eCook Zambia Design Challenge Workshop Report

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March 2019 Final Report

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Executive Summary

The eCook Zambia Design Challenge aimed to facilitate the participatory design of eCook (a battery-supported electric cooking concept), allowing the generic concept to evolve around Zambian cooking practices. Entrepreneurs from the Zambian cookstove, solar lighting and utility sectors worked with everyday cooks to guide the evolution of eCook around their needs and aspirations. In the morning, the cooks used a variety of stoves to prepare typical Zambian dishes, offering feedback to the entrepreneurs on what design features they would like to see on a future eCook product. In the afternoon, groups of entrepreneurs presented their visions for eCook in Zambia. They presented the market segments they planned to target and the marketing strategies they would use to reach them; the business models they would use to make it affordable to poorer households; and the innovation needed to make it all work.

To summarise, this event has shown that efficient electric cooking appliances, such as electric pressure cookers, have significant potential for reducing the size of the battery and therefore the overall cost of an eCook system. They are particularly well suited to the foods that Zambians who fuel stack between charcoal and electricity use, i.e. charcoal for long boiling dishes such as beans and offals. However, there are significant challenges to be overcome in relation to behavioural change. Understanding how people cook, how they aspire to cook and what can motivate them to change their practices will be as important as further technical research to develop DC appliances that are more intuitive and can cook a wider range of foods.

The eCook Zambia Design Challenge was an important step forward in the evolution of the generic eCook concept (cooking on battery-supported electricity) to the needs and aspirations of Zambian cooks. To continue this evolution, further work should focus on the key learning points identified here:

Appliances are cheaper than batteries. Carefully selecting the most efficient electric cooking appliances will reduce the size and therefore cost of the battery bank by significantly more than the cost of the appliance itself. The result is a cheaper overall solution that will be affordable to even poorer consumers.

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

Empowering women to lead this transition will be key. New livelihood opportunities will emerge at all stages of the value chain and women are best placed to take these on. This is both from the perspective of accelerating uptake (for example, women are much more likely to buy a product marketed to them by other women) and ensuring the broadest developmental impact by contributing to gender equity.

Building upon successful financing models will be key to unlocking the poorer and harder to reach rural markets. For example, pay-as-you-go solar lighting and Village Banking.

The development of DC cooking appliances will be a key enabler for eCook. AC appliances require an inverter, which adds cost, bulk, unreliability and inefficiency to the system.

Demand side management. eCook can make a valuable contribution to demand side management of ZESCO's grid, reducing the likelihood that load shedding will return. Especially if the devices can be controlled remotely with a SIM card so that the battery can be charged when surplus power is available instead of at meal times when demand is already peaking.

Electric pressure cookers are already cost competitive with charcoal; however, they require the cook to change their behaviour. Further research is required on how the design could be made more intuitive. Initially, they would need to be packaged with an instruction manual, dedicated cookbook for Zambian foods, and/or training for first time users. An electric pressure cooker alone may not be enough for a household to do all their cooking, as some foods require special pots and constant monitoring. Manually adjusting the heat in the pot is also an important feature that is not available on most models available on the market today.

Insulating cooking devices not only makes them more efficient, but also improves the experience for the cook on hot days who does not want to be heated any further!

Recharging an eCook device should be as simple as possible, or cooks may get to mealtime and be disappointed to find their battery is flat.

LPG-eCook hybrids. The perception of LPG as dangerous by many Zambian households may well change in the future. Investigating the strengths and weaknesses of electric cooking appliances and LPG and considering the value offered by hybrid systems would be wise.

Safety of pressure cookers. Pressure cookers also considered by many to be unsafe, so awareness raising about their safety features may well be necessary.

Cleanliness and speed of cooking are likely to be important selling points for electric pressure cookers.

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

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1 Introduction

This report presents one part of the detailed in country research carried out to explore the market for eCook in Zambia. 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 Design Challenge Workshop to inform the future development of eCook within Zambia. This workshop was convened by the Centre for Energy, Environment and Engineering Zambia (CEEEZ) in partnership with a UK research consortium (Gamos Ltd., University of Surrey and Loughborough University). 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 Zambia, 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*.

1.1 Background

1.1.1 Context of the potential landscape change by eCook

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

1.1.2 Introducing 'eCook'

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

A series of initial feasibility studies were funded by 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.

