# eCook Tanzania Discrete Choice Modelling

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# 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.

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# Executive Summary

This report presents the key learning points from the Discrete Choice Modelling (DCM) survey 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, how they aspire to cook and how compatible this is with battery-supported electricity.

The study has highlighted several opportunities and challenges for future eCook product/service designers. Blackouts and brownouts (voltage dips) seem to be infrequent enough that direct AC electric cooking could be possible for many people. However, electricity is barely used for cooking in Tanzania today, with charcoal and LPG dominating the cooking landscape in urban areas. In rural areas, wood and charcoal dominate. Electricity is perceived as expensive for cooking – given the low prices of cooking fuels, this is not surprising. However the evidence from the cooking diaries shows that cooking with energy-efficient electric cooking appliances is significantly cheaper, indicating that changing this perception will be key to unlocking eCook's potential in Tanzania. In particular, Electric Pressure Cookers (EPCs) seem well matched with Tanzanian consumer preferences, as they can boil & fry, with the boiling part roughly twice as fast as conventional pots.

## 1.1 Methodology

The primary purpose of the Discrete Choice Modelling surveys was to explore people's preferences regarding various aspects of the design and functionality of cooking devices. The survey has also been used to gather valuable data on cooking practices (e.g. the mix of fuels used and the timing of meals), and the quality of electricity supplies. Data on expenditure on cooking fuels is especially useful as this represents disposable income that can be substituted for modern fuel devices.

The surveys were carried out by TaTEDO, who coordinated a team of enumerators to conduct face to face interviews and responses were recorded using the Kobo Collect Android application on a tablet.

Choice models are set up using choice cards, which force the respondent to choose one of the two cards presented. The results provide an understanding of the strength of preference for each attribute, reflecting how important it is in decision making.

## 1.2 Overview of sample

The sample was heavily weighted towards urban participants from Dar es Salaam, but around ¼ were from a single rural town, Kibindu. The sample was female biased, but this is not surprising, as there was


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no cash incentive offered & the focus on cooking likely attracted more female respondents. The mean household size was found to be 4.9 (including children).

## 1.3 Quality of grid electricity

Roughly ¾ of respondents were connected to the national grid, whilst 1/8 were without access to electricity. 1/16 were connected to TaTEDO's solar/biomass hybrid mini-grid in Kibindu.

Blackout patterns were different during load shedding and at other times. Although the frequency of blackouts in both instances was similar, with most occurring once or twice a week, blackouts due to load shedding lasted much longer, typically about a day, compared with 1 or 2 hours for other blackouts

Nearly 80% of grid-connected respondents reported that the voltage is always high enough for cooking with electricity, however as only 5% of respondents actually cook with electricity, it is unclear whether this assessment is from practical experience or speculative.

Participants report that load shedding is most frequent from December to May, however, it is unclear why this is.

## 1.4 Metering

All households with formal connections to the national grid have pre-paid meters. This creates a much more direct link between expenditures & cooking practices, meaning that people are much more likely to be aware of the difference in cost between efficient & inefficient appliances.

However, half the sample (54%) share a meter. This is problematic because these are likely to be the poorest consumers, but by aggregating their bills, they only receive a single lifeline tariff allowance. What is more, it is much more difficult for them to see the cost difference for cooking with energy-efficient appliances. The evidence from the focus groups shows that some landlords/ladies simply prohibit their tenants from cooking with electricity on the presumption that it is too expensive.

It is possible to top up your electricity meter with just enough units to cook a single meal, i.e. in the same way that many people pay for charcoal. However, nobody reported actually doing this. Most respondents (92%) reported topping up their electricity meter every 2-4 weeks. This means there is likely to be a disconnect between what people spend on electricity & their cooking practices, as changing the way you cook won't have an effect on how much you are spending for several weeks.


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## 1.5 Cultural cooking patterns

3 meals per day is the most common cooking pattern, with 55% of respondents always cooking 3 & 90% sometimes doing so. 77% always cook at least 2. Breakfast is typically prepared from 7:30, lunch at 12:30 & dinner at 19:15. Respondents spend an average of 3.3 hours/day cooking.

Coastal Tanzania's hot climate means that only 23% of participants heat water for bathing, however 54% heat it to purify it & 99% heat it for tea/coffee.

## 1.6 Gender

Unsurprisingly, participants reported that women are usually responsible for cooking (72%), however, in 3% of households, men do the majority of cooking & in 25% it is a shared responsibility, indicating that marketing ecook products & services to men is also important. In fact, the evidence from the focus groups suggests that appliances such as electric pressure cookers (EPCs) can make cooking much easier, which may encourage more men to cook.

Responses suggest that purchasing decisions are generally made together, both for cooking & power generation equipment.

## 1.7 Fuel stacking

Most households used multiple fuels for cooking (58%). Charcoal was the most common cooking fuel (70%), followed by LPG (50%) & wood (25%). Electricity (6%)& kerosene (16%) were used by some households as backup fuels.

Of the 94% of respondents who did not use electricity for cooking, only 36% had some prior experience of cooking with electricity.

LPG & kerosene are almost exclusively used indoors, whilst wood & charcoal are used both indoors & outdoors. This may suggest that some households are aware of the health implications of using biomass stoves indoors, or it may simply be that biomass stove users, who are likely to be poorer & therefore have smaller homes, have less indoor space to cook in. Unlike direct ac cooking appliances, battery-supported stoves can be used indoors or outdoors, so the cook is free to choose where they want to cook.

Basic biomass stoves & LPG stoves are the most popular cooking devices amongst participants. Very few people own improved biomass stoves. Electric cooking appliances are also not common, however 5% of respondents own a rice cooker. Rice is a major staple in coastal Tanzania & cooking rice in a rice cooker


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is much easier. Importantly though, it is also very energy-efficient, creating a key opportunity for battery-supported cooking.

Two thirds of the sample (65%) reported using multiple cooking devices, with some households reporting owning up to 7 different cooking devices!

Charcoal is the dominant energy source in urban areas, whilst in rural areas it is split between charcoal & wood. However, this masks the fact that far more biomass fuel is needed to deliver the cooking service, as much of it is wasted during the cooking process.

LPG was widely considered to be the safest fuel.

Charcoal is regarded as convenient whereas firewood was not. 80% of respondents thought that wood it is a burden to collect.

## 1.8 Existing expenditures

Monthly mean expenditures on fuels among respondents who used them for cooking were:

- Electricity (cooking & other applications): 22,000 TZS (10 USD)
- LPG: 15,000 TZS (6.5 USD)
- Kerosene: 9,400 TZS (4 USD)
- Charcoal: 24,000 TZS (10.5 USD)
- Wood: 12,000 TZS (5 USD)

These expenditures seem low compared to expected ecook discounted costs. However, they should be treated with caution, as LPG & charcoal are more commonly used as primary cooking fuels, whilst kerosene & electricity are most commonly used as backup. Fuels, in particular electricity, are also used for other applications in addition to cooking.Unit costs for each fuel were:

- LPG: 3,250 TZS/kg (1.42 USD/kg)
- Kerosene: 2,000 TZS/litre (0.87 USD/litre)
- Charcoal:
  - Urban: 686 TZS/kg (0.3 USD/kg)
  - Rural: 282 TZS/kg (0.12 USD/kg)
- Wood (when purchased): 100 TZS/kg (0.04 USD/kg)

There is a generally trend for some electricity & gas users plus some charcoal & wood users to purchase enough for 2-4 weeks however, 20% of charcoal users, likely the poorest, buy just enough for a few days.


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## 1.9 Health

Respondents agreed that smoke is harmful to health with wood smoke being more harmful than charcoal. Charcoal users believe that the smoke from a charcoal fire is safe compared to LPG and wood users. The same is true for wood users about wood smoke. Wood users also felt the strongest about smoke being good for chasing insects away.

## 1.10 Business models

The majority of participants (82%) felt positively about renting equipment & using a cooker provided by the utility (80%), which will likely result in the lowest monthly cost, as this model has the longest repayment horizon.

Mobile money is likely to be a key enabler for eCook, as it can make collecting small, but regular repayments much easier. The mobile money industry is accelerating rapidly in Tanzania, with over 80% respondents using it, however most of whom do so infrequently (1-2 times a month). Almost all respondents owned mobile phones, indicating high levels of technical proficiency & possibly a greater willingness to adopt new innovations. Half of respondents regularly use the internet & social media platforms, indicating that social media marketing strategies could be employed for ecook products/services, but would likely need to be complimented by other means.

Almost all indicated a preference for paying for high value items in instalments. The majority (62%) indicated that quarterly repayments were preferable to monthly, or weekly. However, this may be a stretch for the 20% of charcoal users who buy fuel every few days.

## 1.11 Discrete choice modelling results

The cooking process design features that appear to be most important to consumers are:

- Taste – there was a clear preference for a device that does not make food taste smoky.
- Power – people preferred a device that would boil fast (compared to slow), but there was no preference for a medium powered device that would boil a bit more rapidly than a slow device.
- Cooking – prefer to be able to both boil and fry
- Cost – preference for low cost device.

Electric Pressure Cookers (EPCs) seem well matched with Tanzanian consumer preferences, as they can boil & fry, with the boiling part roughly twice as fast as conventional pots.


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The most important stove features are:

- Smoke – people would prefer a device that avoids generating any kind of smoke especially wood smoke.
- Capacity – people want to be able to cook for larger numbers of people (8 people).
- Low cost.

People's strongest preference is for a device that avoids the kind of smoke generated by a wood fire. Wood smoke is much thicker than charcoal smoke throughout the entire duration of cooking. However, charcoal smoke contains much higher levels of the silent killer: carbon monoxide.

The only functionality features with significant preference were:

- Ability to cook on both sunny & rainy days.
- Low cost.

Women were found to value a lid for the pot, the ability to fry as well as boil, having 2 hobs instead of 1 & avoiding the smoke from wood fires more than men. This could well be because as principal cooks in most households, they are more in touch with the practicalities of cooking, rather than simply being a consumer of the finished product, tasty food.

Traditional cooking practices such as cooking without a lid, using a single cooking device & preferring a smoky flavour are reflected in choices made by rural respondents.

Respondents classified as more technically proficient were less likely to choose options with smoky flavour and more likely to choose devices that could both boil & fry.

Respondents classified as deprived, older people & rural people all expressed greater preference for smoky flavour.

Rural households, firewood users & respondents classified as deprived all prioritised lower cost options significantly more than others. They were also more willing to tolerate the smoke from wood fires, clearly showing that they are willing to sacrifice their health to stay within their means.

People who used LPG were more willing to accept a device that could do only part of their cooking, which is consistent with their current fuel stacking practices.


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# Table of Contents





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# 2 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 the key learning points from the cooking diaries study, 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*.

## 2.1 Background

### 2.1.1 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.


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### 2.1.2 Introducing 'eCook'

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

A series of initial feasibility studies were funded by 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.

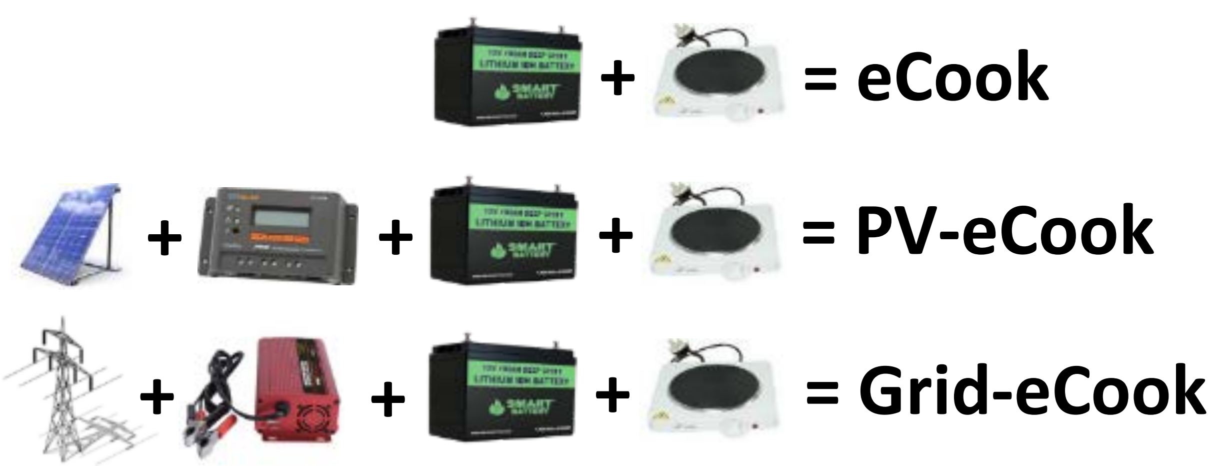


*Figure 1: Pictorial definitions of 'eCook' terminology used in this report.*


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### 2.1.3 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.

## 2.2 Aim

The aim of this study is to explore the preferences of potential users of battery-supported electric cooking products/services in Tanzania.

In particular, the objectives of the study are to gather data on:

- user preferences regarding various aspects of the design and functionality of cooking devices.
- existing expenditures on cooking fuels, cooking practices and the quality of electricity supplies.


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# 3 Methodology

The primary purpose of the Discrete Choice Modelling surveys was to explore people's preferences regarding various aspects of the design and functionality of cooking devices. The survey has also been used to gather valuable data on cooking practices (e.g. the mix of fuels used and the timing of meals), and the quality of electricity supplies. Data on expenditure on cooking fuels is especially useful as this represents disposable income that can be substituted for modern fuel devices. The surveys were carried out by TaTEDO, who coordinated a team of enumerators to conduct face to face interviews and responses were recorded using the Kobo Collect Android application on a tablet.

## 3.1 Descriptor data

Descriptor data was also gathered from respondents, such as age, gender, level of education and so on. Two composite descriptor variables have been calculated representing characteristics of households that might be expected to influence attitudes towards, and eventual adoption of, modern energy cooking devices. A poverty index has been calculated from five variables including the level of education of the respondent and the quality of the dwelling. A technological aptitude index has been calculated from variables representing personal use of media, phones and the internet services. Preferences have then been disaggregated by descriptors and indices to highlight particular aspects that may be more important to specific customer segments.

## 3.2 Discrete Choice Modelling (DCM)

Discrete choice modelling was proposed as the theoretical construct to be used in these surveys, to identify the key characteristics (or parameters) that each product should have to find ready acceptance with consumers. The methodology has considerable advantages over stated preference, particularly in this case of exploring a market for a future product, as it is difficult for a consumer to state what they would like about a product if they do not yet have exposure to the product.

Choice models are set up using choice cards (Figure 2), based on the key parameters identified, each of which has a limited number of 'levels'. The respondent must then choose one of the two cards presented. Discrete choice models predict the probability that an individual will choose an option, based on the levels of each parameter given in the option. Parameters were divided into three sections covering cooking processes (e.g. speed of cooking), stove design (e.g. smoke emissions), and functionality (e.g. financing plans). Each section was assigned four or five parameters, each parameter having between 2 and 4 levels. Each section included a cost parameter (the capital cost of the device), which was considered to be a continuous variable. This enables willingness to pay figures to be



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calculated for different features of a cooking device. The analysis used binary logistic regression to fit predictive models to the data for each section. The results provide an understanding of the strength of preference for each attribute, reflecting how important it is in decision making.

| F6-TZ | | | | |
|---|---|---|---|---|
| Parameta | Chaguo A | | Chaguo B | |
| Gharama ya kila mwezi | 45,000 TZS/mwezi | | 15,000 TZS/mwezi | |
| Matumizi | Sahani 2 + Taa 3 za LED | | Sahani 2 + Televisheni | |
| Upatikanaji | Linatumika wakati wa jua pekee | | Linatumika wakati wa jua pekee | |
| Muundo wa malipo | Malipo ya kila mwezi (matumizi) | TANESCO | Kukopesha kwa muda wa miaka 6 | 6 |
| Usafishaji | Rahisi kusafisha | | Shida kusafisha | |

*Figure 2: Example choice card from the eCook Tanzania DCE survey.*

Fractional orthogonal design[1] was used to limit the number of choices to 16 choice cards per section (Mangham, Hanson, & McPake, 2009). A simple constant comparator approach was used (De Bekker-Grob et al., 2010), in which one of the 16 choice cards was used as a 'reference'[2], and the 15 resulting pairs presented respondents with a choice between this comparator and each of the other choice cards. The literature suggests that respondents get fatigued when presented with too many choices, and a review suggested studies rarely used more than 16 choices (De BekkerGrob, Ryan, & Gerard, 2012). For each technology the choice cards were therefore split in two sets (with 7 & 8 pairs in each), included in a Questionnaire A and Questionnaire B. We then hypothesised that by interspersing the three sections with the descriptor questions, the respondent would be prepared to answer three sets of 7 or 8 pairs. Piloting of the survey instrument confirmed that respondents could indeed respond to 3 sections within a given questionnaire, with a maximum of 8 choice pairs per technology.

Data sets derived from choice modelling are quite different to those from other types of surveys. Firstly, each respondent is asked 7 or 8 questions in each section, resulting in multiple responses per individual. Secondly, each choice comprises a pair of choice cards i.e. two records are generated for each of the questions. The data is, therefore, 'expanded' into a matrix of continuous and

[1] Using SPSS software.

[2] The constant comparator choice card was selected on the basis that the mix of levels represented a mid-level of attractiveness, so one would expect the number of times the comparator was chosen and reject to be roughly balanced.


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categorical dummy variables that represent the characteristics of each choice (the level for each parameter), along with a categorical 'choice' variable – the dependent variable indicating whether the respondent chose or rejected the choice card in the pair presented (World Health Organisation, 2012).

The analysis used binary logistic regression to fit predictive models to the data for each technology because the dependent variable was a dichotomous categorical variable (representing whether the choice card was chosen or not). All of the parameters were entered into the model, which calculated regression coefficients for each, along with p values indicating whether the parameter was significant in the model. The modelling was done using SPSS and further notes on interpreting the results are given in *4.6.1 Interpreting the results.*

### 3.2.1 Sampling design

According to Rose & Bliemer "*an archetypal SCE [stated choice experiment] might require choice data be collected on 200 respondents, each of whom are observed to make eight choices, thus producing a total of 1600 choice observations*" (Rose & Bliemer, 2009). The literature goes on to point out that if the survey design is to include other questions that can be used to disaggregate the data, larger samples are required (Orme, 2010). However, the literature also states that to a large extent, sample size is determined by budgetary constraints. Work by the Consortium for Research on Equitable Health Systems (CREHS) confirms that sample sizes for discrete choice experiments have generally been based on experience rather than mathematical calculation (Wafula et al., 2011), and propose 100 – 150 respondents per sub-group. When considering the acceptable range of sample sizes, the WHO guidelines suggest the sample size must be more than 30 (World Health Organisation, 2012), and at the upper end a review of studies suggests that precision improves only marginally for sample sizes over 300 (Johnson et al., 2013). One of the leading experts in choice modelling states:- "*For robust quantitative research where one does not intend to compare subgroups, I would recommend at least 300 respondents. **For investigational work and developing hypotheses about a market, between thirty and sixty respondents may do.***" (Orme, 2010) (Our emphasis).



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As an initial scoping exercise to test the market for a new cooking concept, the research team decided that given the resources available, a sample of 200 respondents would be sufficient. This would allow disaggregation of the results by several variables (e.g. location, poverty levels, primary fuel use). If necessary, follow on surveys could then be conducted to gain greater clarity on specific issues that may require further disaggregation of the data. Given that each respondent would be working with one half of each set of choice pairs, 200 respondents only yield 100 complete choice pairs. However, as identical surveys were carried out in parallel in 3 countries (Zambia, Tanzania and Myanmar), the full dataset is actually 300.

