MECS Modern Energy Cooking Services

Sustainable Energy Services Organization

Final Report for Managing Testing and Piloting the Dc-Crest Powerhubs in Tanzania

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MECS Modern Energy Cooking Services

Loughborough University

ESMAP Energy Sector Management Assistance Program

Executive Summary

The project assessed and piloted DC Powerhubs systems developed by the CREST to support full-day cooking in off-grid areas of Tanzania. The DC pilot study was conducted at Kazimzumbwi ward, Kisarawe District, Coastal Region in Tanzania. This study aimed to test the viability of energy storage to enable households in off-grid areas to cook with electricity.

In this study, the quantitative and qualitative data were collected through different activities. Three approaches are used to gather data during this field trial including the cooking diaries, a Data Acquisition (DAQ) system, and a living lab. The cooking diaries enable households to record their cooking practices and can evaluate the compatibility of the eCooking Power Stations with the way each household cooks. The DAQ system enabled the monitoring of system performance and usage patterns by sensing, recording, and transmitting a range of technical parameters.

The living lab aimed to set up a platform for co-creation that can empower participants to co-design the eCooking services they aspire to use. The living lab for this study was modified to fit the targeted group. For instance, the mobile research, specifically the participant's WhatsApp group discussion was replaced with the normal group discussions which were conducted weekly. The workshops and interview protocols were slightly improved to ensure interactive and fruitful sessions during project implementation.

The project had two sections, and this report captures the findings for both, the logistics, and the research part of the project. The report explains each methodology applied and findings to ensure a successful study, and quality data acquisition throughout the study period.

The report recommends the improvements that need to be considered for future related studies and suggests the possible next steps for the Powerhub to ensure sustainability. The market development of the system is one of the areas recommended to work on starting with cost establishments.

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1. Introduction

The DC Powerhub project was designed to assess and pilot the DC Powerhub systems developed by the CREST with anticipation to support full-day cooking in off-grid areas. The DC Powerhubs are designed to be charged by solar PV which produces electricity to power the DC appliances through the storage battery. This field trial aimed to test the viability of energy storage to enable households in off-grid areas to cook with electricity.

The project was divided into two main components. These are logistics and research. The logistics component consisted of activities of handling, receiving, testing, installation, and maintenance of the system. During the introduction of the project, the cooking devices i.e. the rice cookers and hot plates to be used in the study raised concern about the small size/volume in comparison to the family size and eating habits of rural people. Participants' concerns were worked out, where larger and more efficient devices were sourced. The DC Electric pressure cookers were designed to serve the purpose, which led to the upgrading of the system and as a result, delays were inevitable.

The research component consisted of activities of the Powerhub study including, recruiting, training, and supporting households to take part in the assessment. To capture both quantitative and qualitative data various methodologies and interactive activities with participants were designed. For quantitative data, two major methodologies were used which are the cooking diaries studies and a Data Acquisition (DAQ) system. On the other hand, qualitative data, the workshops, intake and exit surveys/interviews, as well as weekly group discussions were used.

