eCook Tanzania Cooking Diaries

October 2019 Working Paper

(final report expected December 2019)

Main authors: J. Leary, N. Scott, S. Sago, A. Minja, S. Batchelor, K. Chepkurui, E. Sawe

Associate authors: M. Leach, E. Brown

Innovate Project 132724

Implemented by:

Funded by:

With additional analysis by:

Acknowledgement

The findings presented in this report would not have been possible without the dedication and enthusiasm of the twenty two households who diligently recorded data on everything they cooked for six whole weeks. Their willingness to experiment with new appliances and share their experiences created a rich learning opportunity. We are also grateful to the staff of TaTEDO, both those named as authors and the supporting staff, who helped reveal what really goes on in Tanzanian kitchens. Finally, we thank the donors, UK Aid (DfID) via Innovate UK for partial funding and the directors and shareholders of Gamos who matched the funding for the benefit and public good of Tanzania. Additional analysis was carried out under the Modern Energy Cooking Services (MECS) programme, also funded by UK Aid.

Rights, permissions & disclaimer

Attribution: please cite this work as "J. Leary, N. Scott, S. Sago, A. Minja, S. Batchelor, K. Chepkurui, E. Sawe, Leach M., Brown, E. 2019. "eCook Tanzania Cooking Diaries – October 2019 Working Paper." REAM, Loughborough University, University of Surrey & Gamos Ltd. supported by Innovate UK, UK Aid (DfID) & Gamos Ltd. Available from: www.MECS.org.uk"

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 Tanzania. The aim of this study is to gain a deeper understanding of how Tanzanian 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.

22 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 range of electric cooking appliances, including hotplates, rice cookers, Electric Pressure Cookers (EPCs), induction stoves, kettles and thermo-pots, 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 Dar es Salaam 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 Tanzanian cuisine and that modern energy-efficient appliances are highly desirable to everyday Tanzanian cooks. In particular, the Electric Pressure Cooker (EPC) is 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 some areas of Dar es Salaam, the grid is already strong enough for direct AC cooking, meaning there is an opportunity already on the table to promote off-the-shelf appliances, in particular, EPCs. However, battery-supported appliances are likely to make electric cooking much more attractive, as

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

blackouts and brownouts frequently caused users to revert back to their baseline fuels. LPG is already popular in Dar es Salaam 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.

Appliance choice

Excluding blackouts, almost all meals were cooked on electricity during phase 2, which suggests that the electric appliances selected for the study were broadly compatible with Tanzanian cooking practices. Frying was less common in phase 2, presumably because gas in particular, offers much closer control of heat levels. It could also have been due to voltage dips, which would have reduced stove power output & slowed down frying considerably.

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

EPCs were preferred for dishes that require boiling, as pressure cooking can reduce the time of the boiling stage by half. However, as the data shows, they can also fry & are therefore often referred to as multicookers. 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, however the EPC can only operate with the deep sided pot it is supplied with.

Energy demand

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. 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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Load profiles

Dinners were found to be the most energy-intensive meal on the Tanzanian menu – bad news for utilities, as this coincides with peak demand for electricity. The average load profile in Figure ES-1 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.

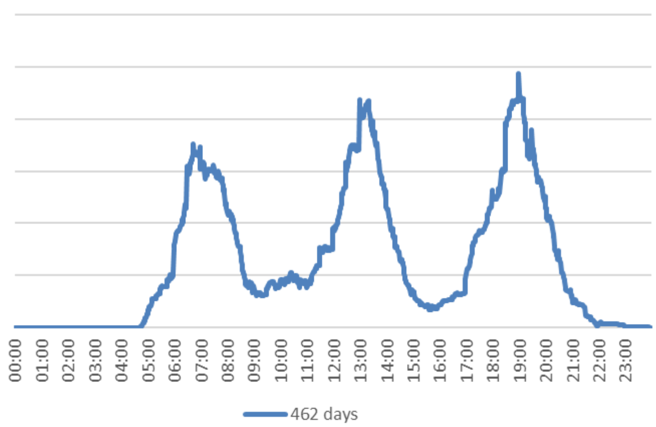


Figure ES-1: Average load profile for all complete days of data recorded during this study.

Fuel stacking

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. They are likely to be a key enabler for electric cooking, especially in poorer neighbourhoods, where blackouts are more frequent.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table of Contents

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

1 Introduction

This report presents one part of the detailed in country research carried out to explore the market for eCook in Tanzania. 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 findings from the design, assembly and testing of a concept prototype to inform the future development of eCook within Tanzania. It is one component of a broader study designed to assess the opportunities and challenges that lay ahead for eCook in high impact potential markets, such as Tanzania, funded through Innovate UK's Energy Catalyst Round 4 by DfID UK Aid and Gamos Ltd. (https://elstove.com/innovate-reports/). 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 Innovate 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 Innovate 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 Innovate 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.

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; Batchelor 2015a; Batchelor 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 UK Aid (DfID) 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 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.

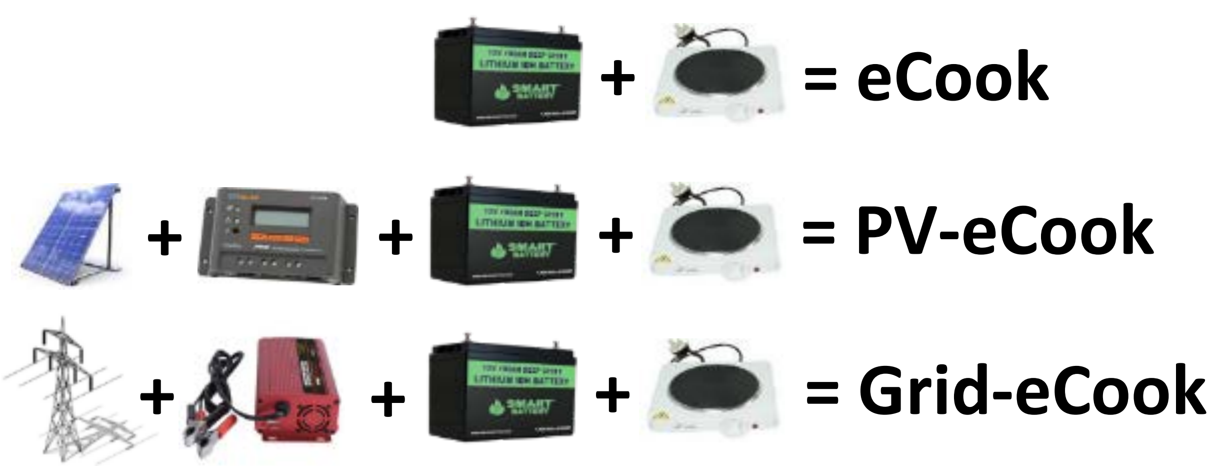


Figure 1: Pictorial definitions of 'eCook' terminology used in this report.

Research@gamos.org | PV-ecook.org
This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

1.1.3 eCook in Tanzania

Given the technical and socio-economic feasibility of the systems in the near future, Gamos, Loughborough University and the University of Surrey 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 Tanzania as the second most viable context for PV-eCook, due to its strong SHS industry and the fact that it is one of the world's biggest charcoal markets, creating several global deforestation hotspots.

The accompanying reports from the other activities carried out in Tanzania can be found at: https://elstove.com/innovate-reports/ and www.MECS.org.uk.

1.2 Aim

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

In particular, the objectives of the study are:

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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

2 Methodology

2.1 The cooking diary 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.

The cooking diary study was applied in Tanzania to offer a deeper exploration into the unique cooking practices of individual households, paired with quantitative measurements of energy consumption. 22 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*
  - Qualitative feedback from participants.

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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

- *Appendix D: Cooking diaries exit survey.*

Data was recorded in two stages:

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

2.2 Cooking diaries in Tanzania

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 6kg cylinders were purchased for participants with larger cylinders. A set of customised metal frames (Figure 2) were assembled to hang the cylinder from to obtain reliable readings, as they were too heavy to take handheld readings without shaking. It proved more convenient, but some households still struggled to get accurate measurements and having to remove the regulator every time they cooked was frustrating for many.

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

Technique	Equipment	Accuracy	Installation	Procedure
Weight	Hanging balance	5-10g	Metal frame 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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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. Households were given free choice of six appliances: kettle, thermo-pot, induction stove, hotplate, Electric Pressure Cooker (EPC) or rice cooker. They were asked to pick two new appliances, which combined with any appliances they already owned, would enable them to do all their cooking and received basic training on how to use each appliance. The appliances were plugged into a plug-in energy meter (Figure 2), with an extension cable, where necessary. 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 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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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 Rice and Ugali eCooking Challenge. A prize was offered to the participant who could cook half kg of rice and half kg ugali 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://www.mecs.org.uk/working-papers/

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

3 Results

3.1 Typical Tanzanian foods

An overview of typical preparation techniques for popular Tanzanian foods is given below, based upon observations made of Tanzanian cooks during the cooking diaries study. 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.

- **Makande -** beans & maize stew, usually wet fried. Many people will pre-cook (boil) in bulk and wet fry portions throughout the week.
- **Maharage -** beans - assumed that other unnamed cereals (peas, lentils, green grams) may well have been put in this category. 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.
- **Nyama/samaki/mboga mchuzi -** meat/fish/veg stew – many people will pre-cook (boil) meat in bulk and wet fry portions throughout the week. Chicken/fish/veg generally cooked for a lot less time than meat, but difficult to separate out without going through the quantity field one by one.

'***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.

- **Ndizi** - Bananas. Usually wet fried, sometimes boiled, sometimes grilled. Will need to check process to differentiate boiled, stewed and grilled. Sometimes also mixed with meat and stewed (ndizi nyama) in a single dish
- **Matoke** - Bananas. Usually wet fried, sometimes boiled. Will need to check process to differentiate boiled and stewed.
- **Wali -** 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** - Tanzanians 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.

'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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

- **Mayai -** eggs - Could be boiled, fried or omlette. If omlette, can often be combined with potatoes (chips mayai), which may need deep frying first.
- **Nyama nyingine/samaki –** other meat/fish - Typically wet or dry fried fried whole or in fillets.
- **Mboga nyingine** – other veg – for example sukuma wiki, spinach, etc. Typically dry fried, sometimes with onions.

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

- ***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.

3.2 Overview of data

3.2.1 Overview of participants

AT THE TIME OF WRITING, REGISTRATION SURVEY DATA HAD NOT YET BEEN PROCESSED

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

3.2.2 Overview of diaries data

Paper records kept by participants were transcribed into digital form using an Excel worksheet. Data from each heating event was entered into a separate column. Although each record related to distinct times of the day, they could cover multiple hearing events e.g. an early morning record could include breakfast, preparing food for a baby, and heating water (3 events).

Heating water is the most common single heating event (Table 3). The number of main meals captured is similar, although breakfast appears to be the most commonly cooked meal by a small margin. N.B. of the 1378 cases with a single heating event (in which the heating event is identified), 16% included a water heating event (n=222). Only 75 of these were allocated to 'Heating water' as the heating event, which means that 146 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.

Table 2 Number of heating events captured in each case

		Frequency	Percent
Valid	1	1407	48.4
	2	854	29.4
	3	330	11.3
	4	4	.1
	Total	2595	89.2
Missing	System	313	10.8
Total		2908	100.0

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.

Table 3 Number of heating events[1]

Heating event	Frequency	Percent
Breakfast	855	29.4

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

Lunch	784	27.0
Dinner	815	28.0
Snack	34	1.2
Baby food	445	15.3
Heat water	1143	39.3
Other	45	1.5

The majority of missing cases in Table 2 are instances in which no food was prepared by the household – see Table 4. This leaves a small number of cases for which data was gathered, but the meal prepared was not recorded.

Table 4 Zero energy meals

	Frequency	Percent
Forgot to fill in a form	36	1.2
Bought food	76	2.6
Ate food prepared earlier without reheating	43	1.5
Ate at a friend/family member's place	48	1.7
Did not eat	84	2.8
Total	287	9.9

Energy consumption is directly proportional to the number of people being cooked for. Overall, the mean number of adults per heating event was 3.8, and the mean number of children was 1.6. If children are weighted the same as adults, then the mean number of persons per hearing event was 4.6. one anomaly was an unexpectedly low number of records when a meal was prepared for five adults – see Figure 3. It was assumed that this was simply a random effect.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

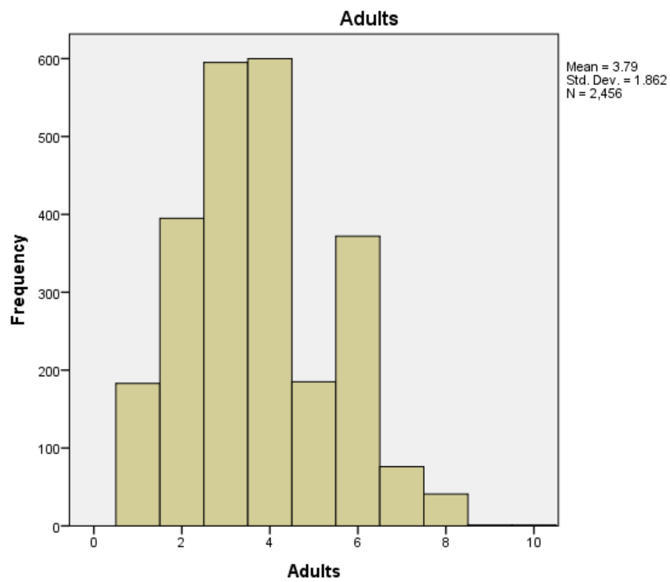


Figure 3 Distribution of adults per heating event

3.3 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 5.

Table 5 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	

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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Electricity	3.6 MJ/kWh	

3.3.1 Phase 1 and Phase 2

The energy consumption for each fuel was plotted against dates for each participant in turn in. The date that each participant shifted from using their 'normal' fuels (Phase 1) to using electricity (Phase 2) could clearly be seen. The number of Phase 1 and Phase 2 records is presented in Table 6. For most participants, around 40% of records are in phase 1. In this section, energy consumptions in the two phases are compared, so data from Jensen has been omitted as it contains no Phase 2 records.

Table 6 Number of cases in the two phases (by participant)

		PHASE		
		1	2	Total
HHIdentifier	Albina	61	91	152
	Anna	66	74	140
	Asnut	56	84	140
	Celestina	51	63	114
	Devota	50	44	94
	Elieshi	67	85	152
	Emelda	51	57	108
	Esther	74	83	157
	Evans	37	116	153
	Hellen	74	90	164
	Jensen	34	0	34
	Joy	71	87	158
	Ludovick	42	80	122
	Mama Anna	67	76	143
	Neema	50	68	118

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

	Nelson	46	89	135
	Regina	62	83	145
	Sago	48	96	144
	Shikuru	9	101	110
	Tamasina	52	65	117
	Upendo	61	79	140
	Vicky	42	126	168
Total		1171	1737	2908

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.

Not all records have valid energy consumption data. Mean total energy consumption figures in Table 7 indicate that energy consumption data was available for 84% of phase 1 records and 82% of Phase 2 records. These figures also indicate that, across all participants, the mean energy used during Phase 2 was only 31% of the energy used during Phase 1. This headline figure will hide all sorts of nuances in the numbers of heating events, the numbers of people cooked for, the types of food cooked, and so on. The following sections go on to unpack energy consumptions in more detail.

Table 7 Mean and Median energy consumptions per heating event (MJ/event)

	Phase 1			Phase 2			Mean Phase 2 energy as % of Phase 1	Median Phase 2 energy as % of Phase 1
HHIdentifier	Mean	Median	N	Mean	Median	N		
Albina	10.5	4.9	61	3.6	2.4	90	34%	49%
Anna	9.8	3.3	53	3.4	1.5	59	35%	46%
Asnut	16.5	6.7	48	2.7	2.2	59	17%	33%
Celestina	15.3	7.6	42	4.9	2.7	41	32%	35%
Devota	21.0	1.8	41	2.5	2.0	40	12%	110%
Elieshi	14.2	7.6	59	5.2	4.0	56	36%	53%

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Emelda	18.3	12.0	45	5.1	2.6	53	28%	22%
Esther	29.1	21.5	65	8.6	3.3	76	29%	15%
Evans	9.0	4.5	29	1.6	1.2	83	18%	26%
Hellen	7.9	4.4	70	3.9	3.1	87	50%	70%
Joy	9.8	3.5	65	1.8	1.9	51	19%	53%
Ludovick	40.4	6.4	38	15.0	5.7	61	37%	89%
Mama Anna	10.9	6.3	63	5.8	3.3	55	53%	52%
Neema	7.4	1.3	23	1.7	1.1	26	22%	81%
Nelson	33.5	30.2	45	4.8	2.9	87	14%	10%
Regina	30.4	14.0	54	7.4	3.4	77	24%	24%
Sago	8.5	3.1	20	4.0	2.3	94	47%	75%
Shikuru	12.4	6.3	9	3.2	3.0	88	25%	48%
Tamasina	14.1	4.4	41	3.4	3.1	59	24%	69%
Upendo	10.9	8.1	55	8.9	7.6	74	82%	95%
Vicky	44.7	44.9	29	10.8	3.4	108	24%	8%
Total	17.6	6.7	989	5.4	2.8	1424	31%	41%

The distribution of energy consumptions (per event) is presented in Figure 4. This includes some very high figures, but the maximum (271 MJ) was a Sunday lunchtime event at which Regina cooked 10 chickens for 33 people, so although it appears to be an outlier, it does appear to be valid and cannot be omitted. The next highest figure (216 MJ) was a dinner event when Ludovick cooked dinner for 6 but he also heated a full, big pot of hot bathing water for over an hour. This might account for up to half of the energy consumed (based on estimates of volume of water, temperature reached, and efficiency of conversion), so it is possible that the energy consumption is erroneous, but it is not obviously wrong.

At the other end of the scale, there are 4 records where foods have been cooked but beginning and end fuels readings are the same, assumed to be in error, so consumption figures have been deleted.

Because of this wide variation in consumption figures, including high figures that may represent exceptional events, median energy consumption figures have been used in the analysis to represent 'normal' heating events.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

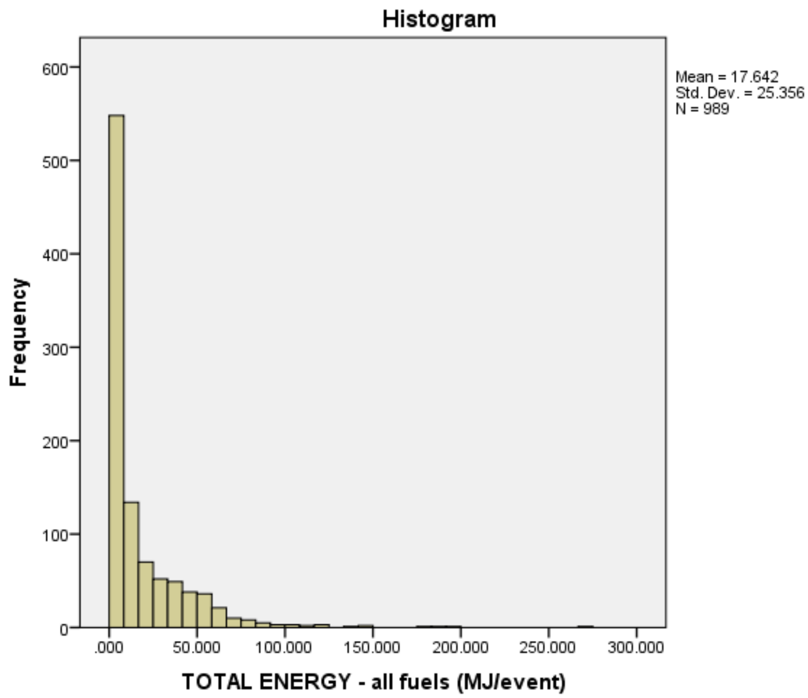


Figure 4 Distribution of total energy consumption (MJ/event)

3.3.2 Mix of fuels

The mix of fuels used in Phase 1 is presented in Figure 5. This shows that charcoal accounts for the majority of energy consumed (59%). This does not mean that charcoal is the most commonly used fuel, as the conversion efficiency of charcoal will be less than that of LPG, for example. During Phase 2, electricity was the dominant fuel used for all heating events, as was intended in the design of the experiment (see Figure 6). Note that only 58% of the total energy consumed during phase 2 was electrical energy. Charcoal accounted for 19% of all energy used in Phase 2. Participants' observations indicated that in many cases charcoal was used because of power cuts.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

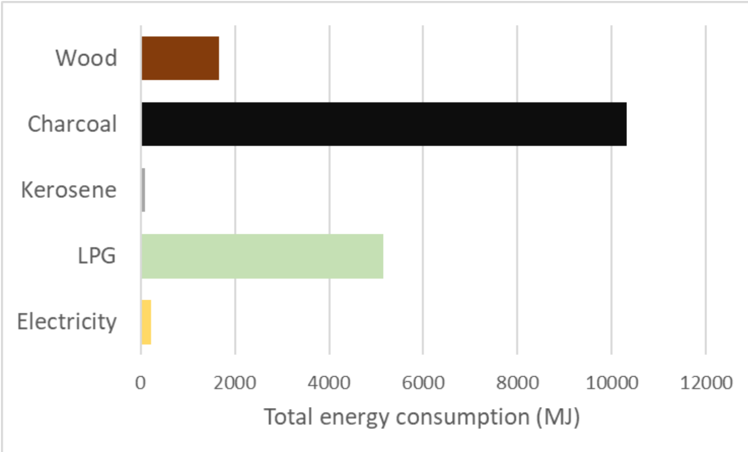


Figure 5 Energy content of fuels used in Phase 1

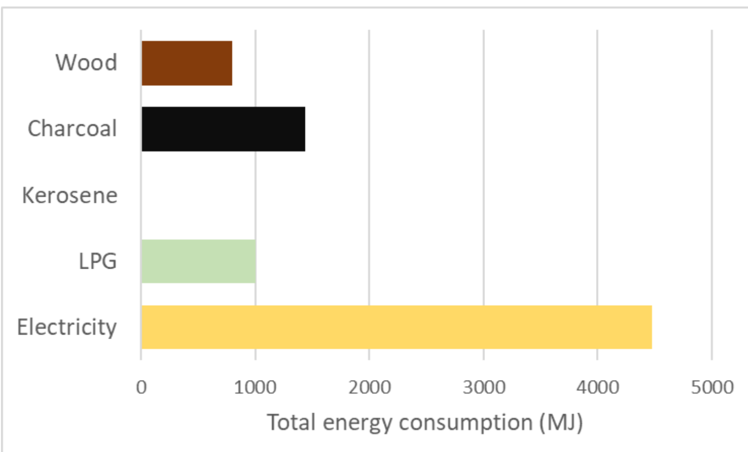


Figure 6 Energy content of fuels used in Phase 2

BASELINE FUELS FEATURE HEAVILY IN PHASE 2, REPORTEDLY DUE TO POWER CUTS. THIS IMPLIES THAT BATTERY-SUPPORTED COOKERS MAY WELL HAVE A MARKET IN DAR ES SALAAM, EVEN IN WEALTHIER NEIGHBOURHOODS.