## 3.3 Computer Assisted Personal Interviewing (CAPI)

Surveys were conducted on tablets with an Android operating system. Compared with paper collection, the reliability of the data is greatly improved and there are significant time savings from completely eliminating the data digitisation step (transcription from paper to computer).

While the team has extensive experience of collecting data on tablets, it was not immediately clear whether CAPI systems could use graphics, and whether respondents would be able to browse options for themselves before making a choice. The first issue of concern was whether respondents would be comfortable with handling the tablet (recent experience of self-administration in rural areas of DRC was mixed), and secondly, the particular software needed to include graphics (for nonliterate respondents).

The KoboCollect digital survey tool was selected because it was designed for challenging contexts and offered the ability for enumerators to show respondents graphics representing the choice cards (Figure 2). The precursor to the eCook DCE surveys was carried out in Kenya in 2016 using the Poimapper Plus platform (Batchelor and Scott, 2016), however bugs in the software and programming challenges lead the team to switch onto the Kobo platform. One disadvantage to CAPI is that it is difficult to create a word document for inclusion as an annex in reports such as this.

## 3.4 Training and piloting

TaTEDO recruited a team of 2 enumerators to carry out the surveys. Training was conducted by TaTEDO and Gamos, guided by instructions from the survey designers at Gamos. Although the enumerators did not have experience with carrying out surveys on tablets, they had good knowledge of smart phones and android devices which proved sufficient during training.

The survey methodology had previously been tested in Kenya, focussing on both health and cooking technologies (Batchelor and Scott, 2016). However, this version of the survey had been adapted to focus solely on cooking, so the field training also acted as pilot testing of the updated survey itself.



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Further updates were made after discussion within the piloting group to adapt the survey to the local context, for example converting currencies and choosing price ranges aligned with current expenditures on cooking fuels. This pilot data was downloaded and verified by the survey designers at Gamos.

The surveys were carried out at busy marketplaces to ensure access to as many potential respondents as possible. No cash incentives were offered, as previous experience with DCE in Kenya showed that when some respondents knew that an incentive was being given after the interview then occasionally it became the main motivation for completing the interview, in which case some respondents gave less well considered responses.

With any household study, it is assumed that poverty will be a key determinant of adoption behaviour and preferences. It can also be asserted that early adopters of new technologies will tend to be those who have already adopted other technologies and are intensive users of other technologies. Where a device meets a need, it is more likely to be adopted by people who are aware of those needs. For example, respiratory infections associated with traditional cooking methods are a major cause of deaths yet demand for improved cookstoves will only be stimulated when people become aware of the consequences of traditional cooking methods. Some of the supporting questions were designed to explore these issues of poverty, adoption of technology, and general level of understanding (or awareness). Given that level of education and ownership of assets are commonly used as determinants of wealth, a high degree of interconnectedness is to be expected between these three issues.

Two composite descriptor variables have been calculated representing characteristics of households that might be expected to influence attitudes towards, and eventual adoption of, modern energy cooking devices. A poverty index has been calculated from five variables including the level of education of the respondent and the quality of the dwelling. A technological aptitude index has been calculated from variables representing personal use of media, phones and the internet services. Preferences have then been disaggregated by descriptors and indices to highlight particular aspects that may be more important to specific customer segments.



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# 4 Results

THE SAMPLE WAS HEAVILY WEIGHTED TOWARDS URBAN PARTICIPANTS FROM DAR ES SALAAM, BUT AROUND ¼ WERE FROM A SINGLE RURAL TOWN, KIBINDU.

Face to face interviews were conducted using Kobo Toolbox CAPI software. The sample of 214 interviews were conducted by two enumerators (Angel and Tafu). Almost three quarters of the sample were drawn from urban areas around the capital, and one quarter were drawn from a single rural town (Kibindu town) – see Table 1 and Figure 3.

*Table 1 Regions and type of settlement*

| | rural | peri-urban | urban | Total |
|---|---|---|---|---|
| Kinondoni (Dar es Salaam) | 0 | 1 | 20 | 21 |
| Ubungo (Dar es Salaam) | 1 | 2 | 69 | 72 |
| Ilala (Dar es Salaam) | 0 | 8 | 36 | 44 |
| Temeke (Dar es Salaam) | 0 | 0 | 1 | 1 |
| Kigamboni (Dar es Salaam) | 0 | 3 | 14 | 17 |
| Other | 59 | 0 | 0 | 59 |
| Total | 60 | 14 | 140 | 214 |

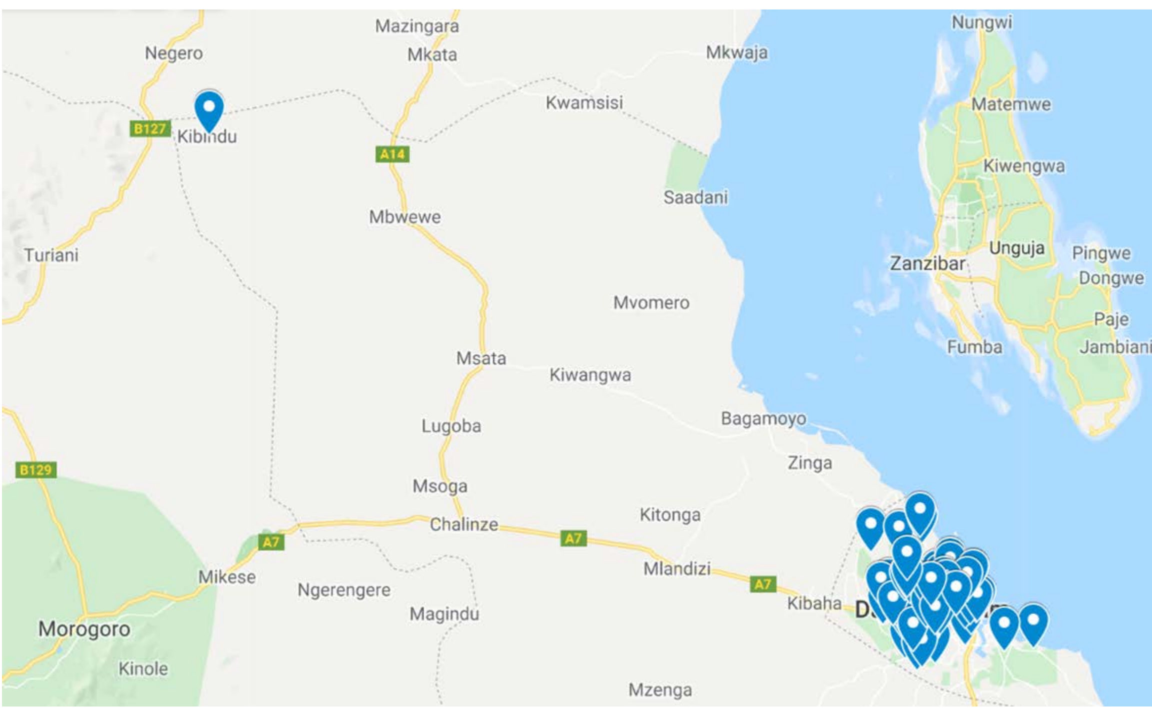


*Figure 3 Geographical spread of survey*


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The mean time taken to walk to the nearest market was 10.3 minutes for urban respondents and 8.1 minutes for rural respondents, so it appears that all rural respondents lived within a short distance of the Kibindu market. Although they were in a rural area, they did not live in remote areas, far from markets and other facilities.

## 4.1 Respondent characteristics

### 4.1.1 Personal characteristics

The sample was predominantly female – 36:74 (male:female).

77% of respondents were either the head of household or the spouse of the head of household.

The mean age of respondents was 35.3 years, but the sample included respondents of a wide age range – see Figure 4.

The sample was split roughly one third with primary education, one third with secondary education, and one third with some kind of tertiary education (see Table 2).

THE SAMPLE WAS FEMALE BIASED, BUT THIS IS NOT SURPRISING, AS THERE WAS NO CASH INCENTIVE OFFERED & THE FOCUS ON COOKING LIKELY ATTRACTED MORE FEMALE RESPONDENTS.

*Table 2 Highest level of education attained*

| | Frequency | Percent |
|---|---|---|
| None | 14 | 6.5 |
| Completed primary | 71 | 33.2 |
| Incomplete secondary | 6 | 2.8 |
| Completed secondary | 62 | 29 |
| Higher than secondary | 61 | 28.5 |
| Total | 214 | 100.0 |

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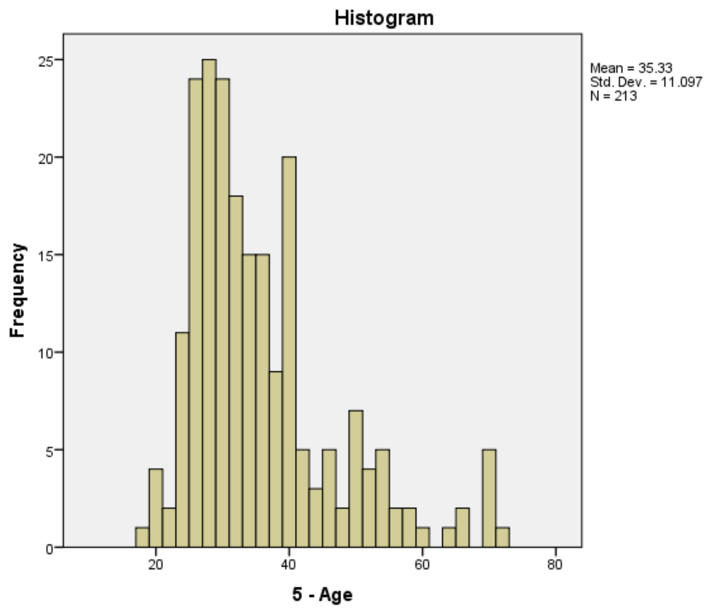


*Figure 4 Age distribution of respondents*

Most respondents both listen to the radio and watch TV (Table 3). They correlate strongly (r = 0.592, p < 0.001), showing that those who watch more TV also listen to the radio more often. 14% were isolated in not accessing either of these types of broadcast media.

*Table 3 Frequency of use of broadcast media*

| | Use of Radio | Valid Percent | Use of TV | Valid Percent |
|---|---|---|---|---|
| not at all | 36 | 16.9 | 56 | 26.3 |
| less than once a week | 33 | 15.5 | 31 | 14.6 |
| at least once a week | 110 | 51.6 | 92 | 43.2 |
| daily | 34 | 16 | 34 | 16 |
| Total | 213 | 100 | 213 | 100 |

Patterns of mobile phone use can serve as a proxy for technical proficiency and ability to adapt to technological innovations. 92% of respondents owned a mobile phone (or SIM card), and most of these were smartphones (Table 4). Although most respondents used a phone several times a day, there remains a sizable minority who did not use a phone at all (Table 5).

Literacy clearly acts as a barrier to fully exploiting the potential of mobile phones, and 9% of respondents were not able to read SMS texts for themselves (n=20). Most of these (n=16) had not used a phone in the previous month.


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*Table 4 Type of phone most commonly used*

| | Frequency | Valid Percent |
|---|---|---|
| Smart phone | 119 | 61.7 |
| Feature phone | 17 | 8.8 |
| Basic phone | 57 | 29.5 |
| Total | 193 | 100.0 |

ALMOST ALL RESPONDENTS OWNED MOBILE PHONES, INDICATING HIGH LEVELS OF TECHNICAL PROFICIENCY & POSSIBLY A GREATER WILLINGNESS TO ADOPT NEW INNOVATIONS.

*Table 5 Frequency of use of mobile phone (in last month)*

| | Frequency | Percent |
|---|---|---|
| not used | 21 | 9.8 |
| weekly | 2 | .9 |
| once or twice a day | 19 | 8.9 |
| several times a day | 172 | 80.4 |
| Total | 214 | 100.0 |

In terms of innovative services, Table 6 and Table 7 show that over half of respondents used the internet and social media services (e.g. Facebook, Viber, WhatsApp) daily. Although 81% used mobile money services (e.g. M-Pesa, Halo-pesa, Airtel Money), only 26% used mobile banking applications (e.g. CRDB Simu Banking).

*Table 6 Frequency of use of internet (in last month)*

| | Frequency | Percent |
|---|---|---|
| not aware of internet | 14 | 6.5 |
| not used | 72 | 33.6 |
| weekly | 15 | 7 |
| once or twice a day | 38 | 17.8 |
| several times a day | 75 | 35 |
| Total | 214 | 100 |

HALF OF RESPONDENTS REGULARLY USE THE INTERNET & SOCIAL MEDIA PLATFORMS, INDICATING THAT SOCIAL MEDIA MARKETING STRATEGIES COULD BE EMPLOYED FOR ECOOK PRODUCTS/SERVICES, BUT WOULD LIKELY NEED TO BE COMPLIMENTED BY OTHER MEANS.


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*Table 7 Frequency of use of social media*

| | Frequency | Valid Percent |
|---|---|---|
| No | 51 | 23.9 |
| Not anymore | 38 | 17.8 |
| Weekly | 9 | 4.2 |
| Once or twice a day | 37 | 17.4 |
| Several times a day | 78 | 36.6 |
| Total | 213 | 100 |

*Table 8 Frequency of use of financial services delivered by mobile*

| | Mobile money | | Mobile banking | |
|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent |
| not used | 39 | 18.6 | 156 | 74.3 |
| 1 or 2 times a month | 103 | 49 | 50 | 23.8 |
| 3 - 10 times a month | 66 | 31.4 | 4 | 1.9 |
| daily | 2 | 1 | | 0.5 |
| Total | 210 | 100 | 210 | 100 |

MOBILE MONEY IS LIKELY TO BE A KEY ENABLER FOR ECOOK, AS IT CAN MAKE COLLECTING SMALL, BUT REGULAR REPLYMENTS MUCH EASIER. THE MOBILE MONEY INDUSTRY IS ACCELERATING RAPIDLY IN TANZANIA, WITH OVER 80% RESPONDENTS USING IT, HOWEVER MOST OF WHOM DO SO INFREQUENTLY (1-2 TIMES A MONTH).

A factor analysis has been conducted, and a single factor extracted based on the following variables:

- Frequency of use of mobile phone
- Use of internet
- Use of social media
- Use of mobile money services
- Use of mobile banking applications

The sample has then been split into two roughly equal parts, classifying technical proficiency, on the basis of this factor score (see Table 9).


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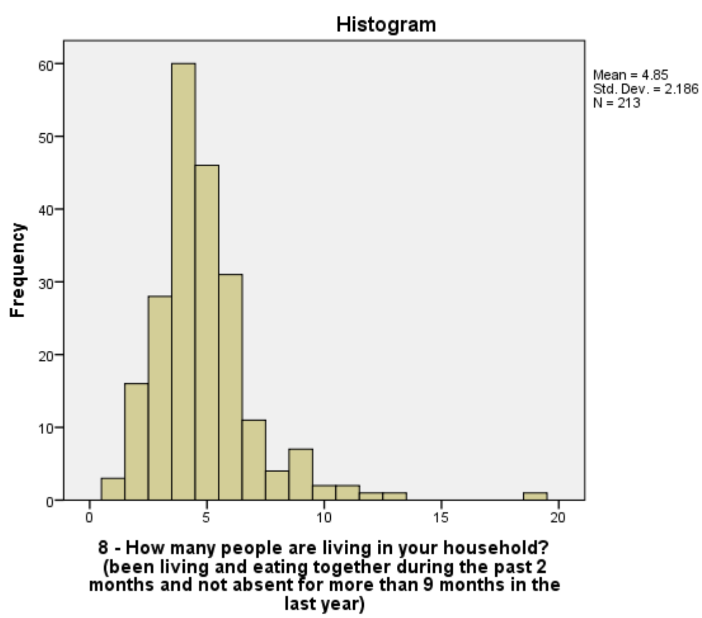
*Table 9 Composite technical proficiency classification*

| | Frequency | Percent |
|---|---|---|
| Low proficiency | 113 | 52.8 |
| High proficiency | 97 | 45.3 |
| Total | 210 | 98.1 |
| Missing | 4 | 1.9 |
| Overall Total | 214 | 100 |

### 4.1.2 Household characteristics

The mean household size was 4.9 (including children). The distribution of household sizes is presented in Figure 5. 53% of households had at least one child under the age of 5 years.

Details of dwelling constructions are presented in Table 10 to Table 12. The households' main sources of drinking water are presented in Table 13.




THE MEAN HOUSEHOLD SIZE WAS FOUND TO BE 4.9 (INCLUDING CHILDREN).

*Figure 5 Distribution of household size (adults + children)*



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*Table 10 Dwelling construction - floor*

| | Frequency | Percent |
|---|---|---|
| Dirt/Mud/Dung | 37 | 17.3 |
| Cement screed | 69 | 32.2 |
| Tiles | 108 | 50.5 |
| Total | 214 | 100 |

*Table 11 Dwelling construction - walls*

| | Frequency | Percent |
|---|---|---|
| Wood / mud / thatch | 20 | 9.3 |
| Mud bricks (traditional) | 28 | 13.1 |
| Corrugated iron sheet | 3 | 1.4 |
| cement block (plastered or not) | 149 | 69.6 |
| Bricks (burnt) | 14 | 6.5 |
| Total | 214 | 100 |

*Table 12 Dwelling construction - roof*

| | Frequency | Percent |
|---|---|---|
| Thatch/palm leaf | 21 | 9.8 |
| Wood | 2 | 0.9 |
| Corrugated iron / cement sheet | 184 | 86.0 |
| Cement | 4 | 1.9 |
| Other | 3 | 1.4 |
| Total | 214 | 100 |

*Table 13 Main source of drinking water*

| | Frequency | Percent |
|---|---|---|
| Piped into dwelling | 88 | 41.1 |
| Piped into yard | 2 | 0.9 |
| Public standpipe | 54 | 25.2 |
| Protected dug well | 21 | 9.8 |
| Unprotected dug well | 11 | 5.1 |
| Protected spring | 3 | 1.4 |
| Unprotected spring | 2 | 0.9 |
| Rainwater | 2 | 0.9 |
| Tanker truck | 1 | 0.5 |
| Bottled water | 30 | 14.0 |
| Total | 214 | 100 |


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A poverty index has been created based on the following variables:

- Level of education of respondent
- Dwelling construction materials (floor, walls and roof)
- Main source of drinking water.

Households have been classified as deprived as indicated in Table 10 to Table 13. They have been classified as deprived on the education indicator if the respondent had no education or primary education only. These five dichotomous indicators show a good deal of internal consistency (Cronbach alpha = 0.814), so they form a reasonable basis upon which to create a composite poverty index. An index has been created by summing the number of aspects in which the household is deprived – see Table 14. For the purposes of the analysis, the sample has been split into two roughly equal parts: 57.5% non-deprived, and 42.5% that are deprived in at least one indicator.

*Table 14 Poverty index*

| | Frequency | Percent |
|---|---|---|
| non-deprived | 123 | 57.5 |
| deprived (at least 1 indicator) | 91 | 42.5 |
| Total | 214 | 100.0 |

## 4.2 Characteristics of household electricity supply

### 4.2.1 Sources of electricity

16.8% of respondents (n=36) claimed they had no electricity – see Table 15. However, the number of sources of electricity listed by each respondent was calculated (excluding rechargeable and dry cell batteries) and as shown in Table 16, only 12.1% of respondents (n=26) were found to no source of electricity. 1 of these respondents simply didn't answer the question meaning only 25 respondents correctly stated that they have no source of electricity. Of the remaining 11 respondents:

- 4 had solar lanterns
- 7 had other

Most respondents had a single source of electricity, but 11% had multiple sources. Among these 24 respondents, the most common combination was national grid and solar lighting.

