Modern Energy Cooking Services - Technology Research Innovation for International Development (MECS-TRIID)

GRANT SPECIFICATIONS DOCUMENT

Notes

Please ensure you have read this MECS-TRIID Grant Specification as well as the MECS-TRIID Guidance Document and the FAQs carefully before completing the Grant Application Form, they will provide valuable information for applicants.

The text will be made available in full on Loughborough University's website. The text may be freely downloaded and translated by individuals or organisations for conversion into other accessible formats. If you have other needs in this regard, please contact Loughborough University at mecs@lboro.ac.uk.

1 Introduction

The Modern Energy Cooking Services Technology Research for International Development (MECS -TRIID) is a new initiative that enables the Modern Energy Cooking Services programme (and thus Department for International Development (DFID)) to fully fund early-stage research projects in support of innovative ideas or concepts that facilitate a transition to modern energy cooking services in countries supported by DFID.

This document provides details of the scope of the competition(s) within the MECS-TRIID initiative. Applicants are advised to consider these specifications along with the Guidance Document to ensure the questions within the Grant Application Form are addressed appropriately.

The number and scope of the MECS-TRIID competitions varies with each round to remain in line with the MECS programme's needs. Generally, it is formed of four targeted calls in specific thematic areas.

The April 2019 MECS-TRIID initiative will comprise of four separate competitions. These will be:

- Theme One: Energy storage for modern energy cooking services
- Theme Two: Grid and infrastructure adaptability;
- Theme Three: Alternative fuels; and
- Theme Four: Business models, Gender, Accessibility (vulnerable groups such as people with disabilities) and inclusion in MECS.

All competitions will use the same Grant Application Form and assessment criteria. Priority will be given to Applications that collaborate with individuals or organisations in countries supported by DFID.

Each individual Application must be specific to one of the four above themes and the exact same idea cannot be submitted in another theme. If a company submits the same idea to two themes, then one of the Applications will be disregarded. Clearly, an application focused on energy storage developments, for example, might also address business models but the applicant must choose under which theme they wish their application to be considered.

If applying to more than one call, applicants will need to demonstrate an ability to deliver the projects. There is a limit of two Applications by a company in total but only one from each of the themes

Applicants should consider and incorporate accessibility (needs for access of those with impairments or disabilities) within their project specifications.

2 Introduction to MECS

2.1 Modern Energy Cooking Services

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 have had limited impact on development outcomes. The multiple problems caused by biomass based cooking, which affect 3 billion people in low income countries, result in 4 million premature deaths annually (which is more than deaths by Malaria, HIV and TB put together, WHO 2018[i]), contribute to climate change, cause loss of economic opportunity and are a particular burden for women. According to the World Bank a 'business-as-usual' approach will not deliver on SDG Global Goal 7 and will result in there being more people using biomass for cooking in 2030 than is the case now (World Bank 2015[ii]). A different strategy that supports the transition of low income economies to the use of modern energy cooking services, creating access to genuinely clean cooking is needed to change this situation. Using emerging innovations and technologies could potentially **leapfrog existing harmful practices in cooking with significant development benefit**.

This programme, Modern Energy Cooking Services (MECS) 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). A key driver is the trajectory of costs that show 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.

Whilst this programme will focus on cooking with genuinely clean modern fuels - including gas (both LPG and Biogas – see Theme 3), the main driver for the research thus far has been the idea that (renewable generated) electricity is going to reach a price point of affordability with associated reliability and sustainability within a few years that will open completely new possibilities and markets. These new opportunities are referred to as 'eCook'.

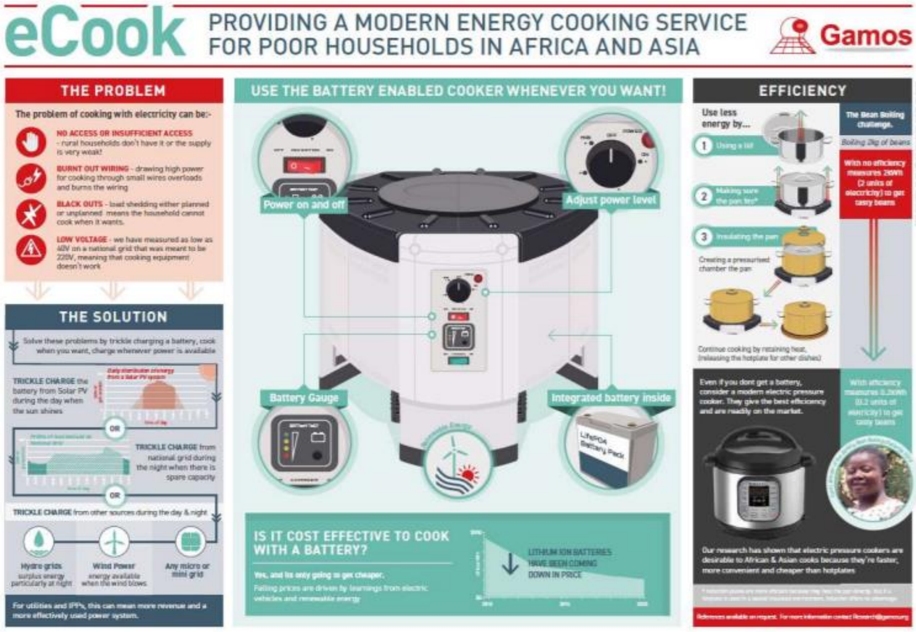

Figure 2.1 Research by the UK universities and innovators is laying the groundwork for a different approach to the enduring problem of cooking

Lessons learned about transitioning markets to electricity are likely to be applicable to gas, and vice versa. Beyond the technologies, research will capture other drivers for transition including understanding and optimisation of fuel stacking; cooking demand and behaviour adaptation; and establishing the evidence base to support a policy enabling environment that will underpin a pathway to scale and support well understood markets and enterprises.

2.2 What we know and what we don't know

Cooking is a uniquely cultural activity and any innovations in cooking must take into account the cultural context and needs of the consumer. Recent research[1] has clarified some of the key cooking behaviours in (East and Southern) Africa, particularly drawing on Zambia, Tanzania and Kenya. While stories abound about Africans cooking beans for four hours or more, **the following is intended to provide a guide for energy consumption and cooking processes commonly found in the key markets for modern energy cooking services**. Proposing to generate more relevant data is within scope of the call.

2.2.1 'Useful energy' consumption

Ravindranath and Ramakrishna (1997) reported that households consume between 0.72 to 1.48 kWh **useful energy** per meal for a family of four (derived from water boiling tests and translated into 'useful energy'). The energy used depends of course **on what was eaten**. Cowan 2008[2] showed how one could generalize into 'light meals'

---

[1] The data to date is based on five field experiences (see *7 Annex: Funders and implementers of piecemeal research to date*).

