MECS
Modern Energy Cooking Services

The MECS East Africa battery supported eCooking field trial using AC powerhubs in Uganda

Project Summary Report

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March 2023

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Loughborough University

ESMAP
Energy Sector Management Assistance Program

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CREEC
CENTRE FOR RESEARCH IN ENERGY AND ENERGY CONSERVATION
Energy for generations

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1. Introduction

The Centre for Research in Energy and Energy Conservation (CREEC) in partnership with Loughborough University under the Modern Energy Cooking services (MECS) program is undertaking the MECS: Piloting eCooking power stations project in Uganda. The Modern Energy Cooking Services (MECS) program focuses on increasing access to clean energy for cooking with electricity in the Global South. A transition to clean energy sources for cooking could substantially reduce people's exposure to harmful smoke from burning biomass (e.g., wood), health effects that mostly impact women and children, and could reduce CO2 emissions and deforestation, both consequences of biomass-based cooking. The Center for Renewable Energy Systems Technology (CREST) field trial, which is part of the MECS program, specifically targets people who currently don't have access to electricity (off-grid) and people who have access to an unreliable grid (weak-grid) who experience a lot of black-outs and therefore can't reliably use electricity for cooking.

The CREST field trial aims to test the potential of two new powerhubs (each designed for one of the target populations i.e. off-grid and weak-grid) to meet the needs of everyday cooks and facilitate a transition to electricity-based cooking. The powerhubs consist of a battery system that can be charged by solar panels for off-grid participants or by the grid for weak-grid participants, which can then power electric cooking appliances such as an electric pressure cooker. The intended outcome of MECS is a market-ready range of innovations (technology and business models) which lead to improved choice of affordable and reliable modern energy cooking services for consumers.

The off-grid (DC) component of the study is still on going, however the weak-grid (AC) component of the study was completed and was conducted from July to December of 2022 in Kiroowoza village, Mukono district, a peri-urban area in Central Uganda characterized with a weak grid. A total of twenty (20) households participated in the pilot study. The AC powerhub is designed to be charged by the grid and sized to be able to support a full day’s cooking.

This report is qualitative in nature and provides insights into participants’ experiences, lessons learned, aspirations and perceptions when using the powerhub for cooking.

1.1. Research Objectives

The main objective of the AC pilot study was to test the potential of AC powerhubs to meet the needs of everyday cooks and facilitate a transition to electricity-based cooking; whilst identifying the strengths and weaknesses of using the electric pressure cooker and powerhubs combination.

2. Methodology

2.1. Introduction

For this study, different approaches were used to gain a real-life performance situation of the powerhubs for everyday cooking activities and their ability to meet the cooking needs of participants.

2.1.1. Approaches Used

2.1.1.1. Community Engagement

At the start of the study, there was an engagement with the local authorities where the project was introduced to them and acted as a gateway to the community participants. Thereafter, a meeting was convened between the local authorities, participants and the research team to introduce the project, demonstrate the project, initiate a working relationship, and seek their interest in the project and answer any questions or concerns.

2.1.1.2. Cooking Diaries

The cooking diaries study approach was used as part of the field trial and it required households to record their cooking practices as well as evaluate the compatibility of the electric powerhubs with their cooking practices. This aimed at providing a standard methodology towards understanding how people cook and how compatible their cooking practices are with innovative modern cooking practices. This provided a reputable dataset of dishes that was comparable between contexts as per the research guidelines. Data on food cooked, cooking processes and times, appliances used, energy measurements were recorded.

2.1.1.3. Data Acquisition System

A smart data acquisition system was used to monitor system performance and usage patterns by sensing, recording and transmitting a range of technical parameters. A2Ei smart meters were used to acquire the data which was remotely transmitted to a server managed by A2Ei.

2.1.1.4. Interviews

Qualitative information was collected in form of interviews to gain an understanding of participants' experiences, lessons learned, aspirations and perceptions towards cooking with the AC powerhubs. Three sets of interviews were conducted which included;

- Intake interviews which were conducted at the beginning after participants had accepted to participate in the study.
- Midline interviews, these were conducted two weeks after the powerhubs had been deployed to determine if participants were getting familiar with the powerhubs.
- Endline or exit interviews were conducted at the end of the cooking diaries to determine how the powerhubs were used, and gauge if any challenges were faced.