*Table 15 Sources of electricity*

| Source | Frequency | Percent |
|---|---|---|
| Grid connection | 153 | 71.5 |
| Solar mini grid | 12 | 5.6 |
| Biomass gasifier mini grid | 4 | 1.9 |
| Other mini grid | 1 | 0.5 |
| Solar home system | 7 | 3.3 |
| Household generator | 3 | 1.4 |
| Household pico-hydro system | 1 | 0.5 |
| Solar lighting system | 22 | 10.3 |
| Rechargeable batteries | 7 | 3.3 |
| Dry cell batteries | 1 | 0.5 |
| Other | 9 | 4.2 |
| No electricity | 36 | 16.8 |

ROUGHLY ¾ OF RESPONDENTS WERE CONNECTED TO THE NATIONAL GRID, WHILST 1/8 WERE WITHOUT ACCESS TO ELECTRICITY. 1/16 WERE CONNECTED TO TATEDO'S SOLAR/BIOMASS HYBRID MINI-GRID IN KIBINDU.

*Table 16 Number of sources of electricity (excluding rechargeable and dry cell batteries)*

| | Frequency | Percent |
|---|---|---|
| 0 | 26 | 12.1 |
| 1 | 164 | 76.6 |
| 2 | 24 | 11.2 |
| Total | 214 | 100.0 |

Respondents with connections to the national grid or to any type of mini grid were asked to give details of the type of connection; results in Table 17 show that there was a relatively even split among national grid users between individual and shared meters. Respondents using a solar mini grid tended to have an informal connection to it.


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*Table 17 Type of connections*

| Source | Informal | Direct connection with shared meter | Direct connection with individual meter | Total |
|---|---|---|---|---|
| National grid | 1 | 80 | 72 | 153 |
| Solar mini grid | 8 | 0 | 4 | 12 |
| Biomass gasifier mini grid | 0 | 2 | 2 | 4 |
| Other mini grid | 1 | 0 | 0 | 1 |

### 4.2.2 Household electrical appliances

Only those respondents who said they had a source of electricity were asked which appliances they had – see Table 18.

*Table 18 Household ownership of electrical appliances*

| Appliance | Frequency | Valid percent |
|---|---|---|
| Radio (battery powered) | 42 | 23.6 |
| Music system (mains powered) | 110 | 61.8 |
| Mobile phone | 175 | 98.3 |
| Television | 140 | 78.7 |
| refrigerator | 103 | 57.9 |
| Electric kettle | 5 | 2.8 |
| Electric water heater | 32 | 18.0 |
| fan | 136 | 76.4 |


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| | | |
|---|---|---|
| Air conditioner | 5 | 2.8 |
| Electric lights | 139 | 78.1 |

### 4.2.3 Quality of supply

Respondents who accessed electricity via the national grid or any type of mini grid (see Table 19) were asked a series of questions relating to quality of supply.

*Table 19 Respondents accessing electricity from a grid*[3]

| | Frequency | Percent |
|---|---|---|
| No | 45 | 21.0 |
| National grid | 153 | 71.5 |
| Mini grid | 16 | 7.5 |
| Total | 214 | 100.0 |

Among national grid users,

- 80% felt that the voltage was adequate for cooking all the time (Table 20),
- 71% had experienced load shedding (at some point in the past) (Table 21). Table 23 shows a clear season trend, for load shedding to occur in the December to April months.
- 88% currently experienced frequent blackouts (defined as more than once a month) (Table 22).

BLACKOUT PATTERNS WERE DIFFERENT DURING LOAD SHEDDING AND AT OTHER TIMES. ALTHOUGH THE FREQUENCY OF BLACKOUTS IN BOTH INSTANCES WAS SIMILAR, WITH MOST OCCURRING ONCE OR TWICE A WEEK, BLACKOUTS DUE TO LOAD SHEDDING LASTED MUCH LONGER, TYPICALLY ABOUT A DAY, COMPARED WITH 1 OR 2 HOURS FOR OTHER BLACKOUTS

Note that load shedding and blackouts were only experienced more than once a month by households connected to the national grid. Blackout patterns were different during load shedding and at other times. Although the frequency of blackouts in both instances was similar, with most occurring once or twice a week (Table 24), blackouts due to load shedding lasted much longer, typically about a day, compared with 1 or 2 hours for other blackouts (Table 25).

---

[3] N.B. household having access to both national and mini grids have been classified as 'National grid' on the basis that they are likely to source most of their energy from the national grid.



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*Table 20 Voltage quality*

| | | National grid | mini grid | Total |
|---|---|---|---|---|
| Is the voltage at your household high enough for cooking? | Yes, all the time | 123 | 7 | 130 |
| | Yes, because I have a voltage stabiliser | 0 | 1 | 1 |
| | Sometimes (only during certain hours each day) | 1 | 2 | 3 |
| | Sometimes (unpredictable) | 29 | 2 | 31 |
| Total | | 153 | 12 | 165 |

*Table 21 Experience of load shedding*

| | | National grid | mini grid | Total |
|---|---|---|---|---|
| Have you experienced load shedding at any point in the past? | No | 25 | 11 | 36 |
| | Yes | 109 | 3 | 112 |
| | Not sure | 19 | 2 | 21 |
| Total | | 153 | 16 | 169 |

*Table 22 Experience of blackouts*

| | | National grid | mini grid | Total |
|---|---|---|---|---|
| Do you currently experience frequent blackouts (more than once a month)? | No | 19 | 16 | 35 |
| | Yes, due to load shedding | 8 | 0 | 8 |
| | Yes, but not due to load shedding | 126 | 0 | 126 |
| Total | | 153 | 16 | 169 |

NEARLY 80% OF GRID-CONNECTED RESPONDENTS REPORTED THAT THE VOLTAGE IS ALWAYS HIGH ENOUGH FOR COOKING WITH ELECTRICITY, HOWEVER AS ONLY 5% OF REPSONDENTS ACTUALLY COOK WITH ELECTRICITY, IT IS UNCLEAR WHETHER THIS ASSESSMENT IS FROM PRACTICAL EXPERIENCE OR SPECULATIVE.



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*Table 23 Months in which load shedding is experienced*

| | Frequency | Valid percent (n=109) |
|---|---|---|
| Jan | 59 | 33.1 |
| Feb | 69 | 38.8 |
| Mar | 88 | 49.4 |
| Apr | 82 | 46.1 |
| May | 19 | 10.7 |
| Jun | 5 | 2.8 |
| Jul | 13 | 7.3 |
| Aug | 11 | 6.2 |
| Sep | 9 | 5.1 |
| Oct | 11 | 6.2 |
| Nov | 11 | 6.2 |
| Dec | 36 | 20.2 |

PARTICIPANTS REPORT THAT LOAD SHEDDING IS MOST FREQUENT FROM DECEMBER TO MAY, HOWEVER, IT IS UNCLEAR WHY THIS IS.

*Table 24 Frequency of blackouts*

| | Load shedding (in past) | | Current blackouts | |
|---|---|---|---|---|
| | Frequency | Valid Percent | Frequency | Valid Percent |
| once a month | 3 | 2.7 | 7 | 5.2 |
| twice a month | 12 | 10.9 | 6 | 4.5 |
| once a week | 19 | 17.3 | 32 | 23.9 |
| twice a week | 62 | 56.4 | 76 | 56.7 |
| every other day | 9 | 8.2 | 8 | 6.0 |
| every day | 4 | 3.6 | 0 | 0 |
| many times a day | 1 | 0.9 | 5 | 3.7 |
| Total | 110 | 100.0 | 134 | 100.0 |


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

*Table 25 Duration of blackouts*

| | Load shedding | | Current blackouts | |
|---|---|---|---|---|
| | Frequency | Valid percent | Frequency | Valid percent |
| under 5 minutes | 0 | 0 | 0 | 0 |
| 10 mins | 0 | 0 | 1 | 0.7 |
| 30 mins | 1 | 0.9 | 10 | 7.5 |
| 1 hour | 2 | 1.8 | 45 | 33.6 |
| 2 hours | 4 | 3.6 | 44 | 32.8 |
| 4 hours | 4 | 3.6 | 11 | 8.2 |
| 8 hours | 37 | 33.0 | 22 | 16.4 |
| 1 day | 60 | 53.6 | 0 | 0 |
| several days | 4 | 3.6 | 0 | 0 |
| More than a week | 0 | 0 | 1 | 0.7 |
| Total | 112 | 100 | 134 | 100.0 |

Among respondents with experience of load shedding, 98% had received some kind of information about a schedule (Table 26). Among those who did receive information (even if not accurate) (n=36), most got this information via local broadcast media (loudspeakers and radio) and from social networks (neighbours).

*Table 26 Received information on load shedding schedule*

| | Frequency | Valid Percent |
|---|---|---|
| Yes | 27 | 24.1 |
| Yes, but it is not accurate | 9 | 8.0 |
| Sometimes | 74 | 66.1 |
| No | 2 | 1.8 |
| Total | 112 | 100.0 |


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*Table 27 Sources of information on load shedding schedules*

| | Frequency | Valid percent (n=38) |
|---|---|---|
| radio | 23 | 63.9 |
| Printed notice | 1 | 2.8 |
| newspapers | 3 | 8.3 |
| internet | 3 | 8.3 |
| SMS | 3 | 8.3 |
| neighbours | 26 | 72.2 |
| loudspeaker | 30 | 83.3 |
| other | 2 | 5.6 |

Table 28 shows that whilst the national grid is available 24 hours a day (not withstanding blackouts, as discussed above), most mini grids are only available at certain times of the day (all are solar mini grids). Those switched on once a day are switched on at 18.00/18:30 and off around 07.00 or 00:30.

*Table 28 Availability of electricity*

| | National grid | mini grid | Total |
|---|---|---|---|
| No, it is on 24 hours a day | 153 | 12 | 165 |
| Yes, it is turned on once a day | 0 | 4 | 4 |
| Total | 153 | 16 | 169 |


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## 4.3 Characteristics of cooking practice

### 4.3.1 Meals and timing

Dinners are the meal most commonly cooked, whereas only around 70% of respondents always cooked lunch or breakfast (Figure 6). Table 29 shows that only 55% of households always cook all three meals.

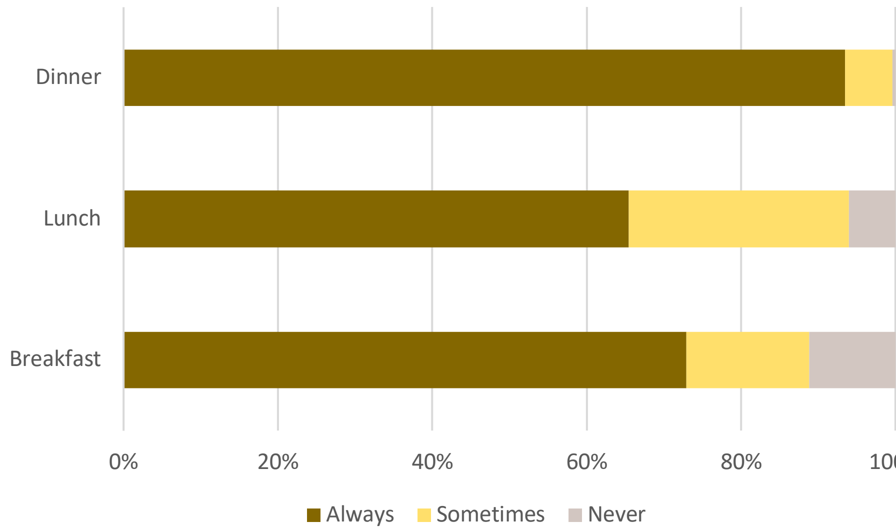


*Figure 6 Meals cooked in the household*

3 MEALS PER DAY IS THE MOST COMMON COOKING PATTERN, WITH 55% OF RESPONDANTS ALWAYS COOKING 3 & 90% SOMETIMES DOING SO. 77% ALWAYS COOK AT LEAST 2.

*Table 29 Number of meals (per day) always cooked*

| | Frequency | Percent |
|---|---|---|
| 0 | 10 | 4.7 |
| 1 | 29 | 13.6 |
| 2 | 58 | 27.1 |
| 3 | 117 | 54.7 |
| Total | 214 | 100.0 |

The survey also asked about heating water for various purposes. Almost all respondents heated water for hot drinks and over half heated water to purify it (Table 30). All respondents who answered the questions heated water for one purpose or another (Table 31).



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*Table 30 Heating water*

| Purpose of heating water | Frequency | Percent |
|---|---|---|
| Heat water for bathing | 47 | 23.3 |
| Heat water for tea/coffee | 199 | 98.5 |
| Heat water for purifying water | 108 | 53.5 |

COASTAL TANANIA'S HOT CLIMATE MEANS THAT ONLY 23% OF PARTICIPANTS HEAT WATER FOR BATHING, HOWEVER 54% HEAT IT TO PURIFY IT & 99% HEAT IT FOR TEA/COFFEE.

*Table 31 Number of uses of heated water*

| | Frequency | Valid Percent |
|---|---|---|
| 1 | 97 | 45.8 |
| 2 | 88 | 41.5 |
| 3 | 27 | 12.7 |
| Total | 212 | 100.0 |

The most common times to start cooking meals (modes) were:

- Breakfast: 7.30
- Lunch: 12.30
- Dinner: 19.15

The distributions of starting times are presented in Figure 7 and show that 90% of households start cooking:

- breakfast between 6.30 and 8.30
- lunch between 12.00 and 14.00
- dinner between 18.30 and 20.20.

BREAKFAST IS TYPICALLY PREPARED FROM 7:30, LUNCH AT 12:30 & DINNER AT 19:15.


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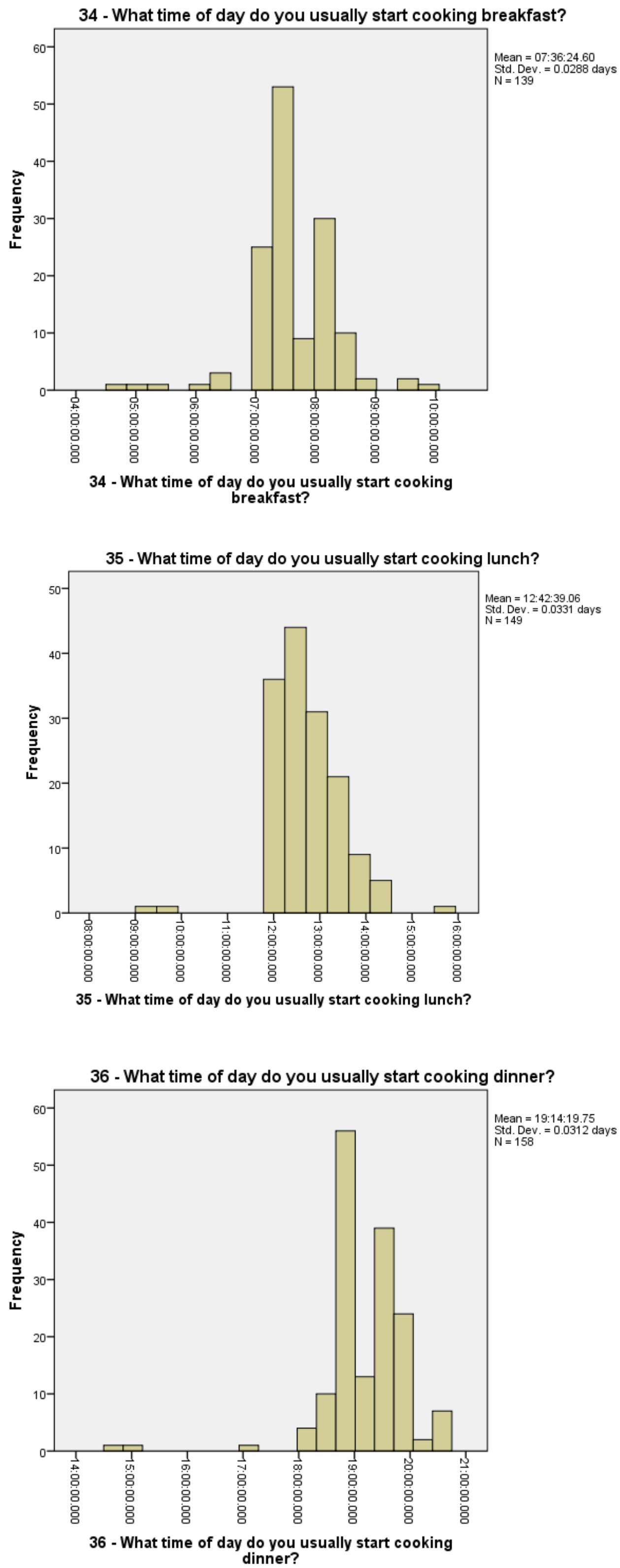


*Figure 7 Distribution of times for starting to prepare meals*



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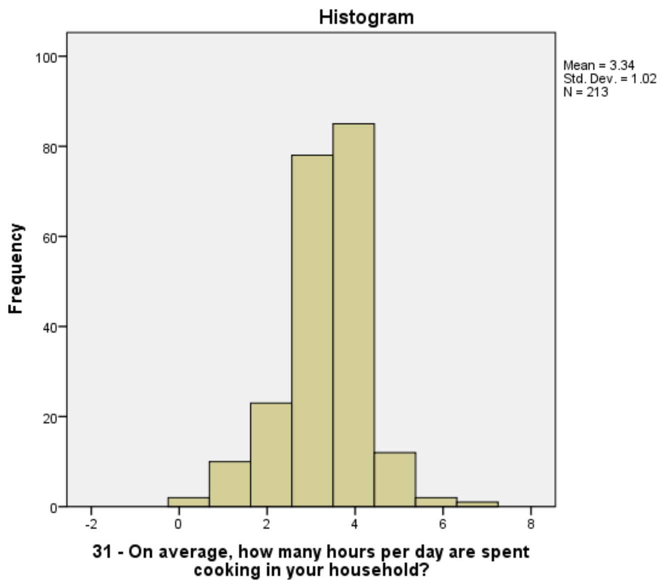
Households spend an average of 3.3 hours/day cooking (median = 3.0 hours/day). Figure 8 shows that the mode is 4 hours/day. As might be expected, there is a strong correlation between time spent cooking and the number of meals always cooked (r = 0.399, p < 0.001).




RESPONDENTS SPEND AN AVERAGE OF 3.3 HOURS/DAY COOKING.

*Figure 8 Distribution of time spent cooking (hours/day)*

In 72% of households, it was a woman who did most of the cooking, and in 25% of household's men and women shared cooking; in only 3% of households did a man do the majority of the cooking. The norm was a female spouse of the head of the household to do the majority of the cooking, although in a substantial number of households cooking was shared[4] (see Table 32). It is interesting to note that other family members were almost as likely to be male as female (N.B. no detail was gathered on who those family members were).

[4] It is assumed that cases where the spouse does the majority of the cooking, yet the gender of that person is 'both' represent households where the man shares cooking with his wife.


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*Table 32 Gender of persons who does most of the cooking in the household*[5]

| Description | Gender | | | Total | Percent |
|---|---|---|---|---|---|
| | Male | Female | Both | | |
| Head of household | 1 | 5 | 0 | 6 | 2.8 |
| Spouse of head | 0 | 108 | 51 | 159 | 74.6 |
| Other family member | 6 | 45 | 51 | 102 | 47.9 |
| Maid / cook | 0 | 30 | 4 | 34 | 16.0 |
| Other | 0 | 0 | 4 | 4 | 1.9 |

UNSURPRISINGLY, PARTICIPANTS REPORTED THAT WOMEN ARE USUALLY RESPONSIBLE FOR COOKING (72%), HOWEVER, IN 3% OF HOUSEHOLDS, MEN DO THE MAJORITY OF COOKING & IN 25% IT IS A SHARED RESPONSIBILITY, INDICATING THAT MARKETING ECOOK PRODUCTS & SERVICES TO MEN IS ALSO IMPORTANT. IN FACT, THE EVIDENCE FROM THE FOCUS GROUPS SUGGESTS THAT APPLIANCES SUCH AS ELECTRIC PRESSURE COOKERS (EPCS) CAN MAKE COOKING MUCH EASIER, WHICH MAY ENOCOURAGE MORE MEN TO COOK

### 4.3.2 Cooking fuels

Charcoal was the most commonly used fuel for cooking, followed by LPG and wood (Table 33). Note that very few households relied on electricity and kerosene as their main cooking fuel, implying these fuels tend to be used as a back-up supply. Most households used multiple fuels for cooking (Table 34). Of the 94% of respondents who did not use electricity for cooking, only 36% had some prior experience of cooking with electricity.

