THE MECS EAST AFRICA BATTERY ECOOKING FIELD TRIAL IN UGANDA

CREST AC EXTENSION PROJECT REPORT

Authors: Jimmy Agaba, Adrian Okorio, Hilda Evelyn Nakyondwa, Agnes Naluwagga, Richard Wani Abataki

Centre for Research in Energy and Energy Conservation

Makerere University, Kampala, Uganda

June 2024

MECS is funded by UK Aid through the Foreign, Commonwealth, and Development Office. It is a partnership between researchers, innovators, policymakers, and ESMAP drawing on their expertise and relevant work from around the world to co-construct new knowledge with practitioners and the private sector. It is led by Loughborough University, UK. The views expressed do not necessarily reflect the UK government's official policies.

Table of Contents

1 Introduction 4
1.1 Background 4
1.2 Research Objective 5
1.3 Geographical scope 5
2 Methodology 6
2.1 Recruitment and Consent 6
2.2 Data Collection Preparation 6
2.3 Data Collection Process 7
2.4 Data Handling and Analysis 8
2.5 Maintenance and Follow-up 8
3 Key Findings 9
3.1 Demographics 9
3.2 Overview of finding 10
3.3 Overview on Energy Usage 14
4 Interviews 16
4.1 Interview one 16
4.2 Interview two 19
4.3 Interview three 22
4.4 Interview four 25
4.5 Interview five 28
4.6 Interview six 31
5 Conclusion and Recommendations 34
Appendix 36

List of tables

Table 1 shows the participants and their reasons for dropping out 9
Table 2: Interview one analysis 17
Table 3: Interview two analysis 19
Table 4: Interview three analysis. 22
Table 5: Interview four analysis. 26
Table 6: Interview five analysis. 29
Table 7: Interview six analysis 32

List of figures

Figure 4 shows the Total Event Energy by Account ID 14
Figure 5 shows the Total Event Time by Account ID 14
Figure 6 shows the Total Event Power by Account ID 14
Figure 7 shows the Average Event Energy by Account ID 15
Figure 8 shows the Average Event Time by Account ID 15
Figure 9 shows the Average Event Power by Account ID 15
Figure 10 shows a summary of key points highlighted during the first interview 16
Figure 11 shows a summary of key points highlighted during the second interview 19
Figure 12 shows a summary of key points highlighted during the third interview 22
Figure 13 shows a summary of key points highlighted during the fourth interview 26
Figure 14 shows a summary of key points highlighted during the fifth interview 29
Figure 15 shows a summary of key points highlighted during the sixth interview 32

Acronyms

A2EI	Access to Energy Institute
AC	Alternating current
CREEC	Centre for Research in Energy and Energy Conservation
CREST	Center for Renewable Energy Systems Technology
CEDAT	College of Engineering, Design, Art, and Technology
EPC	Electric Pressure cookers
MECS	Modern Energy Cooking services

1 Introduction

The report covers background information about the project while describing the key objectives behind the Piloting eCooking Power Stations project extension.

1.1 Background

The Centre for Research in Energy and Energy Conservation (CREEC), in collaboration with Loughborough University as part of the Modern Energy Cooking Services (MECS) program, initiated the MECS: Piloting eCooking Power Stations project in Uganda. MECS aims to enhance access to clean energy for cooking with electricity in the Global South, thereby reducing exposure to harmful smoke from burning biomass and mitigating health effects, CO2 emissions, and deforestation associated with biomass-based cooking, especially impacting women and children.

1.1.1 About CREST

The Center for Renewable Energy Systems Technology (CREST) is an initiative under the MECS program. CREST developed two pilot battery-supported eCooking systems (AC and DC), called PowerHubs. The systems are fundamentally a box with batteries and electronic controllers that can store energy and are sized to be able to support a full day's cooking. The DC version is charged by solar PV, and therefore includes solar panels, while the AC version is charged by the grid, with the energy storage designed to mitigate high power draws and blackouts when cooking. CREST conducted a field trial specifically targeting off-grid and weak-grid populations, aiming to assess the potential of the PowerHubs to facilitate a transition to electricity-based cooking. The goal being to introduce a market-ready range of innovations (technology and business models) that offer improved, affordable, and reliable modern energy cooking services for consumers. The project aimed to assess participants' feedback regarding the use of the AC PowerHub, designed to be grid-charged and capable of supporting a full day's cooking under the CREST project. It presents a thorough analysis of the strategies implemented to meet the set objectives, a comprehensive examination of the findings, the encountered challenges, and the study findings. The study involved twenty (20) households from Kiroowoza village, Mukono district. After the first phase of the project was concluded, participants were asked to use the powerHubs for an additional year. This report contains detailed findings obtained during the second project phase, referred to as the "AC Extension."

1.1.2 About CREEC

The Centre for Research in Energy and Energy Conservation (CREEC) is a non-for-profit institution based in Uganda whose registered office is at Makerere University, College of Engineering, Design, Art, and Technology (CEDAT). The dynamic centre has been able to achieve many milestones in this area by giving methodological, technical, and well researched approaches in the thematic areas of rural electrification, energy for productive use, energy efficiency, household energy, energy entrepreneurship and energy testing. With a mission to enhance access to modern types of energy, the centre for the last 20 years has worked with government organizations, donors, private sector, individuals, and academia to provide innovative programs, technical expertise through capacity building activities providing business support, knowledge sharing and advisory nationally, regionally, and globally. https://www.creec.or.ug/.

1.2 Research Objective

The main objective of the study extension was to get participants' feedback on the continued use of the battery-augmented electric cooking system and understanding the condition of each system.

1.3 Geographical scope

The research study involved participants from Kiroowoza village, Mukono District peri urban an area in central Uganda characterized by a weak grid.

1.3.1 Scope of work

The study extension was carried out through collecting qualitative information and periodic checks of the power stations for maintenance and any repairs as follows.

Participants kept the powerHubs in their homes for one year and used them for their cooking activities.

Participants continued to use the A2EI smart meter every time they used the EPC for cooking activities. This enabled monitoring of the system's performance and usage patterns by sensing, recording, and transmitting a range of technical parameters to the server.

Participants agreed to short interviews about their experiences and perceptions every 2 months on powerhub usage.

At bi-monthly intervals, participants were given the opportunity to indicate their ongoing interest in remaining part of the study or opting out by returning to the powerhub. They were informed that their decision was entirely voluntary. Individuals who chose not to retain the powerhub (whether they did not commence the Extension project or initiated it but later decided to discontinue) were able to withdraw from the research without any repercussions. Following voluntary withdrawal, where feasible, the power station was reallocated to a household that had not yet commenced the study but expressed willingness to participate in the research.

Periodic checks were performed on the powerhubs to ensure their functionality, involving maintenance and repairs. Enumerators provided support to users, helping in understanding the functioning of the powerhubs as needed. This support encompassed activities such as power-cycling to clear faults, recording fault codes, and resetting circuit breakers. In cases where these measures did not resolve an issue, the enumerator sought assistance from a technician.

A co- creation workshop was also done at the end of the extension period.

2 Methodology

2.1 Recruitment and Consent

2.1.1 Recruitment of enumerators and households

During the first phase of the project, CREEC with guidance from the MECS- UK team identified suitable candidates as participating households in the research. PowerHubs were then deployed to the selected and consenting participants, and these are the same systems that were used during this study extension.

CREEC also trained 5 enumerators at the start of the first phase to monitor every 4 participating households and 1 lead field researcher to oversee the work done by enumerators. The enumerators were also trained on how to use the systems, safety procedures, troubleshooting, testing protocols and data collection methods.

Standard usage: Participants were required to continue using the PowerHubs daily to cook their food.

2.1.2 Obtaining participant consent

The participants signed informed consent forms acknowledging their willingness to take part in the study extension. The enumerators started by explaining the purpose and details of the study extension to them and gave them leeway to ask questions. The enumerators also asked the participants their willingness to continue with the study. In cases where the participant was unwilling to continue, they could withdraw without penalty.

2.2 Data Collection Preparation

2.2.1 Power hub and energy meter inspection

The technician carried out trouble shooting following the trouble shooting guide to resolve any issues with the power hubs and energy meters. This was done before the study resumed, after every two months and when a system failed.

2.2.2 Data Collection Tools

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

An interview guide was developed to gain an understanding of participants' long term usage of the power station and electric cooking appliances.

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.

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.

2.2.3 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. 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, the five (5) enumerators were re-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 inconsistencies, 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 having an on-ground local coordinator. These helped to channel and deliver the intended message to the target person(s).

2.3 Data Collection Process

Qualitative and quantitative data was collected via enumerators and smart meters during the research study. This data was then used to evaluate the technical performance of the devices (e.g., energy efficiency, cooking time) and their ability to meet the participants' cooking needs

2.3.1 Energy Meter data

The smart meters recorded quantitative data on technical parameters and transmitted this electronically to a cloud-based data repository. The monitoring systems worked without intervention, however, if a problem was identified appropriate technical expertise was availed to fix them.

2.3.2 Interviews

Enumerators visited the households every two months to obtain feedback from the participants on how the exercise was moving, any perceptions and their aspirations on the research activities. The more in-depth responses for the interview were recorded, transcribed and where necessary translated into English.

Interview data (every two months) for all participating households was recorded.

The following questions were designed in the kobo toolbox, and these were used during the interviews.

i. How has it been going with the power hubs since we last saw you? (ask for details/follow up questions if the participants have given short answers, and ask why to whatever they say to get the reason)
ii. How many times have you used the power hub for cooking activities in your household?
iii. Which challenges have you experienced with using the power hub in your household since we last met last time?
iv. Does the food cooked with power hub get ready as you need it to be?
v. How many times do you experience power cut offs in a month?
vi. How much are you using the EPC? (why that amount?)
vii. What's going well with it? / Highlights? (Powerhub, EPC)
viii. What's not going so well about it? (Powerhub, EPC)
i. Is there anything that we haven't talked about yet that you think would be important for us to know? Is there anything you would like to add, clarify, or adjust?
ii. Do you have any questions for us?

A co-creation workshop was held at the end of the study period with participants in small groups sharing their experiences, likes and dislikes about the cooking system.

2.4 Data Handling and Analysis

The monitoring systems recorded the quantitative data on technical parameters and this data was then electronically transmitted to a cloud-based data repository. The qualitative data was captured by enumerators using an interview guide. The two datasets were then reviewed and analyzed, checking for inconsistencies and in cases where issues were found, enumerators/participants were contacted to resolve them. The monitoring systems worked without intervention, however, if a problem arose, appropriate technical expertise was availed to fix them.

2.5 Maintenance and Follow-up

Enumerators provided support to participants to enable more understanding on the powerhubs as well as assistance as required. This included power-cycling to clear faults, recording fault codes, re-setting circuit breakers etc. Where these actions did not resolve an issue, the enumerator called on the expertise of a qualified technician.

3 Key Findings

This chapter details the discoveries and feedback from study participants' interviews. It provides a summary analysis of the participant demographics and summary feedback from the different interviews conducted and workshop feedback. This data was collected from March 2023 to Feb 2024 at two-month intervals. A total of six (6) sets of interviews were conducted during this time and they have been analyzed separately below.

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.

