eCook Myanmar Discrete Choice Modelling

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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 Myanmar. The aim of this study is to gain a deeper understanding of how Myanmar 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. Electricity tariffs in Myanmar are very low and people who use electricity for cooking regard it as cheap, however users of other fuels often perceive it as expensive. Smoke is considered undesirable by most, both in terms of having to breathe it in whilst cooking and the smoky flavour it gives to the food, however it is considered useful for keeping insects away. From a consumer perspective, the ideal eCook product would be a portable device that can cook for up to 8 people, can boil and fry with a lid on the pot, can operate throughout the year regardless of the weather, is easy to clean & available on a 6 year lease-to-own financing plan. However, product/service designers may have to compromise to reach the bottom of the pyramid, as many of these options are likely to increase the cost to consumers, which is of course often the most important decision making factors for households.

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 CEEEZ, 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.

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

1.2 Key findings

Most respondents (89%) owned mobile phones, indicating high levels of technical proficiency & possibly a greater willingness to adopt new innovations. Mobile phones are relatively new in Myanmar, so most people have leapfrogged straight to the smartphone.

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.

58% of respondents were connected to the national grid, 13% to a mini-grid, 7% to solar home systems & 4% to a generator. Only 1% had no electricity at all. The mean household size was found to be 4.6 (including children). 73% of the sample were deprived in at least one of the indicators relating to education, home construction materials & source of drinking water.

Respondents spend an average of 3.2 hours/day cooking. Breakfast is typically prepared at 5:00, lunch at 10:00 & dinner at 16:00.

Unsurprisingly, participants reported that women are usually responsible for cooking (85%), however, in 5% of households, men do the majority of cooking & in 11% 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.

Almost half of the charcoal users buy monthly, however 20% buy in small quantities on a daily basis. Ecook systems with monthly repayment plans are likely to be attractive to the former, however more frequent repayment options will be necessary to reach the latter, who are likely to be the poorer households. Interestingly, many rural firewood users also reported paying for it.

Electricity & charcoal/firewood are useful for other things too. Almost all participants who cooked with electricity reported using it for lighting (99%) & most for refrigeration (59%). Roughly half of all fuel users reported also using them for water heating, however almost nobody used them for space heating.

There was greatest agreement that firewood is expensive for cooking, less so for LPG, and electricity appears to be regarded as the cheapest fuel (out of these three only). However LPG users believe LPG to be cheap and electricity to be expensive, indicating they are cost sensitive. People using wood tend to believe that both electricity and LPG are expensive.

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LPG users tend to regard it as a safe fuel, unlike everybody else, suggesting that negative perceptions on safety act as a barrier to use of LPG.

People who use wood only weakly agree that it is inconvenient, whereas charcoal users feel most strongly that charcoal is not convenient, suggesting high levels of dissatisfaction with aspects of charcoal use (these are not specified but might include dirty, storage, time to light etc.).

Most respondents were aware that firewood is harmful to health, but they were less likely to feel that charcoal is harmful to health. While smoke was almost universally regarded as a health problem, there was also strong opinion that it was beneficial in controlling insects.

The features of the cooking process that are most important to consumers are:

- Boil and fry - to be able to do both
- Lid – people have a strong preference for a lid, but not for a sealed pot
- Hobs – people prefer double hobs, but interestingly people did not appear to have a preference for 4 hobs over a single hob.
- Taste – there was a clear preference for a device that did not make food taste smoky.
- Cost.

Discharge rate is a key determinant of battery life. Frying generally requires higher power than boiling & 2 hobs require twice as much power as one. Again, system designers may have to choose to trade off usability for cost in budget models.

Cooking with a lid on the pot is more energy-efficient, so will reduce the size of the battery & make ecook systems more affordable. However, a sealed & pressurised pot is even more efficient, so some compromises maty have to be made for the lowest cost systems.

The features of the stove that are most important to consumers are:

- Portable – people would like a device that can be carried in/out of the house
- Capacity – people want to be able to do all their cooking on the device, and they want to be able to cook for larger numbers of people (8 people).
- Smoke – people would prefer a device that avoids generating any kind of smoke.
- Cost.

The functionality features most important to consumers were:

- Availability – people had a strong preference for a system that could cook reliably regardless of the weather.
- Having a device that was easy to clean.
- Finance – people have a strong preference for leasing over utility models. There was a preference for a 6 year lease period over a 3 year period. These findings are potentially difficult to interpret, as people were not given any detail on the relative magnitudes of payments.

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People have a strong preference lease-to-own over utility models, where the user simply makes regular payments for as long as they use the system, without ever gaining ownership. However, product/service designers may have to compromise to reach the bottom of the pyramid, as utility models are likely to have the lowest monthly costs, as they have the longest financing horizon.

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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 Myanmar. 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 Myanmar. 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 Myanmar, funded through Innovate UK's Energy Catalyst Round 4 by DfID UK Aid and Gamos Ltd. (https://elstove.com/innovate-reports/).

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*. 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.

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.

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 DfID UK AID under the PEAKS mechanism (available from https://elstove.com/dfid-uk-aid-reports/). Slade (2015) investigated the technical viability of the proposition, highlighting the need for further work defining the performance of various battery chemistries under high discharge and elevated temperature. Leach & Oduro (2015) constructed an economic model, breaking down PV-eCook 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.

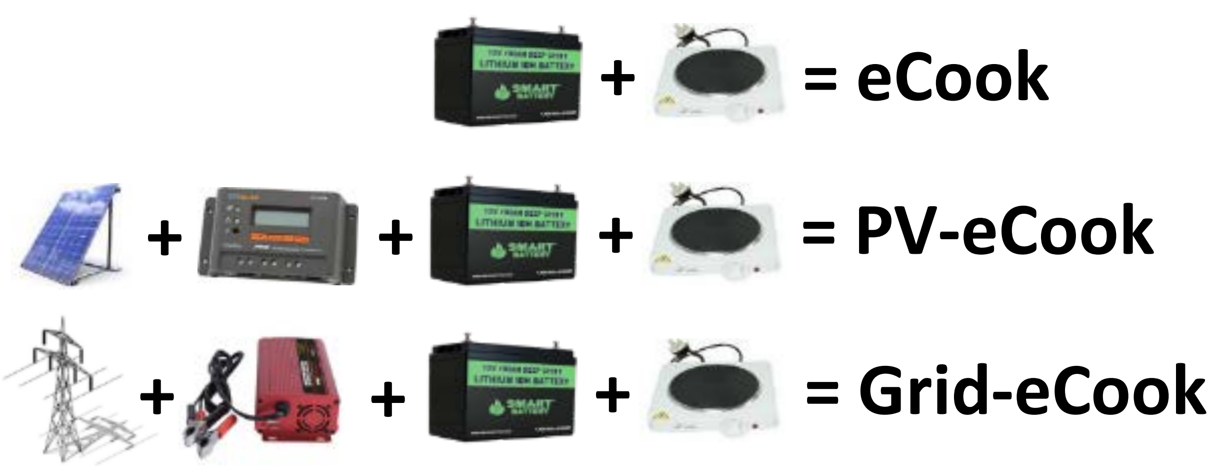

Figure 1: Pictorial definitions of 'eCook' terminology used in this report.

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2.1.3 eCook in Myanmar

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, highlighting that the liberalisation of Myanmar opens the door to a significant charcoal market, with a small percentage of users already cooking on electricity, paving the way for eCook.

The accompanying reports from the other activities carried out in Myanmar can be found at: https://elstove.com/innovate-reports/.

2.2 Aim

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

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 REAM, 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 overstated 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),

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which was considered to be a continuous variable. This enables willingness to pay figures to be 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

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[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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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 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).

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

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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

REAM recruited a team of enumerators, who carried out the surveys alongside members of REAM. Training was conducted by REAM 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. 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.

Principal component analysis has been used to create a combined 'wealth' index that accommodates various characteristics of the respondents:

- household characteristics;
- asset ownership;
- cooking fuels and expenditure; and
- use of technology.

A proxy wealth indicator was calculated on the basis of the first factor extracted from a factor analysis of these supporting indicators, and households were divided into wealth quintiles.

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4 Results

4.1 Overview of data

4.1.1 Geographical locations

Face to face interviews were conducted using Kobo Toolbox CAPI software. The sample of 198 was drawn roughly equally from urban, peri-urban, and rural areas – see Table 1 and Figure 3. Most of the districts identified in Table 1 are in the Yangon area (and have been identified as such), so most of the sample is drawn equally from the Yangon (n=71) and NatMauk (n=76); the remainder was drawn from Mawla, Pauk, and others (n=50).

Table 1 Regions and type of settlement

Region/District	Nr Yangon	rural	peri-urban	urban	Total
		0	1	0	1
Ahlone	X	0	0	10	10
DagonSK	X	0	0	1	1
Hlaing	X	0	0	2	2
Insein	X	0	0	4	4
Kamar_Yut	X	0	0	1	1
Kyee_Myint_Tine	X	0	0	3	3
Lan_Ma_Daw	X	0	0	1	1
MawLa		22	5	1	28
Mayangon	X	0	0	5	5
Myo_Thit	X	20	1	0	21
Nat_Mauk		32	44	0	76
NDagon	X	0	1	5	6
Other		3	1	12	16
Pauk		0	5	0	5
Sanchaung	X	0	0	6	6
SDagon	X	0	0	3	3
Shwe	X	0	4	2	6
Tarmwe	X	0	0	2	2
Total		77	62	58	197

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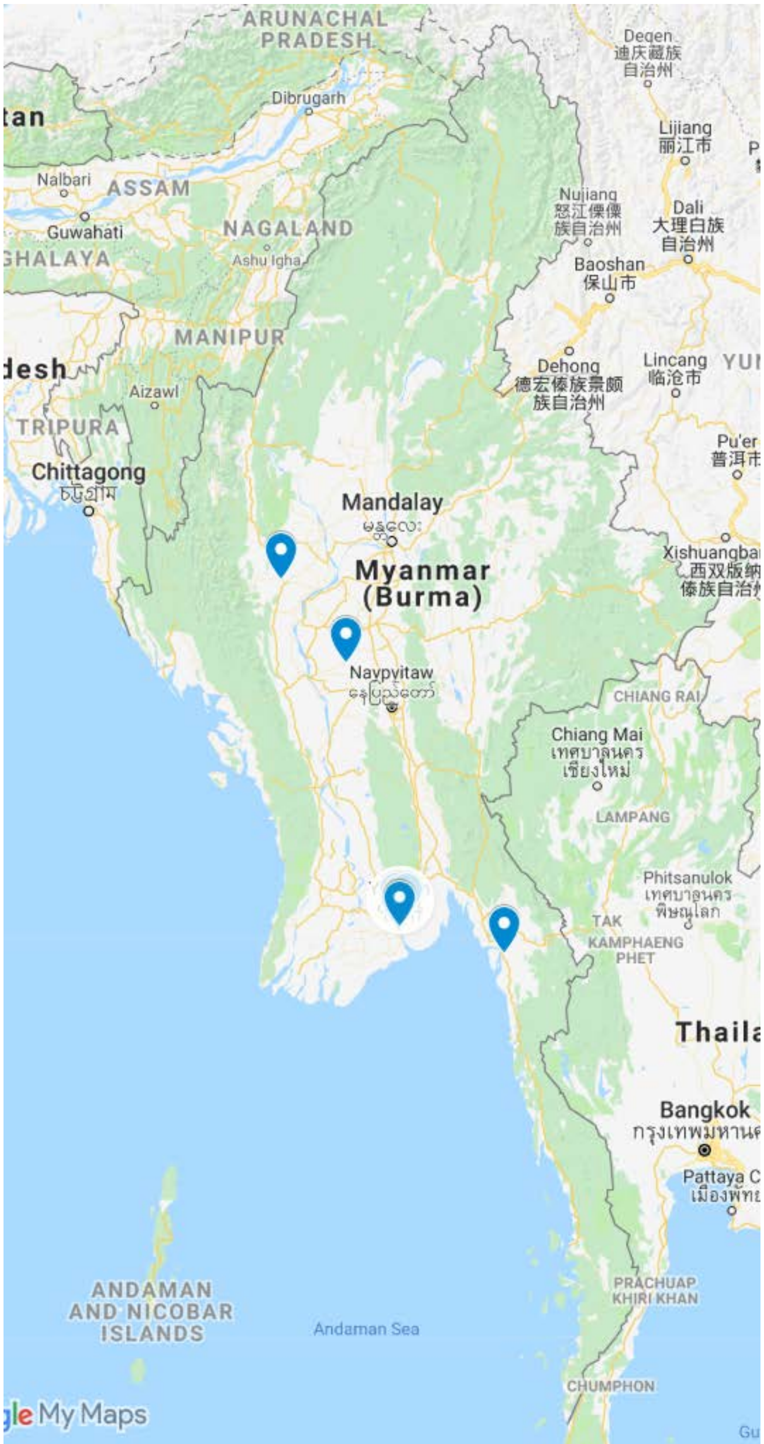

Figure 3 Geographical spread of survey

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Table 2 shows that both rural and urban residents lived similar distances from their local markets, and it was those living in peri-urban areas who were more isolated from commercial centres. However, these mean figures hide some of the extremes; for example, no urban respondents lived more than 25 minutes from their nearest market place, but a few rural residents lived an hour or more away.