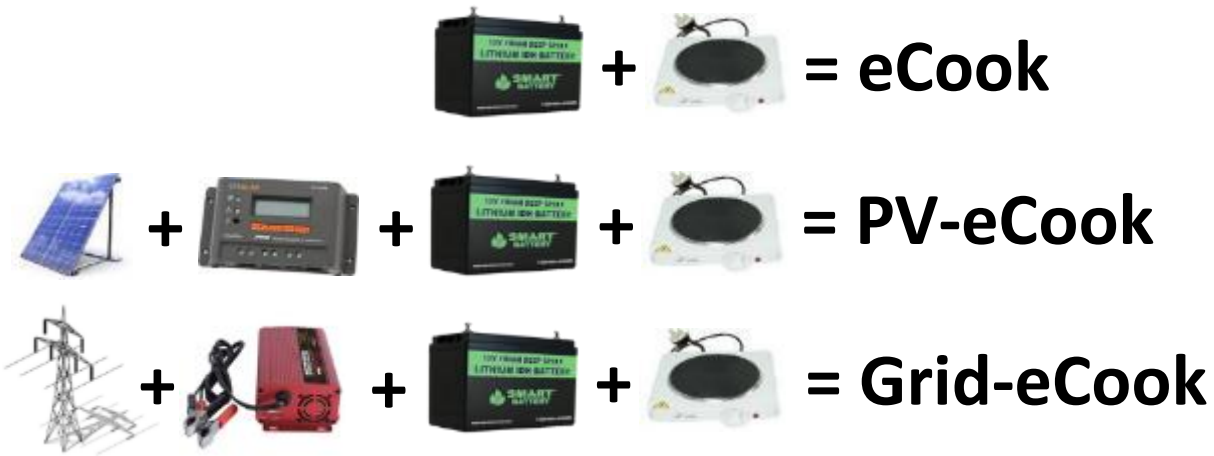

Figure 1: Pictorial definitions of 'eCook' terminology used in this report.

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

1.1.3 eCook in Zambia

Given the technical and socio-economic feasibility of the systems in the near future, Gamos, Loughborough University and the University of Surrey have sought to identify where to focus initial marketing for eCook. Each country has unique market dynamics that must be understood in order to determine which market segments to target are and how best to reach them. Leary et al. (2018) carried out a global market assessment, which revealed Zambia as the third most viable context for PV-eCook, as 10% of the population already cook on electricity and recent load shedding caused a significant number of these users to revert back to charcoal, rapidly accelerating deforestation. However, to be successful, eCook must be tailored to the unique needs and aspirations of Zambian cooks.

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

1.2 Aim & objectives

The aim of the eCook Zambia Design Challenge was to facilitate the participatory design of eCook, allowing the generic concept to evolve around Zambian cooking practices. This was to be achieved by:

- Convening representatives from local cookstove/solar lighting organisations and electrical utilities interested in adding eCook to their product lines.
- Enabling Zambian cooks to guide the evolution of eCook so that it best matches their needs.
- Facilitating experimentation with potential eCook components and configurations.
- Creating lasting partnerships between entrepreneurs, users and researchers that can guide the evolution of eCook in Zambia over the next 5-10 years.

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2 Outline for the day

Participants were asked to divide into three teams, each of whom would independently develop their vision for an eCook product/service in Zambia. Each team was to comprise of entrepreneurs with equal balances of social, technical and business specialists. All teams also included a cook, who's role was to guide their team to create a product/service tailored to their needs and aspirations. Judges from the Rural Electrification Authority and the Ministry of Energy were appointed to evaluate the solutions presented at the end of the day according to the criteria in *Appendix C: Judging Criteria*. The format for this event was inspired by the Great African Bake-off/Cook-off[1] events hosted by Nottingham University in the UK and in partnership with CEEEZ in Livingstone, Zambia under the Barriers project[2].

In the morning session, the cooks were asked to prepare their favourite everyday meal on their own stove and then try cooking it on the eCook prototype. Whilst observing and assisting their cook, teams of entrepreneurs were asked to discuss how they could design a Zambian eCook product around their cook's needs. The output of this session was feedback from cooks on the generic eCook prototype which was intended to create a design specification for Zambian eCook prototypes.

In the afternoon session, the entrepreneurs were asked to develop conceptual designs in response to cooks' feedback, focussing on business models, social impact and technical viability. Flip charts were available to sketch out ideas and tools/components/appliances to build prototypes if time permitted. The intended output of this session was a series of conceptual designs for Zambian eCook products/services that could then be pitched to the audience and a panel of judges.