The first phase of this study had (20) study respondents, only four (4) of these 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 the majority between 30 and 50 years of age, three (3) participants were below 30 years and six (6) were above 50 years of age. Whereas 44% of the participants were formally employed, 56% were either self-employed or were informally employed. Initially, all 20 participants consented to participating in the project extension, however, some participants dropped off during the study as detailed below.

Table 1 shows the participants and their reasons for dropping out

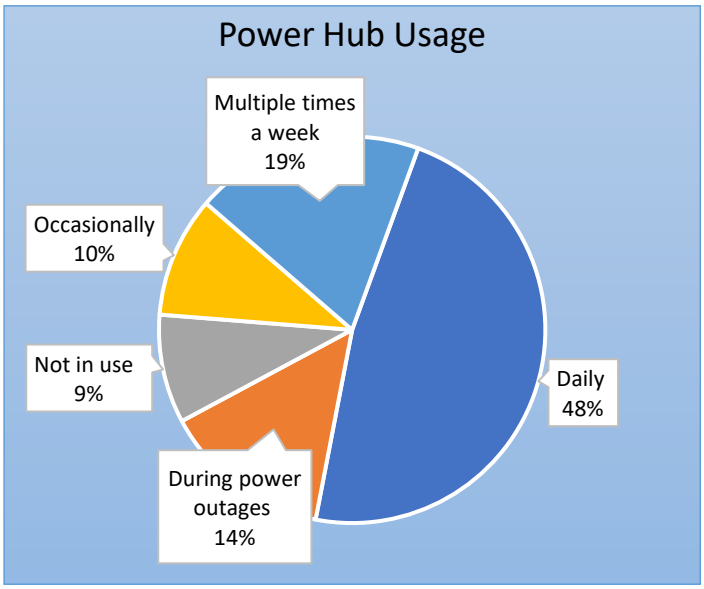
Participant	***Reason for dropping out***
UGAC 004	After consenting to take part in the extension of the study, the participant opted out of the study. This was because of frequent change in domestic help who were the main cooks thus a need for frequent training on powerhub use; in addition, most of them were not interested in cooking with the appliance. In addition, the participant lacked time to devote to the follow up interviews due to a busy schedule. This was also accelerated by her nature of work which involved more fieldwork in upcountry areas.
UGAC 019	Th participant was not available most of the time due to conflicting work schedules and other obligations. Moreso, the participant lost enthusiasm for cooking with the appliance, citing that it cannot be used for deep frying and pastries.
UGAC 001	Limited commitment to participation in the study as the participant was engaged in political leadership. This made it difficult for the participant to meet with the enumerator for study engagements due to an increase in political responsibilities.
UGAC 005	The participant was reluctant to use the appliance and was mostly eating away from home as he had dismissed the domestic help who had learned to use the system; this made the system redundant. He also indicated that whenever the power hub was charging, it made unhealthy noise.
UGAC 011	The participant was transferred away from the study area since he was involved in pastoral work. After the transfer, engaging the participant for the study activities became quite difficult.

3.2 Overview of finding

The overview analysis focuses on the usage of power hubs and EPCs from the 6 interviews.

3.2.1 Power Hub Usage

The responses from the participants about the power hub usage are split into five categories: daily, varied weekly, occasionally, during power outages, and not in use. The results presented in the pie chart show the proportions of the power hub usage throughout the six interviews.



Daily Usage: Nearly half of the responses (48%) reported using the power hubs daily, highlighting their essential role in the participants' everyday lives.

Occasionally: Approximately 10% of the responses indicated occasional use of power hubs. This category includes usage during specific periods such as a one-month time gap, rainy seasons, and when children are at home.

Varied weekly: About 19% of responses reported using power hubs several times a week. This category encompasses varied frequencies such as twice a week, 2-3 times a week, 3-4 times a week, 4-5 times a week, and 5-6 times a week.

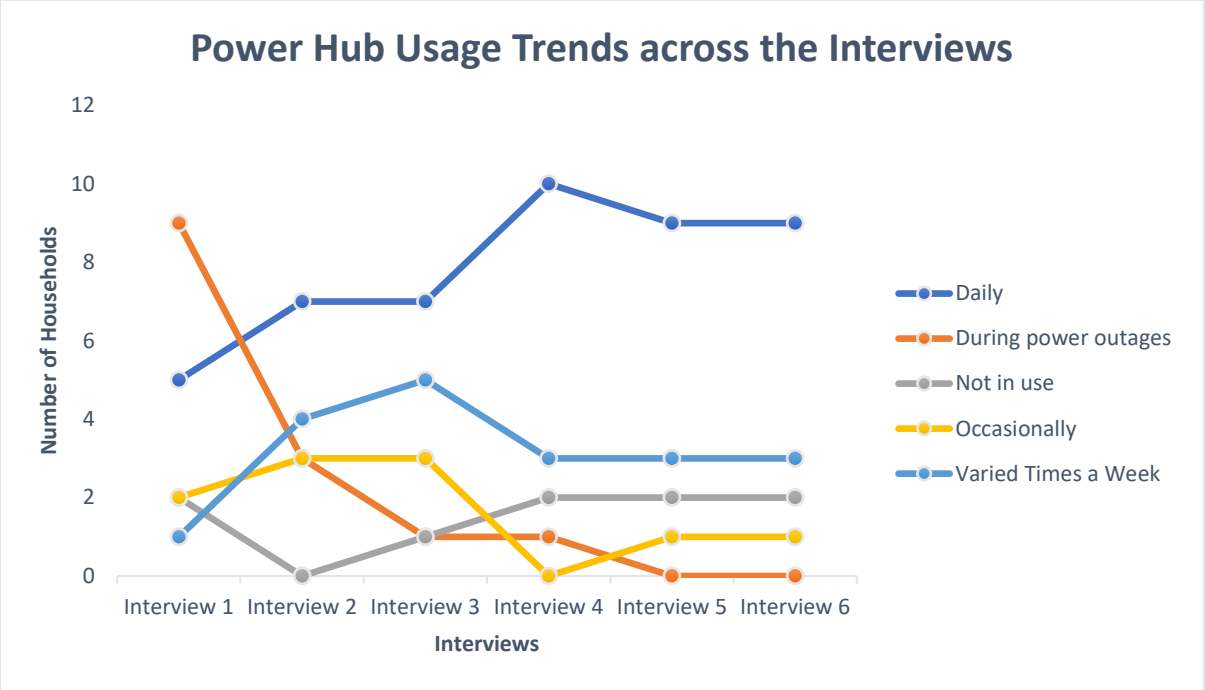
Backup During Power Outages: 14% of responses mentioned using power hubs specifically as a backup during power outages, underscoring their reliability as an alternative power source.

Non-Usage Due to Stable Electricity: A smaller portion of responses (9%) reported occasional non-usage, mainly due to a stable electricity supply in recent periods, technical and socket challenges.

These findings illustrate that while power hubs play a critical role in daily life for many households, they also serve as reliable backups during power interruptions, contributing to their perceived value and importance in ensuring uninterrupted access to electricity.

Power Hub Trends

When asked about their experiences with power hubs since the last interview, participants provided a range of responses, offering valuable insights into the usage trends as presented in the line graph below:



Daily Usage: There is a noticeable upward trend in the daily use of power hubs across the interviews, with the highest daily usage recorded during the fourth interview and the lowest during the first interview. This suggests that participants increasingly integrated the use of power hubs into their daily activities such as cooking, lighting, and phone charging.

During Power Outages: There is a clear declining trend in the use of powerHubs. The highest usage was recorded at the beginning of the interviews, but it steadily decreased in subsequent interviews. This decline may be attributed to a factors like participants adopted the powerHubs into their daily routines, appreciating the system more and integrating it into their regular usage. As a result, the number of participants using the powerHub daily increased thought the study. Some participants however reported more stable electricity during the study period.

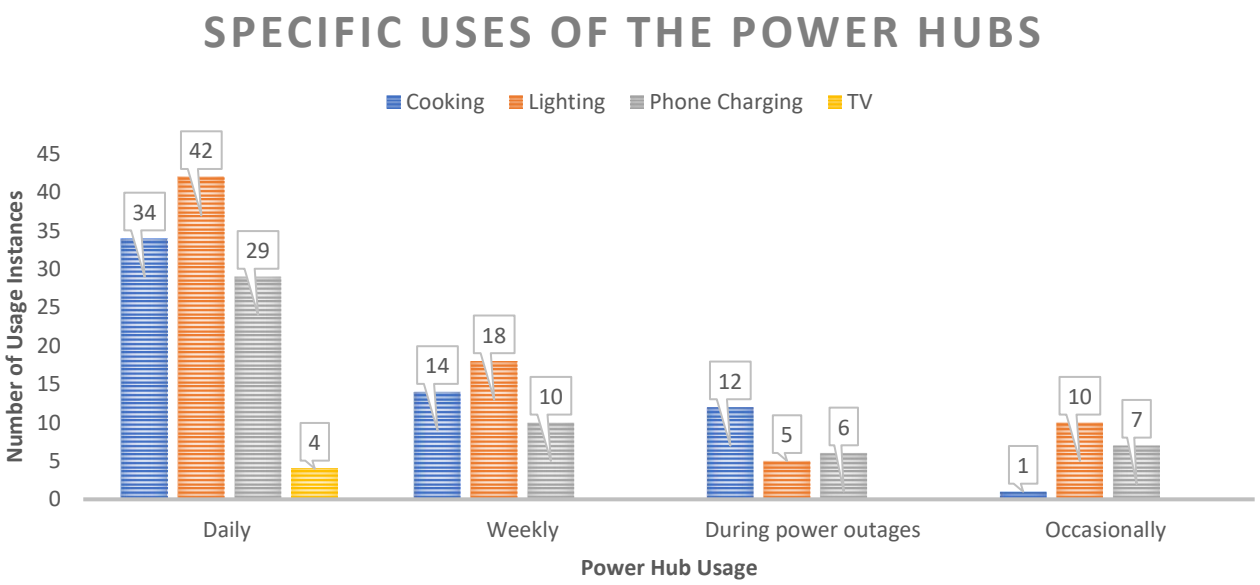
Varied Weekly Use: The occasional and varied weekly use of power hubs shows moderate and stable trends, indicating these as secondary usage patterns among participants.

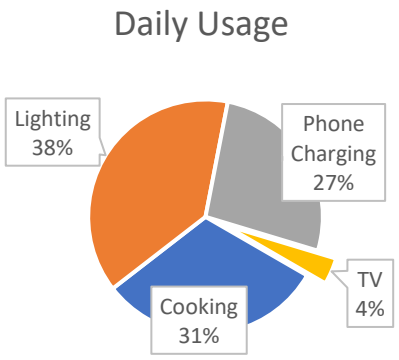
Not in Use: The trend for power hubs not being in use decreases from the first to the second interviews, then increases up to the fourth interview, and remains constant through to the sixth interview. Overall, this category has the fewest responses across the interviews. This lack of usage could be due to technical issues as reported by the participants in the assets register.

