Kitchen Energy Audit for e-Cooking

E-cooking Demo during Baseline Data Collection Exercise (source: SCODE 2023)

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eCooking Capacity Building & Market Development Programme (eCAP)

The eCooking Capacity Building & Market Development programme (eCAP) was implemented in 2023 as a partnership between Kenya Power and two UK-Aid-funded programmes, MECS and UK PACT. eCAP was managed collaboratively by Kenya Power and MECS via the STEER (Sustainable Transitions in Energy, Environment and Resilience) Centre at Loughborough University, UK and Gamos East Africa, Kenya.
Kenya Power owns and operates most of the electricity transmission and distribution system in the country and sells electricity to over 9 million customers. Kenya Power's *Pika na Power* (Cook with Electricity) campaign aims to stimulate demand for electricity and increase the social and environmental impacts of electricity access.

Modern Energy Cooking Services (MECS) and United Kingdom Partnering for Accelerated Climate Transitions (UK PACT) are UKAid-funded programmes with the shared vision of supporting Kenya to transition from unsustainably harvested biomass to renewably-generated electricity.
eCAP aims to accelerate the uptake of eCooking in Kenya by building the capacity of key market actors and driving forward the development of a sustainable eCooking sector by:

- Developing institutional capacity within Kenya Power
- Designing and implementing a pipeline of scalable activities in parallel with the Kenya National eCooking Strategy (KNeCS)
- Identifying pathways for scaling up the *Pika na Power* campaign
- Bringing together Kenya's clean cooking and electricity access sectors to empower a network of eCooking Champions
- Generating evidence on the role of eCooking as a tool for stimulating demand and increasing the social impact of electricity access to inform decision-making by Kenya Power's Board of Directors

For more information on eCAP, visit www.MECS.org.uk.

Acknowledgement

We would like to express our sincerest gratitude to MECS team for their unwavering support throughout the project life and for affording Scode the opportunity to be among MECS' pioneering entities in setting the stage for kitchen energy auditing.

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Executive Summary

As the global community progressively strides towards affordable and clean energy as encapsulated by the 2030 United Nation's sustainable development goal (SDG) number 7, energy auditing is increasingly becoming an important pillar for households to not only understand their energy consumption habits but also explore ways of reducing costs and emissions. In this context, SCODE was tasked by MECS with the development of kitchen energy audit data collection and analysis tools particularly at the household level. There was also a need to develop wiring assessment data collection and analysis tools that would eventually help inform households and relevant stakeholders about readiness to adopt clean cooking through electricity. The project deliverables were final versions of kitchen energy audit data collection and analysis tools comprising of a) Wiring assessment data collection tools, b) Wiring assessment data analysis tools, c) Kitchen Energy Audit Baseline data collection tools, and d) Kitchen Energy Audit Baseline data analysis tools

The first section of the report outlines the methodology which the project undertook in developing, piloting, and deploying kitchen energy auditing and wiring assessment data collection and analysis tools. It includes details on preliminary research on pertinent kitchen energy audit information and wiring assessment, the process of formulating data collection tools and onboarding them onto a software platform for remote and easy data collection, definition and selection of participants (households and enumerators), training of enumerators, collection of data from households,

analysis of the data, upgrading of the tools and ultimately, development of the final versions of the data collection and analysis tools as illustrated below.

The second section of the report primarily presents the findings obtained from analysis of the collected data. It highlights key findings on the socioeconomic status of households, available Ecooking appliances already in use in households and their corresponding electricity consumption, foods commonly cooked in households and their time and cost implications, and fuel consumption costs. Additionally, findings on wiring assessment are highlighted including the current quality of household electricity and quality of household wiring. Using this data, this section comparatively highlights the cost and time benefits that would be enjoyed by households when they switch to Ecooking. Cost-benefit analysis of switching to Ecooking was based on data generated from previous projects funded by MECS on Ecooking using Electric Pressure Cookers (EPCs) as illustrated below.

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Type of Food	Main Fuel Used	Quantity of Fuel Used	Fuel Unit Cost (Ksh)	Used Fuel Cost (Ksh)	Cooking Time (Minutes)	EPC cooking Time (Mins)	EPC Power Consumption (Kwh)	EPC Cooking Power Cost (Ksh)
Rice	Charcoal	0.45	40	18	31	28	0.21	5.50
Meat	Firewood	1.35	10	13.5	86	37	0.12	3.18
Githeri	Charcoal	1.50	40	60	193	116	0.39	10.36
Ugali	Charcoal	0.55	40	22	39	64	0.41	10.72
Vegetables	Firewood	0.60	10	6	25	19	0.18	4.80

Cost-benefit analysis was extrapolated to include common combinations of foods so that the financial implications of cooking particular dish combinations using the different fuels could be compared to using the EPC as illustrated below

	Charcoal		Firewood		EPC	
	Cost (Ksh)	Time (Mins)	Cost (Ksh)	Time (Mins)	Cost (Ksh)	Time (Mins)
Rice, Vegetables	52	80	21	55	10.3	47
Rice, Meat	45	125	28.5	116	8.69	65
Rice, Meat, Vegetables	79	174	34.5	141	13.49	84
Ugali, Vegetables	56	88	12	46	15.53	83
Ugali, Meat, Vegetables	83	182	25.5	132	18.71	120
Ugali, Meat	49	133	19.5	107	13.91	101

It should be noted that data was not collected on the frequency of cooking specific dishes during this study, so the data on typical cost savings was collected from one household. Future iterations of the methodology should seek to collect data on the frequency with which each dish appears on the menu so that more accurate predictions of the cost savings for each specific user can be calculated. It should also be noted that cost savings are noted per month and should be considered when reviewing payback periods.

The second section gives an overview of specific bottlenecks picked up by the wiring assessment tools including upgrades necessary to get HHs wiring up to standard in order to support Ecooking and how much it would cost, as illustrated below.

Component	Unit Cost (Ksh)	Quantity	Cost
Meter Box	1000	1	1000
CCU	2000	1	2000
RCD	300	2	600
Submeter	1000	1	1000
Kitchen Sockets	300	1	300
AVS	4500	1	4500
2.5mm2 Cable	160	5	800

The most common and necessary upgrades were analyzed to give a picture of cost implications to households that did not require to install all the components. A typical example is as illustrated below

Component	Unit Cost (Ksh)	Quantity	Cost
RCD	300	1	300
Kitchen Socket	300	1	300
2.5mm2 Cable	160	5	800

The original objective from the ToR was to develop "a streamlined version of the energy audit methodology that could be applied to kitchens to enable cooks understand the potential costs and benefits of changing the way they cook." The project developed a template checklist indicating data on current cooking practices and what advice would be offered to each of the respondents in terms of the costs and benefits to them of transitioning to eCooking.

The checklist helps the user to calculate how much money they would typically save each month on cooking fuel by adopting eCooking taking into account increases in their electricity bill. Considering the cost of the Ecooking appliance (Ksh 12, 091 for Pawapot EPC), the cost of upgrading kitchen wiring (Ksh 1, 400), and the cost savings (Ksh 1,482), typical payback period would therefore be 9 months.

While all the data collection and analysis has been done using a simple checklist with the right questions and well researched relevant advice depending upon the answers given, this process could be made easier and better streamlined with an app to allow everyday cooks to assess their own kitchens.