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[1] More information available here:

https://mediaspace.nottingham.ac.uk/media/The+Great+African+Bake+Off/1_5zpakkfg

Ray, C., Clifford, M. & Jewitt, S., 2014. The introduction and uptake of improved cookstoves: Making sense of engineers, social scientists, barriers, markets and participation. HEDON, (64: Barriers to Cookstoves).

https://www.youtube.com/watch?v=M5S2ujl-57U

https://climatefocus.com/sites/default/files/Boiling Point 69 Galt %26 Mikolajczyk.pdf

[2] https://www.lcedn.com/barriers

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3 Morning session – introductions & cooking

The morning session began with a welcome from Prof. Francis Yamba, an introduction to the opportunity for eCook in Zambia (as above), and a demonstration of how the eCook prototype works. Dr. Jon Leary demonstrated a prototype eCook device capable of charging from both solar PV and ZESCO's grid. The prototype consisted a 600W PV, 5.5kWh battery storage (2*230Ah 12V batteries), a 24V 1.5kW inverter/charger and a 30A 24V solar charge controller. All components had been sourced within Lusaka. Four electrical cooking appliances were demonstrated – a 1,500W kettle, a 250W slow cooker, a 1,000W electric pressure cooker and a double 1kW hotplate. The system is sized for a small family doing most of their cooking on a mixture of efficient appliances and the electric hotplate.

Figure 2: Demonstration of the eCook prototype during the opening session by Dr. Jon Leary.

Only one appliance could be used at a time due to the limitation of the maximum output power of the inverter, so extension cables were plugged in to the nearest building allowing participants in other groups to cook on grid electricity.

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The hotplate is the most commonly used appliance across Zambia today, but also the least energy efficient. Some households also own a kettle, but few have an electric pressure cooker or a slow cooker. The kettle saves energy by heating water very quickly to avoid heat losses. The slow cooker is very compatible with solar, as it uses a small amount of power throughout the day to slowly cook dishes like meat stew, producing a very tender and flavoursome result. The electric pressure cooker can cook long boiling dishes like offals and beans in approximately half the time and with a fraction of the energy, so is particularly well suited to battery-supported cooking on a regular basis.

Next came a 'show and tell' session with each of the stoves and solar lighting kits brought along by the entrepreneurs. The design principles behind firewood and charcoal stoves from Rasma Engineering, EcoZoom, 3 Rocks, Prime and Ziko were explained, making comparisons to the ordinary mbaula that is found in kitchens throughout Lusaka. Vitalite also showcased their solar home system, which is capable of powering LED lights, a radio and a TV, highlighting the pay-as-you-go mechanism that enables users to repay the high cost of the equipment over time.

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Figure 3: Mr Phiri of Rasma Engineering explaining how their firewood and charcoal braziers were designed around the limitations of the traditional mbaula. Nancy Ng'oma of CEEEZ makes comparison to the Ziko stove, which was often used during load shedding.

Figure 4: Muyunda Akfuna of Vitalite explaining the pay-as-you-go repayment plan for their solar home system. Akfuna also introduced the ultra-efficient EcoZoom charcoal stove and the Prime pellet stove that is no longer marketed due the difficulty in acquiring wood pellets.

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Finally, the cooks each chose a stove and began to cook a meal of their choosing. A plug-in energy meter was used to measure the electricity consumed by the electrical appliances and a hanging balance was used to weigh the charcoal and pellets used in the biomass stoves. An LPG stove was also available, but due to technical difficulties, it was not possible to cook with it during the event.

LPG uptake in Zambia has been limited by the perception that it is unsafe

Figure 5: Daisydaria Mkandawire, Principal Engineer in ZESCO's Demand Side Management department explains that she bought her LPG stove to help cope with load shedding. She uses it for quick frying dishes due to the cost and explains that adoption in Zambia has been limited due to the perception that they are not safe.

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Cooks swapped freely between stoves, trying out the different options and using stoves as they became available. Although it was intended that each cook would cook the same meal on a biomass and an electric stove for direct comparison, time proved insufficient. Technical difficulties with the extension cables meant that only two electrical appliances could be used at a time – one on the eCook prototype and one on the grid. The electric pressure cooker was used to cook beans and subsequently to cook beef stew.

Figure 6: Matrine Musole cooking beef stew on the eCook Zambia PV-eCook concept protoype.

Cooking inefficiently on an efficient electric cooking appliance can use as much energy as cooking on a hotplate.

Most foods can be just as tasty when cooked on electric stoves.

Figure 7: Beef stew boiling down on the electric pressure cooker.

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

Figure 8: Measuring the weight of charcoal used for cooking one of the dishes.

Figure 9: The array of stoves under test during the cooking session.

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Figure 10: 'Food for thought' fuelled the discussions at lunch. Dishes cooked on the electric pressure cooker were deemed just as tasty as their charcoal and firewood counterparts.

Figure 11: On the menu were caterpillars, impwa, beef stew, chicken stew and of course, nshima.

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

4 Afternoon session – cooks' feedback & team presentations

This session involved the cooks sharing their feedback with the group, with a short interval for the teams to address this feedback, before presenting their vision for eCook Zambia to the judging panel.

4.1 Feedback from the cooks

The table below summarizes the feedback from cooks for the different cooking devices used at the event. Cooks were asked to summarise what they liked best about the stove/s they cooked on, what they liked least and therefore what design features they thought would be important for a future eCook appliance.