[2] Cowan 2008 is the only researcher we can find where energy consumption of different fuels is studied with real households cooking real meals. The research was based in South Africa and for electricity respondents used a simple hotplate.

(rice, pasta, eggs) and 'heavier meals' (offal), using real world data from 80 households in South Africa. Figure 2.2 gives his measurements for each meal.

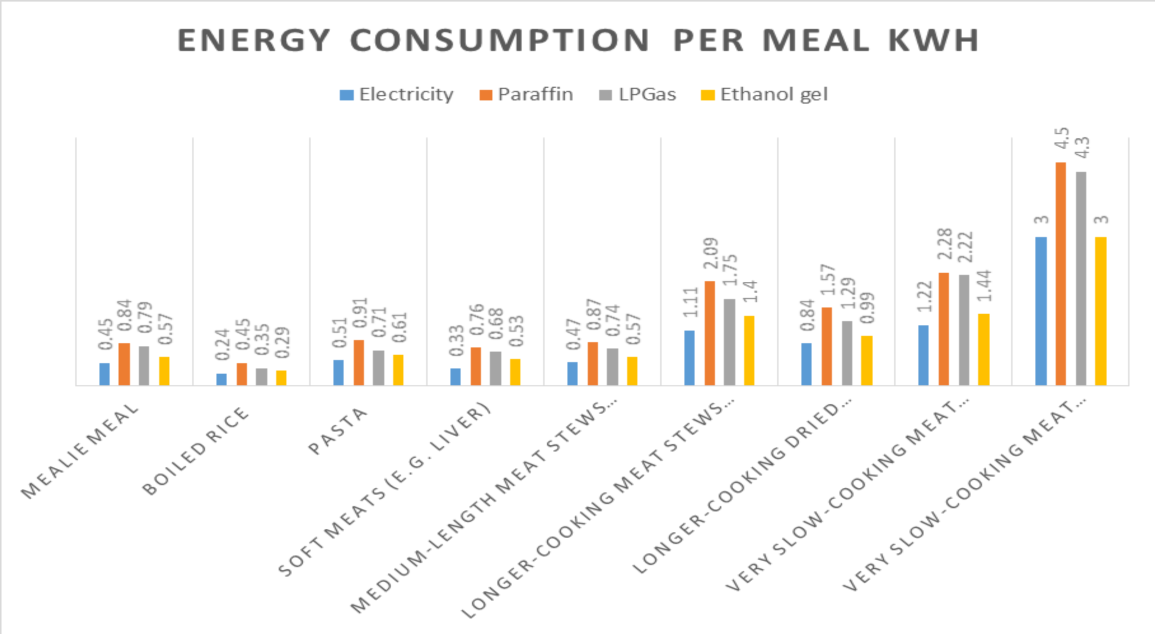

Figure 2.2 Energy Consumption for different meals (for four people) Cowan 2008

Recent research shows the variance for per capita energy consumptions when cooking with electricity across three countries (Scott et al 2018). The average per capita consumption across the three main meals is around 0.65 MJ/person/meal (*Table 2.1*), equivalent to roughly 0.7 kWh/meal for a household of four. Although most meals comprise more than one dish, this is consistent with the data in Figure 2.2.

Households do not necessarily cook each of the meals identified in Table 2.1 every day, the number of household members eating each type of meal varies, and energy is used for more than preparing these three meals e.g. heating water, preparing snacks. Table 2.2 presents figures for total daily household consumptions (Scott et al 2018), which aggregate all of these effects.

Please note that the data is drawn from urban and peri urban households (of differentiated wealth) and is therefore based on the evolved mix of traditional and modern cuisine for those locations. Household sizes from the study are presented in *Table 2.3*. Also please note that the figures in these tables are expressed in MJ not kWh.

Table 2.1 Per capita energy consumption by heating event (MJ/pers/event) –Electricity only

	Kenya			**Tanzania**			**Zambia**		
Heating event	**Q1**	**Median**	**Q3**	**Q1**	**Median**	**Q3**	**Q1**	**Median**	**Q3**
Breakfast	0.39	0.59	1.12	0.17	0.30	0.72	0.03	0.08	0.23
Lunch	0.33	0.65	1.10	0.37	0.68	1.16	0.20	0.40	0.60
Dinner	0.48	0.81	1.30	0.33	0.60	0.94	0.26	0.45	0.84
Heating water	0.84	**1.12**	1.26	0.25	0.51	0.96	0.11	0.15	0.21

Table 2.2 Total daily energy consumption (MJ/household/day) – use of single fuel in a day

	Kenya			Tanzania			Zambia		
	Q1	Median	Q3	Q1	Median	Q3	Q1	Median	Q3
Charcoal				50.4	80.4	115.6	22.7	49.3	77.9
LPG	3.5	8.1	19.0	5.6	14.8	22.2			
Electricity	3.4	5.1	7.8	3.9	7.4	11.3	3.3	5.9	12.5

*Table 2.3 Average number of persons per heating event**

Means	Kenya	Tanzania	Zambia
Adults per heating event	2.3	3.8	2.8
Children per heating event**	1.4	1.6	2.4
Total household members per heating event	3.1	4.6	4.3

*Note, these figures are per meal events and are an average so does not exactly match the per household and median data above – but are indicative.
**Note, these figures are per meal events and are an average so does not exactly match the per household and median data above – but are indicative

A number of factors may affect this total energy consumption. While to date, the sector has focused on the efficiency of fuel conversion (e.g. from Charcoal to heat – an 'improved stove' being that which can give a higher conversion efficiency to the fuel), **the controllability of modern fuels means the <u>process</u> of cooking becomes more significant**[3].

2.2.2 Cooking device (combination of stove and appliance)

There is considerable discussion about the role of induction hobs in bringing electrical cooking to the masses in developing economies. Induction hobs are indeed more efficient than hotplates, however other devices such as electrical pressure cookers (often called multi-cookers) can be as efficient or significantly more efficient for certain foods.

A source of variance of any energy consumption in the above are **efficiency measures**. Putting a lid on a pan is considered best practice. Insulated enclosed spaces such as rice cookers and multi cookers (and kettles) are even more efficient than open pans whether they have induction heating or not. *Figure 2.* discusses where losses occur and how to mitigate them. To date innovations have tended to focus on insulation.

[3] In brief one might say that once lit, a charcoal stove just burns until the food is cooked, while with lpg and electricity, the user can switch the heat on and off easily.