2. Pilot Description

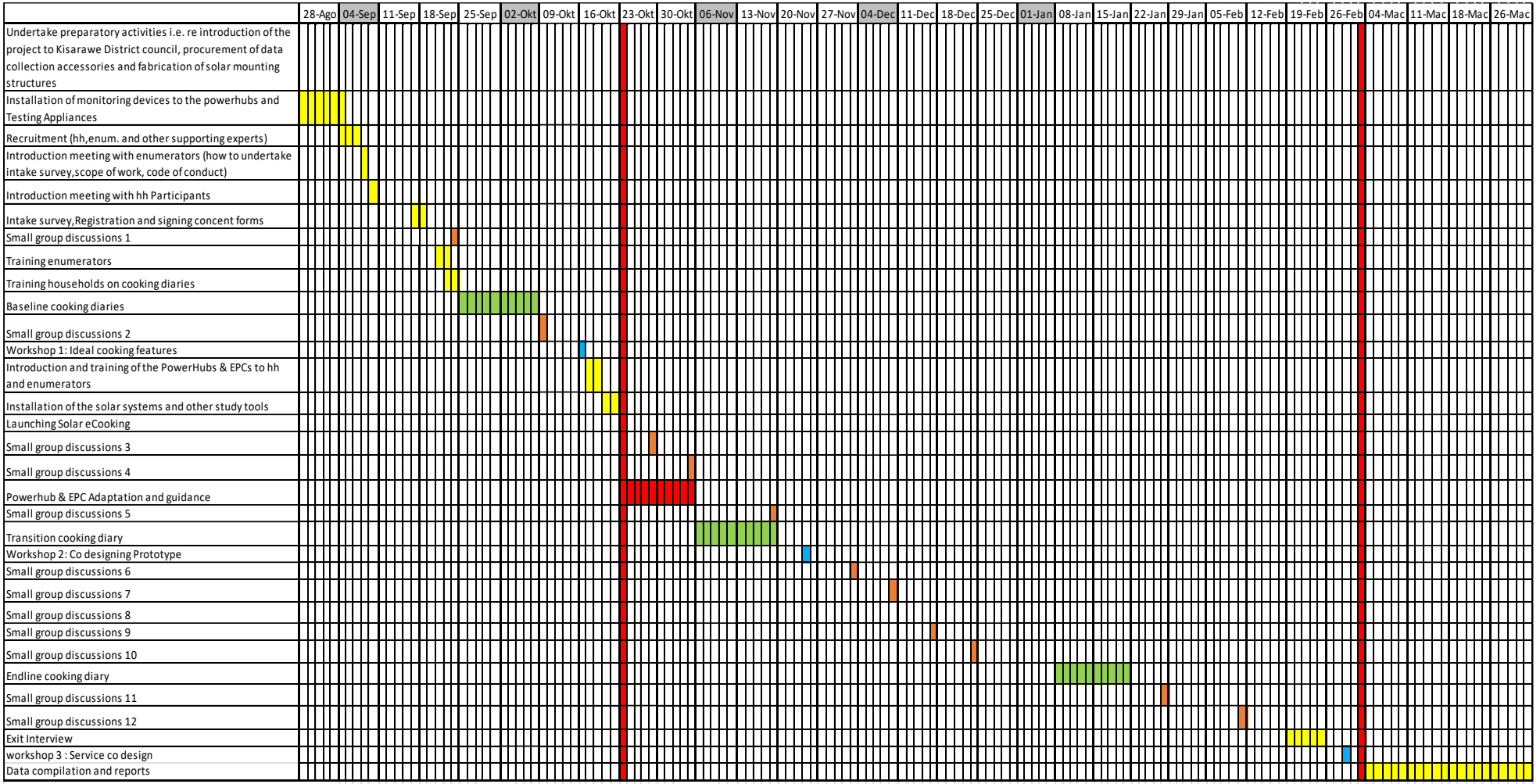
This study was implemented at Kazimzumbwi ward, Kisarawe District, Coastal Region in Tanzania with twenty (20) households selected to test the systems. Various activities were carried out including the Initial preparations which involved undertaking tests of the Powerhubs with EPCs, recruiting the households and enumerators, training enumerators and households on key issues related to the study, distribution, and installation of the study equipment. The details of implemented activities are described in the following respective sections.

2.1. Timeline

This project was designed to be implemented on the contractual agreeable time, which was 8 months. Since many issues emerged related to logistics in delivering the project study

equipment and upgrading the study devices, the timelines for the project had to change and the alterations that happened were communicated to MECs. The latest implementation plan for the project which was reviewed after receiving permission from MECS is shown below.

Figure 1: DC Powerhubs' latest implementation plan.



2.2. Participants and Enumerators

Through the assistance of District, ward, and village government officials, participating households were randomly selected in one village that is not connected to the national grid. The MECS UK team guided how to identify suitable candidates as participating households in the research by sharing the recruitment manuals for off-grid. The main criteria for selecting the households were that the households should not be connected to electricity. Other criteria which were added include, considering first the households managing to have at least two meals per day, and the safety of the house.

Selected households were well informed about the study and consent from all participants was obtained. The informed consent form provided by MECS UK was translated into Swahili and was signed by each participant. Participants were trained on quality data recording for the cooking diaries, participation in workshops, weekly group discussions, and providing required information when enumerators visit the households daily. Participants were also trained on how to use the systems (Powerhubs and appliances). Training conducted imparted knowledge to participating households on health and safety procedures and how to report faults.

Participants and enumerators receiving training from TaTEDO-SESO Facilitators

Through the guidance provided by MECs, the enumerators who met the criteria to some extent were recruited. Locating enumerators with all criteria in rural was a challenge. For instance, not all enumerators could translate the findings, most had a basic secondary

education. A total number of four (4) enumerators were sourced, near participating households, and were hired, whereby each had to monitor five (5) participating households. The organization extended the contract of the lead enumerator for the AC Powerhub study to oversee the work of enumerators. Enumerators were trained on how to use the systems, safety procedures, troubleshooting, and data collection methods.