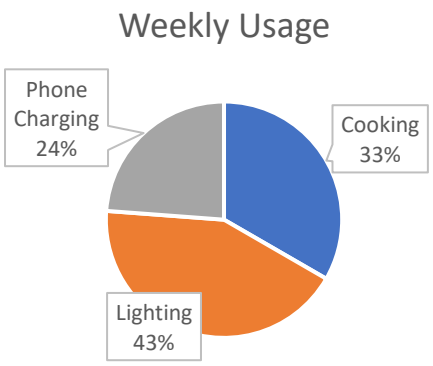
In conclusion, the analysis reveals that daily usage of power hubs is becoming more common, suggesting successful integration into participants' everyday routines. as a result, there is a decline in reliance on power hubs during power outages only. Occasional and varied weekly use remains a secondary but consistent pattern, while non-use is minimal and potentially linked to technical issues as pointed out in the asset register.

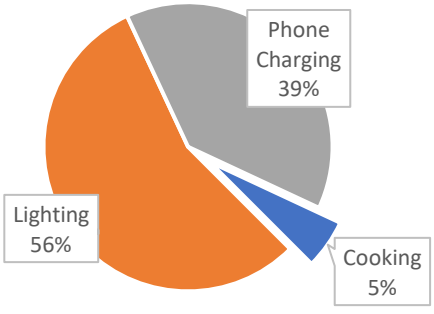
Specific Uses of the Power Hubs across the different Durations

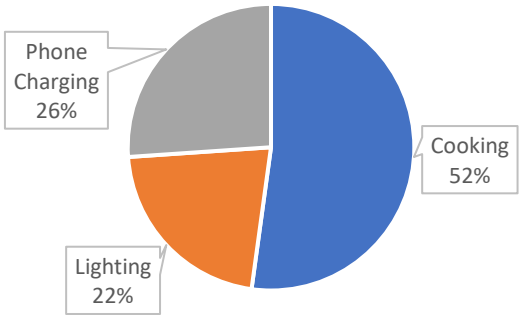
The graphs below examine the frequency of power hub usage for various household activities across the durations (Daily, Weekly, During Power Outages and Occasionally). This analysis will help us understand how often power hubs are used for cooking in the households.











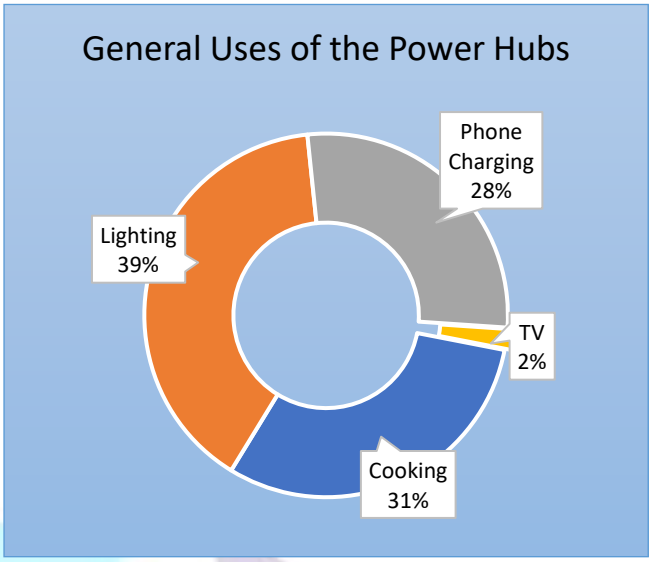
Daily Usage: The power hubs are mainly used everyday for lighting (38%), followed closely by cooking (31%) and charging phones at 27%). Only 4% use it daily for watching TV.

Weekly Usage: On weekly basis, Lighting is again the most common use at 43%, followed by cooking (33%) and finally phone charging (24%).

During Power Outages: Cooking is the most common use at 52%, followed by phone charging (26%) and lighting (22%).

Occasional Usage: Lighting is the most common use at 56%, followed by phone charging (39%) and finally cooking (5%).

Hence in conclusion, the participants significantly reported to use the power hubs for cooking (31% Daily, 33% Weekly, 52% During Power Outages and only 5% Occasionally). The high usage during power outages could have been due to the preference of the participants to use electric cooking methods over traditional ones.



This pie chart shows Power Hub usage across the six interviews, and the results show that overall, the Power Hub is mainly used for lighting (39%), followed by cooking (31%). A significant 28% of the responses reported using it to charge their phones. These figures are much higher than the 2% Power Hub usage for watching TV.

3.3 Overview on Energy Usage

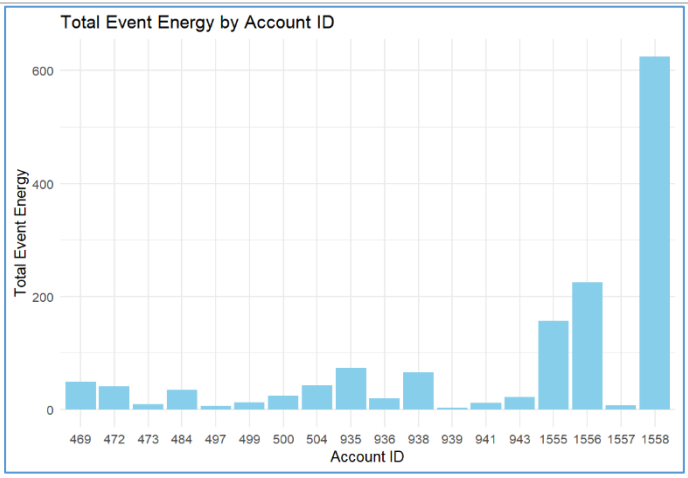


Figure 1 shows the Total Event Energy by Account ID

The bar plot for total event energy reveals significant variability among the participants. Household UGAC_15 (Account 1558) stands out with the highest total event energy, followed by UGAC_16 (1556) and UGAC_19(1555). These households exhibited higher energy usage compared to others suggesting they are the most significant consumers of energy over the observed period. This high total event energy indicates that these participants occasionally used the powerhubs.

In the bar plot for total event time, account UGAC_15 (1558) again emerges as the account with the highest total duration of energy-consuming events. This account is followed by accounts UGAC_16 (1556) and UGAC_19 (1555), similar to the trend observed in total event energy. The substantial total event time for these accounts implies that they spend a significant amount of time cooking with the power hub.

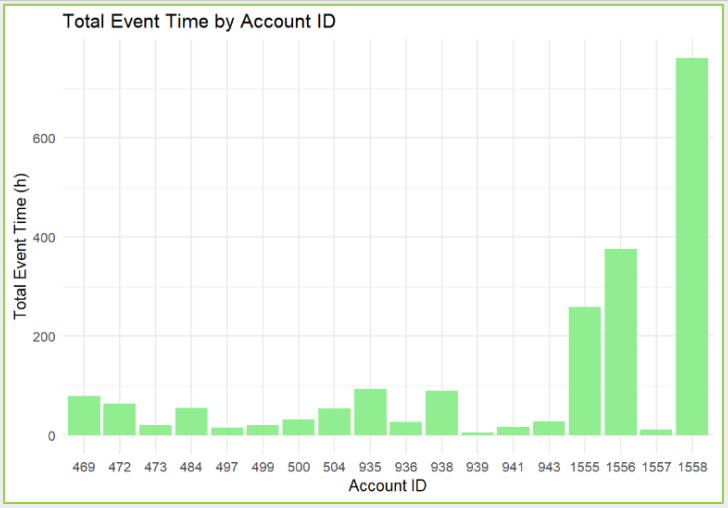


Figure 2 shows the Total Event Time by Account ID

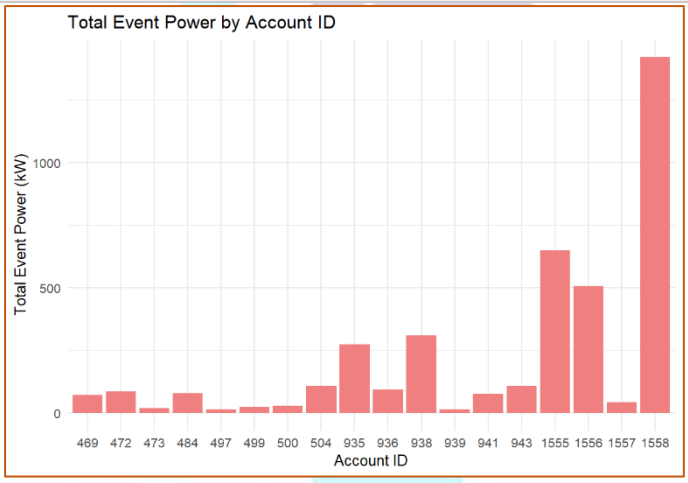


Figure 3 shows the Total Event Power by Account ID

The total event power bar plot underscores the intensity of energy consumption across the accounts. Account UGAC_15 (1558) shows the highest total event power, indicating intensive energy use. UGAC_15 (1558) and UGAC_19 (1555) also exhibit high total event power, reinforcing their status as major energy consumers. This metric, which combines both duration and power consumption, highlights the accounts that not only use a lot of energy but do so at high rates.

The average event energy bar plot provides a different perspective by focusing on the energy consumed per event. UGAC_06 (500) has the highest average event energy, suggesting that while it may not be the highest in total consumption, its individual energy-consuming events are particularly intensive. This pattern is followed by other accounts with relatively high average event energy, indicating infrequent but significant energy use.

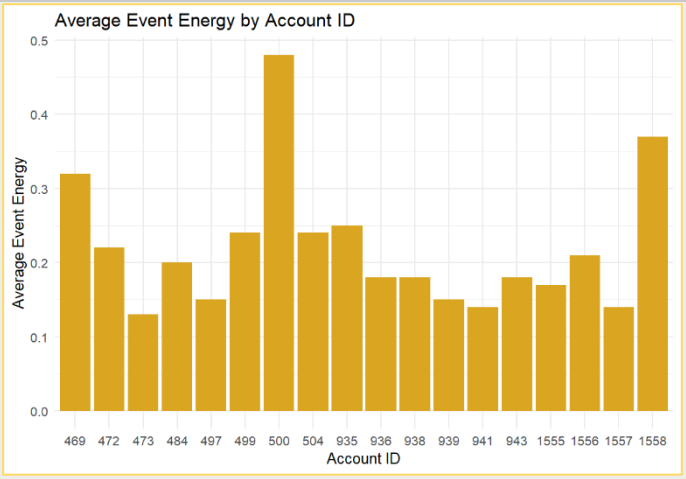


Figure 4 shows the Average Event Energy by Account ID

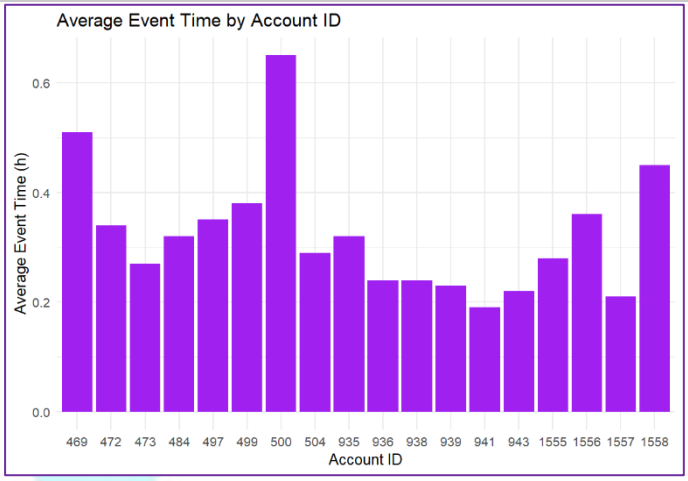


Figure 5 shows the Average Event Time by Account ID

The average event time plot highlights the duration of energy-consuming events for each account. UGAC_06 (500) again stands out with the highest average event time, indicating that its energy-consuming events are not only intensive but also prolonged. This is critical for understanding the nature of energy use, as longer event durations can imply different operational characteristics compared to shorter, more frequent energy use.