The combinations of cooking fuels used by respondents is shown in Table 35:

- Electricity was only used as a supplementary (backup) fuel.
- LPG was always the main fuel when used in conjuncture with electricity and kerosene.
- When charcoal was paired with LPG or wood, respondents were split over which was their main fuel. Otherwise charcoal was nearly always the main fuel.

[5] This was asked as multiple response question, so totals add up to more than 100%.



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

*Table 33 Cooking fuels*

| Fuel | Fuels used[6] | |
|---|---|---|
| | Frequency | Percent |
| Electricity | 12 | 5.6 |
| LPG | 102 | 47.7 |
| Biogas | 2 | 0.9 |
| Kerosene | 34 | 15.9 |
| Charcoal | 151 | 70.6 |
| Wood | 53 | 24.9 |
| Other | 1 | 0.5 |
| Total | | |

MOST HOUSEHOLDS USED MULTIPLE FUELS FOR COOKING (58%). CHARCOAL WAS THE MOST COMMON COOKING FUEL (70%), FOLLOWED BY LPG (50%) & WOOD (25%). ELECTRICITY (6%)& KEROSENE (16%) WERE USED BY SOME HOUSEHOLDS AS BACKUP FUELS.

*Table 34 Number of cooking fuels used*

| | Frequency | Valid Percent |
|---|---|---|
| 1 | 89 | 41.8 |
| 2 | 108 | 50.7 |
| 3 | 14 | 6.6 |
| 4 | 2 | 0.9 |
| Total | 213 | 100.0 |

OF THE 94% OF RESPONDENTS WHO DID NOT USE ELECTRICITY FOR COOKING, ONLY 36% HAD SOME PRIOR EXPERIENCE OF COOKING WITH ELECTRICITY.

[6] N.B. multiple response.


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*Table 35 Combinations of fuels used for cooking and main cooking fuel*

| | n | % | Main cooking fuel breakdown | | | |
|---|---|---|---|---|---|---|
| | | | LPG | Kerosene | Charcoal | Wood |
| LPG | 22 | 10.4 | 22 | - | - | - |
| Kerosene | 1 | 0.5 | - | 1 | - | - |
| Charcoal | 45 | 21.2 | - | - | 45 | - |
| Wood | 21 | 9.9 | - | - | - | 21 |
| Electricity & LPG | 7 | 3.3 | 7 | - | - | - |
| LPG & Kerosene | 10 | 4.7 | 10 | - | - | - |
| LPG & Charcoal | 47 | 22.2 | 21 | - | 26 | - |
| Biogas & Charcoal | 2 | 0.9 | - | - | 2 | - |
| Kerosene & Charcoal | 13 | 6.1 | - | 2 | 11 | - |
| Charcoal & Wood | 28 | 13.2 | - | - | 13 | 15 |
| Wood & Other | 1 | 0.5 | - | - | - | 1 |
| Electricity, LPG & Charcoal | 3 | 1.4 | 2 | - | 1 | - |
| LPG, Kerosene & Charcoal | 8 | 3.8 | 2 | - | 6 | - |
| LPG, Charcoal & Wood | 2 | 0.9 | - | - | 2 | - |
| Electricity, LPG, Kerosene & Charcoal | 1 | 0.5 | - | - | 1 | - |
| LPG, Kerosene, Charcoal & Wood | 1 | 0.5 | - | - | 1 | - |
| Total | 212 | 100 | 64 | 3 | 108 | 37 |


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

The cooking location within the household is split equally between indoors and outdoors (Table 36). Breaking location down by main cooking fuel shows how LPG and kerosene are generally used indoors (Table 37). There are a substantial number of respondents will cook charcoal and wood indoors too.

LPG & KEROSENE ARE ALMOST EXCLUSIVELY USED INDOORS, WHILST WOOD & CHARCOAL ARE USED BOTH INDOORS & OUTDOORS. THIS MAY SUGGEST THAT SOME HOUSEHOLDS ARE AWARE OF THE HEALTH IMPLICATIONS OF USING BIOMASS STOVES INDOORS, OR IT MAY SIMPLY BE THAT BIOMASS STOVE USERS, WHO ARE LIKELY TO BE POORER & THEREFORE HAVE SMALLER HOMES, HAVE LESS INDOOR SPACE TO COOK IN. UNLIKE DIRECT AC COOKING APPLIANCES, BATTERY-SUPPORTED STOVES CAN BE USED INDOORS OR OUTDOORS, SO THE COOK IS FREE TO CHOOSE WHERE THEY WANT TO COOK.

*Table 36 Cooking location (within the household)*

| | Frequency | Valid Percent |
|---|---|---|
| Indoors | 68 | 32.2 |
| Outdoors | 68 | 32.2 |
| Both | 75 | 35.5 |
| Total | 211 | 100.0 |

*Table 37 Cooking location broken down by main cooking fuels*

| Main cooking fuel | Cooking location | | | Total |
|---|---|---|---|---|
| | Indoors | Outdoors | Both | |
| Cylinder gas | 45 | 2 | 17 | 64 |
| Kerosene | 3 | 0 | 0 | 3 |
| Charcoal | 11 | 49 | 47 | 107 |
| Wood | 9 | 17 | 11 | 37 |
| Total | 68 | 68 | 75 | 211 |

### 4.3.3 Cooking devices

Among households in the sample, basic stoves are by far the most commonly used cooking device (Table 38). Gas burners are the next most common device. Note the relatively small number of households using improved stoves, and the absence of electric pressure cookers. Most households have two or three cooking devices (

Table 39). The devices used by households using only a single cooking device (Table 40) are consistent with their choice of cooking fuels (Table 35).


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

*Table 38 Number of households owning cooking devices*

| Device | Frequency | Percent |
|---|---|---|
| 3 stone fire | 65 | 30.4 |
| Basic stove (wood, charcoal etc.) | 166 | 77.6 |
| Improved biomass cookstove | 211 | 3.7 |
| single kerosene burner | 34 | 15.9 |
| Gas burner (portable) - single | 51 | 23.8 |
| Gas burner (portable) - double | 50 | 23.4 |
| Gas cooker (rings and oven) | 5 | 2.3 |
| Gas oven | 3 | 1.4 |
| Induction stove | 2 | 0.9 |
| Electric hotplate - 1 hob | 2 | 0.9 |
| Electric hotplate - 2 hob | 1 | 0.5 |
| Electric Cooker (rings and oven) | 2 | 0.9 |
| Electric oven | 2 | 0.9 |
| Electric water heater | 4 | 1.9 |
| Kettle | 1 | 0.5 |
| Microwave | 5 | 2.3 |
| Toaster | 0 | 0.0 |
| Rice cooker | 10 | 4.7 |
| Electric slow cooker | 0 | 0.0 |
| Electric multicooker (pressure cooker) | 0 | 0.0 |
| Other | 0 | 0.0 |

*Table 39 Number of cooking devices in the household*

| | Frequency | Percent |
|---|---|---|
| 0 | 1 | 0.5 |
| 1 | 74 | 34.6 |
| 2 | 99 | 46.3 |
| 3 | 28 | 13.1 |
| 4 | 8 | 3.7 |
| 5 | 2 | 0.9 |
| 6 | 1 | 0.5 |
| 7 | 1 | 0.5 |
| Total | 214 | 100.0 |

BASIC BIOMASS STOVES & LPG STOVES ARE THE MOST POPULAR COOKING DEVICES AMONGST PARTICIPANTS. VERY FEW PEOPLE OWN IMPROVED BIOMASS STOVES. ELECTRIC COOKING APPLIANCES ARE ALSO NOT COMMON, HOWEVER 5% OF RESPONDENTS OWN A RICE COOKER. RICE IS A MAJOR STAPLE IN COASTAL TANZANIA & COOKING RICE IN A RICE COOKER IS MUCH EASIER. IMPORTANTLY THOUGH, IT IS ALSO VERY ENERGY-EFFICIENT, CREATING A KEY OPPORTUNITY FOR BATTERY-SUPPORTED COOKING.



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

*Table 40 Number of households owning cooking devices – households with single device*

| Device | Frequency | Percent |
|---|---|---|
| 3 stone fire | 21 | 28.4 |
| Basic stove (wood, charcoal, dung etc.) | 37 | 50.0 |
| single kerosene burner | 1 | 1.4 |
| Gas burner (portable) - single | 5 | 6.8 |
| Gas burner (portable) - double | 10 | 13.5 |

TWO THIRDS OF THE SAMPLE (65%) REPORTED USING MULTIPLE COOKING DEVICES, WITH SOME HOUSEHOLDS REPORTING OWNING UP TO 7 DIFFERENT COOKING DEVICES!

The survey also asked about non-cooking electrical appliances; 12 households had fridges, and 4 had freezers but freezer owners all had fridges, so these probably represent fridge-freezers i.e. 5.6% of households had a refrigerator or fridge-freezer.

## 4.4 Fuel consumptions and costs

### 4.4.1 Electricity

All households with formal connections to the national grid (Table 17) have pre-paid meters; 46% have individual pre-paid meters and 54% have shared. Among households connected to a mini-grid, most have a type of tariff other than those listed in the survey (Table 41). Note that there are 3 more types of tariffs than mini grid users as 3 of these users are connected to 2 mini grids.

ALL HOUSHOLDS WITH FORMAL CONNECTIONS TO THE NATIONAL GRID HAVE PRE-PAID METERS. THIS CREATES A MUCH MORE DIRECT LINK BETEWEEN EXPENDITURES & COOKING PRACTICES, MEANING THAT PEOPLE ARE MUCH MORE LIKELY TO BE AWARE OF THE DIFFERENCE IN COST BETWEEN EFFICIENT & INEFFICIANT APPLIANCES.

*Table 41 Types of tariffs - mini-grid users*

| Tariff type | Frequency | Percent (n=19) |
|---|---|---|
| Flat rate | 4 | 21.1 |
| Block tariff | 2 | 10.5 |
| Time of use (peak and off peak) | 3 | 15.8 |
| Application (small business, household etc.) | 1 | 5.3 |
| Other | 9 | 47.4 |


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Table 42 shows how often respondents who use electricity as a cooking fuel tend to top up their prepaid electricity meter: monthly, or twice a month was the most common. The mean monthly expenditure for these respondents was 22,000 TZS (Table 43) and Figure 9 shows that 20,000 TZS was the most common amount respondents payed per month.

*Table 42 Frequency of topping up electricity meter*

| | Frequency | Percent |
|---|---|---|
| 7 | 1 | 8.3 |
| 14 | 3 | 25.0 |
| 15 | 2 | 16.7 |
| 20 | 1 | 8.3 |
| 21 | 1 | 8.3 |
| 30 | 4 | 33.3 |
| Total | 12 | 100.0 |

*Table 43 Monthly expenditure on electricity (TZS/month)*

| N | 12 |
|---|---|
| Mean | 22000 |
| Median | 20000 |
| Mode | 20000 |
| Std. Deviation | 9033.2 |
| 25th Percentile | 15714 |
| 75th Percentile | 28500 |

HOWEVER, HALF THE SAMPLE (54%) SHARE A METER. THIS IS PROBLEMATIC BECAUSE THESE ARE LIKELY TO BE THE POOREST CONSUMERS, BUT BY AGGREGATING THEIR BILLS, THEY ONLY RECEIVE A SINGLE LIFELINE TARIFF ALLOWANCE. WHAT IS MORE, IT IS MUCH MORE DIFFICULT FOR THEM TO SEE THE COST DIFFERENCE FOR COOKING WITH ENERGY-EFFICIENT APPLIANCES. THE EVIDENCE FROM THE FOCUS GROUPS SHOWS THAT SOME LANDLORDS/LADIES SIMPLY PROHIBIT THEIR TENNANTS FROM COOKING WITH ELECTRICIY ON THE PRESUMPTION THAT IT IS TOO EXPENSIVE.


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

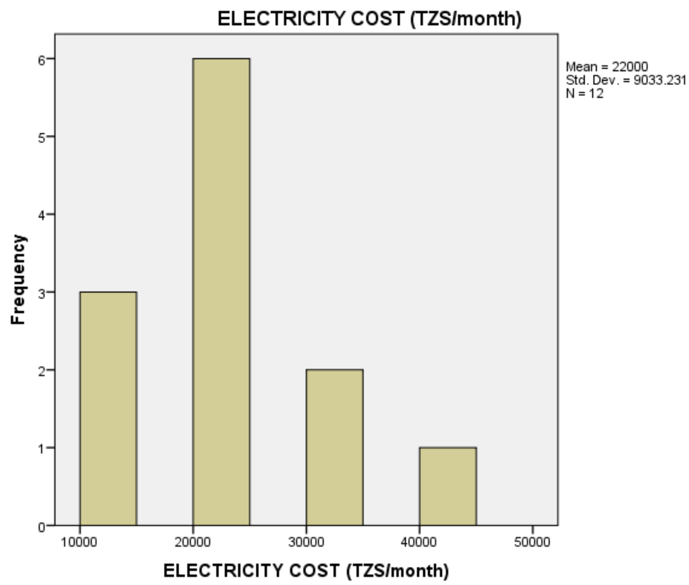


*Figure 9 Monthly expenditure on electricity (TZS/month)*

IT IS POSSIBLE TO TOP UP YOUR ELECTRICITY METER WITH JUST ENOUGH UNITS TO COOK A SINGLE MEAL, I.E. IN THE SAME WAY THAT MANY PEOPLE PAY FOR CHARCOAL. HOWEVER, NOBODY REPORTED ACTUALLY DOING THIS.

MOST RESPONDENTS (92%) REPORTED TOPPING UP THEIR ELECTRICITY METER EVERY 2-4 WEEKS. THIS MEANS THERE IS LIKELY TO BE A DISCONNECT BETWEEN WHAT PEOPLE SPEND ON ELECTRICITY & THEIR COOKING PRACTICES, AS CHANGING THE WAY YOU COOK WON'T HAVE AN EFFECT ON HOW MUCH YOU ARE SPENDING FOR SEVERAL WEEKS.

### 4.4.2 LPG

Respondents reported two different cylinder sizes: 14 kg (roughly 20,000 TZS) and around 30 kg (roughly 45,000 TZS). These do not correspond with standard cylinder sizes of 6gk and 15 kg[7]; however the prices paid for the 30 kg cylinders category are consistent with market prices for 15 kg cylinders:

> *"It should however be noted that, of recent especially in 2016, the prices of LPG appeared to be relatively lower than the equivalent usage quantity price of charcoal (example 1 sack of charcoal cost of TZS 40,000 -60,000 versus one 15 Kg cylinder of LPG cost of TZS 45,000 to 55,000)."*[8]

[7] http://www.esaja.com/lpg-gas/lpg-gas//p/?id1=23347

[8] http://www.ewura.go.tz/wp-content/uploads/2015/04/2017-PETROLEUM-REPORT-web.pdf


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

The weight of LPG cylinders is roughly equivalent to the weight of gas they contain, meaning that when people go to fill their cylinder, the scale used by the LPG dealer will be measuring approximately double the weight of gas it contains. For the purposes of calculating energy consumptions, it has been assumed that these two categories contain 6 kg, and 15 kg of gas respectively. 6kg was the most popular (Table 44). These sizes correlate strongly with price (r = 0.954, p<0.001) with the mean cost of LPG being 3250 TZS/kg (Table 45). The median monthly expenditure was 11,000 TZS/month – see Table 47. Most respondents get a refill every two months (Table 46).

*Table 44 Size of LPG cylinder refills*

| Size (kg) | Frequency | Valid Percent |
|---|---|---|
| 6 | 61 | 60 |
| 15 | 30 | 39.6 |
| Total | 99 | 100.0 |

*Table 45 Calculated unit price of LPG (TZS/kg)*

| Calculated unit price (TZS/kg) | Frequency | Valid Percent |
|---|---|---|
| 1333.33 | 1 | 1.0 |
| 2600.00 | 2 | 2.0 |
| 2666.67 | 3 | 3.0 |
| 2800.00 | 1 | 1.0 |
| 2866.67 | 4 | 4.0 |
| 3000.00 | 11 | 10.9 |
| 3066.67 | 2 | 2.0 |
| 3166.67 | 5 | 5.0 |
| 3200.00 | 1 | 1.0 |
| 3266.67 | 13 | 12.9 |
| 3333.33 | 40 | 39.6 |
| 3500.00 | 4 | 4.0 |
| 3583.33 | 3 | 3.0 |
| 3666.67 | 9 | 8.9 |
| 3833.33 | 1 | 1.0 |
| 4333.33 | 1 | 1.0 |
| Total | 101 | 100.0 |

MONTHLY MEAN EXPENDITURES ON FUELS AMONG RESPONDENTS WHO USED THEM FOR COOKING WERE:

- ELECTRICITY (COOKING & OTHER APPLICATIONS): 22,000 TZS (10 USD)
- LPG: 15,000 TZS (6.5 USD)
- KEROSENE: 9,400 TZS (4 USD)
- CHARCOAL: 24,000 TZS (10.5 USD)
- WOOD: 12,000 TZS (5 USD)

THESE EXPENDITURES SEEM LOW COMPARED TO EXPECTED ECOOK DISCOUNTED COSTS. HOWEVER, THEY SHOULD BE TREATED WITH CAUTION, AS LPG & CHARCOAL ARE MORE COMMONLY USED AS PRIMARY COOKING FUELS, WHILST KEROSENE & ELECTRCITY ARE MOST COMMONLY USED AS BACKUP. FUELS, IN PARTICULAR ELECTRICITY, ARE ALSO USED FOR OTHER APPLICATIONS IN ADDITION TO COOKING.