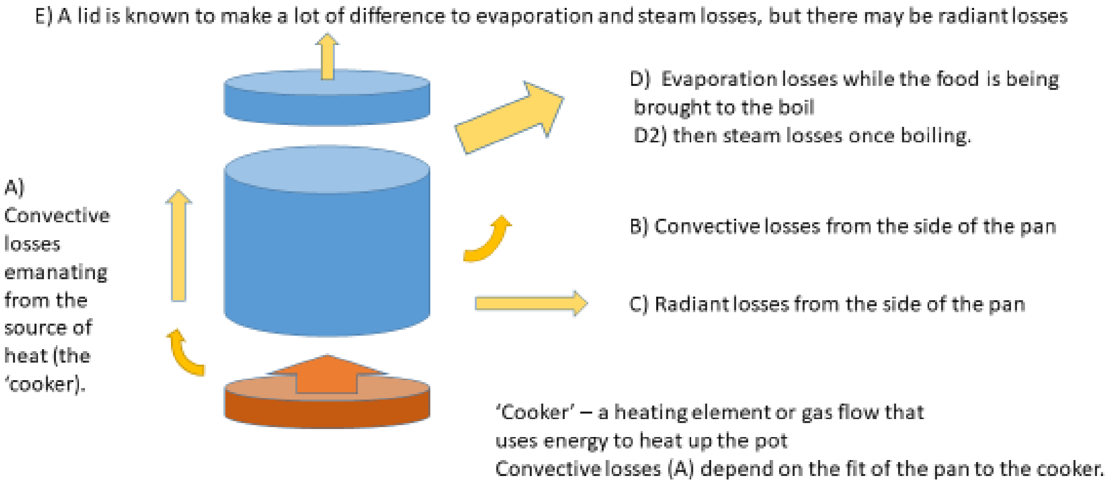

Figure 2.3 Schematic showing main heat losses from a pan during cooking

Table 2.4 Per capita energy consumption (MJ/pers/event) of meals cooked using single electrical device (Phase 2)

Cooking device	**Kenya**			**Tanzania**			**Zambia**		
	Q1	Median	Q3	Q1	Median	Q3	Q1	Median	Q3
Hotplate	0.52	0.83	1.16	0.45	0.75	1.23	0.25	0.47	0.86
Induction hob				0.22	0.38	0.85			
Pressure cooker	0.29	0.63	1.44	0.21	0.44	0.78			
Microwave	0.12	0.32	0.44	0.05	0.12	0.31			
Rice cooker	0.24	0.32	0.59	0.18	0.34	0.51	0.14	0.21	0.22

It should be noted that where the Zambian trial included standard commercial 4 ring hotplate and oven kitchen cookers, energy consumption was generally higher. It is not clear if this is because of the device or a generally lower awareness of energy efficiency.

Please note that we acknowledge that almost all households do some form of fuel stacking and this is likely to continue. For instance, in Ghana, when LPG is in short supply, households cook on charcoal. Innovative systems do not necessarily need to fulfil all the cooking needs of a household. In the studies quoted one household entertained 35 people – at which point they reverted from the electric stove back to charcoal.

2.2.3 Culture and Food

In the more recent work with households in Kenya, Tanzania and Zambia, the food cooked could not be allocated to the categories used by Cowan because the cuisine was different to that of South Africa. However, a crude clustering reduced the meals to the categories found in Table 2.5 and Figure 2.4

Table 2.5 Mean per capital electrical energy consumptions for categories of meal

Classification	Per capita energy consumption (electricity)
3 food	1.04
meat+ staple	0.77
veg+staple	0.69
staple	0.50

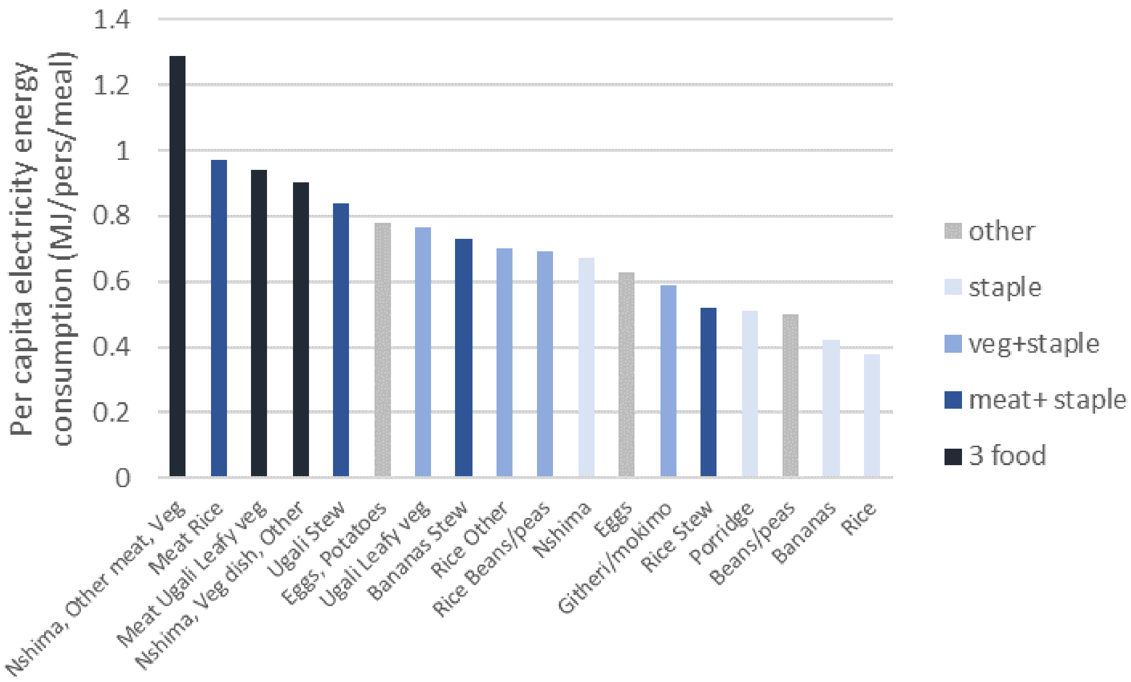

Figure 2.4 Classification of most common meals

In Table 2.6 we give an insight into how frequently meals included particular foods.

Table 2.6 Number of meals containing food types[4] (Breakfast, lunch and dinner heating events only) – Phase 1

	Kenya	Tanzania	Zambia
Dish	%	%	%
Beans/peas	28.6%	20.8%	7.9%
Chapati/pancake	9.5%	4.1%	0.6%
Chicken	3.6%		
Chips	2.5%	2.3%	
Dry fish			3.4%
Eggs	10.8%	4.4%	9.0%
Fish	4.3%		
Mandazi/ Frita	0.1%		5.1%
Game meat			1.1%
Meat	18.8%	28.8%	15.8%
Makande		2.8%	
Githeri/mokimo	8.4%		
Other meat/chicken/fish		7.5%	9.6%
Matoke /Bananas	1.3%	16.3%	
Matumbo	2.1%		
Other	4.5%	31.8%	33.3%
Pasta/noodles	5.4%		2.8%
Porridge	7.3%		
Potatoes/pumpkin	9.8%		6.2%
Pilau	1.8%	5.5%	
Rice	28.0%	23.5%	13.6%
Sausages	1.6%		
Leafy veg	29.0%	13.1%	49.2%
Ugali /Nshima	25.1%	22.0%	67.8%

2.2.4 Renewable energy

If renewable energy sources are to be used to meet cooking demands, then loads must be matched to resource availability. Table 2.7 shows that evening meals are almost all prepared after sunset, given that solar insolation in most sub-Saharan African countries occurs from 06.00 to 18.00 throughout most of the year. Even though breakfasts are prepared after sunrise, the sun will still be weak.