Figure 12: Our 5 cooks sharing their opinions on the stoves they cooked on in the morning.

Table 1: User feedback from the 5 cooks, collated for each stove.

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COOKING DEVICE	FEEDBACK FROM COOKS
ECOZOOM	***Positive characteristics***: smokeless; pots remain clean throughout cooking process; cooks fast; has high heat retention; safer as outer case remains cold while cooking. ***Energy consumption:*** 0.7kg charcoal (~0.5 Kwacha) to cook beans in 3 hour. ***Key learning point for eCook: Could be even more efficient with a stove-top pressure cooker.***
ZIKO STOVE	***Positive characteristics***: has lots of heat; cooks fast. ***Negative characteristics***: too much heat moving upwards towards the cook (note: the user/cook did not know that by keeping the heat control door open while cooking, heat would be moving upwards. This was cleared by an entrepreneur in the audience); too much smoke – turns pots black. ***Energy consumption:*** 3kg charcoal (~8 Kwacha) to cook dried fish in 1hr 40mins ***Key learning point for eCook: heat should be focussed onto the pot, not the cook.***
PRIME STOVE	***Positive characteristics:*** cooks fast, efficient on pellets ***Negative characteristics***: flame was too much; it darkens pots; too much smoke; poor heat retention makes pot handles very hot; reloading pellets complicated. ***Energy consumption***: 0.75kg wood pellets (~3 Kwacha) to cook caterpillars; 3kg pellets to cook various vegetable dishes (12 kwacha). ***Key learning point for eCook: it should be easy to reload/refuel/recharge.***
RASMA STOVE	***Positive characteristics***: cooked vegetables with the right heat; cooks fast; comfortable to cook on; efficient with charcoal. ***Energy consumption***: 0.5kg charcoal (~0.5 Kwacha) to cook vegetables.

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	Key learning point for eCook: it should be easy to adjust the level of heat in the pot.
ORDINARY MBAULA	***Positive characteristics***: easy to light; familiar. ***Negative characteristics***: slow; heat loss very high – bad for the cook on a hot day, makes pot handles very hot. ***Energy consumption***: 1.6kg charcoal to cook impwa (45 mins); 2.5kg charcoal to cook chicken (1hr 30 mins) cooked ***Key learning point for eCook: it should be intuitive to new users.***
ELECTRIC PRESSURE COOKER	***Positive characteristics***: very efficient; cooks fast; clean; safe (note: if user knows how to use it); environmentally friendly; ***Negative characteristics***: pressure release takes too long; does not allow cook to see how cooking is progressing; worried about safety (explosion); difficult to cook on (if using for first time); ***Energy consumption:*** 1kWh (0.15 kwacha for first 200kWh/month, else 0.5 kwacha) cooked beans in 2hrs 30mins; 1.028kWh (0.16 kwacha for first 200kWh/month, else 0.52 kwacha) for beef stew (note: both dishes were cooked with the lid off a lot of the time and too much water, likely to be below 0.5kWh and 1-1.5hrs with lid closed apart from when frying and less water) ***Key learning points:*** • ***would need instruction manual, cookbook and/or training for first time users.*** • ***awareness raising about safety features may be necessary.*** • ***cleanliness and speed important selling points.*** • ***should also include a standard hotplate as some foods require special pots and constant monitoring by the cook.***

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4.2 Team presentations

This final session was designed to showcase the conceptual designs for Zambian eCook products/services. Each team pitched their vision to the audience, with a panel of judges from the Rural Electrification Authority and the Ministry of Energy making the final decision on which team presented the most viable proposition. The judging criteria can be found in *Appendix C: Judging Criteria.*

4.2.1 Team 1. Mpamvu power team

Figure 13: Mpamvu Power presenting their 3 categories of eCook products, each tailored to the needs of different groups of users.

Aim is to:

i. reduce energy consumption
ii. Improve livelihood and safety
iii. an environment friendly device

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Propose 3 packages of eCook

1. For low income: BASIC eCook Package to consist of battery, inverter, 2 plate cooker, 2 LED lights and panels.
2. Medium income: STANDARD eCook Package to consist of battery, inverter, 2 plate cooker, 4 LED lights and panels.
3. High income group; PREMIUM eCook Package to consist of battery, inverter, panels, 1 pressure cooker, 1 slow cooker, rice/nsima cooker (which they will design). These components are to help reduce energy consumption by the target group.

In fact, the Basic eCook package should have included an electric pressure cooker instead of a hotplate. Hotplates are more versatile, but very inefficient, so would require a much bigger battery back to support them. As a result, it is likely that only the more well-off consumers will be able to afford to cook with them on a regular basis.