2.1.1.5. Co-Creation Workshop

A co-creation workshop was organized to co-design the electric cooking services that would drive the aspirations of participants towards electric cooking. This was done in a workshop setting were participants engaged in discussions and activities related to cooking with the powerhubs. This provided a platform for co-creating solutions with end users by enabling them to reflect upon their cooking experiences and trial experiences as they shared potential solutions to the challenges they faced while using the powerhub.

2.2. Participant Selection Criteria

Participants were selected as per the selection criteria below;

- The participants were not cooking with electricity as their main fuel source although some had secondary household electrical appliances like a blender, bread maker and fridge; this was aimed at understanding in what ways cooking with electricity would meet their demands.
- Participants were connected to the grid and were experiencing more than three disruptions of electricity per week, this aimed at understanding the benefit of the cooking power station
- People who were able to read and write in the language in which the material was translated including the informed consent form and user manual to help in collecting high quality data about their cooking practices through writing.
- Participants had a dry place in their home to house the cooking powerhub and electrical appliances provided to avoid the appliances from suffering water damage which would become dangerous to participants.
- The contact person for reporting the cooking practices on behalf of the other members was the primary cook
- The participants were chosen from the same location to ease monitoring and data collection.
- The participants were regular users of electric appliances such as television, lighting and phone charging.

2.3. Data Collection Tools

The following procedures and data collection tools designed in kobo toolbox were used in the study:

- A short registration survey was administered before the baseline data collection started to collect basic demographic information and relevant cooking information to aid the selection process of participating households.
- An intake interview guide was administered for participants that accepted to participate in the study to better understand decision-making in households in order to improve and develop better electricity-based cooking services together with the households.
- A midline interview guide was created with mainly open-ended questions that were administered to the participants to gain an understanding of participants post installation experience of the power station and electric cooking appliances.
- An endline interview guide was developed to gain an understating of participants long term usage of the power station and electric cooking appliances.
- A co-creation workshop guide was developed which allowed participants opportunity to collaboratively develop innovative solutions to the challenges experienced. This was done through audio recording, observations of the groups by the enumerator through note taking and group work which enabled participants share experiences amongst themselves.
- Recorders were used to capture the qualitative discussions to enable transcription after the data collection process.
- A participant consent form was used to get consent before data collection or recording.

- Household Air Pollution (HAP) sensors were used to monitor air quality in the cooking area. Air quality was monitored before and after installation of the powerhub in eight (8) households of the twenty (20) households which were cooking 100% indoors. The HAP sensors collected data on $PM_{2.5}$, temperatures and humidity.
- A2Ei smart meters were used to collect data on how much energy was used by the electric cooking appliance when cooking. Data recorded by the meters was sent to a server managed by A2Ei.

2.4. Data Quality Management

The following measures were taken to ensure quality control of the study process;

- The interviewing team (enumerators) were well trained in collecting qualitative data and conducting focused group discussions as per the interview protocol. This was done for a period of five (5) days before they were sent to the field. An enumerator debrief was always done at the start of any field data collection to minimize errors in collected data.
- Using the MECS UK enumerator training guide, five (5) enumerators were trained on how to use the systems and the appliances (usage, operations, safety procedures, trouble shooting) as per the procedures and data collection methods. Each enumerator monitored four (4) households for easy follow up.
- The lead field researcher was responsible for overseeing the work done by enumerators and reviewing the datasets, checking for inconsistences and following up with enumerators or participants to resolve any arising issues.
- A field data collection work plan was designed to guide the team on when and how to collect the most appropriate data.
- A communications strategy was developed to keep in touch with the participants. This was through the online communication platforms (WhatsApp), SMS, phone calls and also having an on-ground local coordinator. These helped to channel and deliver the intended message to the target person(s).

3. Key Findings

This chapter details the discoveries and feedback from study participants. It provides a summary analysis of the participant demographics and summary feedback from the different interviews conducted as well as workshop feedback.

3.1. Demographics

This section provides details of participants' gender, age, level of education, occupation, household size and the main fuel used in the household for cooking.