The average event power plot emphasizes the rate of energy consumption during individual events. UGAC_07 (941), UGAC_13 (943), and UGAC_14 (938) display high average event power, suggesting that their energy-consuming of power hub usage. These accounts may involve operations or processes that necessitate intense energy usage especially for shorter durations. High average event power indicates significant energy draw per event.

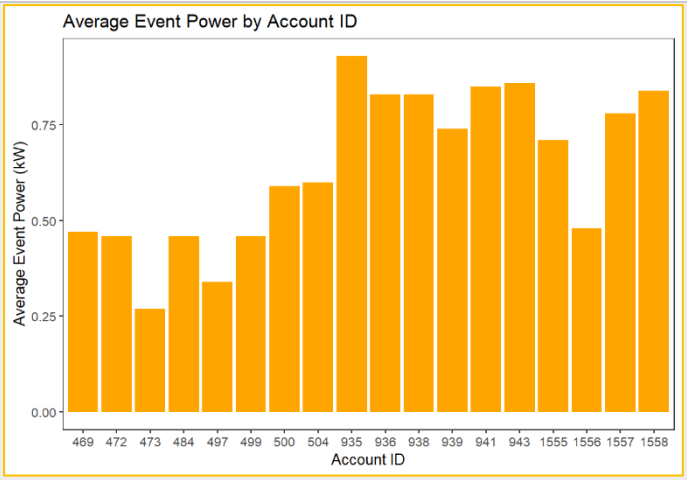


Figure 6 shows the Average Event Power by Account ID

In conclusion, the analysis of total and average event metrics across different accounts provides a comprehensive understanding of energy consumption patterns. Household 15, 16, and household 19 are identified as major energy consumers with high total energy, time, and

power metrics. Conversely, household 06 exhibit high average energy and time per event, indicating intense and prolonged energy use. These insights can guide targeted interventions for energy efficiency, load management, and cost savings.

4 Interviews

4.1 Interview one

Interview one was conducted at the beginning of the extension study. It was observed that the use of Power Hubs and Electric Pressure Cookers (EPCs) among participants reveals several key insights. Power Hubs are primarily valued for their reliability during power outages, offering essential lighting and phone charging capabilities. However, issues such as battery depletion during cooking and high electricity consumption for charging are noted concerns. Conversely, EPCs were praised for their time-saving cooking abilities and versatility across various dishes, though limitations include difficulties in cooking milk and porridge effectively and occasional issues with non-stick coatings. Participants appreciate the EPCs' efficiency but highlight challenges related to electricity usage and specific cooking tasks. Overall, while both devices enhance convenience and functionality in daily life, ongoing improvements are necessary to address technical and operational limitations. Figure 12 below summarizes the key points highlighted during the first interview.

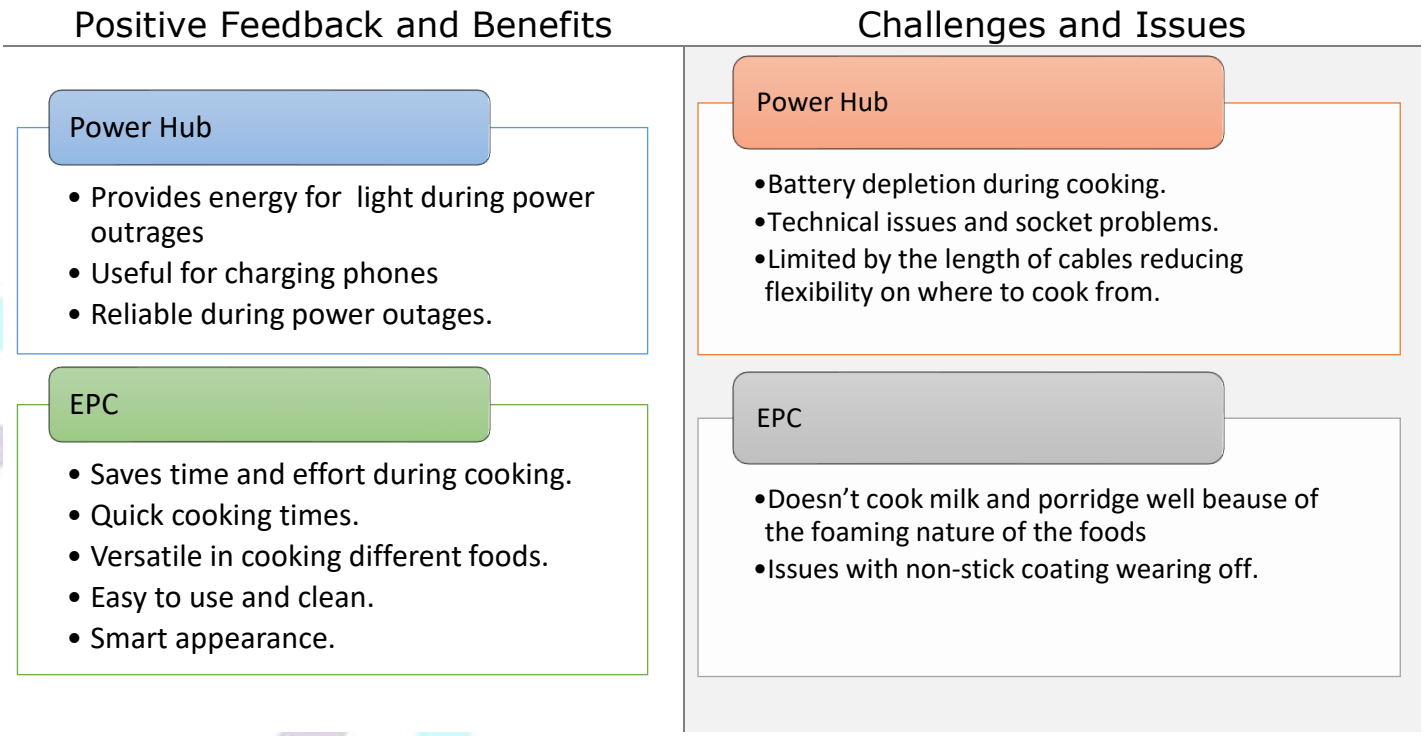


Figure 7 shows a summary of key points highlighted during the first interview

Table 2 below contains the responses of the participants during the first round of interviews. It details the frequency of Power Hub and EPC usage of each participant, and the primary purposes the devices are used for in the household.

Table 2: Interview one analysis

Participant Code	Device	Frequency of Use	Main Benefits	Key Issues
UGAC 001	Power Hub	Not used	N/A	Installation location issue
	EPC	Mostly on weekends	Effective cooking of beans, chicken stew, rice, Irish, and more	Limited use to weekends only due to family availability
UGAC 002	Power Hub	More often	Fast cooking of foods (under 10 minutes)	Previously charged only with solar panels, battery lasted only 30 minutes. Now resolved by using national grid for charging.
	EPC	Every day	Convenient for cooking matooke, cassava, beans, especially for breakfast. Saves time and effort.	Energy meter not lighting green while cooking
UGAC 003	Power Hub	Every day	Saves on electricity costs compared to cooking directly from the national grid. Can continue cooking even when power is off.	Battery running out during cooking, reliance on stable electricity.
	EPC	Every day	Quick, clean cooking. Can cook and eat within 30 minutes, even late at night, as long as there is power.	Cannot cook milk and porridge due to needing more attention, reliance on stable electricity.
UGAC 005	Power Hub	Occasionally	Provides light and power during rainy seasons and when UMEME is unavailable.	No significant issues observed.
	EPC	Twice a week	Fast cooking of beans and cowpeas. Saves time compared to using charcoal.	Steam release noise from pressure cooker.
UGAC 006	Power Hub	Occasionally	Charging phones and providing lighting during power outages.	No significant issues observed.
	EPC	Every day	Quick cooking, versatility in cooking various dishes.	Valve of pressure cooker lost, requiring replacement.
UGAC 007	Power Hub	Occasionally	Charging phones and providing lighting during power outages.	No significant issues observed.
	EPC	Every day	Quick cooking of various dishes, saves time.	No significant issues observed.
UGAC 009	Power Hub	Not working	Lighting during power outages, previously used for cooking.	Powerhub not functional after power outage in December 2022.
	EPC	Every day	Cooking beans, cowpeas, tendons.	No issues reported.
UGAC 010	Power Hub	Every five days	Cooking breakfast and dinner when power is off, charging phones.	Powerhub socket issue after disconnection, no significant impact on usage.
	EPC	Every day	Cooking various dishes efficiently, saving time.	No significant issues reported.

UGAC 011	Power Hub	Infrequent	Lighting and occasional cooking during power outages. Charging phones.	No significant issues reported.
	EPC	3-4 times/week	Cooking various dishes efficiently.	EPC size limitation for larger quantities of food.
UGAC 012	Power Hub	Every five days	Cooking breakfast and dinner when power is off, charging phones.	Powerhub socket issue after disconnection, no significant impact on usage.
	EPC	Every day	Cooking various dishes efficiently, saving time.	No significant issues reported.
UGAC 013	Power Hub	2-4 times/week	Cooking meals and charging phones during power outages.	High electricity consumption during charging.
	EPC	3-4 times/week	Quick cooking, ease of use for various dishes.	No significant issues reported.
UGAC 014	Power Hub	2-4 times/week	Cooking meals and charging phones during power outages.	Occasional issues with initial startup, otherwise no significant problems.
	EPC	3-4 times/week	Quick cooking, ease of use for various dishes.	No significant issues reported.
UGAC 015	Power Hub	Not used	Lighting during power outages, charging phones.	Powerhub not functional after power outage in December 2022.
	EPC	Every day	Warming food, cooking dog's food	No significant issues reported.
UGAC 017	Power Hub	Occasionally	Backup cooking during power outages.	Limited usage due to ongoing availability of electricity, plans to expand usage to tea preparation and bathing water heating.
	EPC	Every day	Efficient, clean cooking with minimal mess.	Concerns about electricity consumption, preference for using charcoal for certain foods like matooke.
UGAC 018	Power Hub	Occasionally	Providing light at night.	Power hub not functional for cooking, reliance on solar-powered lights.
	EPC	Daily	Main source of fuel for cooking various dishes, saving time and effort.	Occasional scratches on the saucepan, pressure release issue with certain foods.
UGAC 019	Power Hub	Occasionally	Charging phones, occasional lighting in the kitchen.	Reluctance to use the power hub for cooking due to perceived inefficiency for heavy tasks like ironing.
	EPC	3-4 times/week	Fast cooking of various dishes like pork, beef, beans, peas, chicken, and mulokoni.	Size limitation of the EPC for cooking larger quantities of food.
UGAC 020	Power Hub	Daily	Cooking breakfast, lunch, and dinner when power is off, charging phones, ironing clothes.	No significant issues reported.
	EPC	Daily	Cooking rice, beans, sweet potatoes, warming milk, preparing breakfast.	No significant issues reported.

