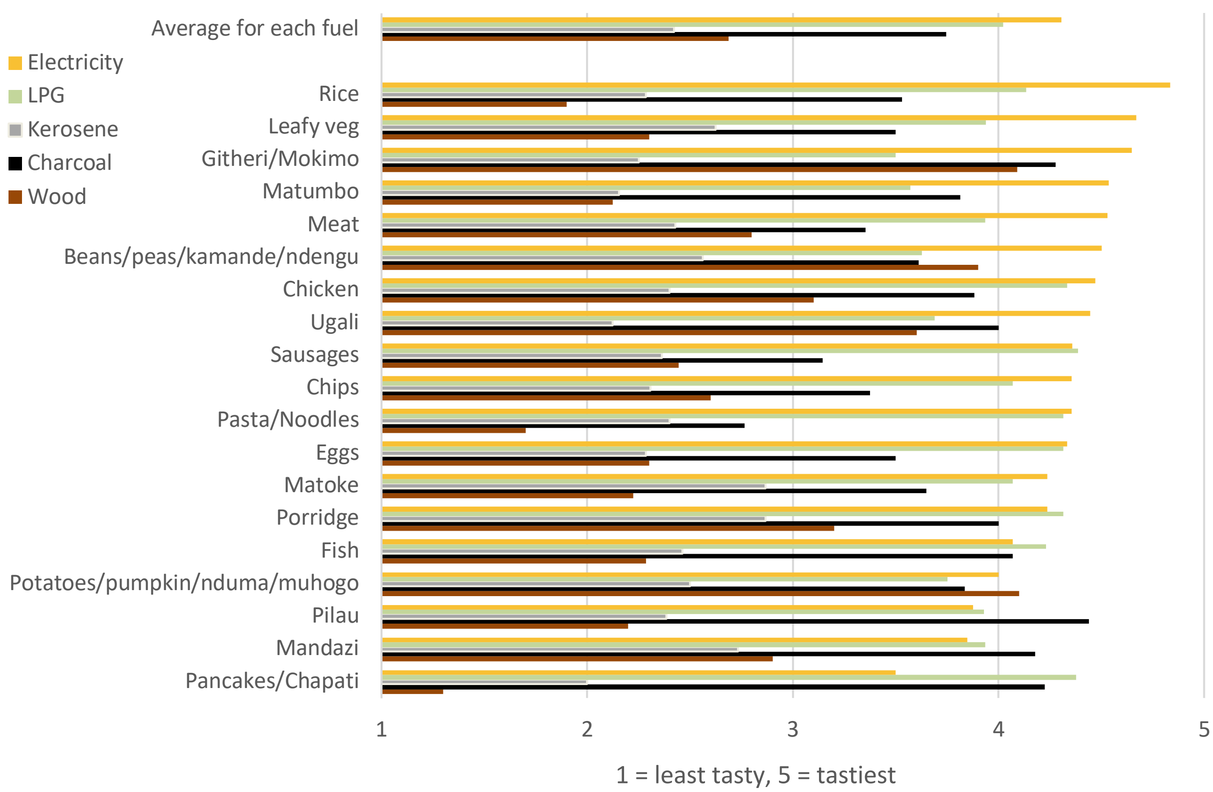

Figure 28: User perceptions of taste across different fuels.

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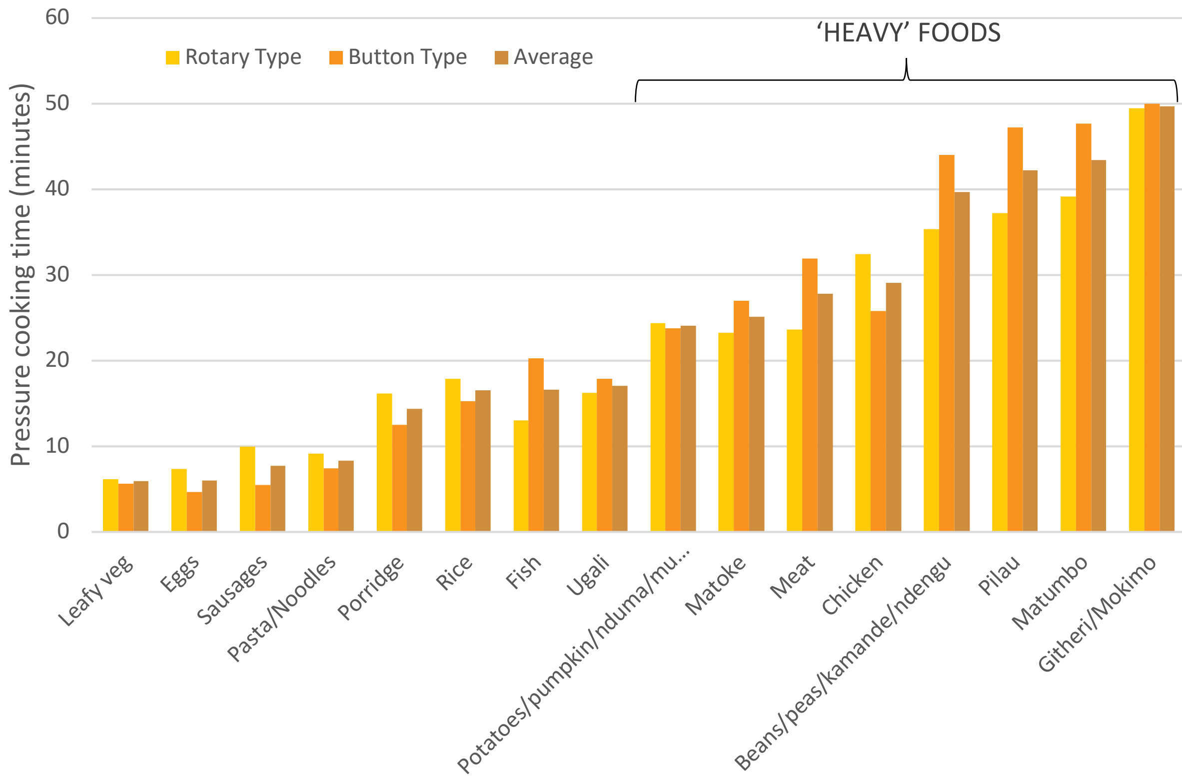
If a neighbour had just bought an EPC and asked how long they should set the timer for each food, what would you tell them?



Which foods are not possible to cook in an EPC?

ALTHOUGH 'HEAVY FOODS' CAN TAKE SEVERAL HOURS ON OTHER FUELS, NO FOOD EXCEEDED A RECOMMENDED COOKING TIME OF 1 HOUR ON AN E.P.C..

Figure 29: EPC cooking times by dish.

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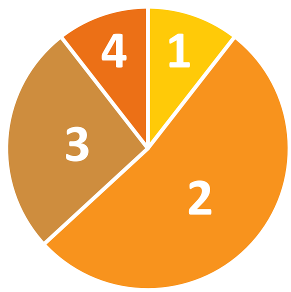
In theory, timings for rotary type EPCs should be lower than for button type, as the former include the time taken to pressurize (which depends on the quantity of food being cooked and its starting temperature), whilst the latter only includes cooking time at pressure. However, Figure 29 shows that whilst this is generally the case for the longest cooking dishes, in fact, it is the opposite for many of the shorter cooking dishes. Further research is needed to understand why this is the case.

How many hobs (rings) do you need for cooking?



> ALTHOUGH A THIRD OF PARTICIPANTS STATED THEY NEED TO COOK 3 OR 4 THINGS SIMULTANEOUSLY, THE SAME PROPORTION WERE ALSO USED TO COOKING ON BIG 4 PLATE COOKERS WITH AN OVEN BEFORE THE STUDY BEGAN.

Figure 30: User needs for simultaneous cooking.

What were the best things about cooking with electricity?

What were the worst things about cooking with electricity?

What do you like most about cooking with charcoal/ firewood?

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What do you like most about cooking with LPG/kerosene?

BEING ABLE TO COOK FASTER & KEEP THE KITCHEN CLEAN ARE BOTH HIGHLY VALUED BY THESE URBAN PARTICIPANTS. PRIORITIES MAY WELL BE DIFFERENT IN RURAL AREAS.

What are the best things about not cooking with charcoal/ firewood?

THE AUTOMATED CONTROL SYSTEMS OF THE E.P.C. & RICE COOKER MAKE COOKING EASIER, ENABLING MULTI-TASKING & PREVENTING FOOD FROM BURNING.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

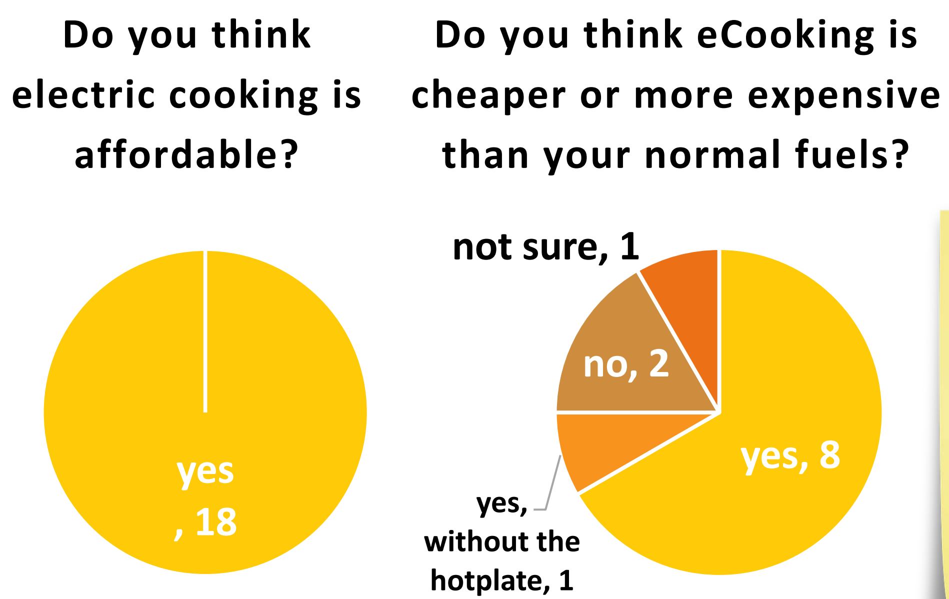
What are the best things about not cooking with LPG/kerosene?

Did you change your cooking behaviour? If yes, how and why?

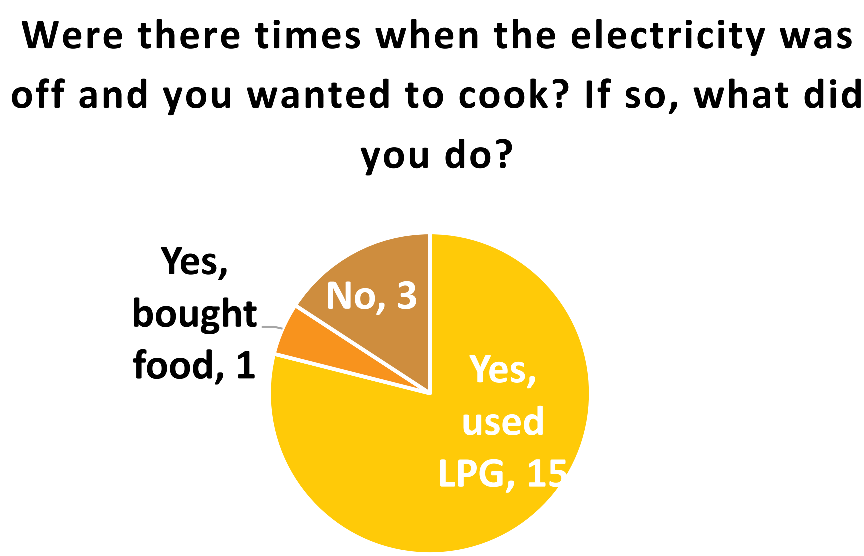
ALTHOUGH OFTEN SEEN AS A BARRIER TO THE ADOPTION OF NEW COOKING TECHNOLOGIES, IN THIS CASE, PARTICIPANTS REPORTED NOT HAVING TO CHANGE THEIR BEHAVIOUR OR THAT IT IS A DRIVER RATHER THAN A BARRIER.

Figure 31: User experience of using different fuels..

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.



ECOOKING WAS UNANIMOUSLY DECLARED AS AFFORDABLE, WITH 2/3 OF RESPONDENTS REPORTING THAT IT WAS CHEAPER THAN THE FUELS THEY USED BEFORE THE STUDY.



80% OF RESPONDENTS REPORTED HAVING TO USE LPG DURINGTHE ECOOKING PORTION OF THE STUDY BECAUSE OF BLACKOUTS, SHOWING THAT BATTERY-SUPPORTED APPLIANCES ARE LIKELY TO BE A KEY ENABLER FOR ELECTRIC COOKING.

Figure 32: User perception of affordability & experience of blackouts..