Table 2 Remoteness - time taken to walk to nearest market place

3 - Is your household in an urban or rural area	Mean	N
rural	10.7	77
peri-urban	21.7	61
urban	10.2	58
Total	13.9	196

4.1.2 Respondent characteristics

4.1.2.1 Personal characteristics

The sample was predominantly female – 33:67 (male:female).

73% of respondents were either the head of household or the spouse of the head of household.

The mean age of respondents was 43.2 years, but the sample included respondents of a wide age range – see Figure 4.

The sample has a high educational status, given that over half had some form of post-secondary education (see Table 3).

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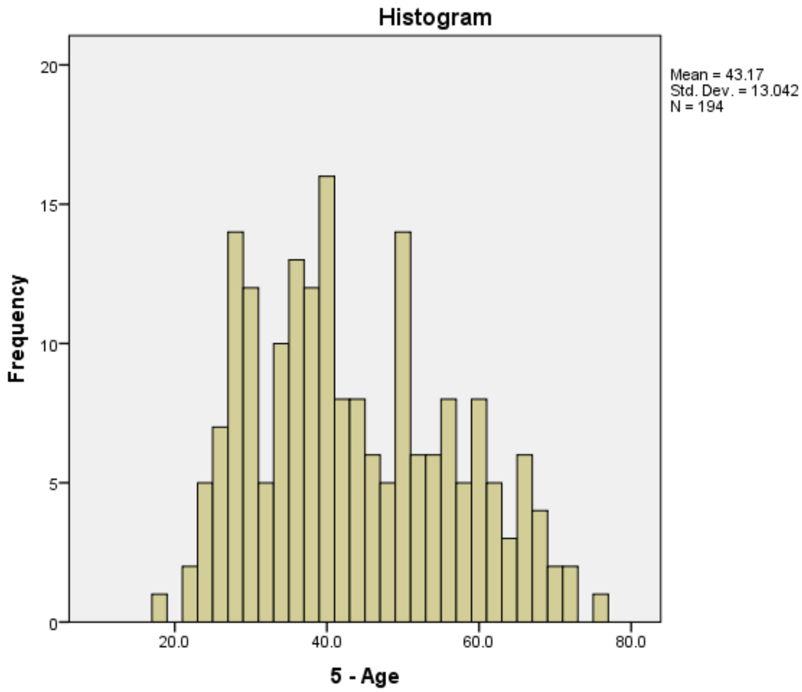

Figure 4 Age distribution of respondents

Table 3 Highest level of education attained

		Frequency	Percent
Valid	none	11	5.6
	incomplete primary	15	7.6
	completed primary	14	7.1
	incomplete secondary	26	13.1
	completed secondary	19	9.6
	higher than secondary	112	56.6
	Total	197	99.5
Missing	System	1	.5
Total		198	100.0

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Most respondents watch TV daily, and less than one half listen to the radio at all (Table 4). They do not correlate, so there is no evidence that one substitutes for the other. 13% (n=25) were isolated in not accessing either of these types of broadcast media.

Table 4 Frequency of use of broadcast media

	Radio		TV	
	Frequency	Percent	Frequency	Percent
not at all	108	54.5	50	25.3
less than once a week	16	8.1	7	3.5
at least once a week	19	9.6	17	8.6
daily	55	27.8	124	62.6
Total	198	100.0	198	100.0

Patterns of mobile phone use can serve as a proxy for technical proficiency and ability to adapt to technological innovations. 89% of respondents owned a mobile phone (or SIM card), and most of these were smartphones (Table 5). Although most respondents used a phone several times a day, there remains a sizable minority (12%) who did not use a phone at all (Table 6).

Literacy clearly acts as a barrier to fully exploiting the potential of mobile phones, and 25% of respondents were not able to read SMS texts for themselves (n=50). However, over half of these had used a phone in the last month, indicating that literacy does not prevent people taking advantage of the phone.

MOST RESPONDENTS (89%) OWNED MOBILE PHONES, INDICATING HIGH LEVELS OF TECHNICAL PROFICIENCY & POSSIBLY A GREATER WILLINGNESS TO ADOPT NEW INNOVATIONS. MOBILE PHONES ARE RELATIVELY NEW IN MYANMAR, SO MOST PEOPLE HAVE LEAPFROGGED STRAIGHT TO THE SMARTPHONE.

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Table 5 Type of phone most commonly used

		Frequency	Percent
Valid	Smart phone	153	77.3
	Feature phone	6	3.0
	Basic phone	15	7.6
	Total	174	87.9
Missing	System	24	12.1
Total		198	100.0

Table 6 Frequency of use of mobile phone (in last month)

		Frequency	Percent
Valid	not used	24	12.1
	weekly	14	7.1
	once or twice a day	69	34.8
	several times a day	91	46.0
	Total	198	100.0

In terms of innovative services, Table 7 to Table 9 show that over half of respondents used the internet and social media services (e.g. Facebook, Viber, WhatsApp) daily. Table 9 indicates that the penetraction of mobile financial services remains low, and mobile banking is more commonly used that mobile money services (12% use compared with 5%).

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 internet (in last month)

		Frequency	Percent
Valid	not aware of internet	50	25.3
	not used	33	16.7
	weekly	8	4.0
	once or twice a day	41	20.7
	several times a day	66	33.3
	Total	198	100.0

Table 8 Frequency of use of social media

		Frequency	Percent
Valid	No	76	38.4
	Yes, I have in the past, but I no longer use	2	1.0
	Yes, weekly	11	5.6
	Yes, once or twice a day	40	20.2
	Yes, several times a day	59	29.8
	Not aware of Facebook/Viber/WhatsApp	8	4.0
	Total	196	99.0
Missing	System	2	1.0
Total		198	100.0

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

Table 9 Frequency of use of financial services delivered by mobile

	Mobile money		Mobile banking	
	Frequency	Percent	Frequency	Percent
not used	187	94.4	172	86.9
1 or 2 times a month	7	3.5	12	6.1
3 - 10 times a month	1	.5	12	6.1
daily	1	.5		
Total	196	99.0	196	99.0
Missing System	2	1.0	2	1.0
Total	198	100.0	198	100.0

A factor analysis has been conducted, and a single factor extracted based on the following variables, which show a good deal of internal consistency (Cronbach alpha = 0.752):

- Frequency of use of mobile phone
- Type of phone used
- Ability to read SMS
- 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 on the basis of this factor score (see Table 10).

Table 10 Composite technical proficiency classification

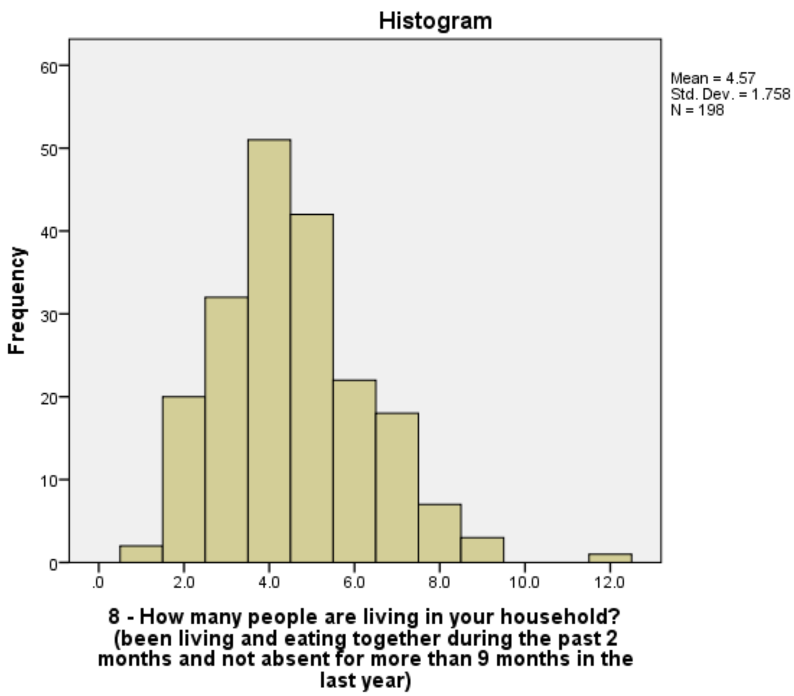
		Frequency	Percent
Valid	low	96	48.5
	high	96	48.5
	Total	192	97.0
Missing	System	6	3.0
Total		198	100.0

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

4.1.2.2 Household characteristics

The mean household size was 4.6 (including children). The distribution of household sizes is presented in Figure 5. 28% of households had at least one child under the age of 5 years.

Details of dwelling constructions are presented in Table 11 to Table 13. The households' main sources of drinking water are presented in Table 14.



THE MEAN HOUSEHOLD SIZE WAS FOUND TO BE 4.6 (INCLUDING CHILDREN).

Figure 5 Distribution of household size (adults + children)

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

Table 11 Dwelling construction - floor

		Deprived	Frequency	Percent
Valid	Dirt/Mud/Dung	X	21	10.6
	Wood/bamboo	X	105	53.0
	Cement screed		51	25.8
	Tiles		19	9.6
	Other		2	1.0
	Total		198	100.0

Table 12 Dwelling construction - walls

		Deprived	Frequency	Percent
Valid	Wood / mud / thatch	X	102	51.5
	Mud bricks (traditional)	X	6	3.0
	Corrugated iron sheet	X	11	5.6
	cement block (plastered or unplastered)		56	28.3
	Bricks (burnt)		22	11.1
	Other	X	1	.5
	Total		198	100.0

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

Table 13 Dwelling construction - roof

		Deprived	Frequency	Percent
Valid	Thatch/palm leaf	x	14	7.1
	Corrugated iron / cement sheet		174	87.9
	Cement		9	4.5
	Total		197	99.5
Missing	System		1	.5
Total			198	100.0

Table 14 Main source of drinking water

		Deprived	Frequency	Percent
Valid	Piped into dwelling		8	4.0
	Piped into yard		9	4.5
	Public standpipe		11	5.6
	Tube well/borehole		78	39.4
	Protected dug well		6	3.0
	Unprotected dug well	X	10	5.1
	Unprotected spring	X	8	4.0
	Rain water		19	9.6
	Cart with tank	X	9	4.5
	Surface (river/pond)	X	10	5.1
	Bottled water		30	15.2
	Total		198	100.0

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

A poverty index has been created on the basis of 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 11 to Table 14. 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 = 0.677), 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 15. For the purposes of the analysis, the sample has been split into two parts: 27% non-deprived, and 73% that are deprived in at least one indicator.

Table 15 Composite Poverty index

		Frequency	Percent
Valid	0	54	27.3
	1	27	13.6
	2	67	33.8
	3	30	15.2
	4	14	7.1
	5	6	3.0
	Total	198	100.0

> 73% OF THE SAMPLE WERE DEPRIVED IN AT LEAST ONE OF THE INDICATORS RELATING TO EDUCATION, HOME CONSTRUCTION MATERIALS & SOURCE OF DRINKING WATER.

4.2 Characteristics of household electricity supply

4.2.1 Sources of electricity

1.0% of respondents had no electricity (n=2). Most respondents had a single source of electricity, but 10% had multiple sources (Table 16); these were reported by people who had some kind of generator (e.g. gasifier, generator) supplemented by a solar home system or lantern.

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

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

		Frequency	Percent
Valid	0	2	1.0
	1	172	86.9
	2	20	10.1
	3	3	1.5
	Total	197	99.5
Missing	System	1	.5
Total		198	100.0

58% OF RESPONDENTS WERE CONNECTED TO THE NATIONAL GRID, 13% TO A MINI-GRID, 7% TO SOLAR HOME SYSTEMS & 4% TO A GENERATOR. ONLY 1% HAD NO ELECTRICITY AT ALL.

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

Table 17 Sources of electricity

Source	Frequency	Percent
Grid connection	114	57.6
Biomass gasifier mini grid	21	10.6
Diesel mini-grid	4	2.0
Other mini grid	1	0.5
Solar home system	14	7.1
Household generator	8	4.0
Other household system	4	2.0
Solar lantern / lighting system	54	27.3
Rechargeable batteries	27	13.6
Dry cell batteries	9	4.5
Other	1	0.5

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

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 18 show that most respondents had shared meters on a national grid supply.

Table 18 Type of connections

Source	Informal	Direct connection with shared meter	Direct connection with individual meter	Total
National grid	8	98	8	114
Biomass gasifier mini grid	0	21	0	21
Diesel mini grid	0	4	0	4
Other mini grid	0	1	0	1

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

4.2.2 Household electrical appliances

Only those respondents who said they had no electricity were asked which appliances they had – see Table 19.

Table 19 Household ownership of electrical appliances

Appliance	Frequency	Valid percent
Radio (battery powered)	86	43.4
Music system (mains powered)	40	20.2
Mobile phone	181	91.4
Non mobile phone	10	5.1
Television	146	73.7
refrigerator	80	40.4
Electric kettle	79	39.9
Electric water heater	8	4.0
fan	78	39.4
Air conditioner	44	22.2
Electric lights	160	80.8

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4.2.3 Quality of supply

Respondents who accessed electricity via the national grid or any type of mini grid (see Table 20) were asked a series of questions relating to quality of supply.

Table 20 Respondents accessing electricity from a grid[3]

		Frequency	Percent
Valid	No	59	29.8
	National grid	114	57.6
	mini grid	24	12.1
	Total	197	99.5
Missing	System	1	.5
Total		198	100.0

[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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Among national grid users,

- 26% felt that the voltage was inadequate for cooking on occasions (Table 21); note that an addition 7% felt that their supply was adequate but only because they had invested in a voltage stabiliser,
- 72% had experienced load shedding (at some point in the past) (Table 22).