Abbreviations and Acronyms

AVS	Automatic Voltage Switcher
CCT	Controlled cooking Test
CCU	consumer Control Unit
HH	Household
IBM	The International Business Machines Corporation
IEEE	Institute of Electrical and Electronics Engineers
KITI	Kenya Industrial Training Institute
KPLC	Kenya Power and Lighting Company
KWH	Kilo Watt Hour
LCD	Liquid Crystal Display
MECS	Modern Energy Cooking Services
ODK	Open Data Kit
OS	Operating System
RCD	Residual Current Device
SDG	Sustainable Development Goals
SPSS	Statistical Package for the Social Sciences
SWH	Solar Water Heater
WH	Watt Hour
WHO	Word Health Organization

Definition of Terms

Controlled Cooking Tests

Cooking dishes repeatedly in controlled conditions using different fuels, taking note of exact weight measurements to ultimately determine and compare the amount of energy used, the cost, and time.

Cost Benefit Ratio

Refers to an indicator that summarizes the overall monetary value of an undertaking, object or a practice such that the higher the cost benefit ratio, the more monetary benefits can be derived from that object, undertaking or practice.

Energy Auditing Tools

Refers to tools that can be used to assess, through data collection and analysis, energy consumption and flow in a bid to identify ways of efficiently using energy without affecting the desired output.

Power Leakage

Refers to a situation whereby electric current deviates from a circuit and comes into contact with a conductive material and dissipates leading to power losses because such current is not put into any productive work such as running an electric appliance.

Table of Contents

List of Tables

List of Figures

Introduction

As the global push for adoption of cleaner and affordable energy intensifies to combat global warming, it has increasingly become evident that there is a lot of potential at the grassroots level. At the grassroot level, the World Health Organization (WHO) estimates that 2.7 billion households still rely on dirty fuels as energy sources (Household Air Pollution, 2022). However, critical to the push for grassroots stakeholders including households to switch to cleaner energy sources is the lack of pertinent information and tools to help them gauge the cost, health, and even time-saving benefits that switching to cleaner sources would have on their livelihoods. In this regard, energy auditing tools and relevant information is increasingly becoming relevant to households compared to previous years when such tools were only used by large-scale organizations and stakeholders to inform better energy and cost-saving policies. Although energy use at the household level relates to various avenues including cooking, lighting, entertainment, space heating, and cooling among others, cooking still remains the most critical high-energy consuming segment in a household. In this regard, SCODE through the support of MECS, as outlined in this document intended to address the shortcomings of availability of energy auditing tools at the household level as well as examining the level of preparedness for households to adopt e-cooking through assessment of their wiring and its ability to support electrified cooking. In so doing, the developed auditing tools would help inform households about the potential benefits of electrifying their cooking as well as the need/lack thereof to upgrade their wiring to support e-cooking.

In this project, SCODE applied energy audit methodology to sample households to:

- Assess power leakages in wiring within premises
- Determine current expenditures on cooking fuels
- Determine potential costs and benefits of changing to cooking with electricity

Ultimately, the project deliverables were final versions of kitchen energy audit data collection and analysis tools comprising of:

a) Wiring assessment data collection tools
b) Wiring assessment data analysis tools
c) Kitchen Energy Audit Baseline data collection tools
d) Kitchen Energy Audit Baseline data analysis tools

Methodology

This section elucidates on the procedure followed in developing both the wiring assessment and kitchen energy audit data collection and analysis tools. It elaborates on the processes and approaches used in collecting data critical to developing the tools and subsequent steps taken to improve them until development of the final versions of both tools. Figure 1 below succinctly illustrates the methodology process.

Figure 1: The Methodology Process

Phase 1: Issues for Kitchen Energy Audit and Wiring Assessment

The first step in developing kitchen energy audit and wiring assessment data collection and analysis tools was to identify and understand the issues pertinent to the process by examining the existing pool of knowledge available.

The project team engaged in desk research in collaboration with expert consultation from an expert in data collection and analysis. Information obtained indicated that while energy audits were common global practices in the energy sector to help inform adoption of energy and cost saving practices, the existing work on energy audits was mainly centered around business energy audits, school kitchens, and general home energy audits. Despite the apparent gap specifically relating to household kitchen energy audits and wiring assessments, information collated from the available energy audits in the aforementioned domains was enough to gain an understanding of the issues and information required to develop household kitchen energy audit and wiring assessment data collection and analysis tools.

Kitchen Energy Auditing

The issues identified that were pertinent to kitchen energy auditing were broadly grouped into four sections:

Section A: Introduction and Identification

This section captures information relating to introduction of the data collection tool as far as what they intend to record, consent needed to proceed, self-identification of enumerators interacting with the data collection tool, unique household identifier, date, time, and physical locations of the households.

Section B: Household Background Information

This section is intended to capture issues and information relating to details of the respondents or household head including gender, religion, literacy level, and marital status. Additionally, sources of income and monthly income of the household head are also captured in this section of the tool. Overall, this section gives a contextual understanding of the kind of household in which the energy auditing and wiring assessment of the kitchen is taking place.

Section C: Kitchen Energy Audit information

This section captures all the key issues about energy sources and use of this energy in the kitchen. Such information includes details on sources of energy (fuels), details on energy consuming appliances available in the kitchen, and details on how energy is consumed in the kitchen vis-à-vis the types of foods cooked.

Section D: Conclusion and Final Submissions

This section gives concluding remarks, captures geo-location information and time of ending the interaction with the auditing tool.

Wiring Assessment

In determining the issues important for developing a wiring assessment data collection and analysis tool, desktop research was also used in collaboration with consultation from in-house electrical experts. Subsequently, the IEEE Wiring Regulations 17th Edition was used to develop the assessment tool in accordance with standards and policies employed by both international regulatory bodies and the Kenyan wiring regulatory body, KPLC.

The issues identified that were critical to developing a wiring assessment data collection and analysis tool were broadly grouped into 3 sections

Section A: Introduction

This section gives a brief introduction about what information the tool captures, assignment of a unique household identifier, date, and time of data collection.

Section B: Wiring Assessment

This section captures the electricity usage in the household, state of electrical installation and wiring, quality of electricity as experienced in the household's vis a vis details surrounding brown outs and black outs, and a segment on E-waste management.

Section C: Conclusion and Final Submissions

This section gives concluding remarks, captures geo-location information and time of ending the interaction with the wiring assessment tool.

Phase 2: Development and Selection of Data Collection and Analysis Software tools

Selection of Data Analysis Software tools

After understanding the issues and information necessary for developing the tools, the project team undertook desk research to identify the most suitable software tools to capture and store the required information. Key considerations in identifying the right software tools were the cost of the tools, ease of use, ease of remote accessibility, technical compatibility with common devices, and ease of customization according to user defined and project-specific parameters.

Among the considered data collection software were Google forms, Open Data Kit (ODK), Kobo ToolBox (KoboCollect), GoSurvey and WhatsApp Surveys. After consideration, the project team decided to use the KoboCollect software developed by the Harvard Humanitarian Initiative. This decision was based on the fact that KoboCollect is an open-source tool thus eliminating cost constraints. Additionally, the KoboCollect Application is widely compatible with devices running on android OS, allows for data collection in off-line mode and on web applications. KoboCollect interface and flexibility as far as customization was concerned was found to be very accommodating relative to the other software tools considered. There was also an element of familiarity in usage as the project team had interacted with the software in previous MECS-Funded projects thus eliminating time that would have been used on user education and familiarization with the software tool.