Table 8 shows that participants used multiple fuels in 14% of heating events in Phase 1, but in only 2% of heating events in Phase 2. Table 9 shows that almost all participants used both LPG and charcoal.

Table 8 Number of fuels used in single heating event

	Phase 1		Phase 2	
	Frequency	Percent	Frequency	Percent
0	180	15%	290	17%
1	831	71%	1417	82%

FUEL STACKING IS CLEARLY PART OF THE KITCKEN ROUTINE FOR KENYAN COOKS: EVERY HHS REPORTED USING AT LEAST 2 FUELS & 14% OF HEATING EVENTS USED MULTIPLE FUELS.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and

2	153	13%	28	2%
3	7	1%	2	0%
Total	1171		1737	

Table 9 Use of fuels by participants (both phases)

	Electricity	LPG	Kerosene	Charcoal	Firewood
Albina	x	x		x	
Anna	x		x	x	
Asnut	x	x		x	
Celestina	x	x		x	
Devota	x	x		x	x
Elieshi	x	x		x	
Emelda	x	x		x	
Esther	x	x		x	x
Evans	x	x		x	
Hellen	x	x		x	x
Joy	x	x		x	
Ludovick	x	x		x	x
Mama Anna	x	x		x	
Neema	x	x			
Nelson	x	x		x	
Regina	x	x		x	x
Sago	x	x		x	
Shikuru	x	x		x	
Tamasina	x	x		x	
Upendo	x	x		x	
Vicky	x			x	x

MEDIAN PER CAPITA PER HEATING EVENT ENERGY CONSUMPTION VALUES INDICATE THAT COOKING WITH CHARCOAL IS 10 TIMES AND LPG IS 5 TIMES MORE ENERGY-INTENSIVE THAN COOKING WITH ELECTRICITY.

3.3.3 Per capita consumptions

It has already been pointed out that energy consumption depends on the number of people being cooked for. Per capita energy consumptions have been calculated simply by dividing the energy

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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 8), so per capita consumptions for heating events using the main fuels only have been calculated (Table 10). This table presents data from 701 out of 960 heating events in Phase 1. Totals indicate that cooking with charcoal uses 5.5 times as much energy as cooking with LPG, and ten times as much energy as cooking with electricity (in Phase 2).

Table 10 Per capita energy consumptions and number of people cooked for – single fuels only

	Phase 1						Phase 2		
	LPG			Charcoal			Electricity		
	Median	People (mean)	N	Median	People (mean)	N	Median	People (mean)	N
Albina	1.0	4.3	33	5.4	4.5	8	0.6	4.3	84
Anna				7.0	3.4	13	0.6	2.5	56
Asnut	2.4	2.5	36	27.1	1.8	6	1.3	2.2	58
Celestina	1.5	4.1	26	9.3	4.0	7	0.6	3.9	39
Devota	0.4	3.4	30				0.5	4.5	37
Elieshi	1.3	4.7	44				0.8	5.0	53
Emelda	1.1	6.0	23	2.7	5.7	6	0.6	4.5	46
Esther	0.9	5.1	13	5.0	6.3	44	0.4	5.7	57
Evans	1.0	4.3	26				0.5	3.1	82
Hellen	1.3	3.6	25	8.6	2.7	6	0.8	3.8	78
Jensen	1.3	7.1	17	3.6	7.5	16			
Joy	0.9	4.0	31				0.4	3.5	66
Ludovick	0.7	5.7	21				1.7	4.7	59
Mama Anna	1.2	4.2	50				0.8	4.0	52
Neema	1.3	1.0	19				0.7	1.8	27
Nelson	1.2	7.9	10	4.1	8.6	31	0.4	7.1	82
Regina	0.7	6.8	30	9.5	7.3	6	0.4	7.1	61
Sago							0.8	2.6	90
Shikuru							0.5	5.3	84
Tamasina	1.5	3.0	19				0.7	3.8	59

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Upendo	1.4	5.9	53				1.1	5.9	66
Vicky				8.7	5.7	27	0.4	5.8	85
Total	1.2	4.5	511	6.0	6.0	190	0.6	4.4	1321

* results shown only for participants with 5 or more cases.

Plotting per capita consumption against number of people (Figure 7) shows that, apart from a few participants with high per capita consumptions, there is a good deal of consistency in the median values among most participants (Phase 1). Whilst this may suggest that per capita consumption does not depend on the total number of persons cooked for, any effect is probably masked by differences in conversion efficiencies of different fuels. These effects have been explored by separating out heating events using only a single fuel. The main fuels used were charcoal, LPG, and wood (see Figure 5), so each has been considered in turn. Figure 8 presents median per capita energy used for heating events where only a single fuel was used:

- Charcoal. When the single outlier (Tamasina) is removed, there is a negative relationship between per capita energy consumption and number of persons ($B = -1.540$, $p < 0.001$).
- LPG. When the two high values (Asnut and Shikuru) are removed, there is no significant relationship between per capita energy consumption and number of persons.
- Wood. Only two participants used wood (Devota and Regina), and only four heating events meet the criteria for the analysis, so it was not possible to reach any realistic conclusions.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

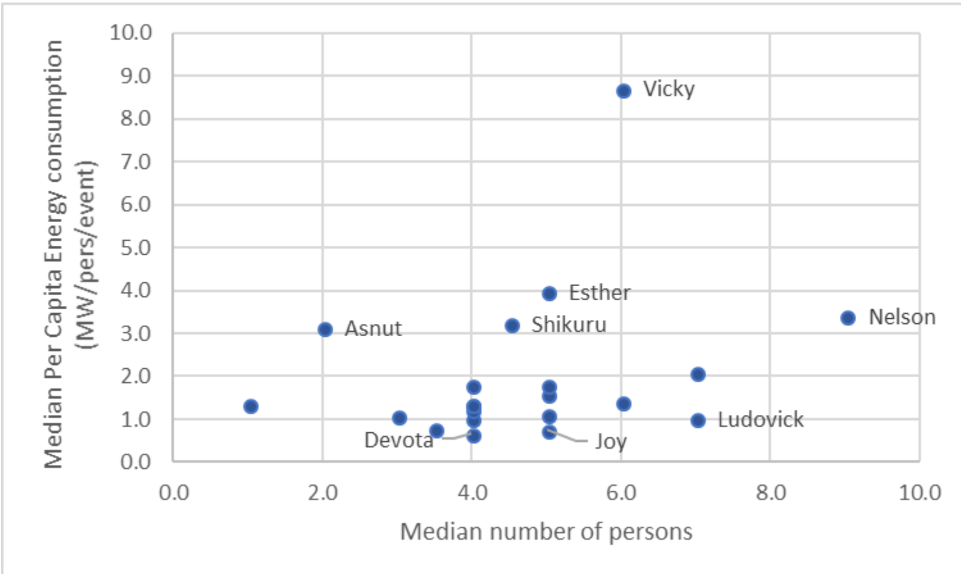
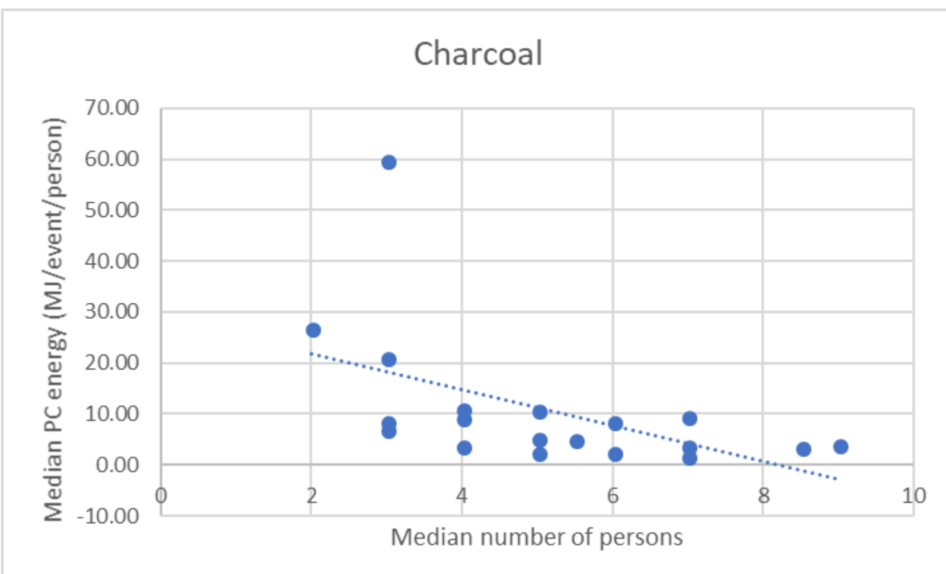


Figure 7 Relationship between per capita energy consumption and number of people – Phase 1



This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

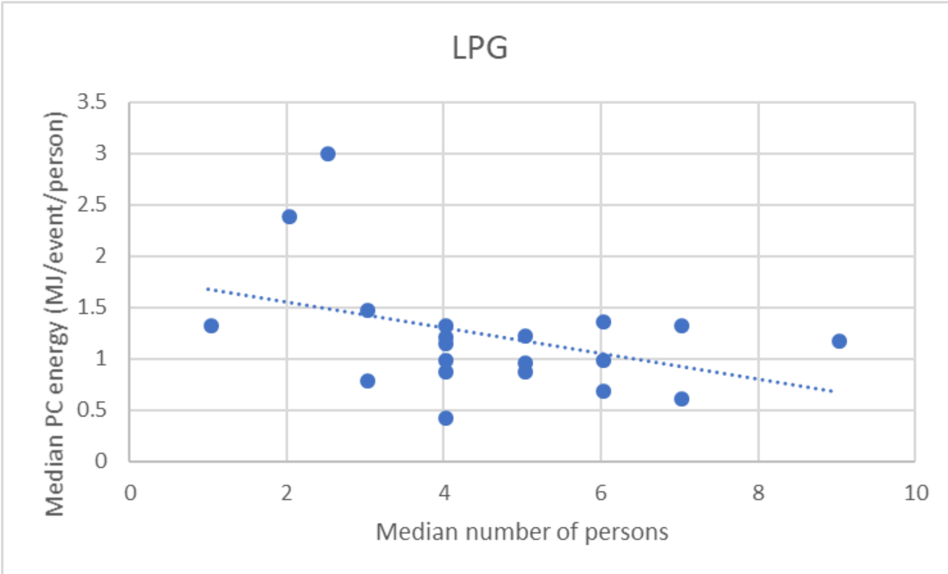


Figure 8 Relationship between per capita energy consumption and number of people – Phase 1 Charcoal and LPG

Figure 9 presents median data for Phase 2, but only those heating events where only electricity was used. When one outlier is omitted (Ludovick), a regression analysis shows that there is no significant relationship between per capita energy consumption and number of persons.

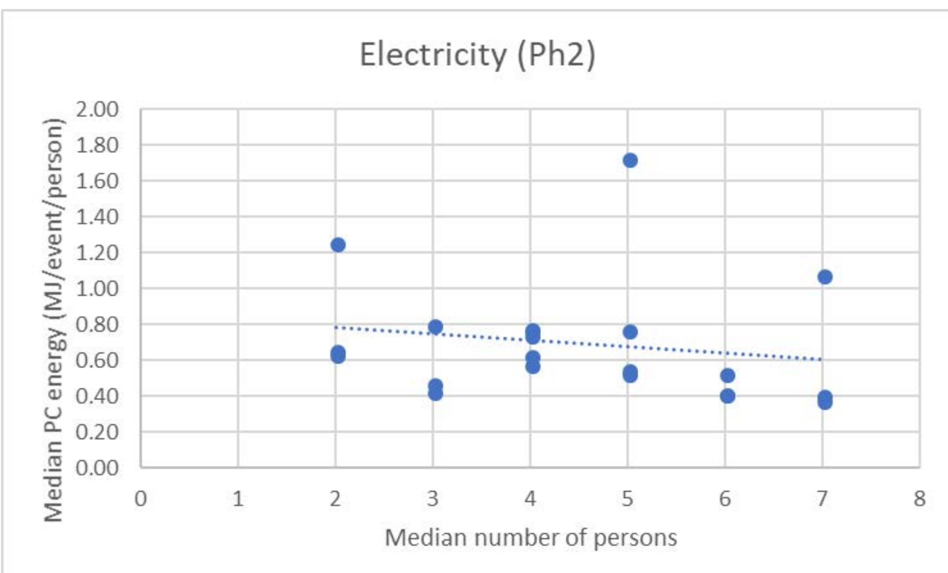


Figure 9 Relationship between per capita energy consumption and number of people – Phase 2

REGRESSION ANALYSES ON THE SINGLE FUEL DATA INDICATE THAT THERE ARE ECONOMIES OF SCALE TO BE GAINED IN THE PER CAPITA ENERGY CONSUMPTION WHEN COOKING FOR MORE PEOPLE ON HIGH THERMAL MASS FUELS SUCH AS CHARCOAL. HOWEVER, AS MODERN FUELS SUCH AS LPG & ELECTRICITY CAN BE TURNED ON & OFF IN AN INSTANT, MEANING THAT COOKING FOR 2 PEOPLE IS NOT SIGNIFICANTLY MORE EFFICIENT THAN COOKING FOR 7.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

These findings indicate that economies of scale can be achieved when using high thermal mass fuels that are not readily controllable i.e. charcoal. LPG and electricity, in contrast, can be turned down and switched off instantly, and these do not exhibit any economies of scale.

3.3.4 Energy consumption by heating event

Summing the energy consumed in all Phase 1 records shows that dinners and water heating consumed the most energy, closely followed by lunches (see Figure 10). The median per capita energy consumptions for each type of heating event illustrate differences in the overall conversion efficiencies associated with different fuels (Figure 11). Figures in Table 11 to Table 13 show that for all fuels, preparing food for babies was the most energy intensive heating event (on a per capita basis). The next most energy intensive event was lunch (electricity and charcoal) and dinner (LPG). Note that per capita energy consumptions for breakfast and heating water were similar.

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.

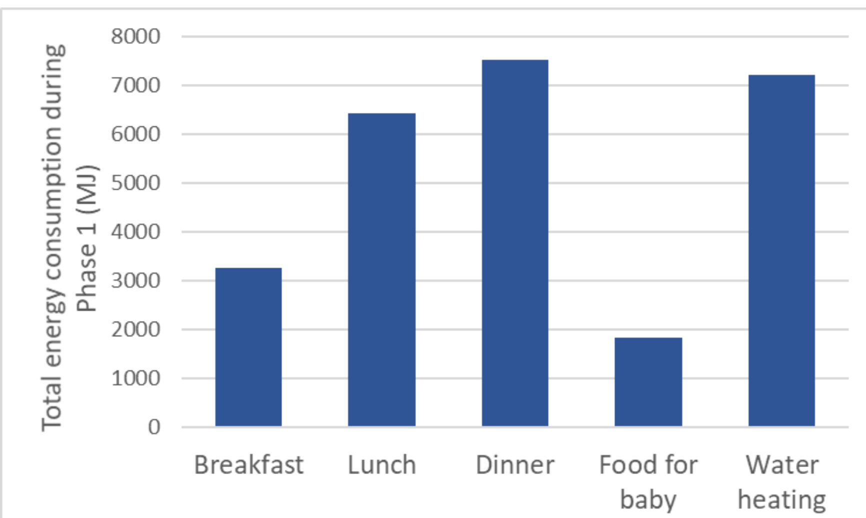


Figure 10 Total energy consumption by heating event (Phase 1)

Table 11 Per capita energy consumption by heating event (MJ/pers/event) (single events only) – Phase 1 LPG only

Heating event	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast	25	2.00	0.75	4.63	0.42	1.84
Lunch	111	2.49	1.05	5.62	0.67	2.02
Dinner	57	1.97	1.12	2.16	0.63	2.17
Heatingwater	5	1.70	1.09	1.61	0.67	3.02
Snack	4	0.59	0.56	0.24	0.38	0.84
Foodforbaby	6	6.27	6.50	2.80	3.92	8.74

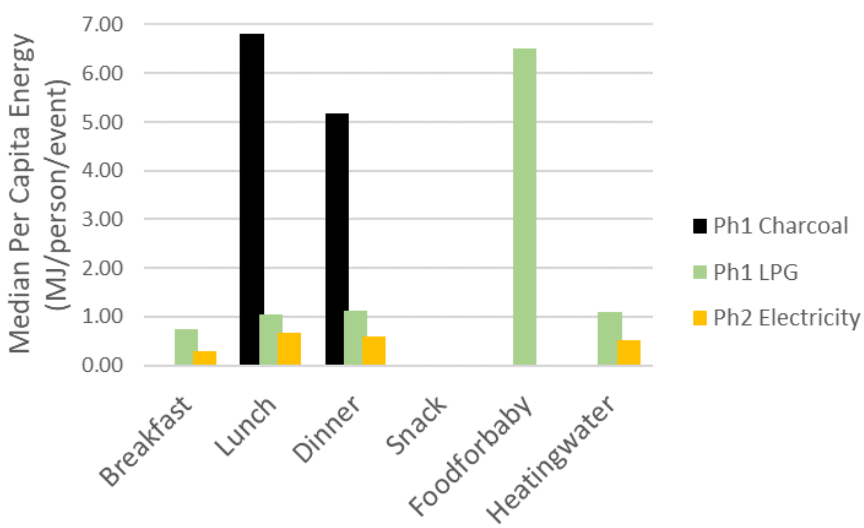
Table 12 Per capita energy consumption by heating event (MJ/pers/event) (single events only) – Phase 1 Charcoal only

Heating event	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast	2	12.76	12.76	7.47	7.48	.
Lunch	57	7.29	6.82	4.14	3.87	10.47
Dinner	48	6.85	5.18	8.27	3.00	8.60
Heatingwater						
Snack						
Foodforbaby						

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 13 Per capita energy consumption by heating event (MJ/pers/event) (single events only) – Phase 2 Electricity only

Heating event	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast	30	0.46	0.30	0.38	0.17	0.72
Lunch	296	0.93	0.68	0.87	0.37	1.16
Dinner	237	0.71	0.60	0.60	0.33	0.94
Heatingwater	49	0.75	0.51	0.75	0.25	0.96
Snack	4	2.40	0.53	3.87	0.34	6.32
Foodforbaby						



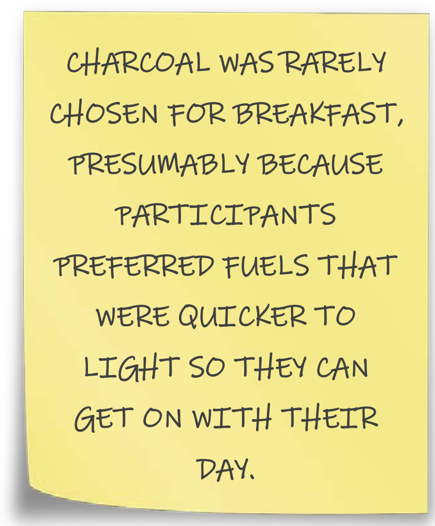


Figure 11 Per capita energy consumptions for different heating events (single events only) (n>=5)

The mix of fuels used for different events in Phase 1 is illustrated in Figure 12. 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. It shows that biomass was most commonly used for dinners and lunches.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

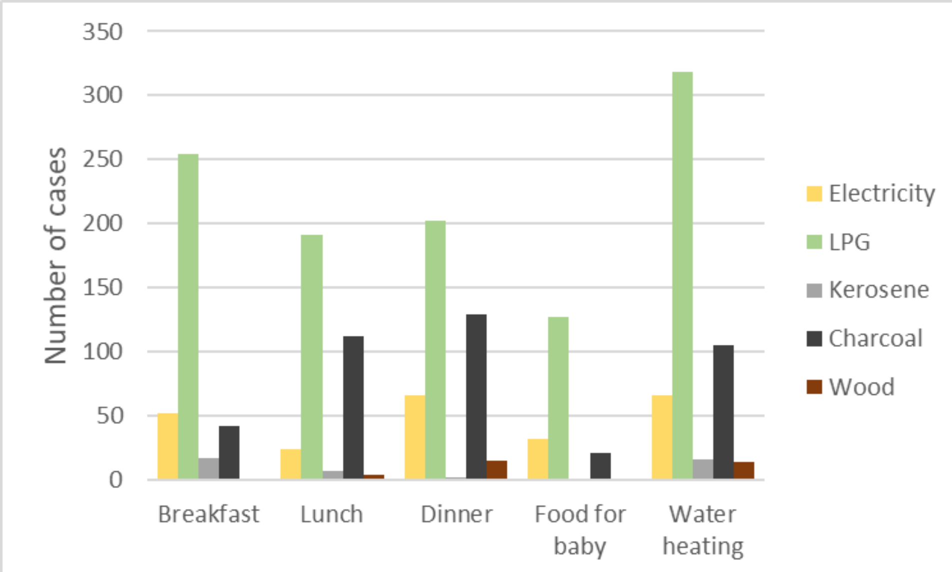


Figure 12 Choice of fuels for heating events (Phase 1)

3.3.5 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 258 person-days in Phase 1 and 330 person-days in Phase 2. The distributions of daily energy consumption in Phase 1 and Phase 2 are presented in Figure 13 and Figure 14 respectively[3].