Participating households were clustered in groups of five and each was assigned one enumerator who visited the households daily and communicated all issues such as technical faults.

2.3. Logistics and Study Equipment

The logistics part of the project involved activities such as handling, receiving, testing, installation, and maintenance of the system and study equipment. MECS UK arranged shipping of the Powerhubs from the factories in China and the TaTEDO-SESO received the equipment at the port of Dar es Salaam and cleared them through customs. Apart from the systems, other study devices received include the cooking appliances (rice cookers and hot plates) which had to be replaced with DC Electric Pressure Cookers (EPCs). This was because the rice cookers and the hot plate sizes seemed not to meet the requirements of participating households based on the portion of food they prepared per meal.

These changes demanded the upgrading of the system to be able to power the EPCs. Materials for upgrading were received, and the system upgrading was done following the guiding instructions provided by MECS. Testing of the system was done to ensure the compatibility before deploying to participants.

Technicians upgrading the systems at TEDO-SESO Facilities.

The initial plan was to install the monitoring system with sensors and a monitoring hub to communicate directly over the mobile phone network with the De Montfort University (UK) server. The effort to get the monitoring systems on time was not possible, after some delays, three DAQ systems were received and installed to three Powerhubs, and the testing was done.

Testing of the systems after installing the monitoring devices.

3. Methodology, Findings and Discussion

The following methodologies were applied during project implementation and information gathering.

3.1. Cooking Diaries

The cooking diaries collected quantitative data aimed to evaluate how well the CREST Power Stations fit the cultural cooking patterns of everyday cooks. The cooking diaries in this study have been modified to facilitate a deeper understanding of the motivations behind fuel stacking. In addition to asking what is cooked and how simply asking why participants chose the cooking device for a particular dish can offer insight into the drivers of fuel stacking. These data were collected in three phases, the baseline, transition, and end lines.

Baseline phase

The baseline cooking data were collected for two weeks at the beginning of the study, before the installation of the Powerhubs. Enumerators and participants were trained on how to collect quality data through the study. Despite the training, it required some extra efforts of one-to-one coaching to ensure quality data collection.

Transition phase.

The transition cooking diaries commenced after receiving the power stations. Data were recorded for weeks. Participants were encouraged to cook as much as possible with the Power Stations. During this period, there were heavy rains which affected the Powerhub charging. On some days, participants could cook only one dish, and Powerhub went off. This was a challenging, but good experience that provided a lesson about the behaviours of Powerhubs in different seasons.

Endline phase

The third cooking diaries took place again for the final two weeks. In this phase, the experience was different from the transition, whereby the area was experiencing sunny seasons. The project team had to encourage participants to continue cooking as much as possible with Powerhubs, instead of providing flexibility (uncontrolled behaviour) as planned, to compensate for the intensive testing which was to be done in transition.

The cooking diaries data protocol was provided to guide data collection. Participants recorded the cooking data in diaries, whereby enumerators collected and recorded into the Kobo toolbox daily. The data entered by enumerators were cleaned by lead enumerators and reviewed by the project coordinator. The cleaned data were downloaded in Excel format and uploaded into the MECS shared folder for further processing.

3.2. Data Acquisition (DAQ) system

Three Powerhubs were installed Data Acquisition (DAQ) system to record data on when the systems are being used and how much power and energy is consumed throughout the trial.

The device can record details such as how often, for how long, and at what time the Power Stations were being used.

The technician installed the devices following the guiding manual provided by MECS. After installation, the Powerhubs with devices were tested, although acquiring data from them was difficult. This was discussed with the partners from CREEC, and the issue was resolved.

Technician fixing the DAQ to the Powerhubs at TaTEDO-SESO clean cooking centre.

3.3. Interviews

The interviews were among the methodologies that were modified after the lessons of the AC Powerhub. The interviews were conducted frequently, protocols were long, and the transcriptions took long. During the DC study, the interviews conducted were reduced into two sets, the intake, and the exit surveys. This modification eliminated two sets of interviews, in which the topics were incorporated into the weekly group discussions and the workshops.

The intake interviews.

Intake interviews were conducted to collect basic demographic information to understand the current cooking practices of participating households before starting cooking data collection. Enumerators recorded the information in a form on Kobo Collect.