Selection of data analysis tools was done through expert consultation with considerations for robustness (ability to store and analyze large data files), compatibility with common devices and KoboCollect data forms, and ease of use. Subsequently, the project team settled on IBM SPSS and Microsoft Excel as the primary data analysis software tools.

Developing Draft Data Collection Tools

Using the issues identified from the research work in phase one, individual questions were drafted accordingly giving attention to the main sections using a Microsoft Word processing software. The details were subsequently input into the KoboCollect Software tool for field administration to households.

Phase 3: Define Participants and Respondents

In defining participants and respondents, the project team embarked on recruitment and training of two enumerators (one man, one woman) to test the draft data collection tools based on the project document. Availability of enumerators post-administering the questionnaires to elaborate on issues raised during data analysis and give feedback from the field was also considered during recruitment. Gender balance was considered with the two enumerators being from both genders.

The project required that the draft tools be initially tested in 5 households and 20 households be engaged during subsequent piloting of the tools. Participating households were selected based on convenience sampling dictated by the project parameters. The project parameters that were considered for households to participate were electricity connection, willingness to participate, basic education, and household size of four members and above.
Using convenience sampling approach, enumerators were required to canvass designated locations while walking and through visual observation approach households that were connected to electricity. Other parameters such as willingness were assessed after initial contact but others such as education level and household size were qualified during analysis. That is, if enumerators approached a household that was willing to participate but during data collection, they realized that the education level and household size parameters were not aligned to project requirements, data was still collected to avoid perceived discrimination of households within that location but excluded during data analysis.

The five households that participated in testing of the draft tools were selected through convenience sampling with reference to their proximity to SCODE's main offices within Bahati sub-county. Enumerators were expected to canvass the area within close proximity of SCODE offices and test the draft tools in willing households.

Before commencement of the field activities, the project team acquired research license from the National Commission for Science, Technology and Innovation (NACOSTI). Additionally, ethical considerations were made as far as data privacy was concerned by requiring that participants sign a consent form expressing their willingness to participate and SCODE's commitment in keeping data confidential.

Phase 4: Testing Draft Tools

Based on parameters identified in Phase 3, the data collection tools were tested in 5 households within the vicinity of SCODE' main offices in Kiamaina Ward, Bahati Subcounty. The 5 households were within walking distance from SCODE's main Offices to ease movement of enumerators and also make it easier for enumerators to consult with the supervisor as it was the first time the tools were being deployed in the field. Household characteristics obtained from administering the draft tools are illustrated in Table 1.

Table 1: Household Characteristics from Draft Tools

Gender (Respondent)	Gender (HH)	Religion (HH)	Age (HI	Highest level of Completed Education	marital status	People in HH	Occupation (HH)	Monthly Income
Male	Male	Christian	Above 60	Primary	Married	6	Self-Employed	5, 001 - 10, 000
Male	Male	Christian	46-60	High School	Married	6	Self-Employed	5, 001 - 10, 000
Female	Female	Christian	Above 60	High School	Widowed	4	Self-Employed	5, 001 - 10, 000
Female	Female	Christian	46-60	Primary	Single	4	Self-Employed	5, 001 - 10, 000
Female	Male	Christian	46-60	Primary	Married	5	Farming	0 - 5,000

Phase 5: Reviewing of Draft Kitchen Energy Audit and Wiring Assessment Data Collection and Analysis Tools and Development Of 1st Generation Tools

A review of data from piloting the draft data collection and analysis tools highlighted a number of issues.

1. Logical flow: Enumerators noted with concern that the coherence and logical flow of some sections of the questionnaires was challenging. For example, a question on fuel use could appear in between a section asking about the foods cooked. Additionally, they noted that the skip logic functionality on some questions was not correctly applied meaning that even if a question was skipped, the ensuing related questions that should have been skipped were still displayed.
2. Ambiguity of some questions: Enumerators and analysis of test data revealed that some questions were ambiguous to both enumerators and respondents thereby eliciting flawed responses. For example, when asking about the occupation, some interpreted that as all the occupations that members of that household pursued for income as opposed to the main income- generating occupation of the household head.
3. Irrelevance of some questions: Enumerators and analysis of test data collected revealed that some questions were irrelevant within the scope of a kitchen energy audit and wiring assessment given the project parameters. Additionally, eCAP partners noted the overlapping of some questions at the beginning of both questionnaires despite the fact that they would be both administered in the same households in succession.
4. Inconsistency in responses: Analysis of test data revealed that some questions, despite eliciting the same kind of responses were fed into the KoboCollect software tool inconsistently by enumerators thereby giving flawed perceptions. For example, names of the same village were often spelt differently making it appear like two different locations when analyzed. Further, eCAP partners noted that responses on quantity of foods cooked always produced inconsistent data making them unhelpful/invalid in the final analysis and in energy auditing in general.

Subsequently, the arrangement and skip logic functionalities of questions was adjusted accordingly to enhance logical flow of the questionnaires. Affected questions were reframed to remove ambiguity while irrelevant questions were removed from the list of questions appearing in the questionnaires. To curb inconsistency, all affected questions were converted to selectable options where enumerators only had to choose from a list provided while an option to choose "none" was also added so that enumerators did not inconsistently type in their variations of the same that included "not applicable", "doesn't have", "no" etc. After amendments the 1st generation tools were developed.

Phase 6: Retraining of the Enumerators

Retraining of enumerators for administering the 1st generation kitchen energy audit and wiring assessment data collection tools was informed by the need to have enumerators with increased technicality to properly administer the questionnaires to elicit required information.

Phase 7: Piloting the 1st generation tool

20 households were selected based on three sampling methods. First, stratified sampling was used based on population density to classify the targeted households into urban and rural strata relative to each other. The project team collected data from 10 households from each strata. Using this approach, Lemolo B in Mogotio Subcounty was selected as a rural setting while Whitehouse estate in Nakuru Town East Sub- County was selected as an urban setting. Secondly convenience sampling was used to select households based on project parameters (grid connectivity, willingness to participate, households with basic education, and household size of 4 persons and above). Enumerators were dropped at central point in each of the two data collection locations and canvassed the area, visually identified households that were connected to the grid, and were willing to participate. Other parameters were considered once the households showed willingness to participate by signing the consent forms provided by the enumerators. Thirdly, simple random sampling was done in the selected locations with the help of field guides who were familiar with the areas selected. Random sampling was necessary to avoid the bias of interviewing households that were too close to each other physically and which shared a lot of cooking and wiring

characteristics thus distorting data on the grounds of similarity and repetition. Field guides helped in directing the enumerators while canvassing the areas. After ensuring that the respondents in the participating households had given consent and duly signed the consent form, the enumerators proceeded to collect data on their smartphones through the KoboCollect App, taking a maximum of 30 minutes in each household depending on the respondent's speed in providing data.