•		ACCESSES ELECTRICITY FROM NATIONAL GRID OR ANY MINI GRID		
		National grid	mini grid	Total
19 - Do you currently experience frequent blackouts (more than once a month)?	No	40	1	41
	Yes, due to load shedding	8	8	16
	Yes, but not due to load shedding	66	15	81
Total		114	24	138

- Table 24 shows a clear season trend, for load shedding to occur in the March to July months.
- 65% currently experienced frequent blackouts (defined as more than once a month) (Table 23).

If anything, it appears that respondents connected to mini grids experienced a poorer quality of supply (although the size of this sub-sample was small). Although a similar proportion felt that the voltage was inadequate for cooking, almost all regularly experience some kind of blackout. The main difference appeared to be that scheduled blackouts (load-shedding) were fewer.

Patterns of blackouts during load shedding and at other times were different. Blackouts due to load shedding occurred more frequently (Table 25) and tended to be of longer duration, most lasting between 30 minutes and 8 hours (Table 26).

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Table 21 Grids voltage quality (is the voltage high enough for cooking?)

	National grid	mini grid
Yes, all the time	76	12
Yes, because I have a voltage stabiliser	8	0
Sometimes (only during certain hours each day)	9	0
Sometimes (unpredictable)	15	1
Never	6	3
Total	114	16

Table 22 Experience of load shedding

		ACCESSES ELECTRICITY FROM NATIONAL GRID OR ANY MINI GRID		
		National grid	mini grid	Total
18 - Have you experienced load shedding at any point in the past?	No	26	19	45
	Yes	83	5	88
	Not sure	5	0	5
Total		114	24	138

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

Table 23 Experience of blackouts

		ACCESSES ELECTRICITY FROM NATIONAL GRID OR ANY MINI GRID		Total
		National grid	mini grid	
19 - Do you currently experience frequent blackouts (more than once a month)?	No	40	1	41
	Yes, due to load shedding	8	8	16
	Yes, but not due to load shedding	66	15	81
Total		114	24	138

Table 24 Months in which load shedding is experienced (National grid users)

	Frequency	Valid percent (n=83)
Jan	2	2.4
Feb	5	6.0
Mar	43	51.8
Apr	64	77.1
May	58	69.9
Jun	37	44.6
Jul	22	26.5
Aug	11	13.3

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

Sep	8	9.6
Oct	2	2.4
Nov	1	1.2
Dec	1	1.2

Table 25 Frequency of blackouts (National grid users)

	Load shedding (n=83)		blackouts (not load shedding) (n=74)	
	Frequency	Valid Percent	Frequency	Valid Percent
once a month	4	4.8	13	17.6
twice a month	17	20.5	26	35.1
once a week	12	14.5	18	24.3
twice a week	17	20.5	9	12.2
every other day	13	15.7	1	1.4
every day	9	10.8	1	1.4
twice a day	7	8.4	1	1.4
many times a day	4	4.8	2	2.7
never			3	4.1
Total	83	100.0	74	100.0
Missing System	31		40	
Total	114		114	

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

Table 26 Duration of blackouts (National grid users)

	Load shedding		Current blackouts	
	Frequency	Valid percent	Frequency	Valid percent
under 5 minutes	1	1.2		
10 mins	2	2.4	5	6.9
30 mins	22	26.5	28	38.9
1 hour	7	8.4	15	20.8
2 hours	14	16.9	12	16.7
4 hours	8	9.6	8	11.1
8 hours	24	28.9	2	2.8
1 day	2	2.4	2	2.8
several days	2	2.4		
A week	1	1.2		
Total	83	100.0	72	100.0

Among national grid users with experience of load shedding, 53% had received some kind of information about a schedule (Table 27). Among those who did receive information (even if not accurate), most got this information via broadcast media (loudspeakers and newspapers, which may or may not be local papers) and from social networks (neighbours).

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Table 27 Received information on load shedding schedule (National grid users who have experienced load shedding)

		Frequency	Percent
Valid	Yes	18	21.7
	Yes, but it is not accurate	14	16.9
	Sometimes	12	14.5
	No	39	47.0
	Total	83	100.0

Table 28 Sources of information on load shedding schedules

	Frequency	Valid percent[4] (n=28)
radio	3	10.7
Printed notice	2	7.1
newspapers	7	25.0
internet	3	10.7
SMS	0	0.0
neighbours	6	21.4
loudspeaker	15	53.6
other	2	7.1

[4] Questions were asked of those receiving information, even if inaccurate (n=32) but only 28 answered.

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Table 29 shows that whilst national grid is always available (notwithstanding blackouts, as discussed above), mini grids are only available at certain times of the day (all are gasifier mini grids). The gasifier mini grid appears to be turned on in the morning from around 6.30 to 10.00, then again in the evening from around 17.30 until 23.00.

Table 29 Availability of electricity

	National grid	mini grid	Total
No, it is on 24 hours a day	41	0	41
Yes, it is turned on twice a day	0	20	20
Total	41	20	61

4.3 Characteristics of cooking practice

4.3.1 Meals and timing

Dinners were the meal most commonly cooked (always or sometimes), although a substantial proportion of respondents sometimes missed dinner (25%) meaning that breakfast was the meal that people most commonly cooked every day (i.e. always) (Figure 6). Table 30 shows that only 30% of households always cook all three meals.

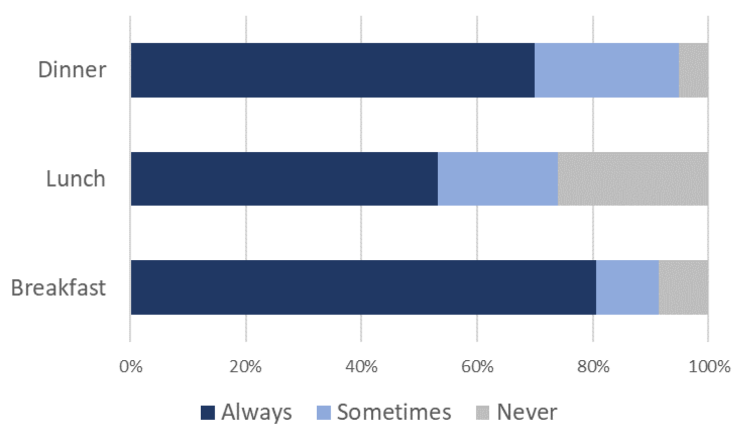


Figure 6 Meals cooked in the household

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

Table 30 Number of meals (per day) always cooked

		Frequency	Percent
Valid	0	7	3.5
	1	45	22.7
	2	86	43.4
	3	60	30.3
	Total	198	100.0

The survey also asked about heating water for various purposes. Almost all respondents heated water for hot drinks but almost none heated water to purify it (Table 31). All respondents who answered the questions heated water for one purpose or another (Table 32).

Table 31 Heating water

Purpose of heating water	Frequency	Valid Percent
Heat water for bathing	27	14.1
Heat water for tea/coffee	191	99.5
Heat water for purifying water	6	3.1

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

Table 32 Number of uses of heated water

		Frequency	Valid Percent
Valid	1	163	84.9
	2	26	13.5
	3	3	1.6
	Total	192	100.0
Missing	System	6	
Total		198	

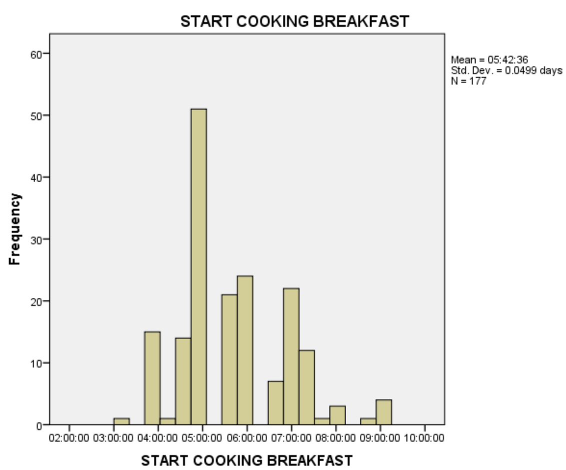
The most common times to star cooking meals (modes) were:

- Breakfast: 5.00
- Lunch: 10.00
- Dinner: 16.00

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

- breakfast between 4.00 and 7.30
- lunch between 7.00 and 11.30
- dinner between 15.00 and 19.00.

BREAKFAST IS TYPICALLY PREPARED AT 5:00, LUNCH AT 10:00 & DINNER AT 16:00.



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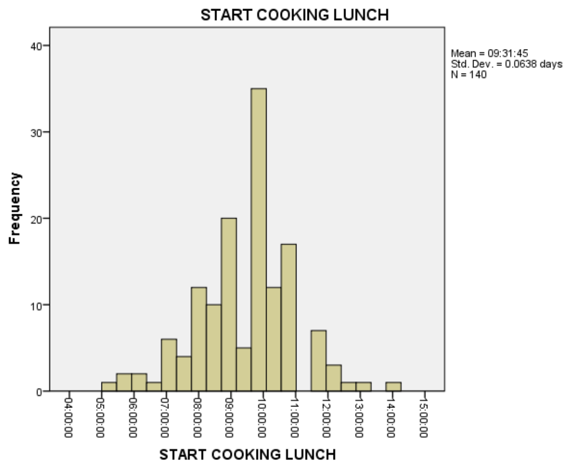

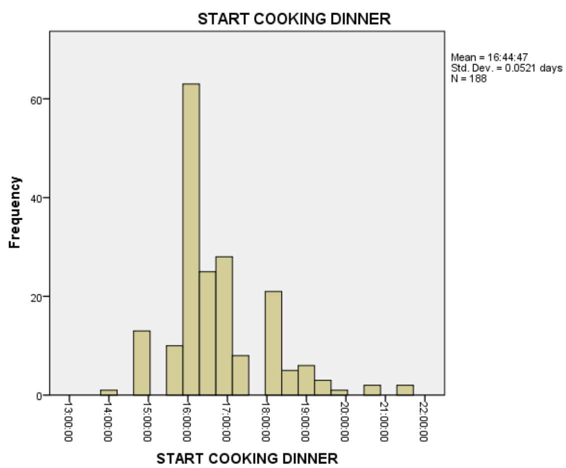

Figure 7 Distribution of times for starting to prepare meals

RESPONDENTS SPEND AN AVERAGE OF 3.2 HOURS/DAY COOKING.

Households spend an average of 3.2 hours/day cooking (median = 3.0 hours/day). Figure 8 shows that the mode is 3 hours/day. As might be expected, there is a strong correlation between time spent cooking and the number of meals always cook (r = 0.521, p < 0.001).

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

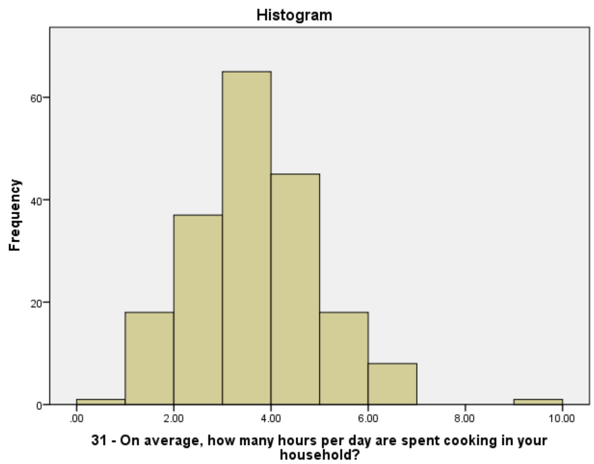

Figure 8 Distribution of time spent cooking (hours/day)

In 85% of households, it was a woman who did most of the cooking, and in 11% of households men and women shared cooking; in only 5% 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[5] (see

UNSURPRISINGLY, PARTICIPANTS REPORTED THAT WOMEN ARE USUALLY RESPONSIBLE FOR COOKING (85%), HOWEVER, IN 5% OF HOUSEHOLDS, MEN DO THE MAJORITY OF COOKING & IN 11% 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

[5] 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 *33*).

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Table 33 Gender of persons who do the majority of cooking in the household[6]

Description	Gender			Total	Percent (n=197)
	Male	Female	Both		
Head of household	7	38	12	57	29
Spouse of head	2	77	12	91	46
Other family member	0	57	6	63	32
Maid / cook	0	2	0	2	1
Other	0	7	0	7	4

4.3.2 Cooking fuels

Wood and electricity were the fuels most commonly used for cooking, followed by charcoal (Table 34). Just under half of households used multiple fuels for cooking (Table 35). Of the 49% of respondents who did not use electricity for cooking, only 10% had some prior experience of cooking with electricity.

Among households using only a single cooking fuel, the majority choses wood and one third chose electricity (see Table 36). The pairing of cooking fuels among those households using two cooking fuels is presented in Table 37, along with the split of fuels regarded as the main cooking fuel. This shows that:

- Electricity was the dominant choice of fuel supplementing other fuels
- There was no clear preference for either fuel as the main cooking fuel among households using electricity with LPG and wood. However, those who used electricity with charcoal mostly used electricity as their main fuel, suggesting that charcoal was only used as a backup fuel.
- Charcoal was most commonly used in combination with wood; most of these used wood as their main fuel, suggesting that charcoal was used as a supplementary fuel, perhaps for specific tasks.