4.2 Interview two

The second set of interviews revealed that participants use Power Hubs mainly for lighting, phone charging, and backup power during outages. The main benefits include providing essential lighting and reliable backup power. However, users face issues such as expensive electricity, weak batteries, damaged sockets, and noise during charging. In contrast, Electric Pressure Cookers (EPCs) are highly valued for their fast, clean, and efficient cooking, which significantly reduces cooking time and enhances food quality. Some challenges with EPCs include difficulties in operation for untrained users, worn-out components, and pressure valve issues. Despite these challenges, EPCs are frequently used and appreciated for their versatility and convenience in meal preparation. Limited use of Power Hubs is primarily due to the availability of stable grid power.

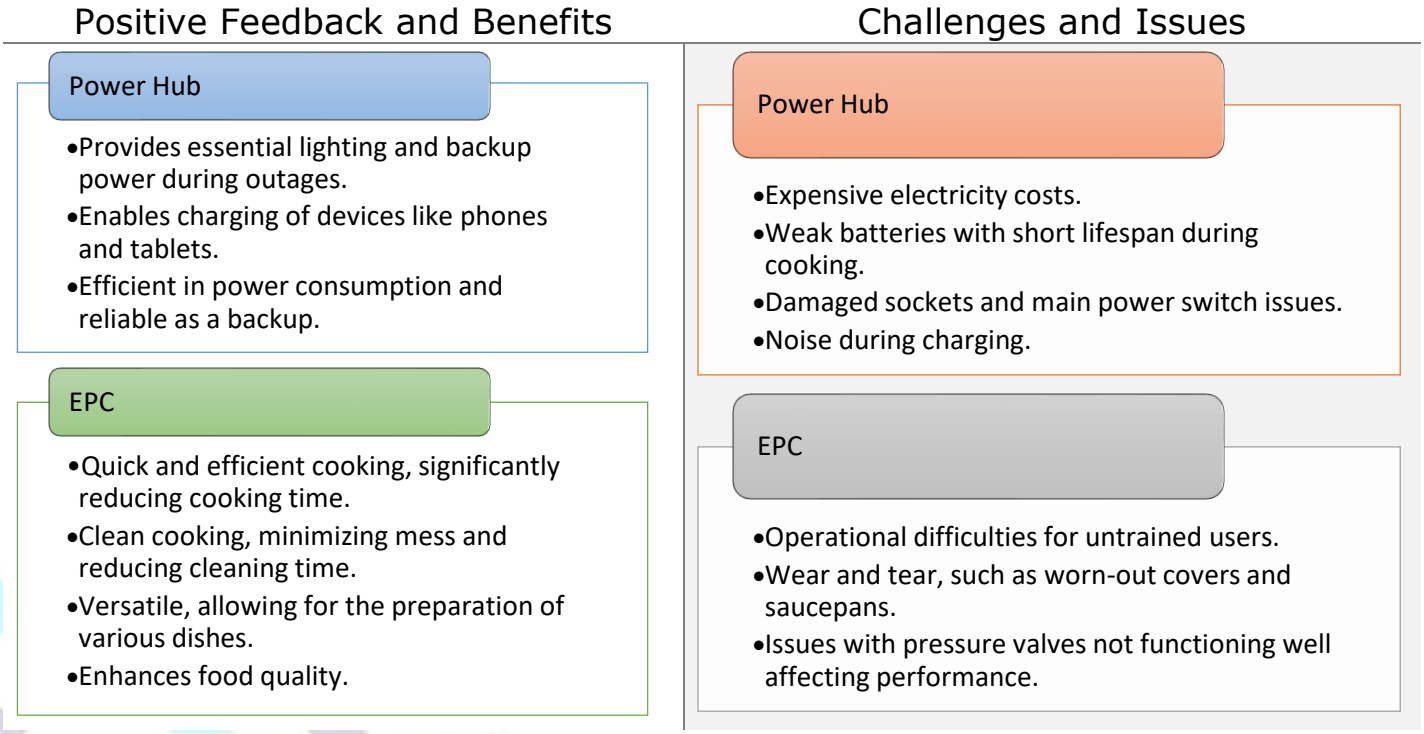


Figure 8 shows a summary of key points highlighted during the second interview

The responses provided by the participants in the second interview round are displayed in Table 3 below. It includes information on each participant's frequency of use, how well they thought the devices worked, the primary advantages they experienced, and the main problems they ran into.

Table 3: Interview two analysis

Participant Code	Device	Frequency of Use	Main Benefits	Key Issues
UGAC 002	Power Hub	Daily for lighting	Provides lighting, helps with cooking when solar charged	Electricity is expensive, request for support

	EPC	Daily for cooking	Cooks faster, is clean, food quality is better	None
UGAC 003	Power Hub	Daily for lighting	Provides lighting	Battery weak, lasts only 20 minutes while cooking
	EPC	Daily for cooking	Works very well	None
UGAC 006	Power Hub	Daily for lighting and charging	Helps with lighting and charging phones	Socket damaged, battery not charging, makes noise
	EPC	Daily for cooking	Saves time, clean, cost-effective	None
UGAC 007	Power Hub	Daily for lighting and charging	Efficient in power consumption, reliable backup	No dislikes, except noise during charging
	EPC	Daily for cooking	Saves time, clean, automatic	None
UGAC 008	Power Hub	Daily for lighting and charging	Reliable during emergencies, provides light	Noisy during charging, takes long to charge
	EPC	Daily for cooking	Cooks fast, clean	Small size, complex to operate
UGAC 009	Power Hub	2-3 times a week and for phone charging	Provides lighting, charges devices quickly	None
	EPC	4-5 times a week	Quick cooking, timesaving, tasty food	None
UGAC 010	Power Hub	Infrequent, used mainly for lighting	Provides lighting during power outages	None
	EPC	5-6 times a week	Quick cooking, timesaving, tasty food	None
UGAC 011	Power Hub	Once a week for cooking, daily for lighting, phone charging, and ironing	Provides lighting, efficient for ironing clothes	None
	EPC	Every day for cooking breakfast	Quick cooking, clean, efficient	Issue with meter not turning on EPC when connected
UGAC 012	Power Hub	Used when grid power is off and for cooking light foods	Provides lighting, backup power for cooking	None
	EPC	Used almost every day	Quick cooking, clean, efficient	None

UGAC 013	Power Hub	Once a week for cooking beans, more often during grid power outages	Provides backup power for cooking	None
	EPC	Almost every day for boiling water and warming dishes	Fast cooking, convenience	None
UGAC 014	Power Hub	Once a week for cooking beans, more often during grid power outages	Provides backup power for cooking, lighting	None
	EPC	Almost every day for cooking various dishes	Fast cooking, convenience	None
UGAC 015	Power Hub	Limited, mainly for lighting and phone charging	Provides lighting, charges devices	Main power switch not turning, unable to charge
	EPC	Limited use, recent usage twice for cooking	Quick cooking, clean	Maid unable to operate, main switch issue
UGAC 016	Power Hub	Used when grid power is off	Provides lighting, backup power for cooking	Main power switch issue, socket problem
	EPC	Used almost every day	Quick cooking, clean, efficient	Cover and saucepan worn out, pressure valve affected
UGAC 017	Power Hub	Limited, mainly for lighting and phone charging	Provides lighting, charges devices	Socket issue, maid unable to operate
	EPC	Limited use, mainly due to maid's inability to operate	Quick cooking, clean, efficient	Maid unable to operate, socket issue
UGAC 018	Power Hub	Daily for lighting and occasional cooking	Provides lighting, charges devices, occasional cooking	Socket issue, maid unable to operate
	EPC	Used daily for cooking various dishes	Fast cooking, convenient	None
UGAC 020	Power Hub	Daily for lighting and occasional cooking	Provides lighting, charges devices, occasional cooking	Socket issue, maid unable to operate
	EPC	Used daily for cooking various dishes	Fast cooking, convenient	No issues reported

4.3 Interview three

The third set of interviews highlighted daily use of Power Hubs mainly for cooking simple meals and providing light during outages, with the main issue being short battery life. Participants appreciated the cost savings on charcoal and the essential functions during outages, such as lighting and phone charging. Electric Pressure Cookers (EPCs) were praised for their efficiency, ease of use, and the quality of food produced, with daily use for a variety of meals. Key benefits included saving time, avoiding burnt food, and being easy to clean, though some participants noted issues with the small size of the cookers and the loud noise during steam release. Overall, users adapted well to these technologies, preferring EPCs over traditional methods due to their convenience and efficiency, while recommending improvements for Power Hub battery life and offering larger EPC models for bigger families.

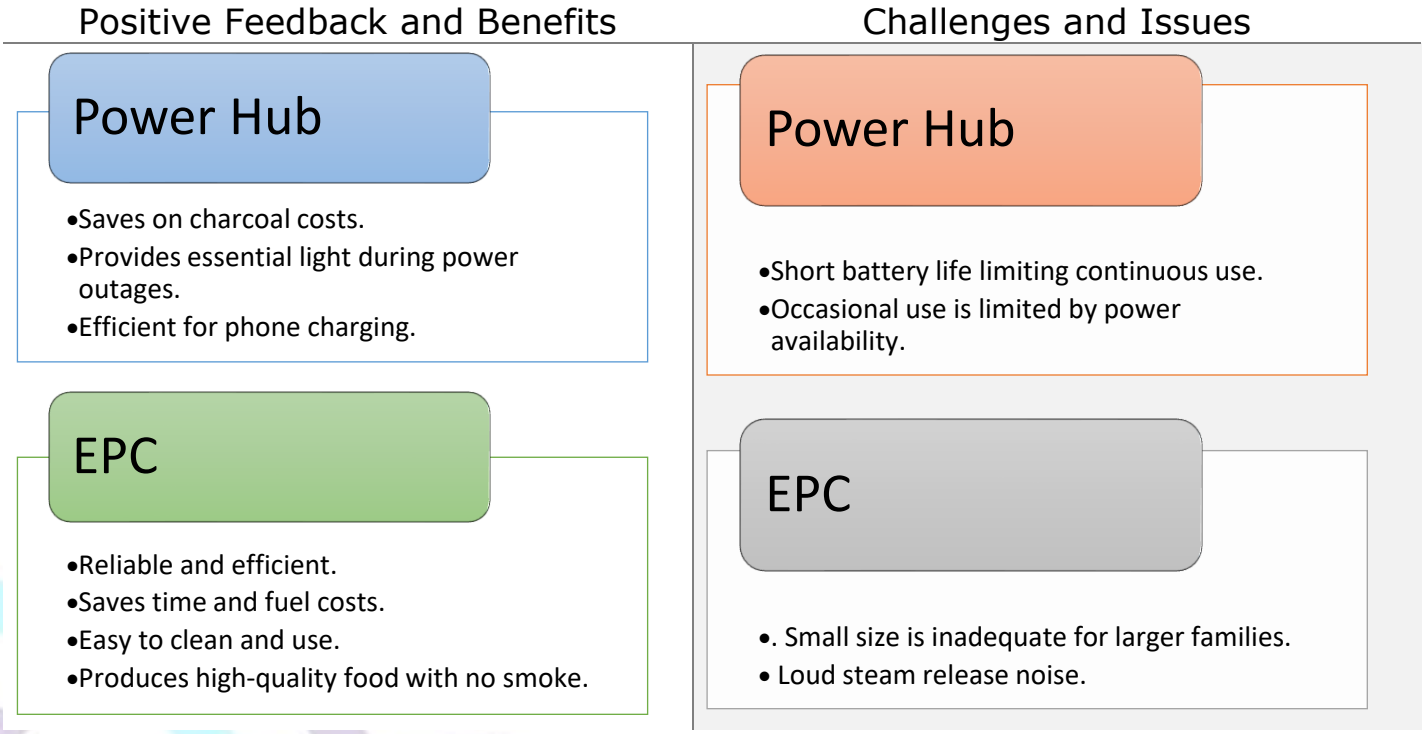


Figure 9 shows a summary of key points highlighted during the third interview

Table 4 below contains the responses of the participants during the third round of interviews. It details the frequency of usage of each participant, their rating of the device efficiency, main benefits they derived from using them and the key issues they faced while using them.