Phase 8: Review of 1st generation and Development of 2nd Generation data Collection and analysis tools

Analysis of data from the 1st generation data collection tools highlighted some issues:

1. Coherence and on-screen appearance of the questions: Enumerators noted that some set of related questions appeared on different pages of the device screen making it cumbersome and time consuming to scroll thereby interfering with overall coherence of the tools. This made them prone to unintentionally skip some questions when the next button was pressed, also making data obtained incoherent.
2. Irrelevance of some questions: analysis of the data from the 1st generation tools revealed that some questions elicited unhelpful or misleading information. For example, a question of fuel preference prompted respondents to answer on which fuel they would prefer to be using even when they did not currently use it instead of capturing information about what fuel they preferred among those they were currently using. Additionally, questions on frequency of cooking foods were noted to be irrelevant because after analysis, the data did not yield any useful insights into energy and fuel consumption.
3. Placement of questions: enumerators noted that some questions seemed misplaced in the context of the kitchen energy audit. For example, questions relating to details of appliances that are used outside the kitchen but in the household such as electric shower heads were found to be misplaced in the context of the kitchen and were better placed in the wiring assessment section
4. Framing of critical questions: Analysis of data obtained from some questions highlighted the fact that it was problematic to make accurate conclusions. For example, generally asking all the kinds of fuels used in a household kitchen did not reveal about stacking

preferences and what fuels were used as primary, secondary, or tertiary fuels unless that data was extrapolated from other questions relating to fuels used to cook particular foods.

Subsequently, relevant changes were made to correct the issues noted and the 2nd generation tools developed

Phase 9: Piloting 2nd Generation Tool

Previous enumerators from the 1st generation piloting phase were used in piloting to gauge and enhance reliability of the tools in preparation for the final phase. The 2nd generation tools were piloted in 20 households based on cluster sampling that considered geographical locations i.e., all five sublocations in Kiamaina Location within Bahati Subcounty were considered. Convenience sampling was also used in consideration of project parameters to select qualified households in each sublocation. Enumerators collected data from 4 households in each sublocation which were connected to the grid and that were convenient for them to visit either by measure of distance (close to where they were dropped by the supervisor) or level of cooperation.

Phase 10: Review and development of 3rd Generation Final Tools

After analysis and review of data collected using the 2nd generation tools, minor adjustment were made in development of the 3rd and final version:

- Grammar was improved and minor questions added to reinforce details of critical data pertinent to calculating the overall energy consumption. For example, questions on wattage of appliances were added in the kitchen energy audit data collection tool. Considerations for individual versus largescale wiring assessment and energy auditing was made by excluding introduction, identification, and household background information sections in the questionnaire for self-administration.
- Largescale assessment and energy auditing could be used by producers and other interested vendors of Ecooking appliances to judge the overall readiness and ability of households in an area to uptake Ecooking and by extension purchase Ecooking appliances. Additionally, by looking at the largescale data of households, such stakeholders can tailor-suite their

marketing campaigns to specifically align with the socioeconomic characteristics of an area, cooking habits, and fuel consumption costs-characteristics of most households within such an area. On the other-hand, individual assessment would inform singular households if their wiring could support Ecooking, costs of upgrading their wiring to support Ecooking, and how much they would save on fuel and time when they switched to Ecooking.

- The skip logic functionality of all questions was reinforced thereby making all relevant questions mandatory to increase the tools' reliability and eliminate input errors that resulted in blank responses.
- The addition of a thermal solar water heating section in the questionnaire to capture data on energy consumption from solar water heating in the kitchen.

Limitations and Assumptions

One of the key limitations in developing the tools for kitchen energy auditing and wiring assessment was the unfamiliarity of household heads and respondents with what energy auditing entails and how it can help them switch to more sustainable, efficient, and cost-effective cooking practices. As such some respondents were reserved about disclosing certain details of their energy and fuel consumption habits such as the power rating of their electric appliances. Nevertheless, the enumerators explained in detail the benefits of energy audits and by extension the need to adopt Ecooking. Further, the sample size of 20 households stipulated by the project requirements was limited in scope leading to low statistical power across the board particularly with reference to household information and the relationship with energy use in the household. However, the findings were enough to provide preliminary insights and can be used for further research

Analysis of the Results

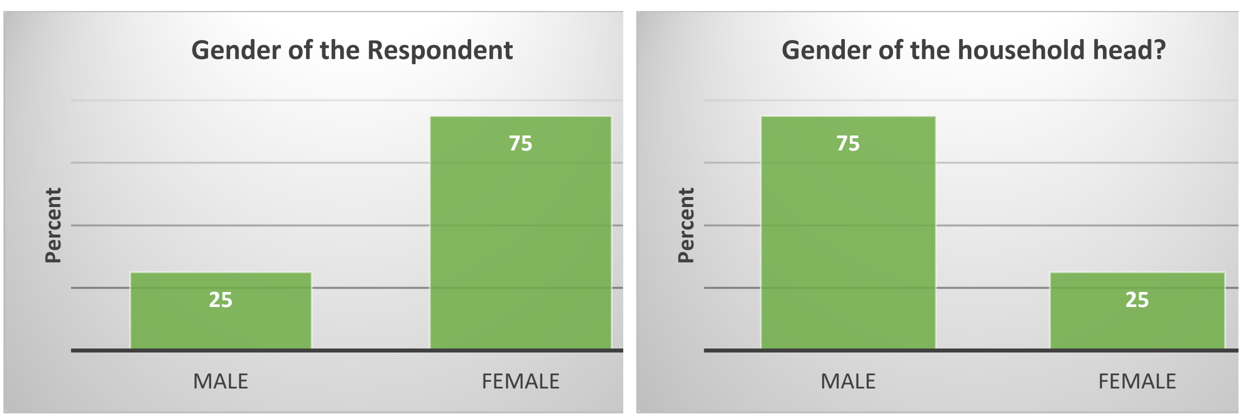
The actionable data collected using the developed kitchen energy audit and wiring assessment tools was limited in the scope of households covered. However, the analysis results highlight the effectiveness of the tool in gathering critical information necessary for energy auditing and wiring assessment. It takes this information and utilizes it to inform the respondent on how their cooking practices might change if they transitioned to eCooking.

Household Information Analysis

Household information gives a contextual background into the socioeconomic standings of households through variables such as gender of household head and respondents, age, marital status, occupation, literacy level, and income bracket. This information is critical in determining the relationship of these variables with other variables such as the sources of energy used in households, types of electric cooking appliances available in household kitchens.