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

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Table 34 Cooking fuels

Fuel	Fuels used[7]		MAIN cooking fuel	
	Frequency	Percent (n=197)	Frequency	Percent (n=197)
Electricity	101	51.3	72	36.5
LPG	34	17.3	15	7.6
Charcoal	60	30.5	20	10.2
Wood	105	53.3	89	45.2
Crops	1	0.5	1	0.5
Other	1	0.5		
Total			197	100.0

Table 35 Number of cooking fuels used

		Frequency	Valid Percent
Valid	1	106	53.8
	2	79	40.1
	3	10	5.1
	4	2	1.0
	Total	197	100.0
Missing	System	1	
Total		198	

[7] N.B. multiple response.

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Table 36 Cooking fuel used - household uses single fuel only

		Frequency	Percent
Valid	Electricity	33	31.1
	Cylinder gas	3	2.8
	Charcoal	6	5.7
	Wood	64	60.4
	Total	106	100.0

Table 37 Combinations of fuels used for cooking (and MAIN cooking fuel) - households using two cooking fuels

	Electricity	LPG	Charcoal	Wood
Electricity				
LPG	19 (elec 10)			
Charcoal	23 (elec 19)	3		
Wood	16 (wood 9)	1	15 (wood 10)	

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The majority of households cook indoors (Table 38). Breaking location down by main cooking fuel shows that only charcoal and wood are used outdoors (Table 39), yet high proportions of charcoal and wood users cook indoors (71% of those using wood as their main fuel).

Table 38 Cooking location (within the household)

		Frequency	Percent
Valid	Indoors	159	80.3
	Outdoors	35	17.7
	Both	3	1.5
	Total	197	99.5
Missing	System	1	.5
Total		198	100.0

Table 39 Cooking location broken down by main cooking fuels

Main cooking fuel	Cooking location			Total
	Indoors	Outdoors	Both	
Electricity	69	3	0	72
Cylinder gas	14	1	0	15
Charcoal	12	6	2	20
Wood	63	25	1	89
Agricultural crops	1	0	0	1
Total	159	35	3	197

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4.3.3 Cooking devices

Among households in the sample, basic stoves are by far the most commonly used cooking device (Table 40). Electric rice cookers are the next most common device, followed by electric frying pans. Note the small number of households using improved stoves. It is interesting to note that people tend to use induction stoves rather than conventional electric hobs. Over one third of households have only a single cooking device (Table 41). The devices used by households using only a single cooking device are mostly biomass (Table 42) don't line up with their choice of cooking fuels, which are mainly electric (Table 36).

Table 40 Number of households owning cooking devices

Device	Frequency	Percent
3 stone fire	44	22%
Basic stove (wood, charcoal, dung etc.)	123	62%
Improved biomass cookstove	4	2%
single kerosene burner		0%
double kerosene burners		0%
Gas burner (portable) - single	24	12%
Gas burner (portable) - double	7	4%
Gas cooker (rings and oven)		0%
Gas oven		0%
Induction stove	24	12%
Electric hotplate - 1 hob	15	8%
Electric hotplate - 2 hob	1	1%
Electric hotplate - more than 2 hob		0%
Electric Cooker (rings and oven)	1	1%

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Electric oven	6	3%
Electric water heater	9	5%
Electric frying pan	68	34%
Kettle	74	37%
Microwave	14	7%
Toaster -	8	4%
Rice cooker	96	48%
Electric slow cooker	1	1%
Electric multicooker (pressure cooker)	9	5%
Other	4	2%

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Table 41 Number of cooking devices in the household

		Frequency	Valid Percent
Valid	1	74	37.8
	2	28	14.3
	3	21	10.7
	4	47	24.0
	5	13	6.6
	6	9	4.6
	7	1	.5
	8	2	1.0
	9	1	.5
	Total	196	100.0
Missing	System	2	
Total		198	

Table 42 Number of households owning cooking devices – households with single device

Device	Frequency	Percent
3 stone fire	18	9.1
Basic stove (wood, charcoal, dung etc.)	50	25.3
Gas burner (portable) - single	2	1.0
Gas burner (portable) - double	3	1.5
Induction stove	1	0.5

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

The survey also asked about non-cooking electrical appliances; 68 households had fridges, and 7 had freezers (4 of which also had fridges, so these probably represent fridge-freezers) i.e. 71 (36%) of households had either a refrigerator or fridge-freezer.

4.4 Fuel consumptions and costs

4.4.1 Electricity

Most households with formal connections to the national grid (Table 18) have shared meters. Among households connected to a mini-grid, most simply pay a flat rate (Table 43).

Table 43 Types of tariffs - mini-grid users

Tariff type	Frequency	Percent (n=24)
Flat rate	22	91.7
Block tariff (different rates for each block of units)	1	4.2
Application (small business, household, lighting only etc.)	2	8.3

Respondents were asked for their monthly expenditure on electricity and how many units they used each month. Table 44 shows that the average paid by national grid users was 10,400 MMK/month, and that mini grid users paid a lot more – around double. Distributions are presented in Figure 9 and Figure 10.

Respondents' estimates of energy consumptions (units used per month) were checked against consumption figures calculated from the monthly costs, which are likely to be recalled more reliably. Calculated consumptions were based on the following tariff structure[8]

- 0-100 kWh 35 MMK/kWh
- 101 -200 kWh 40 MMK/kWh
- > 200 kWh 50 MMK/kWh

[8] https://www.mmtimes.com/news/real-cost-myanmars-electricity.html

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

When omitting a small number of outliers, the calculated consumptions correlated strongly with respondents' estimates ($r = 0.917$, $p < 0.001$), indicating that the estimates are reliable.

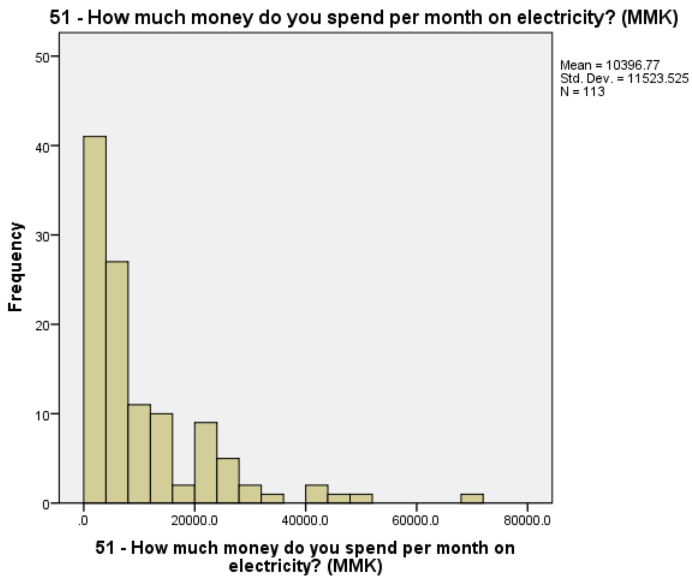

Figure 9 Monthly expenditure on electricity (MMK/month) – National grid users

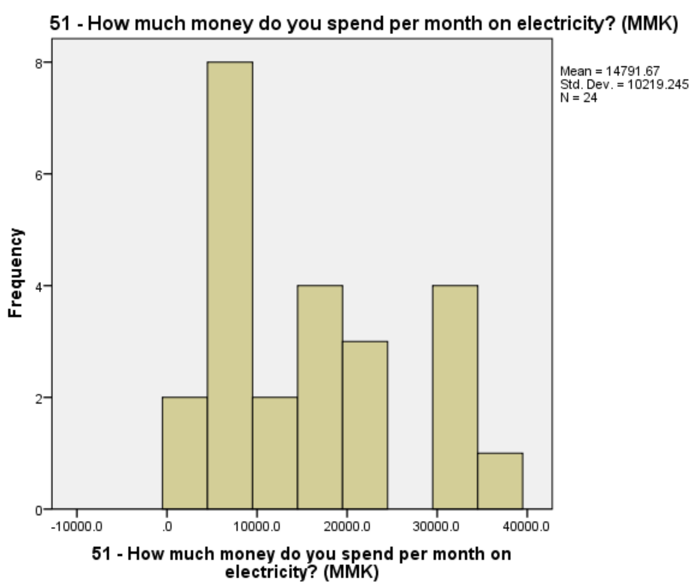

Figure 10 Monthly expenditure on electricity (MMK/month) – Mini grid users

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

Table 44 Monthly expenditure on electricity (MMK/month)

	N	Mean	Median	Std.dev.	25% quartile	75% quartile
National Grid	113	10,397	6,000	11,524	3,000	13,000
Mini grids	24	14,792	13,500	10,219	6,000	20,000

4.4.2 LPG

Respondents appeared to use a wide range of refill sizes (Table 45). The single most common size was 5kg, which is slightly at odds with a recent article that asserts that “most consumers use 220g gas cylinders, but a few use the much bigger 5kg cylinders…”[9]. Respondents all paid different prices for their cylinders, resulting in a wide distribution in unit prices paid (Table 46).

Most respondents get a refill either every month or every two months (see Table 47). Then mean monthly expenditure on LPG was 11,400 MMK/month (Table 48).

[9] https://frontiermyanmar.net/en/lpg-bright-prospects-but-growth-constraints

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Table 45 Size of LPG cylinder refills

Size of refill (kg)		Frequency	Valid Percent
Valid	.3	1	3.0
	.5	2	6.1
	.6	2	6.1
	.9	1	3.0
	1.0	2	6.1
	2.0	2	6.1
	2.5	1	3.0
	3.0	2	6.1
	4.0	3	9.1
	5.0	8	24.2
	7.0	2	6.1
	8.0	2	6.1
	10.0	4	12.1
	12.0	1	3.0
	Total	33	100.0
Missing	System	165	
Total		198	

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Table 46 Calculated unit price of LPG (MMK/kg)

		Frequency	Valid Percent
Valid	1000	1	3.1
	1400	1	3.1
	1500	1	3.1
	1667	1	3.1
	1667	2	6.3
	1800	2	6.3
	2000	2	6.3
	2250	1	3.1
	2500	3	9.4
	2600	3	9.4
	2667	1	3.1
	2786	1	3.1
	2800	1	3.1
	3000	8	25.0
	3500	2	6.3
	3750	1	3.1
	4800	1	3.1
	Total	32	100.0
Missing	System	166	
Total		198	

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Table 47 Period of time that LPG cylinder lasts for (weeks)

		Frequency	Valid Percent
Valid	.3	1	2.9
	.5	1	2.9
	1.0	3	8.8
	1.3	1	2.9
	2.0	2	5.9
	3.0	1	2.9
	4.0	10	29.4
	6.0	3	8.8
	8.0	6	17.6
	10.0	1	2.9
	15.0	2	5.9
	24.0	2	5.9
	30.0	1	2.9
	Total	34	100.0
Missing	System	164	
Total		198	

Table 48 Monthly expenditure on LPG (MMK/month)

N	Mean	Median	Std.dev.	25% quartile	75% quartile
33	11,400	8,000	14,200	3,100	15,000

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4.4.3 Charcoal

Only those respondents who used charcoal for cooking were asked for details of their consumption of charcoal. Charcoal consumption is difficult to assess because people usually buy it in a wide variety of measures e.g. bag, bucket, sack. However, most respondents have estimated the amount of charcoal they purchase in Burmese units of weight (viss[10]). The question did not specify the unit, but given that most respondents specified their answer in terms of viss, it has been assumed that all responses are in viss.

Nearly one half of charcoal users buy charcoal on a monthly basis, but nearly 20% buy small amounts on a daily basis (Table 49). Charcoal is most commonly bought in 10 viss (16 kg) and 1 viss (1.6 kg) amounts (Table 50). Again, nearly 20% of charcoal users usually buy charcoal in small amounts (less than 1 kg).

Table 49 Frequency of purchasing charcoal (days)

		Frequency	Valid Percent
Valid	1.0	11	18.3
	2.0	1	1.7
	4.0	1	1.7
	7.0	2	3.3
	10.0	3	5.0
	15.0	1	1.7
	20.0	3	5.0
	30.0	26	43.3
	40.0	1	1.7
	45.0	3	5.0
	60.0	4	6.7
	90.0	1	1.7
	150.0	1	1.7

ALMOST HALF OF THE CHARCOAL USERS BUY MONTHLY, HOWEVER 20% BUY IN SMALL QUANTITIES ON A DAILY BASIS. ECOOK SYSTEMS WITH MONTHLY REPAYMENT PLANS ARE LIKELY TO BE ATTRACTIVE TO THE FORMER, HOWEVER MORE FREQUENT REPAYMENT OPTIONS WILL BE NECESSARY TO REACH THE LATTER, WHO ARE LIKELY TO BE THE POORER HOUSEHOLDS.

[10] 1 viss = 1.6 kg

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

	200.0	1	1.7
	365.0	1	1.7
	Total	60	100.0
Missing	System	138	
Total		198	

Table 50 Amounts of charcoal bought

		Frequency	Valid Percent
Valid	.8	4	7.8
	1.0	1	2.0
	1.2	2	3.9
	1.6	8	15.7
	3.2	1	2.0
	8.0	3	5.9
	16.0	14	27.5
	19.0	2	3.9
	22.0	1	2.0
	24.0	5	9.8
	32.0	4	7.8
	38.0	2	3.9
	45.0	1	2.0
	48.0	2	3.9
	80.0	1	2.0
	Total	51	100.0
Missing	System	147	
Total		198	

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There are differences in the prices paid for charcoal between rural and urban areas (see Table 51); prices were lowest in peri-urban areas, and highest (more than double) in urban areas. Among all charcoal users, there a strong relationship between the price paid and the amount bought ($r = -0.490$, $p < 0.001$), confirming that those who buy in small quantities pay a premium. When looking at specific typs of settlement, this same relationship was only evident in rural areas ($r = -0.796$, $p < 0.001$).