Table 2.7 Time of day to start preparing meal –Phase 1 (multiple fuels)

	Kenya			Tanzania			Zambia		
Heating event	Q1	Median	Q3	Q1	Median	Q3	Q1	Median	Q3
Breakfast	6:00	6:30	8:28	6:15	7:03	8:16	6:30	7:21	8:00
Lunch	12:02	12:45	13:23	11:59	12:30	13:10	11:03	12:00	13:00
Dinner	18:00	18:52	19:45	17:49	18:30	19:30	17:55	18:12	18:45

[4] Meals can comprise multiple food types, so percentages sum to more than 100%.

2.3 Other things we think we have learnt but need more evidence to confirm:-

2.3.1 Energy generation

- There seem to be no particular issues with generating energy from Solar PV or any other renewable as long as battery charge controllers are in place.
- There are possibilities for using generated energy directly to heat food – but this depends on the match between the time of day the resource is available and when people wish to eat (e.g. direct solar PV cooking is good for lunch – not so great for supper).
- ‘Time shifting’ to better match energy resource and use can be achieved by energy storage. For the most part we think battery storage is the way to go, but there have been interesting experiments in maintaining temperature of food through high insulation (rice cookers, multi cookers), and/or phase change materials.
- Solar PV and wind can be considered different to micro-hydro, diesel/petrol and biomass gasifier powered systems in that the former generally already include energy storage, whilst the latter have storage built into their ‘fuel supply’. In the former, storage is needed to ‘time shift’ the availability of power to mealtimes. In the latter, storage is needed to reduce peak loading below the capacity of the generator by ‘time shifting’ the power demand to off-peak hours.

2.3.2 Electricity networks

- Electric cooking devices can be delivered via home systems, nano, micro, mini, even national grids. There are also opportunities for individual battery integrated appliances. These could be seen as the cooking equivalent of the solar lantern.
- Cooking on national grids has the problem of voltage fluctuations and planned and unplanned blackouts. Consumers cannot always rely on the grid being there when they want it to cook, making it one of the main reasons why people who have electricity do not use it for cooking.
- Wiring, particularly of illegal and semi legal connections is often inadequate for drawing high power, so the currents required for cooking will likely cause wiring to burn out or trip a fuse if attempted.
- For mini and micro grids, the cost of wiring becomes a key cost element. If high power is drawn on low voltage, then the wiring has to be thicker, resulting in significantly more cost.
- The buffer of energy storage at the point of use seems to be an effective way of overcoming the three problems stated above, however, energy storage adds cost to the system.

2.3.3 Energy storage

- A range of battery chemistries is available and constantly evolving, particularly because of electric vehicles and advances in decentralised energy generation.
- Current chemistries most commonly found in commercial use are lead acid and lithium ion.
- Low energy density batteries such as sodium ion (Aqueous 'Salt Water' and non- Aqueous), Nickel Iron and perhaps lead carbon, seem appropriate for stationary energy storage (e.g. cooking but not for electric vehicles). Battery characteristics that are important for cooking applications include (but are not limited to):
    - they allow for significantly more cycles than some lead acid and Lithium based alternatives;
    - they are comprised of significantly less toxic materials leading potentially to easier waste disposal; (they are safer than many batteries during transport to site);
    - such batteries allow for higher Depth of Discharge (DoD) than many other battery chemistries (leading to smaller required storage capacity);
    - they are more tolerant to overcharging, over-discharging and short-circuiting;
    - there is greater potential for local assembly and manufacture;
    - wide range of operating temperatures.

- On the other hand, battery characteristics that would not be desirable for cooking applications include (but are not limited to)
    - take a charge slowly, and give it up slowly (cannot supply sudden large power spikes);
    - significant self-discharge rate e.g. 1% per day;
    - daily gassing (Nickel Iron) may be required to get the expected performance.
- Clearly, the potential of low energy density batteries needs more investigation.
- Lithium based batteries have a much flatter voltage-SoC curve (than say lead acid), making the measurement of the 'remaining charge' difficult.

2.3.4 Voltages

- Voltage fluctuations can affect the performance of cooking appliances as much as blackouts. The power of a resistive element is proportional to the square of the voltage, so halving the voltage reduces power to a quarter.
- Battery chargers usually have a wider range of operating voltages than cooking appliances, however, the effect on charging rate is unknown.
- In order to use commercially available cooking appliances perhaps the simplest thing is to invert the battery voltage back into 110 - 240V AC.
- Most commercial inverters have a maximum peak power, and in order to drive a 1kW heating appliance, the inverter is relatively expensive. A low quality inverter sold with a 1kW rating will likely burn out if operated at 1kW continuously for an hour or more, meaning that lower quality equipment has to be over-rated for cooking Applications.

- Most commercial inverters have cut off points to prevent over discharge of batteries and at 10V on a 12V system cannot easily be used with lead acid in cooking applications (at discharge rates of 1C or above), as the voltage-SoC curve distorts significantly at high C rate meaning the inverter turns off when the batteries are still relatively full. In contrast, the voltage-SoC curve for lithium ion batteries is much less sensitive to C rate.
- Directly powering DC appliances from the battery (or even the generating source) requires bespoke appliances, and control circuits.
- Off-the-shelf AC cooking appliances can be converted to DC. For resistive devices, the heating element must be replaced or rewired, as lower voltage means a lower resistance heating element passing a higher current will be required to achieve similar power output. For appliances with inbuilt control systems (e.g. thermostats), and switches/relays they use will also need to be replaced/rewired.
- High current switch gear for low voltage DC can fail due to arcing.