[3] 3 data points over 200 MJ/day have been omitted from Phase 1 chart and 1 data point over 100 MJ/day has been omitted from Phase 2 chart.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

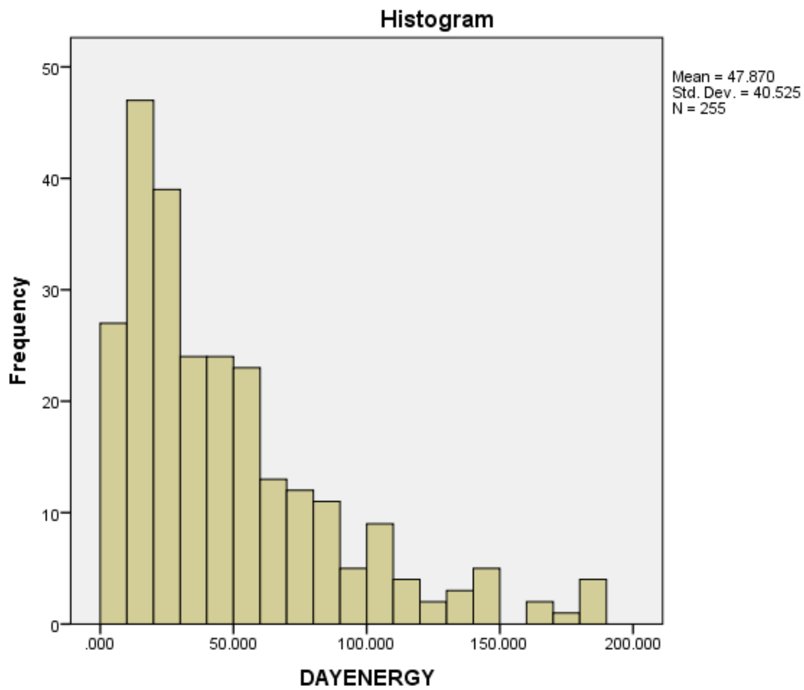


Figure 13 Distribution of daily energy consumption (MJ/day) - Phase 1

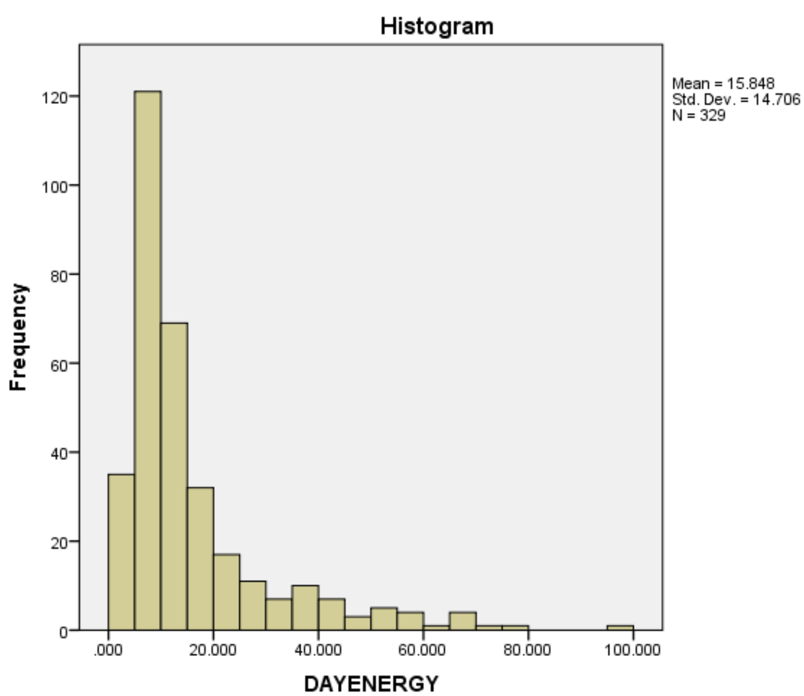


Figure 14 Distribution of daily energy consumption (MJ/day) - Phase 2

THE IMPACT OF TRANSITIONING TO ELECTRICITY ON THE ENERGY-EFFICIENCY OF COOKING IS CLEAR. ELECTRICITY IS THE ONLY FUEL THAT DOESN'T RELY UPON AN OPEN FLAME TO TRANSFER HEAT INTO THE POT. THIS MEANS THE WHOLE POT CAN BE INSULATED, RETAINING THE HEAT INSIDE.

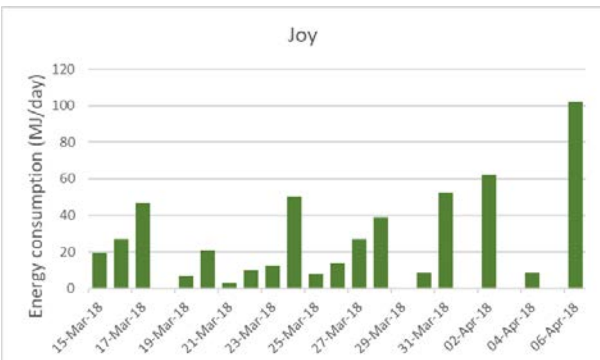
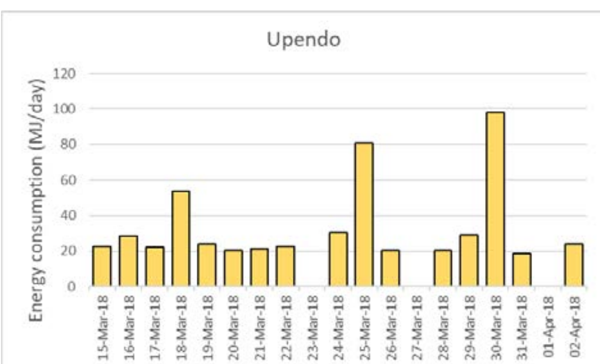
This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Daily energy consumptions for three participants in Phase 1 have been plotted in Figure 15. These three have been chosen as they represent a range of cooking efficiencies:

- Joy – efficient: 0.16 MJ/person/event (0.7 MJ/event (median); mean of 4.5 persons/event)
- Upendo – average: 0.26 MJ/person/event (1.4 MJ/event (median); mean of 5.9 persons/event)
- Regina – inefficient: 0.26 MJ/person/event (2.1 MJ/event (median); mean of 7.9 persons/event)

N.B. on 1st April, Regina cooked for 33 people and the energy consumption for that day was 420 MJ, so note that the scales on each chart are different.

Figure 16 shows a similar set of charts for Phase 2 (N.B. these charts include all fuels used; fuels other than electricity were used during power cuts).

Efficient

Average

Inefficient

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

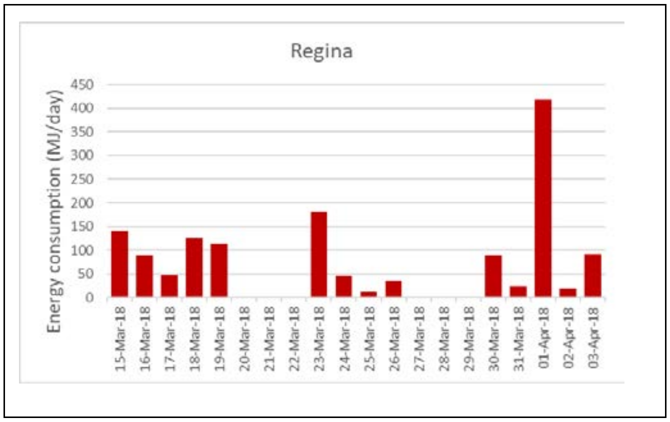
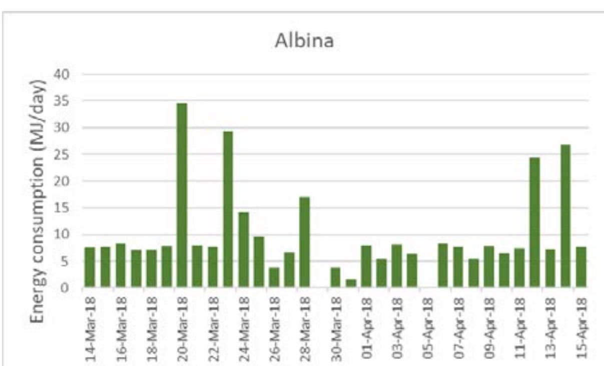
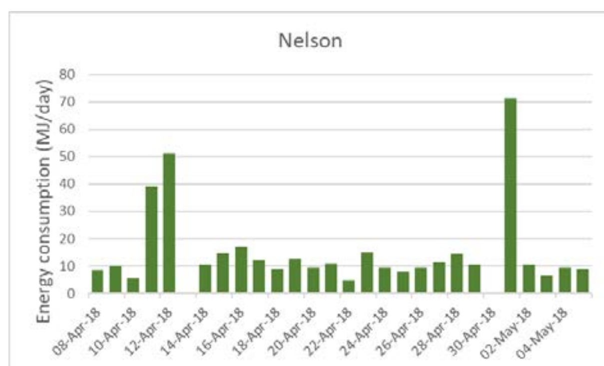
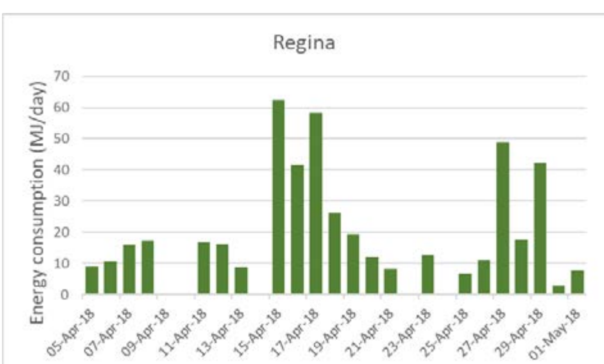


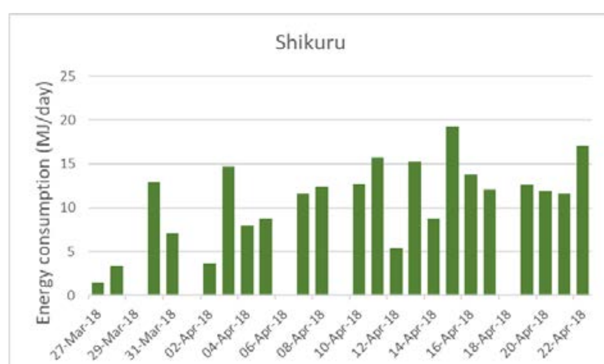
Figure 15 Daily energy consumption - time series (example participants) – Phase 1

Efficient



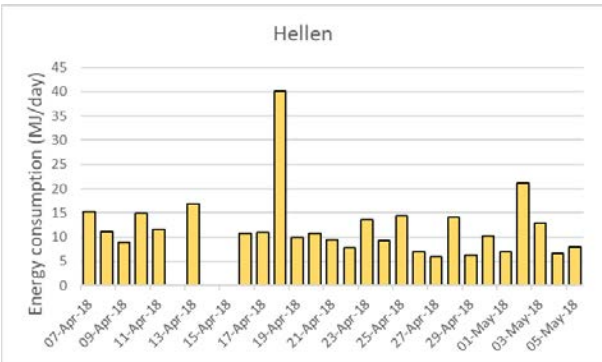


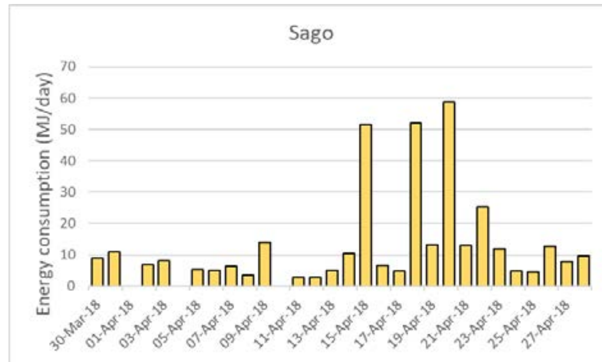




Average

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.





Inefficient

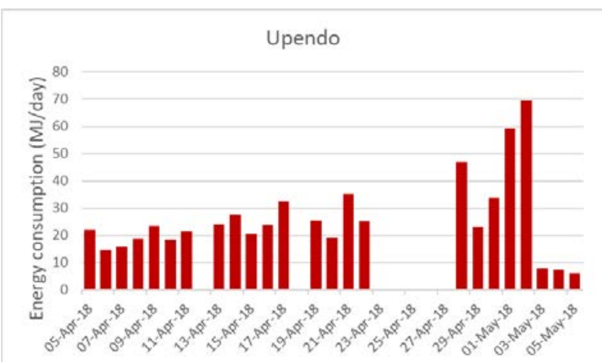
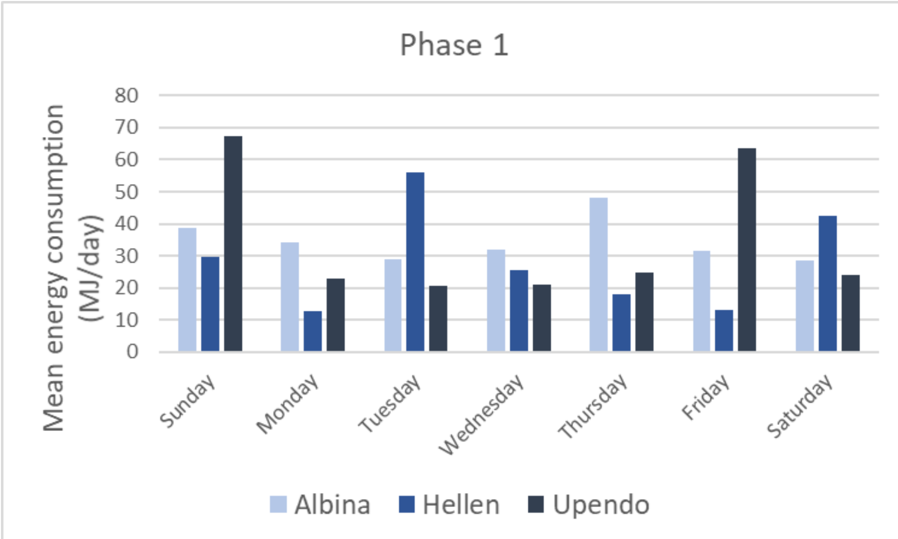


Figure 16 Daily energy consumption - time series (example participants) – Phase 2

Several of the charts in Figure 15 and Figure 16 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 either between the three example participants, or between the two phases. Note that these figures typically represent the means of only 2 to 5 readings.

THE SPIKES IN THE HOUSEHOLD ENERGY DEMAND PROFILES IN PHASE 2 ARE LIKELY DUE TO POWER CUTS, WHEN PARTICIPANTS WERE FORCED TO USE THEIR MUCH MORE ENERGY-INTENSIVE BASELINE FUELS.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.



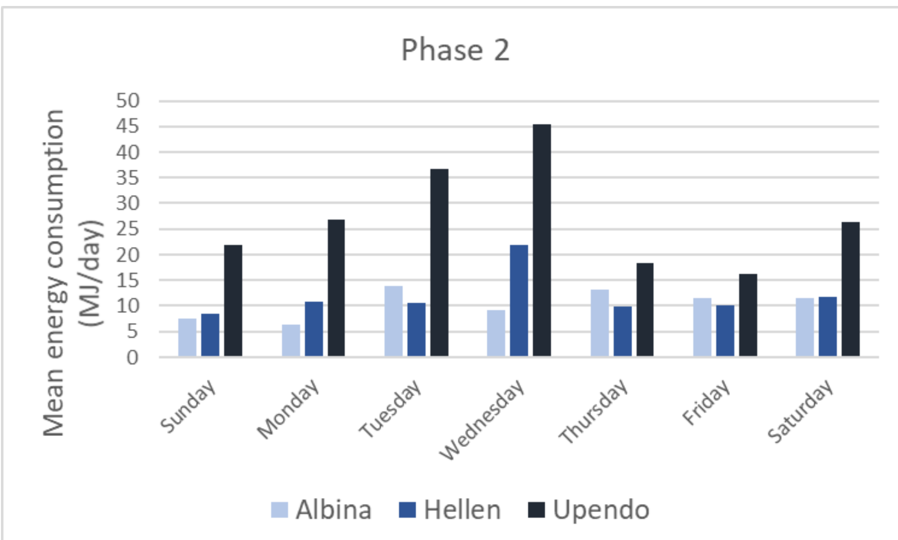


Figure 17 Mean daily energy consumption by day of the week

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. Not all meals are prepared each and every day (and neither are other heating events). Table 14 shows that breakfasts are the most commonly prepared meal, 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 14. 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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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 double the electrical energy required (while the number of people catered for is similar).

Table 14 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	Food for baby	
Charcoal (Phase 1)	31	84.3	50.4	80.4	115.6	83.9%	87.1%	96.8%	96.8%	12.9%	6.1
Kerosene (Phase 1)*	7	6.0	3.5	3.9	9.8	85.7%	42.9%	28.6%	71.4%	0%	3.2
LPG (Phase 1)	109	17.2	5.6	14.8	22.2	87.2%	67.0%	79.8%	81.7%	26.6%	4.1
Electricity (Phase 2)	423	8.8	3.9	7.4	11.3	90.5%	78.3%	81.6%	83.9%	36.6%	4.2

* based on records from one household only

> TAKING INTO ACCOUNT THE NO. PPL. COOKED FOR, COOKING WITH ELECTRICITY USED AN AVERAGE OF 1.76 MJ/PERSON/DAY (0.49 KWH/PERSON/DAY). IN CONTRAST, LPG WAS 3.61 MJ/PERSON/DAY & CHAROAL WAS 13.2 MJ/PERSON/DAY.

3.3.6 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) – Table 14 . 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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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.

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:

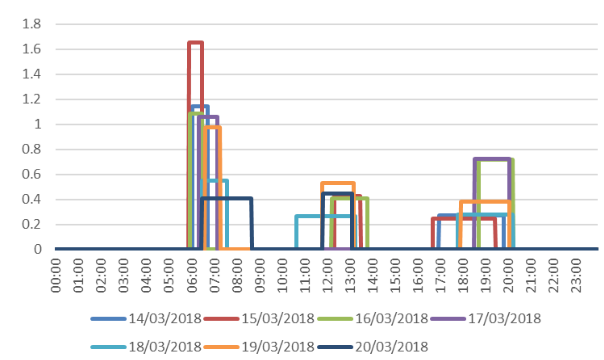
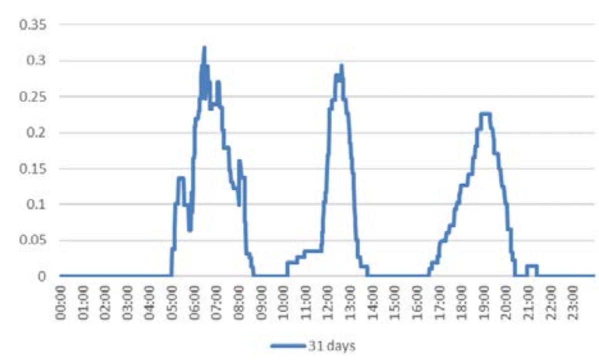
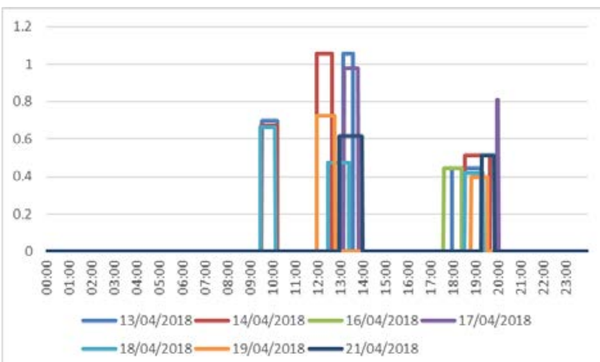
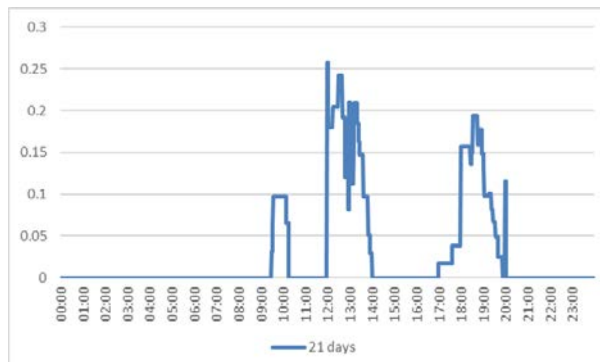
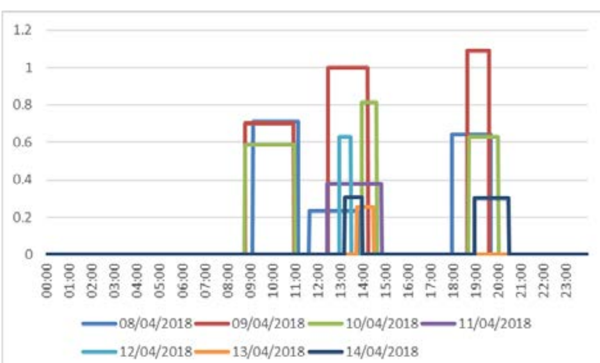
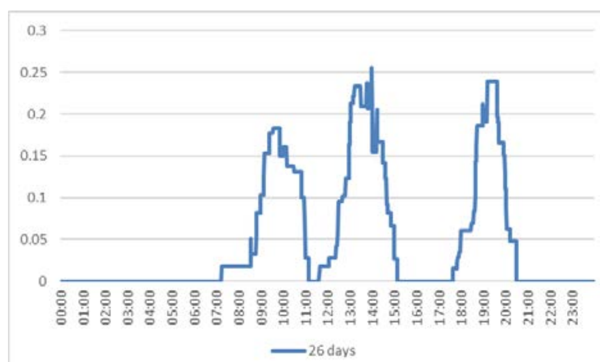
- Some records were omitted because they had incomplete (or nonsensical) electricity meter readings.
- Many records had incomplete start/end times for the heating event
- The duration of the heating event (from start/end times) was compared with the sum of the times estimated to cook individual dishes within the meal. An assumption was made that the top and bottom 10% might represent unreliable timings, so they have been omitted from the analysis.
- 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 18, and an aggregated profile based on all daily profiles calculated for all households is presented in Figure 19. Household ID 13 in Figure 18 illustrates the implications of this method of estimating average loads. Although electricity meter readings were taken for dinners, there was something about the way dinner timings were recorded that gave very long cooking duration times (typically 4 hours). In order not to give misleading figures for average power, these records were omitted, which explains why the aggregated profile is missing an evening peak. Household ID 5 is a similar example; no time data was recorded for the preparation of breakfast dishes, so these records were omitted.