Table 51 Calculated charcoal prices (MMK/kg)

	N	Mean	Median	Std.dev.	25% quartile	75% quartile
Rural	16	300	330	150	160	400
Peri-urban	22	240	190	120	150	310
Urban	12	600	560	380	310	860

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4.4.3.1 Wood

Only those respondents who used wood for cooking were asked for details of their consumption of wood. 62% of respondents that used wood for cooking were in rural areas, 36% in peri-urban areas, and only 2 % in urban areas. It is interesting to note that even in rural areas, substantial numbers of respondents bought their wood (see Table 52).

INTERESTINGLY, MANY RURAL FIREWOOD USERS ALSO REPORTED PAYING FOR IT.

Table 52 Means of procuring wood by settlement type

		TYPE OF WOOD PRECUREMENT			
		Collect only	Collect and buy	Buy only	Total
3 - Is your household in an urban or rural area	rural	20	36	9	65
	peri-urban	6	22	9	37
	urban	0	2	0	2
Total		26	60	18	104

One third of wood users procure it (either bought or collected) on a monthly basis. The next most common frequency is to collect annually. At the other extreme, 10% buy small amounts on a daily basis (Table 53).

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Table 53 Frequency of collecting or purchasing wood (days)

		Frequency	Valid Percent
Valid	1.0	10	9.7
	2.0	1	1.0
	3.0	3	2.9
	5.0	3	2.9
	8.0	1	1.0
	10.0	2	1.9
	15.0	5	4.9
	20.0	7	6.8
	21.0	1	1.0
	25.0	2	1.9
	30.0	34	33.0
	32.0	1	1.0
	40.0	2	1.9
	45.0	1	1.0
	60.0	9	8.7
	90.0	1	1.0
	120.0	2	1.9
	150.0	1	1.0
	180.0	2	1.9
	365.0	15	14.6
	Total	103	100.0
Missing	System	95	
Total		198	

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The question on amount of wood either bought or collected did not specify units, but most respondents specified their answer in viss, so it has been assumed that all responses have been enumerated in viss. Wood is most commonly bought in 150 viss (240 kg) amounts, and this is the case in both rural and peri-urban areas (Table 54). It is only in peri-urban areas that people procure wood in small amounts (less than 10 viss (16 kg).

Table 54 Amount of wood collected or bought

kg	rural	peri-urban
2	0	0
5	0	1
6	0	1
13	0	1
16	2	0
22	0	1
30	1	0
50	1	0
190	2	0
220	3	0
240	13	14
260	7	0
360	1	0
480	9	4
580	1	0
720	0	1
960	1	0
1200	1	1
2400	2	0
4000	1	0
Total	45	24

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

Prices paid for charcoal have been calculated from amounts paid and estimates of the amounts procured. Table 55 indicates that differences in prices between rural and peri-urban areas were modest. The large difference in mean figures is due to a small number of peri-urban respondents who used small amounts of wood purchased at a high price premium. Only among peri-urban respondents was there a relationship between the price paid and the amount bought ($r = -0.472$, $p = 0.020$), confirming that those who buy in small quantities pay a premium.

Note that price figures should be treated with some caution because most respondents both bought and collected wood and the amounts bought are likely to be different from the amounts collected, yet the survey gathered only one figure, so it is not clear precisely what this relates to. It was not possible to estimate wood prices paid by those who only bought their wood, because data on the amounts of wood purchased by this small sub-sample were unreliable.

Table 55 Calculated wood prices (MMK/kg)

	N	Mean	Median	Std.dev.	25% quartile	75% quartile
Rural	30	25	27	1.5	22	29
Peri-urban	24	57	27	80	21	39

In urban areas, most respondents spent 4 to 5 hours collecting wood (71% of respondents). Two respondents took annual expeditions over two days. Most respondents from peri-urban areas (57%) collected wood within 2 hours.

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4.4.4 Energy consumptions

Energy consumptions have been based on the calorific values given in Table 56.

Table 56 Calorific values and conversion efficiencies[11]

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 11 presents the total energy consumed in a month by all respondents in each settlement grouping (remember that the sample is split into roughly similar sized groups - Table 1). This shows that electricity is really only used in urban areas, and wood is predominantly used in rural areas. Interestingly, the amount of charcoal used is similar across all three settlement types.

Note that these fuels will be used for a range of uses other than cooking, and these are explored in Table 58.

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

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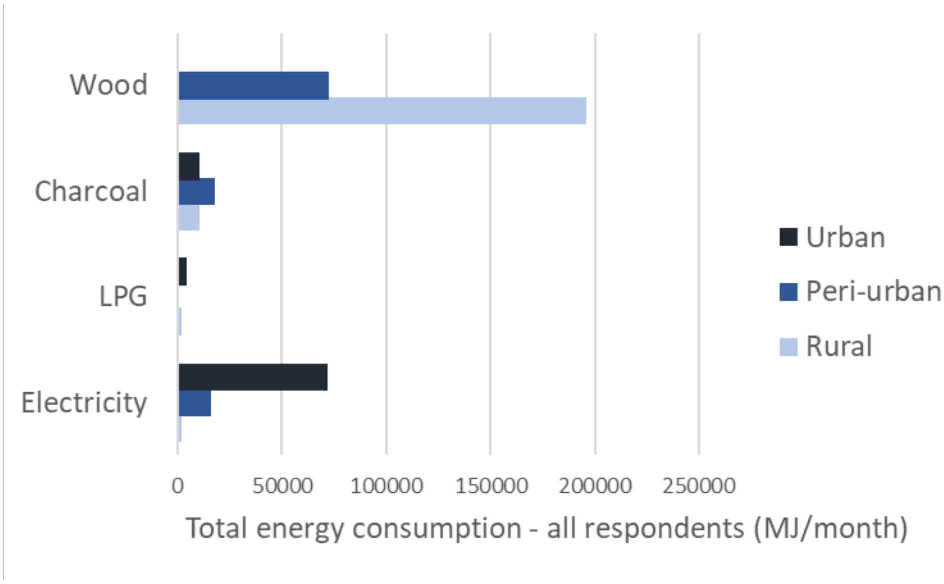

Figure 11 Energy consumptions (totals)

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 12 shows that, among respondents who use these fuels for cooking, specific consumption of electricity is highest in urban areas, and there is a clear progression of increased consumption of wood from urban to rural areas. Again, specific use of charcoal is similar across all three settlement types.

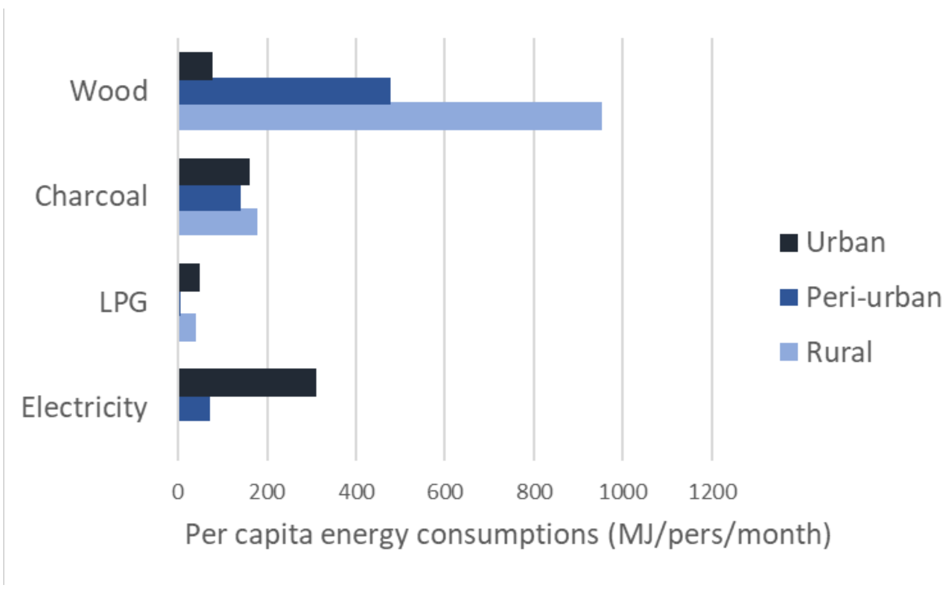

Figure 12 Per capita energy consumptions (valid users)

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The analysis in Figure 12 simply considers differences between different fuels, and takes no account of fuel stacking – use of multiple fuels in a household. The main sources of energy used for cooking, including combinations of fuels, are presented in Table 57 (N.B. only 6% of households use combinations of energy not included in this typology). Household energy consumptions have been calculated only for those households where valid energy consumption data is available for all sources of energy used for cooking.

Table 57 Fuels used for cooking

		Frequency	Percent
Valid	Electricity	33	16.7
	Charcoal	7	3.5
	Wood	64	32.3
	Elec & LPG	19	9.6
	Charcoal & wood	15	7.6
	Electricity & charcoal	23	11.6
	Electricity & wood	16	8.1
	Electricity, LPG, & charcoal	4	2.0
	Electricity, charcoal & wood	4	2.0
	Other	12	6.1
	Total	197	99.5
Missing	System	1	.5
Total		198	100.0

ELECTRICITY & CHARCOAL/FIREWOOD ARE USEFUL FOR OTHER THINGS TOO. ALMOST ALL PARTICIPANTS WHO COOKED WITH ELECTICITY REPORTED USING IT FOR LIGHTING (99%) & MOST FOR REFRIGERATION (59%). ROUGHLY HALF OF ALL FUEL USERS REPORTED ALSO USING THEM FOR WATER HEATING, HOWEVER ALMOST NOBODY USED THEM FOR SPACE HEATING.

It has already been pointed out that each of these fuels may be used for purposes other than cooking. Table 58 shows that electricity is used for more than cooking, all three main fuels are used for water heating, and for some 'other', undisclosed purposes. It is not, therefore, possible to determine cooking energy consumptions from these data.

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Table 58 Additional uses of fuels used for cooking

	Electricity (n=101) Frequency (valid percent)	Charcoal (n=57) Frequency (valid percent)	Wood (n=98) Frequency (valid percent)
lighting	100 (99%)		
refrigeration	60 (59%)		
Water heating	44 (44%)	32 (56%)	67 (68%)
Space heating	2 (2%)	1 (2%)	0 (0%)
other	85 (84%)	41 (72%)	58 (59%)

4.4.5 Cooking times

Results in Table 59 suggest that it takes longer to cook with biomass (wood and charcoal), and cooking with LPG is fastest. However, time spent cooking correlates strongly with the number of meals always cooked ($r = 0.548$, $p < 0.001$), suggesting that the effect may be due to cooking demand rather than fuel. A regression analysis confirms that time spent cooking depends mostly on number of meals cooked, but also choice of fuel. In particular, it is quicker to cook with electricity than with wood; differences between electricity, LPG, and charcoal are not significant.

Table 59 Time spent cooking by choice of main cooking fuel

Means	Electricity (n)	LPG (n)	Charcoal (n)	Wood (n)	KW test (p value)
Time spent cooking (hour/day)	2.8 (70)	2.1 (15)	3.1 (18)	3.8 (88)	< 0.001
Number of people in household	4.0	4.2	4.8	5.0	< 0.001
Number of meals always cooked	1.7	1.4	1.7	2.4	0.004

WHILE SMOKE WAS ALMOST UNIVERSALLY REGARDED AS A HEALTH PROBLEM, THERE WAS ALSO STRONG OPINION THAT IT WAS BENEFICIAL IN CONTROLLING INSECTS.

4.5 Beliefs and attitudes

4.5.1 Perceptions on fuels

Figure 13 and Figure 14 indicate that respondents had little understanding of coal as a cooking fuel (most respondents had no opinion). Charcoal and wood were regarded as easy to access, but only charcoal was generally regarded as safe (N.B. electricity was not included in these questions). It is interesting to note that LPG was not regarded as safe overall, reflecting some kind of negative experiences to date. Half of respondents regarded LPG as difficult to access, which most likely reflects the state of the distribution network.

THERE WAS GREATEST AGREEMENT THAT FIREWOOD IS EXPENSIVE FOR COOKING, LESS SO FOR LPG, AND ELECTRICITY APPEARS TO BE REGARDED AS THE CHEAPEST FUEL (OUT OF THESE THREE ONLY).

A further set of questions on various aspects of different fuels provide further insights (see Figure 15):

- While smoke was almost universally regarded as a health problem, there was also strong opinion that it was beneficial in

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controlling insects.
- Firewood and charcoal appear to be equally convenient (N.B. these two questions were asked in opposite senses), but there was general agreement that collecting firewood was indeed a burden for their families.
- There was greatest agreement that firewood is expensive for cooking, less so for LPG, and electricity appears to be regarded as the cheapest fuel (out of these three only).
- Most respondents were aware that firewood is harmful to health, but they were less likely to feel that charcoal is harmful to health.

MOST RESPONDENTS WERE AWARE THAT FIREWOOD IS HARMFUL TO HEALTH, BUT THEY WERE LESS LIKELY TO FEEL THAT CHARCOAL IS HARMFUL TO HEALTH.