The exit Interview.

The exit interviews were carried out during the week after field data collection ended. This survey aimed to capture the user experience of cooking with the system and provide feedback to inform future studies.

The conversation during the interviews was recorded using enumerators' smartphones. Enumerators had to fill the data into Kobo where they were transcribed into English. The Kobo data were downloaded and uploaded to the shared folder together with the recordings.

3.4. Workshops

Three workshops were carried out throughout the study, which preceded the cooking diaries. The workshops were facilitated by TaTEDO–SESO team and enumerators. Photos and Short videos for the events were recorded using the normal camera as well as the smartphones.

The process of designing the workshop protocols was:

- The workshops were suggested by SD4MECS.
- We reviewed these and made some adjustments to make it more suitable for the Tanzanian context.
- The final versions were sent by SD4MECS.
- They were translated into Swahili.
- Review was done again with MECS representative to redesign the workshops to reflect the rural study.
- The last workshop protocol was re-designed with the TaTEDO–SESO team by considering the availability of workshop theme requirements and the experience gained through the two workshops.

Workshop 1

The first workshop was conducted soon after the completion of baseline cooking diaries. The session aimed at bringing together everyday cooks to identify likes and dislikes in cooking and to discuss questions about cooking with electricity which was successfully attained. The participants had a long discussion about what they liked in cooking, whereby a large number (65%) liked eating and washing utensils. The cooking theme most disliked by this group was fetching firewood, (50%) whereby they termed all firewood-associated tasks including, collecting, preparing, lightning, and using for cooking as a punishment.

Participants and enumerators in groups during Workshop 1

Workshop 2

The second workshop preceded the second phase of cooking diaries data collection, where participants had already gained experience in eCooking. The aim was to identify and discuss the likes and dislikes of cooking with electricity. Also, discuss the ideas to remove the dislikes to improve eCooking as well as brainstorm on the new eCooking appliances to make cooking more convenient.

During the second workshop, it was observed that participants liked EPC because it cooks fast. On the other hand, for the Powerhubs providing light and the option to charge phones were very important aspects to them. However, 90% of the participants disliked the interruption of battery drainage during cooking especially during the rainy season.

Workshop 3

The third workshop was conducted after the third phase of cooking diaries. Initially, the third workshop was designed to enable participants to celebrate after the study while cooking a dish they would like, using an EPC in small groups and recording videos. The workshop was re-designed to reflect the real situation of the DC study where the Powerhub systems are installed in participating households. Also, participants in rural were not provided with smartphones which could help in recording and taking pictures to share as it was for the urban participating group. These brought difficulties in conducting it as it was designed. The re-designed workshop aimed at learning from each other's experiences during the study, acquiring participants' feedback, and discussing the expectations /way forward.

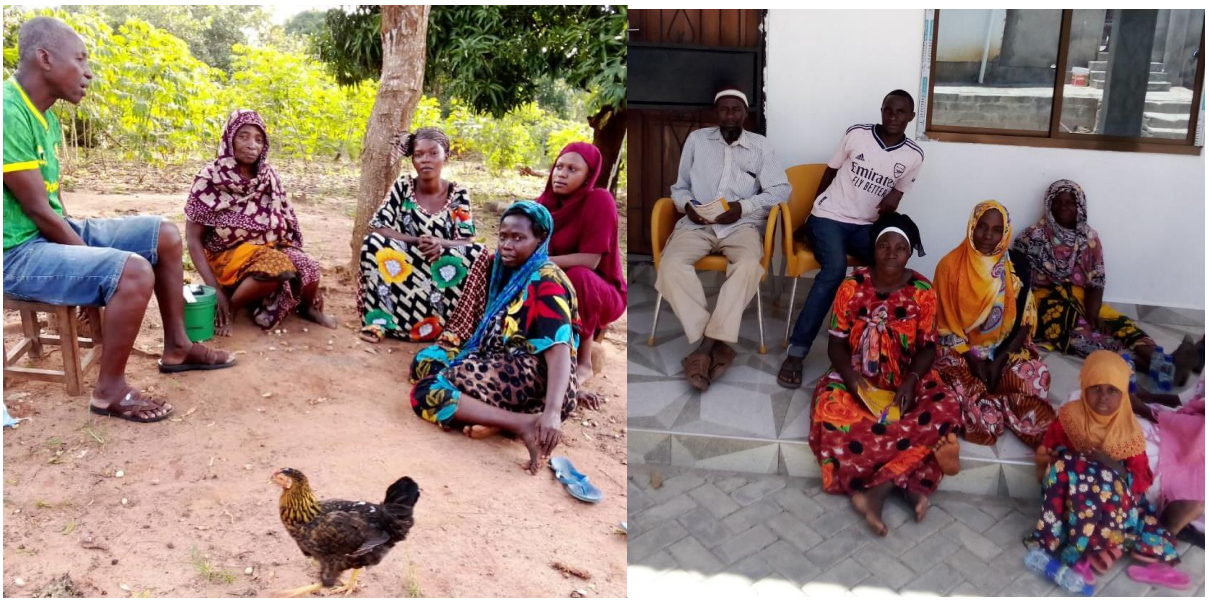
The workshop data were processed by reviewing sticky notes and recorded discussions and writing these up into reports. The translated workshop protocol, recordings, and workshop reports are uploaded in the shared folder and can be accessed for further details.