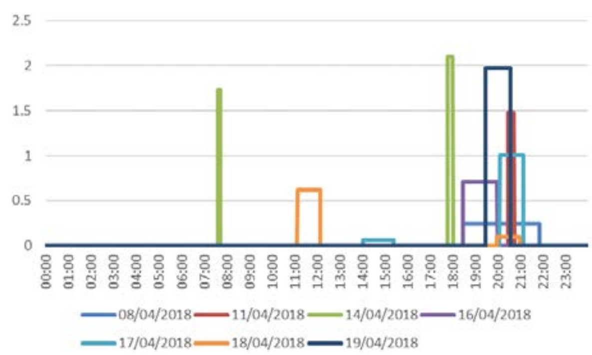
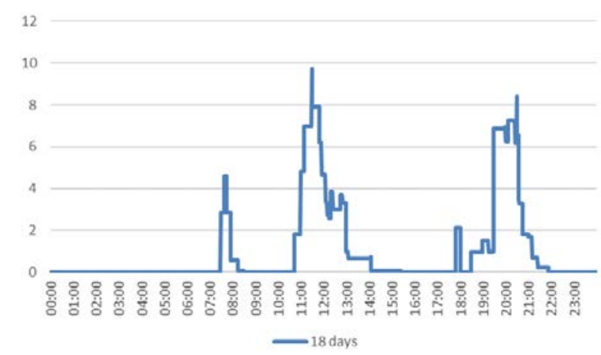
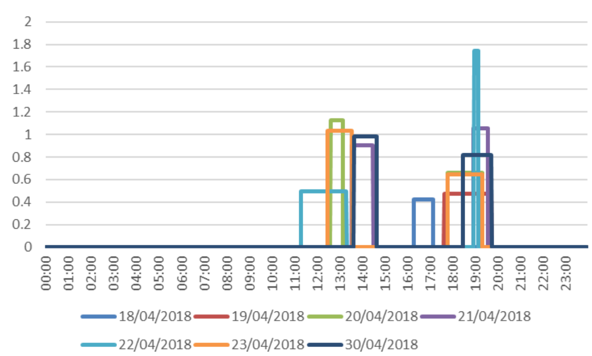
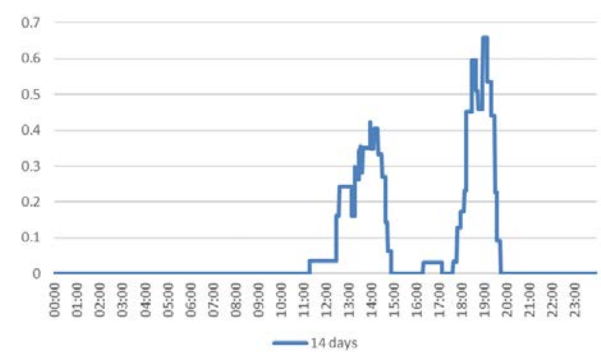
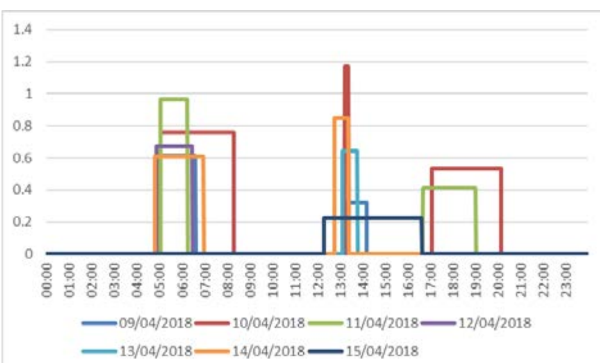
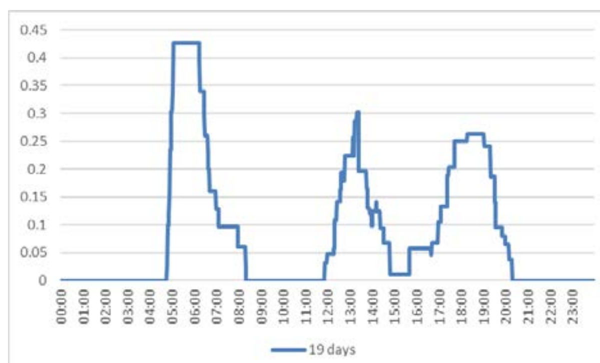
Notwithstanding these shortcomings, most households exhibit three daily peaks in load. There is also a good deal of consistency in the timing of

THE PATTERNS DISPLAYED BY THE LOAD PROFILES VARY CONSIDERABLY. SOME COOKS FOLLOW A REGULAR PATTERN EVERY DAY, WHILST OTHERS REGULARLY CHANGE THEIR ROUTINE. SOME COOK TWICE A DAY, BUT MOST THREE TIMES. DESIGNING A BATTERY-SUPPORTED SYSTEM IS MUCH EASIER FOR HHS WITH REGULAR ROUTINES, AS A BATTERY SIZED FOR THE TYPICAL DAY IS MUCH LESS LIEKLY TO RUN OUT HALF WAY THOGUGH A MEAL.

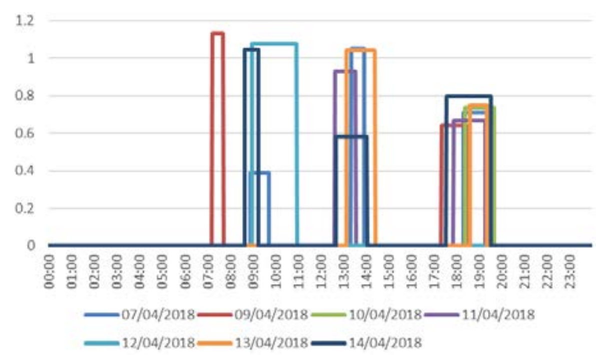
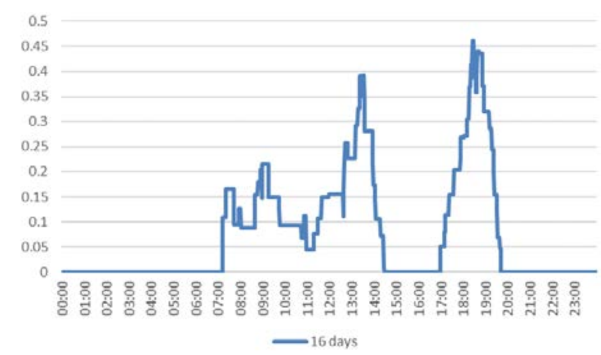
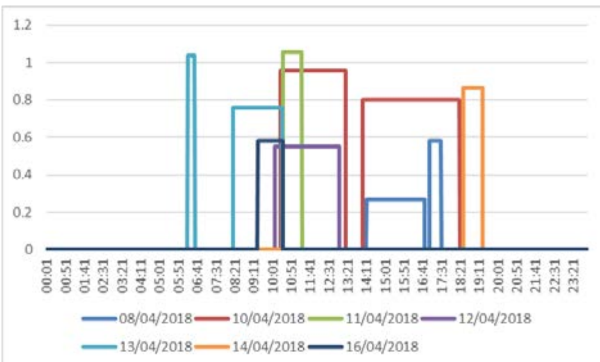
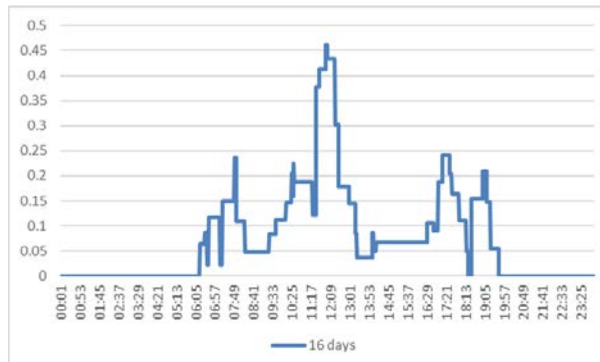
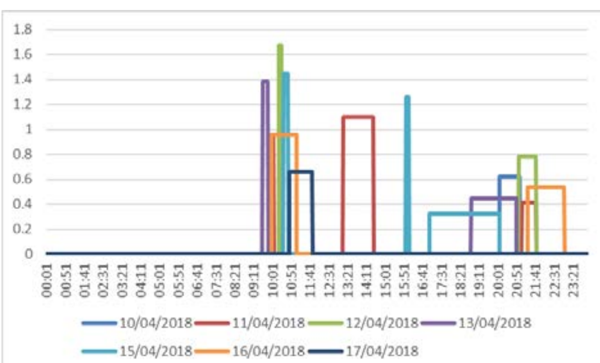
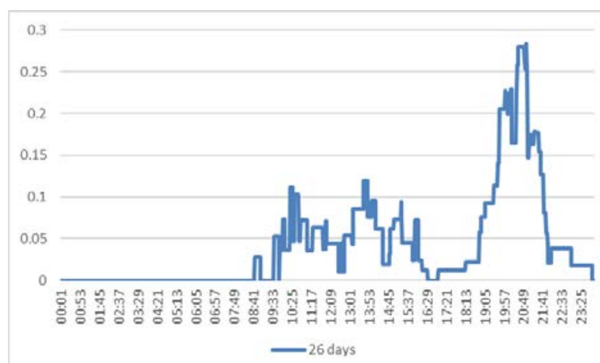
cooking loads, so the combined load (Figure 16) has three well defined peaks.

<table>
<tr><th>ID</th><th>7 day chart</th><th>Aggregate chart (all records)</th></tr>
<tr><td>1</td><td>
</td><td>
</td></tr>
<tr><td>2</td><td>
</td><td>
</td></tr>
<tr><td>3</td><td>
</td><td>
</td></tr>
</table>

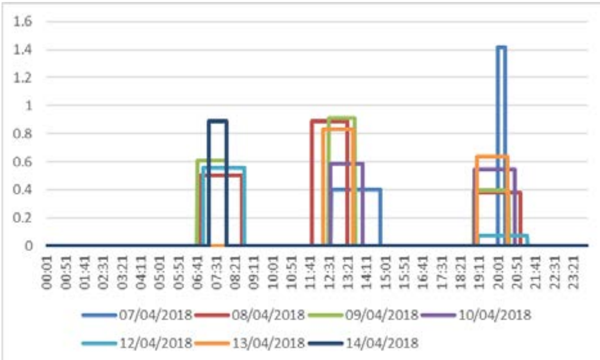
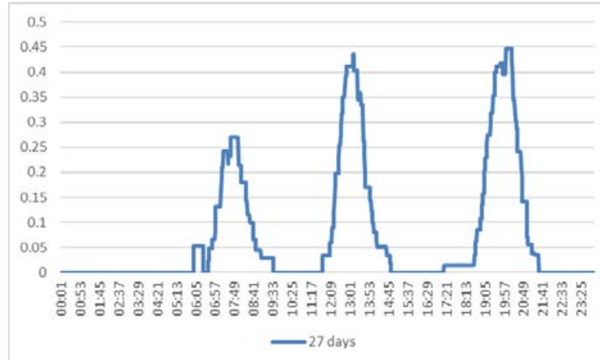
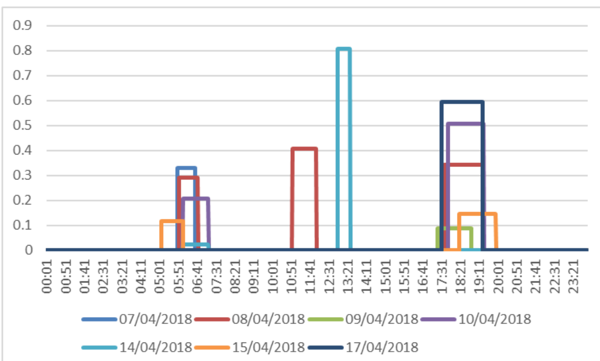
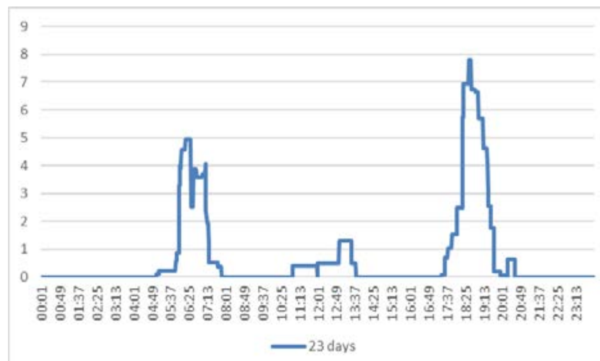
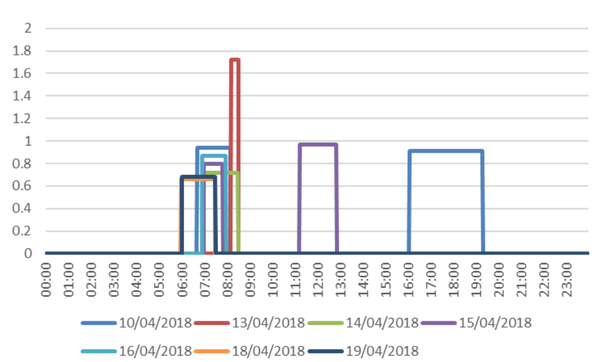
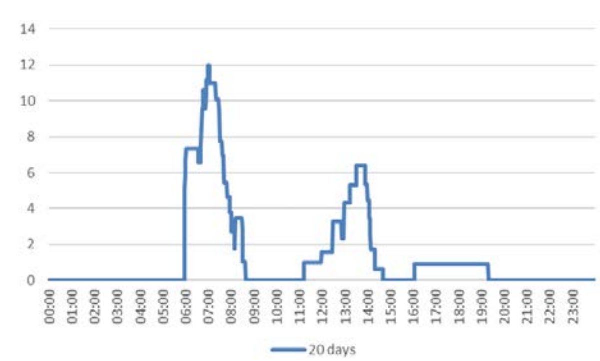
This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

ID	7 day chart	Aggregate chart (all records)
4		
5		
6		

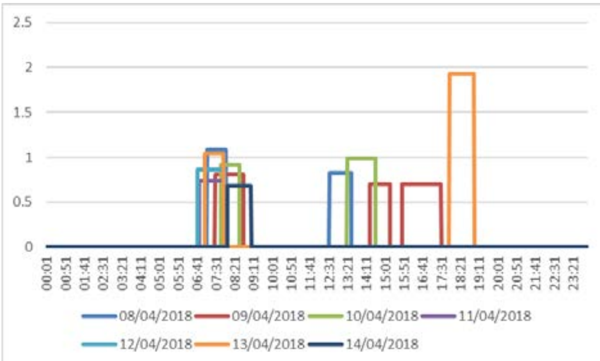
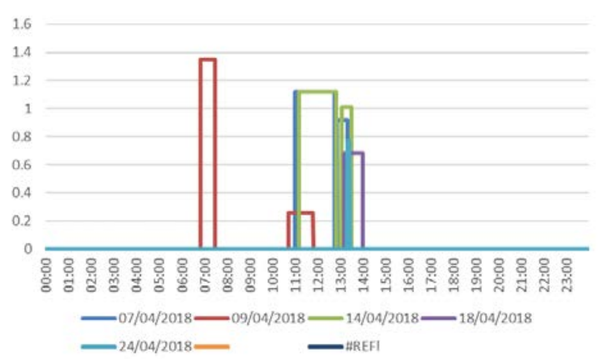
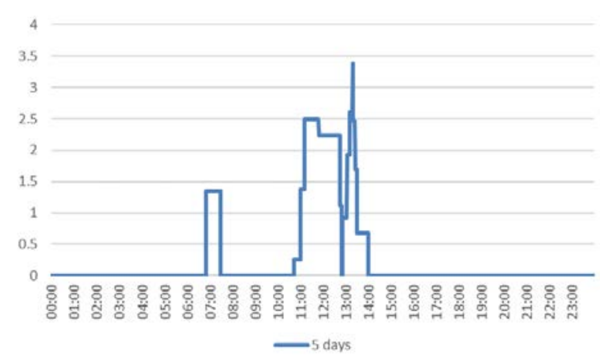
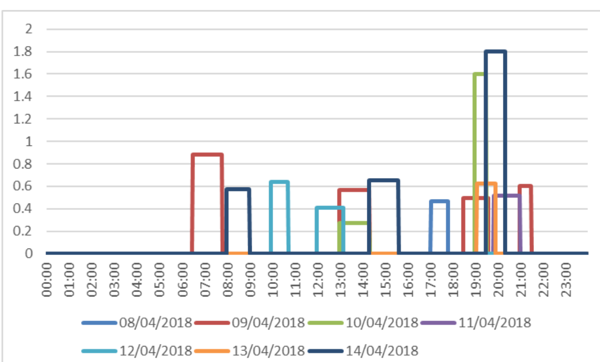
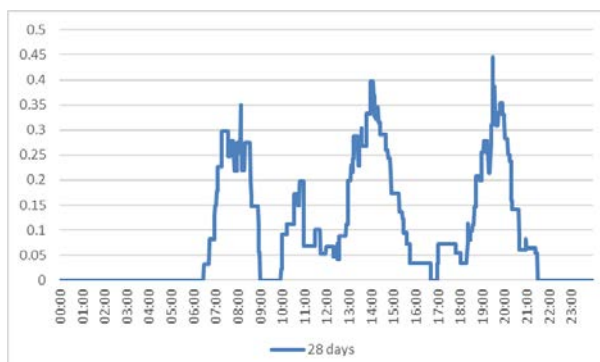
This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

ID	7 day chart	Aggregate chart (all records)
7		
8		
9		

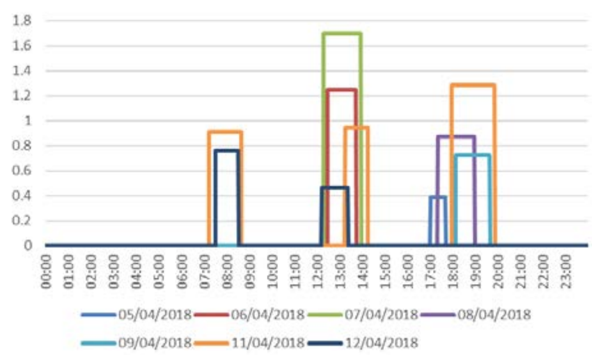
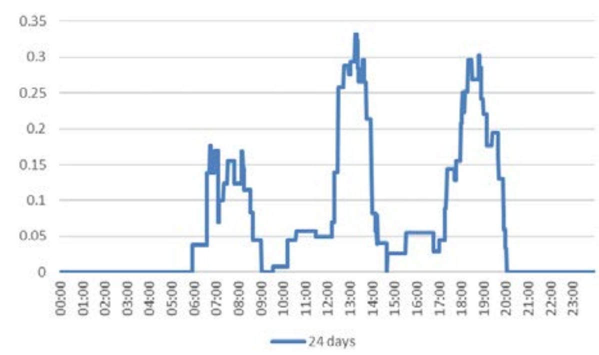
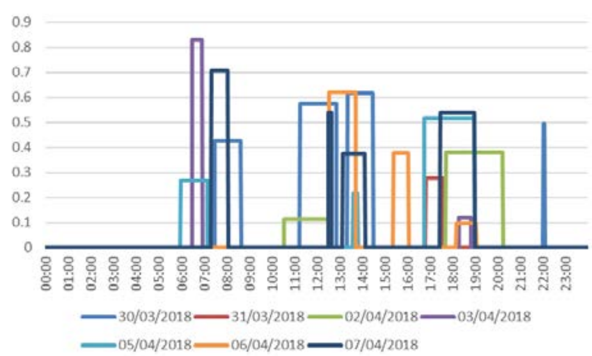
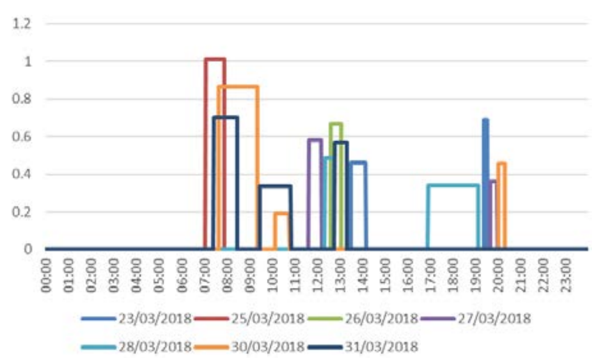
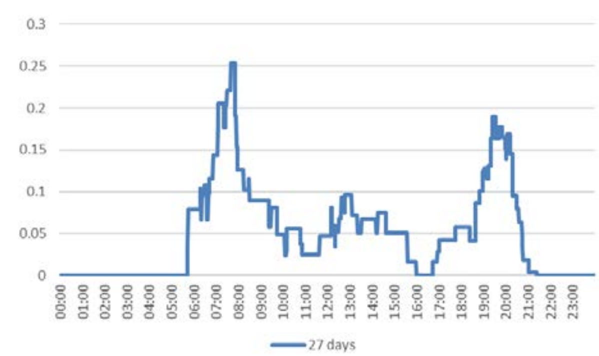
This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

ID	7 day chart	Aggregate chart (all records)
10		
12		
13		

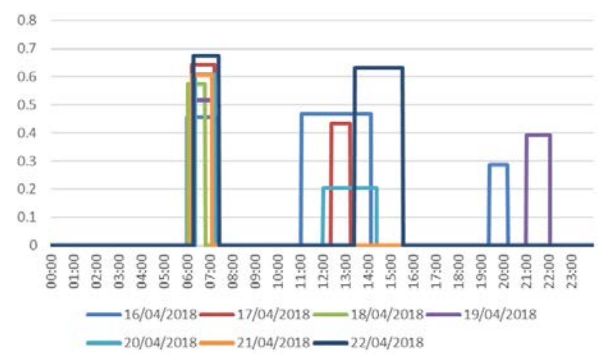
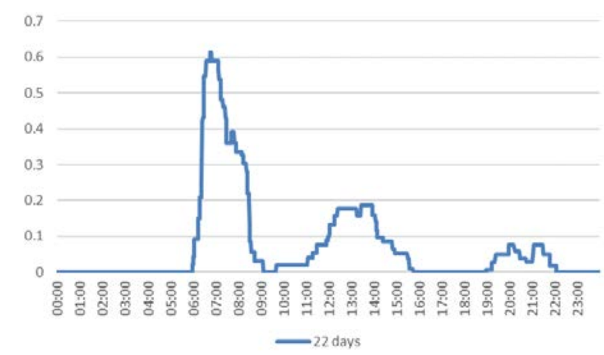
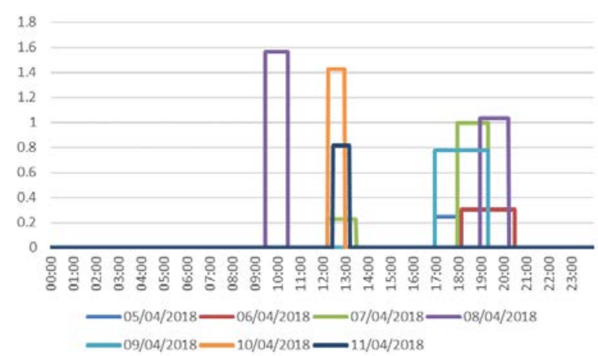
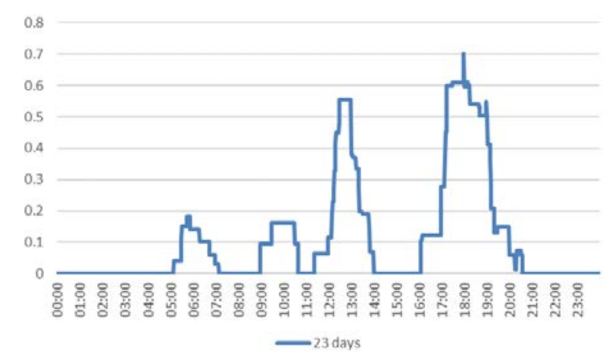
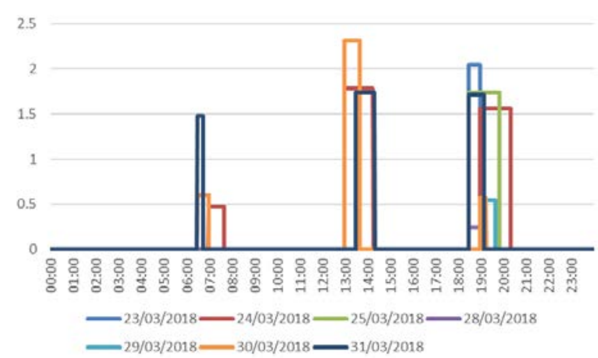
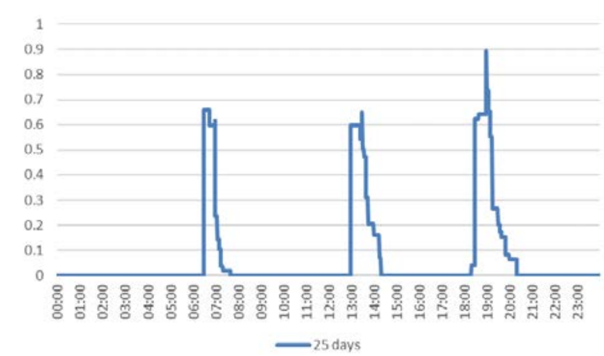
This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