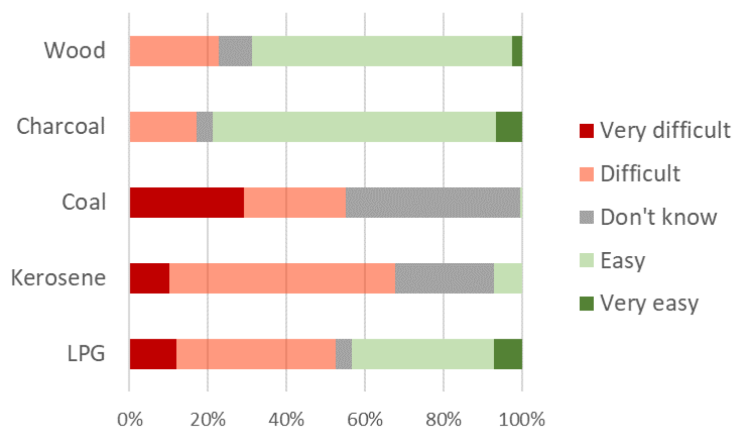

Figure 13 Ease of access to fuels

LPG USERS TEND TO REGARD IT AS A SAFE FUEL, UNLIKE EVERYBODY ELSE, SUGGESTING THAT NEGATIVE PERCEPTIONS ON SAFETY ACT AS A BARRIER TO USE OF LPG.

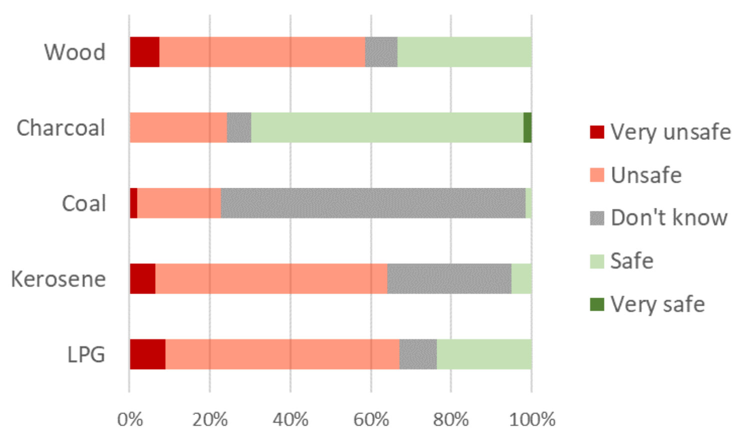

Figure 14 Safety of fuels

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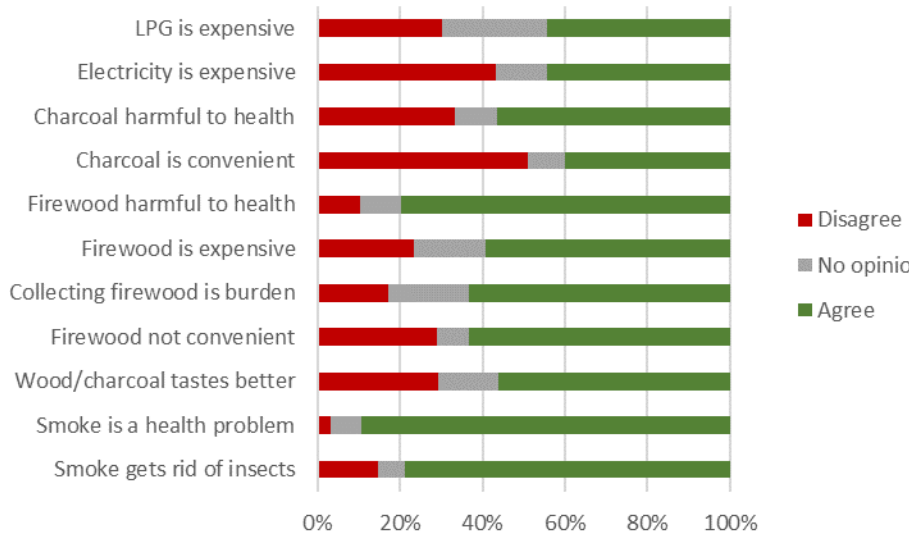

Figure 15 Perceptions of fuels

Mean attitude scores have been calculated for groups of respondents that use each fuel as their main cooking fuel (Table 60). The following relationships can be seen:

- Easy access to wood is an important factor driving use of wood
- Conversely, lack of access to charcoal acts as a barrier to charcoal use i.e. people who use wood feel it is less easy to access charcoal.
- LPG users tend to regard it as a safe fuel, unlike everybody else, suggesting that negative perceptions on safety act as a barrier to use of LPG.
- Charcoal is widely regarded as safe, so safety is not influential in choice of cooking fuel. On the other hand, wood is widely regarded as unsafe, even among those who use wood, so neither is safety of wood influential in the choice of wood as a cooking fuel.
- Smoke is almost universally regarded as a health problem, suggesting that even those who use electricity and LPG as their main cooking fuel still suffer from smoke when using supplementary fuels.
- Similarly, cooking with firewood is widely regarded as harmful to health, so it is not influential in choice of fuel. Interestingly, it is also generally accepted that charcoal is harmful to health, although less so. Although charcoal uses have a neutral view (on average), the difference is not significant.

VIEWS ON THE COST OF ELECTRICITY AND LPG ARE INFLUENTIAL. LPG USERS BELIEVE LPG TO BE CHEAP AND ELECTRICITY TO BE EXPENSIVE, INDICATING THEY ARE COST SENSITIVE. PEOPLE USING WOOD TEND TO BELIEVE THAT BOTH ELECTRICITY AND LPG ARE EXPENSIVE.

PEOPLE WHO USE WOOD ONLY WEAKLY AGREE THAT IT IS INCONVENIENT, WHEREAS CHARCOAL USERS FEEL MOST STRONGLY THAT CHARCOAL IS NOT CONVENIENT, SUGGESTING HIGH LEVELS OF DISSATISFACTION WITH ASPECTS OF CHARCOAL USE (THESE ARE NOT SPECIFIED BUT MIGHT INCLUDE DIRTY, STORAGE, TIME TO LIGHT ETC.).

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- People who use wood only weakly agree that it is inconvenient, whereas charcoal users feel most strongly that charcoal is not convenient, suggesting high levels of dissatisfaction with aspects of charcoal use (these are not specified but might include dirty, storage, time to light etc.).
- There is widespread agreement that firewood is expensive, so cost (and inference with the ability to collect wood) is not influential in choice of fuel.
- Views on the cost of electricity and LPG are influential. LPG users believe LPG to be cheap and electricity to be expensive, indicating they are cost sensitive. People using wood tend to believe that both electricity and LPG are expensive.
- Two factors appear to act as barriers to LPG use: the view that smoke is helpful in controlling insects, and the view that food tastes better when cooked with biomass.

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Table 60 Attitudes by choice of main cooking fuel (mean values)

	Range	What is your MAIN cooking fuel?				
		Electricity	LPG	Charcoal	Wood	K-W P value
N		72	15	20	89	
How easy is it to access LPG?	-2 to +2	0.5	0.93	0	-0.85	**0**
How easy is it to access kerosene?	-2 to +2	-0.58	-0.47	-0.65	-0.85	**0.008**
How easy is it to access coal?	-2 to +2	-0.83	-0.33	-0.9	-0.91	0.132
How easy is it to access charcoal?	-2 to +2	1	0.8	1.1	0.3	**0**
How easy is it to access wood?	-2 to +2	0.11	-0.07	0.75	0.81	**0**
How safe is LPG?	-2 to +2	-0.54	0.33	-0.4	-0.7	**0.005**
How safe is kerosene?	-2 to +2	-0.51	0	-0.55	-0.91	**0**
How safe is coal?	-2 to +2	-0.15	0	-0.2	-0.35	**0.007**
How safe is charcoal?	-2 to +2	0.54	0.53	0.7	0.35	0.394
How safe is wood?	-2 to +2	-0.38	-0.2	-0.3	-0.29	0.908
Smoke from stove is good at chasing insects away.	-1 to +1	0.6	0.07	0.55	0.79	**0.003**
Smoke from cooking fuels is a big health problem.	-1 to +1	0.85	0.73	0.9	0.89	0.857
food tastes better when cooked with charcoal/wood	-1 to +1	0.21	-0.4	0.55	0.38	**0.009**
Cooking with firewood is not convenient.	-1 to +1	0.58	0.73	0.25	0.11	**0.007**
Collecting/preparing firewood is a family burden	-1 to +1	0.58	0.27	0.32	0.44	0.292
Firewood is expensive for cooking.	-1 to +1	0.32	0.47	0.45	0.36	0.845
Cooking with firewood is harmful to health.	-1 to +1	0.76	0.8	0.65	0.65	0.657
Charcoal is convenient to use for cooking.	-1 to +1	-0.25	0.13	-0.5	0.07	**0.026**
Cooking with charcoal is harmful to health.	-1 to +1	0.25	0.47	0.05	0.25	0.609
Electricity is expensive for cooking.	-1 to +1	-0.31	0.47	-0.2	0.22	**0.001**
LPG is expensive for cooking.	-1 to +1	0.01	-0.6	0	0.38	**0**

4.5.2 Purchasing preferences

When it comes to purchasing substantial household items, women are highly likely to be involved in purchasing a cooker (in 88% of cases the female head of household would be involved), but it was men who were more likely to be involved in purchasing a solar panel (men would be involved in 85% of cases, compared with involvement of women in 66% of cases) (Table 61).

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Table 61 Main decision maker for hypothetical household purchases

	Cooking device		Solar panel	
	Frequency	Percent	Frequency	Percent
male head of house	20	10.1	66	33.3
female head of house	95	48.0	28	14.1
joint decision	79	39.9	102	51.5
another relative	4	2.0	2	1.0
Total				

A clear majority of respondents felt that people would like to rent equipment rather than buy it – see Table 62, and this was corroborated by the finding that 71% of respondents would prefer to pay for high value purchases (not specified) by monthly instalments rather than paying the total cost up front. Only a few respondents would prefer making weekly payments, and the remainder were split more or less equally between monthly payments (53%) and quarterly payments (44%).

Table 62 How would people in your neighbourhood feel about the idea of renting equipment?

		Frequency	Percent
Valid	Very opposed	1	.5
	Opposed	27	13.6
	No opinion	27	13.6
	Positive	117	59.1
	Very positive	26	13.1
	Total	198	100.0

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4.5.3 Cooking device preferences

Overall, there appears to be a strong appetite for cooking with some form of modern energy (see Table 63).

Table 63 How many people would switch to modern energy (gas/electric) if fuels cost were the same

		Frequency	Percent
Valid	a few people	2	1.0
	some people	11	5.6
	many people	175	88.4
	Don't know	9	4.5
	Total	197	99.5
Missing	System	1	.5
Total		198	100.0

On details of any proposed design, only one third of respondents felt there was a need to a device to accommodate very large pots as well as medium sized ones. There was a preference for a square design (53% voted for design A, 28% for design B, and 18% for deign C in Figure 16). There was almost universal support for the idea of using cooking appliances (both cooker and pots) provided by the electricity utility company (see Table 64).

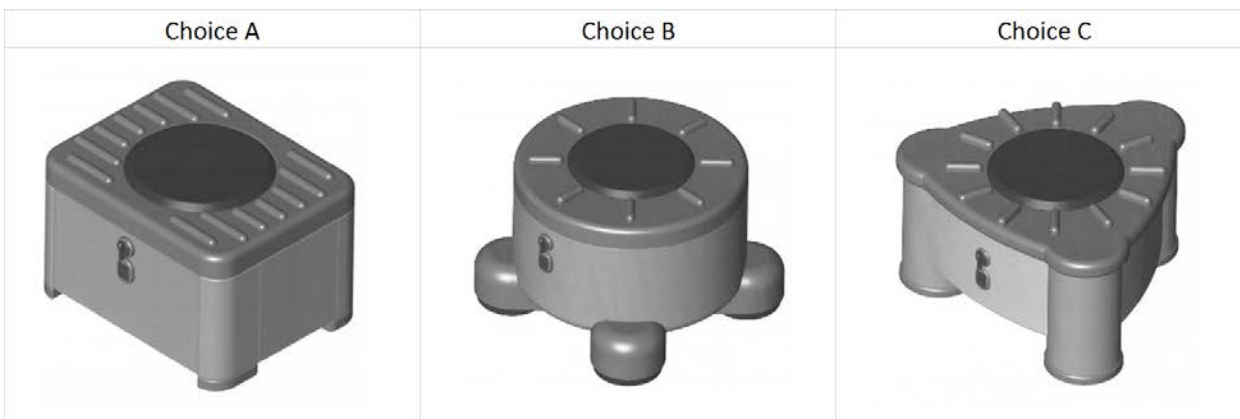

Figure 16 Hypothetical cooking device design options

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Table 64 How would you feel about using cooking appliances provided by the electricity utility?

	Cooker		Pots	
	Frequency	Percent	Frequency	Percent
Opposed	1	.5	1	.5
No opinion	2	1.0	2	1.0
Positive	126	63.6	111	56.1
Very positive	69	34.8	84	42.4
Total	198	100.0	198	100.0

When asked about the hypothetical situation of using firewood, a sizable minority (11%) said they would prefer to use a three stone fire rather than a cookstove, suggesting that there remains some resistance to change from traditional cooking practices. It is interesting to note that the preference of wood burning device is not sensitive to the choice of main cooking fuel. This suggests that even modern energy users (electricity and LPG users) have some kind of affection for the traditional three stone stove rather than completely dismissing it as unacceptably hazardous.