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

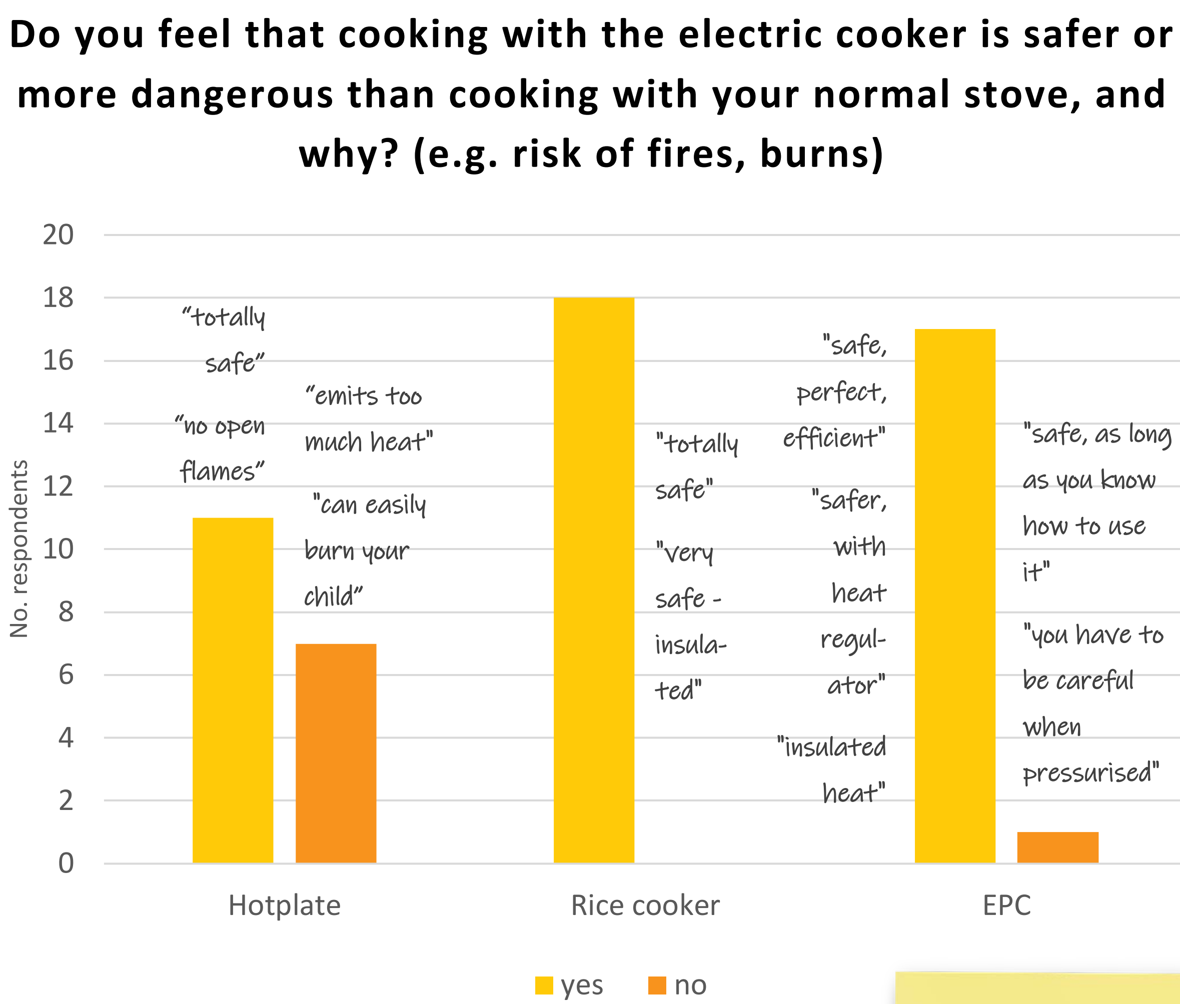
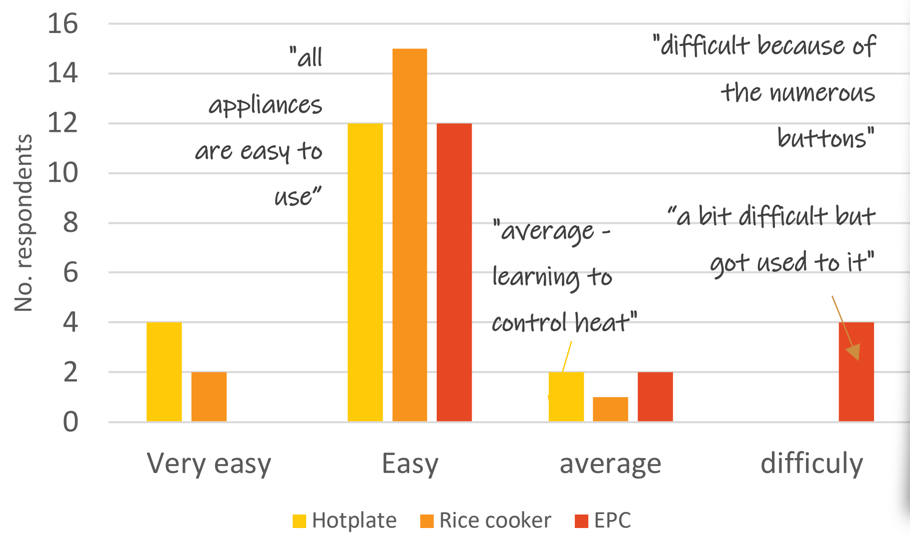


Figure 33: Perceptions of safety.

> DESPITE THE GENERAL PERCEPTION OF STOVE-TOP PRESSURE COOKERS AS UNSAFE, THE EPC WAS RATED AS EVEN SAFER THAN THE HOTPLATE. INSULATION & AUTOMATIC CONTROL ARE KEY SAFETY FEATURES. AS A RESULT, THERE WAS NOT A SINGLE SAFETY CONCERN WITH THE RICE COOKER.

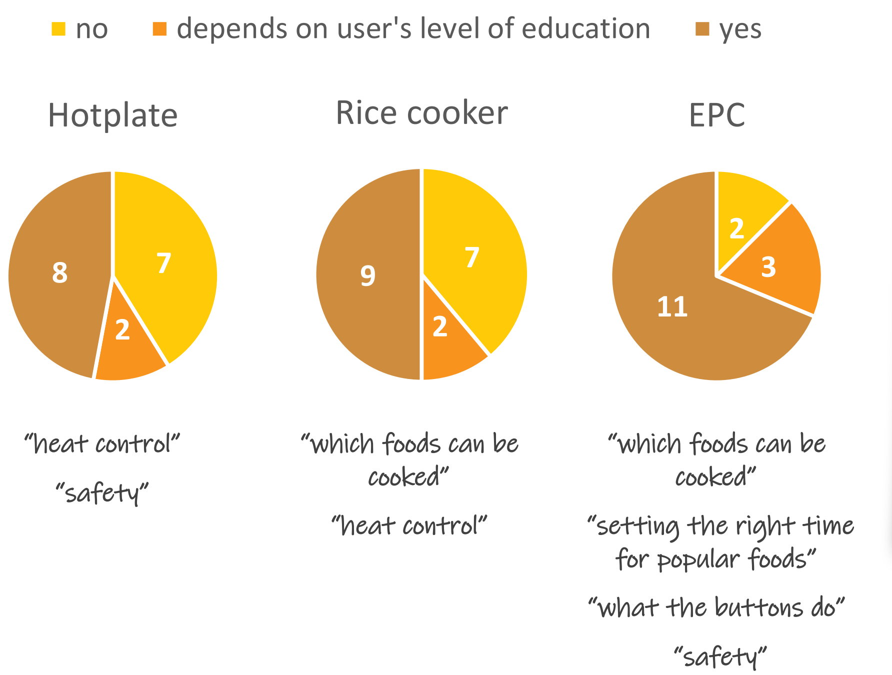
This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

How easy is it to learn to cook on an electric stove?



IT APPEARS THAT ALTHOUGHT THERE IS A STEEP LEARNING CURVE WITH EPCS, ONCE THIS HAS BEEN OVERCOME, THEY ARE RELATIVELY EASY TO USE. ON THE OTHER HAND, HOTPLATES & RICE COOKERS APPEAR MUCH MORE INTUITIVE.

Would people need training on how to use an eCooker, or would they be able to learn by themselves? If so, training on what?



IF EPCS CAME WITH BUTTONS FOR POPULAR LOCAL FOODS, TRAINING REQUIREMENTS COULD BE REDUCED SIGNIFICANTLY. HOWEVER, SAFETY WOULD STILL BE A STRONG CONCERN AMONGST NEW USERS.

Figure 34: User experience of learning to use electric cooking appliacnes.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Would you ever cook using only electricity and no other fuels? If so, why?

THE MOTIVATIONS FOR TRANSITIONING TO ELECTRICITY ARE STRONG, HOWEVER IT SEEMS LIKELY THAT MOST PARTICIPANTS WILL CONTINUE FUEL STACKING TO SOME DEGREE.

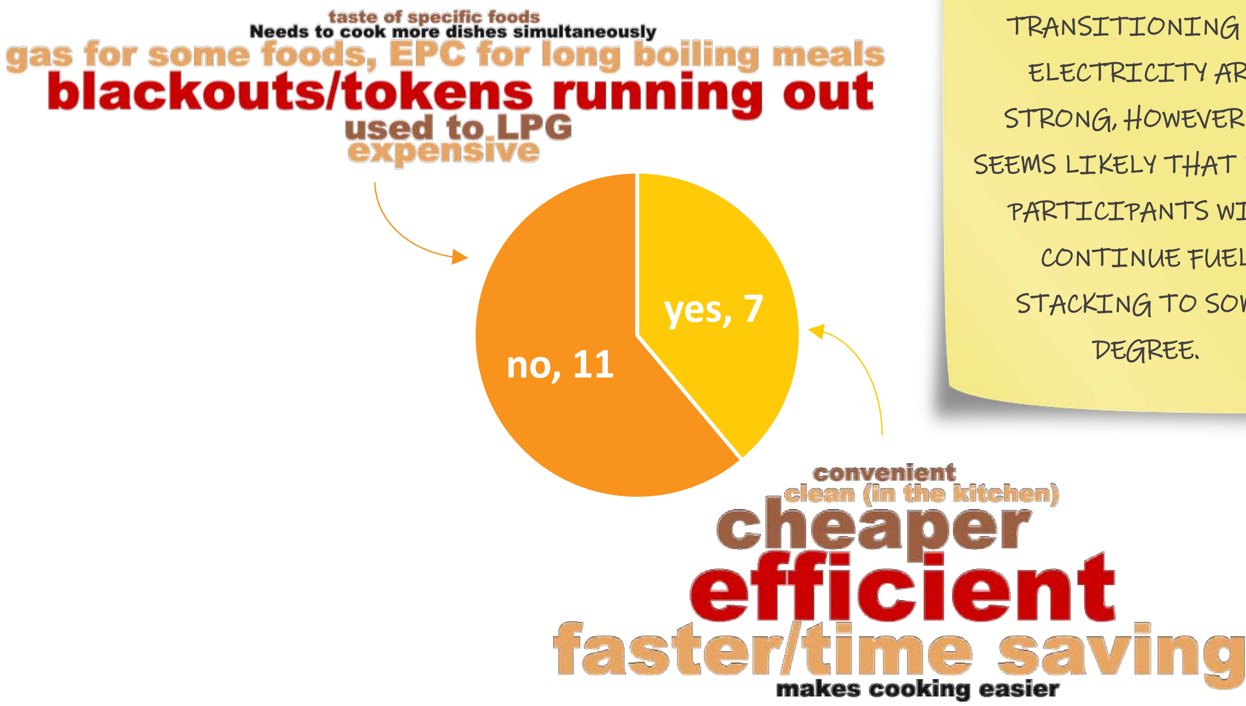


Figure 35: Motivations to continue fuel stacking.

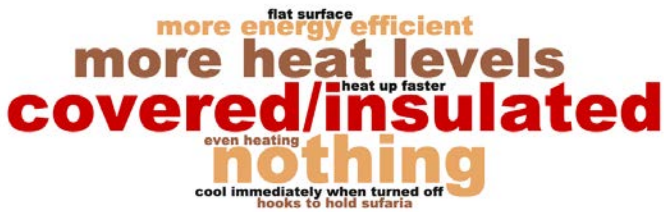
BATTERY-SUPPORTED APPLIANCES WOULD DIRECTLY ADDRESS THE STRONGEST MOTIVATION TO CONTINUE FUEL STACKING: BLACKOUTS.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

What would you change about the design of the electric stoves you have been using?

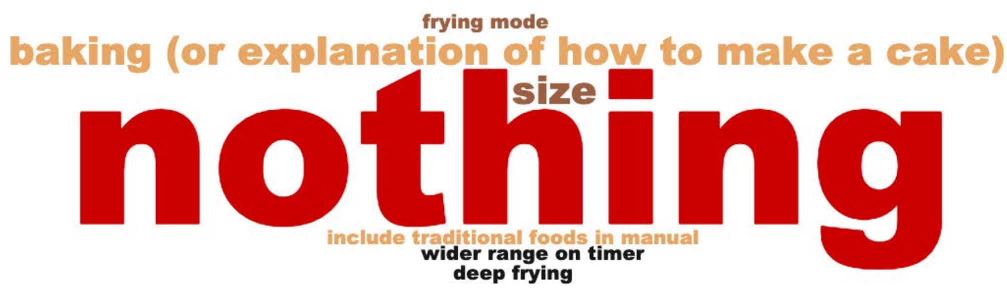
IT SEEMS THE EPC & RICE COOKER ARE ALREADY WELL SUITED TO USER NEEDS, BUT THERE ARE STILL MINOR TWEAKS, SUCH AS MANUAL HEAT CONTROL, THAT COULD MAKE THEM EVEN MORE ATTRACTIVE.

Hotplate:



Rice cooker:

EPC:



If you could design your own completely new eCooker, what would it be like?