Of the twenty (20) study respondents, only four (4) were male, majority were female and were the main cooks in the household with an average household size of six (6) persons. Participants were a representation from different age groups with majority between 30 and 50 years of age, three (3) participants were below 30 years and six (6) were above 50 years of age. 44% of the participants were formally employed while 56% were either self-employed or were informally employed.

Figure 1 is a pie chart showing the fuel usage composition for participants

Charcoal was the most dominant fuel used by the households. 74% of the households used charcoal while 16% of the households used firewood and 11% used LPG as the main fuel. The pie chart showing a breakdown of household fuel usage composition.

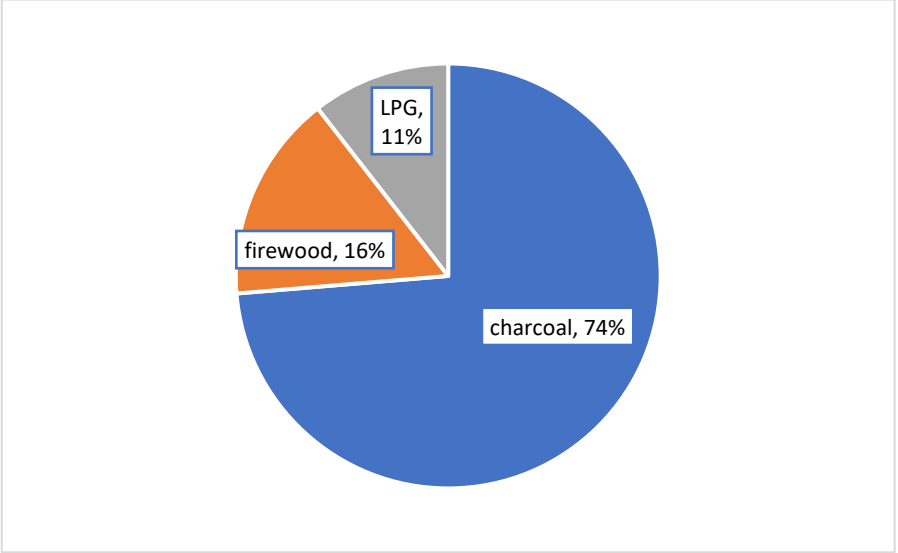
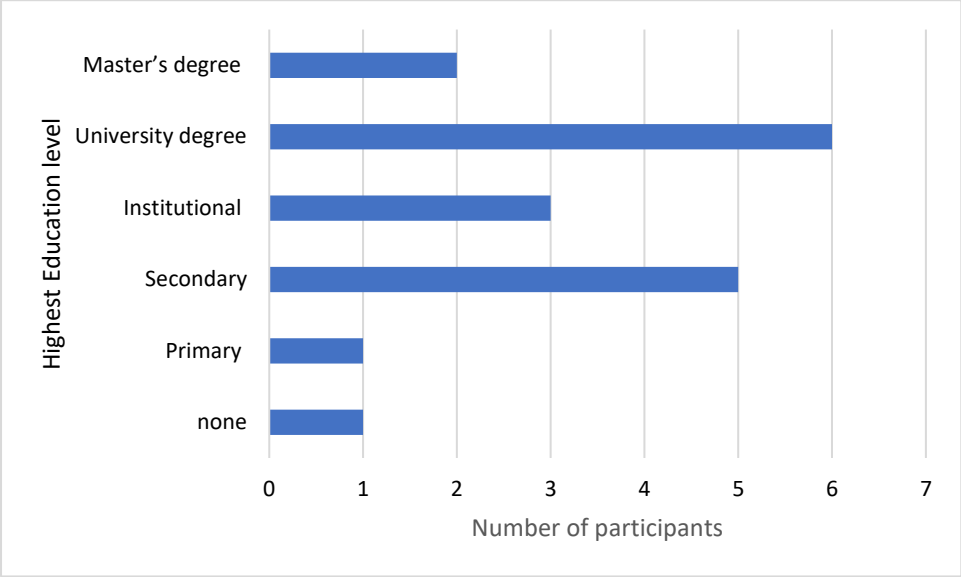


Figure 2 is a bar chart showing the education levels of participants in the study



Majority of the participants had a university degree as their highest level of education followed by those that attained secondary level education. Only one participant had not had any formal education.