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.

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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:

β_x = coefficient of any parameter

β_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:

Cooking:

0 = boil only

1 = boil & fry

SpeedMed

0 = slow

1 = normal

Speedfast

0 = slow

1 = fast

Flavour

0 = no smoky flavour

1 = smoky flavour

Potlid

0 = no lid

1 = pot with lid

Pot sealed

0 = no lid

1 = sealed pot

2 hob:

0 = 1 hob

1 = 2 hob

4 hob:

0 = 1 hob

1 = 4 hob

Results from the binary logistic regression are presented in Table 65.

THE FEATURES OF THE COOKING PROCESS THAT ARE MOST IMPORTANT TO CONSUMERS ARE:

- BOIL AND FRY - TO BE ABLE TO DO BOTH
- LID – PEOPLE HAVE A STRONG PREFERENCE FOR A LID, BUT NOT FOR A SEALED POT
- HOBS – PEOPLE PREFER DOUBLE HOBS, BUT INTERESTINGLY PEOPLE DID NOT APPEAR TO HAVE A PREFERENCE FOR 4 HOBS OVER A SINGLE HOB.
- TASTE – THERE WAS A CLEAR PREFERENCE FOR A DEVICE THAT DID NOT MAKE FOOD TASTE SMOKY.
- COST.

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Table 65 Binary logistic regression – cooking processes

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Cooking(1)	2.255	.192	138.386	1	.000	9.534
	SpeedMed(1)	.246	.206	1.431	1	.232	1.279
	SpeedFast(1)	.442	.218	4.127	1	.042	1.556
	Flavour(1)	-.996	.185	28.941	1	.000	.369
	PotLid(1)	1.521	.247	38.011	1	.000	4.575
	PotSealed(1)	-.159	.210	.569	1	.450	.853
	@2hob(1)	1.013	.183	30.778	1	.000	2.754
	@4hob(1)	-.065	.248	.070	1	.792	.937
	CPCOSTC	-.531	.130	16.681	1	.000	.588
	Constant	-2.266	.247	84.486	1	.000	.104

Note: Compared against a constant only model, the model was significant (χ^2 = 1589, $p < 0.001$, with df = 9); Nagelkerke R^2 = 0.554. Prediction success = 84.1%.

Those design features that appear to be most important to consumers are (see Table 66 for estimates of willingness to pay):

- Cooking – prefer to be able to both boil and fry
- Lid – people have a strong preference for a lid, but not for a sealed pot
- Hobs – people prefer double hobs, but interestingly people did not appear to have a preference for 4 hobs over a single hob.
- Taste – there was a clear preference for a device that did not make food taste smoky.
- Cost.

DISCHARGE RATE IS A KEY DETERMINANT OF BATTERY LIFE. FRYING GENERALLY REQUIRES HIGHER POWER THAN BOILING & 2 HOBS REQUIRE TWICE AS MUCH POWER AS ONE. AGAIN, SYSTEM DESIGNERS MAY HAVE TO CHOOSE TO TRADE OFF USABILITY FOR COST IN BUDGET MODELS.

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Table 66 Willingness to pay for priority characteristics - cooking process

Feature	Willingness to pay (MMK)
boil & fry	42,000
pot with lid	29,000
2 hob	19,000
NO smoky flavour	19,000
Fast	8,000

COOKING WITH A LID ON THE POT IS MORE ENERGY-EFFICIENT, SO WILL REDUCE THE SIZE OF THE BATTERY & MAKE ECOOK SYSTEMS MORE AFFORDABLE. HOWEVER, A SEALED & PRESSURISED POT IS EVEN MORE EFFICIENT, SO SOME COMPROMISES MATY HAVE TO BE MADE FOR THE LOWEST COST SYSTEMS.

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

STSupplementSometimes

0 = always need to use with other stove

1 = sometimes need to use with other stove

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

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0 = cannot be moved (too heavy)

1 = can be carried in/out of the house

STLooks

0 = looks plain

1 = Looks good

Results from the binary logistic regression are presented in Table 67.

Table 67 Binary logistic regression – stove design

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	People6(1)	-.136	.168	.653	1	.419	.873
	People8(1)	.437	.129	11.435	1	.001	1.547
	SupplementSometimes(1)	-.289	.218	1.750	1	.186	.749
	SupplementAll(1)	.848	.135	39.463	1	.000	2.334
	WoodSmoke(1)	-.534	.142	14.035	1	.000	.586
	CharcoalSmoke(1)	-.562	.168	11.235	1	.001	.570
	Portable(1)	.986	.132	55.378	1	.000	2.680
	Looks(1)	-.008	.109	.006	1	.940	.992
	STCOSTC	-.786	.079	100.100	1	.000	.456
	Constant	.827	.211	15.419	1	.000	2.287

Note: Compared against a constant only model, the model was significant ($\chi^2 = 257$, $p < 0.001$, with df = 9); Nagelkerke $R^2 = 0.118$. Prediction success = 59.4%.

Those design features that appear to be most important to consumers are (see Table 68 for estimates of willingness to pay):

- Portable – people would like a device that can be carried in/out of the house
- Capacity – people want to be able to do all their cooking on the device, and they want to be able to cook for larger numbers of people (8 people). Interestingly, a device that cooks for 6 people appears to be no more attractive than one that cooks for 4 people.

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- Smoke – people would prefer a device that avoids generating any kind of smoke.
- Cost.

Table 68 Willingness to pay for priority characteristics – stove design

Feature	Willingness to pay (MMK)
Can be carried in/out of the house	13,000
Can do all cooking on it	11,000
Has no smoke (compared to charcoal smoke)	7,000
Has no smoke (compared to wood smoke)	7,000
Can cook for 8 people	6,000

THE FEATURES OF THE STOVE THAT ARE MOST IMPORTANT TO CONSUMERS ARE:

- PORTABLE – PEOPLE WOULD LIKE A DEVICE THAT CAN BE CARRIED IN/OUT OF THE HOUSE
- CAPACITY – PEOPLE WANT TO BE ABLE TO DO ALL THEIR COOKING ON THE DEVICE, AND THEY WANT TO BE ABLE TO COOK FOR LARGER NUMBERS OF PEOPLE (8 PEOPLE).
- SMOKE – PEOPLE WOULD PREFER A DEVICE THAT AVOIDS GENERATING ANY KIND OF SMOKE.
- COST.

4.6.2.3 Device Functionality

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

FUAvailabe

0 = only works on sunny days

1 = works on sunny and rainy days

FU6yr

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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

Results from the binary logistic regression are presented in Table 69.

Table 69 Binary logistic regression – device functionality

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	LED(1)	-1.623	.163	99.705	1	.000	.197
	Mob(1)	-.103	.186	.303	1	.582	.902
	TV(1)	.396	.221	3.213	1	.073	1.485
	Availabe(1)	1.489	.135	122.323	1	.000	4.435
	@6yr(1)	.894	.165	29.326	1	.000	2.446
	@3yr(1)	.503	.137	13.426	1	.000	1.654
	Cleaning(1)	.910	.129	49.461	1	.000	2.484
	FUCOSTC	-.011	.090	.016	1	.900	.989
	Constant	-.219	.252	.753	1	.386	.804

Note: Compared against a constant only model, the model was significant (χ^2 = 827, $p < 0.001$, with df = 8); Nagelkerke R^2 = 0.344. Prediction success = 75.5%.

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Those design features that appear to be most important to consumers are (see Table 68 for estimates of willingness to pay):

- Availability – people had a strong preference for a system that could cook reliably regardless of the weather.
- Having a device that was easy to clean.
- Finance – people have a strong preference for leasing models over simply making regular monthly payments (for as long as they used the system). There was a preference for a 6 year lease period over a 3 year period. These findings are potentially difficult to interpret, as people were not given any detail on the relative magnitudes of payments.

In addition to these, the results show a potentially counterintuitive finding that respondents would prefer a simple system that only cooks rather than one that provides lighting as well. This can be explained by the fact that almost all of the sample had access to electricity (see Table 16), and the vast majority already had electric lighting (see Table 19), so it stands to reason that this sample sees no utility in a system that provides lighting, which may even to regarded as a wasted resource.

Table 70 Willingness to pay for priority characteristics – device functionality

Feature	Willingness to pay (MMK)
works on sunny and rainy days	1,354,000
easy to clean	828,000
lease over 6 years	813,000
lease over 3 years	457,000

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
- Settlement (rural/urban)

THE FUNCTIONALITY FEATURES MOST IMPORTANT TO CONSUMERS WERE:

- AVAILABILITY – PEOPLE HAD A STRONG PREFERENCE FOR A SYSTEM THAT COULD COOK RELIABLY REGARDLESS OF THE WEATHER.
- HAVING A DEVICE THAT WAS EASY TO CLEAN.

FINANCE – PEOPLE HAVE A STRONG PREFERENCE FOR LEASING OVER UTILITY MODELS. THERE WAS A PREFERENCE FOR A 6 YEAR LEASE PERIOD OVER A 3 YEAR PERIOD. THESE FINDINGS ARE POTENTIALLY DIFFICULT TO INTERPRET, AS PEOPLE WERE NOT GIVEN ANY DETAIL ON THE RELATIVE MAGNITUDES OF PAYMENTS.

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- 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.

PEOPLE HAVE A STRONG PREFERENCE LEASE-TO-OWN OVER UTILITY MODELS, WHERE THE USER SIMPLY MAKES REGULAR PAYMENTS FOR AS LONG AS THEY USE THE SYSTEM, WITHOUT EVER GAINING OWNERSHIP. HOWEVER, PRODUCT/SERVICE DESIGNERS MAY HAVE TO COMPROMISE TO REACH THE BOTTOM OF THE PYRAMID, AS UTILITY MODELS ARE LIKELY TO HAVE THE LOWEST MONTHLY COSTS, AS THEY HAVE THE LONGEST FINANCING HORIZON.

4.6.3.1 Cooking Processes

Results in Table 71 indicate that men felt more strongly that having 2 hobs was preferable to a single hob.

Table 71 Cooking variables disaggregated by gender

Variable	Male (n=490)	Female (n=990)	
Dichotomous variables			Chi-square p value
PRCooking(1)	97%	96%	0.573
PRSpeedMed(1)	4%	6%	0.158
PRSpeedFast(1)	7%	8%	0.475
PRFlavour(1)	4%	6%	0.121
PRPotLid(1)	91%	87%	0.070
PRPotSealed(1)	5%	7%	0.133

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PR2hob(1)	92%	88%	**0.032**
PR4hob(1)	3%	5%	0.166
Continuous variables (means)			MW U-test p value
PRCOST	19,800	19,600	0.267

Table 72 indicates that a device that would cook quickly was of greater interest to urban respondents, which is probably consistent with a stronger preference for 4 hob devices, whereas rural respondents expressed a stronger preference for a 2 hob device. Rural respondents were more keen on pots with a lid.

Table 72 Cooking variables disaggregated by settlement

Variable	Rural (n=578)	Peri-urban (n=458)	Urban (n=436)	
Dichotomous variables				Chi-square p value
Cooking(1)	97%	94%	96%	0.076
SpeedMed(1)	4%	6%	6%	0.342
SpeedFast(1)	6%	9%	9%	**0.027**
Flavour(1)	4%	8%	6%	0.053
PotLid(1)	91%	87%	87%	**0.017**

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PotSealed(1)	5%	7%	7%	0.262
2hob(1)	93%	87%	87%	**0.006**
4hob(1)	2%	5%	6%	**0.003**
Continuous variables (means)				KW test p value
COST	19,700	19,700	19,600	0.644

Comparing choices made by respondents using different fuels as their main coking fuel suggests that people using modern energy (electricity and LPG) expressed a stronger (although still weak) preference for 4 hob devices. Lids were most important to people using wood – further investigation might reveal why e.g. they may wish to prevent smoke or ash contaminating the food.

Table 73 Cooking variables disaggregated by main cooking fuel

Variable	Electricity (n=540)	LPG (n=109	Charcoal (n=150)	Wood (n=667)	
Dichotomous variables					Chi-square p value
Cooking(1)	96%	95%	94%	96%	0.598
SpeedMed(1)	5%	6%	9%	4%	0.055
SpeedFast(1)	10%	6%	5%	7%	0.243
Flavour(1)	5%	5%	9%	6%	0.389
PotLid(1)	88%	84%	85%	91%	**0.042**

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PotSealed(1)	6%	8%	10%	5%	0.091
2hob(1)	89%	84%	85%	92%	**0.014**
4hob(1)	6%	6%	3%	2%	**0.015**
Continuous variables (means)					KW test p value
COST	19,600	19,200	19,500	19,800	0.349

Neither the size of the household nor the age of respondent was found to have an effect on preferences.

Preferences did not appear to depend on technical proficiency, although there was some evidence that respondents who were more familiar with technology might be prepared to pay marginally more (although this was significant only at a 94% confidence level). There was no evidence that those categorised as 'deprived' were willing to pay less than the non-deprived. Neither were any of the other preferences linked to poverty status.