Gender

Figure 2: Gender of Respondent vs Gender of Household Head



Sample results from Figure 2 indicate that while 75% of household heads were male by gender, those willing to respond and available for participation were women (75%)

Occupation

Figure 3: Occupation of Household Head

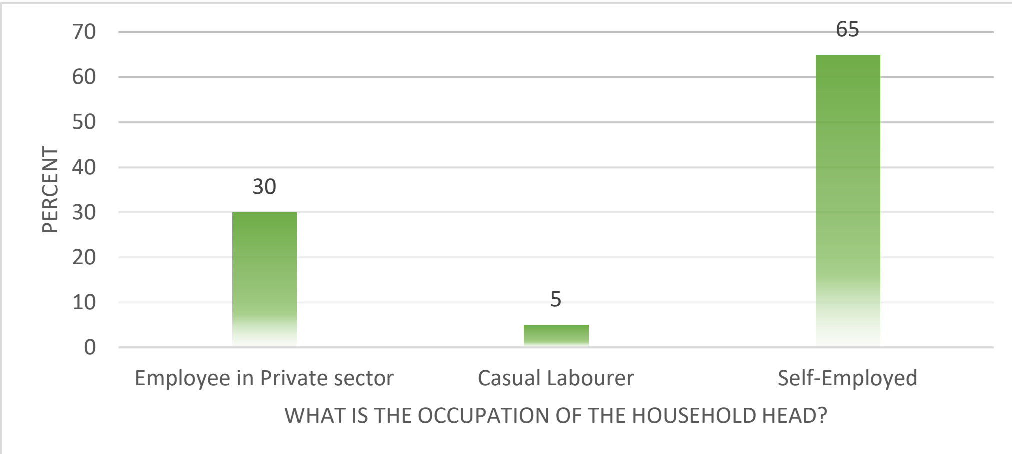
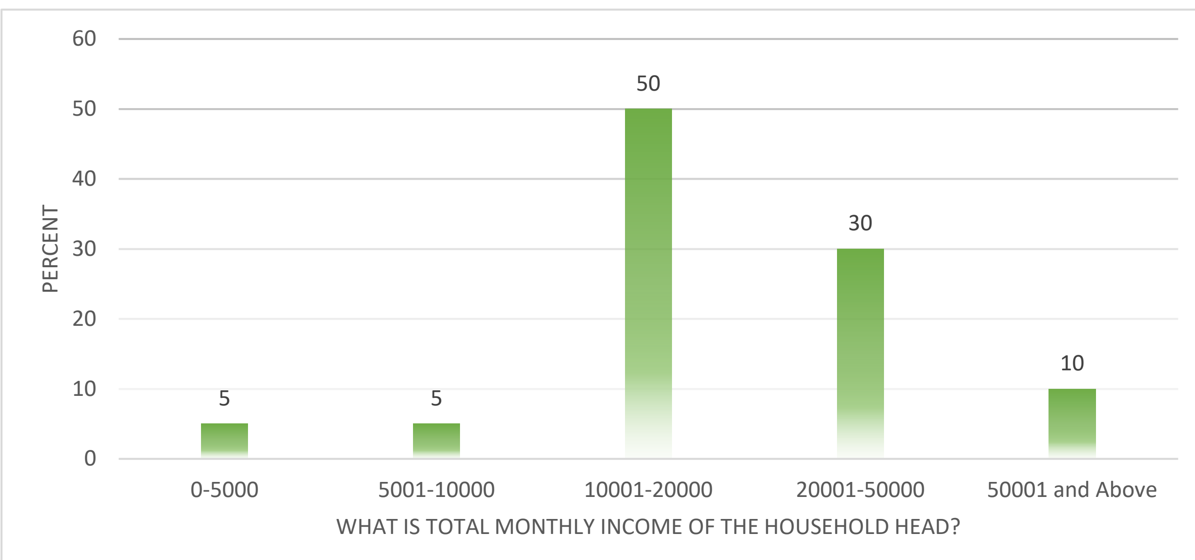


Figure 3 indicates that 65% of household heads were self-employed, 30% were formally employed in the private sector, while 5% were informally employed as casual laborers.

Income

Figure 4: Income of Household Head



Sample results in Figure 4 indicate that 50% of household heads had a monthly income ranging between Ksh 10,001 and 20,000, 30% had an income of between Ksh 20,001 and 50,000, 10% had a monthly income of above Ksh 50,001 and 10% had an income below Ksh 10,000. According to the Kenya National Bureau of Statistics (2017), low income households have a monthly income of less than Ksh 23, 670, middle income households have an income of between Ksh 23, 671 and 119, 999, while upper income households have income of above Ksh 120, 000. On average, nearly 50% of Kenyans earn less than Ksh 10, 000 per month which is consistent with the data collected indicating that 60% of the sampled households are low-income earners.