Figure 3 is a box plot showing the household size variation across the households.

The box plot summarizes the household size of the participants. Majority of the households had a population size between 8 and 4, however, 25% of the households had a total size less than 4 people. The other 25% of the households had a population above 8. One household with a population of 14 stood out as an outlier and was the biggest household in the study.

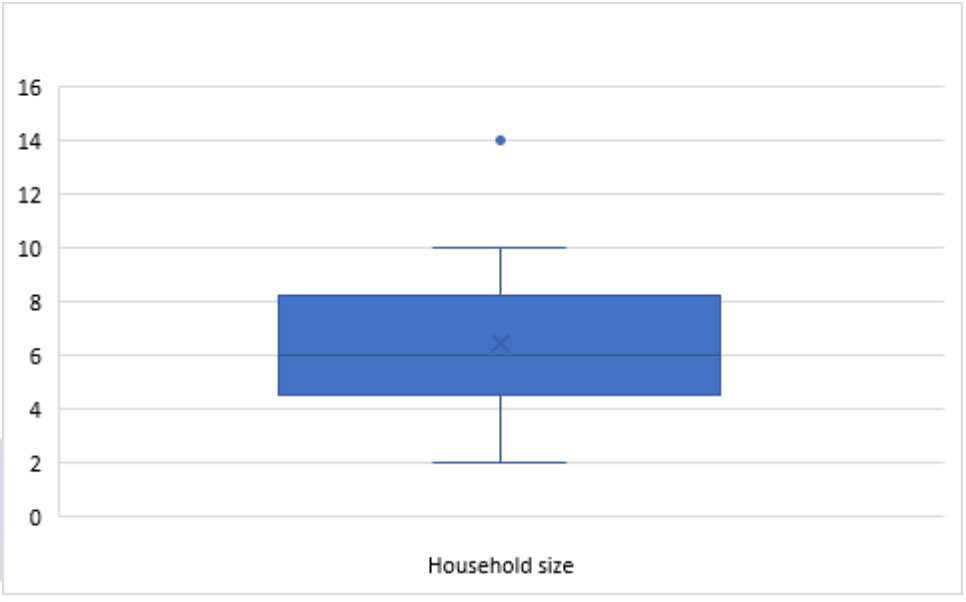
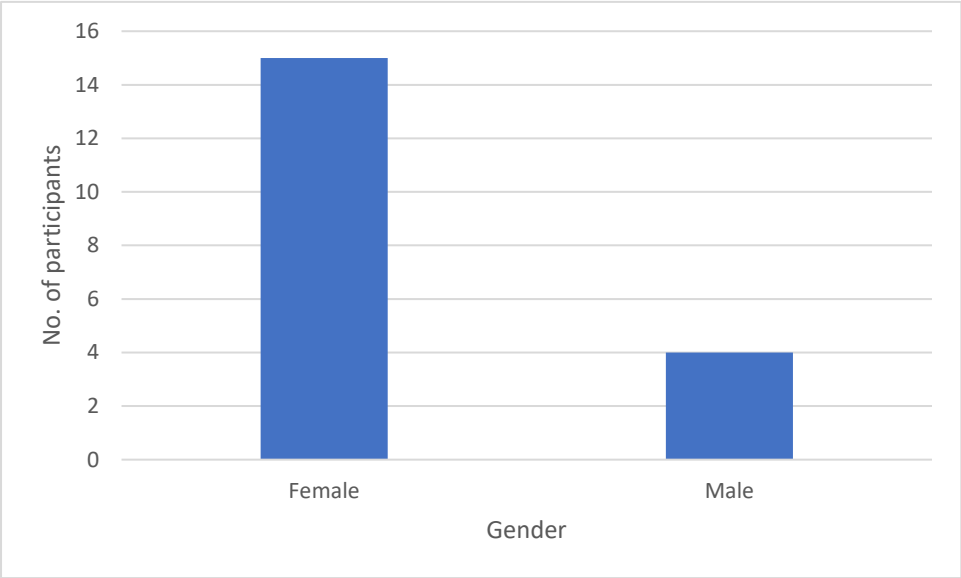


Figure 4 is a bar chart showing the gender composition of the household main cook



In the study population, 79% of the main cooks were female while the other 21% were male.

