MECS
Modern Energy Cooking Services

Center for Renewable Energy Systems Technology (CREST) report on DC Powerhubs

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Executive Summary

1.1 Cooking appliances and fuels:

Fuels mainly used: Prior to the implementation of the project intervention, participants predominantly relied on a combination of charcoal and firewood for their cooking needs. These traditional fuels were favored due to their easy accessibility and affordability. However, a minority of households opted for LPG (liquefied petroleum gas) for its convenience, especially for quick breakfast preparation or when cooking for smaller meals. The preference for charcoal stemmed from its suitability for roasting food, while firewood was preferred for dishes requiring longer cooking times. This fuel usage pattern was influenced by factors such as the availability of resources through practices like agro-forestry. All participants practiced fuel stacking occasionally, which indicates a widespread practice of combining different fuels for cooking. LPG emerged as a preferred option due to its convenience, particularly for faster meal preparation, making it popular among households with smaller cooking needs. Understanding these dynamics is crucial for designing effective interventions aimed at promoting cleaner and more sustainable cooking practices within the community.

Appliances owned: the 3 stone fire emerging as the most utilized appliance. Its widespread adoption can be attributed to its affordability and convenience, particularly well-suited for the rural context where the community resides. Basic biomass stove technologies, including the 3 stone fire and charcoal cookstoves, are favored due to their low cost and ease of operation, with easily accessible fuel sources further enhancing their appeal. LPG technology is prevalent among individuals seeking fast breakfast options or those living alone, appreciating its convenience. Improved biomass stoves are valued for their fuel-saving capabilities and heat retention properties, ideal for steaming purposes. The combination of firewood and charcoal remains the most common fuel choice, influencing the selection of cooking appliances, with households typically opting for a combination of the 3 stone fire and basic charcoal cookstove due to their affordability and reliability.

Fuel acquisition and usage: The data reveals that participants collected firewood from nearby forests, swamps, or gardens. Collection frequency varies widely, with some individuals gathering firewood multiple times per week, while others collect monthly or less frequently. Collection efforts are noted to be labor-intensive, with trips ranging from 25 minutes to 12 hours, emphasizing the substantial time investment required. Despite the effort involved, firewood remains popular due to its affordability and availability, though usage tends to be limited to short periods following collection.

Both buying and occasional collection methods are employed for acquiring charcoal, with accessibility being a key determinant. Purchase frequency varies, ranging from daily to monthly, depending on household needs. While purchasing charcoal is relatively straightforward, collection efforts are less frequent and may entail longer durations. Charcoal costs vary based on quantity, ranging from Ugx 2,000 for small amounts to Ugx 75,000 for larger quantities. Overall, charcoal is perceived as more accessible compared to firewood, contributing to its popularity among households.

LPG adoption, while less common, is favored for its convenience, particularly for quick meal preparation. Usage patterns vary, with some households using LPG regularly while others sparingly. Factors influencing LPG usage include household size, cooking frequency, and availability of alternative fuel sources. Although initial investment costs for LPG equipment,

such as gas cooker stoves and cylinders, are significant, ongoing refill expenses are comparatively less burdensome.

The intervention involved the introduction of DC power hubs and Electric Pressure Cookers (EPCs) in a week gird location (Matuga – Uganda) to promote cleaner and more efficient cooking practices. The power hubs, designed for both off-grid and weak-grid participants, provided a reliable source of electricity for cooking appliances, aiming to reduce reliance on traditional fuels like firewood and charcoal. Key findings from the study indicated significant shifts in cooking fuel preferences. There was a reduction in charcoal and firewood usage, with participants increasingly adopting electricity for cooking. For instance, charcoal usage decreased by up to 75.93%, and firewood by 73.30% during phase II. This shift suggests a growing acceptance of modern cooking technologies, driven by the convenience and efficiency of EPCs. Interviews with participants revealed high satisfaction with the EPCs, highlighting their ease of use, time-saving features, and financial savings. However, challenges such as technical issues. Participants expressed a desire for larger appliances and more reliable power supplies. Recommendations include enhancing the accessibility and affordability of electric cooking technologies, providing ongoing education and training, and improving the reliability of power supply infrastructure.

1.2 Cooking practices and food preferences:

Charcoal Usage: Significant reductions in charcoal usage are observed across various dishes, with percentage decreases ranging from 39% to 78%. This decline in charcoal consumption is indicative of potential shifts towards cleaner or more efficient cooking methods.

Electricity Adoption: A remarkable increase in electricity usage for cooking is evident, with a 100% rise observed across dishes such as rice and beans/peas stew. This shift suggests a growing inclination towards modern cooking technologies, possibly driven by accessibility and convenience.

Firewood Trends: While firewood remains a prevalent cooking fuel, reductions in usage are noted across several dishes, with percentage decreases ranging from 28% to 79%. This decline may reflect efforts to mitigate environmental impacts associated with traditional cooking methods.

Implications and Recommendations: The observed changes in cooking fuel preferences and dish preparation underscore the importance of promoting sustainable cooking practices within the community. Interventions aimed at incentivizing the adoption of cleaner fuels, such as electricity, while supporting efficient use of traditional fuels like firewood, can contribute to improved air quality and environmental conservation.

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 an improved choice of affordable and reliable modern energy cooking services for consumers.

The off-grid (DC) component of the study is still ongoing 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.

Research objectives.

The main objective of the DC pilot study was to test the potential of DC powerhub and EPC combination 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. Other objectives include.

- To determine if solar energy is reliable enough to facilitate cooking activities.

To achieve the desired objective(s), 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.

Introduction

In this study, a structured methodology was employed to thoroughly investigate the introduction and impact of electric cooking technologies using DC powerhubs in Kigulu. The process began with obtaining consent forms and conducting registration interviews to ensure ethical participation and gather essential demographic information. Effective communication among enumerators was facilitated by setting up WhatsApp groups, enhancing coordination throughout the study. Data collection included intake interviews to measure current cooking practices, field testing of the powerhubs, midpoint and exit interviews to capture participants' experiences and feedback and cooking diaries that required participants to record their daily cooking activities in a cooking diary over an eight-week period, divided into two phases. In the first phase, households cooked as usual while data was collected on their cooking habits, energy usage, devices used, and types of foods cooked. Following this, a one-week transition phase introduced households to electric cooking devices, such as electric pressure cookers, aimed at removing barriers to eCooking adoption. Additionally, a one-day co-creation workshop provided a collaborative platform for participants to contribute ideas and solutions, enriching the study with valuable insights from community stakeholders. Participants were encouraged to use electricity as much as possible throughout the study.

Approaches Used

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.

Cooking Diaries

The study was conducted over an eight-week period, divided into two phases. In the first phase, participating households were asked to continue cooking as usual while providing information on their day-to-day cooking activities, energy usage, types of devices utilized, timing of cooking sessions, and the variety of foods prepared. Following this initial phase, a one-week transition period ensued, during which households were introduced to an electric cooking device, specifically an electric pressure cooker (EPC), aimed at overcoming barriers to adopting eCooking practices. In addition to covering the upfront cost of the appliances, the research team offered awareness campaigns, demonstrations, and training sessions to facilitate the households' familiarity with the new device. Once households became comfortable with the electric pressure cooker, the second phase commenced. In this phase, households were encouraged to utilize the EPC for as many meals as possible. The study employed the cooking diaries methodology as part of the field trial, requiring households to document their cooking practices and assess the compatibility of electric power hubs with their routines. This standardized approach aimed to comprehensively understand people's cooking habits and evaluate their compatibility with modern cooking technologies, yielding a

reliable dataset of dishes across different contexts as per research guidelines. Data collected included details on food prepared, cooking processes and durations, appliances employed, and energy consumption measurements.

Phases	Description of tasks for households	Description of research team interaction
Pre- testing Phase	Building rapport with the enumerators and establishing communication	Internally test the KoBo surveys, assign households, interview each other to find questions with gap, test the registration and survey tools,
Phase 1: two weeks	Households cook as they normally do using existing appliances and fuels in the house. Cooks are also asked to keep a note of the meals they cook and the fuels they use on daily basis for two weeks. They are also asked to measure the fuel before and after the cooking activity is done and make note.	Visit households daily to interview and collect data on the meals cooked, the fuel used and how much of it was used to prepare meals for the day.
Transition period: one week	At the beginning of the week participants were introduced to the new appliance (EPC) and trained on how to use it	Available to demonstrate, answer questions and advice on how the appliance may be used.
Phase 2: two weeks	Households were advised to use the EPC in their daily cooking as much as possible. Like Phase 1, households were also asked to keep a record of the meals they cooked, the fuels and appliances they used, and measurement of fuel before and after the cooking event.	Visit households daily or interview households remotely to collect data on foods prepared, cooking and energy consumption

Data Acquisition System

A smart data acquisition (battery meter) system that was embedded onto the DC powerhubs was used to monitor energy usage and providing the details on a screen that the participants would record into their cooking diaries.

Interviews

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

- Intake interviews were conducted at the beginning after participants had agreed 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.

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 where 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.

Data Collection Tools

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

Participant Registration

- 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.

Intake interview guide

- An intake interview guide was administered for participants that accepted to participate in the study to better understand decision-making in households to improve and develop better electricity-based cooking services together with the households.

midline interview

- 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.

endline interview

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

co-creation workshop

- A co-creation workshop guide was developed which allowed participants the 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 to share experiences amongst themselves.

Data collection

- 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.