<table>
<tr><th>ID</th><th>7 day chart</th><th>Aggregate chart (all records)</th></tr>
<tr><td>14</td><td>
</td><td>
</td></tr>
<tr><td>15</td><td>
</td><td>
</td></tr>
<tr><td>16</td><td>
</td><td>
</td></tr>
</table>

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

ID	7 day chart	Aggregate chart (all records)
17		
18		
19		

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

ID	7 day chart	Aggregate chart (all records)
20		
21		
22		

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Figure 18 24 hour load profiles (all households)

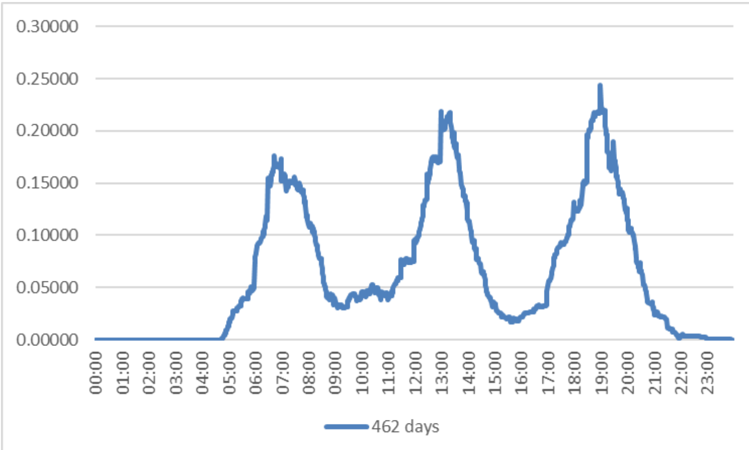


Figure 19 24 hour load profile – aggregated from all households

3.4 Meals cooked

3.4.1 Food types cooked

Separating out foods cooked for breakfast, lunch or dinner only, Table 15 shows that when asked to cook with electricity, participants were less likely to cook ugali, and seem to have substituted it with rice. Most of the other dishes were less frequently cooked in Phase 2, but it is not clear what has been cooked in their place as 'other' is the only dish that was cooked more often in Phase 2. Table 16 shows that participants were less likely to prepare complex meals with multiple dishes in Phase 2 (36% of meals in Phase 2 comprised a single dish only, compared with 27% in Phase 1).

N.B. food information was not submitted in all records. 88% of breakfast/lunch/dinner records in both Phase 1 and Phase 2 contained food information (N=912 and N=1249 respectively).

Table 15 Number of meals containing food types (Breakfast, lunch and dinner heating events only)

	Phase 1	Phase 2

AGGREGATING ALL THE DAILY LOAD PROFILES FROM THROUGHOUT THE STUDY SHOWS A CLEAR TRIPLE PEAKED PROFILE. THIS IS PARTICULARLY RELEVANT FOR GRID OPERATORS, AS

SMALL CHANGES WERE OBSERVED IN THE MENU, THE MOST SIGNIFICANT OF WHICH WAS A SHIFT FROM RICE TO UGALI. AS MANY PARTICIPANTS HAD CHOSEN RICE COOKERS AS ONE OF THEIR APPLIANCES TO TRIAL, THIS IS NOT PARTICULARLY SURPRISING. HOWEVER, UGALI IS ACTUALLY ALSO VERY EASY TO COOK WITH A RICE COOKER, HOWEVER THERE ARE A FEW TRICKS REQUIRED (E.G. STOPPING THE POT FROM SPINNING DURING STIRRING), WHICH MAY HAVE PUT PEOPLE OFF.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and

	N = 1036		N = 1415	
	Frequency	Percent	Frequency	Percent
Ugali	228	22.0%	246	17.4%
Chapati	42	4.1%	34	2.4%
Rice	243	23.5%	385	27.2%
Eggs	46	4.4%	46	3.3%
Bananas	169	16.3%	225	15.9%
Pilau	57	5.5%	59	4.2%
Chips	24	2.3%	20	1.4%
Makande	29	2.8%	20	1.4%
Stew	298	28.8%	363	25.7%
Other meat/fish	78	7.5%	37	2.6%
Other veg	136	13.1%	137	9.7%
Beans	216	20.8%	261	18.4%
Other	329	31.8%	537	38.0%

Table 16 Number of foods included in a heating event (Breakfast, lunch and dinner heating events only)

		PHASE		
		1	2	Total
NUMBER OF FOOD TYPES IN MEAL	1	247	450	697
	2	370	501	871
	3	272	274	546
	4	23	24	47
Total		912	1249	2161

It is not clear from Table 17 that any particular foods lend themselves to being eaten on their own (i.e. as single dish meals), with the exception of porridge, which was not listed on the menu, so fell into the categorisation 'other'.

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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and

Table 17 Occurrence of foods in meals by number of foods in the meal (all heating events, Phase 1 and 2)

	1	2	3	4	Total
Ugali	27	207	219	22	475
Chapati	27	35	15		77
Rice	79	313	223	20	635
Eggs	23	54	15	2	94
Bananas	73	152	155	23	403
Pilau	36	46	27	9	118
Chips	7	20	15	2	44
Makande	21	17	10	1	49
Stew	28	308	298	32	666
Other meat/fish	4	45	60	8	117
Other veg	3	75	178	19	275
Beans	19	198	239	24	480
Other	416	284	196	26	922

3.4.2 Reheating food

For each food item prepared (up to a maximum of four dishes per meal), participants were asked if each dish was freshly cooked or reheated. If all dishes in a meal were reheated, then the meal was classified as reheated, if all were freshly cooked, then the meal was classified as fresh, and if only some of the dishes in the meal were reheated then the meal was classified as partially reheated. Results for all those records that contained only a single heating event are presented in Table 18. This shows that dinners had a higher degree of reheated dishes than lunches (the two meals with large numbers of valid records), and this was true of both Phase 1 and Phase 2.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 18 Number of meals fresh or reheated (single heating event records only)

Phase 1								
	Fresh		Reheated		Partially reheated		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Breakfast	36	65%	8	15%	11	20%	55	100%
Lunch	168	71%	14	6%	55	23%	237	100%
Dinner	148	63%	31	13%	57	24%	236	100%
Snack	4	100%	0	0%	0	0%	4	100%
Food for baby	5	71%	0	0%	2	29%	7	100%
Phase 2								
	Fresh		Reheated		Partially reheated		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Breakfast	31	86%	1	3%	4	11%	36	100%
Lunch	267	77%	23	7%	55	16%	345	100%
Dinner	188	66%	32	11%	67	23%	287	100%
Snack	2	100%	0	0%	0	0%	2	100%
Food for baby	30	100%	0	0%	0	0%	30	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 four dishes are presented in Table 25 and show that beans and pilau were most commonly reheated (in terms of proportion of times they were cooked). In absolute terms, it was beans, stews and rice that were most often reheated.

Table 19 Food types most commonly reheated (individual dishes, cooked as part of meals)

	Fresh	Reheated	Total
Ugali	470 (99%)	6 (1%)	476
Chapati	58 (75%)	19 (25%)	77
Rice	516 (81%)	125 (19%)	641
Eggs	93 (98%)	2 (2%)	95
Bananas	348 (83%)	72 (17%)	420
Pilau	68 (58%)	50 (42%)	118
Chips	39 (89%)	5 (11%)	44
Makande	33 (64%)	19 (36%)	52

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Stew	551 (79%)	147 (21%)	698
Other meat/fish	94 (80%)	24 (20%)	118
Other veg	245 (89%)	31 (11%)	276
Beans	247 (50%)	244 (50%)	491
Other	1033 (91%)	108 (9%)	1141

Reheating food for meal might be expected to take less energy than preparing a meal from scratch (fresh). Dinners cooked using charcoal and LPG (Phase 1) both show a trend of partially reheated meals taking less energy, and fully reheated meals taking less energy still (Table 20 and Table 21). This can also been seen in lunches cooked using LPG, but not among those cooked with charcoal.

Data from meals prepared using only electricity are presented in Table 22 (Phase 2). These confirm that reheated food consumes less energy, but it is interesting that these figures suggest no difference when preparing meals with only partially reheated food.

Table 20 Per capita energy consumption by heating event and reheating (MJ/pers/event) – Phase 1 charcoal only

Heating event	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Lunch						
Fresh	47	6.87	6.82	3.67	3.83	9.57
Partially reheated	9	9.64	11.11	5.96	4.03	13.69
Dinner						
Fresh	31	8.07	6.23	9.99	3.59	8.72
Reheated	3	3.50	2.99	1.94	1.87	.
Partially reheated	14	4.85	3.74	2.45	2.96	7.65

Table 21 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	18	2.49	0.78	5.41	0.43	1.94
Partially reheated	7	0.75	0.75	0.54	0.30	0.90
Lunch						

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Fresh	79	2.73	1.34	6.37	0.81	2.33
Reheated	7	0.58	0.34	0.64	0.22	0.78
Partially reheated	25	2.27	0.78	3.44	0.58	2.15
Dinner						
Fresh	38	2.53	1.68	2.43	0.87	3.46
Reheated	8	0.71	0.39	0.76	0.18	1.49
Partially reheated	10	0.99	1.05	0.58	0.41	1.38

Table 22 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
Lunch						
Fresh	224	0.95	0.71	0.86	0.40	1.21
Reheated	21	0.49	0.24	0.80	0.12	0.46
Partially reheated	51	1.02	0.72	0.89	0.42	1.28
Dinner						
Fresh	156	0.78	0.63	0.63	0.37	1.00
Reheated	26	0.21	0.14	0.20	0.07	0.30
Partially reheated	55	0.76	0.64	0.51	0.37	0.98

1/10 OF ALL MEALS ARE REHEATED, WHICH HAS SIGNIFICANT IMPLICATIONS FOR ENERGY DEMAND, AS REHEATING USES ROUGHLY ¼ OF THE ENERGY OF COOKING FROM FRESH. HOWEVER, MEALS WITH SOME REHEATED COMPONENTS USE ROUGHLY THE SAME AMOUNT OF ENERGY AS THOSE WITH NONE. LUNCHES & DINNER ARE REHEATED EQUALLY OFTEN.

In 19% of all records, some food was prepared in advance (i.e. to be eaten at a later time) (see Table 23). Where multiple heating events are recorded on one case, it is not possible to determine which of the events involved preparing food in advance. Therefore, Table 24 considers only those records that related to a single heating event. Table 24 shows that food is most commonly precooked at lunchtimes. Table 25 shows that combinations of rice, ugali, and stews are most commonly cooked in advance. Note that where some food was partially reheated and the meal comprises multiple foods, it is not possible to determine precisely which food was reheated.

Table 23 Preparing food in advance

		Frequency	Percent	Valid Percent
Valid	No	1926	66.2	78.4
	Some	476	16.4	19.4
	All	56	1.9	2.3
	Total	2458	84.5	100.0
Missing	System	450	15.5	
Total		2908	100.0	

Table 24 Preparing food in advance by heating event (records containing single event only)

	No	**Some**	**All**	**Total**
Breakfast	90	13	2	105
Lunch	385	159	29	573
Dinner	416	81	6	503
Snack	6	2		8
Food for baby	6	1	2	9
Heating water	56	1		57
Other	12			12
Total	971	257	39	1267

Table 25 Meals most commonly prepared in advance

	FOOD PREPARED IN ADVANCE			Total
	No	Some	All	

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Other	300	66	8	374
Rice Beans	77	39	3	119
Ugali Stew	50	20	3	73
Rice Stew	78	15	1	94
Bananas Stew	40	13	0	53
Ugali Beans	25	12	2	39
Rice	63	12	1	76
Ugali Other	18	12	0	30
Bananas	58	11	4	73
Stew Other	29	11	1	41
Ugali Stew Beans	24	10	0	34
Rice Stew Beans	23	9	0	32
Pilau Stew	7	8	3	18

3.4.3 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 26 to Table 28. Furthermore, records in which food was reheated have been omitted from the results.

Electrical energy consumption is broken down further in Section 3.5.4 where the efficiency of different electrical devices is discussed.

UNFORTUNATELY, SAMPLE SIZES FOR MOST DISHES & MEAL COMBINATIONS WERE TOO SMALL TO MAKE MEANINGFUL COMPARISONS BETWEEN THEM IN TERMS OF ENERGY CONSUMPTION.

*Table 26 Specific energy consumptions (MJ/pers/event) - single food meals**

Food	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Phase 1 LPG						
Bananas	7	2.81	1.57	2.82	0.45	4.48
Other	23	1.93	0.67	4.39	0.36	1.34
Pilau	2	0.48	0.48	0.04	0.45	.
Rice	5	1.69	1.34	1.03	0.90	2.65

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Ugali	10	0.94	0.90	0.51	0.53	1.34
Phase 1 Charcoal						
Makande	2	5.81	5.81	0.24	5.64	.
Pilau	2	3.92	3.92	2.91	1.87	.
Phase 2 Electricity						
Bananas	19	0.59	0.42	0.51	0.22	0.71
Beans	5	0.45	0.28	0.52	0.08	0.90
Makande	6	0.32	0.35	0.20	0.12	0.45
Other	44	0.77	0.37	1.48	0.23	0.69
Other v	2	0.10	0.10	0.01	0.09	.
Pilau	9	0.32	0.21	0.34	0.14	0.40
Rice	36	0.68	0.34	0.81	0.18	1.03
Stew	11	0.97	0.55	1.22	0.28	0.95
Ugali	7	0.59	0.54	0.44	0.21	0.76

*Table 27 Specific energy consumptions (MJ/pers/event) - two food meals**

Food	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Phase 1 LPG						
Bananas Other	5	2.04	1.12	2.35	0.56	3.97
Bananas Stew	6	3.04	3.02	1.84	1.45	4.73
Eggs Other	10	3.54	1.49	7.09	0.36	2.31
Makande Other	2	0.54	0.54	0.50	0.19	.
Pilau Other	2	2.76	2.76	3.06	0.60	.
Rice Bananas	2	5.21	5.21	3.72	2.58	.
Rice Beans	4	0.40	0.28	0.28	0.22	0.70
Rice Other veg	2	1.06	1.06	0.40	0.78	.
Rice Stew	8	3.17	2.05	3.59	0.49	6.10
Stew Beans	2	0.36	0.36	0.19	0.22	.
Ugali Beans	4	1.42	0.75	1.60	0.44	3.08
Ugali Other meat/fish	6	1.48	1.05	0.94	0.77	2.49
Ugali Other veg	6	1.03	0.66	0.81	0.50	1.65

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Ugali Stew	18	1.42	0.94	1.64	0.77	1.46
Phase 1 Charcoal						
Bananas Stew	2	9.88	9.88	1.89	8.54	.
Chapati Stew	2	7.79	7.79	2.20	6.23	.
Rice Beans	5	20.53	7.48	21.44	4.01	43.58
Rice Other meat/fish	3	3.98	2.96	1.78	2.94	.
Rice Stew	7	6.91	7.48	3.83	2.99	8.72
Ugali Beans	4	8.30	9.29	3.64	4.49	11.12
Ugali Other veg	7	3.22	3.32	1.05	2.21	4.19
Ugali Stew	4	7.00	7.97	2.78	4.05	8.97
Phase 2 Electricity						
Bananas Chips	3	0.70	0.59	0.25	0.53	.
Bananas Other	7	0.84	0.43	0.80	0.36	1.50
Bananas Other veg	3	0.31	0.32	0.18	0.13	.
Bananas Stew	15	0.77	0.60	0.62	0.44	0.78
Beans Other	6	0.92	0.93	0.37	0.58	1.30
Eggs Chips	2	0.99	0.99	1.29	0.08	.
Eggs Other	6	0.57	0.42	0.58	0.13	0.99
Pilau Other	3	0.59	0.60	0.19	0.40	.
Pilau Stew	4	0.48	0.35	0.31	0.29	0.80
Rice Beans	33	0.92	0.78	0.71	0.32	1.29
Rice Other	17	0.76	0.79	0.37	0.43	1.05
Rice Other veg	6	0.57	0.46	0.43	0.21	1.00
Rice Stew	34	0.69	0.53	0.52	0.37	0.83
Stew Other	9	0.63	0.39	0.51	0.20	1.12
Ugali Beans	11	1.17	1.12	0.73	0.74	1.45
Ugali Other	11	1.31	0.75	1.37	0.51	1.52
Ugali Other meat/fish	3	0.76	0.80	0.64	0.10	.
Ugali Other veg	11	0.72	0.64	0.43	0.42	1.19
Ugali Stew	17	0.65	0.52	0.44	0.42	0.69

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

*Table 28 Specific energy consumptions (MJ/pers/event) - three food meals**

Food	Frequency	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Phase 1 LPG						
Bananas Stew Beans	2	2.91	2.91	2.22	1.34	.
Bananas Stew Other	3	1.69	1.87	0.95	0.67	.
Bananas Stew Other veg	2	3.30	3.30	1.50	2.24	.
Rice Bananas Stew	2	4.26	4.26	1.58	3.14	.
Rice Other meat/fish Beans	2	5.30	5.30	5.60	1.34	.
Rice Stew Beans	5	1.41	1.42	0.62	0.90	1.93
Rice Stew Other veg	2	1.46	1.46	0.63	1.01	.
Ugali Other veg Beans	4	1.65	0.95	1.94	0.31	3.70
Ugali Stew Beans	5	2.57	1.49	3.47	0.41	5.28
Ugali Stew Other veg	7	2.54	1.19	3.31	0.75	2.80
Phase 1 Charcoal						
Rice Other veg Beans	3	5.85	4.98	2.08	4.35	.
Rice Stew Other veg	7	6.62	8.72	3.70	2.62	8.72
Ugali Bananas Stew	2	27.09	27.09	3.23	24.80	.
Ugali Stew Beans	2	11.59	11.59	0.53	11.21	.
Ugali Stew Other	2	8.80	8.80	2.35	7.14	.
Ugali Stew Other veg	5	8.37	7.48	2.01	6.73	10.47
Phase 2 Electricity						
Bananas Pilau Stew	2	1.21	1.21	0.46	0.88	.
Bananas Stew Beans	2	0.62	0.62	0.25	0.44	.
Bananas Stew Other	3	0.23	0.09	0.26	0.07	.
Bananas Stew Other veg	3	0.69	0.68	0.27	0.43	.
Eggs Other veg Other	2	0.56	0.56	0.20	0.41	.
Pilau Stew Other	2	0.81	0.81	0.79	0.25	.
Rice Bananas Beans	4	0.73	0.77	0.29	0.44	0.99
Rice Bananas Other	2	0.75	0.75	0.24	0.59	.
Rice Bananas Other veg	2	1.49	1.49	1.56	0.38	.
Rice Beans Other	7	1.14	1.14	0.86	0.34	1.85
Rice Other veg Beans	4	0.90	0.62	0.78	0.39	1.70
Rice Stew Beans	10	1.29	0.86	1.33	0.41	1.57

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Rice Stew Other	6	0.71	0.50	0.54	0.32	1.18
Rice Stew Other veg	4	0.96	0.97	0.61	0.37	1.55
Ugali Bananas Beans	2	0.93	0.93	0.06	0.89	.
Ugali Bananas Other	4	0.99	0.91	0.42	0.63	1.42
Ugali Bananas Stew	7	0.83	0.83	0.34	0.57	1.00
Ugali Beans Other	6	1.58	1.28	1.48	0.63	2.29
Ugali Chips Other	2	1.69	1.69	0.95	1.02	.
Ugali Other meat/fish Beans	4	1.80	1.67	1.41	0.58	3.16
Ugali Other veg Beans	3	1.05	1.26	0.38	0.61	.
Ugali Other veg Other	2	1.59	1.59	1.35	0.64	.
Ugali Stew Beans	9	1.12	1.08	0.77	0.24	1.83
Ugali Stew Other	9	0.84	0.90	0.46	0.42	1.14
Ugali Stew Other veg	11	0.62	0.58	0.21	0.50	0.67

The meals (food combinations) most commonly cooked are presented in Table 29[4]

Table 29 Most commonly prepared meals

Meal description	Frequency	Percent	Single fuel Frequency	Only electricity Frequency	Only LPG Frequency	Only charcoal Frequency	Median per capita electricity energy consumption (MJ/pers/meal)
Rice Beans	67		62	45	6	11	0.71
Rice Stew	71		65	44	11	10	0.52
Rice	60		56	47	7	2	0.27
Ugali Stew	63		58	34	19	5	0.57
Bananas	30		30	22	8	0	0.42
Rice Other	37		26	24	1	1	0.70
Bananas Stew	36		33	23	7	3	0.73

[4] >=2% of all meals (breakfast, lunch, dinner, or snack).