3.5. Weekly Group discussions

The weekly group discussion approach was designed to replace the mobile research approach through WhatsApp group which was one of the living lab methods implemented during the AC Powerhub study. The changes were due to the experience gained during the AC study that participants were less interactive/dormant and unconversant with the approach despite the efforts to motivate them. To achieve its goal of understanding the experiences of everyday cooks and co-design the strategy had to be improved to suit the rural study.

The weekly group discussions were designed such that, each enumerator had to gather with the respective five participants to conduct meetings weekly except for the weeks with intensive data collection such as cooking diaries and workshops. During the gathering, they discussed the weekly theme, which was the same as those for the weekly WhatsApp group discussion. Slight modifications of the themes were done to make them simple/ and easy to understand to encourage participation.

Various themes such as, feedback on the cooking diary, likes & dislikes in cooking, cooking dishes with different fuels, PowerStation's first thoughts, cooking space, experience in cooking with EPC, learning about other's experiences, undercooking and overcooking, trying new dishes, cooking preferences and feedback on the study were discussed. The report for each theme and the main report summarizing key learnings were prepared. All reports have been shared and can be accessed for more details.



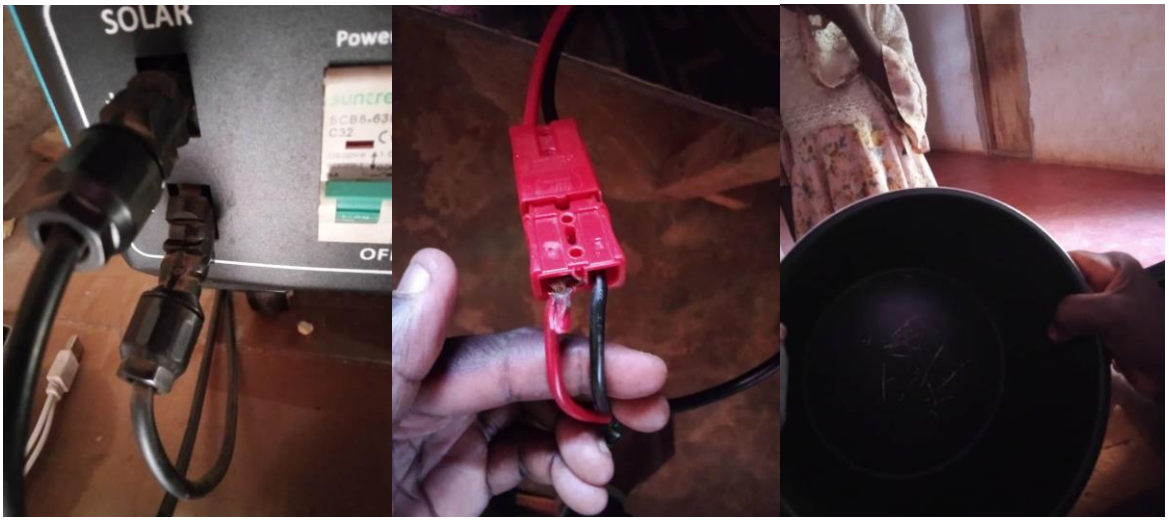
Participants and enumerators in groups during weekly group discussions

The method has worked successfully for the off-grid group and has helped improve communication and interaction among participants, experience sharing, and assisting one another on various issues they found challenging.