Table below shows the equipment used to enhance data collection during the study.

Powerhub used during the DC study	
	Used a 50kg with accuracy of 10g calibrated digital scale to measure the weight of firewood or charcoal used to cook dishes or boil water. It has a hook that allows easy measurement of the bundled-up fuel. It has an easy to- read backlit LCD screen with a push- button control that allows taring/ zeroing and switch off and on. It has a power supply of a 3V CR2032 battery.
Used a 50kg with accuracy of 10g calibrated digital scale to measure the weight of firewood or charcoal used to cook dishes or boil water. It has a hook that allows easy measurement of the bundled-up fuel. It has an easy to- read backlit LCD screen with a push- button control that allows taring/ zeroing and switch off and on. It has a power supply of a 3V CR2032 battery.	

The electric pressure cooker used during the study. It's a 500w DC powerhub	

Data Quality Management

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

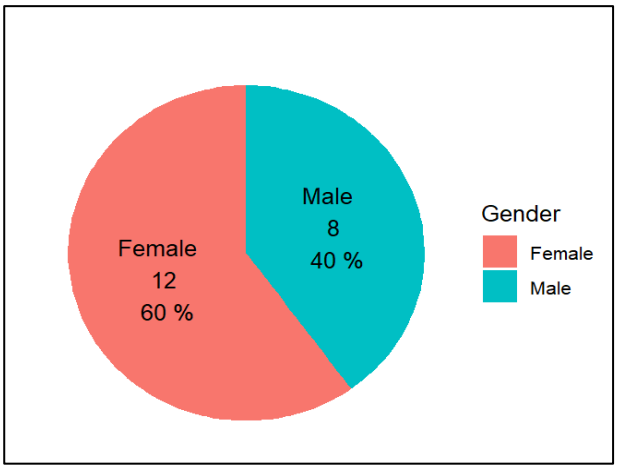
- The interviewing team (enumerators) were well trained in collecting qualitative data and conducting focused group discussions as per the interview protocol. This was done for a period of five (5) days before they were sent to the field. An enumerator debrief was always done at the start of any field 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 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 also having an on-ground local coordinator. These helped to channel and deliver the intended message to the target person(s).

Key Findings

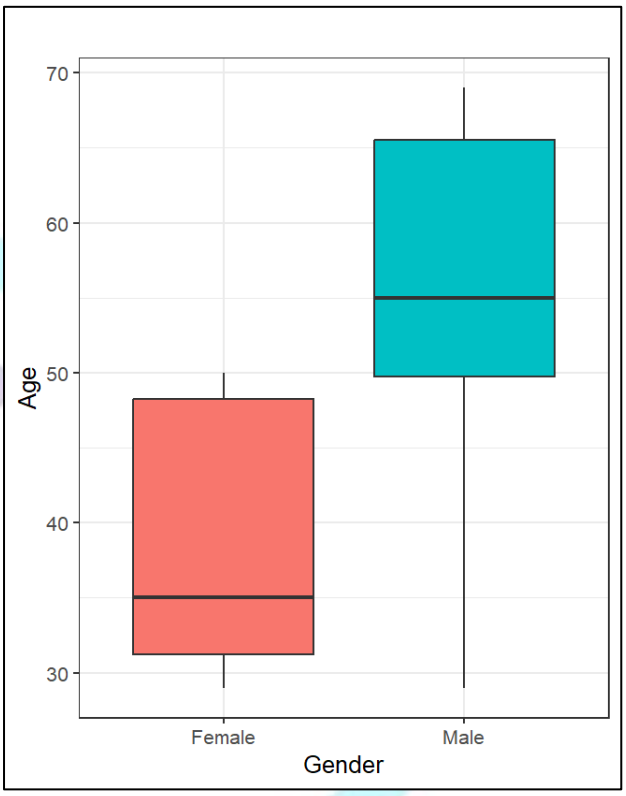
Demographics

Gender composition

The registration survey shows a gender disparity in participation, with 12 responses from females which caters for 60 percent of the study sample and 8 from males catering for 40% of the study sample. This is mainly to the fact the ladies participate more in the cooking activities, hence justifying their higher number. The reason is that some of these families are female headed and others use female house helps which justifies the high number of females compared to males.



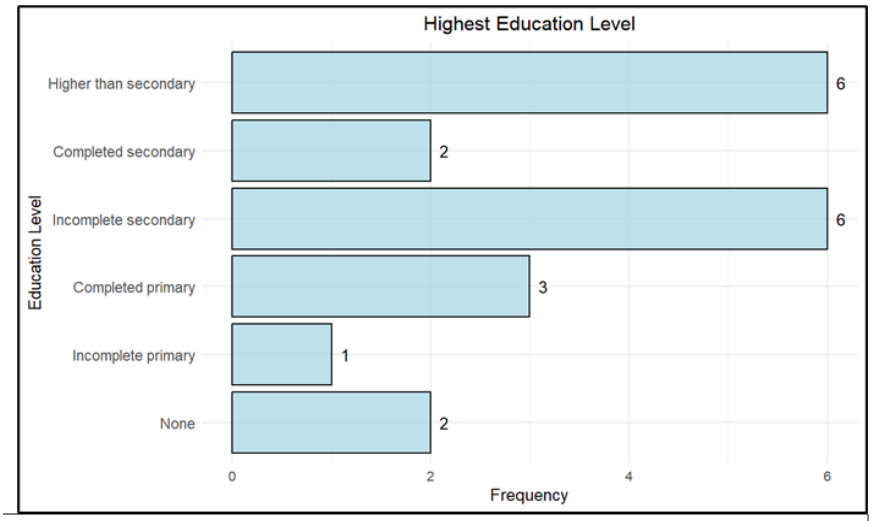
Age composition



Statistics	Female	Male
Min	29	29
25th	31	50
50th	35	55
mean	39	55
75th	48	66
Max	50	69

The statistics above present the distribution of ages for both females and males for the registered participants in Kigulu. Each statistic represents a specific percentile of the data: the minimum age observed is 29 for both genders, the 25th percentile is 31 for females and 50 for males, the median (50th percentile) age is 35 for females and 55 for males, the mean age is 39 for females and 55 for males, the 75th percentile age is 48 for females and 66 for males, and the maximum age observed is 50 for females and 69 for males. These statistics give insights into the age distribution of the sampled population, highlighting differences between females and males at various percentiles. It's noted that the males generally were older than the females registered in the study. There is a statistical significance between the age of females and males. This further suggests that the men involved in the study were of advanced age compared to the females. Since females are always involved in the day-to-day cooking activities, they were

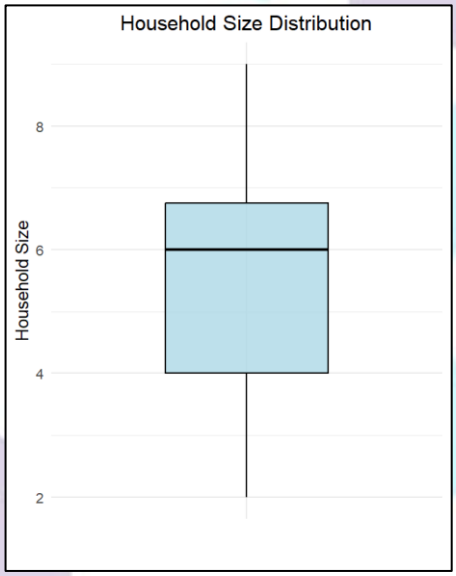
motivated to be part of study to try out the new technologies that would simplify their cooking needs to be able to do other activities outside the kitchen.



Education level	*Gender*	*Count*
None	Female	1
	Male	1
Incomplete primary	Female	1
	Male	0
Completed primary	Female	3
	Male	0
Incomplete secondary	Female	2
	Male	4
Completed secondary	Female	2
	Male	0
Higher than secondary	Female	3
	Male	3

The chart shows the educational attainment for the participants, categorized into various levels: none, incomplete primary, completed primary, incomplete secondary, completed secondary, and higher than secondary. The figures represent the number of individuals falling into each category, with 2 having no formal education, 1 having an incomplete primary education, 3 having completed primary education, 6 having incomplete secondary education, 2 having completed secondary education, and 6 having educational levels higher than secondary. This summary offers insights into the educational background of the group, illustrating the distribution across different levels of education.

The table breaks down the education level by gender showing the comparison of male and female participants across different Education levels.



The box plot shows the distribution of household sizes within the sample group. With a median household size of 6 and a mean of 5.85, The interquartile range (IQR) spans from 4 to 6, showing that most households are of that size. However, the presence of outliers, including households with sizes of 2, 3, and 9, as indicated by the whiskers of the box plot. While the most common household sizes appear to be between 4 and 6 members. It's noted that on average, 2 people perform the cooking in the different households. This suggests that these were mostly nuclear families but also some of the household members like school going children were always at school.