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

3.5 Cooking appliances

3.5.1 Detail on how participants cook

RICE/BEANS, RICE/STEW & UGALI/STEW WERE THE MOST COMMON MEAL COMBINATIONS.

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

- Cooking appliance 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.

The cooking appliances used to cook individual foods are presented in Table 30. Note that any single record (or meal) can contain information on up to four foods, so the table includes each separate food–appliance combination. This shows that 9% of foods were cooked with electricity in Phase 1. Table 31 shows that boiling is by far the most commonly used cooking process. Note that participants did less frying when using only electricity in Phase 2; this can also be seen in the lower use of frying pans in Table 32. Participants were more likely to use lids when cooking electricity only (see Table 33).

Table 30 Appliances used to cook foods (frequencies)

	Phase 1	Phase 2 (electric only)
Charcoal Stove	565	4
Gas stove	1224	6
Grill / oven	2	0
Electric hotplate	63	1280
Induction hotplate	3	203
Heater	0	1
Electric kettle	0	3
Electric pressure cooker	17	522
Microwave	49	84
Rice cooker	46	163
Other	28	0
Total	1997	2266

FRYING WAS LESS COMMON IN PHASE 2, PRESUMABLY BECAUSE GAS IN PARTICULAR, OFFERS MUCH CLOSER CONTROL OF HEAT LEVELS. IT COULD ALSO HAVE BEEN DUE TO VOLTAGE DIPS, WHICH WOULD HAVE REDUCED STOVE POWER OUTPUT & SLOWED DOWN FRYING CONSIDERABLY.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 31 Cooking processes used to cook foods (frequencies)

	Phase 1	Phase 2 (electric only)
Fry	340	237
Boil	1548	1627
Grill	0	0
Steam	0	4
Bake	5	6
Microwave	49	78
Pressure cook	21	262
Other	2	0
Total	1965	2214

Table 32 Utensils used to cook foods (frequencies)

	Phase 1	Phase 2 (electric only)
Bowl / plate	48	109
Frying pan	187	94
Kettle	1	1
Pot big	129	43
Pot medium	944	818
Pot small	686	597
Other	2	1
Total	1997	1663

Table 33 Use of lid when cooking foods (frequencies)

	Phase 1	Phase 2 (electric only)
No	686	472
Some	224	331
Yes	1089	1453
Total	1999	2256

ALTHOUGH MANY PARTICIPANTS ALREADY OWNED ELECTRIC COOKING APPLIANCES BEFORE THE STUDY, THEY WERE RARELY USED. COOKING RICE IN A RICE COOKER WAS THE ONLY SUBSTANTIAL USE OF ELECTICITY FOR COOKING AMONGST PARTICIPANTS IN PHASE 1.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and

3.5.2 Characteristics of different cooking devices

Given that equal numbers of participants had access to LPG and charcoal (Table 9), it can be assumed that differences in the choice of devices used to cook foods reflect choice (rather than availability). Table 34 shows that, in Phase 1, participants preferred to cook most foods using LPG, with the exception of rice. Rice is also the only food that participants commonly used electrical devices to cook in Phase 1. There appears to be a strong preference to cook some foods using gas (e.g. eggs, bananas, Other (mostly porridge)), whereas opinion is more balanced for other foods (e.g. ugali, stew, beans).

Table 35 shows that simple hotplates were most commonly used for all foods, but this may reflect appliances provided rather than preferences.

Table 34 Cooking devices used to cook different food types - Phase 1 (frequencies)

	Charcoal Stove	Gas stove	Grill / oven	Electric hotplate	Induction hotplate	Heater	Electric kettle	Electric pressure cooker	Microwave	Rice cooker	Other
Ugali	76	134	0	7	0	0	0	1	0	0	3
Chapati	8	29	1	0	0	0	0	0	3	0	1
Rice	100	76	0	2	0	0	0	6	9	40	0
Eggs	2	40	0	3	0	0	0	1	0	0	0
Bananas	32	123	0	13	0	0	0	0	4	0	0
Pilau	20	25	0	1	0	0	0	0	3	6	3
Chips	3	20	0	0	0	0	0	0	0	0	1
Makande	17	8	0	0	0	0	0	1	2	0	0
Meat/fish/veg stew	110	171	0	7	1	0	0	1	4	0	1
Other meat/fish	21	39	0	2	0	0	0	0	2	0	4
Other veg	53	72	0	4	1	0	0	0	0	0	0
Beans	87	110	0	4	0	0	0	0	2	0	2
Other	32	355	1	15	1	0	0	6	6	0	12

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 35 Cooking devices used to cook different food types - Phase 2 (frequencies)

	Charcoal Stove	Gas stove	Grill / oven	Electric hotplate	Induction hotplate	Heater	Electric kettle	Electric pressure cooker	Microwave	Rice cooker	Other
Ugali	0	1	0	150	10	0	0	29	2	22	0
Chapati	0	0	0	21	0	0	0	0	2	0	0
Rice	0	1	0	76	14	0	0	127	16	120	0
Eggs	0	0	0	26	10	0	0	5	0	0	0
Bananas	0	0	0	127	14	0	0	51	7	2	0
Pilau	0	0	0	24	0	0	0	20	5	4	0
Chips	0	0	0	14	1	0	0	0	0	0	0
Makande	0	0	0	5	0	0	0	13	1	0	0
Meat/fish/veg stew	1	0	0	192	37	0	1	71	7	3	0
Other meat/fish	0	0	0	23	2	0	0	4	2	1	0
Other veg	0	1	0	62	42	0	2	5	0	2	0
Beans	1	0	0	158	19	0	0	49	12	1	0
Other	2	3	0	387	54	1	0	137	10	8	0

Table 36 shows that boiling is mostly done on done on gas stoves (62% of foods boiled), but a higher proportion of frying is done on gas stoves (71% of foods fried). This is probably because foods are fried for a shorter time, and LPG can be turned on/off instantly, plus it also offers more precise temperature control.

The equivalent table for Phase 2 is not so interesting as it probably reflects the electrical devices provided to participants, but it does show that on a small number of occasions, participants tried using pressure cookers for a variety of cooking processes, notably frying (see Table 37.

Table 36 Cooking processes used with different cooking devices - Phase 1 (frequencies)

	Fry	Boil	Grill	Bake	Microwave	Pressure cook	Other
Charcoal Stove	75	456	2	3	1	1	0
Gas stove	234	944	2	1	0	16	1
Grill / oven	1	0	0	1	0	0	0

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Electric hotplate	14	48	0	0	0	0	0
Induction hotplate	1	2	0	0	0	0	0
Heater	0	0	0	0	0	0	0
Electric kettle	0	0	0	0	0	0	0
Electric pressure cooker	0	13	0	0	0	4	0
Microwave	0	1	0	0	47	0	0
Rice cooker	0	45	0	0	1	0	0
Other	6	19	1	0	0	0	1

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 37 Cooking processes used with different cooking devices - Phase 2 (frequencies)

	Fry	Boil	Grill	Steam	Bake	Microwave	Pressure cook	Other
Charcoal Stove	0	3	1	0	0	0	0	0
Gas stove	0	5	0	0	0	0	1	0
Grill / oven	0	0	0	0	0	0	0	0
Electric hotplate	180	1066	0	0	1	0	0	0
Induction hotplate	28	168	0	0	0	0	0	0
Heater	0	1	0	0	0	0	0	0
Electric kettle	3	0	0	0	0	0	0	0
Electric pressure cooker	26	218	0	2	5	0	260	0
Microwave	0	5	0	0	0	78	1	0
Rice cooker	0	161	0	2	0	0	0	0
Other	0	0	0	0	0	0	0	0

EPCs WERE PREFERED FOR DISHES THAT REQUIRE BOILING, AS PRESSURE COOKING CAN REDUCE THE TIME OF THE BOILING STAGE BY HALF. HOWEVER, AS THE DATA SHOWS, THEY CAN ALSO FRY & ARE THREFORE OFTEN REFERRED TO AS MULTICOOKERS. 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., HOWEVER THE EPC CAN ONLY OPERATE WITH THE DEEP SIDED POT IT IS SUPPLIED WITH.

3.5.3 Fuel stacking

The number of cooking appliances used in preparing each meal (or case) in Phase 1 is presented in Table 38. In only 16% of cases were more than one cooking device used. The mix of devices used to prepare these meals is given in Table 39, and suggests that participants are mixing LPG with charcoal and with electricity. These are the fuels that almost all participants used during the experiment (see Table 9).

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 38 Number of cooking devices used in preparing meals - Phase 1

		Frequency	Percent	Valid Percent
Valid	1	791	67.5	84.5
	2	139	11.9	14.9
	3	6	.5	.6
	Total	936	79.9	100.0
Missing	System	235	20.1	
Total		1171	100.0	

Table 39 Cooking devices used by participants who use multiple devices preparing single meal

Cooking device	Frequency
Charcoal	82
Gas stove	125
Grill / over	1
Hotplate	11
Induction hob	2
Pressure cooker	7
Microwave	21
Rice cooker	40
Other	7

THE DATA ON ENERGY CONSUMPTION PER APPLIANCE IS DIFFICULT TO INTERPRET, AS ELECTRIC APPLIANCES ARE OFTEN USED FOR VERY SPECIFIC FOODS OR PROCESSES. FOR EXAMPLE, THE DATA SUGGESTS THAT MICROWAVES ARE THE MOST EFFICIENT DEVICES, HOWEVER THEY ARE LIKELY ONLY USED FOR REHATING, WHICH WE KNOW USES A FRACTION OF THE ENERGY OF COOKING FROM FRESH. IN CONTRAST, THE EPC HAS A MEDIAN ENERGY CONSUMPTION AROUND HALF THAT OF THE HOTPLATE, YET WE KNOW THAT THEY ARE MOST COMMONLY USED TO COOK THE MOST ENERGY INTENSIVE DISHSES, 'HEAVY FOODS'.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and

3.5.4 Energy used by different electrical appliances (Phase 2)

Per capita electrical energy figures in Table 40 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 35). In order to make more meaningful comparisons, the specific energy consumption for different foods and combinations are presented in Table 41.

CUTTING THE DATA UP ONE STEP FURTHER TO DISAGGREGATE BY FUELS, THEN BY APPLIANCE EXASPERATES THE SAMPLE SIZE ISSUES EVEN FURTHER, MAKING MEANINGFUL COMPARISONS IMPOSSIBLE.

Table 40 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
Hotplate	256	1.00	0.75	0.88	0.45	1.23
Induction hob	35	0.77	0.38	1.39	0.22	0.85
Pressure cooker	129	0.59	0.44	0.54	0.21	0.78
Microwave	25	0.27	0.12	0.48	0.05	0.31
Rice cooker	11	0.40	0.34	0.31	0.18	0.51

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 41 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
Hotplate						
Bananas Chips	2	0.56	0.56	0.04	0.53	.
Bananas Other	4	0.62	0.40	0.59	0.25	1.23
Bananas Other veg	2	0.22	0.22	0.14	0.13	.
Bananas Stew	3	0.59	0.69	0.25	0.31	.
Beans Other	4	0.87	0.88	0.40	0.48	1.25
Eggs Chips	2	0.99	0.99	1.29	0.08	.
Pilau Other	3	0.59	0.60	0.19	0.40	.
Rice Beans	4	0.62	0.26	0.74	0.24	1.36
Rice Stew	6	0.42	0.39	0.07	0.36	0.48
Stew Other	7	0.75	0.72	0.51	0.21	1.12
Ugali Beans	7	1.28	1.12	0.85	0.74	1.58
Ugali Other	9	1.51	0.94	1.44	0.62	2.48
Ugali Other veg	3	0.97	0.78	0.52	0.58	.
Ugali Stew	5	0.88	0.67	0.69	0.47	1.41
Bananas Pilau Stew	2	1.21	1.21	0.46	0.88	.
Bananas Stew Beans	2	0.62	0.62	0.25	0.44	.
Bananas Stew Other veg	3	0.69	0.68	0.27	0.43	.
Rice Stew Beans	3	2.49	1.93	2.03	0.81	.
Rice Stew Other veg	2	0.95	0.95	0.98	0.26	.
Ugali Bananas Beans	2	0.93	0.93	0.06	0.89	.
Ugali Bananas Other	4	0.99	0.91	0.42	0.63	1.42
Ugali Bananas Stew	6	0.80	0.73	0.36	0.54	1.01
Ugali Beans Other	5	1.87	1.48	1.45	0.94	3.00
Ugali Chips Other	2	1.69	1.69	0.95	1.02	.
Ugali Other meat/fish Beans	3	2.19	2.68	1.45	0.56	.
Ugali Other veg Other	2	1.59	1.59	1.35	0.64	.
Ugali Stew Beans	7	1.16	1.08	0.78	0.23	1.91
Ugali Stew Other	3	0.77	0.90	0.52	0.19	.
Ugali Stew Other veg	6	0.72	0.66	0.24	0.53	0.88

Research@gamos.org | PV-ecook.org

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Bananas	7	0.88	0.55	0.67	0.23	1.39
Other	15	0.91	0.55	1.41	0.35	0.83
Pilau	2	0.21	0.21	0.07	0.16	.
Rice	7	1.30	1.52	0.65	0.55	1.77
Stew	5	1.73	0.95	1.51	0.49	3.37
Ugali	4	0.87	0.75	0.38	0.59	1.25
Induction hob						
Bananas Stew	3	0.43	0.45	0.10	0.32	.
Rice Beans	4	0.71	0.89	0.43	0.27	0.97
Rice Other veg	2	0.20	0.20	0.03	0.18	.
Rice Stew	2	0.84	0.84	0.81	0.26	.
Ugali Other veg	3	0.38	0.28	0.27	0.17	.
Ugali Stew	2	0.81	0.81	0.55	0.42	.
Bananas	3	0.51	0.49	0.19	0.33	.
Other	3	2.90	0.25	4.59	0.24	.
Other veg	2	0.10	0.10	0.01	0.09	.
Ugali	2	0.22	0.22	0.09	0.15	.
Pressure cooker						
Bananas Stew	5	0.60	0.60	0.16	0.45	0.76
Eggs Other	6	0.57	0.42	0.58	0.13	0.99
Rice Beans	4	0.95	0.84	0.31	0.73	1.28
Rice Other	6	0.81	0.92	0.41	0.44	1.15
Rice Stew	3	0.67	0.67	0.16	0.52	.
Ugali Stew	6	0.58	0.52	0.21	0.43	0.71
Bananas Stew Other	3	0.23	0.09	0.26	0.07	.
Eggs Other veg Other	2	0.56	0.56	0.20	0.41	.
Bananas	5	0.49	0.42	0.40	0.22	0.80
Beans	2	0.90	0.90	0.62	0.47	.
Makande	4	0.39	0.39	0.21	0.20	0.58
Other	21	0.50	0.23	0.58	0.13	0.65
Pilau	5	0.45	0.26	0.42	0.16	0.85
Rice	20	0.65	0.28	0.90	0.18	0.72
Stew	4	0.48	0.47	0.12	0.38	0.60
Microwave						

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Rice Beans	5	0.71	0.29	0.98	0.19	1.44
Rice Stew	2	0.43	0.43	0.08	0.38	.
Bananas	3	0.28	0.12	0.30	0.09	.
Beans	2	0.08	0.08	0.04	0.05	.
Other	3	0.11	0.05	0.11	0.04	.
Rice	4	0.13	0.06	0.14	0.05	0.27
Rice cooker						
Rice	4	0.26	0.26	0.12	0.15	0.37

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

3.6 Time

3.6.1 Time taken to cook food types

The times taken to cook individual food types in Phase 1 are presented in Table 42 (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 – Ugali, Other meat/fish, Beans, Meat/fish/veg stew, Bananas
- About 30 mins – Chapati, Rice, Pilau, Makande
- Longer – chips.

Table 43 shows that all foods took longer to cook with electricity under Phase 2. It also appears that the distinction between the 20 minute and the 30 minute groups of foods disappears, leaving all foods taking around 30 minutes (except the Quick and Longer groups).

Table 42 Time taken to cook food types – Phase 1 (minutes)

Food	N	Mean	Median	SD	25% Quartile	75% Quartile
Eggs	46	9.3	5.5	8.5	4	10.5
Other veg	133	14.1	11.0	12.1	7	20
Ugali	225	23.2	20.0	13.4	15	30
Other meat/fish	72	24.2	20.0	18.3	10	30
Beans	204	33.2	20.0	42.4	10	30
Meat/fish/veg stew	296	28.7	22.5	24.0	10	40
Bananas	173	27.7	24.0	22.0	11	35
Chapati	42	34.3	30.0	29.9	9.5	52.5
Rice	232	31.4	30.0	19.5	20	44.75
Pilau	58	34.7	30.0	30.7	10	46.25
Makande	29	74.0	30.0	81.7	8.5	120
Chips	24	49.7	42.5	38.9	20	60

GROUPING THE DISHES SOLELY BY TIME REVEALS THAT 'HEAVY FOODS' SUCH AS BEANS & MAKANDE DON'T ALWAYS TAKE A LONG TIME TO COOK. IN FACT, THEY ACTUALLY BECOME MORE LIKE STAPLES WHEN THEY HAVE BEEN PRE-COOKED. PRE-COOKING IS AN IMPORTANT ENERGY & TIME-SAVING PRACTICE THAT INVOLVES BATCH-COOKING CEREALS (& SOMETIMES TOUGHER CUTS OF MEAT), THEN STORING THEM. AT A LATER TIME, A SAUCE IS USUALLY PREPARED, THEN THE PRE-COOKED FOOD SIMPLY MIXED IN & HEATED THROUGH.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 43 Time taken to cook food types – Phase 2 (minutes)

Food	N	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Eggs	41	16.5	14.0	10.6	10	20
Other veg	113	20.7	15.0	19.2	9.5	25
Other meat/fish	32	27.7	25.5	14.5	18	40
Pilau	53	33.7	28.0	26.7	14	44.5
Ugali	214	33.2	30.0	17.7	20	41
Chapati	23	42.3	30.0	40.0	15	58
Rice	349	30.1	30.0	15.5	20	38
Bananas	200	32.1	30.0	21.0	16	45
Chips	15	35.0	30.0	18.4	19	60
Meat/fish/veg stew	309	30.9	30.0	20.9	16	40
Beans	238	41.0	30.0	41.2	17	58
Makande	19	74.3	55.0	80.4	18	70

3.6.2 Time taken to prepare meal

The times taken to prepare lunches and dinners were similar, and breakfasts took less time (Table 44). Over 90% of lunches and dinners in Phase 1 were prepared within 2.5 hours (150 minutes), whereas most breakfasts were prepared within around 1.5 hours – see Figure 20.

Table 44 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	191	56.3	52	34.2	29	80
Lunch	252	73.0	64	51.5	32	102
Dinner	269	73.9	63	49.0	35	108
Water heating	254	74.6	69	45.7	40	99

IN CONTROLLED COOKING TESTS, EPCS CAN COOK 'HEAVY FOODS' LIKE BEANS IN HALF THE TIME. HOWEVER, THE COOKING DIARIES DATASET SHOWED THAT COOKING TIMES ACTUALLY INCREASED WHEN SWITCHING TO ELECTRICITY. THIS COULD BE BECAUSE OF UNFAMILIARITY WITH THE DEVICES (E.G. DEPRESSURISING TOO EARLY & HAVING TO REPRESSURISE) OR BROWNOUTS CAUSING THE COOKERS TO SLOW DOWN, FURTHER INVESTIGATION IS NEEDED TO UNDERSTAND WHY.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

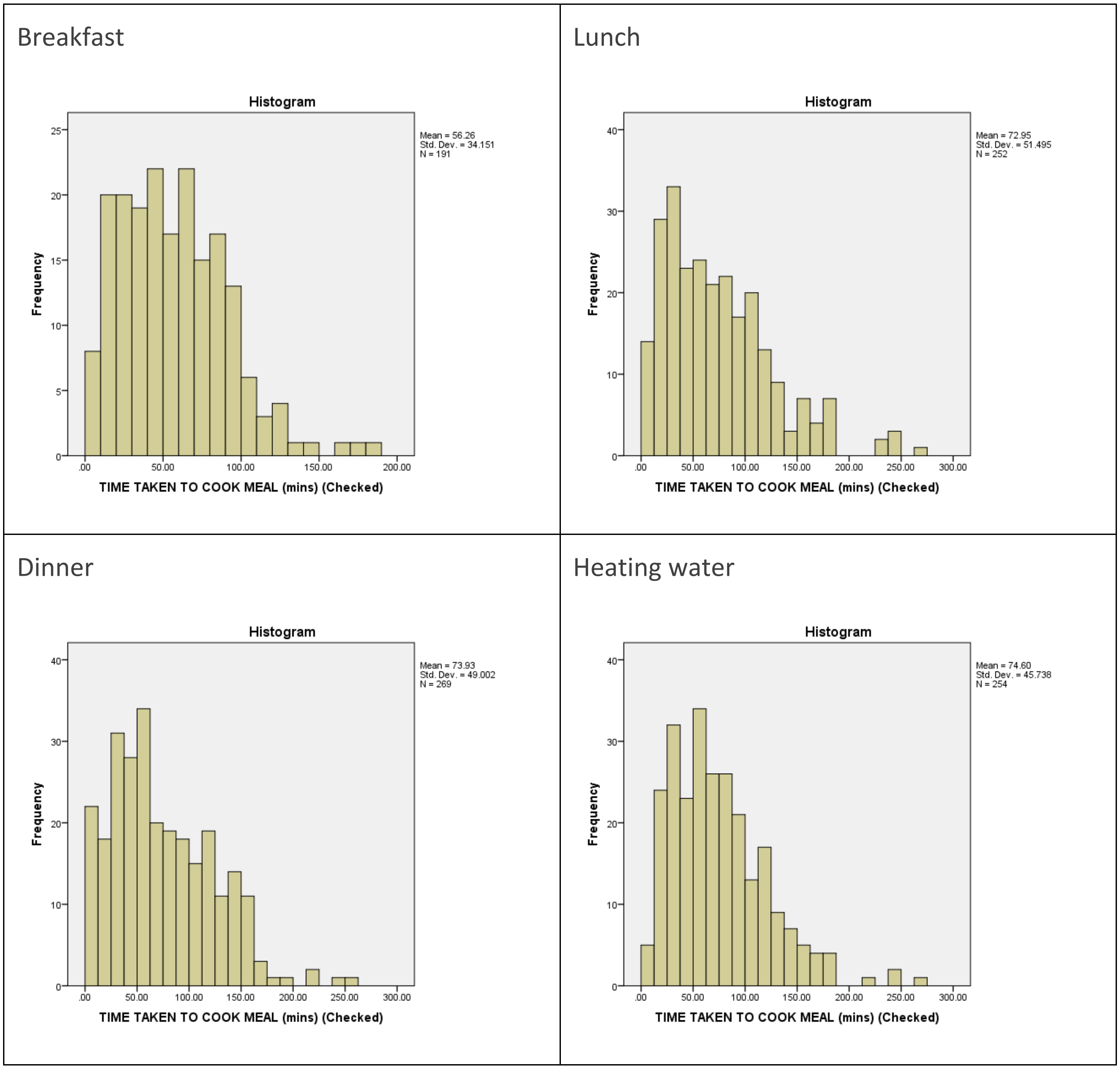


Figure 20 Distributions of durations of heating events (minutes) – Phase 1

Despite the finding that the time taken to cook individual foods took longer when cooking with electricity, the total time taken to prepare meals in Phase 2 was only slightly longer (see Table 45). Breakfasts took 8-10 minutes longer, lunches took about the same time, dinners took 5-10 minutes longer, and water heating took 2-4 minutes longer.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 45 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	247	65.9	60	37.2	40	89
Lunch	297	72.2	60	46.8	40	94
Dinner	295	78.7	73	47.0	44	110
Water heating	320	78.9	71	43.7	46	105