Business model

i. Create awareness on different platforms
ii. Engage micro financing institutions

Ways to address cooks' feedback

i. Using induction stove to restrict heat to pot
    a. Cooks faster and does not drain batteries
ii. Clean, sustainable and convenient to use product

Marketing: Budget for campaigns and demonstrations.

Q&A:

- QUESTION FROM JUDGE: How does the premium package respond to load shedding?
    - ANSWER: The load shedding we have been experiencing is because of low water levels. Through the introduction of energy efficient appliances, we can target the biggest domestic load, cooking, hence saving electricity and water.
- QUESTION FROM JUDGE: How are you going to factor out initial cost as the target group cannot afford?
    - ANSWER: We are banking on the price of solar products to keep going down. Introducing different packages with costs spread out using pay-as-you-go to allow the targeted groups pay in comfort.
- QUESTION: What are the ideal prices of the packages?
    - ANSWER: On average: ZMW300 per month for BASIC eCOOK; ZMW500 per month for STANDARD eCOOK; ZMW1000 per month for PREMIUM eCOOK.

eCook can make a valuable contribution to demand side management of ZESCO's grid, reducing the likelihood that load shedding will return.

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

4.2.2 Team 2. Efficient home solar system

Figure 14: Team 2 presenting their vison for an all DC 'Efficient Home Solar System' by rewiring an off-the-shelf AC electric hotplate for 12V DC.

Aim to provide a product that is efficient, cheap and long-lasting.

Package will consist of:

- Panel
- Charge controller
- Battery
- DC cooking appliance
    - Avoids having to include an inverter.
    - This idea is coming from the cigarette lighter in a car. It has an 8 coil heater with 1920W of power from 12V. For example, an element with 6 heating points of 1200W could be connected to an off-the-shelf ceramic hotplate to convert it to 12V DC.

The development of DC cooking appliances will be a key enabler for eCook.

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

Marketing

i. Target rural and peri-urban areas.
ii. Urban areas will be targeted for people that love innovation, e.g. pressure cookers.
iii. Sales models:
    a. Cash and carry
    b. 6-months pay-as-you-go
    c. 12-months pay-as-you-go
    d. 18-months pay-as-you-go
iv. Community outreach:
    a. Radio, TVs, roadshows and billboards

Ways to address cooks' feedback

- Excess power to be used for any other systems in the home

Q&A:

- QUESTION FROM JUDGE: How have you factored in safety for your product?
- ANSWER: This is just a prototype. Safety issues will be taken into consideration when they sit down with engineers. But some safety measures include:
    - Off-the-shelf ceramic hotplates have tough insulation, therefore safe.
    - Regulators will be installed in system to control charging and discharging.
    - Selector switches to be used to set a selected temperature/heat.

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4.2.3 Team 3. Speaking for the voiceless

Figure 15: Team 3 explaining how they would use strategies such as financing through the Village Banking and training local women to market, install and support eCook products to reach out into the rural areas where the need is greatest.

Aim: To speak for the people in rural areas.

Motivations

i. Reduce deforestation.
ii. Reduce distance that women and children cover during wood fuel collection/gathering.

Marketing strategies

Key marketing messages: eCook is safe, clean and saves money.

Target low income groups in urban and rural areas, both women and men.

Packages will include:

i. Solar cooker and panels
ii. Improved firewood stoves

To be sold at market places, work places and hardware shops, e.g. S.I. Limbada.

Building upon successful institutions such as Village Banking will be key to reaching the hardest to reach, but most in need rural consumers.

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

Awareness raising strategies:

i. Competitions, e.g. eCook design challenge
ii. Door-to-door campaigns.
iii. Trade Fairs (e.g. Copperbelt Trade Fair), campaigns, hospitals, schools.

Business models: village banking, distribute through existing stove vendors.

They will train local women on how to install systems and provide after-sales service.

Empowering women throughout the value chain will be key to accelerating uptake and ensuring that eCook has the broadest developmental impact possible.

4.3 COMMENTS FROM JUDGES

The judges thanked all participants for their efforts during the competition.

1. All teams had identified a viable target market.
2. There were some interesting business models proposed, but more detail was needed on the costs to tell whether the numbers will add up.
3. Most teams responded to the cooks' feedback, but could have been more specific.
4. All teams had innovative ideas, both in terms of technical innovation and innovative marketing strategies.
5. No team completely addressed the technical viability, as the size and cost of the systems were not completely disclosed
6. There was lack of coordination when making presentations, perhaps due to the limited time available to prepare.