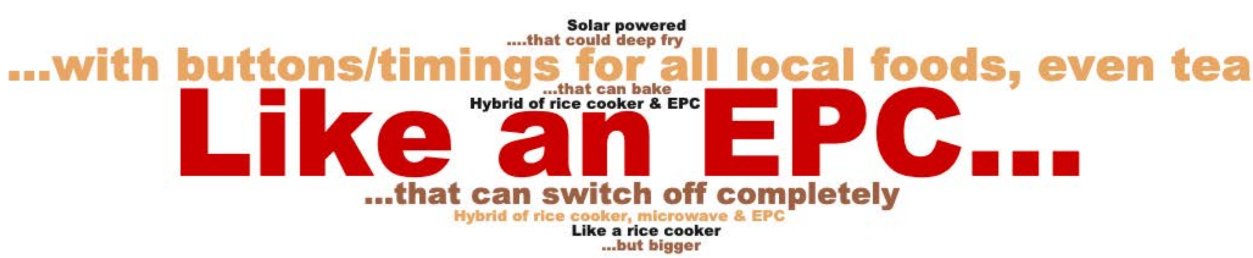
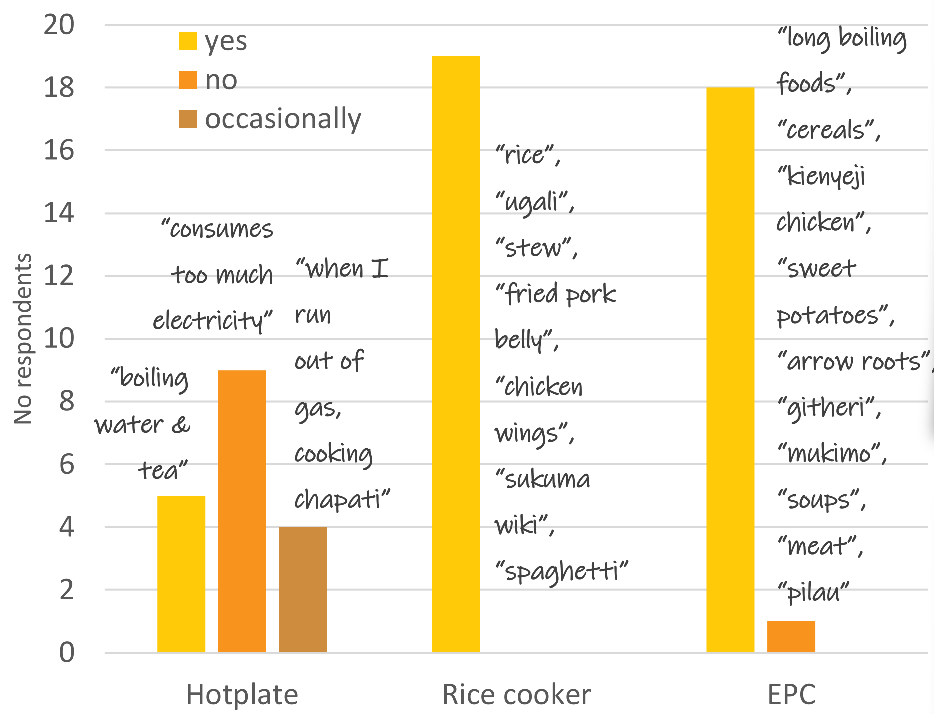


Figure 36: Electric cooking appliance design modifications that could enhance user experience.

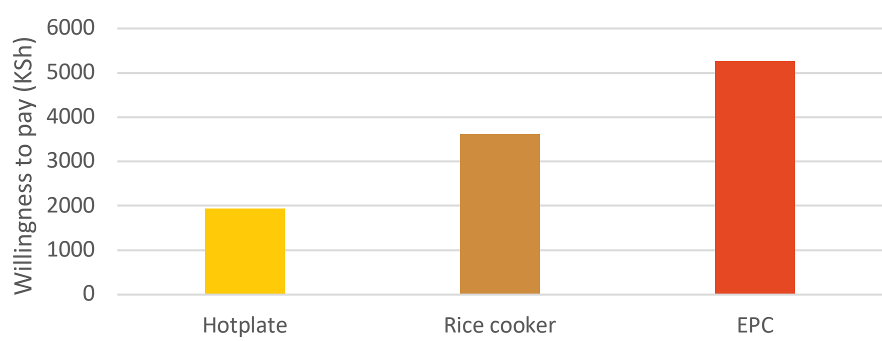
This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

We are done with our survey and are leaving the cookers with you. Will you continue using the e-cookers or will you switch back to your old stove?



THE RICE COOKER & EPC HAVE FOUND A PLACE IN ALMOST EVERY PARTICIPANT'S HOME. THEIR ABILITY TO COOK FASTER, CHEAPER & AUTONOMOUSLY IS HIGHLY VALUED.

Would you buy this cooker if you saw one in a shop now? If so, how much would you be prepared to pay for this cooker (KSh)?



HOTPLATES ARE THE LEAST POPULAR APPLIANCE, WITH USER FEEDBACK SHOWING THAT THEY CONSUME TOO MUCH ELECTRICITY COMPARED TO THE INSULATED RICE COOKER & EPC. THEIR STRENGTH IS BEING ABLE TO USE DIFFERENT POTS, BUT CONTROLLING HEAT LEVELS IS DIFFICULT COMPARED TO LPG, SO MOST WILL NOT CONTINUE USING THEM AFTER THE STUDY.

Figure 37: Valuation of the usefulness of each appliance.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

3.7.2 Githeri eCooking Challenge

The results of the Githeri eCooking Challenge show that almost all households were clearly capable of cooking very efficiently (80-90% savings) when they want to. On a hotplate, cooking ½kg githeri usually exceeds 2kWh and can even reach 4kWh if using the slowest cooking beans, leaving the lid off, etc. Figure 38 shows that almost all households (16/19) were able to complete the challenge with under 0.4kWh – a 80-90% saving over hotplates.

THE GITHERI eCOOKING CHALLENGE SHOWS THAT PARTICIPANTS CAN COOK VERY EFFICIENTLY WHEN THEY WANT TO & THAT 80-90% SAVINGS ON LONG BOILING DISHES ARE CREDIBLE IN REAL KITCHEN ENVIRONMENTS.

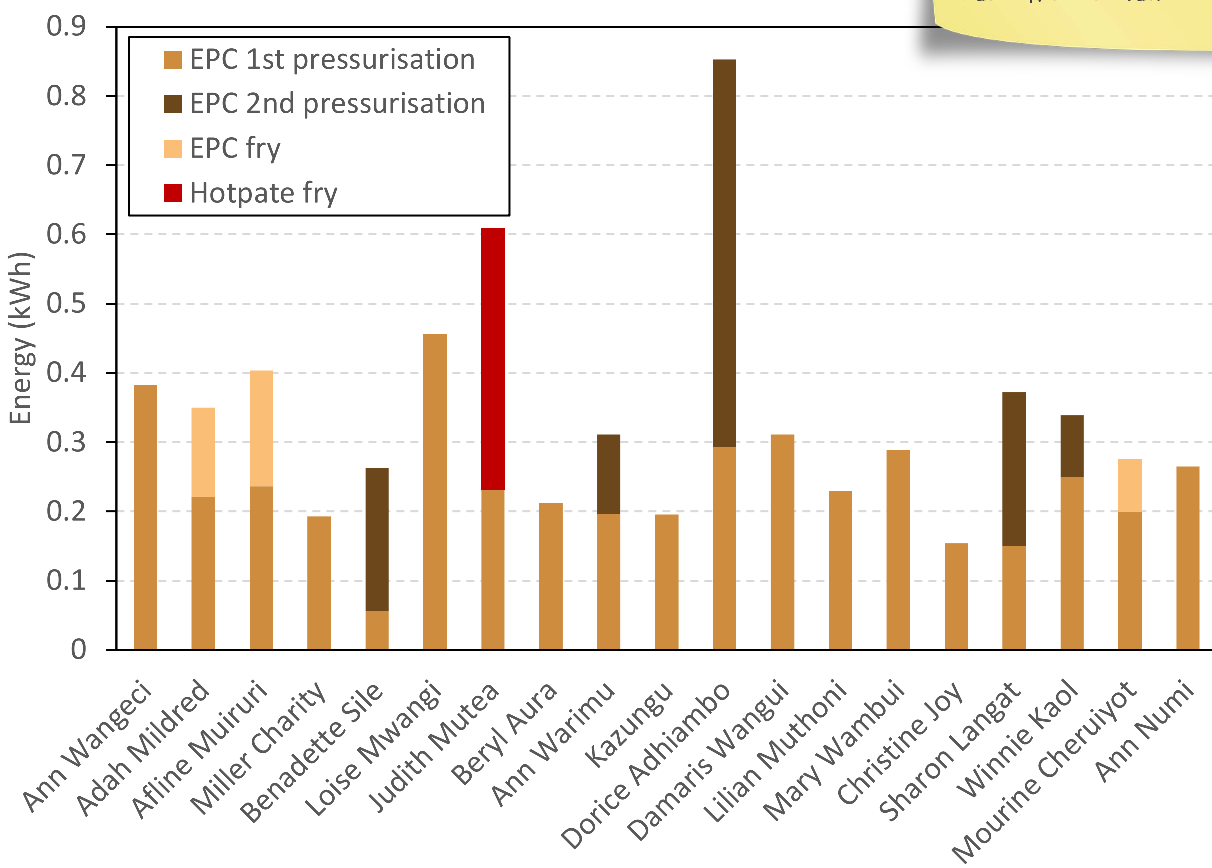


Figure 38: Energy consumption during the Githeri eCooking Challenge by participant, appliance and process.

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The most efficient participant (Christine Joy) used just 0.154kWh. She depressurised just once, did not fry, used fresh maize, soaked both the beans and maize overnight, did not add any additional ingredients (except salt and a stock cube) and had a completely sealed pressure valve. However, she could have used even less energy by choosing a quicker cooking bean variety, starting with leftover hot water from other cooking activities (e.g. making tea), using just enough water rather than a bit too much that is simply poured away at the end and/or adding extra insulation around the EPC to minimise heat loss (e.g. a fireless cooker or towel).

ALTHOUGH RE-PRESSURISING AFTER OPENING THE EPC BEFORE THE FOOD IS READY CAN ALMOST DOUBLE ENERGY CONSUMPTION, IT IS MERELY THE DIFFERENCE BETWEEN 'ULTRA-EFFICIENT' & 'VERY EFFICIENT', I.E. 70-80% SAVINGS OVER A HOTPLATE, RATHER THAN 80-90%.

Figure 38 disaggregates each participant's total energy score by appliance and by process. All participants chose an EPC for the boiling stage, with just one household deciding to switch to a hotplate for frying. On average, the first pressurisation used 0.238kWh. The 5 participants who had to add a second pressurisation an almost identical 0.239kWh on average, however as their first pressurisation was shorter, it only used an average of 0.189kWh (making a total of 0.428kWh for these 5 participants). The 3 participants who fried using the EPC used an average of 0.219kWh for their first pressurisation, adding a further 0.125kWh on average to fry, making a total of 0.343kWh. The participant who switched to the hotplate to fry used 0.232kWh, adding 0.378kWh to fry, totalling 0.61kWh.

WHILST BEAN VARIETY & SOAKING CAN HAVE A BIG INFLUENCE ON COOKING TIME (& THEREFORE COST) ON A HOTPLATE, MOST OF THE ENERGY REQUIRED FOR COOKING WITH AN EPC GOES INTO GETTING THE CONTENTS TO PRESSURE, I.E. THE FIRST 5-20 MINS. MAINTAINING PRESSURE FOR 1 HOUR DOESN'T USE MUCH MORE ENERGY THAN MAINTAINING IT FOR 30 MINS.

Other variables that were recorded, but seemingly had little to no impact on energy consumption included: leaky pressure valves, adding extra ingredients, variety of bean and soaking time. 5 participants reportedly had leaky pressure valves (Ann Wangeci, Beryl, Ann Numi, Mourine, Mary), however it is unclear how significant these leaks were. The mass of the extra ingredients (mostly salt, stock cubes, tomatoes and onions) was small compared to the ½ kg of beans and maize and they cook comparatively quickly, so the only time they noticeably extended the cooking time (and therefore energy) was when they were fried. Participants chose either red beans (wairimu, saitoti or rosecoco), yellow beans or a mix of the two, none of which have extremely low or high cooking times. Nobody chose ndengu (mung beans), which cook in half

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the time of most other beans, however they are not usually used to prepare githeri and most Kenyans do not consider them a bean. Although all participants used fresh maize, none used fresh beans, presumably simply due to local availability at the time of the study. 15 participants soaked their beans, most overnight (11), some for 6 hrs (2), some for 2hrs (2) and 1 for just 15 mins. Soaking beans can reduce cooking times by up to half, however, seemingly the marginal extra cost of maintaining pressure for an extra half an hour or more is seemingly insignificant compared to the high energy input required to pressurise and fry.

Finally, two variables were constant amongst all participants, so it was again not possible to assess their impact. No participants used left over hot water from other kitchen activities, which could have significantly reduced the energy required to pressurise, as going from 100°C to 120°C should require significantly less energy than going from 20°C to 120°C. All participants turned off the appliance as soon as the food was ready.

Most participants reported that they learned to cook from their mother (16), a couple (2) from their grandmother and one was self-taught. Many (9) stated that the best ingredients come from up-country, others from a local shop (7) and some from a specific market or supermarket (4). Most (12) reported that apart from the fuels/appliances they use, the techniques they use to prepare githeri have not changed from when they were growing up. Others reported that they now soak the beans, fry & boil together, boil maize first then beans, use different proportions of beans to maize, and/or use soft maize instead of hard. About half (8) stated that they always use the same recipe, several (5) sometimes soak the beans and several others (6) said their recipe depends on the ingredients and fuel/appliance. Soaking dried ingredients was the most common shortcut reported (15), followed by using fresh instead of dried ingredients (3).

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4 Evaluation

Whilst this cooking diaries study has enabled us to shed new light on what everyday Kenyan cooks really do in their kitchens, the following section seeks to understand the limitations in the data obtained and offer constructive recommendations for the next round of cooking diaries, both in Kenya and internationally.

User feedback on the survey was very positive, with all (18/18) saying they would like to participate in follow up surveys. Some (7/17) reported being hesitant when initially approached, thinking that it would be too complicated or that they would be too inexperienced with electric appliances. However, most were happy to have learned new things during the study, in particular how to save time and money in the kitchen. Figure 39 suggests that the right appliances were chosen and sufficient training was given, however the additional material developed in parallel to the cooking diaries study will be able to act as valuable additional training resources. This material is currently collated in the Kenya eCookBook (available from www.MECS.org.uk) and is being transformed into more engaging content, such as jpegs to share on social media and YouTube videos in partnership with local food bloggers.