3.2. Community Engagements

Two community engagements were carried out. The first engagement was to initiate contact and introduce the project to the community. The second was to do a cooking demonstration for a practical engagement with the participants to further establish interest in the project, understand the community's cooking behaviors and to get feedback on the project design. Majority of the participants were women who do most of the cooking activities. The first one meeting consisted of mostly household heads as opposed to the second one which consisted of non-household head members, mostly women who cooked at home. They were excited about the opportunity and were very much willing to be part of the trial. They shared their expectations of the project which were addressed.

3.3. Intake Interviews

These interviews were aimed to determine the current cooking practices of the participants, their favorite foods, fuels and how they prepared the meals. Participants also described the steps taken when cooking each food. These interviews were conducted in the first week of July 2022.

The findings from the intake interviews revealed that most people prepare local delicacies as their favorite dishes of which matooke the most common dish was preferred by the participants. The respondents were in central Uganda where matooke is a cultural food and loved by majority of the people.

Whilst women were the main cooks in the households, the household heads who were mostly male were responsible for providing money to buy food for cooking. Participants highlighted that they preferred stocking food rather than daily purchases to manage finances. In most homes, house helps were the primary cook during week days. The main meals prepared were breakfast, lunch and supper. However, most people prepared more dishes at supper since that is when most of the household members were home after the day's work. Availability of time

and fuel influenced participants' frequency of cooking. Most participants revealed that they cooked mostly when they had time after doing the day's work.

The most common dishes prepared were rice, matooke, beans and meat in most of the households. Rice was often boiled, matooke was often prepared by wrapping in banana leaves, beans and meat were mostly boiled. Special meals like fish, meat and chicken were often prepared during weekends when all household members were available.

The fuel that was mostly used for cooking was charcoal. Participants preferred using charcoal to prepare matooke, boil beans and meat since they take longer period to get ready. However, other fuels like firewood, LPG and electricity were also being used by a few of the participants. Households that had LPG often used it mostly for warming food.

The common cooking appliances used were the charcoal stove, LPG stove and three stone fire. However, one of the participants had bio-gas. Electricity was also used but to a lesser extent, this was for boiling water and cooking fast foods. Participants spent between UGX 2,000 to UGX 5,000 per day on buying fuels.

3.4. Midline Interviews

An understanding of participants post installation experiences of the powerhubs and electric cooking appliances were evaluated through a midline interview.

The participants were excited about receiving the powerhubs and the electric pressure cookers in their homes. This was seen through the honeymoon period where systems were used to boil most of their foods. Participants also reduced their expenditure on buying other fuels like charcoal firewood and LPG to explore the potential of cooking with electricity using a powerhub. They liked the power station for cooking hard foods like beans because of its ability to cook within the shortest time and in a convenient way. Participants would carry out other activities without worry of closely monitoring the electric pressure cooker since it had a timer. However, some participants mistook the electric pressure cooker for a rice cooker which could be partly the reason why rice was the most dominant dish prepared using the electric pressure cooker. However, another possible reason would be that rice cooked really well in the appliance.

Participants found the powerhubs very helpful when there was a power blackout given that they were able to complete their cooking activities without worry. However, it was noted that they also used the powerhubs to charge phones and for lighting; and some preferred to use the powerhub mainly for these purposes and cooking as a backup.

They however noted that the powerhubs could not cook more than one dish before they were depleted which raised a concern that if power is to blackout for the whole day, it would be hard for them to cook with the EPCs and only resort to charcoal as the next available option.

The limitation of having one pot for preparing food caused a serious challenge for people to easily switch cooking different dishes, they did not like the inconvenience of first emptying the pot and cleaning it before using it for another dish. Participants that did not fry their foods found it much easier to just boil food without challenges.

Participants did not like the unpleasant hissing noise from the powerhub while it charged, this was more pronounced in the night. They thus preferred connecting it to charge during day time

only and switched it off in the night. Because the powerhub was not fully plugged in at all times, it was difficult to determine when the powerhub required charging because the display of the status of charging was not functional.