Final scoring:

- Third: Team SPEAKING FOR THE VOICELESS, 20 points
- Second: Team EFFICIENT HOME SOLAR SYSTEM, 30 points
- First: Team MPAMVU POWER TEAM, 30 points – awarded first place at judges' discretion

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

Figure 16: Our judges, Mr. Vijue Moonga representing REA and Mr. Elijah Chibwe representing DoE sharing their thoughts on the three presentations.

Figure 17: The winning team, Mpavu Power after receiving their prizes, an electric pressure cooker, from Prof. Yamba, Director of CEEEZ.

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

5 Evaluation

Overall, the eCook Zambia Design Challenge achieved its aim of facilitating the participatory design of eCook, allowing the generic concept to evolve around Zambian cooking practices. Although the actual schedule for the day ended up quite different to the agenda, it was an enjoyable event that certainly laid the foundations for lasting partnerships between entrepreneurs, users and researchers that can guide the evolution of eCook in Zambia over the next 5-10 years.

The key positive elements of the event were:

- The event was fun and everyone felt like they got something out of it.
- The competitive format made the day exciting.
- Cooking is central to every household, so everybody could relate to the task at hand.
- Eating the food we had prepared together at lunch provided extra 'food for thought' to fuel the discussion during the break.
- Allowing extra space for the 'show and tell' session at the beginning was a good way to learn about the backgrounds of the participants and a platform for sharing some the energy saving products (for lighting and cooking) available on the market.

To improve similar events in the future, the following points should be considered:

- ***Future events should target a broader community of entrepreneurs.***
  - Representatives from local cookstove/solar lighting organisations and electrical utilities interested in adding eCook to their product lines were present, but the event could have had a broader impact if representatives from more organisations had participated.
  - There were not enough participants to have equal balances of social, technical and business specialists on each team, meaning that some teams presented very technical solutions without thinking enough about business models and marketing strategies, and vice versa.
  - It is challenging to guarantee attendance, so a flexible agenda should be planned that allows the format of the event to be varied according to the number of people able to attend and their roles.
- ***Allow more time for technical experimentation.***
  - A variety of eCook components and tools were available during the day, however only one group considered re-configuring the hardware.
  - To facilitate more in-depth experimentation and prototyping, the event could have been reformatted into two parts. After receiving feedback from the cooks, there could have been a break for several weeks to allow the teams to go away and develop a prototype, after which everyone would reconvene for a demonstration and explanation in front of the judging panel.
  - However, this would likely have required more resources, both for hardware and tools for prototyping from the organisers and time from the participants. It is likely that the teams

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would also have required technical assistance to develop the prototypes from technicians and/or product designers. They may also have required a workshop to carry out their experiments.

- ***Ensure the electrical infrastructure is strong enough to support high continuous loads from cooking appliances.***
    - Technical difficulties with the extension cables and time restrictions prevented all cooks from being able to cook the same dish on electricity.
- ***Be more systematic in planning who cooks what and with which fuel/stove.***
    - The chaotic format that the cooking session ended up taking made it difficult to compare directly between fuels and stoves.
    - Quantity of each dish was not recorded.
    - Some cooks switched stoves to cook another dish and some stoves were already alight from the previous cook.
- ***Study the influence of the cook as much as the stove itself.***
    - The style of cooking has as much influence on energy use as the fuel itself.
    - Many stoves were not operated as the designers had expected, as the cooks had not used them before.
- ***Structure presentations to make their messages clearer.***
    - This could be achieved by giving each team a fixed time and a structured format for the presentation at the beginning, e.g. by using a PowerPoint template (if a projector is available) with 1 slide per section from the judging criteria.

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6 Conclusion

The eCook Zambia Design Challenge was an important step forward in the evolution of the generic eCook concept (cooking on battery-supported electricity) to the needs and aspirations of Zambian cooks. To continue this evolution, further work should focus on the key learning points identified here:

Appliances are cheaper than batteries. Carefully selecting the most efficient electric cooking appliances will reduce the size and therefore cost of the battery bank by significantly more than the cost of the appliance itself. The result is a cheaper overall solution that will be affordable to even poorer consumers.

Figure 18: The future evolution of eCook in Zambia?

Empowering women to lead this transition will be key. New livelihood opportunities will emerge at all stages of the value chain and women are best placed to take these on. This is both from the perspective of accelerating uptake (for example, women are much more likely to buy a product marketed to them by other women) and ensuring the broadest developmental impact by contributing to gender equity.

Building upon successful financing models will be key to unlocking the poorer and harder to reach rural markets. For example, pay-as-you-go solar lighting and Village Banking.

The development of DC cooking appliances will be a key enabler for eCook. AC appliances require an inverter, which adds cost, bulk, unreliability and inefficiency to the system.

Demand side management. eCook can make a valuable contribution to demand side management of ZESCO's grid, reducing the likelihood that load shedding will return. Especially if the devices can be controlled remotely with a SIM card so that the battery can be charged when surplus power is available instead of at meal times when demand is already peaking.