4.6.3.2 Stove Design

Results in Table 74 indicate that men and women have different design preferences. The ability to cook for large numbers of people (8) is more important to women. Men were more likely to feel that wood smoked was acceptable whereas women were less willing to put up with wood smoke, preferring to live with charcoal smoke. Interestingly, it was men who were more likely to feel that looks were important. Perhaps not surprisingly, women appeared willing to pay more for a cooking device.

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Table 74 Stove design variables disaggregated by gender

Variable	Male (n=460)	Female (n=924)	
Dichotomous variables			Chi-square p value
People6(1)	15%	12%	0.075
People8(1)	57%	69%	**< 0.001**
SupplementSometimes(1)	6%	5%	0.359
SupplementAll(1)	22%	17%	**0.047**
WoodSmoke(1)	30%	22%	**0.002**
CharcoalSmoke(1)	52%	63%	**< 0.001**
Portable(1)	81%	85%	0.054
Looks(1)	31%	24%	**0.008**
Continuous variables (means)			MW U-test p value
COST	17,300	18,000	**0.020**

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Stove design preferences were not sensitive to settlement (rural, peri-urban or urban), with the exception of a lower tolerance of charcoal smoke among per-urban respondents (chi-square p = 0.046).

The clearest finding from Table 75 is that charcoal users appear to be most price sensitive. Findings also suggest that LPG users are most keen on being able to cook for large numbers of people (8), but note that the number of households represented in this sub-sample is small (n=15).

Table 75 Stove design variables disaggregated by main cooking fuel

Variable	Electricity (n=504)	LPG (n=98)	Charcoal (n=140)	Wood (n=630)	
Dichotomous variables					Chi-square p value
People6(1)	15%	7%	14%	13%	0.254
People8(1)	62%	78%	62%	65%	**0.026**
SupplementSometimes(1)	7%	8%	4%	3%	**0.017**
SupplementAll(1)	19%	14%	17%	19%	0.653
WoodSmoke(1)	27%	21%	24%	24%	0.614
CharcoalSmoke(1)	56%	68%	57%	61%	0.093
Portable(1)	83%	92%	79%	84%	0.076
Looks(1)	29%	19%	31%	24%	0.071
Continuous variables (means)					KW test p value
COST	17,800	19,800	16,800	17,500	**< 0.001**

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Table 76 indicates that respondents preferring a high capacity device that can cook for eight people come from larger households, as might be expected. Portability also appears to be more important to respondents from larger households. On the other hand, an attractive appearance is less important to people from larger households. Respondents who were prepared to accept charcoal smoke came from larger households, which is consistent with findings in Table 77.

Table 76 Number of persons in household by stove design variable responses

Number of persons in household (mean)	Response to parameter variable		
	0	1	MW U-test p value
People6(1)	4.6	4.3	**0.026**
People8(1)	4.2	4.8	**< 0.001**
SupplementSometimes(1)	4.5	4.5	0.716
SupplementAll(1)	4.6	4.3	**0.005**
WoodSmoke(1)	4.6	4.3	**0.002**
CharcoalSmoke(1)	4.2	4.8	**< 0.001**
Portable(1)	4.0	4.7	**< 0.001**
Looks(1)	4.6	4.3	**< 0.001**

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

Table 77 Household size by choice of main cooking fuel (analysis of households)

38 - What is your MAIN cooking fuel?	Mean	N
Electricity	4.014	72
Cylinder gas	4.200	15
Charcoal	4.750	20
Wood	5.022	89
Total	4.579	197

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Exploring the mean age of respondents who made particular choices shows that respondents prepared to tolerate charcoal smoke were older. Looks tended to be important to slightly younger respondents.

Table 78 Age of respondents by stove design variable responses

Age of respondent (mean)	Response to parameter variable		
	0	1	MW U-test p value
People6(1)	43.6	42.8	0.521
People8(1)	42.6	44.0	0.061
SupplementSometimes(1)	43.7	38.9	**0.002**
SupplementAll(1)	43.5	43.5	0.935
WoodSmoke(1)	44.2	41.3	**< 0.001**
CharcoalSmoke(1)	41.9	44.6	**< 0.001**
Portable(1)	42.1	43.8	0.099
Looks(1)	44.0	42.1	**0.023**

Preferences relating to stove design parameters did not appear to depend on either technical proficiency or poverty status.

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

4.6.3.3 Device Functionality

None of the choice parameter variables were sensitive to gender, settlement type, choice of main cooking fuel, or size of household.

Table 79 shows that people who preferred a device that is easy to clean tend to be older, while those who prefer a device that is always available (irrespective of the weather) tend to be younger.

Table 79 Age of respondents by device functionality variable responses

Age of respondent (mean)	Response to parameter variable		
	0	1	MW U-test p value
LED	42.8	44.4	**0.041**
Mobile	43.6	42.9	0.538
TV	43.4	43.5	0.877
works on sunny and rainy days	44.0	42.5	**0.036**
lease over 6 years	43.5	43.3	0.972
lease over 3 years	43.5	43.2	0.720
easy to clean	42.1	44.1	**0.007**

Preferences relating to device functionality parameters did not appear to depend on either technical proficiency or poverty status.

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. Electricity tariffs in Myanmar are very low and people who use electricity for cooking regard it as cheap, however users of other fuels often perceive it as expensive. Smoke is considered undesirable by most, both in terms of having to breathe it in whilst cooking and the smoky flavour it gives to the food, however it is considered useful for keeping insects away. From a consumer perspective, the ideal eCook product would be a portable device that can cook for up to 8 people, can boil and fry with a lid on the pot, can operate throughout the year regardless of the weather, is easy to clean & available on a 6 year lease-to-own financing plan. However, product/service designers may have to compromise to reach the bottom of the pyramid, as many of these options are likely to increase the cost to consumers, which is of course often the most important decision making factors for households.

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

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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[12] cooking solutions by the end of the decade. However, they state that this business-as-usual scenario will still leave over one- half (57%)

[12] 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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of the developing world's population without access to clean cooking in 2020, and 38% without even 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 17 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[13] (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

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

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

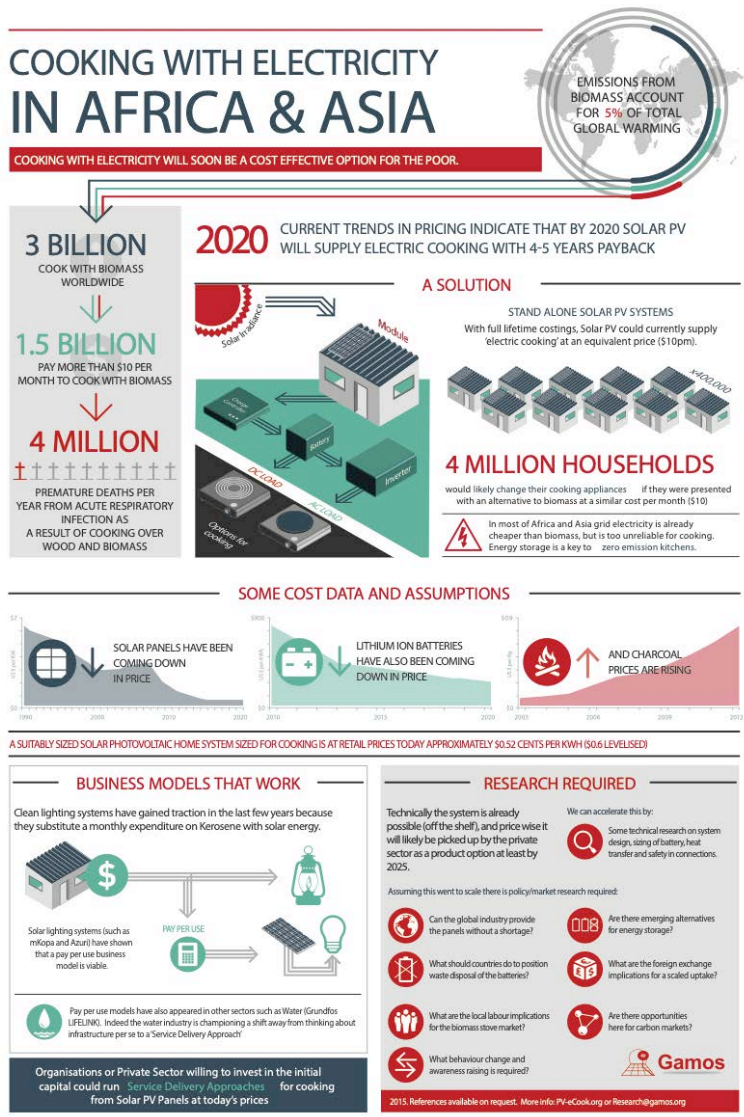

Figure 17 Infographic summarising the concept in order to lobby research and policy actors.

The Brown and Sumanik-Leary paper in the series examines the lessons learned from four transitions – the uptake of electric cooking in South Africa, the roll out of Improved Cookstoves (ICS), the use of LPG and the uptake of Solar Home Systems (SHS). They present many behavioural concerns, none of which preclude the proposition as such, but all of which suggest that any action to create a scaled use of solar electric cooking would need in depth market analysis; products that are modular and paired with locally appropriate appliances; the creation of new, or upgrading of existing, service networks; consumer awareness raising; and room for participatory development of the products and associated equipment.

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

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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[14]. 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[15]. Women and children are disproportionally affected by health impacts and bear much of the burden of collecting firewood or other traditional fuels.

Greenhouse gas emissions from non-renewable wood fuels alone total a gigaton of CO_2e per year (1.9-2.3% of global emissions)[16]. 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

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

[15] 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

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

warming globally – residential solid fuel burning accounts for up to 25 percent of global black carbon emissions[17]. 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[18].

Africa's cities are growing – another Nigeria will be added to the continent's total urban population by 2025[19] 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[20]. 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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[17] http://cleancookstoves.org/impact-areas/environment/

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

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

[20] 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[21]. 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[22], 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

[21] 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.

[22] 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 18 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.

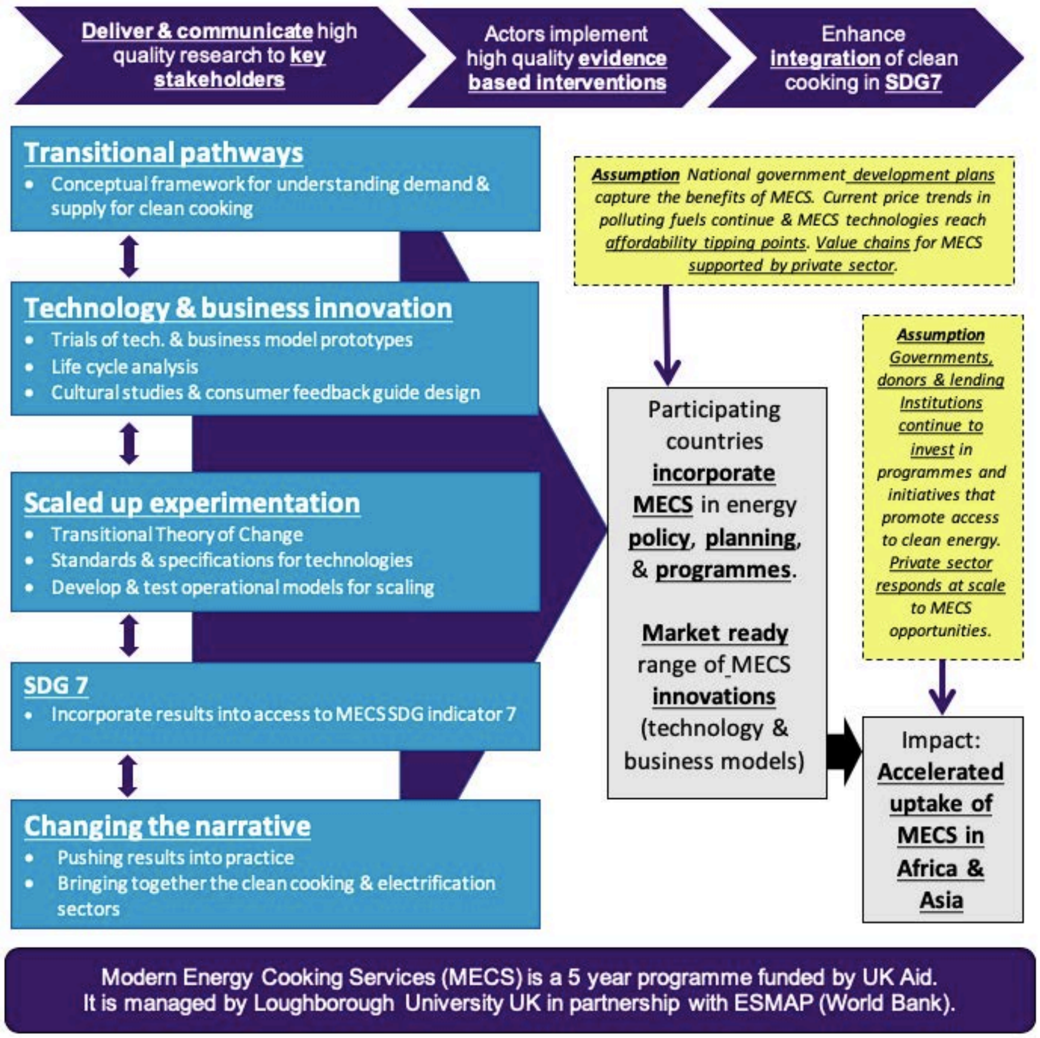

Figure 18: Overview of the MECS programme.

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