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

*Table 46 Period of time that LPG cylinder lasts for (weeks)*

| How long a cylinder lasts (weeks) | Frequency | Valid Percent |
|---|---|---|
| 3 | 1 | 1.0 |
| 4 | 13 | 12.7 |
| 5 | 1 | 1.0 |
| 6 | 5 | 4.9 |
| 7 | 4 | 3.9 |
| 8 | 36 | 35.3 |
| 9 | 11 | 10.8 |
| 10 | 2 | 2.0 |
| 12 | 14 | 13.7 |
| 14 | 2 | 2.0 |
| 16 | 9 | 8.8 |
| 18 | 1 | 1.0 |
| 20 | 2 | 2.0 |
| 21 | 1 | 1.0 |
| Total | 102 | 100.0 |

UNIT COSTS FOR EACH FUEL WERE:

- LPG: 3,250 TZS/KG (1.42 USD/KG)
- KEROSENE: 2,000 TZS/LITRE (0.87 USD/LITRE)
- CHARCOAL:
  - URBAN: 686 TZS/KG (0.3 USD/KG)
  - RURAL: 282 TZS/KG (0.12 USD/KG)
- WOOD (WHEN PURCHASED): 100 TZS/KG (0.04 USD/KG)

*Table 47 Monthly expenditure on LPG (TZS/month)*

| N | 101 |
|---|---|
| Mean | 15069 |
| Median | 11000 |
| Mode | 10000 |
| Std. Deviation | 9246.297 |
| 25th Percentile | 9900 |
| 75th Percentile | 20000 |


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

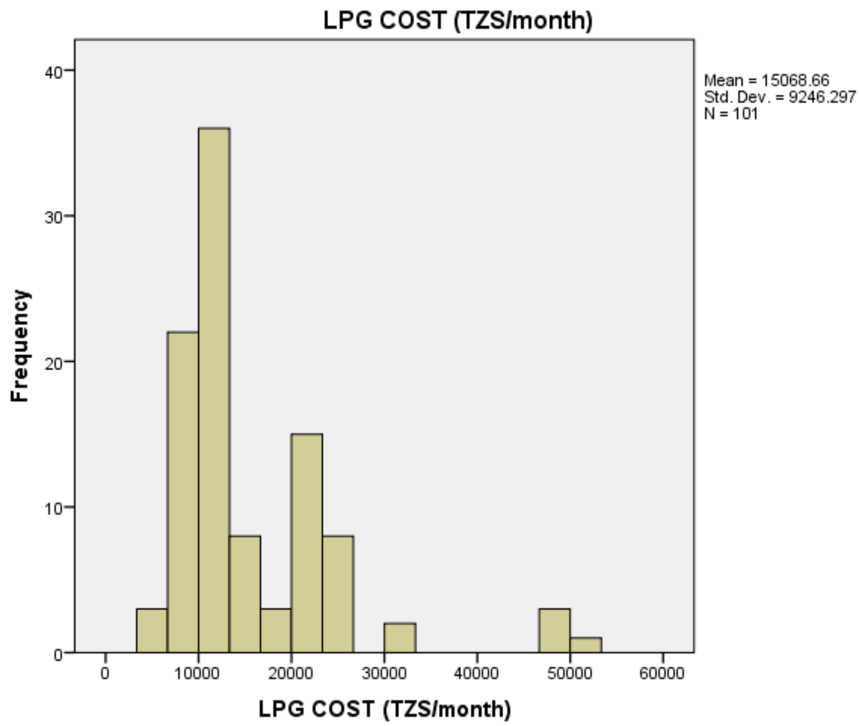


*Figure 10 Calculated unit price of LPG (TZS/kg)*

### 4.4.3 Kerosene

Only those respondents who used kerosene for cooking were asked for details on their consumption of kerosene. The mean cost of kerosene was calculated to be around 2000 TZS/Litre (Table 48Table 45). The price spent per month correlated well with the amount used each month (r = 0.866, p<0.001), indicating that the given prices were roughly accurate. Most kerosene users consume around 4 litres/month (Table 49). The median monthly expenditure was 9000 TZS/month (Table 50).

*Table 48 Calculated unit price of kerosene (TZH/Litre)*

| | Frequency | Valid Percent |
|---|---|---|
| 1200.00 | 1 | 2.9 |
| 1400.00 | 1 | 2.9 |
| 1666.67 | 4 | 11.8 |
| 1714.29 | 3 | 8.8 |
| 1800.00 | 4 | 11.8 |
| 2000.00 | 13 | 38.2 |
| 2200.00 | 2 | 5.9 |
| 2250.00 | 4 | 11.8 |
| 2400.00 | 1 | 2.9 |
| 3000.00 | 1 | 2.9 |
| Total | 34 | 100.0 |


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

*Table 49 Amount of kerosene used each month (Litres/month)*

| | Frequency | Valid Percent |
|---|---|---|
| 1 | 1 | 2.9 |
| 2 | 2 | 5.9 |
| 3 | 2 | 5.9 |
| 4 | 10 | 29.4 |
| 5 | 8 | 23.5 |
| 6 | 6 | 17.6 |
| 7 | 2 | 5.9 |
| 9 | 2 | 5.9 |
| 10 | 1 | 2.9 |
| Total | 34 | 100.0 |

*Table 50 Monthly expenditure on kerosene (TZS/month)*

| N | 34 |
|---|---|
| Mean | 9405.88 |
| Median | 9000.00 |
| Mode | 9000 |
| Std. Deviation | 3384.630 |
| 25th Percentile | 7800.00 |
| 75th Percentile | 12000 |

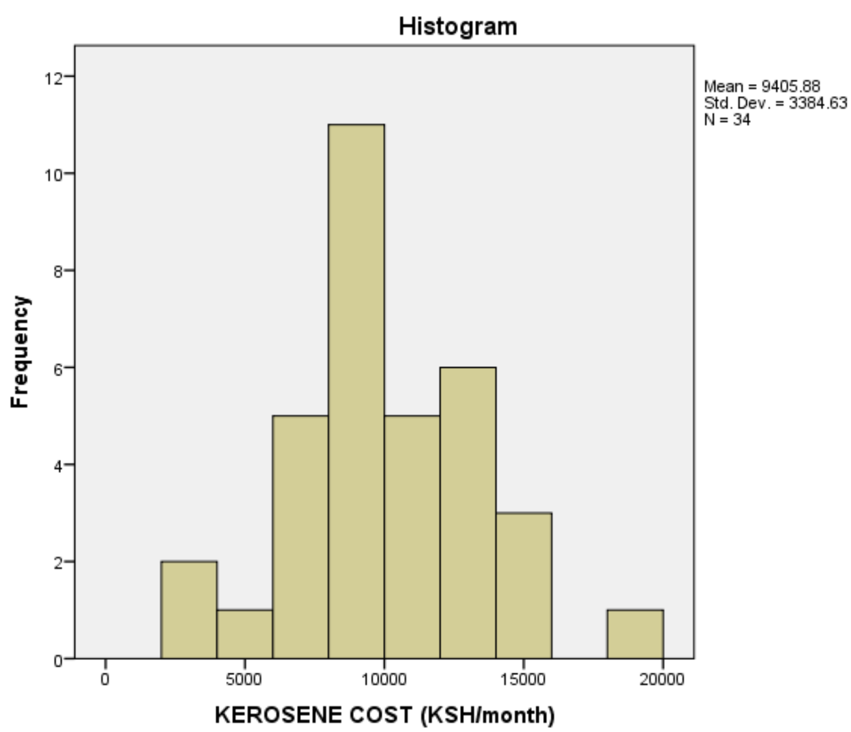


*Figure 11 Calculated unit price of kerosene (TZS/kg)*


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

### 4.4.4 Charcoal

Only those respondents who used charcoal as a cooking fuel were asked for details of their consumption of charcoal. Charcoal consumption is difficult to assess because people buy it in a wide variety of measures e.g. bag, bucket, sack. Many respondents have estimated the amount of charcoal in kg, and others have described the measure used; estimated capacities of these measures are given in Table 51.

*Table 51 Estimated capacity of charcoal measures*

| | Kg |
|---|---|
| bag | 25 |
| sack | 25 |
| Large sack | 50 |
| Small bucket | 4 |
| Large bucket | 15 |
| plastic bag | 2.5 |

THERE IS A GENERALY TREND FOR SOME ELECTRICITY & GAS USERS PLUS SOME CHARCOAL & WOOD USERS TO PURCHASE ENOUGH FOR 2-4 WEEKS HOWEVER, 20% OF CHARCOAL USERS, LIKELY THE POOREST, BUY JUST ENOUGH FOR A FEW DAYS.

Charcoal is most commonly bought in 25 kg and 15 kg amounts (corresponding to sacks and buckets respectively – see Table 52) however a substantial number of respondents, 20%, buy charcoal in small amounts (less than 5 kg). There are huge differences in the prices paid for charcoal between rural and urban areas (see Table 53). The range of specific prices was much higher in urban areas with a mean of 686 TZS/kg compared to 282 TZS/kg in rural areas. Almost a third of charcoal users buy charcoal on a monthly basis, but nearly 20% buy small amounts every 2-3 days (Table 54).

*Table 52 How much charcoal (kg)*

| | Frequency | Valid Percent |
|---|---|---|
| 1 | 1 | 1.0 |
| 2 | 5 | 4.8 |
| 2 | 4 | 3.8 |
| 3 | 3 | 2.9 |
| 4 | 6 | 5.7 |
| 5 | 2 | 1.9 |
| 8 | 2 | 1.9 |
| 15 | 28 | 26.7 |
| 20 | 4 | 3.8 |
| 25 | 44 | 41.9 |
| 30 | 2 | 1.9 |
| 45 | 1 | 1.0 |
| 50 | 2 | 1.9 |
| 100 | 1 | 1.0 |
| Total | 105 | 100.0 |


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

*Table 53 Calculated price of charcoal (TZS/kg)*

| | Urban (n=85) | Rural (n=20) |
|---|---|---|
| Mean | 686 | 282 |
| Median | 600 | 220 |
| Mode | 600 | 100 |
| Std. Deviation | 186.547 | 231.222 |
| 25th Percentile | 600 | 100 |
| 75th Percentile | 800 | 394 |

*Table 54 Period of time that charcoal lasts for (days)*

| | Frequency | Valid Percent |
|---|---|---|
| 1 | 8 | 5.3 |
| 2 | 26 | 17.2 |
| 3 | 9 | 6.0 |
| 4 | 5 | 3.3 |
| 5 | 5 | 3.3 |
| 6 | 3 | 2.0 |
| 7 | 9 | 6.0 |
| 8 | 1 | .7 |
| 9 | 1 | .7 |
| 10 | 3 | 2.0 |
| 14 | 6 | 4.0 |
| 15 | 4 | 2.6 |
| 20 | 10 | 6.6 |
| 21 | 2 | 1.3 |
| 25 | 2 | 1.3 |
| 30 | 44 | 29.1 |
| 40 | 3 | 2.0 |
| 42 | 1 | .7 |
| 45 | 3 | 2.0 |
| 50 | 1 | .7 |
| 60 | 4 | 2.6 |
| 90 | 1 | .7 |
| Total | 151 | 100.0 |

*Table 55 Monthly expenditure on charcoal (TZS/month)*

| N | 151 |
|---|---|
| Mean | 24343 |
| Median | 17143 |
| Mode | 15000 |
| Std. Deviation | 19594.278 |
| 25th Percentile | 12857 |
| 75th Percentile | 30000 |



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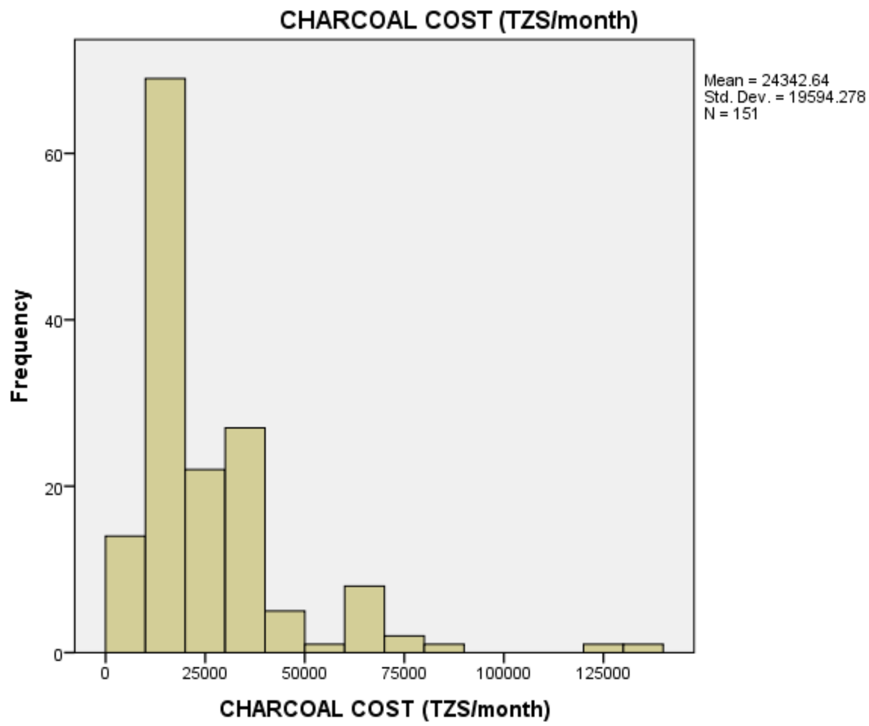


*Figure 12 Calculated unit price of charcoal (TZS/kg)*

### 4.4.5 Wood

Only those respondents who used wood for cooking were asked for details of their consumption of wood. 90% of respondents that used wood for cooking were in rural areas. Units of wood included:

- Bundle
- Bundle carried by hand
- Large bundle (carried by hand cart)
- Large bucket

No indication was given of the mass of wood associated with these units, so it was assumed that a bundle was roughly 10kg. Every respondent collects their own wood and it takes 2-3 hours to do so – see Table 56. On top of this, 48% of respondents also buy wood and the most common price paid is 100TZS/kg (Table 57). Nearly all respondents who bought wood did so at least once a week, whereas those who gathered wood (i.e. those who paid nothing) tended to gather enough to last longer (Table 58). It costs those who sometimes buy their wood a mean average of 10,000 TZS/month (Table 59).

*Table 56 How long does it take to collect wood (kg)*

| | Frequency | Valid Percent |
|---|---|---|
| 1 | 4 | 7.5 |
| 2 | 15 | 28.3 |
| 3 | 24 | 45.3 |
| 4 | 8 | 15.1 |
| 5 | 1 | 1.9 |
| Total | 52 | 100.0 |

*Table 57 Calculated price of wood (TZS/kg)*

| | Frequency | Valid Percent |
|---|---|---|
| 0 | 27 | 64.3 |
| 50.00 | 1 | 2.4 |
| 100.00 | 9 | 21.4 |
| 120.00 | 1 | 2.4 |
| 150.00 | 1 | 2.4 |
| 200.00 | 1 | 2.4 |
| 300.00 | 2 | 4.8 |
| Total | 42 | 100 |

*Table 58 Period of time that wood lasts for (days)*

| | Purchased | | Collected | |
|---|---|---|---|---|
| | Frequency | Valid percent | Frequency | Valid percent |
| 1 | 5 | 20 | 0 | 0 |
| 2 | 2 | 8 | 1 | 3.7 |
| 3 | 7 | 28 | 3 | 11.1 |
| 4 | 1 | 4 | 3 | 11.1 |
| 5 | 4 | 16 | 5 | 18.5 |
| 6 | 1 | 4 | 0 | 0 |
| 7 | 2 | 8 | 2 | 7.4 |
| 8 | 1 | 4 | 1 | 3.7 |
| 10 | 0 | 0 | 3 | 11.1 |
| 12 | 0 | 0 | 1 | 3.7 |
| 14 | 1 | 4 | 4 | 14.8 |
| 15 | 0 | 0 | 1 | 3.7 |
| 30 | 1 | 4 | 3 | 11.1 |
| Total | 25 | 100 | 27 | 100 |


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

*Table 59 Monthly expenditure on wood (TZS/month)*

| N | 25 |
|---|---|
| Mean | 12197 |
| Median | 10000 |
| Mode | 15000 |
| Std. Deviation | 7682.593 |
| 25th Percentile | 6500 |
| 75th Percentile | 15000 |

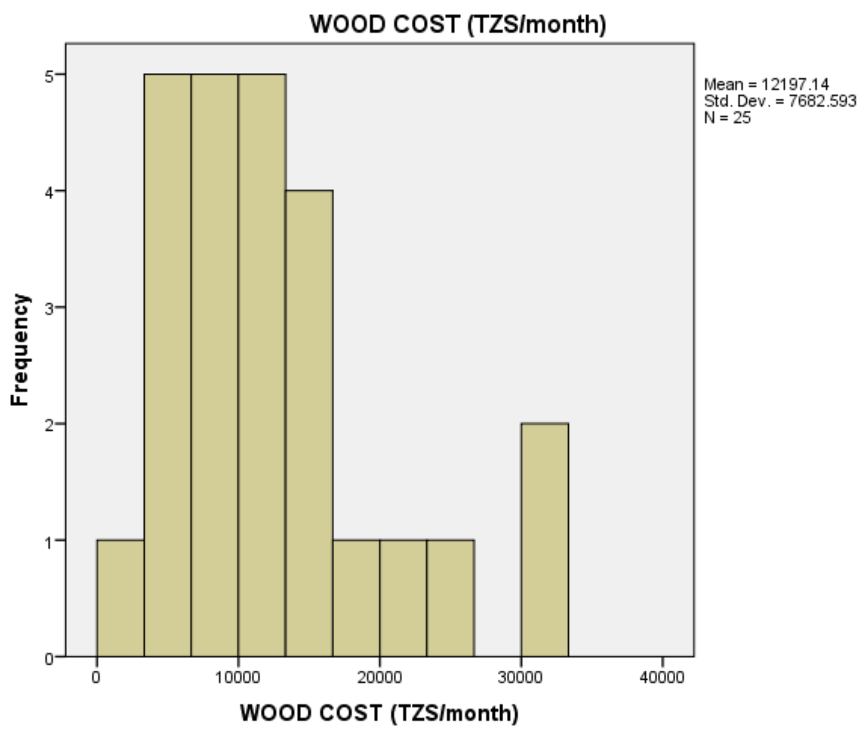


*Figure 13 Calculated unit price of wood (TZS/kg)*


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### 4.4.6 Energy consumptions

Energy consumptions have been based on the calorific values given in Table 60. Electrical energy consumptions were calculated from monthly electricity costs based on the D1 monthly electricity tariffs published by TANESCO[9]:

- 0-75 kWh 100 TZS/kWh
- > 75 kWh 350 TZS/kWh

*Table 60 Calorific values and conversion efficiencies[10]*

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

Figure 14 presents the total energy consumed in a month by all respondents in each settlement grouping (i.e. the urban sample is roughly three times the size of the rural sample). This shows that energy content of wood and charcoal consumed is similar in rural areas, but charcoal is the dominant energy source in urban areas. It is worth noting that while it can be assumed that wood, charcoal and LPG are used only for cooking, it is quite likely that kerosene will be used for lighting as well as cooking. Similarly, electricity will be used for a range of other uses.

CHARCOAL IS THE DOMINANT ENERGY SOURCE IN URBAN AREAS, WHILST IN RURAL AREAS IT IS SPLIT BETWEEN CHARCOAL & WOOD. HOWEVER, THIS MASKS THE FACT THAT FAR MORE BIOMASS FUEL IS NEEDED TO DELIVER THE COOKING SERVICE, AS MUCH OF IT IS WASTED DURING THE COOKING PROCESS.

[9] http://www.tanesco.co.tz/index.php/customer-service/tariffs

[10] 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.

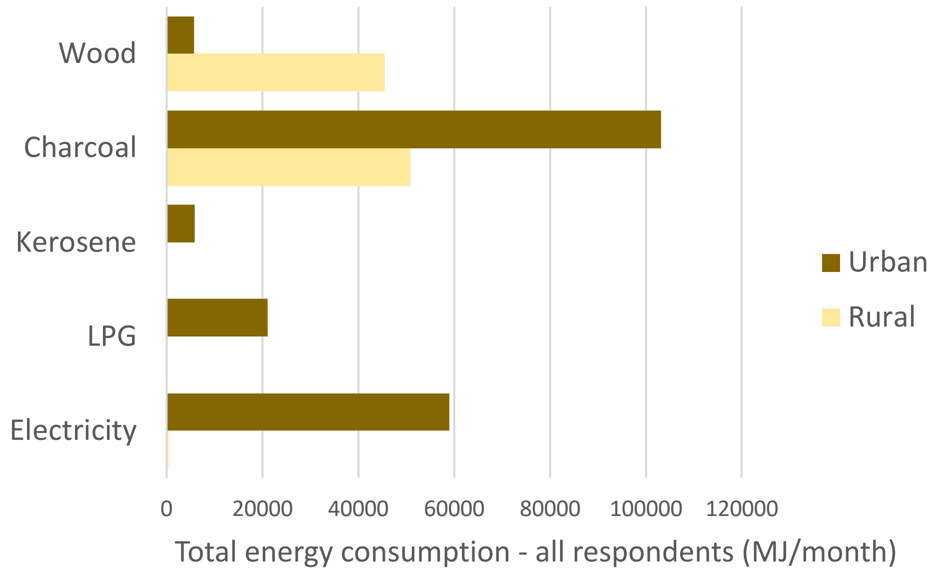


*Figure 14 Energy consumptions*

Energy consumptions have been divided by the number of household members to arrive at estimates of per capita energy consumptions for each fuel. Results in Figure 15 shows that, among respondents who use these fuels for cooking, specific consumption of electricity and LPG is similar among rural and urban respondents. However, rural users appear to use substantially more wood and charcoal.