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Electric pressure cookers are already cost competitive with charcoal; however, they require the cook to change their behaviour. Further research is required on how the design could be made more intuitive. Initially, they would need to be packaged with an instruction manual, dedicated cookbook for Zambian foods, and/or training for first time users. An electric pressure cooker alone may not be enough for a household to do all their cooking, as some foods require special pots and constant monitoring. Manually adjusting the heat in the pot is also an important feature that is not available on most models available on the market today.

Insulating cooking devices not only makes them more efficient, but also improves the experience for the cook on hot days who does not want to be heated any further!

Recharging an eCook device should be as simple as possible, or cooks may get to mealtime and be disappointed to find their battery is flat.

LPG-eCook hybrids. The perception of LPG as dangerous by many Zambian households may well change in the future. Investigating the strengths and weaknesses of electric cooking appliances and LPG and considering the value offered by hybrid systems would be wise.

Safety of pressure cookers. Pressure cookers also considered by many to be unsafe, so awareness raising about their safety features may well be necessary.

Cleanliness and speed of cooking are likely to be important selling points for electric pressure cookers.

The findings from the Design Challenge Workshop will be combined with those from the other activities that have been carried under the eCook Zambia 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/.

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

[3] 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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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

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electricity sectors from public and private sources" (ibid). The document calls for the Bank Group's 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 19 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[4] (Batchelor 2015b; Brown & Sumanik-Leary 2015; Leach & Oduro 2015; Slade 2015). The commission arose from discussions between consortium members, DFID, and a number of other entities with an interest in technological options for cleaner cooking e.g. Shell Foundation and the Global Alliance for Clean Cookstoves.

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

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

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and LPG. Drawing on published and grey literatures, many variables were considered (e.g. cooking energy needs, technology performance, component costs). There is uncertainty in many of the 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.

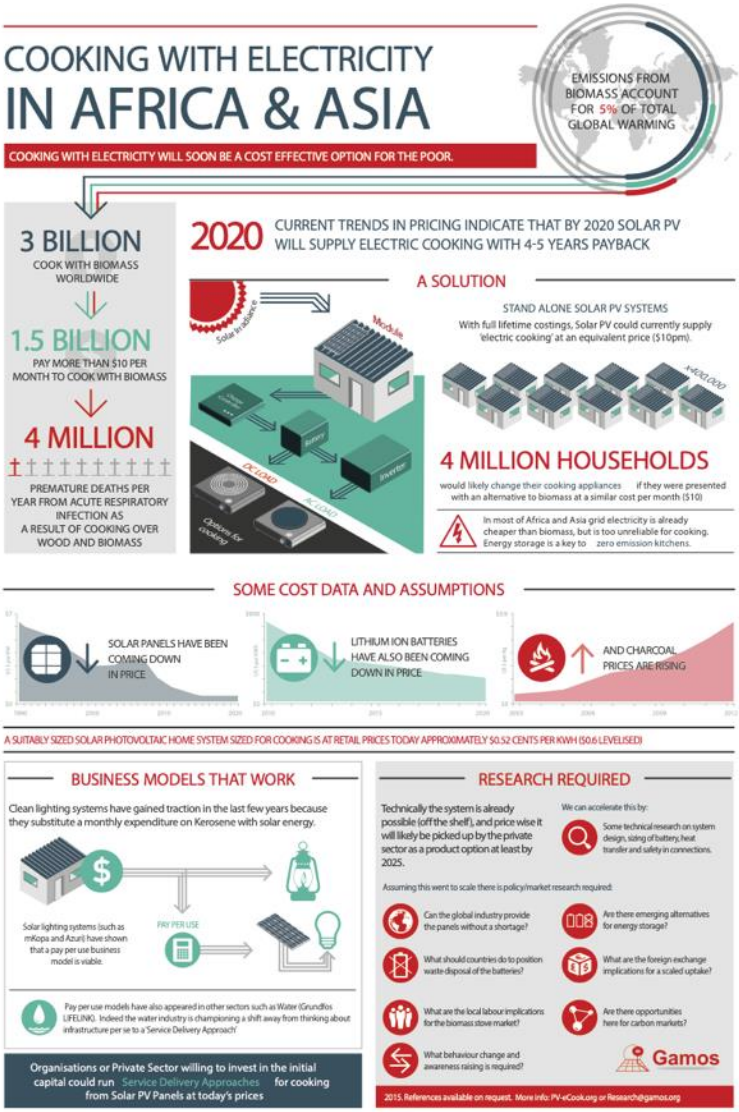

Figure 19 Infographic summarising the concept in order to lobby research and policy actors.