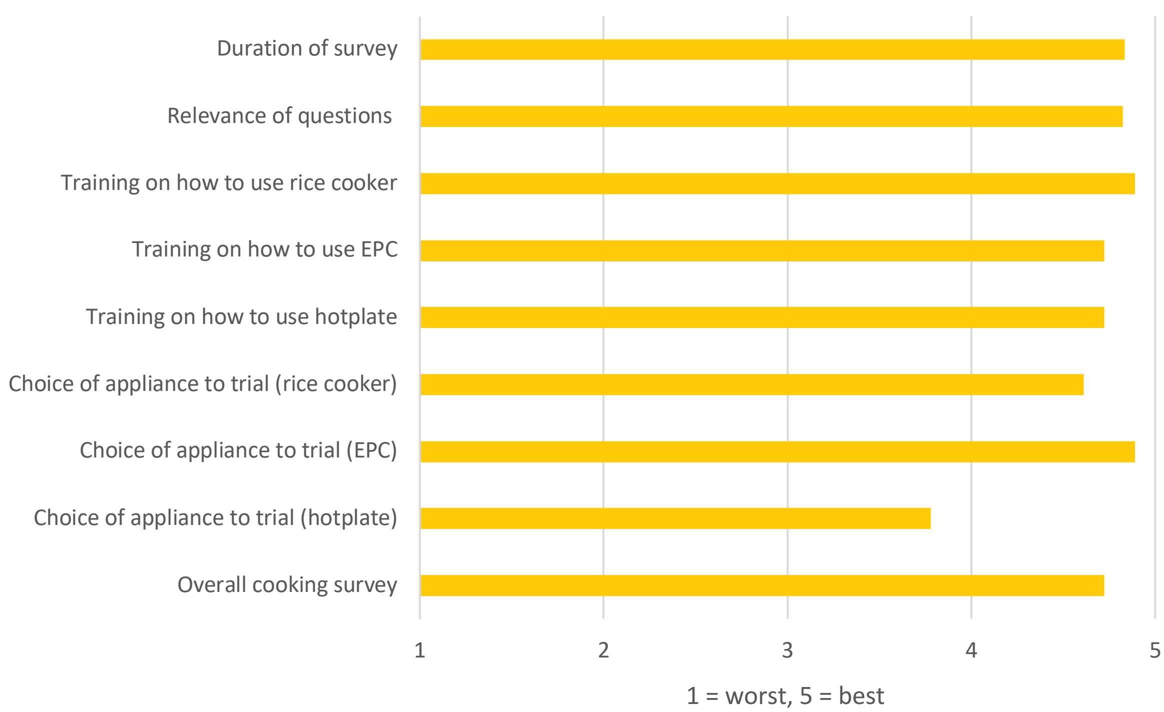

Figure 39: User feedback on cooking diaries survey.

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4.1 LPG measurements

LPG was without doubt the most challenging fuel to measure on a per meal basis. This is because the amount of LPG consumed per meal is relatively small compared to the total mass of the cylinder. As a result, weighing instruments need to have both a relatively high range and accuracy. A single meal such as frying an egg to serve with bread, can use as little as 5g of LPG. Meanwhile, most Kenyan households that cook with gas have either a 6kg or 13kg cylinders – when full, the weight doubles to 12kg and 26kg respectively. As a result, only the three options in the bottom right of Table 66 are suitable. Of these options, the handheld digital hanging balance was selected for this study, as it was already in use for the charcoal measurements. These instruments have a range of 40kg and an accuracy of 5-10g, however asking the participants to lift a full 13kg (i.e. 26kg) cylinder before and after each meal was not practical, so 3kg cylinders were purchased for these participants.

LPG WAS THE HARDEST FUEL TO MEASURE, BUT GAS METERS THAT MEASURE BY VOLUME INSTEAD OF WEIGHT OFFER A PROMISING, BUT SIGNIFICANTLY MORE EXPENSIVE OPTION FOR FUTURE STUDIES.

Table 66: Categorisation of commonly available weighing instruments by range and accuracy.

	Low range (<10kg)	High range (>10kg)
Low accuracy (>20g)		**Bathroom scales** **Handheld analogue hanging balance**
High accuracy (<20g)	**Kitchen scales**	**Handheld digital hanging balance** **Fixed base analogue hanging balance** **Flat market produce scales**

Whilst charcoal can be subdivided into small quantities so that the whole sack doesn't need to be weighed each time, LPG cannot. Relatively large (>1kg) amounts of charcoal are also used for each meal, meaning that holding the hanging balance by hand was still sufficiently accurate. For LPG, this is not the case and unsteady hands regularly introduce errors of 50g or more. As a result, a hanging point was either found or created (using screw in hooks) in each participant's kitchen. Whilst it was intended that these hanging points be far enough from any obstructions to avoid the possibility of the cylinder contacting them during weighing, it was clear that this was happening in some households. After reviewing the data for some participants, the weights of the after measurement of one meal did not match up with the before measurement of the subsequent meal, in one case by over 1kg!

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A further complication is added in households with a separate stove connected via a pipe and regulator, as this connection distorts any weight measurement. Most commonly available regulators are designed to be removed every few weeks when the cylinder is empty and experience with the cooking diaries study in Dar es Salaam showed that removing them before and after every meal resulted in premature failure. Regularly removing the regulator is also very inconvenient for the participants and also presents a safety risk if they are not familiar with changing the regulator or if it wears prematurely. The 3kg cylinders purchased for this study came with stove-top burners (see Figure 40) and many of the participants with 6kg cylinders also had stove-top burners. In these cases, the entire assembly could simply be hung from the hanging balance, however care had to be taken as after cooking, it is very hot. There was only one option available for stove-top burners for the 3kg stoves and they were not good quality. Controlling the heat level was difficult, as the rotary knob was very sensitive, and the heat level often drifted during cooking. Only a small range of the heat knob resulted in an efficient (blue) flame for cooking, with the rest resulting in a huge (up to 30cm) yellow flame. They were also only anchored at one point (via the gas valve, which created a safety risk, especially when repeatedly lifting the cylinder to weigh it, as the entire weight of the cylinder is straining that one point, rapidly wearing the screw threads between sections and several have since been observed to fail.

Figure 40: Hanging balance weighing a 3kg LPG cylinder with stove-top burner (left) and calibrating the natural gas meter using a flat market produce scale (right, regulator was removed when taking measurements).

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Of course, gas can also be measured by volume, so other options include a gas meter designed for natural gas and Pay as You Go flow meters. A natural gas meter was imported from the UK (see Figure 40), and was used by one participant in the study with great success. However, the meter cost of 50USD, with an additional 40USD for adaptors to fit LPG hose. Importing 20 of these would also have incurred shipping costs and import duties, adding significant lead time, which made it an impractical solution given the limited time and budget available. A number of companies have recently started selling LPG using a Pay as You Go business model in Kenya, notably Envirofit and PayGo Energy. They use a gas flow meter on top of the cylinder to measure consumption for billing purposes, however this would be an ideal measurement tool for the cooking diaries study. However, concerns have been raised by some in the industry that volume measurements are not significantly accurate, as volume is proportional to temperature, so customers have reported that the same meal costs vastly different amounts on different days. It should be noted that gas meters are also not compatible with stove top burners - this could be solved by purchasing a single burner counter-top stove, but again at extra expense.

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4.2 Data limitations

4.2.1 Single fuel data

'UN-STACKING' THE COOKING PRACITCES OF HHS THAT FUEL STACK COULD PROVIDE MORE DATA TO MAKE DIRECT COMPARISONS BETWEEN FUELS. THIS STUDY OBTAINED A LOT OF ELECTRICITY & LPG, LIMITED CHARCOAL & KEROSENE DATA.

One of the main aims of the cooking diaries study was to understand how charcoal users might transition to electricity, however very little data was actually collected. When selecting participants, potential candidates were asked which fuels they cooked with to ensure that there was a sufficient number of charcoal users in the study. However, shortly before data collection started, the Governement of Kenya enforced a 90 day ban on logging, which caused the price of charcoal to double in Nairobi. The direct consequence of this was that few of the households who usually cooked with charcoal actually did during the study. This was compounded by the fact that many households had 3kg gas cylinders purchased for them so that they could be weighed during the study (see LPG measurement issues above). As most households used LPG for at least a portion of their cooking, when faced with the choice of using charcoal at double the normal price or gas for free, there was little reason to continue using charcoal.

Options for mitigating this issue in the future include adding an extra step to Phase 1 (baseline) to 'unstack' each fuel; subsidising the price of any fuels experiencing price spikes whilst also ensuring participants pay for all other fuels at the same rate they usually pay and/or selecting participants who only cook with one fuel. Currently the cooking diaries methodology only includes two phases: Phase 1 (baseline) and Phase 2 (transition to electricity). Phase 1 is designed to capture current cooking practices by simply observing how each participant currently cooks, which usually involves stacking several different fuels. Some of these fuels (in this case kerosene and charcoal) are used so rarely, that there is not enough data to make meaningful comparisons with other fuels. The amount of data for each fuel could be increased by extending Phase 1 with several periods of cooking only on each of the fuels that each participant current uses. For example, a participant who fuel stacks charcoal and LPG could cook for 2 weeks stacking the two as they naturally do, then 2 weeks cooking just on charcoal followed by 2 weeks cooking just on LPG, before moving on to electricity in Phase 2.

4.2.2 Dish level data

Partly as a consequence of the above and partly because of the meal level resolution of data collection, it was very difficult to make meaningful comparisons between fuels and appliances. It was hoped that

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dishes could be categorised according to their energy and time signatures, facilitating the transferability of the results to other contexts. For example, parallel research in the kitchen laboratory for the eCookBook clearly showed that 'heavy foods' such as beans, matumbo (tripe) and githeri (beans & maize stew) all take several hours and several kWh to boil on a hotplate, yet can be cooked for roughly half the time and 10-40% of the energy using an EPC. Attempts were made to group these dishes together during the data analysis phase based upon their energy and time signatures, however this was not successful because insufficient data points were available and it was suspected that many participants had misinterpreted the reheating (simply warming up again), pre-cooking (boiling the beans for storage) and partially cooked (combining pre-cooked beans with a freshly made sauce) options.

APPLIANCE LEVEL SUB-METERING, 'UN-STACKING' BY APPLIANCE DURING PHASE 2 & OR FIXED MENUS COULD ENABLE MUCH BROADER DISH-LEVEL COMPARISONS ACROSS FUELS & APPLIANCES.

The data collection forms are set up to record a before and after energy reading for every meal, however, data is also collected on how each dish that composes that meal is cooked. As a result, whilst making comparisons between meals is easy, as a lot of data exists, making comparisons between individual dishes is difficult. Dish level energy data is limited to the meals where only a single dish is cooked. For some single pot meals like matoke (banana stew), this may happen reasonably often, but for others like ugali, this is relatively uncommon as it is a staple that usually accompanies another dish. The data for electric appliances is subdivided even further because three appliances were available, each of which is likely to use a different amount of energy.

The solution for electric appliances is relatively straight forward – sub meter each appliance and ask users to record dish level energy data. However, this would be more challenging for kerosene, as it would require multiple weight measurements whilst the stove is hot, and even more so for LPG, as many people use multi-burner stoves. However, the biggest challenge would be for charcoal, as charcoal is burned during lighting and continues to burn after cooking has finished. As a result, cooking three dishes independently (i.e. lighting and allowing the remaining charcoal to burn out each time) would consume more charcoal than cooking a three dish meal in one go. Perhaps the only way to achieve dish level energy measurements with charcoal is to have the stove sitting on top of a flat scale throughout cooking, taking measurements of the empty stove, after filling with the first load of charcoal, after starting cooking, then after each dish is completed and finally of any remaining charcoal that can be resused. This has obvious practical challenges, but it would allow the decomposition of dish level data if the charcoal burned during lighting and burn out were divided evenly between each dish.

Another way to increase the amount of dish level data for each fuel/appliance is to 'unstack' them, as described in the preceeding section. This could also occur in Phase 2, with participants spending a two week period cooking solely on a single (or perhaps pair of identical) appliance. This would be challenging for some appliances (e.g. kettles), but perhaps an agreement could be made with participants, whereby it is decided beforehand which dishes will be cooked on which appliance during which period. It may also be worth including a quantitative metric of user satisfaction with how each dish turned out, so as to pinpoint what the strengths and weaknesses of each fuel/appliance are.

Finally, more directly comparable data could be obtained by setting fixed menus. These could be decided in advance by each participant, or by the group as a whole, and data collection would involve cycling though a daily or weekly menu with each fuel/appliance a sufficient number of times to allow enough data points to be collected. However, this would then create a slightly less realistic dataset, as whilst some houeseholds may have regular menus that they stick to quite closely, others will not and for some of those it simply won't be possible at all due to participant's other commitments (e.g. having to work late unexpectedly).

4.3 Enumerator visits & digitisation of data

Many issues with the dataset were only discovered long after data collection had finished due to the slow pace of follow up visits, digitisation of the data and analysis of the dataset. Enumerators were contracted to visit the households daily and asked to digitise the paper forms as soon as they were collected. However with 10 households for each enumerator to visit, this was simply not possible, even though households had been selected based upon their proximity to the enumerators home. What is more, the sheer volume of data recorded on paper forms meant that it often was not digitised until months later. As a result, issues that could easily have been corrected at the time, such as faulty meters, other cooks in the household not recording data properly or not recording during blackouts, often went undetected, resulting in data having to be corrected or excluded.

DIGITISING DATA COLLECTION & REDUCING THE NUMBER OF HHS MONITORED BY EACH ENUMERATOR COULD GREATLY INCREASE THE QUALITY OF THE DATA SET.