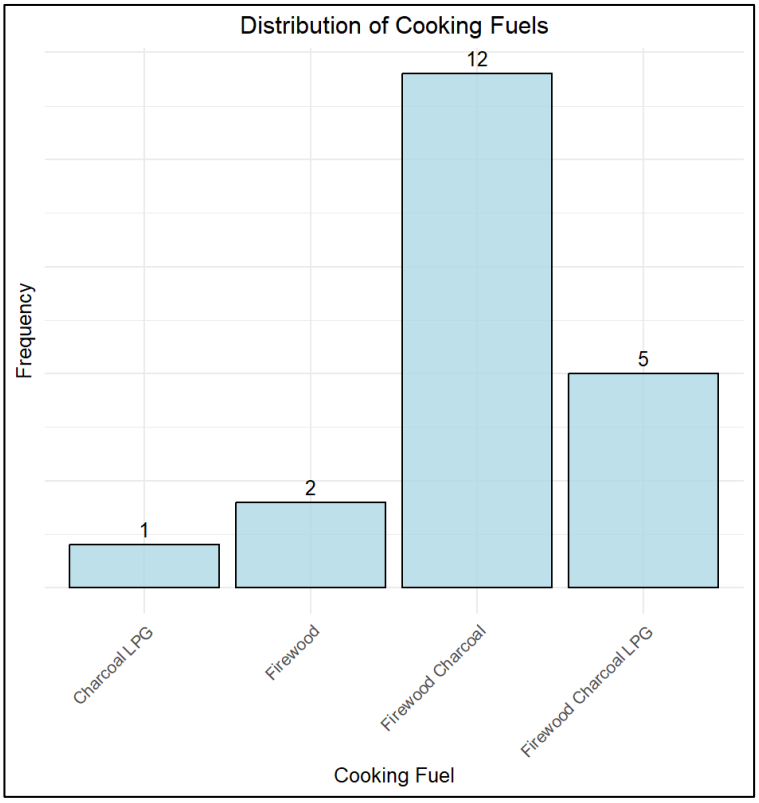
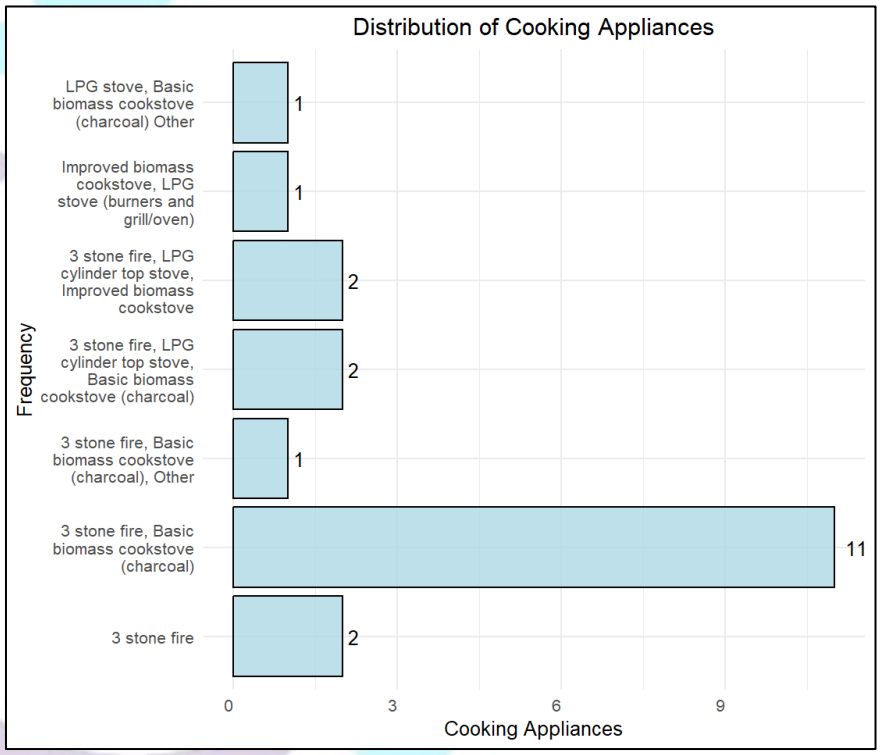


Figure shows the distribution of cooking fuels used before the study commenced. 60% of the participants used a combination of charcoal and firewood. Whereas the minority used a combination of charcoal and LPG. It's noticeable that all the participants practiced fuel stacking before the project was introduced to them. Charcoal and firewood fuels are easily accessible. Some have got shambas and most of them are practicing agro-forestry where they are getting wood fuel but also charcoal and firewood are cheap and easy to access and acquire.

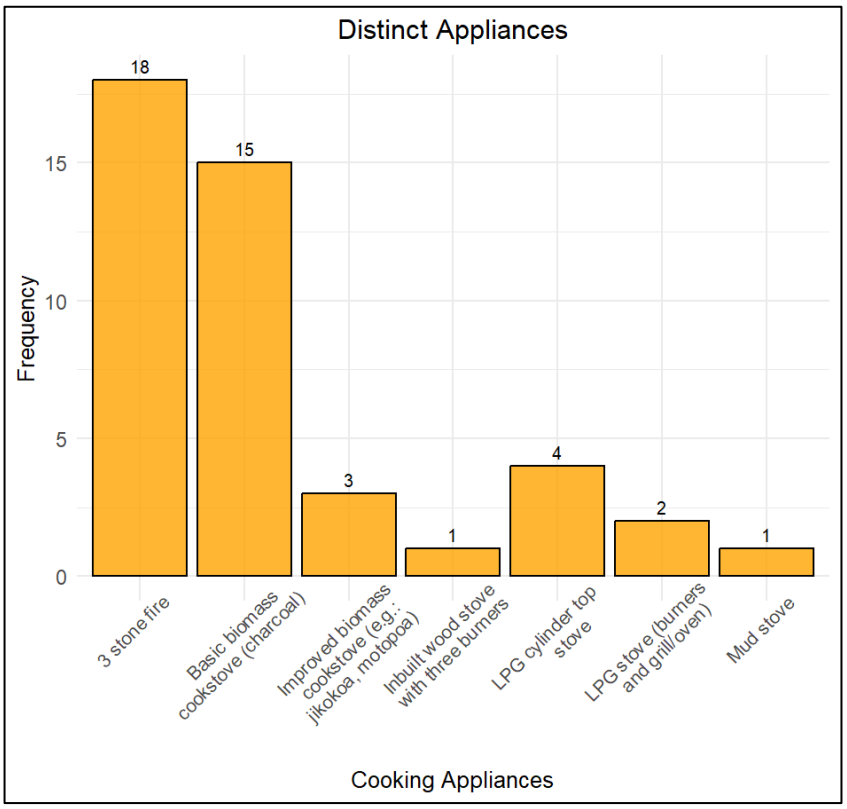
People who are using LPGs use it for convenience purposes because it can get food ready very fast and conveniently, especially for breakfast. For people with small household numbers, they embraced LPGs because the quantity of food required for preparation was little. The essence of having charcoal and LPG is that in cases where food needs to be roasted before cooking would first be subjected to charcoal roasting. Foods that also take a long time to get ready like beans were preferred to be prepared using charcoal or firewood therefore making it a preferred fuel.



From the figure above it's noted that a combination of firewood and charcoal is the most used. A fuel of choice usually determines which appliances the household shall use. It's noticed most households used a combination of a 3 stone fire and a basic charcoal cookstove. The 3 stone fire and the baseline charcoal stove were used in combination because of their affordability (they are cheap to buy). The fuels used in both technologies are also affordable, easy to acquire and reliable.

A combination of other appliances which ranked number 2 were used because of their availability, accessibility, reliability, and convenience (LPG).

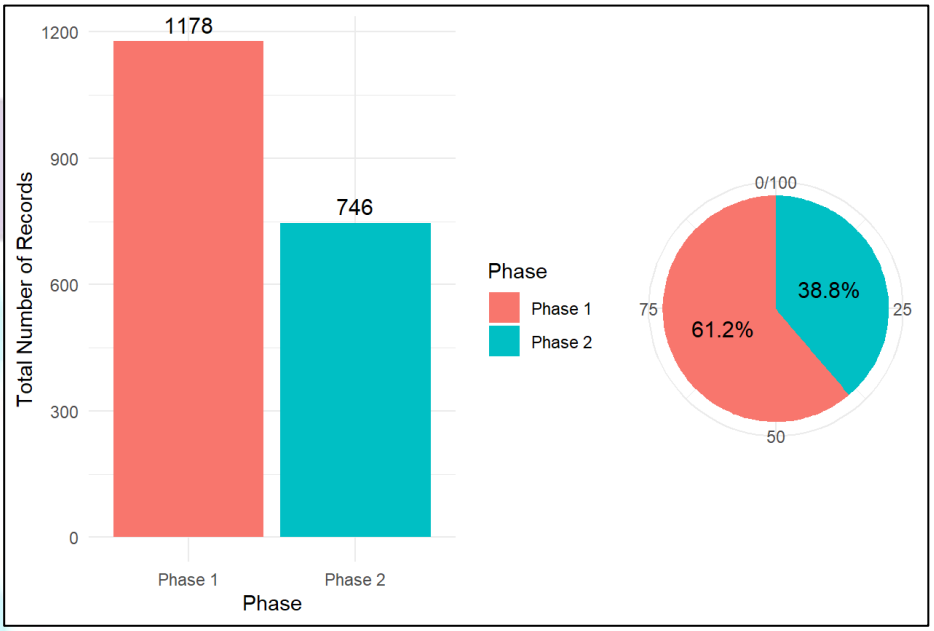
The chart shows the distinct appliances used and it's noted that the 3 stone fire is the most used appliance. The 3 stone fire was mostly used because the community was rural and found that the technology is cheap and convenient to use to them. The fuel used is also easily accessible. Basic biomass stove technologies are cheap, and charcoal fuel can easily be accessed and it's easy to operate. The LPG technology was used because of the essence of fast foods for breakfast and people that stay alone since it is convenient to them. Improved biomass was used because of the fuel saving, and ability to retain heat that can be used for steaming purposes.