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

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

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7.1.3 Summary of related projects

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

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

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

7.2 Appendix B: List of participants

NAME	INSTITUTION/ORGANIZATION	ROLE
Mr. Frank A. Muyunda	Vitalite	Participant
Ms. Thabo Mulapani	Vitalite	Participant
Mr. Jasiel Mashowo	Lusaka Back Packers	Participant
Ms. Harriet Hamutete	ZENGO	Participant
Ms. Matrine Musole	Cooking diaries participant	Cook
Ms. Esther Musole	Cooking diaries participant	Cook
Mr. Vijue Moonga	REA	Judge
Mr. Elijah Chibwe	DoE	Judge
Mr. Steward Makanse	Act to Save	Participant
Mr. Rashid Phiri	Rasma Engineering	Participant
Ms. Lorna Matewere	Baraka Zambia	Participant
Mr. John Matewere	Baraka Zambia	Participant
Mr. Imasiku Muyunda	Cooking diaries research assistant	Participant
Ms. Elizabeth Musonda	ZENGO	Participant
Ms. Presia Chingembu	Vitalite	Cook
Ms. Daisydaria Mkandawire	Zesco Limited	Participant
Ms. Sitali Muneku	Cooking diary participant	Cook
Mr. George M. Makhaza	Vitalite	Cook
Mr. Fabian Banda	UNZA-TDAU	Judge
Mr. Njobvu	Interested party	Participant
Dr. Jon Leary	GAMOS	Facilitator
Prof F.D. Yamba	CEEEZ	Facilitator
Mr. Francis Mwila	CEEEZ	Facilitator
Ms. Nancy Serenje Ng'oma	CEEEZ	Facilitator

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7.3 Appendix C: Judging Criteria

Judges:

- Mr. Vijue Moonga, REA
- Mr. Elijah Chibwe, DoE

Criteria	0	5	10
Target market and impact	The target market is unclear.	The target market is defined, but the social or environmental benefits of this choice are not clear.	The target market is well defined and there are clear social and environmental benefits behind this choice.
Business model	The business model is not credible.	The business model could be credible, but needs further work. Little mention of marketing strategies is made.	A proposal for a credible business opportunity is supported by a well-designed marketing strategy.
Responding to cooks' feedback	The cooks' feedback is totally ignored. No-one would adopt this product.	Some of the cooks' feedback is addressed in stove design. Some people may adopt this product.	Most feedback from most cooks is clearly addressed. This is a product that people would readily adopt.
Technical viability	The design would not work.	The design may work, but it may not be efficient.	The design is technically credible and would work efficiently.
Innovation	There is nothing novel about this design.	Some aspects of the technical design or business model are novel.	Both the technical design and the business model are novel ideas.

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Criteria	Team name:	Team name:	Team name:	Team name:	Team name:
	Score (0-10)	Score (0-10)	Score (0-10)	Score (0-10)	Score (0-10)
Target market and impact	/10	/10	/10	/10	/10
Business model	/10	/10	/10	/10	/10
Responding to cooks' feedback	/10	/10	/10	/10	/10
Technical viability	/10	/10	/10	/10	/10
Innovation	/10	/10	/10	/10	/10
Total	/50	/50	/50	/50	/50
Additional comments					

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1.1 Appendix D: Agenda

Time	Session	CEEEZ	Cooks	Entrepreneurs	Judges	Description	Output
09:00	Set up	Setting up	Setting up	Cooks & CEEEZ		Briefing with cooks & set up stoves	
10:00	Opening	Speaking	Listening	Listening		Introducing eCook and the programme for the day. Explaining competitive format and technical, economic and social judging criteria.	Teams of entrepreneurs with equal balances of social, technical and business specialists.
10:15	Bake-off	Facilitating	Cooking & giving feedback	Listening & asking questions		Cooks prepare their favourite everyday meal on their own stove and then try cooking it on the eCook prototype. Teams of entrepreneurs discuss how they could design a Zambian eCook product around the cooks' needs.	Feedback from cooks on generic eCook prototype & design specifications for Zambian eCook prototypes.
12:30	Lunch	Eating	Eating	Eating			
13:30	Prototyping	Facilitating	Listening & giving feedback	Prototyping	Judges briefing from 15:00	Entrepreneurs develop conceptual designs in response to cooks' feedback, focussing on business models, social impact and technical viability. Flip charts are available to sketch out ideas and tools/components/appliances to build prototypes where possible.	A series of designs for Zambian eCook.
16:00	Pitching	Facilitating	Pitching	Pitching	Judging	Showcasing the conceptual designs for Zambian eCook and pitching the business model.	The winning design for a Zambian eCook
16:40	Awards	Speaking	Listening	Listening		Prize giving ceremony & discussing next steps.	

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