3.6. Daily Physical Households Visits

All participants were visited daily by enumerators and regularly by the project and technical team. During physical visits, participants were encouraged to call enumerators and the project coordinator/team whenever they experienced any challenge. Technicians visited the participating households to service all the Powerhubs, undertake troubleshooting, and repair Powerhubs with faults.

During physical visits, enumerators noted down every fault/challenge with the system and shared a short report with the team in the WhatsApp group for further action. The reports and the photos taken during the physical visit provided basic information to the technical team to plan and prepare material for undertaking troubleshooting and maintenance of the systems. Immediate actions such as rearrangements of the systems that were poorly arranged for instance Powerhubs that were placed in insufficient air circulation area, disconnecting and re-connecting the Powerhubs which switched off due to charge drainage were taken immediately by enumerators.



Various photos taken during daily physical visits to report different cases.

During the daily visits, the most repeated Powerhub fault reported was the drainage of the Powerhub, especially during rainy days which led to the system switching off. Enumerators had to disconnect and re-connect for the Powerhub to start charging again. This had a negative implication of weakening the cables and the connections.

The physical visits by enumerators enabled the technical faults to be resolved on time, and participants continued to enjoy the eCooking. It also builds confidence in the participants in using the systems as most were fearing electric accidents.

4. Conclusion and Recommendations

During the implementation of this study, the observations, participants' reactions, and the feedback provided revealed that the Powerhubs are of great help to off-grid people. At the initial stages of the study, the momentum and participants' morale were low. Participants did not believe that the study would take place and would be provided with the systems to test.

This was realized when participants were asked to share their fears about cooking with electricity during workshop 1, and they all first asked if the appliances were there and if it was real that they would be provided with the appliances to test for free. The situation was well understood by the project team, because of the long delay caused by the upgrading of the devices.

Participants were very happy and grateful to see what they dreamt about two years back had come to pass. After receiving the systems, participants expressed how they have been saved from the punishment of firewood fetching, preparing, and using. One participant commented that "We *no longer 'smoke' when we are cooking*". They can also cook anytime even at night as cooking is indoor. Previously they used to cook early because they feared snakes and bad insects as cooking was done outdoor kitchen.

Participants had to walk far to charge their phones and pay for the service. They have saved this money for charging to buy food as they can now charge with the Powerhubs. This is the same for the money used to buy candles, which now get light through the bulbs provided.

Despite the exciting stories from participants, there have been challenges with the systems of battery drainage especially during cloud/rainy season which interrupts cooking. This was seriously experienced when participants received the systems, and when they were asked about their dislikes of eCook during workshop 2, 90% of the participants were annoyed with the incident.

The secondary impact of the battery charge drainage is that participants knowingly or unknowingly keep on cooking despite the sign of low voltage on the display until it switches off. When it switches off, it cannot no longer charge the battery, until it is disconnected and re-connected. This leads to weakening the cables and the connections, and as a result, they get burnt/melted.

Some measures are manageable on the participants' side, for instance, they advised each other to be more careful when using the system and ensure checking of the charge status of the battery before starting to use the system.

Other measures were advised to be taken into consideration in future design. One of them is to increase the capacity of the system so that can store charge for a long time.
During the last sessions of the study (workshop 3, and the exit survey) participants requested to be considered to continue testing the appliances, which will enable further understanding of the system.

TaTEDO-SESO concurs with the suggestions of the participants of designing more powerful systems and the idea to keep on testing the system. This will enable the project team to continue learning about the system stability and behaviour change over the prolonged period of use.

It is believed that the Powerhubs are expensive for such a rural population and considered to be for some middle and high-income people. For future studies, the affordability aspect may be potential to consider especially when dealing with rural areas. The project team also recommends the following.

- The plan to import the Powerhub spare parts that cannot be sourced locally should be incorporated into future studies. This should also include the EPC spare parts and the extra inner pot.
- The methodologies of this study for qualitative data acquisition were highly participatory, with participants encouraged to input into the research process which benefited both the team and the participants. Participants felt empowered and responsible for the improvements and taking care of the systems. The faults and other changes were communicated, and the issues were resolved on time.
- As participants keep on testing the systems and share the good news with their neighbours, the pricing structure of the system needs to be worked out as the demand has been stimulated. By considering the findings during the AC study period, the AC extension study, and this DC study, the recommendations given, and the future plans of introducing and use of Powerhubs to accelerate eCooking, there is a need for collaboration of the research team both TaTEDO and MECs to establish the costs of the Powerhub systems for further market development.