2.3.5 Appliances (including stoves)

- A significant advantage of electrical cooking appliances over stoves/ovens using other fuels is the lack of a need for air flow. Even LPG requires air flow which wastes heat. Therefore, electrical cooking can be highly insulated retaining heat and maintaining temperature
- It is temperature that cooks most food rather than the ‘input of energy’ (e.g. fireless cookers can retain temperature and even cook beans).
- There are resistive heating element **hotplates** that are ‘inefficient’ because they allow heat loss downwards and around the side of the pan (if it’s ill-fitting).
- While **induction hobs** overcome the downward heat loss and the losses up the side of the pan, they don’t automatically address the savings that can be made from putting on a lid and even from insulating the sides of the pan.
- Commercial Induction hobs internally convert AC electricity into DC to generate high frequency fluctuations in the magnetic field.
- DC induction circuits (12V 1000W) are available for hobbyists and can be purchased from China. They tend to be supplied with helical coils rather than flat spirals used in induction hobs.
- **Pressure cooking** raises the internal temperature of the pan above 100 degrees and therefore cooks food faster (and generally with less energy than an open pan).
- Insulation of the cooking process greatly decreases the energy consumption.
- **Multicookers** (which are sometimes modern pressure cookers with an integrated hotplate and control system) and **rice cookers** tend to use resistive heating elements enclosed in partial insulation, and for some foods use significantly less energy than induction hobs.
- Rice cookers are poorly named – they can fry and cook other foods.
- Rice cookers and multicookers are energy efficient but there is room for improvement in their insulation.
- Leaving a rice cooker on warm mode for several hours can use almost as much energy as cooking the rice in the first place

- Automatic control of the heating process (e.g. rice cookers, multicookers and some induction stoves) can save significant amounts of energy, especially when combined with insulation.
- Specialist appliances such as a **kettle** are efficient as the resistive heating element is 'touching' the water. Although they have high power consumption, they heat water very quickly, leaving little time for the heat to escape (assuming the hot water is used immediately). However, significant energy is often wasted when more water is boiled than is required.
- **Thermo-pots** which are kettles with insulation, are even more efficient, but of course restricted in what they can 'cook' (boiling water for tea and coffee).
- **Microwaves** are energy efficient but may have limited applicability to Africa? We don't know.
- **Fan Ovens** tend to be more efficient than older 'static' ovens.
- **Specialist appliances** such as the toaster can be efficient but are limited in their range of cooking. Indeed, egg boilers can use one tenth of the energy used by a pan with a lid and minimal water on a hotplate.

2.3.6 Consumer behaviour

- In Zambia where electricity has been used with westernised 'cookers' i.e. 4 hotplates and an oven, on average households used substantially more for cooking than those given portable hotplates and other appliances. (i.e. people introduced to electric cooking with some sense of energy consumption are likely to use less than those who started using without a particular awareness.)
- In 4 countries studied, electric multicookers (which include a pressure cooking possibility) could cook most of the culturally appropriate food.
- Electric pressure cookers are highly compatible with the foods cooked in the 3 African countries studied, as long boiling dishes such as beans and tripe can be cooked in half the time and with a fraction of the energy.
- Frying onions/tomatoes for a sauce uses just as much energy as boiling beans when cooking using an electric pressure cooker.
- Processed foods generally require less energy to cook, e.g. maize flour vs. whole maize, however fresh foods generally require less energy to cook than dried foods.
- In 4 countries studied, with instruction, households were willing to use rice cookers for foods other than rice. In Myanmar, for example, many people already used rice cookers for cooking soup.

Note:- In responding to the challenges outlined below it might be important to state the assumed median and extremes of energy consumption for the targeted market. In the absence of specific market data, the proposers can use the above figures as a guideline. Please note that solutions based on renewable energy will have to also take into account the seasonal variations of the resource, and the proposers should make explicit the assumptions they are making about days without sunshine, or days with wind.

3 Theme One: Energy storage for cooking

3.1 Overview

This specification is for applicants who wish to apply for Theme One - the thematic competition on energy storage for cooking in countries supported by DFID.

This competition will fund research into developing new solutions and approaches towards energy storage which may improve the performance and delivery of modern energy cooking services and which will provide tangible and impactful benefits.

Where possible, applicants should consider and incorporate accessibility issues (for example in relation to those with disabilities) within their project specifications. Links to the other themes should be explicitly mentioned and are welcomed

3.2 Background

As outlined in the general introduction, there are emerging possibilities for enhancing the transition of African and Asian economies to modern energy cooking services, by the inclusion of energy storage. To date, research has focused on the potential for utilising Lead Acid, Lithium Ion Phosphate and Salt Water chemistries in batteries. While Lead Acid seems to have limited application, the ongoing price falls of Lithium based batteries driven by the learnings from manufacture in the electronic industry, electric vehicles and larger and domestic scale energy storage, suggests that Lithium based batteries may be, for the near future, the 'chemistry of choice'. Salt water and Nickel Iron batteries also hold some promise.

There has also been limited research on Phase Change materials as a mechanism for matching cooking demand with energy supply. While thermal based solutions are in scope, we note that culturally the aspirational nature of electricity will likely lead to stronger consumer acceptance of chemical batteries over phase change alternatives.

However, to date, research has been limited.

3.3 Scope of Competition

This targeted call is to stimulate ideas generation and to test initial concepts around how energy storage could be used in the transition towards the use of modern energy cooking services in one or more countries supported by DFID.

The call will fund around 1-3 projects (at a level of up to GBP 30,000 each) which will offer innovative approaches to this challenge and provide best value for money.

To inform MECS/ DFID, the call will fund genuinely innovative projects rather than traditional research projects. Therefore, this call is designed to support practical and applied research that leads to the development of a prototype, proof of concept or feasibility study.

Examples of Applications which are in the scope for this theme include (but not limited to) projects to:

Demonstrate, model and experiment the relative merits of different battery chemistries for this particular application.
Key Challenge:– There will be varying degrees of power draw on the energy storage depending on the final system design, however, to date research has focused on the need of the consumer to draw energy for high power applications (approximately 1kW), for an hour, resulting in C rates of 1 to 2C (if the battery is sized for one days supply). While other work continues to mitigate the high-power draw, the effect of C rates on battery chemistries could be modelled and demonstrated.

Mitigate the detrimental effects of higher C rates

Key Challenge:- As described above, high power draw from cookers could result in high C rates. Innovations such as super capacitors that seek to mitigate the detrimental effects of high current demand or spikes could be considered.

Modelling of sizing and system configurations that achieve the desired effect of delivery on demand

Key Challenge:- as described above, the sizing and design of the system will affect its longer and short term performance. As the use of energy storage with modern energy cooking services is in itself novel, the challenge fund will accept modelling of the whole system designed to better understand long and short term performance.

Extension of battery life

Key Challenge:- How can the battery life be extended in this context. We acknowledge that this may include other chemistries (as above) and mitigating C rates (as above). It may also include micro environment temperature control for the battery, training of operators and maintenance teams or other technology or behavioural innovations we are not yet aware of.

Leveraging the learning from electric vehicles for application to modern energy cooking services

Key Challenge:- There is in an accelerating interest in electric vehicles resulting in improved understanding of energy storage (and high power delivery, rapid charge and discharge, and system configurations). What can MECS learn from the electric vehicle industry that will lead to applications in modern energy cooking services in countries supported by DFID.

Safety issues

Key Challenge:- Lithium Ion Phosphate batteries have the potential to overheat and explode. The batteries for cooking are likely to be large enough to cause serious harm should they overheat. How can the safety of the batteries for this application be enhanced beyond standard Battery Management Systems.