Overview of the data

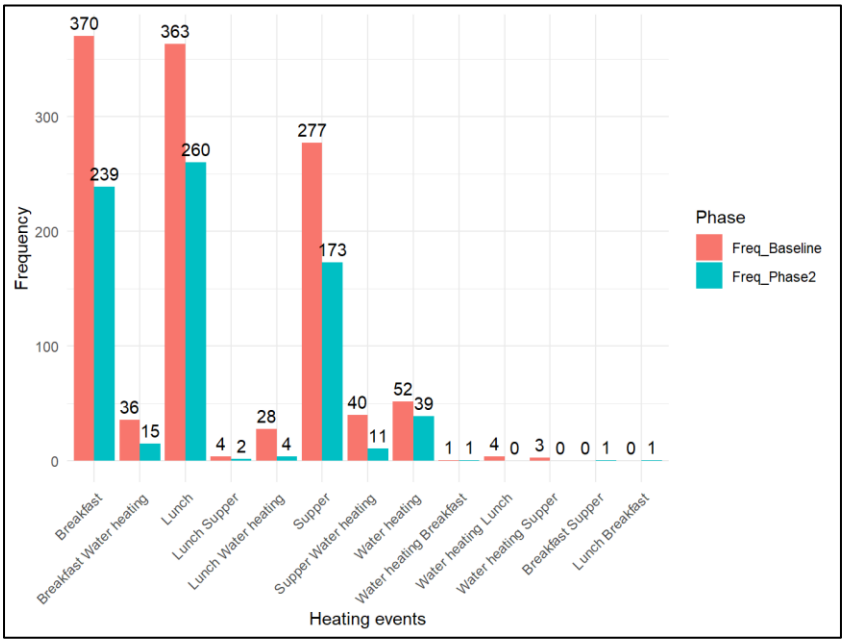
Total records for phase 1 and 2

There is a drop in the number of records by 22.4%. Phase one had 1178 cooking diary records while phase two had 746 cooking diary records. There was a honeymoon period where participants were very excited about the study, and they would cook multiple dishes to understand how much fuel it takes for them to cook different dishes. With the introduction of the cooking appliance, most participants were afraid of cooking multiple dishes because they were still learning how the technology works but there were also myths about food cooked with electricity never being tasty hence cooking fewer dishes using EPCs. The availability of only one pot also restricted members from being able to cook different dishes. After gaining steady state within the first two weeks, users gained familiarity with the appliance leading to a reduction in the multiple dishes that would be prepared because of



rational decisions. (Basing on culture limitations, improved technology vs the new technology they are not familiar with.)

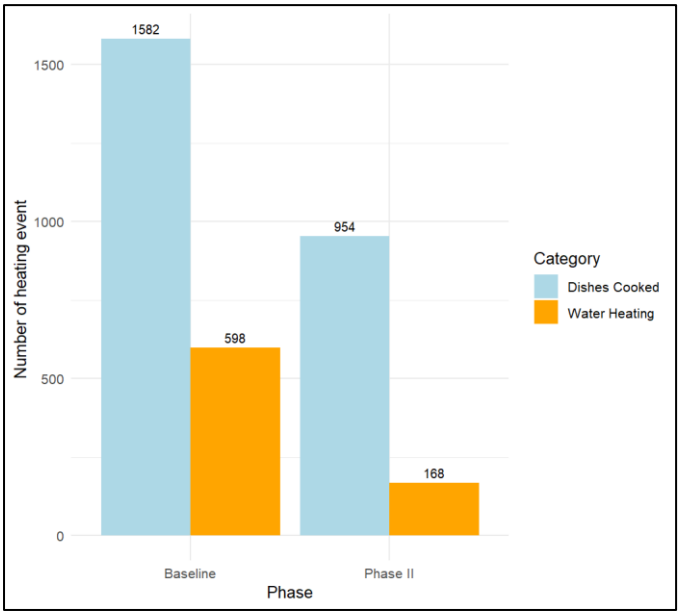
Purpose of heating



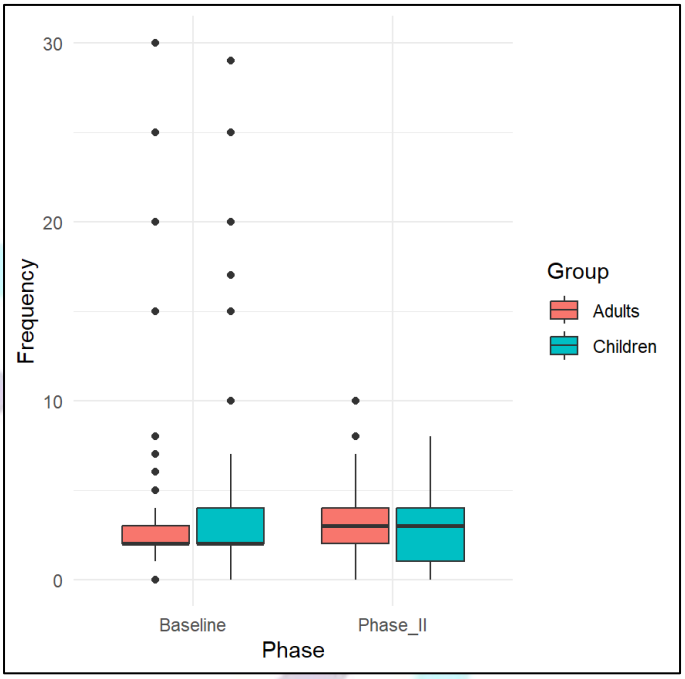
It was noticed that for the single meals, which include breakfast, lunch and supper, they were mostly cooked independently. However, on a smaller scale for both phases, batch cooking was realized especially when water was boiled alongside preparing lunch.

Participants are always interested in eating fresh food to care more about their health. The meals across phases one and two show a high degree of consistency as depicted in the graph suggesting that participants were able to incorporate the EPCs into cooking according to their usual menus.

Purpose of heating event



Dishes cooked from baseline phase to phase two reduced. Dishes cooked from the baseline study dropped by 25% from 1582 to 954. Water heating from baseline phase one to phase two reduced by 56% from 598 to 168. Due to the safety aspects, most participants would be hesitant to cook dishes that they are not sure are compatible with the EPCs. For example, froth foods like Gnuts for fear of foaming and getting into contact with the electronics. Another reason for this decline could be convenience in food preparation for example, if a participant wanted to cook traditionally steamed matooke, the EPC might not be their go-to appliance, thus reducing the dishes prepared but since participants were encouraged to use electricity as much as possible, therefore they preferred to cook simpler and fewer meals which reduced on the traditional ways to maximize the EPC usability

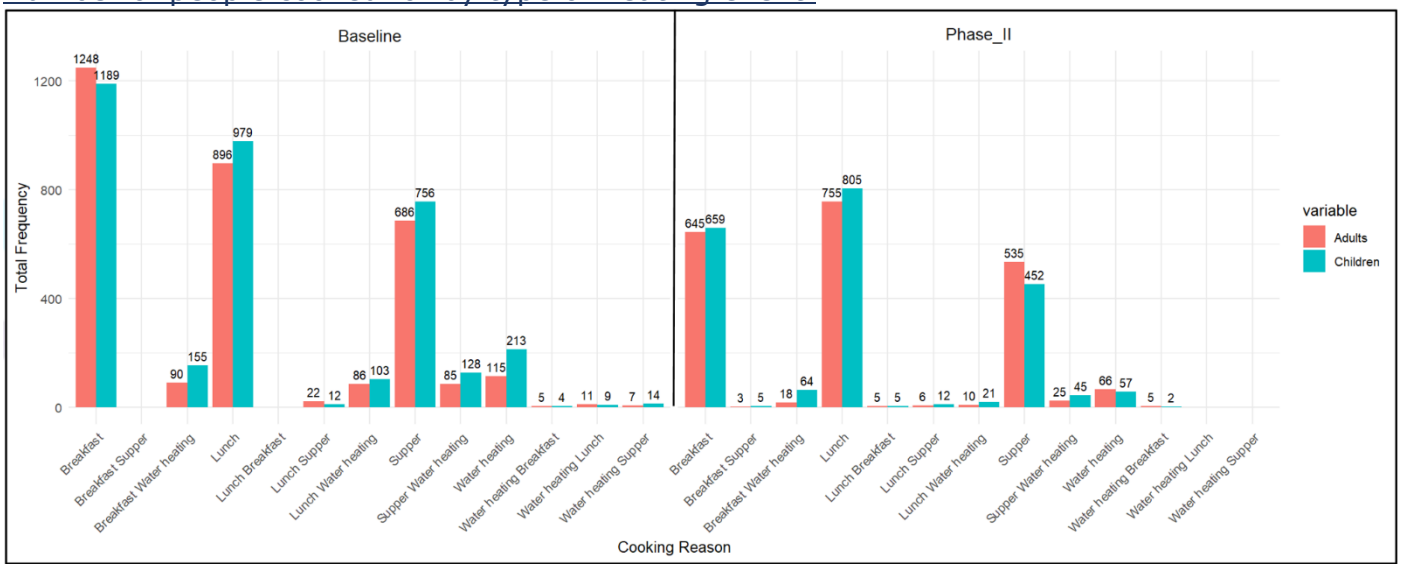


Number of people cooked for

The box plot shows the number of adults and children cooked for in the different phases.