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To increase the quality of the dataset, it is recommended that if collecting data as detailed as this in the future, each enumerator monitor just 5 households and a digital data collection system be created. Although most participants (15/17) stated that enumerator visits were helpful and frequent enough, more frequent visits could greatly increase the quality of the data, as small issues could be corrected on the day, rather than having to correct of completely remove questionable data at a later date. It was noticed that many participants were writing down the key bits of information (time, energy & basic information about the dish) on a notepad during cooking. They would later transcribe this onto the full diary form when they had more time available. This suggests that if an enumerator were to visit each day, they could sit down with the participant and enter the data from the notepad into a digital form, for example using a tablet with a specially designed questionnaire in a data collection app such as Kobo Collect. This data would be uploaded to the server by each enumerator at the end of each day, then downloaded and checked by the lead researcher the following day. This would also help to reduce the errors in the transcription phase, as the participant would be able to remember any missing details (except energy readings) from that same day. Digitising the paper forms was often done in bulk under extreme time pressure, making the possibility of errors during transcription high.

4.4 Sample diversity

This study used convenience sampling as a means to get some initial data as quickly as possible. As a result, most participants were middle class and all were urban. Future studies in Kenya should seek to understand how different sectors of society cook, in particular poorer households and rural households, and identify regional differences in cooking.

THIS STUDY HAS OFFERED AN INITIAL EXPLORATION OF KENYAN COOKING. FOLLOW UP STUDIES SHOULD EXPLORE THE DIFFERENCES BETWEEN URBAN/RURAL, POOR/WEALTHY & DIFFERENT REGIONS OF THE COUNTRY.

This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

5 Conclusion

The cooking diaries study in Kenya has shown that cooking with electricity is compatible with Kenyan cuisine and that modern energy-efficient appliances are highly desirable to everyday Kenyan cooks. In particular, the Electric Pressure Cooker (EPC) as a prime candidate for future eCook products, as it can significantly reduce the energy demand for the biggest energy consumers: "long boiling" dishes. In fact, in many areas of Nairobi, the grid is already strong enough for direct AC cooking without a battery, meaning there is a considerable opportunity already on the table to promote off-the-shelf appliances, in particular, EPCs. LPG is already popular in Nairobi and while electric hotplates do not offer anything new for LPG users, the ability to cook faster and multi-task, whilst also saving money make a fuel stacking scenario with EPCs extremely attractive.

The findings from this study will be combined with those from the other activities that have been carried under the eCook Kenya Market Assessment. Together they will build a more complete picture of the opportunities and challenges that await this emerging concept. Further outputs will be available from https://elstove.com/innovate-reports/ and www.MECS.org.uk.

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6 Appendix

6.1 Appendix A: Problem statement and background to LCT eCook project

6.1.1 Beyond business as usual

The use of biomass and solid fuels for cooking is the everyday experience of nearly 3 Billion people. This pervasive use of solid fuels—including wood, coal, straw, and dung—and traditional cookstoves results in high levels of household air pollution, extensive daily drudgery required to collect fuels, and serious health impacts. It is well known that open fires and primitive stoves are inefficient ways of converting energy into heat for cooking. The average amount of biomass cooking fuel used by a typical family can be as high as two tons per year. Indoor biomass cooking smoke also is associated with a number of diseases, including acute respiratory illnesses, cataracts, heart disease and even cancer. Women and children in particular are exposed to indoor cooking smoke in the form of small particulates up to 20 times higher than the maximum recommended levels of the World Health Organization. It is estimated that smoke from cooking fuels accounts for nearly 4 million premature deaths annually worldwide – more than the deaths from malaria and tuberculosis combined.

While there has been considerable investment in improving the use of energy for cooking, the emphasis so far has been on improving the energy conversion efficiency of biomass. Indeed in a recent overview of the state of the art in Improved Cookstoves (ICS), ESMAP & GACC (2015), World Bank (2014), note that the use of biomass for cooking is likely to continue to dominate through to 2030.

> "Consider, for a moment, the simple act of cooking. Imagine if we could change the way nearly five hundred million families cook their food each day. It could slow climate change, drive gender equality, and reduce poverty. The health benefits would be enormous." ESMAP & GACC (2015)

The main report goes on to say that "The "business-as-usual" scenario for the sector is encouraging but will fall far short of potential." (ibid,) It notes that without major new interventions, over 180 million households globally will gain access to, at least, minimally improved[7] cooking solutions by the end of the decade. However, they state that this business-as-usual scenario will still leave over one- half (57%) of the developing world's population without access to clean cooking in 2020, and 38% without even

[7] A minimally improved stove does not significantly change the health impacts of kitchen emissions. "For biomass cooking, pending further evidence from the field, significant health benefits are possible only with the highest quality fan gasifier stoves; more moderate health impacts may be realized with natural draft gasifiers and vented intermediate ICS" (ibid)

minimally improved cooking solutions. The report also states that 'cleaner' stoves are barely affecting the health issues, and that only those with forced gasification make a significant improvement to health. Against this backdrop, there is a need for a different approach aimed at accelerating the uptake of truly 'clean' cooking.

Even though improved cooking solutions are expected to reach an increasing proportion of the poor, the absolute numbers of people without access to even 'cleaner' energy, let alone 'clean' energy, will increase due to population growth. The new Sustainable Development Goal 7 calls for the world to "ensure access to affordable, reliable, sustainable and modern energy for all". Modern energy (electricity or LPG) would indeed be 'clean' energy for cooking, with virtually no kitchen emissions (other than those from the pot). However, in the past, modern energy has tended to mean access to electricity (mainly light) and cooking was often left off the agenda for sustainable energy for all.

Even in relation to electricity access, key papers emphasise the need for a step change in investment finance, a change from 'business as usual'. IEG World Bank Group (2015) note that 22 countries in the Africa Region have less than 25 percent access, and of those, 7 have less than 10 percent access. Their tone is pessimistic in line with much of the recent literature on access to modern energy, albeit in contrast to the stated SDG7. They discuss how population growth is likely to outstrip new supplies and they argue that "unless there is a big break from recent trends the population without electricity access in Sub-Saharan Africa is projected to increase by 58 percent, from 591 million in 2010 to 935 million in 2030." They lament that about 40% of Sub-Saharan Africa's population is under 14 years old and conclude that if the current level of investment in access continues, yet another generation of children will be denied the benefits of modern service delivery facilitated by the provision of electricity (IEG World Bank Group, 2015).

> "Achieving universal access within 15 years for the low-access countries (those with under 50 percent coverage) requires a quantum leap from their present pace of 1.6 million connections per year to 14.6 million per year until 2030." (ibid)

Once again, the language is a call for a something other than business as usual. The World Bank conceives of this as a step change in investment. It estimates that the investment needed to really address global electricity access targets would be about $37 billion per year, including erasing generation deficits and additional electrical infrastructure to meet demand from economic growth. "By comparison, in recent years, low-access countries received an average of $3.6 billion per year for their electricity sectors from public and private sources" (ibid). The document calls for the Bank Group's

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energy practice to adopt a new and transformative strategy to help country clients orchestrate a national, sustained, sector-level engagement for universal access.

In the following paragraphs, we explore how increasing access to electricity could include the use of solar electric cooking systems, meeting the needs of both supplying electricity and clean cooking to a number of households in developing countries with sufficient income.

6.1.2 Building on previous research

Gamos first noted the trends in PV and battery prices in May 2013. We asked ourselves the question, is it now cost effective to cook with solar photovoltaics? The answer in 2013 was 'no', but the trends suggested that by 2020 the answer would be yes. We published a concept note and started to present the idea to industry and government. Considerable interest was shown but uncertainty about the cost model held back significant support. Gamos has since used its own funds to undertake many of the activities, as well as IP protection (a defensive patent application has been made for the battery/cooker combination) with the intention is to make all learning and technology developed in this project open access, and awareness raising amongst the electrification and clean cooking communities (e.g. creation of the infographic shown in Figure 41 to communicate the concept quickly to busy research and policy actors).

Gamos has made a number of strategic alliances, in particular with the University of Surrey (the Centre for Environmental Strategy) and Loughborough University Department of Geography and seat of the Low Carbon Energy for Development Network). In October 2015, DFID commissioned these actors to explore assumptions surrounding solar electric cooking[8] (Batchelor, 2015b; Brown and Sumanik-Leary, 2015; Leach and Oduro, 2015; Slade, 2015). The commission arose from discussions between consortium members, DFID, and a number of other entities with an interest in technological options for cleaner cooking e.g. Shell Foundation and the Global Alliance for Clean Cookstoves.

Drawing on evidence from the literature, the papers show that the concept is technically feasible and could increase household access to a clean and reliable modern source of energy. Using a bespoke economic model, the Leach and Oduro paper also confirm that by 2020 a solar based cooking system could be comparable in terms of monthly repayments to the most common alternative fuels, charcoal and LPG. Drawing on published and grey literatures, many variables were considered (e.g. cooking

[8] The project has been commissioned through the PEAKS framework agreement held by DAI Europe Ltd.

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energy needs, technology performance, component costs). There is uncertainty in many of the parameter values, including in the assumptions about future cost reductions for PV and batteries, but the cost ranges for the solar system and for the alternatives overlap considerably. The model includes both a conservative 5% discount rate representing government and donor involvement, and a 25% discount rate representing a private sector led initiative with a viable return. In both cases, the solar system shows cost effectiveness in 2020.

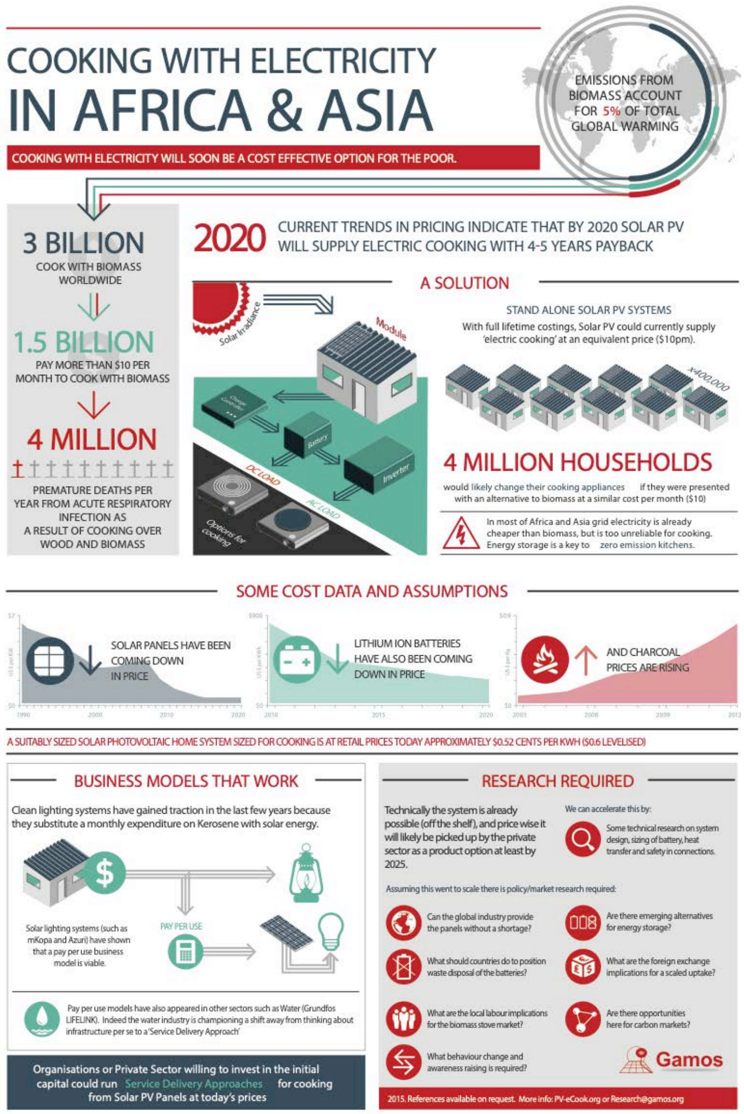

Figure 41 Infographic summarising the concept in order to lobby research and policy actors.

The Brown and Sumanik-Leary paper in the series examines the lessons learned from four transitions – the uptake of electric cooking in South Africa, the roll out of Improved Cookstoves (ICS), the use of LPG

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and the uptake of Solar Home Systems (SHS). They present many behavioural concerns, none of which preclude the proposition as such, but all of which suggest that any action to create a scaled use of solar electric cooking would need in depth market analysis; products that are modular and paired with locally appropriate appliances; the creation of new, or upgrading of existing, service networks; consumer awareness raising; and room for participatory development of the products and associated equipment.

A synthesis paper summarising the above concludes by emphasising that the proposition is not a single product – it is a new genre of action and is potentially transformative. Whether solar energy is utilised within household systems or as part of a mini, micro or nano grid, linking descending solar PV and battery costs with the role of cooking in African households (and the Global South more broadly) creates a significant potential contribution to SDG7. Cooking is a major expenditure of 500 million households. It is a major consumer of time and health. Where households pay for their fuelwood and charcoal (approximately 300 Million) this is a significant cash expense. Solar electric cooking holds the potential to turn this (fuelwood and charcoal) cash into investment in modern energy. This “consumer expenditure” is of an order of magnitude more than current investment in modern energy in Africa and to harness it might fulfil the calls for a step change in investment in electrical infrastructure.