Due to the bulkiness of the powerhub, there was need to create space in the households' kitchens which was difficult to avail at the start. However, with participants' optimism towards the study, they agreed to re-arrange their kitchens and create space. Some of the household heads were impressed by the powerhub's potential to handle the cooking tasks and offered to buy them.

3.5. Co-creation Workshop

In this session, participants engaged in structured small group discussions to draw out feedback on new ideas, likes and dislikes of using the powerhub systems. It was conducted in the format of focused group discussions moderated by the enumerators. This provided a platform for co-creating solutions with end users by enabling them to reflect upon their cooking and experiences and share solutions.

Figure 5 photo showing a group of participants during the co-creation workshop

Below are some questions that were asked by the participants during the co-creation workshop.

Questions on the power stations

Participants asked if the power stations could be used when electricity was off. This was the most popular question among the participants, followed by questions on whether the power stations could use solar to charge. Participants were also curious about the price of the powerhubs and if they could purchase the powerhubs. Participants were interested in knowing if the powerhubs come with spare parts and if they are safe for all household activities like ironing. Below is a summary of questions asked by participants;

Table 1 below shows the questions asked on power stations

Questions on the power stations
- How much is the powerhub? - Can the powerhub connect to TV? - Can we get a smaller sized powerhub? Is there a smaller version of the powerhub? - If am interested in it, can you sell it to me? - How can the noise it makes during charging be minimized? - Does the powerhub consume too much electricity during charging? - Does it cause electricity shock? - If it gets spoilt, does it have spare parts? - The hub is part of the package. Why don't you give us the whole package, instead of just the electric pressure cooker at the end of the study? - Is the power station cheap to operate? - Is it safe for ironing and washing machines? - Can it be charged by solar?

Advantages and disadvantages of the powerhubs

Advantages of the powerhub; participants found the powerhubs very useful especially when there was a power blackout. They used them as a backup system to cook and provide good lighting for the households when there was a power blackout. The powerhubs were used to charge devices like phones when electricity was off

Disadvantages of the powerhubs; A few features of the powerhubs were less appealing to participants especially the noise it makes when charging. Participants found the powerhubs bulky in size, expensive to purchase and maintain. Participants noted that the powerhubs charged slowly and were complicated to use especially if the user is not properly trained on how to use them.

Participants reported that the powerhub would only support cooking one or two dishes before the battery is depleted when there was a power blackout.

Table 2 shows the advantages and disadvantages as expressed by the participants

Advantages	Disadvantages
- The powerhub is very good, it saved me time. Once power went off and I remained cooking. - It eases charging of devices and at a faster rate. - It enables cooking when power is off - It charges my phone when the electricity is off. - It is cheaper than using the power direct. - It is easy to learn to use. - It shows signs when handled badly - Provides light to the house in case of power shortage - Good for lighting when there's power cut with UMEME - Charging of phones and laptops	- It makes noise during charging - It doesn't charge fully - I think it is expensive to maintain - It's too big hence occupying a lot of space - It's a bit complicated to operate - It is bulky in size - It might easily cause electricity shocks - It requires some technical knowledge to operate - It is expensive to purchase - Delicate if not handled properly - I think it is expensive to operate - It makes noise - Too big - Charges slowly - Requires proper training to use - Has low voltage

Advantages	Disadvantages
- Great for cooking food when power runs out - If fully charged you can save time when it comes to multi-tasking	- It charges gadgets slowly - It is very heavy to carry by one person. - It consumes a lot of space and cannot easily be moved. - It's on power direct - It consumes a lot of power when charging - It takes too much time for the better to get full - It is easy to forget when to charge - No guide on how to use it sometimes you can forget what to press

Likes about cooking

Participants highly appreciated how efficient cooking with electricity is, the cleanliness when using electricity for cooking, the ability to save time and money when compared to other fuels like charcoal. Participants reported that some foods such as rice had a better taste when cooked in the electric pressure cooker compared to other fuels. Being able to cooking conveniently inside the house was another attribute of the powerhub that the participants liked and appreciated.