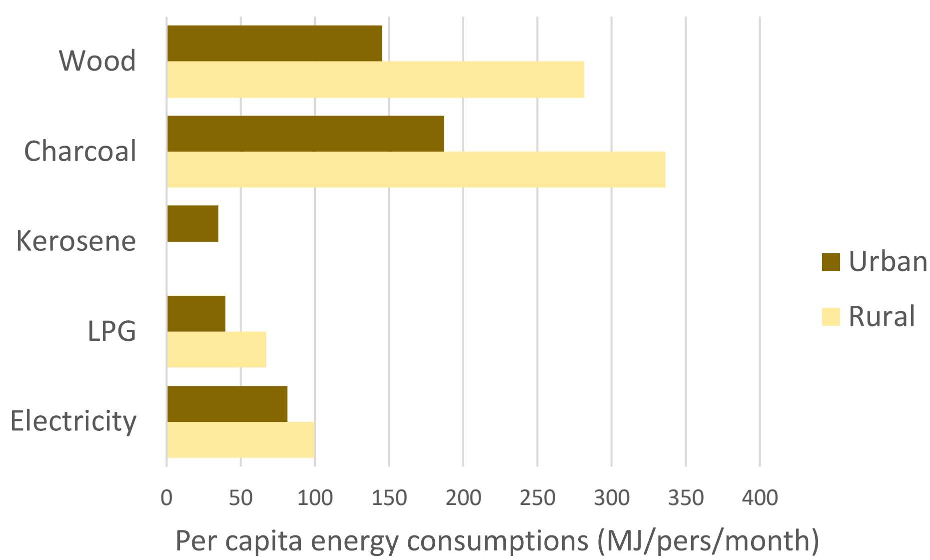


*Figure 15 Per capita energy consumptions (valid users)*


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It has already been pointed out that each of these fuels may be used for purposes other than cooking. Therefore, when calculating the total monthly expenditure on fuel, households that also use their fuel for space heating were ignored (n=12) as it requires a substantial amount of energy to heat a room compared to other uses such as lighting. Figure 16 shows the price paid for fuel each month for cooking and water heating against the percentage of respondents who pay that amount. So about 50% of the respondents spend less than 4000 TZS a month.

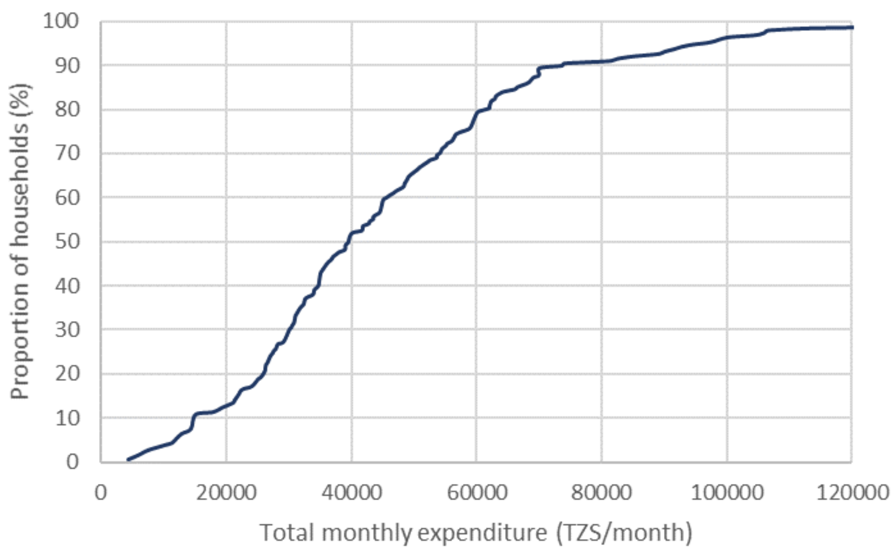


*Figure 16 Total monthly expenditure on all fuels (TZS/month)*


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## 4.5 Beliefs and attitudes

### 4.5.1 Perceptions on fuels

Figure 17 indicates that respondents regard wood as being the hardest to access which is unsurprising considering over 70% of respondents live in urban areas. 80% of respondents thought charcoal was the easiest fuel to get hold of followed by LPG and kerosene. While LPG was widely considered to be the safest fuel (Figure 18), respondents felt strongest about wood with half of respondents believing it is very safe. (N.B. electricity was not included in these questions)

LPG WAS WIDELY CONSIDERED TO BE THE SAFEST FUEL.

A further set of questions on various aspects of different fuels provide further insights (see Figure 19):

CHARCOAL IS REGARDED AS CONVENIENT WHEREAS FIREWOOD WAS NOT. 80% OF RESPONDENTS THOUGHT THAT WOOD IT IS A BURDEN TO COLLECT.

- Respondents agreed that smoke is harmful to health with wood smoke being more harmful than charcoal. A small majority also believes that smoke is good for repelling insects.
- Charcoal is regarded as convenient whereas firewood was not (N.B. these two questions were asked in opposite senses). 80% of respondents thought that wood it is a burden to collect.
- Electricity, LPG and wood were all considered to be expensive, however more respondents disagreed that LPG is expensive than the other 2 fuels.

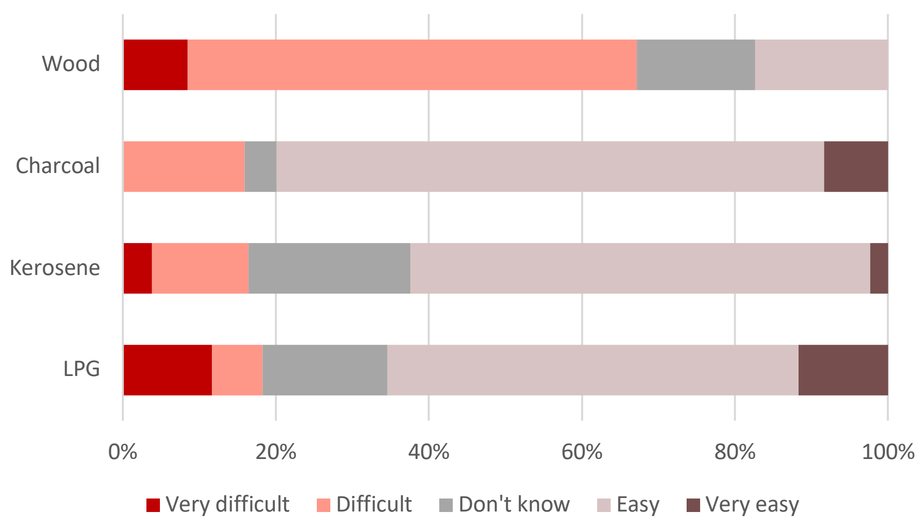


*Figure 17 Ease of access to fuels*


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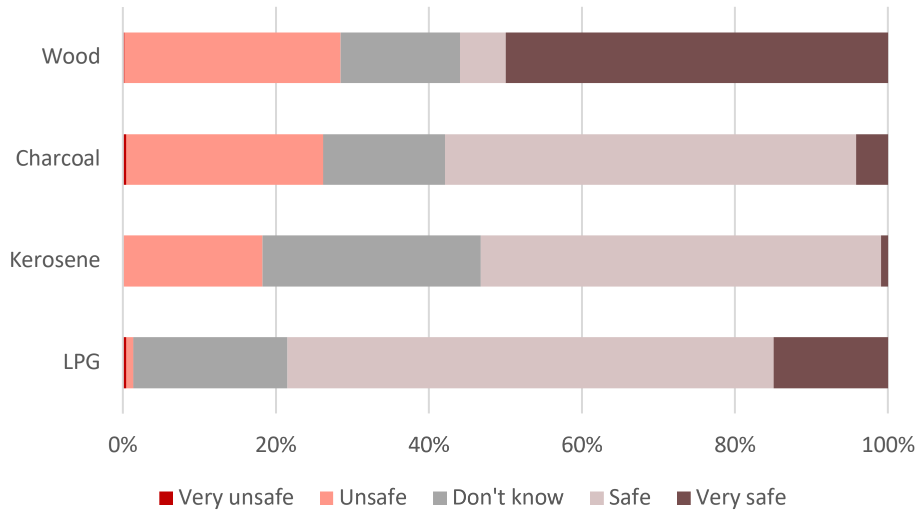


*Figure 18 Safety of fuels*

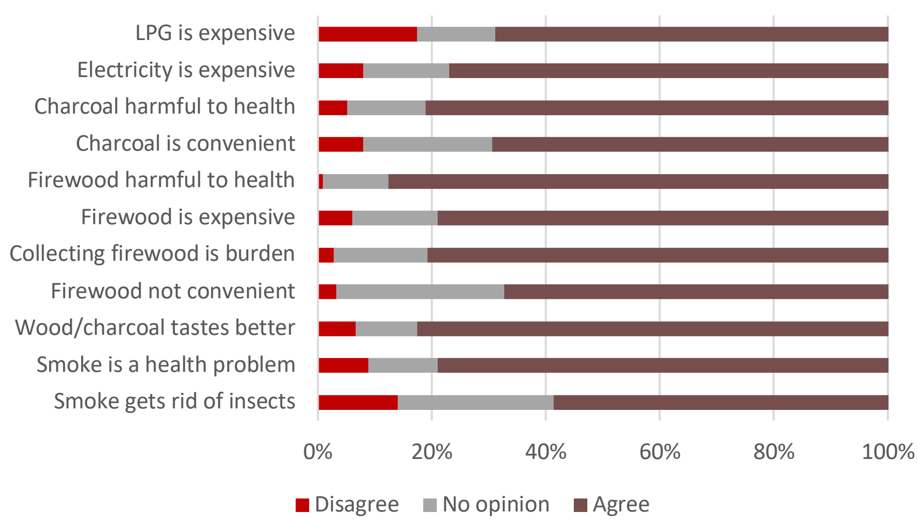


*Figure 19 Perceptions of fuels*

RESPONDENTS AGREED THAT SMOKE IS HARMFUL TO HEALTH WITH WOOD SMOKE BEING MORE HARMFUL THAN CHARCOAL. CHARCOAL USERS BELIEVE THAT THE SMOKE FROM A CHARCOAL FIRE IS SAFE COMPARED TO LPG AND WOOD USERS. THE SAME IS TRUE FOR WOOD USERS ABOUT WOOD SMOKE. WOOD USERS ALSO FELT THE STRONGEST ABOUT SMOKE BEING GOOD FOR CHASING INSECTS AWAY.


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Mean attitude scores have been calculated for groups of respondents that use either LPG, charcoal or wood as their main cooking fuel (Table 61). Electricity and kerosene were not included in this table as there were only 3 respondents who use kerosene as their main cooking fuel and none who use electricity. The following relationships can be seen:

- Wood users find difficult to access LPG or kerosene which is unsurprising as 90% of them live in rural areas. LPG users do not find it as easy to access charcoal as charcoal and wood users. Both LPG and charcoal users find it hard to get hold of wood.
- While LPG is generally regarded as a safe fuel, LPG and charcoal users considered it much safer than wood users, suggesting that negative perceptions on safety act as a barrier to use of LPG, especially in rural areas. LPG and charcoal users also regarded kerosene and charcoal as safe fuels whereas they did not think wood was.
- Charcoal users believe that the smoke from a charcoal fire is safe compared to LPG and wood users. The same is true for wood users about wood smoke. Wood users also felt the strongest about smoke being good for chasing insects away.
- Charcoal and wood users found LPG to be more expensive than LPG users did. They also thought that charcoal was more convenient compared to LPG users.
- Strangely, wood users thought that wood was more inconvenient to collect than LPG or charcoal users did. This could have been because LPG and charcoal users are unaware of how long it might take, or they were assuming that they would collect it from a market rather than from felling down trees.


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*Table 61 Attitudes by choice of main cooking fuel (mean values)*

| | Range | What is your MAIN cooking fuel? | | | K-W |
|---|---|---|---|---|---|
| | | LPG (64) | Charcoal (108) | Wood (37) | P value |
| How easy is it to access LPG? | -2 to +2 | 1.08 | 0.70 | -1.19 | <0.001 |
| How easy is it to access kerosene? | -2 to +2 | 0.58 | 0.61 | -0.39 | <0.001 |
| How easy is it to access charcoal? | -2 to +2 | 0.34 | 0.94 | 0.78 | <0.001 |
| How easy is it to access wood? | -2 to +2 | -0.95 | -0.62 | 0.22 | <0.001 |
| How safe is LPG? | -2 to +2 | 1.08 | 0.92 | 0.68 | 0.003 |
| How safe is kerosene? | -2 to +2 | 0.52 | 0.41 | -0.08 | <0.001 |
| How safe is charcoal? | -2 to +2 | 0.28 | 0.64 | -0.38 | <0.001 |
| How safe is wood? | -2 to +2 | -0.49 | -0.41 | -0.54 | 0.431 |
| Smoke from stove is good at chasing insects away. | -1 to +1 | 0.34 | 0.45 | 0.76 | 0.006 |
| Smoke from cooking fuels is a big health problem. | -1 to +1 | 0.63 | 0.75 | 0.78 | 0.301 |
| food tastes better when cooked with charcoal/wood | -1 to +1 | 0.62 | 0.83 | 0.81 | 0.112 |
| Cooking with firewood is not convenient. | -1 to +1 | 0.59 | 0.65 | 0.73 | 0.323 |
| Collecting and preparing firewood is (or would be) a burden for my family. | -1 to +1 | 0.67 | 0.79 | 0.92 | 0.022 |
| Firewood is expensive for cooking. | -1 to +1 | 0.80 | 0.72 | 0.68 | 0.940 |
| Cooking with firewood is harmful to health. | -1 to +1 | 0.98 | 0.82 | 0.81 | 0.007 |
| Charcoal is convenient to use for cooking. | -1 to +1 | 0.34 | 0.79 | 0.68 | <0.001 |
| Cooking with charcoal is harmful to health. | -1 to +1 | 0.87 | 0.69 | 0.81 | 0.046 |
| Electricity is expensive for cooking. | -1 to +1 | 0.66 | 0.71 | 0.70 | 0.789 |
| LPG is expensive for cooking. | -1 to +1 | 0.22 | 0.64 | 0.65 | 0.017 |

## 4.5.2 Purchasing preferences

The responsibility of purchasing substantial household items is split relatively evenly between the genders when purchasing of a cooking device. This was less true in the case of buying a solar panel, the responsibility fell more with the men (men would be involved in 95% of cases, compared with involvement of women in 83% of cases) – see Table 62. Having said this, in both cases it would have been a joint decision more than three quarters of the time.


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*Table 62 Main decision maker for hypothetical household purchases*

| | Cooking device | | Solar panel | |
|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent |
| male head of house | 21 | 9.8 | 37 | 17.3 |
| female head of house | 27 | 12.6 | 10 | 4.7 |
| joint decision | 165 | 77.1 | 166 | 77.6 |
| another relative | 1 | .5 | 1 | .5 |
| Total | 214 | 100.0 | 214 | 100.0 |

RESPONES SUGGEST THAT PURCHASING DECISIONS ARE GENERALLY MADE TOGETHER, BOTH FOR COOKING & POWER GENERATION EQUIPMENT.

A clear majority of respondents felt positively about the idea of renting equipment rather than buying it – see Table 63. When making high value purchases, most respondents (84%) would prefer to pay in monthly instalments than up front. If the respondents were to be paying for a purchase in instalments, 62% would prefer to pay every 3 months as oppose to weekly or monthly.

*Table 63 How would people in your neighbourhood feel about the idea of renting equipment?*

| | Frequency | Percent |
|---|---|---|
| Very opposed | 7 | 3.3 |
| Opposed | 12 | 5.6 |
| No opinion | 20 | 9.3 |
| Positive | 160 | 74.8 |
| Very positive | 15 | 7.0 |
| Total | 214 | 100.0 |

THE MAJORITY OF PARTICIPANTS (82%) FELT POSITIVELY ABOUT RENTING EQUIPMENT & USING A COOKER PROVIDED BY THE UTILITY (80%), WHICH WILL LIKLELY RESULT IN THE LOWEST MONTHLY COST, AS THIS MODEL HAS THE LONGEST REPAYMENT HORIZON.

### 4.5.3 Cooking device preferences

Overall, there appears to be a strong appetite from respondents for cooking with some form of modern energy if the cost the same as the current fuel (see Table 64).

*Table 64 How many people would switch to modern energy (gas/electric) if fuels cost were the same*

| | Frequency | Percent |
|---|---|---|
| a few people | 2 | .9 |
| some people | 18 | 8.4 |
| many people | 188 | 87.9 |
| Don't know | 6 | 2.8 |
| Total | 214 | 100.0 |


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On details of any proposed design, three quarters of respondents felt there was a need for a device to accommodate very large pots as well as medium sized ones. There was a preference for the square and circular designs (44% voted for design A, 41% for design B, and 15% for design C in Figure 20). There was strong support (almost 80% positive) for the idea of using cooking appliances being provided by the electricity utility company (see Table 65).

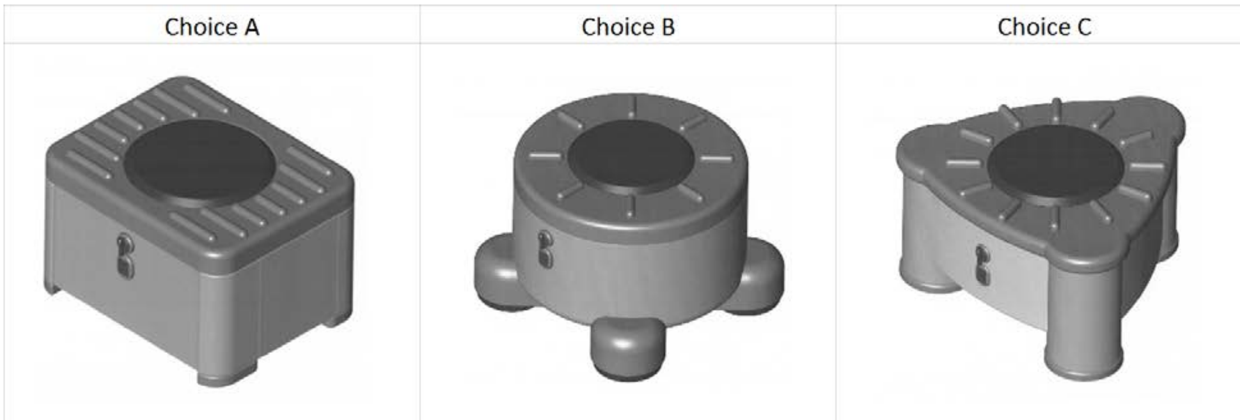


*Figure 20 Hypothetical cooking device design options*

*Table 65 How would you feel about using cooking appliances provided by the electricity utility?*

| | Frequency | Percent |
|---|---|---|
| Very opposed | 5 | 2.3 |
| Opposed | 10 | 4.7 |
| No opinion | 9 | 4.2 |
| Positive | 159 | 74.3 |
| Very positive | 31 | 14.5 |
| Total | 214 | 100 |

ALMOST ALL INDICATED A PREFERENCE FOR PAYING FOR HIGH VALUE ITEMS IN INSTALLMENTS. THE MAJORITY (62%) INDICATED THAT QUARTERLY REPAYMENTS WERE PREFERABLE TO MONTHLY, OR WEEKLY. HOWEVER, THIS MAY BE A STRETCH FOR THE 20% OF CHARCOAL USERS WHO BUY FUEL EVERY FEW DAYS.