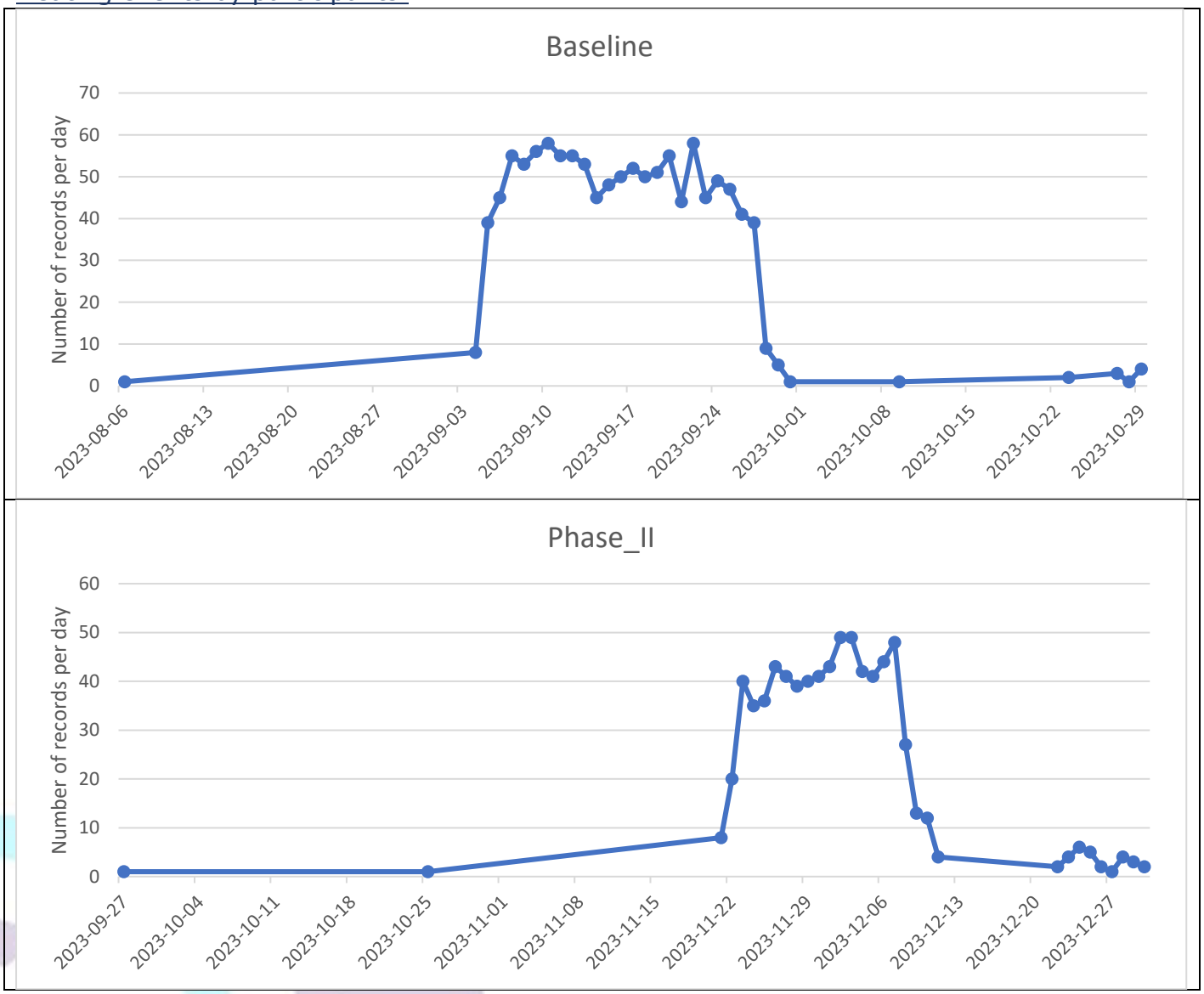
It is noted that in the baseline study, fewer adults on average were available for the different phases. The median for the baseline was 2 and for phase two the median changed to 3. During the baseline study, the adults were not at home so they would entrust their baseline technology with the children or house helps and had little to no worries on the safety of the cooking technologies. During phase two the adults would find it easier to have meals while at home because the eCooking appliance would take the shortest time to get meals ready as it would be convenient for them. The adults would not be comfortable letting children operate these appliances without their supervision for safety reasons so they would ensure that they were around to monitor the cooking activities.

Number of people cooked for by type of heating event.



Across the different phases, it is noticed that breakfast, lunch and supper are the most important meals for the different families. In both phases batch cooking is noticed but on a smaller scale. During the baseline study, breakfast is prepared more than any other meals however in the second phase after introduction of the EPCs, lunch is the most preferred meal.

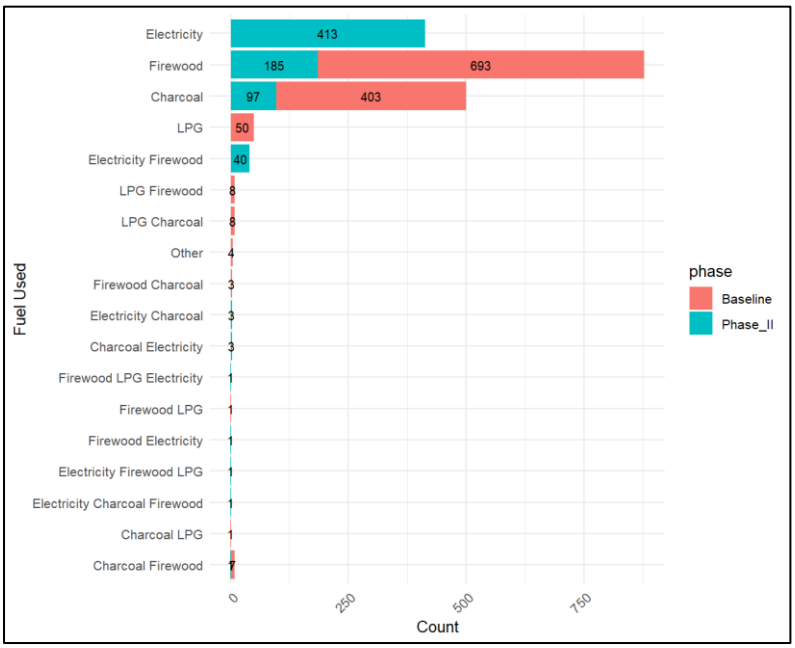
Heating events by participants.



The data provided shows the cooking behavior of a participant across two phases: Phase II and the Baseline. In both phases, the participant provided data for a similar number of days (approximately two weeks), indicating consistency in their participation. They cooked on approximately the same number of days in both phases, suggesting a consistent engagement with cooking activities over time. However, there were fluctuations in the number of records when they cooked, with some days showing higher cooking frequency than others. When comparing the trends between Phase II and the Baseline, it's evident that the participant maintained a relatively consistent cooking habit throughout both periods. While there were fluctuations in cooking frequency in both phases, it appears that the participant cooked slightly more frequently during Phase II compared to the Baseline. This suggests a potential positive impact of the eCook intervention on cooking behavior, although further analysis would be needed to confirm the significance of this difference.

Energy consumption by heating event

Fuels used.



The chart shows the fuels used in the different stages of the project. Across the phases, electricity, firewood and charcoal are the dominant fuels. However, electricity was only used in phase two after the EPC was introduced. Fuel stacking was done but on a smaller scale as seen from the graph above. Participants preferred preparing meals like matooke, fried Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin using traditional fuels. However, for meals that required boiling for longer hours like beans, simple meals like rice, participants used mostly the EPC. In phase two, charcoal usage was reduced by 75.93% and firewood reduced by 73.30% as seen from the table below. This implies that electricity can substitute charcoal and firewood.

Fuel Used	***Baseline***	***Phase_II***	***percentage change***
Charcoal	403	97	-75.93
Charcoal Firewood	7	1	-85.71
Firewood	693	185	-73.30

During the baseline, charcoal and firewood were the primary sources of cooking energy, it is common practice for households to use these stoves daily, often multiple times a day. These fuels are typically used for all cooking needs, including boiling water, preparing meals, and heating food, making consecutive use of firewood or charcoal stoves a standard routine. However, in Phase II, the introduction of electric pressure cookers significantly reduced the usage of charcoal and firewood, as households adopted the Electric pressure cooker resulting in a decline in traditional fuel use.

Per capita energy consumption using a single fuel only in Mega-joules

To obtain the energy consumption per capital, some assumptions are taken into consideration. The energy usage per capita per dish was obtained by;

$$\frac{(F_b - F_a) * Cv}{n}$$

Where;

- 'F_b' representing the available fuel amount before cooking.
- 'F_a' representing the available fuel amount after cooking.
- 'Cv' representing the calorific value.
- 'n' representing the number of people cooked for.