Dislikes about cooking

Participants expressed that cooking is time consuming especially when using biomass fuels like charcoal and firewood compared to LPG and electricity. On the other hand, fuels like LPG, charcoal were expensive to purchase. Some fuels like LPG were associated with accidents if not carefully handled. The preparation process was found to be time consuming and inconvenient especially if it was associated with handling of charcoal.

Kitchen conditions using different fuels

- **Electricity**
  Participants reported little to no heat generated when powerhubs were used for the cooking purposes, the temperatures within the kitchen remained normal which created a favorable and safe environment within the cooking space.

- **Charcoal**

Participants indicated that charcoal generates unpleasant emissions which makes them uncomfortable while cooking. These caused dizziness, tearing, red eyes, running nose and general body weakness. This was a result of poor ventilations within the kitchens.

- **LPG**
  LPG was considered clean however it produced a lot of heat in the kitchen. Some participants reported sweating when using LPG to cook which was not very comfortable.

- **Firewood**
  Firewood produced a lot of heat and smoke when it was used for cooking which inconvenienced users.

3.6. Asset Register Focus on Equipment

During the study period, issues that required technical attention were reported and are described in the table below;

Table 3 showing the technical faults and solutions that occurred during the study period

Household	Technical fault	Solution
UGAC 010	A water leakage from the roof as a result of improper installation of the wire from the solar panel. This was done to avoid drilling. installation of wire from solar panel to a wire from the solar panel was making water flow through the wall since the wire had been directed from the ridge	Reinstallation of the wire by drilling through the roof and ceiling and filling with bondex to stop the leakage.
UGAC 012	Broken plug for the smart meter	Plug was replaced
UGAC 020	Burnt plug for the smart meter and plug stuck in the wall socket.	An assessment revealed that the kitchen socket was connected by a low cable rating 1.5mm which could not support cooking. This cable was therefore replaced by 2.5mm cable.
UGAC 018	Powerhub could not cook when not plugged in power; once power went off, the powerhub switched off as well.	The battery for the powerhub was depleted and needed boosting. It was boosted using a Cadex and the powerhub became functional.
UGAC 008	Powerhub not operational	The powerhub circuit had a loose connection from inverter circuit breakers. This fastened and the dry soldering areas were re-soldered to fix the lose connection.
UGAC 003	The powerhub was not fully charging, was always reading below 25% charge.	An assessment revealed that the solar controller was faulty. A new solar controller was bought and replaced.

3.7. Endline Interviews

This includes findings from the survey that was conducted at the end of the study to capture the user experience of cooking with electricity and obtain feedback to inform the future studies

Participants actively used the powerhubs and electric pressure cookers in the duration of the study. Cooking habits drastically changed for the better for participants. The information obtained revealed that people used the powerhub mostly during the honeymoon period, and the data collection phase. This helped them explore the potential of the powerhub i.e., what it can or cannot cook. The interview also revealed that there was a change in cooking routines; participants prepared hard foods like beans mostly with the EPCs after realizing that it is cost effective, time saving and convenient.

It was also found out that the powerhub system could serve more than just cooking, it could also provide light. However, most participants expressed their concern for the powerhub not being able to cook more than one or two dishes when power was off.

There were no incidences of accidents reported throughout the study period.

Some savings were realized in terms of participants' cooking fuel expenditures after starting to use the powerhub for cooking. These savings were channeled to cater for other home needs.

Some participants believed that their traditional foods still needed to be prepared with the traditional fuels for a better taste and preservation of culture.

4. Conclusion

Data from the cooking diaries phase of the field trial showed that in phase II of the study, 52% of the meals were cooked using the electric pressure cooker powerhub system and 48% was a combination of other cooking technologies like charcoal stove, firewood stoves, gas stove sand microwaves. Therefore, a significant part of the cooking was done using the powerhub system.

Findings from the study suggest that the powerhub has potential to support cooking activities when the power blacks out for a few hours leaving room for improvement on the battery capacity. Features such as the size of the powerhub, noise during charging were some of the major concerns and require improvement. Participants used the powerhub for other purposes besides cooking based on what their immediate needs at a given time; therefore, if the main purpose is to use it for cooking, the designed product should be designed to only facilitate cooking otherwise the system should be designed to cater for different user needs as seemed to be the case during interviews.