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6.1.3 Summary of related projects

A series of inter-related projects have led to and will follow on from the research presented in this report:

- Gamos Ltd.'s early conceptual work on eCook (Batchelor, 2013).
  - The key **CONCEPT NOTE** can be found here.
  - An early infographic and a 2018 infographic can be found here.
- Initial technical, economic and behavioural feasibility studies on eCook commissioned by DfID (UK Aid) through the CEIL-PEAKS Evidence on Demand service and implemented by Gamos Ltd., Loughborough University and University of Surrey.
  - The key **FINAL REPORTS** can be found here.
- Conceptual development, stakeholder engagement & prototyping in Kenya & Bangladesh during the "*Low cost energy-efficient products for the bottom of the pyramid*" project from the USES programme funded by DfID (UK Aid), EPSRC & DECC (now part of BEIS) & implemented by University of Sussex, Gamos Ltd., ACTS (Kenya), ITT & UIU (Bangladesh).
  - The key **PRELIMINARY RESULTS** (Q1 2019) can be found here.
- A series of global & local market assessments in Myanmar, Zambia and Tanzania under the "*eCook - a transformational household solar battery-electric cooker for poverty alleviation*" project funded by DfID (UK Aid) & Gamos Ltd. through Innovate UK's Energy Catalyst Round 4, implemented by Loughborough University, University of Surrey, Gamos Ltd., REAM (Myanmar), CEEEZ (Zambia) & TaTEDO (Tanzania).
  - The key **PRELIMINARY RESULTS** (Q1 2019) can be found here.
- At time of publication (Q1 2019), a new DfID (UK Aid) funded research programme '*Modern Energy Cooking Services*' (MECS) lead by Prof. Ed Brown at Loughborough University is just beginning and will take forward these ideas & collaborations.

This data and material have been funded by UK AID from the UK government; however, the views expressed do not necessarily reflect the UK government's official policies.

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6.1.4 About the Modern Energy Cooking Services (MECS) Programme.

Sparking a cooking revolution: catalysing Africa's transition to clean electric/gas cooking.

www.mecs.org.uk | mecs@lboro.ac.uk

Modern Energy Cooking Services (MECS) is a five-year research and innovation programme funded by UK Aid (DFID). MECS hopes to leverage investment in renewable energies (both grid and off-grid) to address the clean cooking challenge by integrating modern energy cooking services into the planning for access to affordable, reliable and sustainable electricity.

Existing strategies are struggling to solve the problem of unsustainable, unhealthy but enduring cooking practices which place a particular burden on women. After decades of investments in improving biomass cooking, focused largely on increasing the efficiency of biomass use in domestic stoves, the technologies developed are said to have had limited impact on development outcomes. The Modern Energy Cooking Services (MECS) programme aims to break out of this "business-as-usual" cycle by investigating how to rapidly accelerate a transition from biomass to genuinely 'clean' cooking (i.e. with electricity or gas).

Worldwide, nearly three billion people rely on traditional solid fuels (such as wood or coal) and technologies for cooking and heating[9]. This has severe implications for health, gender relations, economic livelihoods, environmental quality and global and local climates. According to the World Health Organization (WHO), household air pollution from cooking with traditional solid fuels causes to 3.8 million premature deaths every year – more than HIV, malaria and tuberculosis combined[10]. Women and children are disproportionally affected by health impacts, and bear much of the burden of collecting firewood or other traditional fuels.

[9] http://www.who.int/indoorair/health_impacts/he_database/en/

[10] https://www.who.int/en/news-room/fact-sheets/detail/household-air-pollution-and-health https://www.who.int/gho/hiv/epidemic_status/deaths_text/en/, https://www.who.int/en/news-room/fact-sheets/detail/malaria, https://www.who.int/en/news-room/fact-sheets/detail/tuberculosis

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Greenhouse gas emissions from non-renewable wood fuels alone total a gigaton of CO_2e per year (1.9-2.3% of global emissions)[11]. The short-lived climate pollutant black carbon, which results from incomplete combustion, is estimated to contribute the equivalent of 25 to 50 percent of carbon dioxide warming globally – residential solid fuel burning accounts for up to 25 percent of global black carbon emissions[12]. Up to 34% of woodfuel harvested is unsustainable, contributing to climate change and local forest degradation. In addition, approximately 275 million people live in woodfuel depletion 'hotspots' – concentrated in South Asia and East Africa – where most demand is unsustainable[13].

Africa's cities are growing – another Nigeria will be added to the continent's total urban population by 2025[14] which is set to double in size over the next 25 years, reaching 1 billion people by 2040. Within urban and peri-urban locations, much of Sub Saharan Africa continues to use purchased traditional biomass and kerosene for their cooking. Liquid Petroleum Gas (LPG) has achieved some penetration within urban conurbations, however, the supply chain is often weak resulting in strategies of fuel stacking with traditional fuels. Even where electricity is used for lighting and other amenities, it is rarely used for cooking (with the exception of South Africa). The same is true for parts of Asia and Latin America. Global commitments to rapidly increasing access to reliable and quality modern energy need to much more explicitly include cooking services or else household and localized pollution will continue to significantly erode the well-being of communities.

Where traditional biomass fuels are used, either collected in rural areas or purchased in peri urban and urban conurbations, they are a significant economic burden on households either in the form of time or expenditure. The McKinsey Global Institute outlines that much of women's unpaid work hours are spent on fuel collection and cooking[15]. The report shows that if the global gender gap embodied in such activities were to be closed, as much as $28 trillion, or 26 percent, could be added to the global annual

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[11] Nature Climate Change 5, 266–272 (2015) doi:10.1038/nclimate2491

[12] http://cleancookstoves.org/impact-areas/environment/

[13] Nature Climate Change 5, 266–272 (2015) doi:10.1038/nclimate2491

[14] https://openknowledge.worldbank.org/handle/10986/25896

[15] McKinsey Global Institute. *The Power of Parity: How Advancing Women's Equality can add $12 Trillion to Global Growth*; McKinsey Global Institute: New York, NY, USA, 2015.

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GDP in 2025. Access to modern energy services for cooking could redress some of this imbalance by releasing women's time into the labour market.

To address this global issue and increase access to clean cooking services on a large scale, investment needs are estimated to be at least US$4.4 billion annually[16]. Despite some improvements in recent years, this cross-cutting sector continues to struggle to reach scale and remains the least likely SE4All target to be achieved by 2030[17], hindering the achievement of the UN's Sustainable Development Goal (SDG) 7 on access to affordable, reliable, sustainable and modern energy for all.

Against this backdrop, MECS draws on the UK's world-leading universities and innovators with the aim of sparking a revolution in this sector. A key driver is the cost trajectories that show that cooking with (clean, renewable) electricity has the potential to reach a price point of affordability with associated reliability and sustainability within a few years, which will open completely new possibilities and markets. Beyond the technologies, by engaging with the World Bank (ESMAP), MECS will also identify and generate evidence on other drivers for transition including understanding and optimisation of multi-fuel use (fuel stacking); cooking demand and behaviour change; and establishing the evidence base to support policy enabling environments that can underpin a pathway to scale and support well understood markets and enterprises.

The five year programme combines creating a stronger evidence base for transitions to modern energy cooking services in DFID priority countries with socio-economic technological innovations that will drive the transition forward. It is managed as an integrated whole, however the programme is contracted via two complementary workstream arrangements as follows:

- An Accountable Grant with Loughborough University (LU) as leader of the UK University Partnership.
- An amendment to the existing Administrative Arrangement underlying DFID's contribution to the ESMAP Trust Fund managed by the World Bank.

[16] The SE4ALL Global Tracking Report shows that the investment needed for universal access to modern cooking (not including heating) by 2030 is about $4.4 billion annually. In 2012 investment was in cooking was just $0.1 billion. Progress toward Sustainable Energy: Global Tracking Report 2015, World Bank.

[17] The 2017 SE4All Global Tracking Framework Report laments that, "Relative to electricity, only a small handful of countries are showing encouraging progress on access to clean cooking, most notably Indonesia, as well as Peru and Vietnam."

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The intended outcome of MECS is a market-ready range of innovations (technology and business models) which lead to improved choice of affordable and reliable modern energy cooking services for consumers. Figure 42 shows how the key components of the programme fit together. We will seek to have the MECS principles adopted in the SDG 7.1 global tracking framework and hope that participating countries will incorporate modern energy cooking services in energy policies and planning.

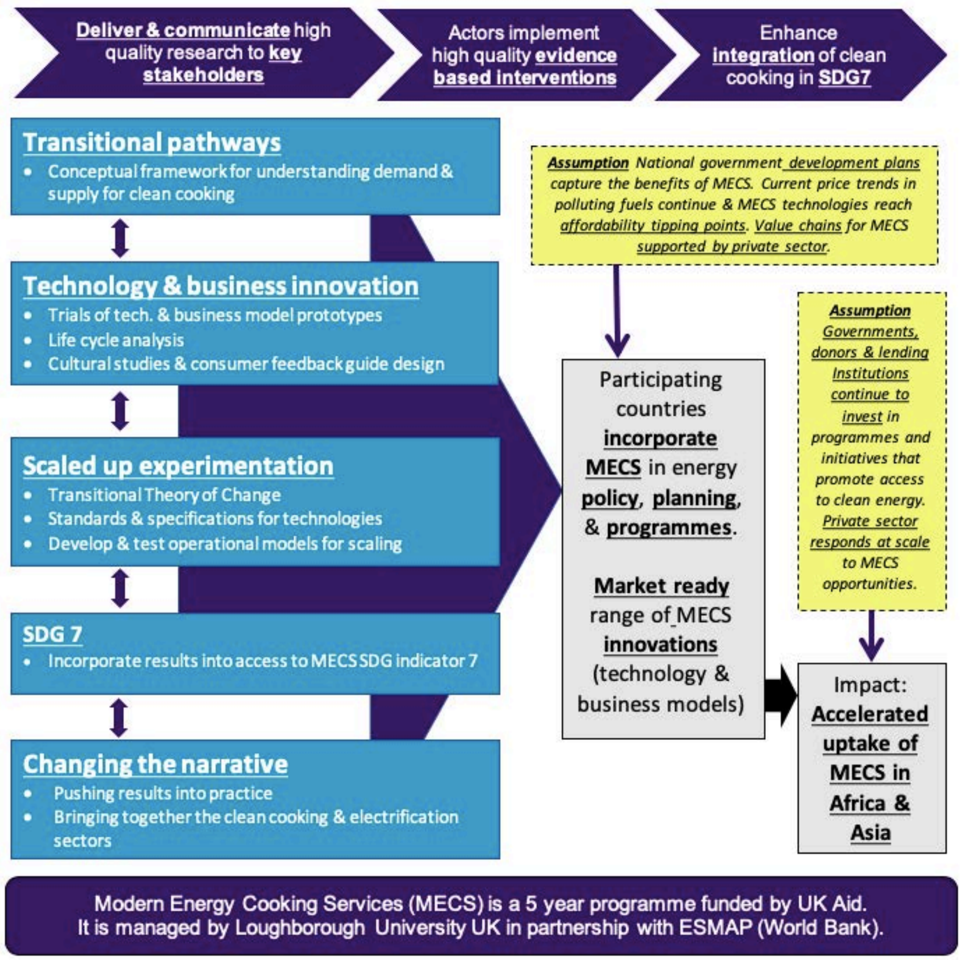

Figure 42: Overview of the MECS programme.

6.2 Appendix B: Cooking diaries registration form

6.2.1 Cooking Diaries Information Sheet

Good (morning/afternoon). My name is ____________________ from the African Centre for Technology Studies (ACTS). We are doing a project with Gamos (UK) on cooking practices in low income countries (in both Africa and Asia). I understand you have kindly volunteered to participate in the household cooking survey. This is part of an international research programme that aims to promote a transition from hazardous and polluting biomass fuels to clean, modern cooking fuels.

How you can assist:

- You will be asked some basic information on your household as part of this registration process.
- You will be asked to keep a diary of all you cook and how you cook it over the next 6 weeks.
- During the first two weeks, please cook as you always do and simply record what you are doing in the data sheets.
- After two weeks, you will be asked to try cooking only with electricity to see how quickly you can adapt, and how practical this is. If you are already cooking solely with electricity, we may ask you to change your practices in some way.
- At the end of the exercise, a short exit survey will ask you how you got on.

How we will support you:

- I will visit tomorrow and then at least once a week (at a time that suits you) to see how you are getting on, answer any questions you may have, and collect the data sheets. In between visits, please don't hesitate to contact me with any questions on this number: ____________. If you are able to send copies of the data sheets to us electronically using WhatsApp or equivalent, we can offer remote assistance.
- If you do not own an electric rice cooker and pressure cooker, we will provide one for the second part of the trial.
- We will pay for any additional electricity that you use for cooking during the survey.

The project meets the criteria for ethical research contained within the Code of Practice of the African Centre for Technology Studies. Your name will not appear in any data that shall be made publicly available and the information you provide will be strictly used for research purposes. It is up to you to decide whether to take part or not. Choosing not to take part or withdrawing at any point will not disadvantage you in any way. If there are questions that you would prefer not to answer then we respect your right not to answer them.

We will produce reports, guidance materials and academic papers detailing the findings from the research, which will be used to inform manufacturers and policy-makers in Kenya, Africa, and globally.

With your permission, we would like to use photos of your cooking appliances, pots/pans and of you cooking to illustrate these.

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6.2.2 Checklist for enumerators

6.2.2.1 Household selection

Whilst any household that has an electricity supply good enough to cook on can in theory participate in the cooking diary study, the best households are:

- Households where there is one main cook, as many cooks require more training and often only some see the value in participating in the research study. This main cook should be:
    - Interested in the findings of the research study, as this will motivate them to record high quality data.
    - Well organized and literate.
- Households where the main cook volunteers to participate, rather than the head of their household volunteering them.
- Households that cook 2-3 times a day, rather than regularly buying food out or eating at a friend/family member's place.
- Low income households are our target market, but middle/high income households are likely to be easier to recruit and to be able to fill in the forms.

We are looking for a range of households in the following categories:

- Large (>9 people), medium (5-8 people) and small (1-4 people) households.
- Households that cook on electricity, gas, kerosene, charcoal or a mixture.