Disposal Issues

Any energy storage will come to the end of its life eventually. At that point how can the storage be recycled, or safely disposed of. To date recycling of Lithium based batteries has not been cost effective. What processes are on the horizon or can be conceived that mitigate this lack of recycling for Lithium. What are the implications from other chemistries?

Managing energy storage

There are possibilities of matching the charging and discharging of the energy storage to the generating and demand of the energy. There are possibilities for control through remote monitoring and control boxes. While this may fall under Theme Two, part of “Grid and Infrastructure availability”, there may be scope for energy storage management that fits more clearly in this theme.

Ideas for projects are not just limited to those noted above, other ideas are welcome but must meet the requirements in the Guidance Document.

Projects supported through this MECS-TRIID application must deliver a robust assessment of the benefits that their Applications can bring. Successful Applications will need to demonstrate clearly the following:

- What MECS challenges the innovation is aiming to solve;
- Evidence of state-of-the-art innovation being carried out in contrast to what is current practice in this field;
- That the team has the skills and expertise to deliver the project plan;

The MECS Programme seeks genuinely innovative solutions and would welcome applications from organisations or consortia that can see a role for their technologies, tools and approaches in delivering benefits in this space.

3.4 Out of Scope

- Large oversized energy storage; i.e. that is functional but is unlikely to be affordable in the next few years. For instance, setting a household level storage at 5kWh would likely be cost prohibitive for the target markets.
- Energy storage that has a development path of ten years or more. There are exciting cutting-edge emerging technologies that could have application in ten years or more, which we probably would consider out of scope for this call.

3.5 Budget

The indicative budget for this call is up to GBP30,000 per project to fund between 1-3 projects depending on the quality of applications. Applicants may only submit one application for this theme. The final number of projects funded will depends on the quality of applications, value-for-money, and the policy needs of DFID.

Applicants are encouraged to consider the scoring matrix in the development of their Grant Application Form to ensure the development of credible applications, especially innovation, impact, and value for money of the application.

If you feel you have an idea that justifies funding beyond the GBP 30,000, please email the MECS team directly at mecs@lboro.ac.uk with a brief summary of the challenge and innovation by 14th May 2019.

4 Theme Two: Grid and infrastructure adaptability

4.1 Overview

This specification is for applicants who wish to apply for Theme Two - the targeted competition on improving the potential integration of cooking into national and local electricity infrastructures (both on grid and off grid) in Africa and South Asia by creating innovative disruptive modern energy cooking services solutions

Applicants should consider and incorporate accessibility issues within their project specifications.

Links to the other themes should be explicitly mentioned and are welcomed.

4.2 Background

Building on the introductory outline above, while the original concept of eCook was based on Solar home systems, it is clear now that eCook has potential within grid architectures of varying sizes. Moreover, there are clear opportunities for the introduction of cooking to enhance the financial returns and cash flows of grid operators within these different contexts.

Micro and mini grids working in ‘off-grid’ areas, often struggle to get a financial return, and need to include an anchor customer of productive power in order to approach any semblance of financial sustainability. Within these contexts, the only ways of increasing system usage revolve around either supporting customers to develop productive uses of energy which can generate income or providing mechanisms for converting expenditure on other costs to greater electricity consumption. Conversion to electric cooking (where consumers are already paying for their cooking fuel) is one of the few examples of the latter

Africa is also expanding its national, and even regional, grid networks. National actions creating new generating capacity in countries such as Uganda (since July 2016 installed capacity has increased from 862MW to 1158MW), Ethiopia and Kenya, suggest that such countries will shortly (or in some cases have already) move from a shortage of power to a potential surplus for which they are looking for enhanced sources of demand. Access challenges will remain and getting the grid to reach all households and enabling consumers to connect to the grid remains extremely problematic. As described above for mini-grids, the prospects of repurposing household expenditure on traditional fuels such as charcoal into electricity could also add revenue streams to the grid and improve the economics of the system as a whole.

4.3 Scope of Competition

To inform the above the MECS programme will fund genuinely innovative projects designed to support the development of a modelling, prototype, proof of concept, or feasibility study.

Examples of Applications which are in scope for this theme include (but are not limited to):

Economic scenario modelling that shows the role of cooking in grid development

Key Challenge:- There is a need to demonstrate to policy decision makers and implementers of grids that the inclusion of modern energy cooking services under certain conditions would enhance their financial returns. The models should clearly state the conditions under which their modelling results apply.

Innovative ideas for improving the quality (strength, reliability and sustainability) of supply by the inclusion of cooking in grids

Key Challenge:- Beyond the economic and financial view of the grid, there are possibilities in improving the quality of the supply. An example innovation here might include modelling how improved energy storage at a domestic level enables end of grid transformers to improve quality.

Innovative configurations of systems and networks that provide for cooking. For instance, should energy storage for the (mini, micro, nano) grid be held in one location or distributed to each household

Key Challenge:- While the theme above discusses energy storage per se, under this theme one may research the role of the storage on the wider grid. Should mini and micro grids be built with centralised storage or does the inclusion of modern energy cooking services suggest a more decentralised model. In particular cooking requires relatively high power draws, and therefore to have the storage close to the place of use could potentially mitigate expenditure on supporting infrastructure.

Experimentation with tariffs on a (mini, micro) grids to illustrate consumers' willingness to pay

Key Challenge:- As discussed above, the inclusion of modern energy cooking services will likely be best applied where there is a cash expenditure on traditional fuels Experimenting with tariffs on off-grid services might be one way to explore consumers actual substitution of cooking expenditure.

Other experimentation that demonstrates consumers wiliness to pay

Key Challenge:- While the existing research has been predicated on a substitution of expenditure from the traditional fuel towards the modern fuel, households rarely make simple financial calculations. Perceptions that electricity is expensive persist, mitigating the substitution, whilst perceptions that electricity is 'modern' might support the substitution. Innovative experimentation on willingness to pay will be considered under the programme.

Control of grids to match supply and demand (for cooking), including micro control of equipment, zone switching, etc

Key Challenge:- It has been common in industrialised countries to offer different tariff rates at different times to influence demand profiles. While generating capacity has been lacking in some major sites in Africa, there have also been examples of blackout zoning, again to manage demand. When considering cooking, one research group has proposed micro switching of appliances by the network operator to control demand (this potentially works well with items such as rice cookers). With the near ubiquity of mobile phone data services, one can also envisage control of networks, junctions, appliances, through over the air controls.

Projects supported through this MECS-TRIID application must deliver a robust assessment of the modern energy cooking services benefits that their Applications can bring. Successful Applications will need to demonstrate clearly the following:

- What MECS challenges the innovation is aiming to solve?
- Evidence of state-of-the-art innovation being carried out in contrast to what is current practice in this field;
- That the team has the skills and expertise to deliver the project plan.