Table 4: Interview three analysis.

PARTICIPANT CODE	DEVICE	FREQUENCY OF USE	MAIN BENEFITS	KEY ISSUES
UGAC 002	Power Hub	Daily (mainly breakfast)	Saves on charcoal costs, cooks simple meals	Short battery life
	EPC	Daily	Reliable, no issues, saves on fuel costs	None

UGAC 003	Power Hub	Twice daily	Cooks meals without electricity	Short battery life
	EPC	Daily	Saves time, avoids burnt food	Small size
UGAC 005	Power Hub	Occasionally (rainy seasons)	Provides light, charges phones	None
	EPC	Twice weekly	Easy to clean, saves time	Loud steam release noise
UGAC 006	Power Hub	Daily (charging, lighting)	Provides light during outages	None
	EPC	Daily	Easy to use, cooks variety of meals	None
UGAC 007	Power Hub	Occasionally (1 month gap)	Provides light and charging during outages	None
	EPC	Daily	Clean, efficient, no smoke	None
UGAC 008	Power Hub	Daily (charging, lighting, cooking once a month)	Reliable backup during power outages, charges phones, saves on cooking fuel	Short battery life, noise when charging, occupies space
	EPC	Daily	Time-saving, no smoke, good taste	Small size, multiple switches needed for operation
UGAC 009	Power Hub	Twice or thrice a week (for lighting during power outages)	Provides lighting during power outages	None
	EPC	2-3 times a week	Cooks quickly, especially beans, meat, tendons	Green indicator not lighting (resolved), cable stopped working
UGAC 010	Power Hub	Twice or thrice a week	Reliable, used for charging and lighting during outages	None
	EPC	Occasionally (mainly when children are home)	Cooks faster, especially rice and beans	None
UGAC 011	Power Hub	Daily (for lighting)	Provides lighting in the kitchen and dining rooms	Cooks slowly compared to direct connection to UMEME
	EPC	Daily (boiling eggs, cooking	Cooks faster, especially helpful in the mornings	Currently not working,

		beans, rice, and meat)		previously made irritating noise
UGAC 012	Power Hub	Three times a week (cooking), daily (charging phones)	Helps to minimize electricity usage for lighting, reliable for daily use	None
	EPC	Two to three times a day	Cooks a variety of meals quickly and efficiently	None
UGAC 013	Power Hub	Three to four times a week (cooking), daily (charging phones)	Provides backup power for cooking, phone charging, and ironing clothes	High electricity consumption for charging
	EPC	Daily	Prepares different kinds of sauces/stews, boils water, fast cooking	Prefers firewood for some meals, occasional non-use of meter
UGAC 014	Power Hub	Stopped two weeks ago due to socket issues	None	Loose socket, EPC plug sticking in socket, high electricity consumption for charging
	EPC	Stopped due to power connection issues	None	Connection issues with measuring meter and wall socket
UGAC 015	Power Hub	3-4 times a week (when charged)	Conserves grid electricity, used for simple cooking and lighting	Inconsistent charging behavior, potential meter plug damage
	EPC	4-5 days a week	Fast cooking, easy to use, conserves electricity, cooks variety of meals	Worn out pot coating, difficulty making 'posho' due to rotating pot
UGAC 016	Power Hub	Used during power outages	Cooks, makes tea/boiling water, charges phones and laptops	Hard to turn power button, complex operation, occasional forgetting to charge
	EPC	Daily	Cooks various meals, reduces reliance on other fuels	None

UGAC 017	Power Hub	Daily (charging, lighting, cooking beans, peas, rice)	Charges phones, provides lighting, cooks specific meals	Overwhelmed with electricity bill, restricted usage due to family concerns
	EPC	Occasional (cooks beans, peas, rice, fish)	Saves electricity, cooks fast meals	Family discourages usage during tight financial periods
UGAC 018	Power Hub	Used occasionally due to malfunction	Provides intermittent lighting, unreliable for cooking	Power hub malfunction, disappointing performance
	EPC	Daily (cooks most meals except quick dishes)	Efficient, saves on fuel costs, reliable	None
UGAC 020	Power Hub	Daily (charging, lighting, cooking rice, sweet potatoes, beef)	Reliable for daily cooking and charging, ease of use	Meter connectivity issues, occasional charging interruptions
	EPC	Daily (cooking rice, sweet potatoes, beef)	Cooks flavorful meals, preferred for specific dishes	Family resistance to usage due to high perceived energy consumption

4.4 Interview four

The fourth set of interviews shows that participants frequently use Power Hubs daily for lighting and occasionally for cooking, with key benefits being nighttime lighting and assistance with cooking. Main issues include battery short lifespan, socket problems, noise during charging, and high electricity consumption. Electric Pressure Cookers (EPCs) are used daily or several times a week for cooking, praised for their speed, cleanliness, and efficiency, leading to better food quality and time-saving. Issues with EPCs are minimal, with some users noting worn-out components, occasional technical issues, and a preference for traditional cooking methods among older family members. Overall, the devices are well-received, though improvements in battery life and technical support are needed.

Positive Feedback and Benefits	Challenges and Issues

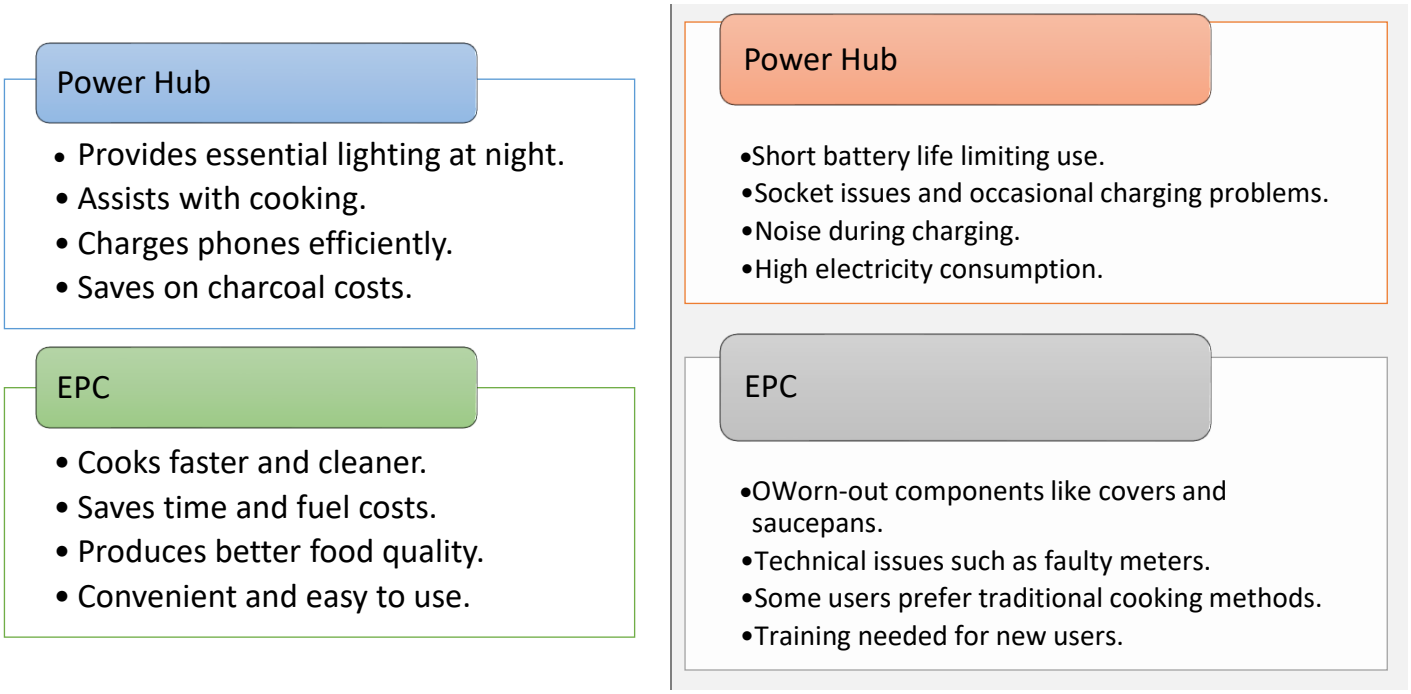


Figure 10 shows a summary of key points highlighted during the fourth interview

Table 5 below contains the responses of the participants during the fifth round of interviews. It details the frequency of Power Hub and EPC usage of each participant, their rating of the device efficiency, main benefits they derived from using them and the key issues they faced while using them.

Table 5: Interview four analysis.