6.2.2.2 What to take to each household

- Clipboard & 2x pens
- 2x energy meters
- 1x multi-plug extension
- Printed forms:
    - 1x registration form
    - 5x meal/water heating form
    - 1x daily summary form
- Tape measure
- Solid fuel or gas users: digital weighing scale
- Gas users: small cylinder, regulator and hose clips, quick release & /stove top burners

6.2.2.3 Registration process

Complete consent form and registration survey

- Please leave the information sheet with the participant (remembering to fill in your contact details) and take the registration survey with you
- If the household is unsure about whether they want to sign up or not, suggest a trial for one night

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Talk through the diary forms:

- Cooking diary forms:
  - Cooks should fill out one form every time they use a cooking appliance.
    - A cooking appliance is defined as a device that cooks food or heats water.
  - Fill out sample form for the last meal you cooked and last time you used a cooking appliance in between meals to demonstrate
  - Ask participant to fill out sample form from last meal they cooked and last time you used a cooking appliance in between meals whilst you are there to help
    - Make sure they are aware of the fuel measurements, which must be collected both BEFORE and AFTER each time they use a cooking appliance
- Daily summary form
  - Cooks fill out one form at the end of each day.
- Notepad section
  - This can be helpful in noting down the essential information if in a hurry whilst cooking or if a maid is cooking in the day who is unable to fill out the full form. This information should be transferred to a diary form as soon as you have time or by interviewing the maid as soon as you see them.

Practice taking fuel measurements

- Electricity:
  - The aim is to work out how much energy was used by cooking appliances during that meal
  - We need TIME and ENERGY both BEFORE and AFTER cooking
    - Show how to reset to zero before cooking
    - Show how to cycle through readings to set to Kw/h
- Solid fuel:
  - The aim is to calculate the weight of charcoal, wood etc. burnt during that meal
  - We need the weigh of the bag of fuel BEFORE and AFTER the meal
  - We will subtract the AFTER weight from the BEFORE to calculate the charcoal burnt on the stove
  - Ask people to show you the bag they store their fuel in
    - If it is a box or a big sack, ask the household to put more charcoal out than they think they will use into a plastic bag and weigh this before and after cooking
    - Make sure they know to put any remaining charcoal that has not gone onto the fire back into the bag before weighing
  - Gas:
    - If a household has a big gas cylinder that is too heavy to weigh, we should purchase a small cylinder and ask them to use that instead.
    - Look for a suitable place to hang the scale from to get reliable measurements. If no place is available, make sure they can hold the scale standing to get accurate measurements.
    - Weigh the cylinder before and after cooking, as with solid fuel.
    - Make sure the regulator is detached before taking each measurement, as the hose will pull on the cylinder and distort the reading.

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- Kerosene
  - Weigh the whole stove before and after as above

Remember to measure and photograph pots/pans/buckets/kettles and photograph all cooking appliances, taking measurements of all hotplate diameters and noting the power rating of all electrical cooking appliances.

When you return the next day, review the forms the cook has filled out and describe to them the meals/water you think they cooked/heated. If your description matches what and how they actually cooked, then you have verified that they are capable of recording data independently. However, you should still continue to check up on them once a week, to collect the forms they are producing and answer any questions they may have.

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6.2.3 Cooking Diaries Registration Form

6.2.3.1 CONSENT

Do you, ______________ consent to be part of this study? (Yes/No)

Do you consent to any photos taken during the course of this study being used in research publications? (Yes/No) ______________

Name: __________________________ Signature: _____________ Contact No.: _____________

Date: ______________

6.2.3.2 Details of participant

1. Age: ....
2. Gender: ☐ Male ☐ Female ☐ Other
3. What is the highest level of school you have attended?

   ☐ None ☐ Incomplete primary ☐ Completed primary ☐ Incomplete secondary ☐ Completed secondary ☐ Higher than secondary

6.2.3.3 INFORMATION ON YOUR HOUSEHOLD

4. Location:_____________
5. Type of area: ☐ Urban ☐ Peri-urban ☐ Rural
6. How many people live in the household? ______________
7. Who cooks in your household?

Name	Relationship to head of household	What proportion of the cooking do they do? (e.g. 50%, ¼, all)	When do they cook? (e.g. lunchtime only, all meals, special occasions)

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8. How many rooms in the dwelling (bedrooms plus kitchen, bathroom, living room etc.)? _______
9. Type of dwelling (options to be edited to suit country context):

   ☐ Compound house ☐ Flat/apartment ☐ Semi-detached house ☐ Separate house

10. Construction
    a. Walls

       ☐ Wood / mud / thatch ☐ Mud bricks (traditional) ☐ Corrugated iron sheet ☐ Cement block (plastered or unplastered) ☐ Bricks (burnt) ☐ Other………………………………………

    b. Roof

       ☐ Thatch/palm leaf ☐ Wood ☐ Corrugated iron / cement sheet ☐ Cement ☐ Tiles

       ☐ Other _____________

    c. Floor

       ☐ Dirt/Mud/Dung ☐ Cement ☐ Tiles ☐ Wood ☐ Other _____________

11. Where is the kitchen located?
    - ☐ Outdoor ☐ Indoor, no outdoor area for solid fuel stoves ☐ Indoor, with outdoor area for solid fuel stoves
12. Where do light your jiko?

    ☐ Indoors ☐ Outdoors ☐ Sometimes indoors, sometimes outdoors

13. Please indicate how many of the following appliances are owned (even if not used).

    Please take a photo of all appliances.

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3 stone fire

LPG cylinder-top stove

Electric hotplate (portable)

Kettle

Rice cooker

Electric pressure cooker

Basic biomass cookstove

LPG stove

Electric cooker (portable hotplate & grill)

Microwave

Electric frying pan

Induction stove

Improved biomass cookstove

LPG stove (burners & grill/oven)

LPG/electric burners/hotplates with gas grill/oven

LPG/electric burners/hotplates with electric grill/oven

Electric cooker (hotplates & grill/oven)

Kerosene stove

Type of cooking device (see above for examples)	Brand or local name/s	How many?	When is it used?	What do you usually use it for? e.g. quick things in the morning, when the gas runs out, when there is a blackout, for beans and long cooking dishes	How many hotplates/burners does it have? What is their diameter (cm)?	Power rating, W (electric only)
			☐ Regularly ☐ Occasionally ☐ Never		No. ………. Diameter/s (cm) ………………………	
			☐ Regularly ☐ Occasionally ☐ Never		No. ………. Diameter/s (cm) ………………………	
			☐ Regularly ☐ Occasionally ☐ Never		No. ………. Diameter/s (cm) ………………………	

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			☐ Regularly ☐ Occasionally ☐ Never		No. .... Diameter/s (cm)	
			☐ Regularly ☐ Occasionally ☐ Never		No. .... Diameter/s (cm)	
			☐ Regularly ☐ Occasionally ☐ Never		No. .... Diameter/s (cm)	
			☐ Regularly ☐ Occasionally ☐ Never		No. .... Diameter/s (cm)	
			☐ Regularly ☐ Occasionally ☐ Never		No. .... Diameter/s (cm)	

14. Measurement of pots/pans/pressure cookers/kettles

    Please take a photo of all pots/pans/pressure cookers/kettles

Is it a pressure cooker, kettle or a big/medium/small pot or pan etc?	**How many?**	**Diameter (cm) and Height (cm) OR Volume (litres)**

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15. Fuel Measurements

Charcoal/wood/kerosene/LPG users & fuel stackers only:

	Charcoal	Wood	Kerosene	LPG
How often do you usually buy charcoal/wood/kerosene/LPG?				
What quantity do you usually purchase (kg)?				
How much does this cost (KES)?				

All households:

- Is your bill pre-paid or post-paid? _________________
- Is your meter individual or shared? _________________
- How often do you usually buy electricity units? ________________
- When you buy electricity units, how much do you normally spend on average per month (KES)? _______________
- Do you know how many units this gets you? _________________

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6.3 Appendix C: Cooking diary form

Household Identifier: ____________________________ | Date: ______________ **DIARY FORM** Please fill in one form every time you cook or heat water vKE250518

BEFORE COOKING	AFTER COOKING
Time: ____________ | Electricity: ____________kWh | LPG:____________kg | Kerosene:___________ltrs	*Time:* ____________ | Electricity: ____________kWh | LPG:____________kg | Kerosene:___________ltrs
Other fuel (please state which):_________________________:____________kg	Other fuel (please state which):_________________________:____________kg
*Charcoal:*__________*kg* | *Firewood:*__________*kg* | *How long did it take to light the fire?* __________ *mins*	*Charcoal:*__________*kg* | *Firewood:*__________*kg* *Did you save any charcoal/wood for later?* No ☐ Yes ☐

WHO COOKED? Name of cook: ______________________________ Gender of cook: Female ☐ Male ☐

WHAT DID YOU COOK/HEAT WATER FOR? Breakfast ☐ Lunch ☐ Supper ☐ Snack ☐ Food for baby ☐ Water heating ☐ Other: ____________________

HOW MANY PEOPLE DID YOU CATER FOR? Adults: _____ Children: _____

DID YOU SERVE ANY FOOD THAT DID NOT REQUIRE COOKING e.g. bread, pre-cooked chapatis, fruits, salad? No ☐ Yes. If so, which: ____

	WHICH DISHES DID YOU PREPAPRE? Please tick just ONE from each row	COOKING DEVICES? *Tick all that apply*	COOKING UTENSILS? *Tick all that apply*	QUANTITY (E.G. ½ CHICKEN)	DID YOU PUT A LID ON?	FRESH OR REHEATED	SAVING FOR LATER?	COOKING PROCESSES? *Tick all that apply*	DURAT-ION?
DISH 1	Pancakes/Chapati ☐ Pilau ☐ Matumbo ☐ Githeri/mokimo ☐ Chips ☐ Matoke ☐ Pasta/noodles ☐ Rice ☐ Chicken ☐ Eggs ☐ Mandazi ☐ Sausages ☐ Leafy veg ☐ Meat ☐ Beans/peas/kamande/ndengu ☐ Ugali ☐ Potatoes/pumpkin/nduma/muhogo ☐ Fish ☐ Porridge ☐ Other__________	Rice cooker ☐ Pressure cooker ☐ Microwave ☐ Electric hotplate ☐ Electric kettle ☐ Kerosene stove ☐ Gas stove ☐ Charcoal stove ☐ Firewood stove ☐ Other____________	Sufuria big ☐ Kettle ☐ Sufuria med ☐ Frying pan ☐ Sufuria small ☐ Bowl/plate ☐ Pressure cooker ☐ Other__________	________ ________ ________	Yes ☐ No ☐ Some of the time ☐	Fresh ☐ Reheated ☐ Partially cooked ☐	None ☐ Leftovers ☐ Precooking ☐ Preparing a meal in advance ☐	Boil ☐ Wet fry ☐ Dry fry ☐ Deep fry ☐ Grill ☐ Steam ☐ Bake ☐ Microwave ☐ Pressure cook ☐ Other__________	____ hrs ____ mins
DISH 2	Pancakes/Chapati ☐ Pilau ☐ Matumbo ☐ Githeri/mokimo ☐ Chips ☐ Matoke ☐ Pasta/noodles ☐ Rice ☐ Chicken ☐ Eggs ☐ Mandazi ☐ Sausages ☐ Leafy veg ☐ Meat ☐ Beans/peas/kamande/ndengu ☐ Ugali ☐ Potatoes/pumpkin/nduma/muhogo ☐ Fish ☐ Porridge ☐ Other__________	Rice cooker ☐ Pressure cooker ☐ Microwave ☐ Electric hotplate ☐ Electric kettle ☐ Kerosene stove ☐ Gas stove ☐ Charcoal stove ☐ Firewood stove ☐ Other____________	Sufuria big ☐ Kettle ☐ Sufuria med ☐ Frying pan ☐ Sufuria small ☐ Bowl/plate ☐ Pressure cooker ☐ Other__________	________ ________ ________	Yes ☐ No ☐ Some of the time ☐	Fresh ☐ Reheated ☐ Partially cooked ☐	None ☐ Leftovers ☐ Precooking ☐ Preparing a meal in advance ☐	Boil ☐ Wet fry ☐ Dry fry ☐ Deep fry ☐ Grill ☐ Steam ☐ Bake ☐ Microwave ☐ Pressure cook ☐ Other__________	____ hrs ____ mins
DISH 3	Pancakes/Chapati ☐ Pilau ☐ Matumbo ☐ Githeri/mokimo ☐ Chips ☐ Matoke ☐ Pasta/noodles ☐ Rice ☐ Chicken ☐ Eggs ☐ Mandazi ☐ Sausages ☐ Leafy veg ☐ Meat ☐ Beans/peas/kamande/ndengu ☐ Ugali ☐ Potatoes/pumpkin/nduma/muhogo ☐ Fish ☐ Porridge ☐ Other__________	Rice cooker ☐ Pressure cooker ☐ Microwave ☐ Electric hotplate ☐ Electric kettle ☐ Kerosene stove ☐ Gas stove ☐ Charcoal stove ☐ Firewood stove ☐ Other____________	Sufuria big ☐ Kettle ☐ Sufuria med ☐ Frying pan ☐ Sufuria small ☐ Bowl/plate ☐ Pressure cooker ☐ Other__________	________ ________ ________	Yes ☐ No ☐ Some of the time ☐	Fresh ☐ Reheated ☐ Partially cooked ☐	None ☐ Leftovers ☐ Precooking ☐ Preparing a meal in advance ☐	Boil ☐ Wet fry ☐ Dry fry ☐ Deep fry ☐ Grill ☐ Steam ☐ Bake ☐ Microwave ☐ Pressure cook ☐ Other__________	____ hrs ____ mins
WATER 1	Drinking/purifying ☐ Bathing ☐ Tea/coffee/cocoa/chocolate ☐ Other______________	Rice cooker ☐ Pressure cooker ☐ Microwave ☐ Electric hotplate ☐ Electric kettle ☐ Kerosene stove ☐ Gas stove ☐ Charcoal stove ☐ Firewood stove ☐ Other________	Sufuria big ☐ Kettle ☐ Sufuria med ☐ Frying pan ☐ Sufuria small ☐ Bowl/plate ☐ Pressure cooker ☐ Other__________	*How full?* 1/4 ☐ Full ☐ 1/2 ☐ 2x ☐ 3/4 ☐ 4x ☐ Other________	Yes ☐ No ☐ Some of the time ☐	Fresh ☐ Still warm ☐	*In a Thermos flask:* None ☐ All ☐ Some ☐	*How hot?* Boiling ☐ Hot ☐ Warm ☐	____ hrs ____ mins
WATER 2	Drinking/purifying ☐ Bathing ☐ Tea/coffee/cocoa/chocolate ☐ Other________	Rice cooker ☐ Pressure cooker ☐ Microwave ☐ Electric hotplate ☐ Electric kettle ☐ Kerosene stove ☐ Gas stove ☐ Charcoal stove ☐ Firewood stove ☐ Other________	Sufuria big ☐ Kettle ☐ Sufuria med ☐ Frying pan ☐ Sufuria small ☐ Bowl/plate ☐ Pressure cooker ☐ Other__________	*How full?* 1/4 ☐ Full ☐ 1/2 ☐ 2x ☐ 3/4 ☐ 4x ☐ Other________	Yes ☐ No ☐ Some of the time ☐	Fresh ☐ Still warm ☐	*In a Thermos flask:* None ☐ All ☐ Some ☐	*How hot?* Boiling ☐ Hot ☐ Warm ☐	____ hrs ____ mins

ANY OTHER OBSERVATIONS? e.g. Did the fire take long to light? Did you burn food? Did power go off/gas run out during cooking? If so, please explain?