The MECS programme seeks genuinely innovative solutions and would welcome Applications from any organisations or consortia that can see a role for their technologies, tools and approaches in delivering benefits in this space.

4.4 Out of Scope

- Any applications which only incorporate cooking as a peripheral component of a more generalised project on grid loads and business models.
- Measurement or experimentation with fuel stacking behaviours, where the alternative fuel is biomass. Fuel stacking is widely practiced and will be something to consider in the longer term, but it should not form a key part of the response to this challenge on grid and infrastructure availability.

4.5 Budget

The indicative budget for this call is up to GBP30,000 per project to fund between 1-3 projects depending on the quality of Applications. Applicants may only submit one Application for this theme. The final number of projects funded will depends on the quality of Applications, value-for-money, and the policy needs of DFID.

Applicants are encouraged to consider the scoring matrix in the development of their Grant Application Form to ensure the development of credible Applications, especially innovation, impact, and value for money of the Application.

If you feel you have an idea that justifies funding beyond the GBP 30,000, please email the MECS team directly at mecs@lboro.ac.uk with a brief summary of the challenge and innovation by 14th May 2019.

5 Theme Three: Alternative fuels

5.1 Overview

This specification is for applicants who wish to apply for Theme Three - the thematic competition on innovations with respect to alternative fuels in countries supported by DFID.

The competition will fund research into developing new solutions and approaches that improve the implementation and adoption of Modern energy cooking services based on fuels other than electricity and provide tangible benefits.

Links to the other themes should be explicitly mentioned and are welcomed.

5.2 Background

The first two themes focus on electricity as a major potential fuel for cooking with modern energy. There is also of course a rising momentum of work on Liquid Petroleum Gas, Ethanol and Biogas among other possibilities.

MECS has been funded on the basis that it is trying something other than 'business as usual' in the cooking sector. As discussed above, 3 billion cooking on biomass leads to 4 million deaths a year, and a number of associated problems. The deaths are predominantly associated with air pollution, both within the household and within the community.

LPG as a petroleum based fuel solves the localised air pollution by offering a tier 5 stove. Regarding the carbon balance and climate change, however, LPG is not necessarily the best option, nevertheless it (and derivatives such as natural gas) are likely to remain important sources of 'relatively' clean cooking for some years to come. It is therefore important to consider how to make LPG supplies reliable, affordable and sustainable, and to ensure efficient use of LPG.

Biogas as an alternative to petroleum based gas, has had a long history within the development sector. At scale and attached to supplies such as municipal waste, it has shown itself to be reliable, affordable and sustainable. However, actions to apply it at the domestic level have achieved mixed results. In this call we will consider innovative approaches to biogas that can be used for cooking. This may include institutional delivery (school, hospitals) but the proposition must be innovative and show how it will be affordable, reliable and sustainable and offers an alternative to what has been tried before.

Ethanol production as a fuel has prompted debates about food substitutions and use of land. However, at the household level it does present a clean cooking solution. Recent research suggests existing stoves cook food quite slowly and consumer acceptance is low. Innovations at the household level for the use of ethanol for cooking are within scope.

Solar thermal. MECS is focused on using modern energy for cooking services. In its background documents, when it discusses the use of 'solar' it refers to using solar PV to deliver electrical energy that is then used for cooking (often with the mediation of energy storage). Solar thermal cookers have had a long history in development and have generally been slow to gain widespread acceptance and go to scale. This call will entertain innovative approaches to the use of solar thermal cooking equipment if it is accompanied with a socio-economic proposition as to why it will have greater acceptability than previous attempts to use solar thermal.

Applications relating to heat pumps are also in scope for this call.

5.3 Scope of Competition

To inform MECS/DFID, the call will fund innovative projects rather than traditional research projects. Therefore, the call is designed to support practical and applied research that leads to the development of a prototype, proof of concept or feasibility study.

Examples of Applications, and their key issues, which are in the scope for grants include (but are not limited to) projects to:

Improve the reliability, affordability and sustainability of supply of LPG
Key Challenge:- This may include novel business models for the supply chain, for retail and for pay as you go type services.

Improve the efficiency of use of LPG

Key Challenge:- While stoves and burners may be almost maximised in their efficiency of conversion of the LPG fuel, there is considerable scope for improving the efficiency of the cooking processes. There is the potential for cooking utensils that can improve the heat transfer by a significant amount.

Improve the applicability of ethanol as a modern energy cooking service

Key Challenge:- This may include novel stoves that utilise the ethanol more effectively matching its heat transfer more to cooking patterns of use.

Biogas as an alternative to petroleum based gas

Key Challenge:- Innovative ideas for the utilisation of biogas for either domestic or public supply of cooking services would be welcome. Such ideas should demonstrate how the innovation will enhance the reliability, affordability and sustainability of biogas supply and use.

Solar thermal as an additional or alternative cooking medium

Key Challenge:- As discussed briefly above, solar thermal cookers have potential in some limited markets, but have rarely gone to scale. Any innovation of the use of solar thermal must be accompanied by a diagram or photo showing clearly the size and footprint, and state clearly how it fits the emerging way of life within its target market.

Unknown alternatives

Key Challenge:- There is the possibility that there is a clean cooking innovation that we have not considered, and this can be submitted (but please see 'out of scope')

The above examples are not exhaustive. Ideas for projects covering other key challenges are welcome and are not limited to those noted above but must meet the requirements in the Guidance Document.

Projects supported through this MECS -TRIID application must deliver a robust assessment of the benefits that their Applications can bring. Successful Applications will need to demonstrate clearly the following:

- What MECS challenges the innovation is aiming to solve;
- Evidence of state-of-the-art innovation being carried out in contrast to what is current practice in this field;
- That the team has the skills and expertise to deliver the project plan
- That the team involves a partner institution based in countries supported by DFID.

The MECS Programme seeks genuinely innovative solutions and would welcome Applications from all organisations or consortia that can see a role for their technologies, tools and approaches in delivering benefits in this area of modern energy cooking services.

5.4 Out of Scope

- Solutions to provide or distribute tier (1,2 3) 4 and 5 biomass solid fuel- based stoves

5.5 Budget

The indicative budget for this call is up to GBP30,000 per project to fund between 1-3 projects depending on the quality of Applications. Applicants may only submit one application for this theme. The final number of projects funded will depend on the quality of Applications, value-for-money, and the policy needs of DFID.

Applicants are encouraged to consider the scoring matrix in the development of their Grant Application Form to ensure the development of credible applications, especially the innovation, impact, and value for money of the Application.

If you feel you have an idea that justifies funding beyond the GBP 30,000, please email the MECS team directly at mecs@lboro.ac.uk with a brief summary of the challenge and innovation by 14th May 2019.