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## 4.6 Consumer preferences

### 4.6.1 Interpreting the results

Discrete choice modelling was used as a means of exploring the key characteristics (or parameters) that cooking devices should have in order to find ready acceptance with consumers. Choice models are set up using choice cards, based on the key parameters identified, each of which has a limited number of 'levels'. The respondent must then choose one of the two cards presented. Discrete choice models predict the probability that an individual will choose an option, based on the levels of each parameter given in the option.

Three sets of choices were posed to respondents, representing different aspects of cooking device design:

- Cooking processes – boiling and frying, speed (power), use of lid, number of hobs
- Stove – capacity, smoke emissions, portability and looks
- Additional functionality – lights, mobile phone charging, TV, financing options, ability to clean.

The two main figures to look for in the results tables in the following sections are the beta coefficients (B), which reflect the strength of preference for each attribute, and whether each coefficient is significant in the model (Sig). If a variable is significant (Sig<0.05), then the larger the B value (positive or negative), the more important it is in the making a choice.

Other statistics presented include the standard error (S.E.), which is a measure of how precise the beta value is likely to be – a large standard error means that that the actual beta value may lie within a wider range. The odds ratio (Exp(B)) is the change in odds resulting from a unit change in the predictor variable and is another measure of the influence the variable has on people's choice, as is the Wald statistic. As all variables have been separated out into dichotomous dummy variables, the degrees of freedom (df) for all variables is 1.

Where the cost variable is significant in a model, a measure of willingness to pay (also known as implicit price) can be derived for each attribute from the ratio of the coefficients (Hanley, Mourato and Wright, 2001):

$$WTP = \frac{-\beta_x}{\beta_c}$$

where:

$\beta_x$ = coefficient of any parameter

$\beta_c$ = coefficient of cost parameter



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### 4.6.2 Discrete choice modelling results

#### *4.6.2.1 Cooking processes*

The variables used in the analysis are:

CPCooking:

0 = boil only

1 = boil & fry

CPSpeedMed

0 = slow

1 = normal

CPSpeedfast

0 = slow

1 = fast

CPFlavour

0 = no smoky flavour

1 = smoky flavour

CPPotlid

0 = no lid

1 = pot with lid

CPPot sealed

0 = no lid

1 = sealed pot

CP2hob:

0 = 1 hob

1 = 2 hob

CP4hob:

0 = 1 hob

1 = 4 hob

THE COOKING PROCESS DESIGN FEATURES THAT APPEAR TO BE MOST IMPORTANT TO CONSUMERS ARE:

- TASTE – THERE WAS A CLEAR PREFERENCE FOR A DEVICE THAT DOES NOT MAKE FOOD TASTE SMOKY.
- POWER – PEOPLE PREFERRED A DEVICE THAT WOULD BOIL FAST (COMPARED TO SLOW), BUT THERE WAS NO PREFERENCE FOR A MEDIUM POWERED DEVICE THAT WOULD BOIL A BIT MORE RAPIDLY THAN A SLOW DEVICE.
- COOKING – PREFER TO BE ABLE TO BOTH BOIL AND FRY
- COST – PREFERENCE FOR LOW COST DEVICE.

Results from the binary logistic regression are presented in Table 66.

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*Table 66 Binary logistic regression – cooking processes*

| | | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|---|
| Step 1[a] | CPCooking(1) | .275 | .117 | 5.513 | 1 | .019 | 1.316 |
| | CPSpeedMed(1) | .218 | .146 | 2.236 | 1 | .135 | 1.244 |
| | CPSpeedFast(1) | 1.101 | .133 | 68.272 | 1 | .000 | 3.007 |
| | CPFlavour(1) | -1.420 | .129 | 121.059 | 1 | .000 | .242 |
| | CPPotLid(1) | .277 | .186 | 2.220 | 1 | .136 | 1.319 |
| | CPPotSealed(1) | .076 | .144 | .276 | 1 | .599 | 1.079 |
| | CP2hob(1) | -.038 | .134 | .081 | 1 | .776 | .963 |
| | CP4hob(1) | .203 | .159 | 1.631 | 1 | .202 | 1.225 |
| | CPCOSTC | -.416 | .028 | 219.491 | 1 | .000 | .660 |
| | Constant | 2.086 | .214 | 95.316 | 1 | .000 | 8.050 |

Note: Compared against a constant only model, the model was significant ($\chi^2$ = 521, p < 0.001, with df = 9); Nagelkerke $R^2$ = 0.199. Prediction success = 62.1%.

Those design features that appear to be most important to consumers are (see Table 67 for estimates of willingness to pay):

- Taste – there was a clear preference for a device that does not make food taste smoky.
- Power – people preferred a device that would boil fast (compared to slow), but there was no preference for a medium powered device that would boil a bit more rapidly than a slow device.
- Cooking – prefer to be able to both boil and fry
- Cost – preference for low cost device.

ELECTRIC PRESSURE COOKERS (EPCS) SEEM WELL MATCHED WITH TANZANIAN CONSUMER PREFERENCES, AS THEY CAN BOIL & FRY, WITH THE BOILING PART ROUGHLY TWICE AS FAST AS CONVENTIONAL POTS.

*Table 67 Willingness to pay for priority characteristics - cooking process*

| Feature | WTP (TZS) |
|---|---|
| Smokey flavour | -34,100 |
| High power (fast boiling) | 26,500 |
| Boil and fry | 6,600 |



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*4.6.2.2 Stove*

The variables used in the analysis are:

STPeople6:

0 = cooks for 4 people

1 = cooks for 6 people

STPeople8:

0 = cooks for 4 people

1 = cooks for 8 people

STSupplementAll

0 = always need to use with other stove

1 = you can do all your cooking on it

STWoodSmoke

0 = no smoke

1 = gives same smoke as wood fire

STCharcoalSmoke

0 = no smoke

1 = gives same smoke as charcoal fire

STPortable

0 = cannot be moved (too heavy)

1 = can be carried in/out of the house

STLooks

0 = looks plain

1 = Looks good

THE MOST IMPORTANT STOVE FEATURES ARE:

- SMOKE – PEOPLE WOULD PREFER A DEVICE THAT AVOIDS GENERATING ANY KIND OF SMOKE ESPECIALLY WOOD SMOKE.
- CAPACITY – PEOPLE WANT TO BE ABLE TO COOK FOR LARGER NUMBERS OF PEOPLE (8 PEOPLE).
- LOW COST.



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

Results from the binary logistic regression are presented in Table 68.

*Table 68 Binary logistic regression – stove design*

| | | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|---|
| Step 1[a] | STPeople6(1) | .079 | .146 | .293 | 1 | .588 | 1.082 |
| | STPeople8(1) | .464 | .130 | 12.755 | 1 | .000 | 1.591 |
| | STSupplementAll(1) | -.030 | .148 | .042 | 1 | .838 | .970 |
| | STWoodSmoke(1) | -1.865 | .161 | 134.596 | 1 | .000 | .155 |
| | STCharcoalSmoke(1) | -.964 | .158 | 37.290 | 1 | .000 | .381 |
| | STPortable(1) | .219 | .117 | 3.476 | 1 | .062 | 1.245 |
| | STLooks(1) | -.064 | .117 | .295 | 1 | .587 | .938 |
| | STCOSTC | -.463 | .028 | 282.645 | 1 | .000 | .629 |
| | Constant | 3.190 | .217 | 215.183 | 1 | .000 | 24.283 |

Note: Compared against a constant only model, the model was significant ($\chi^2$ = 557, $p < 0.001$, with df = 8); Nagelkerke $R^2$ = 0.212. Prediction success = 63.2%.

Those design features that appear to be most important to consumers are (see Table 69 for estimates of willingness to pay):

- Smoke – people would prefer a device that avoids generating any kind of smoke especially wood smoke.
- Capacity – people want to be able to cook for larger numbers of people (8 people).
- Cost – preference for low cost device.

*Table 69 Willingness to pay for priority characteristics – stove design*

| Feature | WTP (TZS) |
|---|---|
| No wood smoke | 40,300 |
| No charcoal smoke | 20,800 |
| Cater for 8 people | 10,000 |

PEOPLE'S STRONGEST PREFERENCE IS FOR A DEVICE THAT AVOIDS THE KIND OF SMOKE GENERATED BY A WOOD FIRE. WOOD SMOKE IS MUCH THICKER THAN CHARCOAL SMOKE THROUGHOUT THE ENTIRE DURATION OF COOKING. HOWEVER, CHARCOAL SMOKE CONTAINS MUCH HIGHER LEVELS OF THE SILENT KILLER: CARBON MONOXIDE.



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#### *4.6.2.3 Device Functionality*

> THE ONLY FUNCTIONALITY FEATURES WITH SIGNIFICANT PREFERENCE WERE:
>
> - ABILITY TO COOK ON BOTH SUNNY & RAINY DAYS.
> - LOW COST.

The variables used in the analysis are:

FULED

0 = 2 hobs

1 = 2 hobs + 3 LED lights

FUMob

0 = 2 hobs

1 = 2 hobs + charge mobile phone

FUTV

0 = 2 hobs

1 = 2 hobs + television

FUAvailable

0 = only works on sunny days

1 = works on sunny and rainy days

FU6yr

0 = pay each month (utility)

1 = lease over 6 years

FU3yr

0 = pay each month (utility)

1 = lease over 3 years

FUCleaning

0 = awkward to clean

1 = easy to clean


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Results from the binary logistic regression are presented in Table 70.

*Table 70 Binary logistic regression – device functionality*

| | | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|---|
| Step 1[a] | FULED(1) | -.151 | .169 | .798 | 1 | .372 | .860 |
| | FUMob(1) | .133 | .191 | .483 | 1 | .487 | 1.142 |
| | FUTV(1) | .239 | .185 | 1.673 | 1 | .196 | 1.270 |
| | FUAvailabe(1) | 1.804 | .141 | 162.934 | 1 | .000 | 6.073 |
| | FU6yr(1) | .026 | .168 | .025 | 1 | .875 | 1.027 |
| | FU3yr(1) | -.058 | .155 | .142 | 1 | .707 | .943 |
| | FUCleaning(1) | -.207 | .127 | 2.687 | 1 | .101 | .813 |
| | FUCOSTC | -.506 | .028 | 322.458 | 1 | .000 | .603 |
| | Constant | 1.941 | .213 | 82.695 | 1 | .000 | 6.969 |

Note: Compared against a constant only model, the model was significant ($\chi^2$ = 941, p < 0.001, with df = 8); Nagelkerke $R^2$ = 0.338. Prediction success = 72.8%.

There is only one design feature that appear to be important to consumers (in addition to cost), which is the ability to cook on both sunny and rainy days (see Table 71 for an estimate of willingness to pay). None of the other design features are significant in the model.

*Table 71 Willingness to pay for priority characteristics – device functionality*

| Feature | WTP (TZS) |
|---|---|
| Not weather dependent | 35,700 |



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### 4.6.3 Disaggregating choices

Further analysis was conducted to explore differences in preferences between different groups of respondents. The effects of five demographic variables were investigated:

- Gender
- Type of settlement (rural/urban)
- Choice of main cooking fuel
- Size of household
- Age of respondent
- Technical proficiency
- Poverty status

This analysis simply looked for relationships between these variables and each of the modelling variables among the cards that were chosen by respondents, i.e. those sets of choice parameters that were 'preferred' by respondents.

#### *4.6.3.1 Cooking Processes*

Results in Table 72 suggest that women are more engaged with cooking practice, as they were more likely to choose options with a lid (as opposed to no lid), double hobs (as opposed to single), and a more versatile device that can both boil and fry. They also tended to make more expensive choices. Men were more likely to choose options including smoky flavour.

WOMEN WERE FOUND TO VALUE A LID FOR THE POT, THE ABILITY TO FRY AS WELL AS BOIL, HAVING 2 HOBS INSTEAD OF 1 & AVOIDING THE SMOKE FROM WOOD FIRES MORE THAN MEN. THIS COULD WELL BE BECAUSE AS PRINCIPAL COOKS IN MOST HOUSEHOLDS, THEY ARE MORE IN TOUCH WITH THE PRACTICALITIES OF COOKING, RATHER THAN SIMPLY BEING A CONSUMER OF THE FINISHED PRODUCT, TASTY FOOD.

*Table 72 Cooking variables disaggregated by gender*

| Variable | Male (n=411) | Female (n=1198) | |
|---|---|---|---|
| Dichotomous variables | | | Chi-square p value |
| Boil and fry | 71% | 77% | **0.014** |
| Medium power (speed) | 18% | 14% | 0.067 |
| High power (speed) | 18% | 16% | 0.444 |
| Smoky flavour | 22% | 16% | **0.009** |


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| | | | |
|---|---|---|---|
| Pot with lid | 54% | 64% | **0.001** |
| Sealed pot | 23% | 23% | 0.785 |
| 2 hobs | 57% | 69% | **<0.001** |
| 4 hobs | 18% | 11% | **<0.001** |
| Continuous variables (means) | | | MW U-test<br>p value |
| COST (TZS) | 48,500 | 52,200 | **<0.001** |

TRADITIONAL COOKING PRACTICES SUCH AS COOKING WITHOUT A LID, USING A SINGLE COOKING DEVICE & PREFERRING A SMOKY FLAVOUR ARE REFLECTED IN CHOICES MADE BY RURAL RESPONDENTS.

Traditional cooking practices such as cooking without a lid, using a single cooking device, and preferring a smoky flavour are reflected in choices made by rural respondents (see Table 73), although the majority of options selected by rural respondents had 2 hobs. It is somewhat contradictory to find that while rural respondents were less likely to choose an option with a lid, they were more likely to choose an option with a sealed pot.

*Table 73 Cooking variables disaggregated by settlement*

| Variable | Rural (n=451) | Peri-urban (n=107) | Urban (n=1051) | |
|---|---|---|---|---|
| Dichotomous variables | | | | Chi-square<br>p value |
| Boil and fry | 72% | 79% | 77% | 0.088 |
| Medium power (speed) | 18% | 13% | 14% | 0.075 |
| High power (speed) | 17% | 15% | 17% | 0.88 |
| Smoky flavour | 28% | 18% | 14% | **<0.001** |
| Pot with lid | 53% | 65% | 65% | **<0.001** |
| Sealed pot | 28% | 22% | 21% | **0.014** |
| 2 hobs | 57% | 72% | 69% | **<0.001** |
| 4 hobs | 16% | 10% | 11% | 0.061 |
| Continuous variables (means) | | | | MW U-test<br>p value |
| COST (TZS) | 47,400 | 53,000 | 52,700 | **<0.001** |


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Comparing choices made by respondents using different fuels as their main cooking fuel suggests that preferences among people mainly using wood are substantially different to the preferences of charcoal and LPG users. They are more keen on smoky flavour, less keen on multiple hobs, less keen to be able to both boil and fry, and more cost sensitive. They are less likely to choose options with a lid (as opposed to no lid), but more likely to choose options with a sealed pot (Table 74).

*Table 74 Cooking variables disaggregated by main cooking fuel*

| Variable | LPG (n=471) | Charcoal (n=825) | Wood (n=268) | |
|---|---|---|---|---|
| Dichotomous variables | | | | Chi-square p value |
| Boil and fry | 77% | 78% | 68% | **0.007** |
| Medium power (speed) | 15% | 13% | 20% | **0.036** |
| High power (speed) | 17% | 16% | 18% | 0.759 |
| Smoky flavour | 16% | 15% | 31% | **<0.001** |
| Pot with lid | 62% | 66% | 48% | **<0.001** |
| Sealed pot | 20% | 22% | 30% | **0.009** |
| 2 hobs | 65% | 71% | 52% | **<0.001** |
| 4 hobs | 14% | 10% | 18% | **0.001** |
| Continuous variables (means) | | | | KW test p value |
| COST (TZS) | 51,500 | 53,400 | 44,800 | **0.007** |

Table 75 shows that respondents who selected options with a device that could both boil and fry came from slightly smaller households. Smaller households were also associated with choosing a pot with a lid, and multiple hobs (double). Correlations between household size and cost choices were not significant.


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*Table 75 Cooking variables disaggregated by size of household*

| Size of household (mean) | Response to parameter variable | | |
|---|---|---|---|
| | 0 | 1 | MW U-test p value |
| Boil and fry | 5.02 | 4.78 | **0.033** |
| Medium power (speed) | 4.81 | 5.01 | 0.163 |
| High power (speed) | 4.82 | 4.94 | 0.518 |
| Smoky flavour | 4.79 | 5.06 | 0.3 |
| Pot with lid | 5.01 | 4.73 | **0.011** |
| Sealed pot | 4.8 | 4.96 | 0.078 |
| 2 hobs | 5.01 | 4.74 | **0.032** |
| 4 hobs | 4.81 | 5 | 0.39 |

Preferences are also sensitive to age. Table 76 paints a picture of older respondents making more conservative choices. For example, respondents who chose smoky flavour options were older, as were respondents who were satisfied with a device that boiled only. There is some contradiction in the preferences for lids and hobs, as those who preferred no lid were older yet those who preferred a sealed lid were older, and similarly those who preferred a single hob (as opposed to a double) were older, yet those who preferred a 4 hob (as opposed to a single) unit were older. This may reflect higher levels of income among a certain section of older respondents.


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*Table 76 Cooking variables disaggregated by age*

| Age of respondent (mean) | Response to parameter variable | | |
|---|---|---|---|
| | 0 | 1 | MW U-test p value |
| Boil and fry | 36.7 | 34.8 | **<0.001** |
| Medium power (speed) | 34.9 | 36.9 | **0.007** |
| High power (speed) | 35.2 | 35.5 | 0.642 |
| Smoky flavour | 34.8 | 37.5 | **<0.001** |
| Pot with lid | 36.8 | 34.3 | **<0.001** |
| Sealed pot | 35.0 | 36.2 | **0.027** |
| 2 hobs | 37.2 | 34.2 | **<0.001** |
| 4 hobs | 35.0 | 37.1 | **0.009** |

Respondents classified as more technically proficient were less likely to choose options with smoky flavour and more likely to choose devices that could both boil and fry (Table 77). They were more likely to choose a double hob (over a single), yet less likely to choose a 4 hob (over a single), and they were more likely to select options with a lid yet less likely to select sealed pot options.

RESPONDENTS CLASSIFIED AS MORE TECHNICALLY PROFICIENT WERE LESS LIKELY TO CHOOSE OPTIONS WITH SMOKY FLAVOUR AND MORE LIKELY TO CHOOSE DEVICES THAT COULD BOTH BOIL & FRY.



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*Table 77 Cooking variables disaggregated by technical proficiency*

| Variable | Low technical proficiency (n=848) | High technical proficiency (n=729) | |
|---|---|---|---|
| Dichotomous variables | | | Chi-square p value |
| Boil and fry | 72% | 79% | **0.001** |
| Medium power (speed) | 18% | 13% | **0.004** |
| High power (speed) | 17% | 17% | 0.946 |
| Smoky flavour | 24% | 12% | **<0.001** |
| Pot with lid | 55% | 68% | **<0.001** |
| Sealed pot | 26% | 19% | **<0.001** |
| 2 hobs | 59% | 71% | **<0.001** |
| 4 hobs | 15% | 11% | **0.023** |
| Continuous variables (means) | | | MW test p value |
| COST (TZS) | 49,100 | 53,400 | **<0.001** |

There was a clear distinction in preferences between households classified as deprived and those that were not. Deprived households chose lower cost options, were more likely to choose options with a smoky flavour, and were less likely to choose options with a lid (as opposed to no lid) and options with double hobs (as opposed to a single hob) (Table 78).