____

____

6.4 Appendix D: Cooking diaries exit survey

COOKING DIARY KENYA- EXIT INTERVIEW

Please remember to take with you:

- This form
- A pen
- A clipboard
- An energy meter (in case theirs is broken)
- A hanging scale(in case theirs is broken)

Please remember to collect:

- Energy meters (unless you think the participant will continue to use them to optimise their cooking practices)
- Hanging scales
- LPG cylinder &burner (unless they want to purchase them at half the price we paid for them
- Any additional diary forms

Name: __________________________ Date: _______________ Location:______________

Which fuel/sdid you cook with before thesurvey?……………………………………………………………………………………………

	Had you ever tried cooking with an ecookeror pressure cooker before this study?	Which ecookersor pressure cookers did you already own?
Hotplate		
Rice cooker		
Stove-top pressure cooker		
Electric pressure cooker		

As we come to the end of the survey, we take this opportunity to thank you for your endurance throughout the period. We are glad that all went well from our side, however we wish to hear from you with a few questions below.

Githeri eCooking Challenge

I would like to ask that you prepare githeri for the Githeri eCooking Challenge I had informed you about some weeks back. The competition is judged solely on energy use, so as long as the githeri is judged by the enumerator/s to be as tasty as they expect githeri to be, then the winning household is simply the one that uses the lowest number of units to cook githeri using¼ kg maize and ¼ kg beans. We will pay for the ingredients you use.

There will be a prize for the Githeri eCooking Challenge, which will be presented to the winner after all exit survey interviews have been completed.

Observe throughout the cooking process, noting down which energy saving/wasting practices the participant employs. If appropriate, you can also begin to ask the other questions in the survey whilst the rice/ugali is cooking. Once cooking has finished, note down the total number of units used.

Where/from who did you learn the techniques for cooking githeri?

....

....

....

Has your technique changed or have you noticed people preparing githeri differently from when you were a child/growing up?

....

....

....

Where do the best - in your view - ingredients come from (country/type/ process/brand/area/shop)?

....

....

....

Do you use the same technique to cook githeri everytime or does it depend on what type of result you want (soft/hard) and/or time available (fast/slow) and/or the type of maize/beans you buy?

....

....

....

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If you need to cook faster what shortcuts might you take?

……

……

……

Total units used to cook githeri with ¼ kg maize and ¼ kg beans: ________kWh

Chosen appliance/s: ____________________ If they use a kettle to boil water specifically for the challenge, please list the kettle here as one of the chosen appliances and make sure it is plugged into an energy meter (see below). Using left over warm water from other things (e.g. making tea) is allowed.

Which energy saving techniques do you plan to employ during the Githeri eCooking Challenge and why?

……

……

……

……

By observation, please note the energy saving/wastingpracticesthey actually employed:

1. Did they choose an insulated appliance? Yes☐ No ☐
2. Did they use a lid? No☐Yes - if so:
   a) How many times did they open the lid during cooking? ______________
   b) What percentage of the total cooking time was the lid on the pan for?
      - Less than 25%☐
      - 25--50% ☐
      - 50-75%☐
      - Above 75%☐
3. Did they add any other ingredients? No☐ Yes, if so:
   a) which? _____________________________
   b) why? ______________________________
   c) how finely were they chopped? Roughly sliced☐ Finely sliced☐ Roughly chopped☐ Finely chopped☐
4. Did they raise the boiling point of water to decrease the cooking time? No☐ Yes - if so how?:
   a) Did they add salt?No☐ Yes☐
   b) PRESSURE COOKER ONLY: Did they pressure cook (i.e. close the pressure valve and allow the pressure cooker to pressurise)?No☐ Yes – if so:

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- Did they correctly judge the cooking time, avoiding depressurising and re-pressurising? Yes☐ No - if so, how many times did they de-pressurise and re-pressurise? _________
- Was the pressure valve completely sealed? Yes☐ No, it leaked a bit☐ No, it leaked a lot☐

5. Did they pour out any water during the cooking process? No☐ Yes - if so, when and why? ____
6. Did they control the heating process manually? No☐Yes - if so:
   a) HOTPLATE & INDUCTION STOVE ONLY: Did they turn the heat down low once reaching boiling point to simmer instead of boil?No☐ Yes☐
   b) Did they turn off the stove as soon as the food is ready (e.g. not leaving a rice cooker on warm mode or not leaving a hotplate on whilst removing the pan)Yes☐ No – if so, how long did they leave it on for? ________
   c) Did they add extra insulation, e.g. with a Wonderbag? No☐ Yes☐
7. Did they fry at all? No☐ Yes - if so, for how many minutes? ____
8. Which variety of beans did they use? ____________
   a) Did they chooseaspecialvariety of beans because they know it cooks quickly?No☐ Yes☐
   b) Did they use fresh or dried beans? Fresh☐Dried☐
   c) Ddid they soak them before cooking? No☐ Yes – if so, for how long? ___________ and how hot was the water? cold☐ warm☐ hot☐ boiling☐
   d) Did they soak it before cooking? No☐ Yes – if so, for how long? ___________ and how hot was the water? cold☐ warm☐ hot☐ boiling☐
9. Which variety of maize did they use? ____________
   a) Did they choosea specialvariety of maize because they know it cooks quickly?No☐ Yes☐
   b) Did they use fresh or dried maize? Fresh☐Dried ☐
   c) Did they soak it before cooking? No☐ Yes – if so, for how long? ___________ and how hot was the water? cold☐ warm☐ hot☐ boiling☐
10. Did they use left over hot/warm water from the kettle (or other appliance) that had been boiled for something else? No☐ Yes☐ - If they boil the kettle especially for the challenge, how much energy did it use, as this energy should later be added to the total? _______kWh
11. ☐Did they use any other energy saving techniques? If so, please describe

    ____
    ____

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E-recipe

Time	Energy (kWh)	Comments

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Your experience of cooking with electricity

1. How did the eCookerssuit the way you cook in your home?

   (score:1 = strongly disagree; 2 = disagree; 3 = no opinion; 4 = agree; 5 = strongly agree)

	HOTPLATE					***RICE COOKER***					***PRESSURE COOKER***					
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Comments
It was easy to control heat																
Iwas able to multi-task whilst the eCooker was cooking																
The eCookercould cook fast enough																
Long cooking dishes were cooked much faster																
The eCookerwas hot enough																
The eCooker oftenburnt the food																
All my pots fit on the eCooker																
The pot it came with was big enough																
Food cooked using the eCooker tasted better than usual																

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Pots were stable on the eCookers																
The eCookermade the pots dirty																
The eCookeritself was easy to clean																
The eCookerlooked good in my kitchen																
There is enough space for the eCooker in my kitchen																
Operating the eCooker was easy																
The eCooker was safe to use																
I prefer to use an electric kettle for water boiling																

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2. How easy is it to cook each food on the eCookers?
(score:1 = strongly disagree; 2 = disagree; 3 = no opinion; 4 = agree; 5 = strongly agree)

	HOTPLATE					***RICE COOKER***					***PRESSURE COOKER***					
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Comments
Pancakes/chapatti																
Githeri/mokimoo																
Pasta/noodles																
Eggs																
Meat																
Ugali																
Fish																
Mandazi																
Porridge																
Pilau																
Chips																
Rice																
Sausages																
Matumbo																

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This research is funded by DfID/UK Aid, EPSRC, RCUK & DECC (now BEIS) through the USES programme.

Matoke																
Chicken																
Leafy veg																
Beans/peas/kamande/ndengu																
Potatoes/pumpkin/nduma/muhogo																

3. Did you miss the smokey flavor of food? If so, for which dishes in particular?

………

………

………

………

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4. Do foods taste different when cooked on different fuels? If so, please rank each fuel for each food, giving 1 to the tastiest and 5 to the least tasty. If there's no difference between two or more fuels, please give the same number.

	Wood	Charcoal	Kerosene	LPG	Electricity	Comments
Pancakes/chapatti						
Githeri/mokimoo						
Pasta/noodles						
Eggs						
Meat (stewed)						
Meat (fried)						
Meat (nyamachoma)						
Ugali						
Fish						
Mandazi						
Porridge						
Pilau						
Chips						
Rice						
Sausages						

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Matumbo						
Matoke						
Chicken						
Leafy veg						
Beans/peas/kamande/ndengu						
Potatoes/pumpkin/nduma/muhogo						

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5. If a neighbour had just bought an electric pressure cooker and asked you how long they should set the timer for to cook each food, what would you tell them?
   Which type of pressure cooker do they have? button-type☐ rotary-type☐
   What is the make and model number of their pressure cooker? ……………………………………………………………….

	Pressure cooking time (put an x if not possible to pressure cook)	Comments
Githeri/mokimoo		
Pasta/noodles		
Eggs		
Meat		
Ugali		
Fish		
Mandazi		
Porridge		
Pilau	Meat + rice	
Rice		
Sausages		
Matumbo		
Matoke		
Chicken		
Leafy veg		

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Beans/peas/kamande/ndengu		
Potatoes/pumpkin/nduma/muhogo		

6. How many hobs (rings) or separate appliances do you need for cooking? 1☐ 2☐ 3☐ 4☐
7. What were the best things about cooking with electricity?

....

....

....

....

8. And what were the worst things about cooking with electricity?

....

....

....

....

9. What do you like most about cooking with charcoal/firewood?

....

....

....

....

10. What do you like most about cooking with LPG/kerosene?

....

....

....

....

11. What are the best things about not cooking with charcoal/ firewood?

....

....

....

....

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12. What are the best things about not cooking with LPG/kerosene?

……

……

……

………

13. Did you change your cooking behaviour? If yes, how and why?

……

……

……

……

14. Do you think electric cooking is affordable?

……

……

……

……

15. Do you think cooking with electricity is cheaper or more expensive than cooking with the fuels you normally use?

……

……

……

………

16. Were there times when the electricity was off and you wanted to cook or heat water? If so, what did you do?

……

……

……

………

17. Do you feel that cooking with the electric cooker is safer or more dangerous than cooking with your normal stove, and why? (e.g. risk of fires, burns)

Hotplate………
……

Rice cooker………
……

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Pressure cooker……
……

18. How easy is it to learn to cook on an electric stove?

Hotplate……
……

Rice cooker……
……

Pressure cooker……
……

19. Would people need training on how to use an eCooker, or would they be able to learn by themselves? If so, what should the training focus on?

Hotplate……
……

Rice cooker……
……

Pressure cooker……
……

20. Would you ever cook using only electricity and no other fuels - and explain why?

……
……
……
……

21. If you could change one thing about the design of each eCooker, what would you change?

Hotplate……
……

Rice cooker……
……

Pressure cooker……
……

22. If you could design your own completely new eCooker, what would it be like?

……
……

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……

……

23. We are done with our survey and are leaving the cookers with you. Will you continue using the eCookers or will you switch back to your old stove? If so, what will you continue to use them for?

Hotplate……

………

Rice cooker………

………

Pressure cooker………

………

24. We are not going to ask you to pay for the eCookers. Would you buy this cooker if you saw one in a shop now? If so, how much would you be prepared to pay for this cooker (KSh)?

Hotplate……

………

Rice cooker………

………

Pressure cooker………

………

Missing data

We have tried our best to learn as much as we can about how you cook, but we appreciate that the tools we are using are limited. Please help us to understand what we may have missed.

25. Are there any meals that were cooked or water that was heated in your household since the beginning of the study that were not recorded on the forms you have given to us? If so, why?

………

………

………

……

26. Is there anything else that you think is important about the way you cook that we have not yet captured?

………

………

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……

……..

How you feel about the survey

27. In the table below, please give us your opinions of the study. Tick where appropriate, where 1 is the worst and 5 the best

QUESTION	1(worst)	2	3	4	5(best)
Overall cooking survey					
Choice of appliance to trial (pressure cooker)					
Choice of appliance to trial (rice cooker)					
Choice of appliance to trial (hotplate)					
Training on how to use pressure cooker					
Training on how to use rice cooker					
Training on how to use hotplate					
Relevance of questions					
Duration of survey					

28. When you were approached to be part of this cooking survey were you hesitant?Has it been different to what you expected?

……

……

……

……

29. At the beginning of the e-cooking phase, what was your expectation and was it met?

……

……

……

……

30. What do you think we could have done better in the survey?

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………

………

………

………

31. Were the enumerator's visits helpful or did you feelit was too much or too little?

………

………

………

………

32. If we were to do another similar survey in the future would you be willing to be part of it? Yes☐ No☐

END OF SURVEY – Please thank the household for participating in the survey and the Gitehri Boiling Challenge.

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