Fuel	*Calorific Value*
Charcoal	30
Firewood	18
LPG	46
Kerosene	43.1
Electricity	3.6

	Baseline			**Phase_II**		
Statistic	Charcoal	Firewood	LPG	Charcoal	Firewood	Electricity
Min	0.100	0.090	0.000	0.132	0.059	0
25th percentile	2.333	3.535	0.076	2.098	3.960	0.03
Median	4.020	6.430	0.280	3.799	7.078	0.18
Mean	5.953	9.706	0.828	4.624	9.678	0.27645
75th percentile	7.205	12.321	0.977	6.000	13.614	0.35
Max	45.570	128.430	4.370	23.925	42.300	3.77
N	403	693	50	97	185	413

In comparing the energy usage between the baseline and Phase II of eCook, we can see some important changes. In the baseline, people used more charcoal and firewood for cooking compared to Phase II. Charcoal usage decreased from before, meaning people used less of it for cooking. The same happened with firewood, which also went down in usage. This is a good sign because using less charcoal and firewood is better for health and the environment. In Phase II, people started using electricity for cooking, which was not used before. Electricity usage in mega joules per capita was much lower than charcoal and firewood. This means eCook helped people to cook using cleaner energy, which is better for everyone.

In the baseline, people used a lot of charcoal and firewood for cooking. But with eCook, they started using less of these traditional fuels. This is because eCook provides an alternative way to cook using electricity, which is cleaner and safer. The data showed that people used less charcoal and firewood in Phase II compared to before. This is good news because it means people are using more sustainable energy sources for cooking. It also means they are reducing the smoke and pollution caused by burning charcoal and firewood.

While the usage of LPG (liquefied petroleum gas) stayed about the same, the big change was the introduction of electricity for cooking in Phase II. Electricity usage in MJ per capita was much lower than other fuels, which shows that eCook is helping people to cook more efficiently. Using electricity for cooking is also safer and cleaner than using charcoal or firewood. Overall, the data suggests that eCook is making a positive impact by reducing the use of traditional fuels like charcoal and firewood and promoting the use of cleaner energy sources like electricity.

Dishes cooked.

The table below describes different the dishes cooked in the baseline.

	Baseline		Phase 2		
Dish	N	%	N	%	% change
Other	152	9.63	186	20.04	10.41
Rice	183	11.60	146	15.73	4.14
Beans/Peas Stew	103	6.53	98	10.56	4.03
Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (boil or steam)	167	10.58	87	9.38	-1.21
Matooke (boiled)	116	7.35	71	7.65	0.30
Porridge	134	8.49	68	7.33	-1.16
Matooke (steamed)	73	4.63	58	6.25	1.62
Ugali (posho)	115	7.29	41	4.42	-2.87
Ground nut paste	0	0.00	36	3.88	3.88
Katogo	59	3.74	35	3.77	0.03
Goat/Meat Stew	76	4.82	23	2.48	-2.34
Eggs	20	1.27	17	1.83	0.56
Leafy Vegetables (cabbage, nakati, dodo, malakwang, gobe etc)	75	4.75	17	1.83	-2.92
Fish Stew	40	2.53	12	1.29	-1.24
Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (boil and fry)	13	0.82	8	0.86	0.04
Spaghetti (pasta)	26	1.65	7	0.75	-0.89
Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (fried or deep fried)	39	2.47	7	0.75	-1.72
Chicken stew	12	0.76	5	0.54	-0.22
Chapati	5	0.32	2	0.22	-0.10
Millet cassava mix bread (Karo)	6	0.38	2	0.22	-0.16
Fish in groundnut stew	0	0.00	2	0.22	0.22
Chicken fried	1	0.06	0	0.00	-0.06

Egg plants	8	0.51	0	0.00	-0.51
Egg plants in ground nut	1	0.06	0	0.00	-0.06
Fried fish	1	0.06	0	0.00	-0.06
Ground nut pasta	16	1.01	0	0.00	-1.01
Ground nut paste/sauce	64	4.06	0	0.00	-4.06
Katunkuma	1	0.06	0	0.00	-0.06
Liver	1	0.06	0	0.00	-0.06
Maize	1	0.06	0	0.00	-0.06
Mandazi	1	0.06	0	0.00	-0.06
Milk	33	2.09	0	0.00	-2.09
Silver fish (mukene)	24	1.52	0	0.00	-1.52
Tea	9	0.57	0	0.00	-0.57
Tomato soup	3	0.19	0	0.00	-0.19

To analyze the change in cooking practices between the Baseline and Phase II, we first counted the number of times each dish was prepared and expressed it as a percentage of all dish records. In Phase II, there was an increase in the percentage of dishes such as "Other," "Rice," "Beans/Peas Stew," and "Ground nut paste". This indicated that these dishes were cooked more frequently during Phase II compared to the Baseline. Conversely, dishes like "Ugali (posho)" and "Porridge" were prepared less often during Phase II. Overall, the most commonly cooked foods during Phase II were "Rice," "Beans/Peas Stew," and "Other."

Note: *For both phases, "other" was composed of mainly "Tea" and "Milk" however, it also contained foods like groundnuts mixed with potatoes, egg plants, matooke in groundnuts, sliver fish (Mukene) and chapati.*

When analyzing the change in cooking practices due to eCook, we observed that dishes like "Rice" and "Beans/Peas Stew" were cooked more often when using electricity, suggesting that participants may have found it more convenient to prepare these dishes with electric cooking appliances. Conversely, traditional dishes like "Ugali (posho)" were less frequently prepared during Phase II, possibly indicating a shift away from traditional cooking methods.

Next, we examined the most common dishes prepared for each meal (breakfast, lunch, and dinner) and expressed them as percentages. In Phase II, "Rice" and "Beans/Peas Stew" remained popular across all meals, indicating their versatility and preference among participants. However, there were variations in the frequency of other dishes between meals. For example, "Matooke (boiled)" was more commonly prepared for dinner, while "Porridge" was more popular for breakfast.

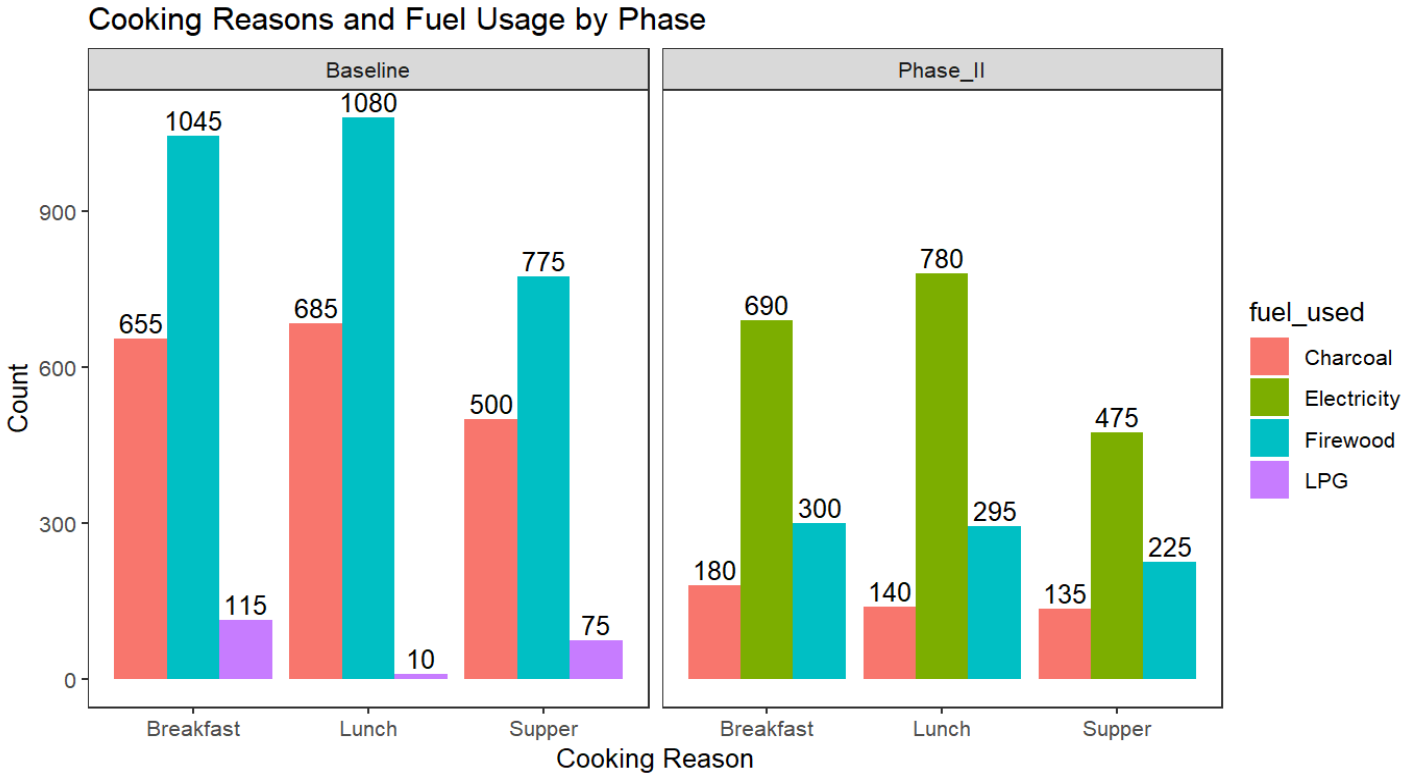
The introduction of eCook seemed to have influenced cooking practices by making certain dishes more accessible or convenient to prepare with electric cooking appliances. Dishes like "Rice" and "Beans/Peas Stew" were cooked more often during Phase II, possibly due to the efficiency and ease of using electric cooking methods for these dishes. Conversely, traditional dishes like "Ugali (posho)" saw a decrease in frequency, suggesting a shift towards more modern cooking practices facilitated by eCook technology.