Literacy Levels

Figure 5: Highest Level of Completed Education of Household Head

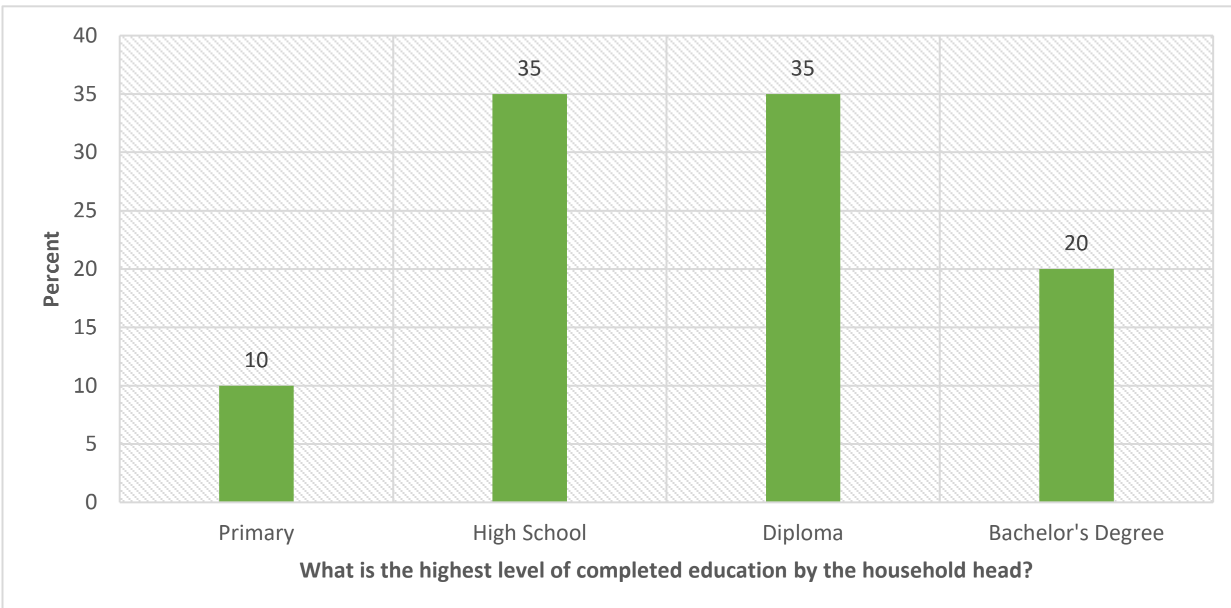


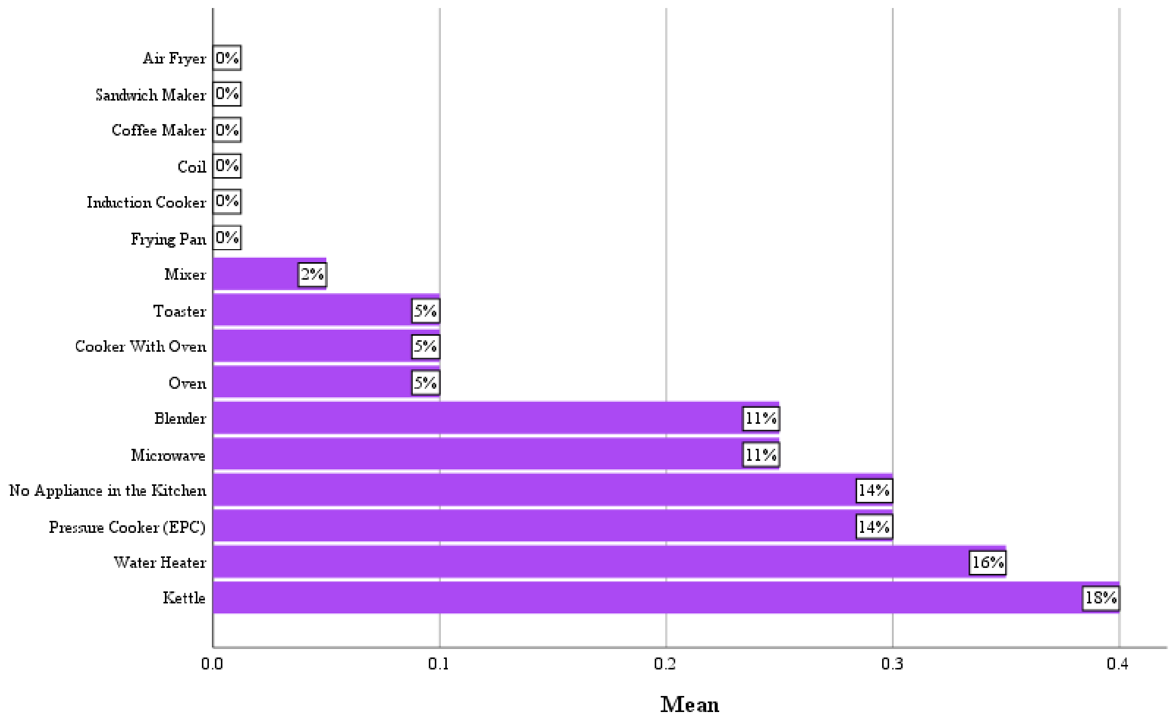
Figure 5 shows that 35% of household heads listed high school and diploma education as their highest level of completed education, 20% had attained a bachelor's degree while 10% listed primary school education.

In general, the household information data indicated that household heads were largely male, had some level of formal education, were middle income earners, and were self-employed in business. Taking this into account, to incentivize households to switch to Ecooking, Ecooking devices need to be developed and priced to fit into the earning bracket of middle-income households. Based on the results, it could also be noted that most household heads are literate enough to use Ecooking devices and also comprehend the benefits of switching to Ecooking.

Kitchen Energy Audit

Electric Appliances and Wattages, Time, Frequency of Use

Figure 6: Electric Appliances in Household Kitchens



According to Figure 6, the most common e-cooking appliances available in households are the electric kettle (18%), Water Heater (16%), Electric Pressure Cooker (14%) Microwave (11%), and Blender (11%). The higher than national average of households with EPCs is explained by the fact that SCODE has had previous marketing campaigns in the visited areas with particular emphasis on EPCs.

Foods Cooked

Figure 7: Foods Commonly Cooked in Household Kitchens

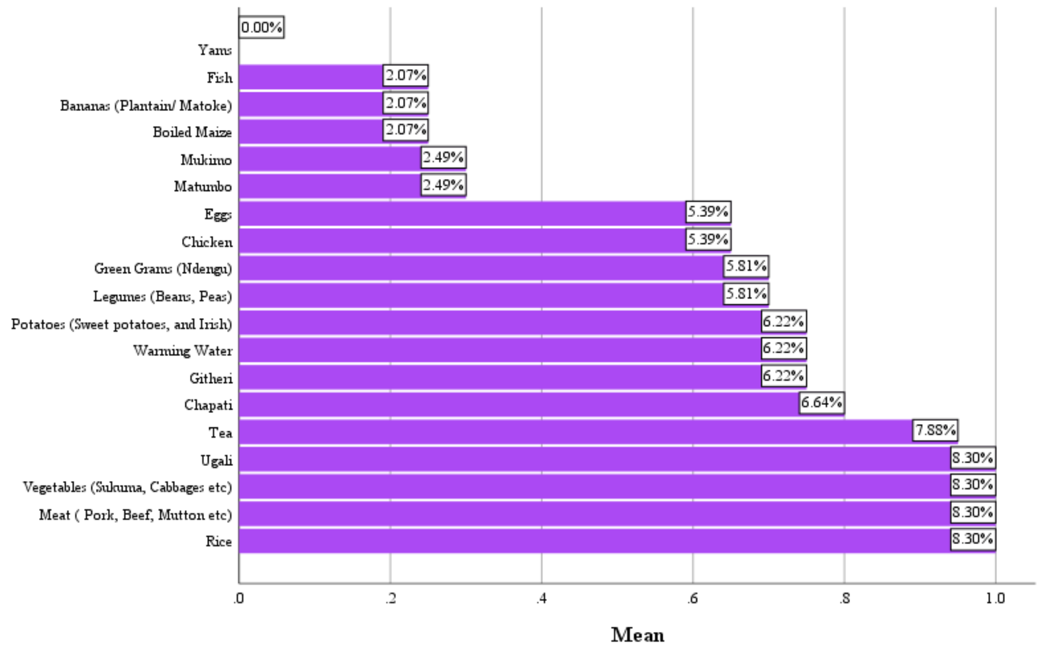


Figure 7 depicts what foods are commonly cooked in household kitchens. The data can then be analysed in a number of ways including the time taken to cook each food using different fuels as indicated in Figure 8 below.