6 Theme Four: Business models, Gender, Accessibility (vulnerable groups such as people with disabilities) and inclusion in MECS

6.1 Overview

This specification is for applicants who wish to apply for Theme Four - the thematic competition on Delivery models, Gender, Inclusion and Vulnerable Groups in countries supported by DFID.

This competition will fund research into developing new services, solutions, and approaches which can demonstrate how modern energy cooking services can be made equitable for men and women, people of different social groups and people with different physical, sensory or cognitive impairments or mental health issues and which will provide tangible and impactful benefits.

6.2 Background

While connecting poor households to the grid in low income countries is in itself a challenge, even those who are connected rarely use grid electricity for cooking. It has been said that this is because electricity is more expensive than other options, however recent research suggests that this is not always the case as discussed above, and that there are other barriers and neglected drivers that are resulting in such little use of electricity for cooking.

There has been little research on why electricity is not widely used in low income countries for cooking and we would welcome proposals that seek to better understand current attitudes towards electric and gas cooking and their implications for the success of MECS initiatives.

Current cooking practices are determined by the interplay of a complex and diverse set of factors which are still not fully understood by researchers and those working in the sector. They also differ significantly across different geographies, even within the same country or even region. These practices also produce and are produced by significant inequalities in relation to gender, age, income and a wide range of other social differences. From the outset, we want to know how modern energy cooking services will affect these existing inequalities and how interventions can best be designed to address such issues.

6.3 Scope of Competition

Examples of Applications, and their key issues, which are in the scope for grants include (but are not limited to) projects to:

Identify and evidence the drivers and barriers for the uptake of electricity for cooking
Key Challenge:- In urban areas where connections to the grid are available and households have made the connection, why do they not then use it for at least some of their cooking. Data to date suggests that even the use of kettle for making tea and coffee are not common among the middle class of countries supported by DFID.

Improve the understanding on the intra and inter household dynamics that might lead to a greater diversity of cooking fuels
Key Challenge:- It has been said that men make decisions about technology, and have limited concern and interest in making the cooking process easier and more effective. It has also been said that the extended family has an influence on purchases for the household (the Mother in Law factor). It has also been said that households are greatly influenced by their neighbours. The design and execution of innovative research that improves our understanding of this is within scope.

Improve the understanding of the potential of a wider range of business models and use cases, particularly in relation to the poorest and most marginalised
Key Challenge:- The Pay as you Go model has been successfully utilised for solar home systems and is emerging as a mechanism to overcome some constraints concerning the purchase of LPG gas cylinders. However, there is a growing body of work that indicates that off-grid electrification initiatives have largely failed in their attempts to bring electricity to the poorest sectors of society. Providing energy access to the poorest is acknowledged to be difficult; where potential customers may lack the ability to pay, lack knowledge and capacity which can lead to low margins and difficulty in attracting investors.

Clearly, these problems will be intensified in the case of providing electric cooking options for these same sectors, particularly in those cases where individuals do not currently pay for their fuel. We would welcome proposals that focus on this dilemma and offer novel ways of financing stoves and the electrical infrastructure itself, that explore how much can be done by bringing costs down and payment terms and how indirect subsidies might be used to promote access

Improve the understanding of the potential of a wider range of business models and use cases to promote greater involvement of women employees and entrepreneurs in the delivery of modern energy cooking services and enhance the development gender-responsive service delivery
Key Challenge:- Women are under-represented as employees, entrepreneurs and decision-makers in all areas of almost any industrial and business sector. There are emerging valuable lessons of setting up women as maintenance technicians for Solar Home systems. Given that **modern energy cooking services** will likely be an emerging, novel and growing sector, what business models could be employed that would ensure that women are represented in the workforce and decision-making, and the development of a diverse array of business models to facilitate greater women's participation and more gender-responsive customer service.

Improve the collection of data on cooking patterns among different social groupings.
Key Challenge:- Developing datasets of households cooking patterns suitably disaggregated for energy consumption, wealth indicators, gender and vulnerability can be financially expensive and time-consuming. As a result, there is little evidence to understand the differences in behaviour of people from different social groups; between men and women, young and old, rich and poor, people with or without physical, sensory or cognitive impairments or mental health issues. The need for data will grow as **modern energy cooking services** policies and infrastructure are developed and should be used as a basis to adapt to or target different social groups thus ensuring 'no one is left behind'.

Demonstration of rapid uptake
Key Challenge:- As the possibilities of **modern energy cooking services** emerge, within scope is a demonstration of how quickly and rapidly uptake may be. The demonstration processes should be novel and will likely build on existing community engagement. Demonstrations should show how the localised uptake could be scaled.

Ideas for projects are not just limited to those noted above, other ideas are welcome but must meet the requirements in the Guidance Document.

Projects supported through this MECS-TRIID application must deliver a robust assessment of the social benefits that their Applications can bring. Successful Applications will need to demonstrate clearly the following:

- What MECS challenges the response is aiming to solve;
- Evidence of innovation being carried out in practice currently in this field;
- That the team has the skills and expertise to deliver the project plan;
- That the team involves a partner institution based in countries supported by DFID.

The MECS Programme seeks genuinely innovative solutions and would welcome Applications from any organisations or consortia that can see a role for their appropriate technologies, tools and approaches in delivering benefits in this space.

6.4 Out of Scope

- General micro finance schemes for which modern energy cooking services are a small part or one of many options for consumers to borrow money.
- Delivery through self-help group models where modern energy cooking services are a small part or one of many options for consumers to borrow money.
- Broad socio-cultural studies on intra household decision making, where modern energy cooking services is only a peripheral subject.

6.5 Budget

The indicative budget for this call is up to GBP 30,000 per project to fund between 2-5 projects depending on the quality of Applications. Applicants may only submit one application for this theme. The final number of projects funded will depends on the quality of Applications, value-for-money, and the policy needs of DFID.

Applicants are encouraged to consider the scoring matrix in the development of their Application to ensure the development of credible Applications, especially innovation, impact and value for money of the Application.

If you feel you have an idea that justifies funding beyond the GBP 30,000, please email the MECS team directly at mecs@lboro.ac.uk with a brief summary of the challenge and innovation by 14th May 2019.

7 Annex: Funders and implementers of piecemeal research to date

The concepts, data and key learning points presented here result from a series of inter-related projects:

- Gamos Ltd.'s early conceptual work on eCook (Batchelor 2013).
  - The key **CONCEPT NOTE** can be found here.
  - An early infographic can be found here
  - 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** (Q4 2018) 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** (Q4 2018) can be found here.

In addition, during 2018 the collaboration between KAPEG, AEPC and PEEDA have trialled the protocol in Nepal.

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.

[i] WHO 2018 http://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health

[ii] World Bank (2015); Atur, Varadarajan; Jammi, Ramachandra. 2015. World Bank Group support to electricity access, FY2000-2014: an independent evaluation. Washington, D.C. : World Bank Group.