Participant code	Device	Frequency of Use	Main Benefits	Key Issues
UGAC 002	Power Hub	Every day for lighting; occasional cooking	Provides lighting at night; Helps with cooking	None
	EPC	Every day for cooking	Cooks faster, cleaner, better food compared to others	None
UGAC 003	Power Hub	Only for lighting	Provides lighting at night	Battery lasts only 20 minutes for cooking
	EPC	Every day	Works well	None
UGAC 006	Power Hub	Every day for lighting; occasional cooking	Provides lighting at night; Helps with cooking	Socket issues preventing cooking; occasionally not charging
	EPC	Every day	Cooks faster, cleaner, better food compared to others	None

UGAC 007	Power Hub	When electricity goes off; Every day for lighting; Occasional cooking	Provides lighting at night; Charges phones; Assists with cooking	Occasional issues with charging; produces noise during charging
	EPC	4-5 times a week	Fast cooking, clean, automatic	None
UGAC 008	Power Hub	When electricity goes off; Every day for lighting; Occasional cooking	Provides lighting at night; Charges phones; Assists with cooking	Produces noise during charging
	EPC	5-6 times a week	Fast cooking, clean, timesaving	None
UGAC 009	Power Hub	2-3 times a week	Provides lighting at night; Assists with cooking	None
	EPC	3 times a week	Fast cooking, clean, timesaving	None
UGAC 010	Power Hub	2-3 times a week	Provides lighting at night; Assists with cooking	None
	EPC	5-6 times a week	Fast cooking, clean, timesaving	None
UGAC 011	Power Hub	Every day for lighting; occasional cooking	Provides lighting at night; Charges phones; Assists with cooking	Occasionally forgets to charge the battery; Main power switch hard to turn
	EPC	4 times a week	Fast cooking, clean, automatic	Meter issue, not transmitting power signal
UGAC 012	Power Hub	Every day for lighting; occasional cooking	Provides lighting at night; Assists with cooking	None
	EPC	Every day	Fast cooking, clean, timesaving	None
UGAC 013	Power Hub	Occasionally, particularly when grid power is off	Provides lighting at night; Assists with cooking	High electricity consumption
	EPC	Every day	Fast cooking, clean, timesaving	None
UGAC 014	Power Hub	Once a week; more often when grid power is off	Provides lighting at night; Assists with cooking	None
	EPC	Every day	Fast cooking, clean, timesaving	None

UGAC 015	Power Hub	Lights functioning; Occasional charging of phones	Provides lighting at night; Charges phones	Unable to charge due to faulty main power switch
	EPC	Varied	Fast cooking, convenient, allows multitasking	Cover and saucepan worn out; pressure valve affected
UGAC 016	Power Hub	Every day for lighting; occasional cooking	Provides lighting at night; Helps with cooking	Power hub is so huge, takes up a lot of space in the kitchen
	EPC	Every day	Cooks fast, saves fuel, standardizes cooking time	None
UGAC 017	Power Hub	Not in use	Provides lighting at night; Charges phones	Socket issues preventing cooking; new maid not trained to operate
	EPC	Not in use	Fast cooking, clean, saves fuel, standardizes cooking time	New maid not trained to operate; participant waiting for training
UGAC 018	Power Hub	Not in use	Provides lighting at night	Socket issues preventing cooking; technical issues during use
	EPC	Every day	Fast cooking, variety of dishes, fuel-saving	None
UGAC 020	Power Hub	Every day for lighting; occasional cooking	Provides lighting at night; Assists with cooking; Charges phones	Occasional need for more frequent charging due to rainy season
	EPC	Every day	Fast cooking, saves fuel, standardizes cooking time	Grandmother prefers firewood, limiting EPC usage

4.5 Interview five

The fifth set of interviews indicates that participants commonly use Power Hubs daily for lighting and phone charging, with occasional cooking. The main benefits include reliable lighting at night, phone charging, and assistance with cooking, particularly during power outages. However, key issues reported include short battery life, noise during charging, high electricity consumption, and technical problems like loose socket connections and difficulties in switching on the device. Electric Pressure Cookers (EPCs) are used daily for cooking a variety of meals, praised for their speed, cleanliness, energy efficiency, and ease of use. Challenges with EPCs

are minimal but include small size, high power consumption, and occasional technical issues like broken handles and valves. Overall, participants appreciate the time and cost savings provided by these devices, though improvements in power hub durability and EPC capacity could enhance user satisfaction further.

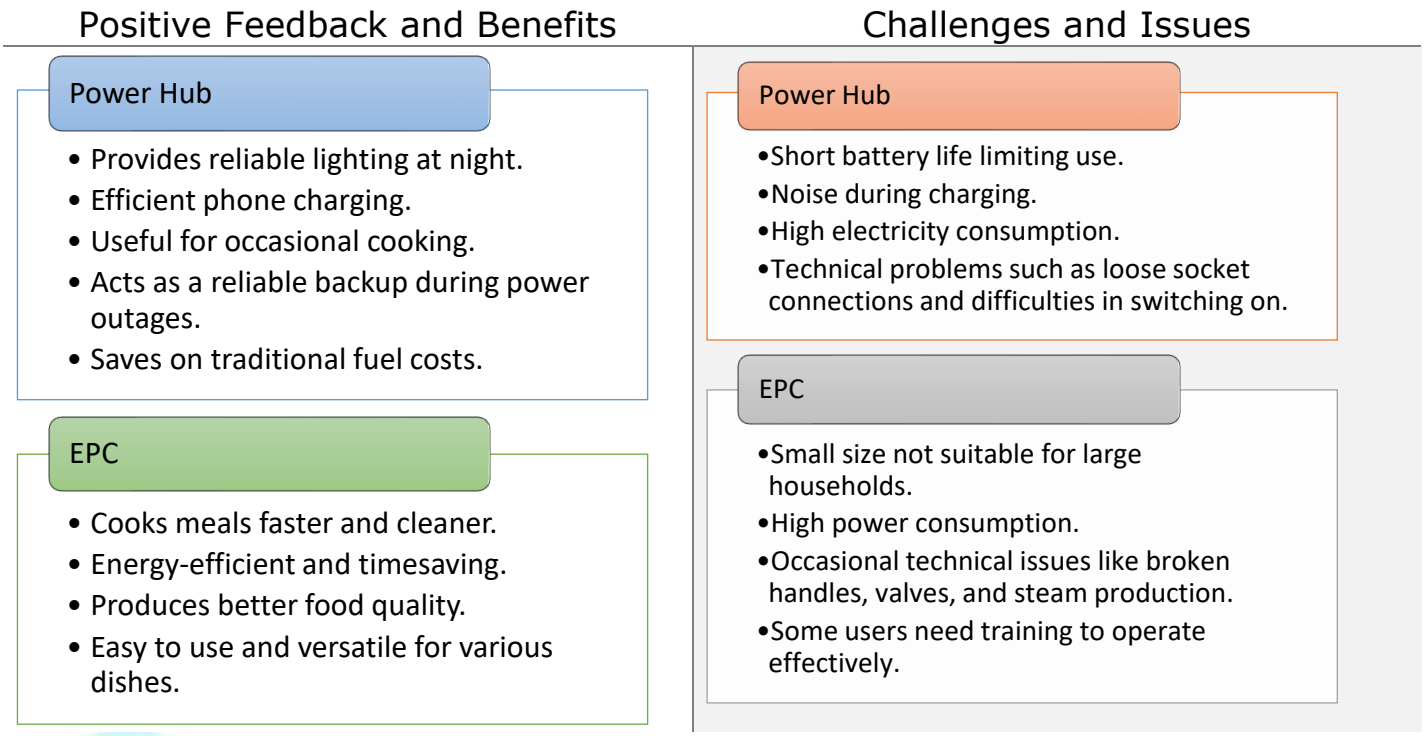


Figure 11 shows a summary of key points highlighted during the fifth interview

Table 6 below contains the responses of the participants during the fifth round of interviews. It details the frequency of Power Hub and EPC usage of each participant, their rating of the device efficiency, main benefits they derived from using them and the key issues they faced while using them.

Table 6: Interview five analysis.

Participant Code	Device	Frequency of Use	Main Benefits	Key Issues
UGAC 002	Power Hub	Daily (for lighting)	Lighting at night, occasional cooking with solar charge	Battery lasts only 20 minutes
	EPC	Daily	Faster cooking, cleanliness, good food quality	None
UGAC 003	Power Hub	Rarely (for lighting)	Lighting at night	Battery lasts only 20 minutes, insufficient for cooking
	EPC	Daily	Faster cooking, cleanliness, good food quality	None

UGAC 006	Power Hub	Not in use	Lighting at night, phone charging (before damage)	Heavy to carry, loose socket connection, requires frequent charging, difficult to switch on
	EPC	Daily	Faster cooking, cleanliness, lack of smoke, timesaving	High power consumption, small size for large households, difficulty for untrained individuals
UGAC 007	Power Hub	3-4 days/week	Lighting, phone charging, occasional cooking	None
	EPC	Daily	Timesaving, power efficiency, cleanliness	None
UGAC 008	Power Hub	Daily (for lighting and phone charging)	Reliable backup during power outages, solar recharging, timesaving for cooking	Produces noise when charging, power consumption during recharging
	EPC	Daily	Fast cooking, cleanliness, ease of use	Small size, steam production when releasing pressure
UGAC 009	Power Hub	Once a week (when power goes off)	Lighting, phone charging, cooking	None
	EPC	Daily	Fast cooking, energy efficiency, easy operation	Menu button damaged, requires repair
UGAC 010	Power Hub	Not in use	Not used for the last 2-3 months	Not applicable
	EPC	Daily (except Sundays)	Fast cooking, energy efficiency, good food quality	Not applicable
UGAC 012	Power Hub	Daily	Charging phones, lighting, occasional cooking	None
	EPC	Daily	Cooking various dishes, warming stew, boiling water	None
UGAC 013	Power Hub	4-5 times/week	Charging phones, lighting, boiling water for tea, occasional cooking	High electricity consumption for charging
	EPC	Daily	Cooking various meals, consistent performance	Not suitable for certain dishes, high electricity consumption
UGAC 014	Power Hub	Not specified	Lighting, phone charging, occasional cooking	Not charging, switch issue, rusted USB connection

	EPC	Not specified	Keeping food warm, cooking simple meals	Concerns about boiling milk, size for large family, need for additional bulb
UGAC 015	Power Hub	Not specified	Lighting, mobile phone charging, occasional cooking	Not charging, switch issue, rusted USB connection
	EPC	Daily	Cooking various meals, warming stew, boiling water	Broken handle, broken pressure valve, worn-out saucepan, slow heating
UGAC 016	Power Hub	Not specified	Lighting, phone charging, occasional cooking	Occupies a lot of space
	EPC	Daily	Quick cooking, ease of use, versatility	None
UGAC 017	Power Hub	Daily (for lighting)	Provides lighting despite charging issues	Not charging, unable to support cooking activities
	EPC	Daily	Fast and tasty cooking, versatile	None
UGAC 018	Power Hub	Daily	Provides lighting, charges mobile phones, connects TV, supports cooking activities	Inconsistency in working properly with EPC, occasional issues with technicians
	EPC	Daily	Wide range of dishes prepared, reliable cooking results, easy to teach others to use	None
UGAC 020	Power Hub	Daily	Cooking activities (connecting EPC), ironing, watching TV, charging phones, providing lights	No reported issues
	EPC	Daily	Cooking various foods (rice, black tea, sweet potatoes, ground nuts, cassava)	Occasional noise and vapor leakage during cooking rice

4.6 Interview six

The sixth set of interviews reveals that Power Hubs are primarily used daily for lighting and phone charging, with occasional cooking. Key benefits include reliable lighting at night, backup power during outages, and solar recharging. However, issues such as short battery life, noise during charging, high electricity consumption, and various technical problems (loose socket connections, difficulty switching on, and rusted USB connections) were noted. Electric Pressure Cookers (EPCs) are used daily for a variety of cooking tasks and are praised for their speed, cleanliness, energy efficiency, and ease of use. Challenges include high power consumption, small size for larger households, and occasional technical issues like broken handles, pressure valves, and steam production during pressure release. Overall, participants appreciate the efficiency and convenience of EPCs despite the few issues reported.