		Baseline		Phase_II		
	Dish	Count	Percentage	Count	Percentage	percentage change
Breakfast	Other	39	9%	160	11%	2%
	Porridge	32	8%	112	8%	0%
	Matooke (boiled)	17	4%	32	2%	-2%
	Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (boil or steam)	11	3%	35	2%	0%
	Rice	2	0%	35	2%	2%
	Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (fried or deep fried)	21	5%	5	0%	-5%
	Eggs	7	2%	13	1%	-1%
	Beans/Peas Stew	0	0%	15	1%	1%
	Katogo	1	0%	14	1%	1%
	Matooke (steamed)	1	0%	13	1%	1%
Lunch	Rice	53	13%	113	8%	-5%
	Beans/Peas Stew	17	4%	109	8%	3%
	Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (boil or steam)	11	3%	113	8%	5%
	Ugali (posho)	27	7%	57	4%	-3%
	Matooke (steamed)	11	3%	68	5%	2%
	Matooke (boiled)	12	3%	55	4%	1%
	Other	6	1%	45	3%	2%
	Leafy Vegetables (cabbage, nakati, dodo, malakwang, gobe etc)	21	5%	29	2%	-3%
	Goat/Meat Stew	11	3%	35	2%	0%
	Katogo	9	2%	36	2%	0%
Supper	Rice	26	6%	74	5%	-1%
	Matooke (boiled)	13	3%	41	3%	0%
	Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (boil or steam)	13	3%	40	3%	0%
	Other	14	3%	38	3%	-1%
	Ugali (posho)	8	2%	39	3%	1%
	Beans/Peas Stew	6	1%	38	3%	1%
	Goat/Meat Stew	10	2%	20	1%	-1%
	Katogo	5	1%	25	2%	1%
	Matooke (steamed)	4	1%	26	2%	1%
	Ground nut paste/sauce	7	2%	14	1%	-1%

Dishes cooked using different fuels (top 20 most cooked meals)

Fuel	Dish	Baseline		Phase_II		percentage change
		Count	Percentage	Count	Percentage	
Charcoal	Rice	87	8.22%	22	4.07%	-4%
	Other	62	5.86%	34	6.30%	0%
	Porridge	43	4.06%	4	0.74%	-3%
	Ugali (posho)	40	3.78%	10	1.85%	-2%
	Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (boil or steam)	37	3.50%	6	1.11%	-2%
Electricity	Other	0	0.00%	98	18.15%	18%
	Rice	0	0.00%	87	16.11%	16%
	Beans/Peas Stew	0	0.00%	59	10.93%	11%
	Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (boil or steam)	0	0.00%	28	5.19%	5%
Firewood	Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (boil or steam)	126	11.91%	36	6.67%	-5%
	Beans/Peas Stew	69	6.52%	18	3.33%	-3%
	Rice	80	7.56%	20	3.70%	-4%
	Matooke (steamed)	48	4.54%	22	4.07%	0%
	Ugali (posho)	72	6.81%	11	2.04%	-5%
	Matooke (boiled)	69	6.52%	18	3.33%	-3%
	Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (boil or steam)	126	11.91%	36	6.67%	-5%
	Ugali (posho)	72	6.81%	11	2.04%	-5%
	Ground nut paste/sauce	47	4.44%	0	0.00%	-4%
	Rice	80	7.56%	20	3.70%	-4%

When comparing the number of dishes cooked per meal between Baseline and Phase II, it becomes apparent that there were shifts in cooking practices with the introduction of eCook technology. During Phase II, there was a noticeable increase in the percentage of meals where only one dish was cooked, indicating a potential trend towards simpler meal preparations. This suggests that the adoption of electric cooking appliances might have influenced participants to streamline their meal planning and preparation, possibly due to factors like convenience or cooking efficiency. A decrease in meals observed during Phase II can be attributed to the convenience and efficiency of electric cooking appliances, where participants prepared one-pot meals where ingredients and sauces are combined, such as matooke in groundnuts or groundnuts mixed with potatoes. While this suggests a trend towards simpler meals, it's also possible that some unrecorded fuel stacking occurred, where participants might have continued using traditional fuels alongside electric appliances for certain dishes, leading to an underreporting of total fuel use.

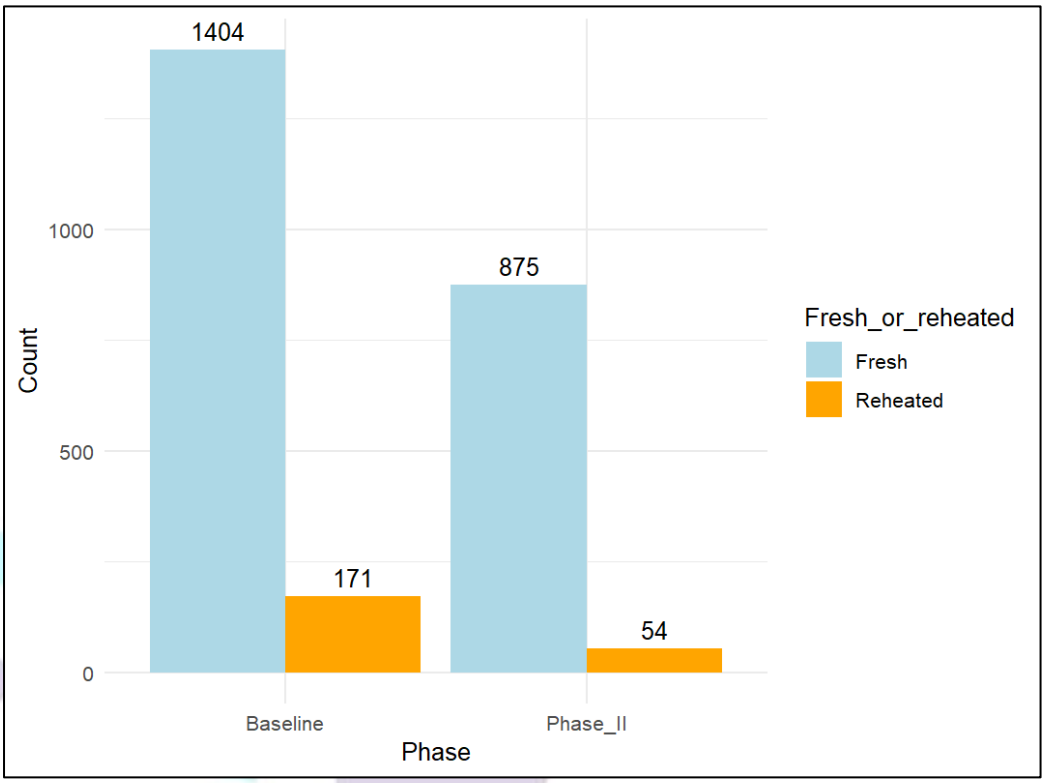


The chart reveals distinct shifts in cooking habits and fuel usage between the baseline and Phase II. Phase II shows a notable increase in the use of Electricity for Breakfast and Lunch, contrasting with Phase I where participants relied on Firewood and LPG.

Analyzing the breakdown of dishes cooked using different fuels reveals interesting insights into participants' cooking preferences and challenges. For instance, during Phase II, there was a significant increase in the number of dishes cooked using electricity compared to Baseline. Foods like "Rice," "Beans/Peas Stew," and "Other" dishes saw a notable shift towards electric cooking, indicating a preference for these foods when using electric appliances. Conversely, certain dishes like "Ground nut paste/sauce" and "Matooke (boiled)" were less commonly cooked using electricity, suggesting potential challenges or limitations associated with electric cooking for these specific foods. (foods that foam)

Furthermore, the comparison highlights dishes that posed challenges when cooked using electricity. For example, "Ground nut paste/sauce" was exclusively cooked using firewood or charcoal during Baseline, indicating that participants may have found it difficult to prepare this dish using electric cooking appliances. Similarly, dishes like "Matooke (steamed)" and "Ugali (posho)" showed a decrease in the percentage of meals cooked with electricity during Phase II, suggesting that these foods may require specific cooking techniques or equipment not readily available with electric cooking.

Overall, the data underscores the impact of eCook technology on cooking practices, with a shift towards simpler meal preparations and a notable preference for certain dishes when using electric appliances. While electricity offers convenience and versatility for cooking various foods, there are still challenges associated with certain dishes, highlighting the need for further exploration and adaptation of electric cooking methods.



Reheating

	Baseline		Phase_II	
	Fresh	Reheated	Fresh	Reheated
Beans/Peas Stew	67	35	84	14
Leafy Vegetables (cabbage, nakati, dodo, malakwang, gobe etc)	61	12	16	1
Matooke (boiled)	114	2	69	2
Katogo	54	5	28	7
Matooke (steamed)	65	8	57	1
Rice	168	15	141	5
Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin (boil or steam)	160	7	85	2

In the baseline and Phase II, the frequency of fresh and reheated meals for each dish was examined. During Phase II, there was an increase in the number of times certain dishes were served fresh, such as "Beans/Peas Stew," "Matooke (boiled)," and "Rice." This suggests that participants may have been more inclined to prepare these dishes freshly with the introduction of eCook technology. Conversely, dishes like "Leafy Vegetables" and "Katogo" saw a decrease in the number of fresh servings during Phase II, indicating a potential shift towards reheating meals or preparing them in advance.

The comparison also revealed insights into the impact of eCook on the ability to prepare food for later consumption. While some dishes showed an increase in fresh servings during Phase II, others, such as "Sweet potatoes/ irish potatoes/ cassava/ yams/ pumpkin," exhibited a decrease in fresh servings.