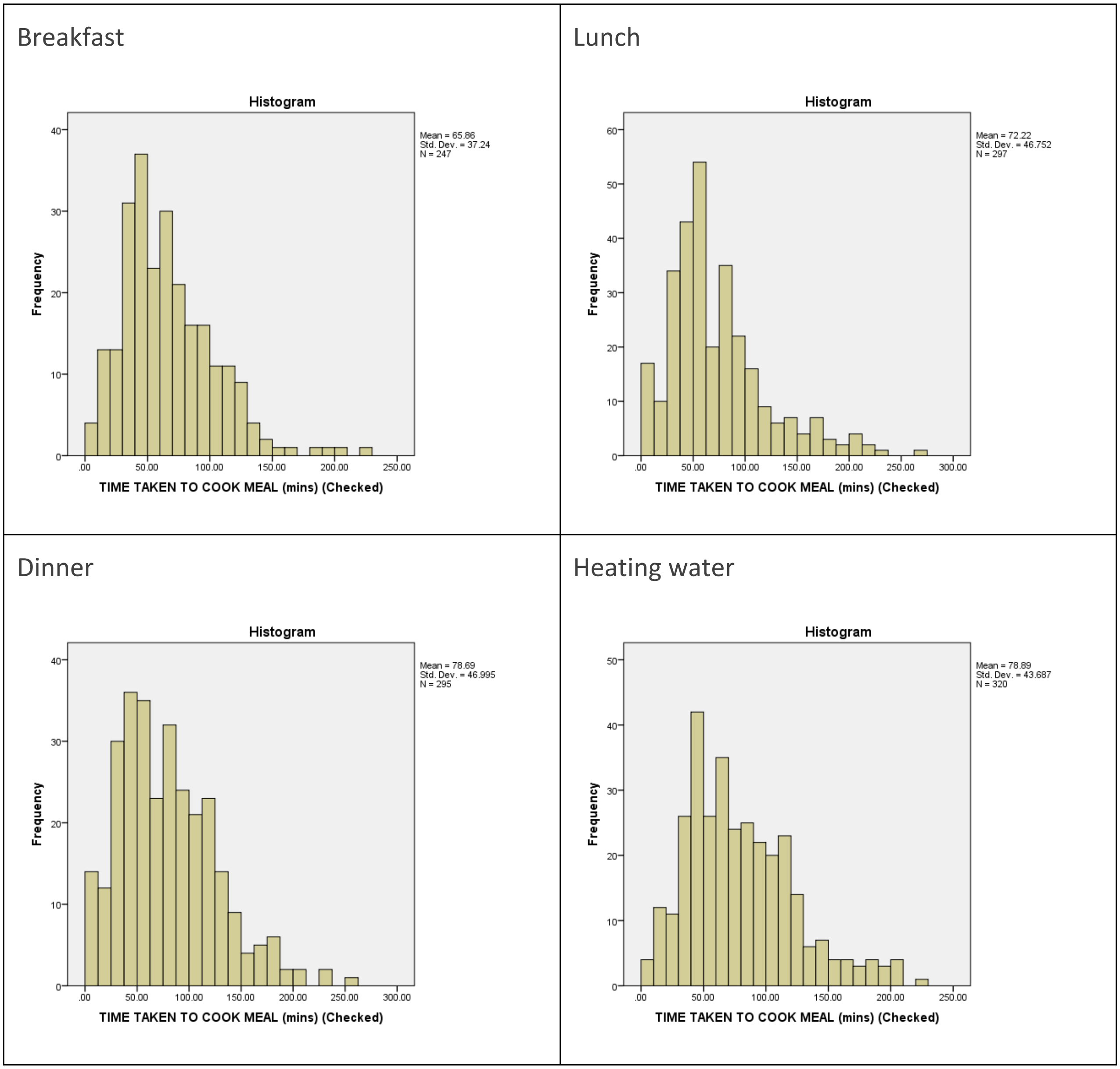


Figure 21 Distributions of durations of heating events (minutes) – Phase 2

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

3.6.3 Time of day

Table 46 Time of day to start preparing meal –Phase 1 (multiple fuels)

Heating event	N	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast	351	7.21	7.03	1.31	6.15	8.16
Lunch	323	12.31	12.30	1.39	11.59	13.10
Dinner	353	18.31	18.30	1.30	17.49	19.30

Water heating has two peak times of the day – morning (roughly 6.00 to 7.00) and evening (17.00 to 19.00) – see Figure 22

Table 47 Time of day to start preparing meal –Phase 2 (electricity only)

Heating event	N	Mean	Median	Std.dev.	25% Quartile	75% Quartile
Breakfast	461	7.08	6.58	1.23	6.14	7.54
Lunch	398	12.22	12.30	1.25	11.49	13.10
Dinner	406	18.16	18.22	1.24	17.21	19.01

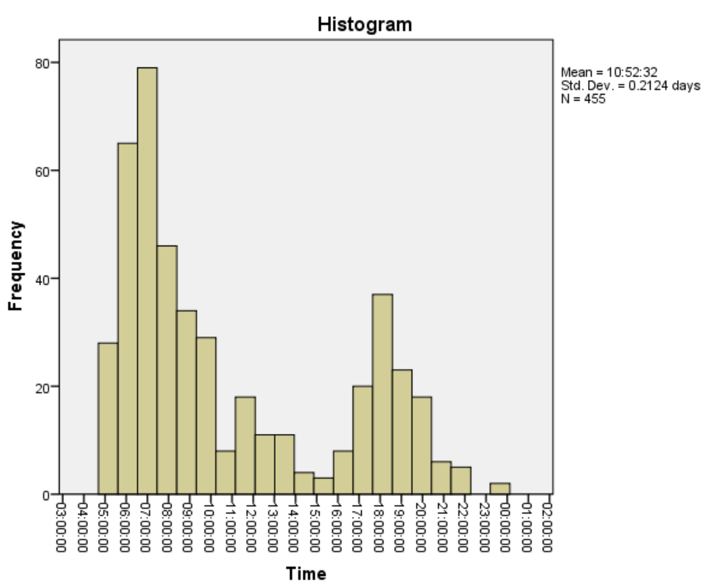


Figure 22 Time of day to start water heating (Phase 1)

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

3.7 Water heating

Water heating was usually heated for a single purpose (Table 48), and the most common use of hot water was for making hot drinks and for bathing (Table 49). Water was usually heated as part of a heating event rather than being heated on its own (heating water event) – this can be seen in Table 50, which shows that water heating most often occurred in records with multiple heating events. However, this makes it difficult to identify which heating events (e.g. breakfast, lunch etc.) most commonly involved water heating, because allocating water heating to both breakfast and lunch, for example, is effectively be double counting. Nevertheless, this approach has been taken in preparing Table 51, which indicates 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 BATHING OR TEA/COFFEE.

Table 48 Number of purposes for heated water (max 4)

		Frequency	Valid Percent
Valid	1.00	914	71.9
	2.00	281	22.1
	3.00	54	4.2
	4.00	23	1.8
	Total	1272	100.0
Missing	System	1636	
Total		2908	

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 49 Purposes for heated water

Purpose of heating water	Frequency	Percent (n=1272[5])
Purifying drinking water	208	16.4
Bathing	628	49.4
Tea / coffee	809	63.6
Other	85	6.7

Table 50 Purposes of heating water (all records)

Purpose of heating water	Number of heating events in record				Total
	1	2	3	4	
Purifying drinking water	50	135	22		207
Bathing	130	265	224	4	623
Tea / coffee	69	493	235	3	800
Other	6	52	22		80
Total					1710

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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 51 Purpose of water heating by heating events (Phases 1 and 2)

Heating event	Purify drinking	Bathing	Hot drinks	Other	Total
Breakfast	68	267	679	26	1040
Lunch	52	38	26	8	124
Dinner	73	253	90	45	461
Snack	1	21	8	1	31
Food for baby/child	24	231	236	20	511
Heating water	166	536	730	75	1507
Other	1	2	2	2	7
Total	385	1348	1771	177	3681

The energy consumption for heating water for different purposes can only be deduced from those records that pertain only to the heating of water (heating event), and only for a single purpose. This restricts the analysis to a small sub-set of cases so it has not been possible to compare energy consumptions between Phase 1 and Phase 2. Only data on per capita energy consumptions for heating water for bathing (where n>-5) are presented in Table 52.

Table 52 Per capita energy consumed by heating water for different purposes (MJ/pers/event) - Phase 2 (single use of water in water heating events only)

	Frequency	Mean (MJ/event)	Median	Std.dev.	25% Quartile	75% Quartile
Bathing Phase 2 Electricity	40	0.64	0.47	0.54	0.24	0.94

Even in Phase 1 when participants were cooking with charcoal, 11% of water heating events used electric devices. In Phase 2, most water was heated on hotplates (53%), but this probably reflects the devices provided to participants i.e. not all participants were given electric kettles.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 53 Devices used to heat water (single use of water in water heating events only)

	Phase 1	Phase 2 (electric only)
Charcoal stove	142	12
Gas stove	348	30
Electric heater		18
Microwave		2
Electric hotplate	26	388
Induction hob		85
Electric kettle	37	202
Total	553	737

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Microwave	2	.0	.1	.1
	Electric kettle	276	2.4	16.8	17.0
	Gas stove	502	4.3	30.6	47.6
	Electric hotplate	541	4.7	33.0	80.5
	Charcoal Stove	207	1.8	12.6	93.2
	Heater (geyser)	18	.2	1.1	94.3
	Induction	94	.8	5.7	100.0
	Total	1640	14.1	100.0	
Missing	System	9992	85.9		
Total		11632	100.0		

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

The utensils used to heat water for different purposes are presented in Table 54. It is interesting to note that kettles are rarely used for making hot drinks, which are mostly prepared using pots.

Table 54 Utensils used to heat water (all water heating events)

		WATERPURPOSE				Total
		Purify drinking water	Bathing	Tea / hot drinks	Other	
UTENSIL USED TO HEAT WATER	Sufuria big	125	176	19	43	363
	Sufuria medium	47	177	511	16	751
	Sufuria small	19	55	209	26	309
	Kettle	12	192	53	0	257
	Other	2	0	1	0	3
Total		205	600	793	85	1683

The majority of utensils are mostly filled with water for heating (Table 55).

Table 55 How much water is heated (all water heating events)

	Sufuria big	Sufuria medium	Sufuria small	Kettle	Other	Total
Quarter full	3	5	6	0	0	14
Half full	44	207	40	18	0	309
3/4 full	52	190	88	6	1	337
Full	225	286	142	147	1	801
Two utensils full	22	32	1	5	0	60
Four utensils full	6	5	1	2	0	14
Other	6	6	30	79	1	122
Total	358	731	308	257	3	1657

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

All utensils are usually used with a lid (Table 56). People are more likely to use a lid on small pots than on medium and large pots.

Table 56 Use of lids (all water heating events)

		UTENSIL USED TO HEAT WATER					Total
		Sufuria big	Sufuria medium	Sufuria small	Kettle	Other	
USE OF LID HEATING WATER	No	102	221	67	7	0	397
	Some	5	8	3	0	0	16
	Yes	247	499	236	248	3	1233
Total		354	728	306	255	3	1646

In one half of water heating events, an insulated flask is used to keep water hot (assumed to be for use at a later time) - Table 57. Water heated by most types of device are commonly stored in flasks, although water heated by charcoal stoves is most likely to be stored in a flask. Although this suggests that water is put on a charcoal stove when cooking, and stored for later, this is not immediately evident from Table 58. This table shows that water is heated on the embers in only one third of cases (when water is heated using charcoal). Whether water is heated on the embers or not, in 66% of cases at least some is stored in a flask.

HOT WATER IS FRQUENTLY STORED IN THERMOS FLASKS – AN IMPORTANT ENERGY-SAVING PRACTICE.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 57 Use of flask by type of water heating device (all water heating events)

		USE OF FLASK - HEATING WATER			
		No	Some	Yes	Total
DEVICE USED TO HEAT WATER	Microwave	1	1	0	2
	Electric kettle	150	110	12	272
	Gas stove	180	163	85	428
	Electric hotplate	247	195	92	534
	Charcoal Stove	69	38	86	193
	Heater (geyser)	17	0	0	17
	Induction	29	50	14	93
	Other	32	43	8	83
Total		725	600	297	1622

Table 58 Use of flask by use of residual heat in fire to heat water

		USE OF FLASK - HEATING WATER			
		No	Some	Yes	Total
HEATED WATER ON EMBERS OF FIRE - HEATING WATER	No	35	27	42	104
	Yes	21	12	28	61
Total		56	39	70	165

In 78% of water heating events, water is boiled (Table 59). 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 60 shows that gas stoves and electric hotplates are the devices that have the highest proportion of 'hot' water.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Table 59 Temperature of water used for different purposes

		TEMPERATURE OF WATER - HEATING WATER			
		Warm	Hot	Boiling	Total
WATERPURPOSE	Purify drinking water	1	4	213	218
	Bathing	83	241	303	627
	Tea / hot drinks	1	45	765	811
	Other	0	5	81	86
Total		85	295	1362	1742

Table 60 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	Microwave	0	0	2	2
	Electric kettle	8	23	243	274
	Gas stove	29	100	372	501
	Electric hotplate	29	112	399	540
	Charcoal Stove	5	21	181	207
	Heater (geyser)	11	7	0	18
	Induction	1	16	77	94
	Other	2	15	73	90
Total		85	294	1347	1726

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

The time taken to heat bathing water is similar to the time taken to boil water for hot drinks (Table 61), which implies that only modest volumes of water are used for bathing. Electric kettles, geysers, and induction hobs are used to heat water quickly (Table 62). 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. Note that induction hobs are much faster than standard electric hotplates.

Table 61 Time taken to heat water for different purposes (minutes)

WATERPURPOSE	Mean	N	Std. Deviation	Median
Purify drinking water	45.8	138	41.24608	30.0
Bathing	22.4	430	19.87545	14.0
Tea / hot drinks	24.3	618	18.00427	20.0
Other	38.8	60	21.09903	30.0
Total	26.7	1246	23.71110	20.0

Table 62 Time taken to heat water using different devices (minutes)

DEVICE USED TO HEAT WATER	Mean	N	Std. Deviation	Median
Microwave	18.0	2	16.97056	18.0
Electric kettle	16.1	217	14.54192	10.0
Gas stove	21.6	246	19.44543	15.0
Electric hotplate	32.1	507	20.29024	29.0
Charcoal Stove	43.8	81	39.53273	40.0
Heater (geyser)	10.5	16	3.46410	10.0
Induction	15.1	91	13.47974	10.0
Other	34.6	69	39.08382	22.0
Total	26.5	1229	23.58169	20.0

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

3.8 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 Rice and Ugali eCooking Challenge.

3.8.1 Responses to exit survey questions

AT THE TIME OF WRITING, EXIT SURVEY DATA HAD NOT YET BEEN PROCESSED

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

4 Evaluation

Whilst this cooking diaries study has enabled us to shed new light on what everyday Tanzanian 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 Tanzania and internationally.

4.1 LPG measurements

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.

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 Tanzanian 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 63 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.

Table 63: 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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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!

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. Some smaller cylinders come with stove-top burners (see Figure 23) 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.

Figure 23: 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).

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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 23), 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 Tanzania, notably Kopa Gas. 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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

4.2 Data limitations

4.2.1 Dish level data

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 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 in Kenya 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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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, by asking participants to spend a set periods of time cooking solely on one fuel. 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

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

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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

in the household not recording data properly or not recording during blackouts, often went undetected, resulting in data having to be corrected or excluded.

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.

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

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 Tanzania should seek to understand how different sectors of society cook, in particular poorer households and rural households, and identify regional differences in cooking.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

5 Conclusion

The cooking diaries study in Tanzania has shown that cooking with electricity is compatible with Tanzanian cuisine and that modern energy-efficient appliances are highly desirable to everyday Tanzanian 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: 'heavy foods'. In fact, in some areas of Dar es Salaam, the grid is already strong enough for direct AC cooking, meaning there is an opportunity already on the table to promote off-the-shelf appliances, in particular, EPCs. However, battery-supported appliances are likely to make electric cooking much more attractive, as blackouts and brownouts frequently caused users to revert back to their baseline fuels. LPG is already popular in Dar es Salaam 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 Tanzania 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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

6 Appendix

6.1 Appendix A: Problem statement and background to Innovate 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[6] 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

[6] 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)

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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 24 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[7] (Batchelor 2015b; Brown & Sumanik-Leary 2015; Leach & 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 energy needs, technology performance, component costs). There is uncertainty in many of the

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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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.

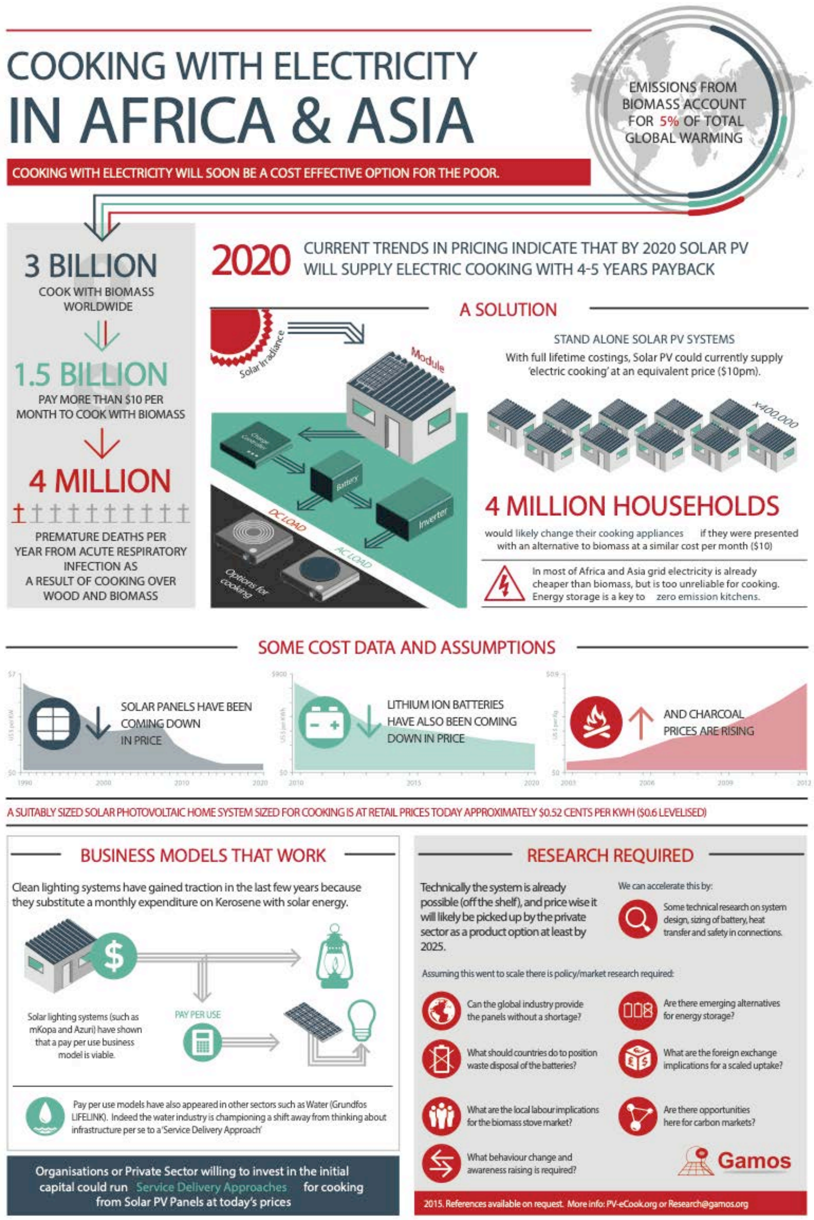


Figure 24 Infographic summarising the concept in order to lobby research and policy actors.

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 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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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.

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[8]. 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[9]. Women and children are disproportionally affected by health impacts and bear much of the burden of collecting firewood or other traditional fuels.

Greenhouse gas emissions from non-renewable wood fuels alone total a gigaton of CO_2e per year (1.9-2.3% of global emissions)[10]. 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

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

[9] 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

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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

warming globally – residential solid fuel burning accounts for up to 25 percent of global black carbon emissions[11]. 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[12].

Africa's cities are growing – another Nigeria will be added to the continent's total urban population by 2025[13] 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[14]. 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 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.

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

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

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

[14] 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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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[15]. 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[16], 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.

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

---

[15] 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.

[16] 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."

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

consumers. Figure 25 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.