RESPONDENTS CLASSIFIED AS DEPRIVED, OLDER PEOPLE & RURAL PEOPLE ALL EXPRESSED GREATER PREFERENCE FOR SMOKY FLAVOUR.



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*Table 78 Cooking variables disaggregated by poverty status*

| Variable | Non-deprived (n=925) | Deprived in at least 1 indicator (n=684) | |
|---|---|---|---|
| Dichotomous variables | | | Chi-square p value |
| Boil and fry | 77% | 73% | 0.068 |
| Medium power (speed) | 14% | 17% | **0.049** |
| High power (speed) | 17% | 16% | 0.499 |
| Smoky flavour | 14% | 24% | **<0.001** |
| Pot with lid | 65% | 57% | **0.001** |
| Sealed pot | 21% | 25% | **0.04** |
| 2 hobs | 70% | 60% | **<0.001** |
| 4 hobs | 11% | 15% | **0.026** |
| Continuous variables (means) | | | MW test p value |
| COST (TZS) | 52,800 | 49,200 | **<0.001** |

#### *4.6.3.2 Stove Design*

Results in Table 79 show that women were more likely to choose options that would do all of their cooking, and were cheaper. Men were more likely to choose options that would cook for larger numbers of people, appeared to be less averse to charcoal smoke.


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*Table 79 Stove design variables disaggregated by gender*

| Variable | Male (n=410) | Female (n=1197) | |
|---|---|---|---|
| Dichotomous variables | | | Chi-square p value |
| Cooks for 6 people | 8% | 13% | **0.003** |
| Cooks for 8 people | 71% | 62% | **0.001** |
| Can do all cooking | 13% | 21% | **<0.001** |
| Gives wood fire smoke | 19% | 18% | 0.766 |
| Gives charcoal fire smoke | 68% | 62% | **0.028** |
| Device is portable | 79% | 75% | 0.141 |
| Looks good | 22% | 25% | 0.254 |
| Continuous variables (means) | | | MW U-test p value |
| COST (TZS) | 52,500 | 49,500 | **0.001** |

RURAL HOUSEHOLDS, FIREWOOD USERS & RESPONDENTS CLASIFIED AS DEPRIVED ALL PRIORITISED LOWER COST OPTIONS SIGNIFICANTLY MORE THAN OTHERS. THEY WERE ALSO MORE WILLING TO TOLERATE THE SMOKE FROM WOOD FIRES, CLEARLY SHOWING THAT THEY ARE WILLING TO SACRIFICE THEIR HEALTH TO STAY WITHIN THEIR MEANS.

Rural respondents were more willing to choose options with wood smoke (Table 80), but it is interesting to note that differences in tolerance of charcoal smoke were not significant. There was a progression of sensitivity to cost, from urban to rural, where rural respondents were most cost sensitive.



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*Table 80 Stove design variables disaggregated by settlement*

| Variable | Rural (n=450) | Peri-urban (n=107) | Urban (n=1050) | |
|---|---|---|---|---|
| Dichotomous variables | | | | Chi-square p value |
| Cooks for 6 people | 12% | 15% | 11% | 0.524 |
| Cooks for 8 people | 62% | 65% | 65% | 0.499 |
| Can do all cooking | 20% | 21% | 18% | 0.697 |
| Gives wood fire smoke | 25% | 16% | 15% | **<0.001** |
| Gives charcoal fire smoke | 61% | 65% | 64% | 0.52 |
| Device is portable | 74% | 78% | 77% | 0.428 |
| Looks good | 27% | 22% | 23% | 0.252 |
| Continuous variables (means) | | | | MW U-test p value |
| COST (TZS) | 47,500 | 49,300 | 51,500 | **<0.001** |

Respondents from households currently using wood as their main cooking fuel were least averse to wood smoke, were more likely to want to cook for smaller numbers, and were most cost sensitive (Table 81). People who used LPG were more willing to accept a device that could do only part of their cooking, which is consistent with the way in which most people LPG stoves.

PEOPLE WHO USED LPG WERE MORE WILLING TO ACCEPT A DEVICE THAT COULD DO ONLY PART OF THEIR COOKING, WHICH IS CONSISTENT WITH THEIR CURRENT FUEL STACKING PRACTICES.


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

*Table 81 Stove design variables disaggregated by main cooking fuel*

| Variable | LPG (n=470) | Charcoal (n=825) | Wood (n=267) | |
|---|---|---|---|---|
| Dichotomous variables | | | | Chi-square p value |
| Cooks for 6 people | 9% | 14% | 12% | **0.021** |
| Cooks for 8 people | 69% | 63% | 61% | 0.059 |
| Can do all cooking | 14% | 22% | 20% | **0.004** |
| Gives wood fire smoke | 14% | 17% | 27% | **<0.001** |
| Gives charcoal fire smoke | 68% | 62% | 60% | **0.036** |
| Device is portable | 79% | 75% | 73% | 0.094 |
| Looks good | 21% | 24% | 28% | 0.083 |
| Continuous variables (means) | | | | MW U-test p value |
| COST (TZS) | 53,700 | 49,300 | 47,300 | **<0.001** |

Respondents who chose options able to cater for larger numbers (8 people) came from larger households, as did respondents who chose options that gave off wood smoke (Table 82).


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*Table 82 Stove design variables disaggregated by size of household*

| Size of household (mean) | Response to parameter variable | | |
|---|---|---|---|
| | 0 | 1 | MW U-test p value |
| Cooks for 6 people | 4.9 | 4.6 | 0.19 |
| Cooks for 8 people | 4.6 | 5.0 | **0.042** |
| Can do all cooking | 4.9 | 4.6 | 0.132 |
| Gives wood fire smoke | 4.9 | 4.7 | 0.495 |
| Gives charcoal fire smoke | 4.6 | 5.0 | **0.035** |
| Device is portable | 4.7 | 4.9 | 0.549 |
| Looks good | 4.9 | 4.6 | 0.072 |

Preferences relating to stove design parameters did not appear to depend on the age of the respondent. Respondents classified as more technically proficient were more averse to wood smoke (but not to charcoal smoke), and willing to pay more (Table 83).


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*Table 83 Stove design variables disaggregated by technical proficiency*

| Variable | Low technical proficiency (n=847) | High technical proficiency (n=728) | |
|---|---|---|---|
| Dichotomous variables | | | Chi-square p value |
| Cooks for 6 people | 12% | 11% | 0.639 |
| Cooks for 8 people | 62% | 67% | 0.058 |
| Can do all cooking | 20% | 18% | 0.519 |
| Gives wood fire smoke | 22% | 14% | **<0.001** |
| Gives charcoal fire smoke | 62% | 66% | 0.083 |
| Device is portable | 75% | 77% | 0.215 |
| Looks good | 26% | 22% | 0.076 |
| Continuous variables (means) | | | MW test p value |
| COST (TZS) | 48,900 | 51,900 | **<0.001** |

Households classified as deprived were more likely to choose options that gave off wood smoke and were more cost sensitive (Table 84).


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*Table 84 Stove design variables disaggregated by technical proficiency*

| Variable | Non-deprived (n=924) | Deprived in at least 1 indicator (n=683) | |
|---|---|---|---|
| Dichotomous variables | | | Chi-square p value |
| Cooks for 6 people | 11% | 13% | 0.351 |
| Cooks for 8 people | 65% | 63% | 0.4 |
| Can do all cooking | 19% | 19% | 1 |
| Gives wood fire smoke | 15% | 23% | **<0.001** |
| Gives charcoal fire smoke | 65% | 62% | 0.373 |
| Device is portable | 77% | 75% | 0.516 |
| Looks good | 23% | 26% | 0.174 |
| Continuous variables (means) | | | MW test p value |
| COST (TZS) | 51,400 | 48,700 | **0.002** |


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#### *4.6.3.3 Device Functionality*

The only gender difference evident in Table 85 is a slightly stronger preference among men for a device that works on both sunny and rainy days.

*Table 85 Device functionality variables disaggregated by gender*

| Variable | Male (n=411) | Female (n=1197) | |
|---|---|---|---|
| Dichotomous variables | | | Chi-square p value |
| Hobs + 3 LEDs | 44% | 49% | 0.086 |
| Hobs + phone charging | 16% | 19% | 0.299 |
| Hobs + TV | 19% | 17% | 0.411 |
| Works on sunny & rainy days | 47% | 40% | **0.006** |
| 6-year lease | 18% | 19% | 0.559 |
| 3-year lease | 37% | 33% | 0.185 |
| Easy to clean | 61% | 66% | 0.056 |
| Continuous variables (means) | | | MW U-test p value |
| COST (TZS) | 33,400 | 33,700 | 0.849 |

Differences between rural, peri-urban and urban respondents were not significant.

Functionality was not, generally, sensitive to the choice of main cooking fuel (Table 86). Charcoal users were slightly less likely to choose options that could cook on all days, which might reflect a willingness to use standby fuels when charcoal is not available.



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*Table 86 Device functionality variables disaggregated by main cooking fuel*

| Variable | LPG (n=470) | Charcoal (n=825) | Wood (n=267) | |
|---|---|---|---|---|
| Dichotomous variables | | | | Chi-square p value |
| Hobs + 3 LEDs | 46% | 50% | 44% | 0.195 |
| Hobs + phone charging | 16% | 20% | 17% | 0.151 |
| Hobs + TV | 19% | 16% | 19% | 0.361 |
| Works on sunny & rainy days | 46% | 39% | 42% | **0.025** |
| 6-year lease | 17% | 21% | 18% | 0.252 |
| 3-year lease | 36% | 32% | 38% | 0.12 |
| Easy to clean | 62% | 67% | 62% | 0.167 |
| Continuous variables (means) | | | | MW U-test p value |
| COST (TZS) | 34,700 | 33,500 | 32,000 | 0.166 |

There was no evidence that choices were sensitive to the size of the household. Neither were they generally sensitive to the age of the respondent (Table 87), with the exception that respondents who preferred a package including lights were slightly younger.


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*Table 87 Device functionality variables disaggregated by size of household*

| Age of respondent (mean) | Response to parameter variable | | |
|---|---|---|---|
| | 0 | 1 | MW U-test p value |
| Hobs + 3 LEDs | 35.6 | 34.9 | **0.03** |
| Hobs + phone charging | 35.3 | 35.1 | 0.862 |
| Hobs + TV | 35.3 | 35.2 | 0.829 |
| Works on sunny & rainy days | 35.2 | 35.3 | 0.68 |
| 6-year lease | 35.3 | 35.2 | 0.813 |
| 3-year lease | 35.1 | 35.5 | 0.31 |
| Easy to clean | 35.9 | 34.9 | 0.052 |

None of the variables were sensitive to the level of technical proficiency of the respondent, nor the poverty status of the household.


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

# 5 Conclusion

The study has highlighted several opportunities and challenges for future eCook product/service designers. The study has highlighted several opportunities and challenges for future eCook product/service designers. Blackouts and brownouts (voltage dips) seem to be infrequent enough that direct AC electric cooking could be possible for many people. However, electricity is barely used for cooking in Tanzania today, with charcoal and LPG dominating the cooking landscape in urban areas. In rural areas, wood and charcoal dominate. Electricity is perceived as expensive for cooking – given the low prices of cooking fuels, this is not surprising. However the evidence from the cooking diaries shows that cooking with energy-efficient electric cooking appliances is significantly cheaper, indicating that changing this perception will be key to unlocking eCook's potential in Tanzania. In particular, Electric Pressure Cookers (EPCs) seem well matched with Tanzanian consumer preferences, as they can boil & fry, with the boiling part roughly twice as fast as conventional pots.

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.

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# 7 Appendix

## 7.1 Appendix A: Problem statement and background to Innovate eCook project

### 7.1.1 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[11] 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

[11] 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)


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

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

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

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

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


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

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

### 7.1.2 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 21 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[12] (Batchelor, 2015b; Brown and Sumanik-Leary, 2015; Leach and Oduro, 2015; Slade, 2015). The commission arose from discussions between consortium members, DFID, and a number of other entities with an interest in technological options for cleaner cooking e.g. Shell Foundation and the Global Alliance for Clean Cookstoves.

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

[12] 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.

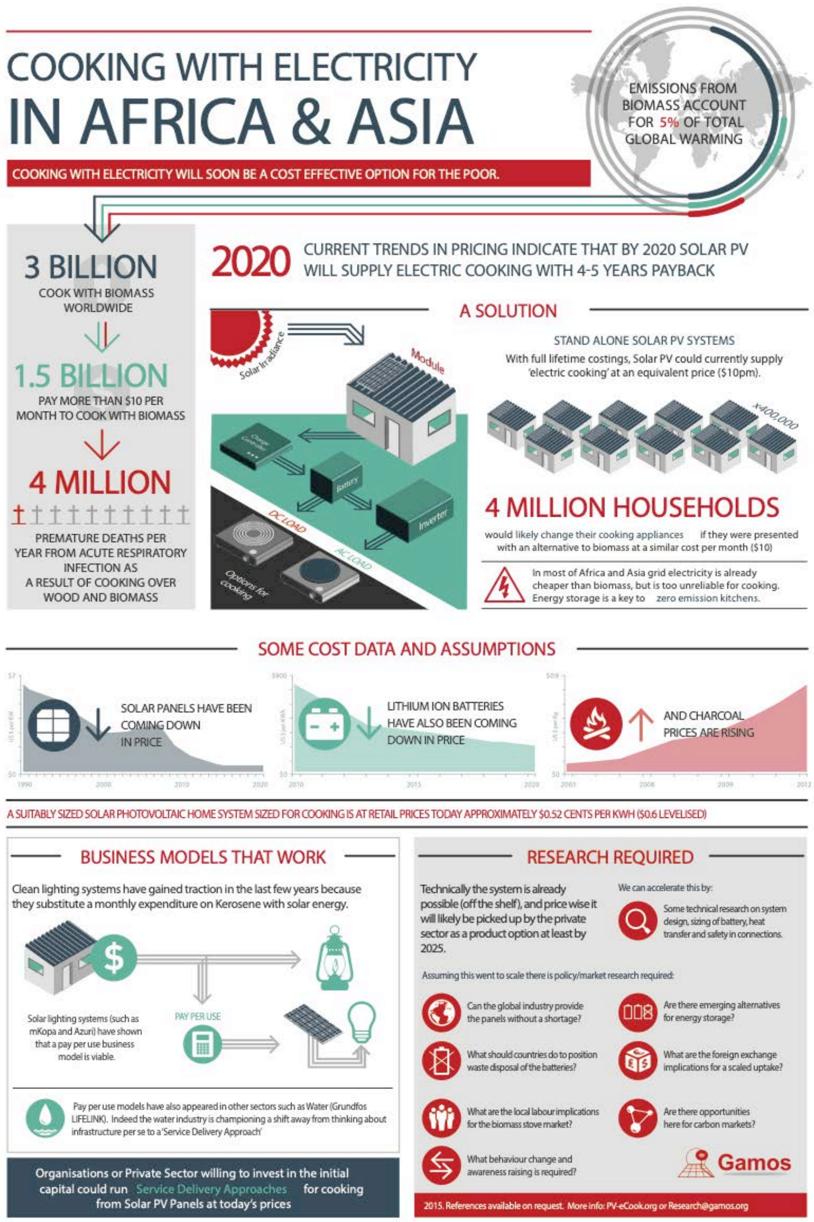


*Figure 21 Infographic summarising the concept in order to lobby research and policy actors.*


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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.



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### 7.1.3 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.

#### 7.1.4 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[13]. 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[14]. 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 $CO_2$e per year (1.9-2.3% of global emissions)[15]. 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

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

[14] 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

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


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warming globally – residential solid fuel burning accounts for up to 25 percent of global black carbon emissions[16]. 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[17].

Africa's cities are growing – another Nigeria will be added to the continent's total urban population by 2025[18] 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[19]. 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.

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

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

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

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


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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[20]. 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[21], 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

[20] 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.

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



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consumers. Figure 22 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.

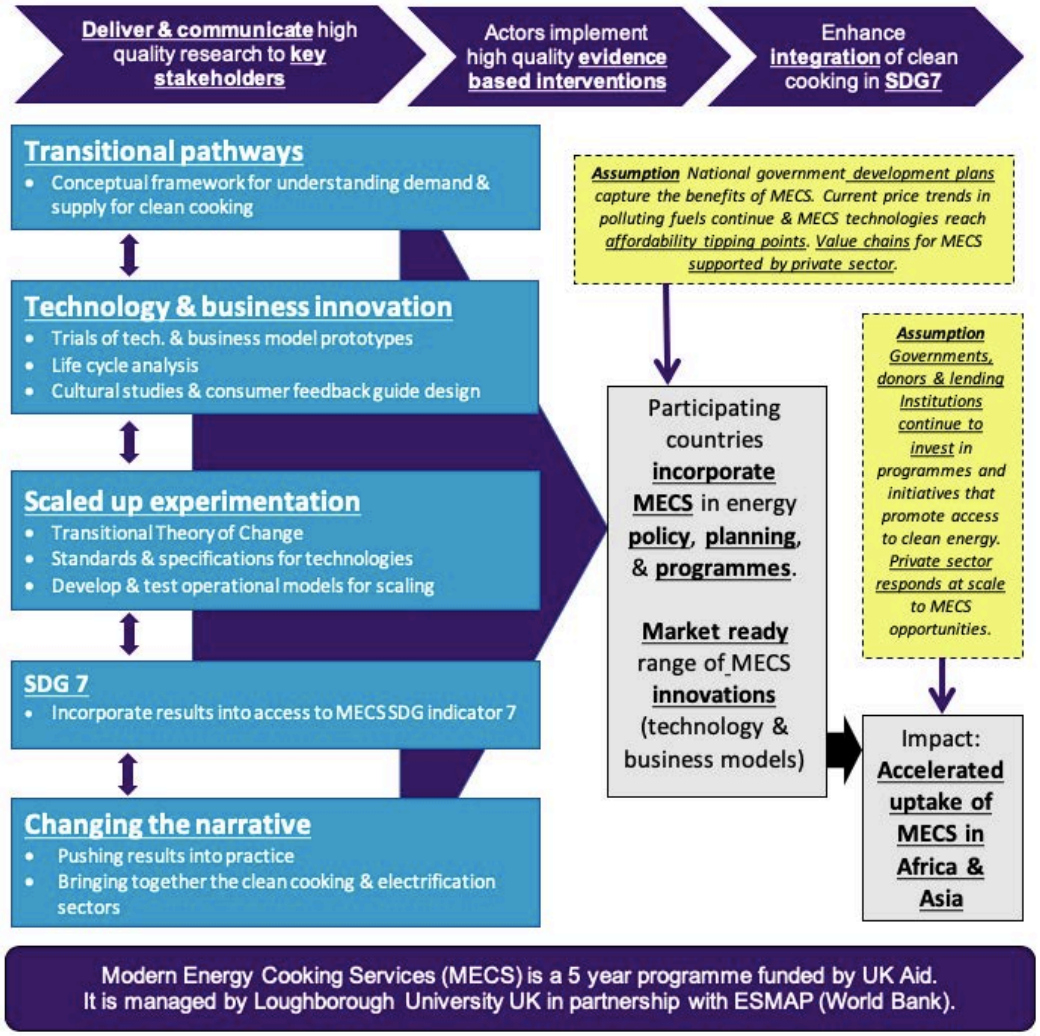


*Figure 22: Overview of the MECS programme.*


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