Fuels Used to Cook Foods vs Time Taken

Figure 8: Fuels Used to cook Foods vs Time Taken

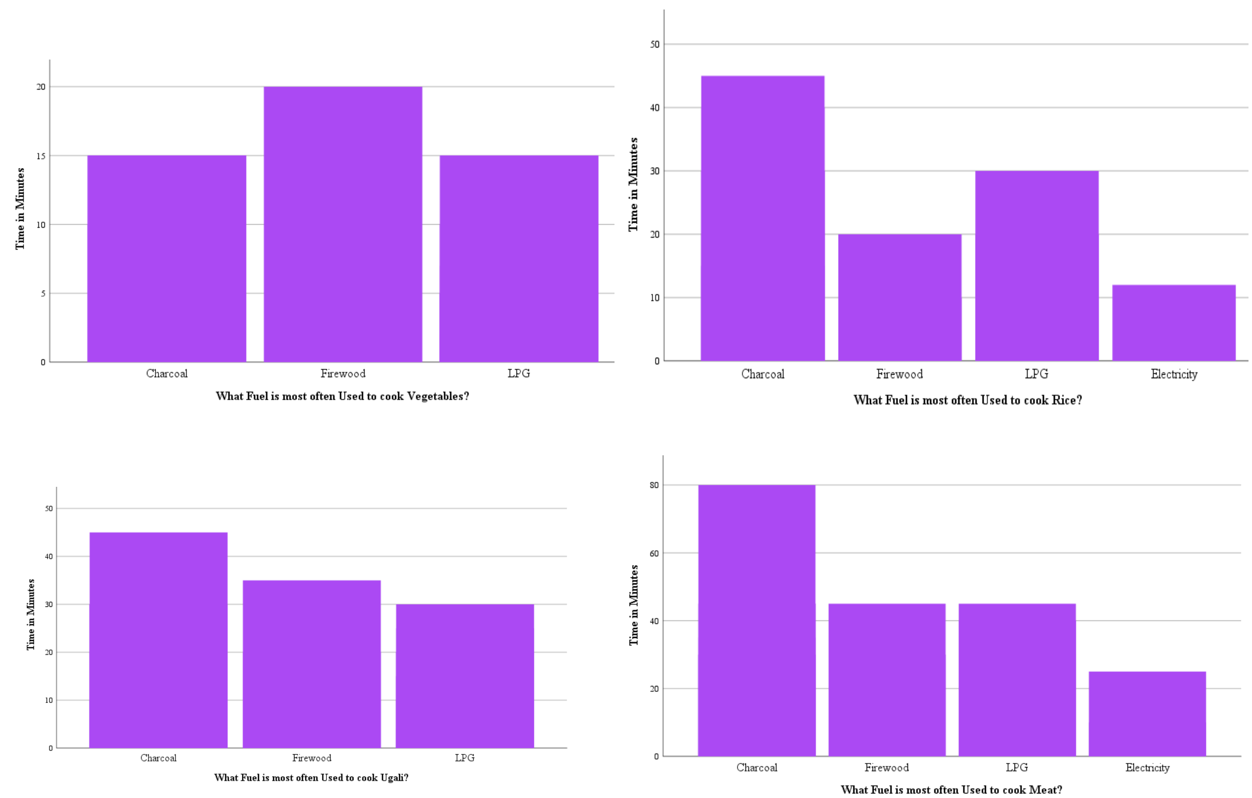


Figure 8 above depicts sample data on the types of foods cooked versus the time taken when using different fuels. When compared against CCT's of individual foods and fuels, cost benefit ratio can thus be calculated as shown in Table 1 below. Additionally, the kitchen energy data collection tool also avails data on methods of cooking for all foods to be able to inform decisions on e-cooking appliance suitability.

Table 2: Cost Benefits of transitioning to ecooking

Type of Food	Main Fuel Used	Quantity of Fuel Used	Fuel Unit Cost (Ksh)	Used Fuel Cost (Ksh)	Cooking Time (Minutes)	EPC cooking Time (Mins)	EPC Power Consumption (Kwhs)	EPC Cooking Power Cost (Ksh)
Rice	Charcoal	0.45	40	18	31	28	0.21	5.50
Meat	Firewood	1.35	10	13.5	86	37	0.12	3.18
Githeri	Charcoal	1.5	40	60	193	116	0.39	10.36
Ugali	Charcoal	0.55	40	22	39	64	0.41	10.72
Vegetables	Firewood	0.6	10	6	25	19	0.18	4.80

According to Table 2, the cost savings of using an EPC (Ksh 5.5) to cook Rice when compared to using charcoal (Ksh 18) is Ksh 12.5. Similarly, the time savings when cooking rice using an EPC and using charcoal is 3 minutes. When cooking meat and vegetables using firewood, it would cost about Ksh 13.5, and Ksh 6 respectively compared to an EPC which would cost Ksh 3 and Ksh 5.8 respectively implying a cost saving of Ksh 1.2 and Ksh 10.3 respectively. In terms of time savings, the EPC would save a cook 49 minutes when cooking meat and 6 minutes when cooking vegetables as compared to using firewood.

Specific data on the frequency of cooking each food with regard to exactly how many times households cooked a dish was not collected. Data was collected on the type of foods cooked in a week regardless of how often the foods were cooked. Subsequently, cost-benefit analysis was pegged on potential customers getting to know the cost and time benefits of switching to Ecooking for every instance they choose an EPC over other fuels in preparing a dish as shown in Table 3 below. However, it is assumed that dishes are prepared separately in different pots.

Table 3: Cost Benefits Considering Popular Dishes

	Charcoal		Firewood		EPC	
	Cost (Ksh)	**Time (Mins)**	**Cost (Ksh)**	**Time (Mins)**	**Cost (Ksh)**	**Time (Mins)**
Rice, Vegetables	52	80	21	55	10.31	47
Rice, Meat	45	125	28.5	116	8.69	65
Rice, Meat, Vegetables	79	174	34.5	141	13.49	84
Ugali, Vegetables	56	88	12	46	15.53	83
Ugali, Meat, Vegetables	83	182	25.5	132	18.71	120
Ugali, Meat	49	133	19.5	107	13.91	101

Besides accessing the types of foods cooked in households to explore how switching to Ecooking can save on time and costs, the fuels used are also critical in showing the maximum cost benefits of switching to Ecooking. In particular, households could compare the compounded monthly costs of their primary, secondary, and tertiary fuels to assess whether it would be cheaper to exclusively switch to Ecooking or at least substitute one of their fuels. Data and analysis on fuels is presented in Figures 9 and 10