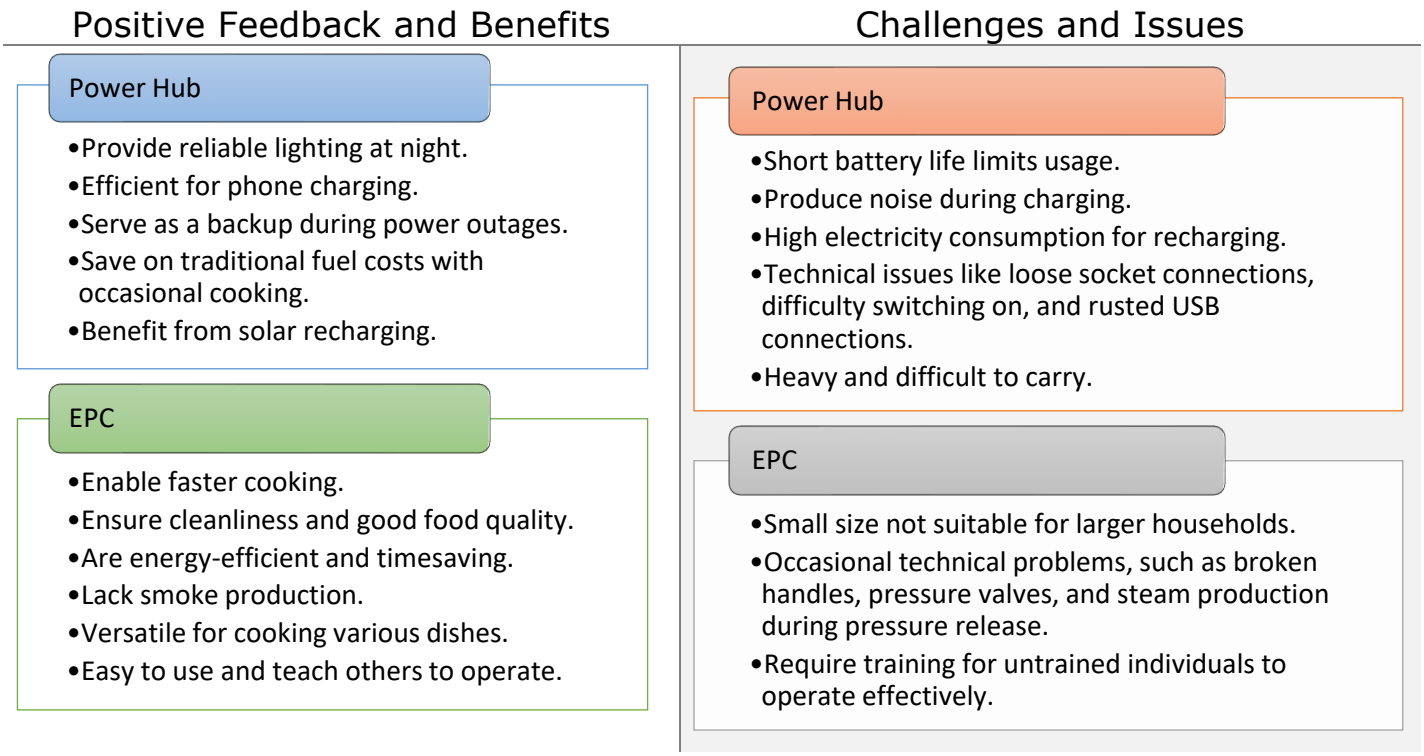


Figure 12 shows a summary of key points highlighted during the sixth interview

Table 7 below contains the responses of the participants during the sixth round of interviews. It details the frequency of Power Hub and EPC usage of each participant, their rating of the device efficiency, main benefits they derived from using them and the key issues they faced while using them.

Table 7: Interview six analysis

PARTICIPANT CODE	DEVICE	FREQUENCY OF USE	MAIN BENEFITS	KEY ISSUES
UGAC 002	Power Hub	Daily (for lighting)	Lighting at night, occasional cooking with solar charge	Battery lasts only 20 minutes
	EPC	Daily	Faster cooking, cleanliness, good food quality	None
UGAC 003	Power Hub	Rarely (for lighting)	Lighting at night	Battery lasts only 20 minutes, insufficient for cooking
	EPC	Daily	Faster cooking, cleanliness, good food quality	None
UGAC006	Power Hub	Not in use	Lighting at night, phone charging (before damage)	Heavy to carry, loose socket connection, requires frequent charging, difficult to switch on

	EPC	Daily	Faster cooking, cleanliness, lack of smoke, timesaving	High power consumption, small size for large households, difficulty for untrained individuals
UGAC 007	Power Hub	3-4 days/week	Lighting, phone charging, occasional cooking	None
	EPC	Daily	Timesaving, power efficiency, cleanliness	None
UGAC 008	Power Hub	Daily (for lighting and phone charging)	Reliable backup during power outages, solar recharging, timesaving for cooking	Produces noise when charging, power consumption during recharging
	EPC	Daily	Fast cooking, cleanliness, ease of use	Small size, steam production when releasing pressure
UGAC 009	Power Hub	Once a week (when power goes off)	Lighting, phone charging, cooking	None
	EPC	Daily	Fast cooking, energy efficiency, easy operation	Menu button damaged, requires repair
UGAC 010	Power Hub	Not in use	Not used for the last 2-3 months	Not applicable
	EPC	Daily (except Sundays)	Fast cooking, energy efficiency, good food quality	Not applicable
UGAC 012	Power Hub	Daily	Charging phones, lighting, occasional cooking	None
	EPC	Daily	Cooking various dishes, warming stew, boiling water	None
UGAC 013	Power Hub	4-5 times/week	Charging phones, lighting, boiling water for tea, occasional cooking	High electricity consumption for charging
	EPC	Daily	Cooking various meals, consistent performance	Not suitable for certain dishes, high electricity consumption
UGAC 014	Power Hub	Not specified	Lighting, mobile phone charging, occasional cooking	Not charging, switch issue, rusted USB connection
	EPC	Not specified	Keeping food warm, cooking simple meals	Concerns about boiling milk, size for large family, need for additional bulb

UGAC 015	Power Hub	Not specified	Lighting, mobile phone charging, occasional cooking	Not charging, switch issue, rusted USB connection
	EPC	Daily	Cooking various meals, warming stew, boiling water	Broken handle, broken pressure valve, worn-out saucepan, slow heating
UGAC 016	Power Hub	Not specified	Lighting, mobile phone charging, occasional cooking	Occupies a lot of space
	EPC	Daily	Quick cooking, ease of use, versatility	None
UGAC 017	Power Hub	Daily (for lighting)	Provides lighting despite charging issues	Not charging, unable to support cooking activities
	EPC	Daily	Fast and tasty cooking, versatile	None
UGAC 018	Power Hub	Daily	Provides lighting, charges mobile phones, connects TV, supports cooking activities	Inconsistency in working properly with EPC, occasional issues with technicians
	EPC	Daily	Wide range of dishes prepared, reliable cooking results, easy to teach others to use	None
UGAC 020	Power Hub	Daily	Cooking activities (connecting EPC), ironing, watching TV, charging phones, providing lights	No reported issues
	EPC	Daily	Cooking various foods (rice, black tea, sweet potatoes, ground nuts, cassava)	Occasional noise and vapor leakage during cooking rice

5 Conclusion and Recommendations

The study findings across multiple interviews provide valuable insights into participant behaviors, challenges, and preferences, highlighting the evolving role of these devices in daily life and during emergencies.

Throughout the study, there was an increase in the daily use of power hubs for essential tasks such as lighting, cooking, and phone charging. This trend indicates successful integration into participants' daily routines, reflecting the reliability and convenience offered by the power hubs. Participants increasingly relied on these devices not only during power outages but also for regular household activities. Initial high usage of power hubs during power outages gradually declined over subsequent interviews. This decline is attributed to participants adopting the power hubs into their daily lives, appreciating their reliability beyond emergency situations. Moreover, few participants reported improved stability in grid electricity during the study period, but still preferred to use the power hubs for cooking and lighting. Weekly usage patterns

showed consistent reliance on power hubs for lighting and occasional cooking, indicating secondary but stable usage patterns among participants. Non-usage of power hubs was minimal and mainly linked to reported technical issues noted in the asset register, emphasizing the importance of addressing these concerns to maximize device utilization.

Feedback from participants highlighted several challenges, including short battery life, noise during charging, and occasional technical issues with connectivity and device operation. Despite these challenges, participants expressed overall satisfaction with the functionality and convenience of power hubs, particularly in improving household energy access and reducing reliance on traditional energy sources.

Some of the recommendations include.

- Technical Enhancements: Address reported technical issues through product improvements and maintenance strategies to enhance device reliability and user experience.
- User Education and Support: Provide comprehensive training and ongoing support to users to optimize power hub usage, troubleshoot common issues, and promote efficient energy management practices.
- Product Development: Explore opportunities for developing larger capacity power hubs and improving energy efficiency to meet diverse household energy needs effectively.

Appendix

Table shows the totals of energy usage by different households recorded by the monitoring system

Account ID	***Power Hub***	*Total event energy*	*Total event time (h)*	*Total event power (Kw)*
469	UGAC 08	48.970	78.667	72.402
472	UGAC 02	40.260	63.967	85.672
473	UGAC 20	9.590	19.783	19.399
484	UGAC 10	34.370	54.217	77.357
497	UGAC 09	6.630	15.350	15.140
499	UGAC 01	12.840	20.333	24.862
500	UGAC 06	23.700	31.617	29.020
504	UGAC 12	42.630	53.233	108.153
935	UGAC 04	73.220	93.167	273.520
936	UGAC 03	20.240	27.133	93.940
938	UGAC 14	65.690	88.667	308.393
939	UGAC 05	3.090	4.567	14.747
941	UGAC 07	11.890	16.583	75.051
943	UGAC 13	21.820	27.567	106.791
1555	UGAC 19	156.970	258.517	649.385
1556	UGAC 16	224.980	375.600	506.653
1557	UGAC 17	7.440	11.300	42.683
1558	UGAC 15	624.450	761.217	1421.525

Table shows the averages of energy usage by different households recorded by the monitoring system

Account ID	***Power Hub***	*Average event energy*	*Average event time (h)*	*Average event power (Kw)*
469	UGAC 08	0.320065359	0.51416122	0.473218781
472	UGAC 02	0.215294118	0.342067736	0.458136699
473	UGAC 20	0.133194444	0.274768519	0.269426404
484	UGAC 10	0.202176471	0.318921569	0.455041087
497	UGAC 09	0.150681818	0.348863636	0.344090909
499	UGAC 01	0.237777778	0.37654321	0.460407407

500	UGAC 06	0.483673469	0.645238095	0.59224423
504	UGAC 12	0.235524862	0.294106814	0.597528122
935	UGAC 04	0.24820339	0.315819209	0.927185323
936	UGAC 03	0.179115044	0.240117994	0.831331117
938	UGAC 14	0.177540541	0.23963964	0.833493935
939	UGAC 05	0.1545	0.228333333	0.73736321
941	UGAC 07	0.135113636	0.18844697	0.852852697
943	UGAC 13	0.175967742	0.222311828	0.861220373
1555	UGAC 19	0.172116228	0.283461257	0.712044617
1556	UGAC 16	0.212646503	0.355009452	0.478877947
1557	UGAC 17	0.135272727	0.205454545	0.776047138
1558	UGAC 15	0.368842292	0.449625911	0.839648681