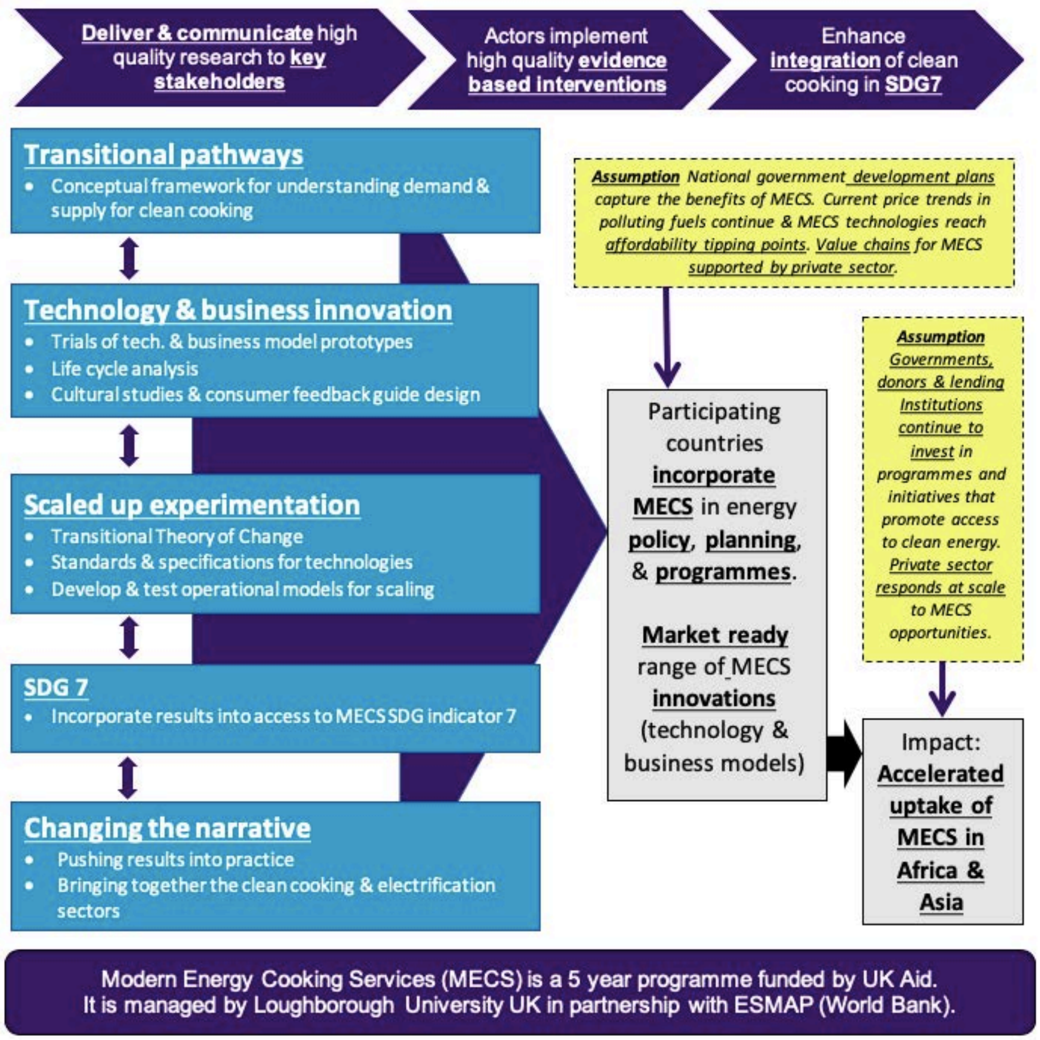


Figure 25: Overview of the MECS programme.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and 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 Tanzanian Traditional Energy Development Organisation (TaTEDO). We are doing a project with Loughborough University and 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 hob, 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 Loughborough University's Ethical Advisory Committee. 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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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 Tanzania, 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.

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, charcoal or a mixture.

6.2.2.2 What to take to each household

- Clipboard & 2x pens
- 2x energy meters
- 2x plug adaptors (1x 3 pin square to 2 pin round, 1x multiplug to 3 pin square)
- Printed forms:
    - 1x registration form
    - 5x meal/water heating form
    - 1x daily summary form
    - 1x notepad form
- Tape measure
- Solid fuel or gas users: digital weighing scale
- Gas users: small cylinder, regulator and hose clip

6.2.2.3 Registration process

Complete consent form and registration survey

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

- 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

Talk through cooking diary forms:

- Meal/water heating form:
  - 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 form
  - 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 meal/water heating 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
    - Readings must be taken BEFORE cooking appliances are turned on and AFTER they are turned off
- 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, have a stand made.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

- 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.
-

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.

6.2.3 Cooking Diaries Registration Form

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: ______________

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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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)

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-detatched 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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

☐ 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 you cook?

    ☐ 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.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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		No. ……….	

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

			☐ Occasionally ☐ Never		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) ………………………	
			☐ 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?	**Diameter (cm) and Height (cm) OR Volume (litres)**

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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 (TZS)?				

All households:

- How often do you usually buy electricity units? ________________
- When you buy electricity units, how much do you normally spend (TZS)? _______________
- Do you know how many units this gets you? _________________
- Are there different rates according to how many units you purchase?

Units	Rate

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

6.3 Appendix C: Cooking diary form

Jina .... Tarehe:...................... **TAFADHALI JAZA FOMU TOFAUTI KILA UNAPOPIKA AU KUCHEMSHA MAJI** Tanzania v180321

1 Ulitumia vyombo vya kupikia kupika nini? Kifungua kinywa☐ Chakula cha mchana☐ Chakula cha jioni☐ vitafunwa☐ Chakula cha mtoto☐ Kuchemsha maji☐ Mengine: ________

2 Kabla kutumia vyombo vya kupikia

2.1 Ulianza kupika saa ngapi? SAA: ____________

2.1.1 Kama unatumia umeme: Weka mita:Nambaza MITA 1: ____________ kWh, MITA 2: ____________ kWh, MITA 3: ____________ kWh

2.1.2 Kama unatumia gesi/mafuta ya taa: Uzito wa gesi/mafuta ya taa kabla kupika: Gesi: ____________kg Mafuta ya taa: ____________kg

2.1.3 Kama unatumia mkaa/kuni: Uzito wa mkaa/kuni kabla kupika: Mkaa: _______kg Kuni: ________kg Mengine ___________ : ___________kg
ilikuchukua muda gani kuwasha moto? Dakika ____________, moto ulishawashwa kabla☐

3 Wakati unapika (ama muda mfupi baada ya kupika)

3.1 Ulipikia watu wangapi? Watu wakubwa: ____________ Watoto: ____________

3.2 Ulitenga vyakula vyovyote ambavyo hukuvipika? Hapana ☐ Ndio, vingine havikuhitaji kupikwa(kama mkate, matunda) Ni vitu gani haswa? ____________.
Ndio,nilipika vyakula vingine mapema na sikupasha moto?__________. Ndio, nilinuanua/nilipewa vyakula ambavyo vilikuwa vimepikwa? ____________.

3.3 Ulitayarisha vyakula vya kutumia baadaye? Hapana☐ Ndio☐ Baadhi☐

	3.4 Je, ulipika vyakula vyovyote? Tafadhali tumia mstari mmoja kwa kila chakula kisha ujaze sehemu zote kuhusu hicho chakula	Ujazo kwa mfano (1/2 kuku, vikombe 2, kilo 1)	Vyombo vya kupikia? Tafadhali chagua vyote vinavyofaa	Je, ulitumia vyombo tofauti (sufuria,sahani,chungu)? Tafadhali chagua vyote vinavyofaa:		Freshi au vyakula vya kupasha moto?	Njia ya kupika? Tafadhali chagua njia zote ulizotumia	Muda wa kupika
CHAKULA 1	Ugali☐ Chapati☐ Pilau☐ Wali☐ Mayai☐ Ndizi☐ Chips☐ Makande☐ Maharage☐ Nyama/Samak/Mboga Mchuzi☐ Nyama nyingine/Samaki☐ Mboga nyingine☐ Vingine____________		Jiko la mkaa☐ Jiko la gesi☐ Oveni☐ Jiko la umeme☐ Induction hotplate☐ Birika la umeme☐ Rice cooker☐ Electric pressure cooker☐ Microwave☐ Heater☐ Vingine ______________	Sufuria: kubwa☐ / kati☐ / dogo☐. Bakuli/sahani☐ Kikaangio☐ Birika☐ Vingine__________	*Je, ulifunika?* Hapana☐ Ndio☐ Ulifunika kwa muda☐	Freshi☐ Kupasha ☐	Kaanga☐ Kuoka☐ Chemsha☐ Choma☐ Microwave☐ Mvuke☐ Pressure cooking☐ Nyngine________	Masaa ____ Dakika ____
CHAKULA 2	Ugali☐ Chapati☐ Pilau☐ Wali☐ Mayai☐ Ndizi☐ Chips☐ Makande☐ Maharage☐ Nyama/Samak/Mboga Mchuzi☐ Nyama nyingine/Samaki☐ Mboga nyingine☐ Vingine____________		Jiko la mkaa☐ Jiko la gesi☐ Oveni☐ Jiko la umeme☐ Induction hotplate☐ Birika la umeme☐ Rice cooker☐ Electric pressure cooker☐ Microwave☐ Heater☐ Vingine ______________	Sufuria: kubwa☐ / kati☐ / dogo☐. Bakuli/sahani☐ Kikaangio☐ Birika☐ Vingine__________	*Je, ulifunika?* Hapana☐ Ndio☐ Ulifunika kwa muda☐	Freshi☐ Kupasha ☐	Kaanga☐ Kuoka☐ Chemsha☐ Choma☐ Microwave☐ Mvuke☐ Pressure cooking☐ Nyngine________	Masaa ____ Dakika ____
CHAKULA 3	Ugali☐ Chapati☐ Pilau☐ Wali☐ Mayai☐ Ndizi☐ Chips☐ Makande☐ Maharage☐ Nyama/Samak/Mboga Mchuzi☐ Nyama nyingine/Samaki☐ Mboga nyingine☐ Vingine____________		Jiko la mkaa☐ Jiko la gesi☐ Oveni☐ Jiko la umeme☐ Induction hotplate☐ Birika la umeme☐ Rice cooker☐ Electric pressure cooker☐ Microwave☐ Heater☐ Vingine ______________	Sufuria: kubwa☐ / kati☐ / dogo☐. Bakuli/sahani☐ Kikaangio☐ Birika☐ Vingine__________	*Je, ulifunika?* Hapana☐ Ndio☐ Ulifunika kwa muda☐	Freshi☐ Kupasha ☐	Kaanga☐ Kuoka☐ Chemsha☐ Choma☐ Microwave☐ Mvuke☐ Pressure cooking☐ Nyngine________	Masaa ____ Dakika ____

Kwa maelezo zaidi, maoni au malalamiko, wasilianana: shimasago@gmail.com sawe_en@yahoo.com, jon.k.leary@gmail.com au mkuu wa Utafiti, Dr. Ed Brown, E.D.Brown@lboro.ac.uk
Kwa maelezo zaidi juu ya utafiti huu unapatikana katika tovuti : www.PV-eCook.org
Huu utafiti umedhaminiwa na DfID/UK kupitia msaada wa kuvumbua nishati kichocheo ya Uingereza

Jina .... Tarehe:...................... **TAFADHALI JAZA FOMU TOFAUTI KILA UNAPOPIKA AU KUCHEMSHA MAJI** Tanzania v180321

3.5 Je,ulichemsha maji? Tafadhali jaza sababu na ujazo sehemu zote	Njia unazotumia?	Ulitumia sufuria la ujazo gani?		Je,ilijaa kwa ujazo gani?	Kiasi cha joto cha maji?	Je,uliweza kuyatunza kwenye thermos kwa ajili ya matumizi ya baadaye?	Muda wa kuchemsha	**Kama unatumia mkaa, je ulitumia mpaka ukazima?**
Kuoga ☐	Jiko la mkaa ☐ Jika la gesi ☐ Heater ☐ Microwave ☐ Birika la umeme ☐ Jiko la umeme ☐ Induction hotplate ☐ Vingine________	Sufuria: kubwa ☐ / kati ☐ / dogo ☐ Birika ☐ Vingine________	*Je,ulifunika?* Hapana ☐ Ndio ☐ Wakati mwingine ☐	¼ ☐ ½ ☐ ¾ ☐ Kamili ☐ 2x ☐ 4x ☐ Vinginevyo______	Joto ☐ Moto ☐ Yaliyochemka ☐	Hapana ☐ Kiasi ☐ Yote ☐	Masaa _____ Dakika _____	Ndio ☐ Hapana ☐
Maji ya kunywa ☐	Jiko la mkaa ☐ Jika la gesi ☐ Heater ☐ Microwave ☐ Birika la umeme ☐ Jiko la umeme ☐ Induction hotplate ☐ Vingine________	Sufuria: kubwa ☐ / kati ☐ / dogo ☐ Birika ☐ Vingine________	*Je,ulifunika?* Hapana ☐ Ndio ☐ Wakati mwingine ☐	¼ ☐ ½ ☐ ¾ ☐ Kamili ☐ 2x ☐ 4x ☐ Vinginevyo______	Joto ☐ Moto ☐ Yaliyochemka ☐	Hapana ☐ Kiasi ☐ Yote ☐	Masaa _____ Dakika _____	Ndio ☐ Hapana ☐
Chai/kahawa/ kakao/Milo ☐	Jiko la mkaa ☐ Jika la gesi ☐ Heater ☐ Microwave ☐ Birika la umeme ☐ Jiko la umeme ☐ Induction hotplate ☐ Vingine________	Sufuria: kubwa ☐ / kati ☐ / dogo ☐ Birika ☐ Vingine________	*Je,ulifunika?* Hapana ☐ Ndio ☐ Wakati mwingine ☐	¼ ☐ ½ ☐ ¾ ☐ Kamili ☐ 2x ☐ 4x ☐ Vinginevyo______	Joto ☐ Moto ☐ Yaliyochemka ☐	Hapana ☐ Kiasi ☐ Yote ☐	Masaa _____ Dakika _____	Ndio ☐ Hapana ☐
Kwa matumizi mengine______ ___	Jiko la mkaa ☐ Jika la gesi ☐ Heater ☐ Microwave ☐ Birika la umeme ☐ Jiko la umeme ☐ Induction hotplate ☐ Vingine________	Sufuria: kubwa ☐ / kati ☐ / dogo ☐ Birika ☐ Vingine________	*Je,ulifunika?* Hapana ☐ Ndio ☐ Wakati mwingine ☐	¼ ☐ ½ ☐ ¾ ☐ Kamili ☐ 2x ☐ 4x ☐ Vinginevyo______	Joto ☐ Moto ☐ Yaliyochemka ☐	Hapana ☐ Kiasi ☐ Yote ☐	Masaa _____ Dakika _____	Ndio ☐ Hapana ☐

4	**Baada ya kutumia vifaa vya kupikia**	
4.1	**Ulimaliza kupika saa ngapi?** SAA:____________	
4.2	**Kama unatumia umeme:**	**Weka mita: Namba za MITA 1:** ____________ kWh, **MITA 2:** ____________ kWh, **MITA 3:** ____________ kWh
4.3	**Kama unatumia gesi/mafuta ya taa:**	Uzito wa gesi/mafuta ya taa baada ya kupika: Gesi: ____________kg Mafuta ya taa: ____________kg
4.4	**Kama unatumia mkaa au kuni:**	Uzito wa mkaa/kuni baada ya kupika: Mkaa: ________kg Kuni: ________kg Mengine: ____________kg Je,uliacha moto uwake mpaka uwe jivu ? ndio ☐ hapana ☐, nilihifadhi kwa matumizi ya baadaye ☐
4.5	**Mambo yaliyojitokeza?** (je,uliunguza chakula? je,moto ulichukua muda kuwaka kuliko kawaida?Je, marafiki walikutembelea? Je umeme ulikatika siku mzima?) kama ndiyo toa maelezo	____________ ____________ ____________

Kwa maelezo zaidi, maoni au malalamiko, wasilianana: shimasago@gmail.com sawe_en@yahoo.com, jon.k.leary@gmail.com au mkuu wa Utafiti, Dr. Ed Brown, E.D.Brown@lboro.ac.uk

Kwa maelezo zaidi juu ya utafiti huu unapatikana katika tovuti : www.PV-eCook.org

Huu utafiti umedhaminiwa na DfID/UK kupitia msaada wa kuvumbua nishati kichocheo ya Uingereza

6.4 Appendix D: Cooking diaries exit survey

COOKING DIARY TANZANIA - EXIT INTERVIEW

Please remember to take with you:

- This form
- A pen
- A clipboard
- An energy meter (in case theirs is broken)
- A measuring jug (for rice & water measurements)
- Unga
- Rice

Please remember to collect:

- All energy meters
- Hanging scales
- Hanging stand
- LPG cylinder & regulator
- Any completed forms

Name: __________________________ HH ID:_________________Date: _______________ Location:______________

Which fuel/s did you cook with before the survey?………………………………………………………………………………………………

	Had you ever tried cooking with an ecooker before this study?	Which ecookers did you already own?	Which ecookers did you start using as part of this study?
Hotplate			
Therma-pot			
Kettle			
Rice cooker			
Stove-top pressure cooker			
Electric pressure cooker			

Induction stove			

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.

Rice and Ugali eCooking Challenge

I would like to ask that you prepare rice and ugali for the Rice & Ugali eCooking Challenge I had informed you about some weeks back. The competition is judged solely on energy use, so as long as the rice & ugali are judged by the enumerator/s to be as tasty as they expect rice & ugali to be, then the winning household is simply the one that uses the lowest number of units to cook rice with ½kg dry rice and ugali with 2 litres of water. You are permitted to use our rice and unga or to use your own.

There will be a prize for the Rice and Ugali 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 rice/unga?

Rice:……

………

Ugali:………

………

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

Rice:……

………

Ugali:………

………

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

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Rice:………

……

Ugali:……

……

Do you use the same technique to cook rice/ugali 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 rice/unga you buy?

Rice:………

……

Ugali:……

……

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

Rice:………

……

Ugali:……

……

Rice

Total units used to cook rice with ½kg dry rice: ________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)

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

……

……

……

……

By observation, please note the energy saving/wasting practices they 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%☐

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

- 25--50% ☐
- 50-75% ☐
- Above 75% ☐

3. Did they add any other ingredients? No☐ Yes – if so, what? ________________
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:
      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? ________
5. Did they soak the rice before cooking? No☐ Yes – if so, for how long? __________ and what temperature was the water? _____________
6. Did they rinse the rice before cooking? No☐ Yes – if so, how many times? _________ and what temperature was the water? _____________
7. Did they pour out any water during the cooking process? No☐ Yes - if so, why? ______________
8. 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? _______
9. Did they fry at all? No☐ Yes - if so, for how many minutes? ____
10. Which variety of rice did they use? ___________
    a) Did they choose a special variety of rice because they know it cooks quickly? No☐ Yes☐
11. 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
12. ☐ Other/s. Please describe
    ____
    ____
    __

Ugali

Total units used to cook ugali with 2 litres of water: ________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)

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

……

……

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

………

………

By observation, please note the energy saving/wasting practices they 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, what? _________________
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:

      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? ________
5. 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? _______
6. Did they fry at all? No☐ Yes - if so, for how many minutes? ____
7. Which variety of unga did they use? ___________
   c) Did they choose a special variety of unga because they know it cooks quickly? No☐ Yes☐
8. 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
9. ☐ Other/s. Please describe

   ____

   ____

   __

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Your experience of cooking with electricity

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

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

	Hotplate					Therma-pot					Kettle					Rice cooker					Electric pressure cooker					Induction stove					
QUESTION	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Comment
It was easy to control heat																															
Ecooker could cook fast enough																															
Long cooking dishes were cooked much faster																															
Ecooker was hot enough																															
Ecooker burnt the food																															
My pots didn't fit on the ecooker																															
Rice/ugali cooked on electric stoves just didn't taste the same																															
Food cooked using the ecooker tasted																															

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

better than usual																															
I missed the smokey flavor of food																															
Pots were unstable on electric stoves																															
The ecooker didn't make the pots dirty																															
The ecooker looked good in my kitchen																															
There is nowhere to put the ecooker																															
Operating the ecooker was easy																															
Ecooker was safe to use																															
I prefer to use an electric kettle for water boiling																															

2. How many hobs (rings) or separate appliances do you need for cooking?

   [ ] 1 [ ] 2 [ ] 3 [ ] 4

3. What were the best things about cooking with electricity?

   ……

   ……

   ……

   ……

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

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

………
………
………
………

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

………
………
………
………

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

………
………
………
………

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

………
………
………
………

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

………
………
………
………

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

………
………
………
………
………………………………

10. Do you think electric cooking is affordable?

………
………
………

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

……
………………………………

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

……

……

……

……

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

……

……

……

………

13. 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)

Induction Stove ………
……

Hotplate……
……

Kettle………
……

Rice cooker………
……

Therma-Pot ………
……

Pressure cooker………
……

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

Induction Stove ………
……

Hotplate……
……

Kettle………
……

Rice cooker………
……

Therma-Pot ………
……

Research@gamos.org | PV-ecook.org

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Pressure cooker………
……

15. Would people need training on how to use an ecooker, or would they be able to learn by themselves?

Induction Stove ………
……

Hotplate……
……

Kettle………
……

Rice cooker………
……

Therma-Pot ……
……

Pressure cooker………
……

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

……
……
……
……

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

Induction Stove ………
……

Hotplate……
……

Kettle………
……

Rice cooker………
……

Therma-Pot ……
……

Pressure cooker………
……

18. 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?

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

Induction Stove ………
………

Hotplate……
………

Kettle………
………

Rice cooker………
………

Therma-Pot ……
………

Pressure cooker………
………

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

19. 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 (TZS)?

Induction Stove ……
……

Hotplate………
……

Kettle……
……

Rice cooker……
……

Therma-Pot ………
……

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.

20. 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?

……
……
……
……….

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

……
……
……
……….

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

How you feel about the survey

22. In the table below, please give us you 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 (induction stove)					
Choice of appliance to trial (pressure cooker)					
Choice of appliance to trial (rice cooker)					
Choice of appliance to trial (therma-pot)					
Choice of appliance to trial (kettle)					
Choice of appliance to trial (hotplate)					
Training on how to use induction stove					
Training on how to use pressure cooker					
Training on how to use rice cooker					
Training on how to use therma-pot					
Training on how to use kettle					
Training on how to use hotplate					
Relevance of questions					
Duration of survey					

23. When you were approached to be part of the electric cooking survey were you hesitant? Has it been different to what you expected?

……
……
……

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

………
……………………………………

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

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

26. Were the enumerator's visits helpful or did you feel it was too much or too little?

………

………

………

………

27. If we were to do another similar survey in the future would you be willing to be part of it?

………

END OF SURVEY

Thank the household for participating in the survey and the Rice and Ugali eCooking Challenge.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.

This research is funded by DfID/UK Aid and Gamos through the Innovate UK Energy Catalyst and the MECS programme.