When examining reheating practices across all dishes, it becomes evident that reheating was more common during Phase I compared to Phase II. This trend was particularly notable for dishes like "Beans/Peas Stew" and "Katogo," indicating that these foods were frequently prepared in advance and reheated for consumption. Conversely, dishes like "Matooke (steamed)" and "Rice" were less commonly reheated, suggesting that participants may have preferred to prepare these dishes fresh during Phase II.

Interviews

Intake interviews

Through a series of interviews, we gained valuable insights into the cooking habits, preferences, and challenges faced by participants in our study. Across all interviews, a strong appreciation for traditional foods emerged, with staples like rice, cassava, matooke, and sweet potatoes being favored for their accessibility, taste, and cultural significance. Participants emphasized the importance of meticulous planning, considering factors such as time, cost, convenience, and sharing meals with loved ones in their cooking routine.

Fuel choice played a significant role in cooking practices, with participants primarily using firewood for its affordability and accessibility, despite concerns about smoke and health implications. Some expressed interest in adopting modern cooking appliances like pressure cookers and solar-powered devices to enhance efficiency and mitigate challenges associated with traditional methods. However, challenges in fuel procurement, such as cost and availability, were noted, highlighting the need for practical solutions to improve cooking experiences.

Overall, these interviews provided valuable insights into the dynamics of cooking in households, reflecting broader challenges and aspirations related to food preparation, resource management, and environmental sustainability. The participants' experiences underscored the importance of tradition, innovation, and practicality in shaping cooking practices, enriching our understanding of culinary habits within the community.

Midline interviews

The participants' experiences with e-cooking varied, but overall, they expressed satisfaction with the convenience and efficiency of the Power Station and electric cooking appliances. Many participants reported cooking a variety of foods using the Electric Pressure Cooker (EPC), including staple dishes like rice, beans, cassava, and meat. Some participants also experimented with other dishes such as 'katogo,' a Ugandan dish combining cassava and beans, and 'matooke' with groundnut paste. These dishes were chosen for their cultural significance and were successfully prepared using the EPC, yielding satisfactory results.

Likes and dislikes regarding e-cooking were commonly mentioned by participants, providing insight into their overall satisfaction and areas for improvement. Many participants appreciated the speed and ease of cooking with the EPC, noting that meals were prepared faster compared to traditional methods. They also highlighted the improved taste and cleanliness of food cooked with e-cooking appliances, attributing this to the sealed cooking environment and precise temperature control. Additionally, participants welcomed the reduction in fuel expenditure and the ability to cook without relying on firewood or charcoal.

However, some participants expressed concerns or dislikes related to the Power Station and electric cooking appliances. One recurring issue was the size and portability of the Power Station, with participants finding it bulky and difficult to transport. Weather-related challenges, such as the impact of rain on charging performance, were also mentioned, highlighting the need for improved resilience and weatherproofing. Additionally, some participants encountered minor mishaps or technical issues during their initial usage of the appliances, such as difficulty finding the right cooking settings or experiencing malfunctions with certain buttons. Despite these challenges, participants generally remained optimistic

about the potential of e-cooking to improve their daily lives and expressed eagerness to continue using the technology.

Overall, participants' experiences with e-cooking reflected a mixture of satisfaction with its benefits and challenges associated with its implementation. The variety of foods cooked, coupled with positive feedback on taste and efficiency, underscored the potential of e-cooking to revolutionize traditional cooking practices. However, addressing concerns related to appliance design, functionality, and performance in adverse conditions will be crucial for enhancing user experience and promoting widespread adoption of e-cooking technologies.

Co-creation Workshops

The interviews provide valuable insights into the perceptions and experiences of users regarding electric cooking (E-cooking) practices. Users generally appreciate the convenience, time-saving nature, and environmental benefits associated with E-cooking. However, concerns about dependency on electricity, technical issues, and product limitations underscore the need for further refinement and improvement in E-cooking technologies. Emphasizing usability, reliability, and sustainability can enhance the overall user experience and foster wider adoption of E-cooking methods.

Among the likes, users’ express admiration for the convenience and time-saving attributes of E-cooking, highlighting its efficiency in meal preparation and the ability to multitask. Additionally, they appreciate the cleanliness, energy efficiency, and safety associated with electric cooking appliances. Versatility in cooking various dishes quickly, easy operation, and the preservation of food nutrients are also cited as positive aspects of E-cooking.

Despite the benefits, users raise concerns about dependency on electricity, perceived addiction to electric cooking, and challenges in planning and managing cooking activities. Technical issues such as noise, charging time, and usability, as well as limitations in capacity and functionality, are also mentioned as drawbacks. Moreover, some users express dissatisfaction with the ongoing costs and maintenance requirements associated with E-cooking appliances.

Advantages of E-cooking include time-saving meal preparation, environmental benefits such as reduced emissions and resource conservation, and convenience in multitasking while cooking. E-cooking is also praised for its energy efficiency, safety features, and ability to preserve food nutrients. Moreover, users appreciate the versatility of electric cooking appliances and their role in enhancing the overall meal preparation experience.

Disadvantages of E-cooking include dependency on electricity, which poses limitations during power outages, and concerns about ongoing costs and technical reliability. Users also cite issues such as space constraints, noise, and product limitations, indicating a need for improvement in product design and functionality. Additionally, some users express dissatisfaction with the perceived addiction to electric cooking and challenges in planning and managing cooking activities.

Endline Interviews

The endline interviews provided comprehensive insights into participants' experiences with Electric Pressure Cookers (EPCs) and PowerHub appliances, encompassing their likes, dislikes,

feedback, common questions, cost analysis, challenges, key insights, overall impact, and user satisfaction, as well as the appliances' impact on routines.

Participants expressed appreciation for the EPCs' ease of use, time-saving features, cleanliness, and financial savings. They particularly liked the appliances' ability to multitask, maintain food taste and nutrients, and simplify cooking routines. However, dislikes were noted, notably the small size of the saucepan, limiting cooking capacity, especially for larger families.

Feedback from participants was largely positive, with expressions of gratitude for the study's benefits. However, some participants highlighted challenges such as the lengthy interview process and uncertainty about the fate of the appliances post-study. Suggestions for improvement included reducing interview questions and extending the project to more households.

Common questions revolved around the cost of the appliances, their market availability, and the possibility of keeping them after the study. Participants also inquired about expanding the project to include additional appliances and connecting other electric devices to the system.

A cost analysis revealed varying price ranges for the appliances, reflecting participants' willingness to pay and preferred payment modes. Participants' willingness to pay ranged from as low as 300,000 UGX to as high as 8,000,000 UGX. Payment preferences varied, with some preferring cash payments (one-time or monthly) and others preferring installments.

Challenges included technical issues, power shortages, and the need for larger capacities. Nonetheless, key insights highlighted the appliances' positive impact on routines, including time and effort savings, improved cooking experiences, and enhanced financial management.

Overall, participants expressed high satisfaction with the appliances, emphasizing their convenience, efficiency, and cost-effectiveness. The appliances significantly transformed participants' cooking routines, offering benefits such as reduced cooking times, cleaner cooking areas, and enhanced food quality.

Conclusion

The introduction of DC power hubs and EPCs has the potential to transform cooking practices in off-grid communities, promoting cleaner and more efficient cooking methods. While traditional fuels remain prevalent due to their accessibility and cost, there is a clear inclination towards modern cooking technologies. With targeted interventions and support, the transition to electricity-based cooking can be accelerated, leading to significant health, environmental, and economic benefits.

Some of the insights form the study include:

- **Fuel Stacking and Preferences**: Despite introducing EPCs, fuel stacking remains prevalent due to the availability and affordability of traditional fuels like charcoal and firewood. LPG is preferred for its convenience but is not widely adopted due to higher initial costs.

- **Electric Cooking Adoption**: The increase in electricity usage for cooking suggests a positive reception towards electric cooking technologies. The convenience and efficiency of EPCs are evident, but the transition is gradual.
- **Environmental and Health Benefits**: Reduced reliance on charcoal and firewood can lead to improved air quality and reduced deforestation, benefiting both health and the environment.

Some of the recommendations from the study include.

- **Enhance Accessibility to Electric Cooking Technologies**: Increase the availability and affordability of EPCs and other electric cooking appliances. Subsidies or financial support could help lower the initial investment barrier.
- **Education and Training**: Conduct ongoing education and training programs to familiarize households with electric cooking appliances and promote their benefits. This can enhance adoption and proper usage.
- **Incentivize Clean Fuel Use**: Provide incentives for households to use cleaner fuels and technologies. This could include discounts on electricity or LPG, or rewards for consistent use of electric cooking appliances.
- **Supportive Infrastructure**: Improve the reliability of the power grid and expand off-grid solutions like solar power systems to ensure consistent electricity supply for cooking.
- **Monitor and Evaluate**: Continuously monitor the adoption of electric cooking technologies and assess their impact on fuel consumption, cooking practices, and household well-being. Feedback from participants should guide future interventions.

Appendix

Table showing the enumerators that participated in the project

Name	**Roles**
Nathan Kayeera	Project technician
Claire Turyahebwa	Enumerator
Janney Nabanoba	Enumerator
Ronald Ndyamuhaki	Enumerator
Alvin Araka	Enumerator
Daphine Akankwatsa	Enumerator