Fuels Used, Cost, and Fuel Stacking

Figure 9: Primary, Secondary, and Tertiary Fuels

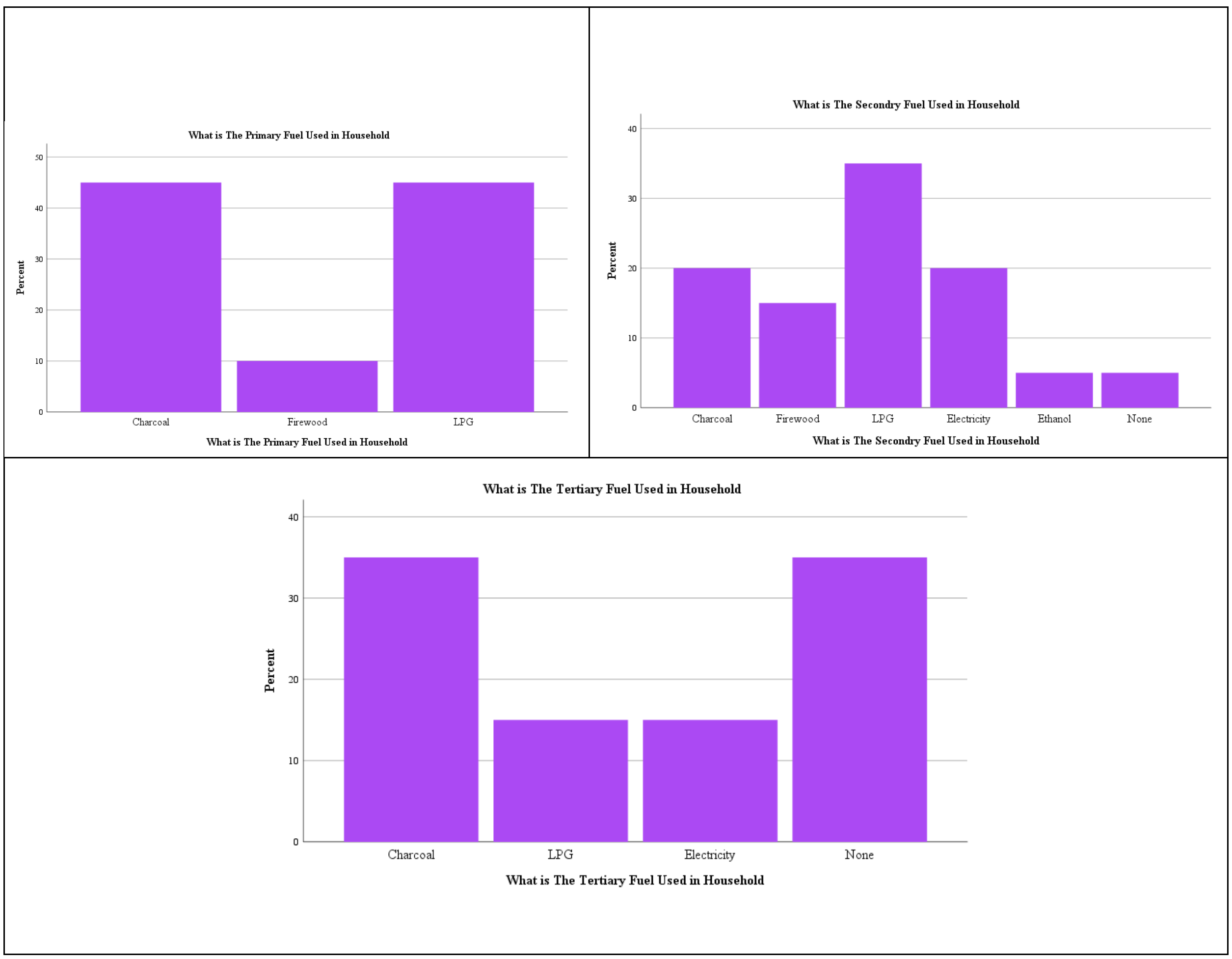
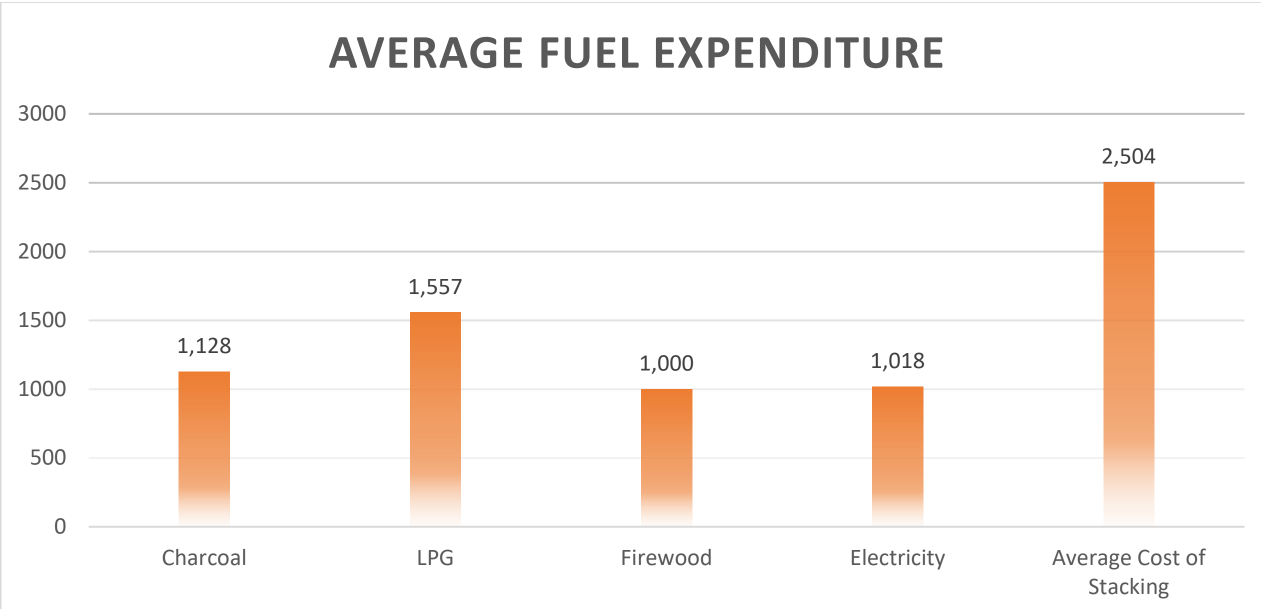


Figure 9 displays sample data on fuel usage in household kitchens depicting the most common fuels used as energy sources for cooking. When used with Figure 10 below, average costs of fuels can be computed and cost benefits of switching between fuels demonstrated.

Figure 10: Average Fuel Expenditure per Month for Household Kitchens



Electricity expenditure represents data collected from 20 households on the costs of cooking using CREST AC power hubs. The average cost of stacking represents the amount of money spent by households that were using more than one fuel regardless of their stacking combination and therefore it is not equal to the sum of the other three fuels. Households that used charcoal for cooking in their energy mix spent an average of Ksh 1,128, those that used LPG spent an average of Ksh 1, 557, and those that used firewood spent an average of Ksh 1, 000 monthly.

Wiring Assessment

This section presents an overview of specific bottlenecks picked up by the wiring assessment tools including wiring upgrades necessary to support Ecooking and the cost of getting HHs wiring up to standard.

Table 4: Wiring Upgrade Costs

Component	Unit Cost (Ksh)	Quantity	Cost
Meter Box	1000	1	1000
CCU	2000	1	2000

RCD	300	2	600
Submeter	1000	1	1000
Kitchen Sockets	300	1	300
AVS	4500	1	4500
2.5mm2 Cable	160	5	800

The wiring upgrade costs helps the user to calculate how much money they would typically save each month on cooking fuel by adopting eCooking taking into account increases in their electricity bill. The cost of the ecooking appliance (Ksh 12, 091 for Pawapot EPC) and the cost of upgrading their wiring (Ksh 1,400). Therefore, considering the cost savings (Ksh 1,482) as shown Table 3, the typical payback period would therefore be 9 months. Sample data displayed in Table 6 was collected from one of the participating households.

While Table 4 represents the worst-case scenario whereby a household would need to acquire all the missing components, data from Tables 7 to 12 shows that over 95% (19 HHs) had the requisite wiring installations to support Ecooking including a standard meter box, CCU, and RCD. However, 25% (5 HHs) did not have a socket in the kitchen where an Ecooking device could be plugged in. Therefore, for these households, upgrading their wiring to support Ecooking would require the installation of a socket in the kitchen and a separate RCD culminating in total costs of Ksh 1,400 exclusive of labor costs as shown in Table 5

Table 5: Typical Wiring Upgrade Costs

Component	**Unit Cost (Ksh)**	**Quantity**	**Cost**
RCD	300	1	300
Kitchen Sockets	300	1	300
2.5mm2 Cable	160	5	800

Table 6: Sample Fuel Cost Savings per Month

	Type of Fuel	Quantity of Fuel/Month	Fuel Unit Cost	Fuel Total Cost/ Month	Current Monthly Electric Bill	Total Cost of Fuels and Electric Bill (TcF&B)	EPC Power consumption Cost and Electric Bill (TcEPC&B)	Cost Savings Per Month
Primary Fuel	Charcoal	1 bag	1600	1600				
Secondary fuel	Firewood	1 donkey Cart	900	900				
Tertiary fuel				0				
			Total Cost	**2500**	1087	3587	2105	1482

Source: SCODE Kitchen Energy Audit Tool Data

Quality of HH Electricity

Data collected on factors influencing choice of household cooking fuels showed that availability was a major factor. This means that when people are choosing the type of fuel to use they often choose what is easily available. As such blackouts and brownouts might act as bottlenecks to cooking with electricity. The research found that in Kiamaina ward, blackouts and brownouts are rare and hence not a major concern for ecooking.

Blackouts

Figure 11: Occurrence of Electricity Blackouts

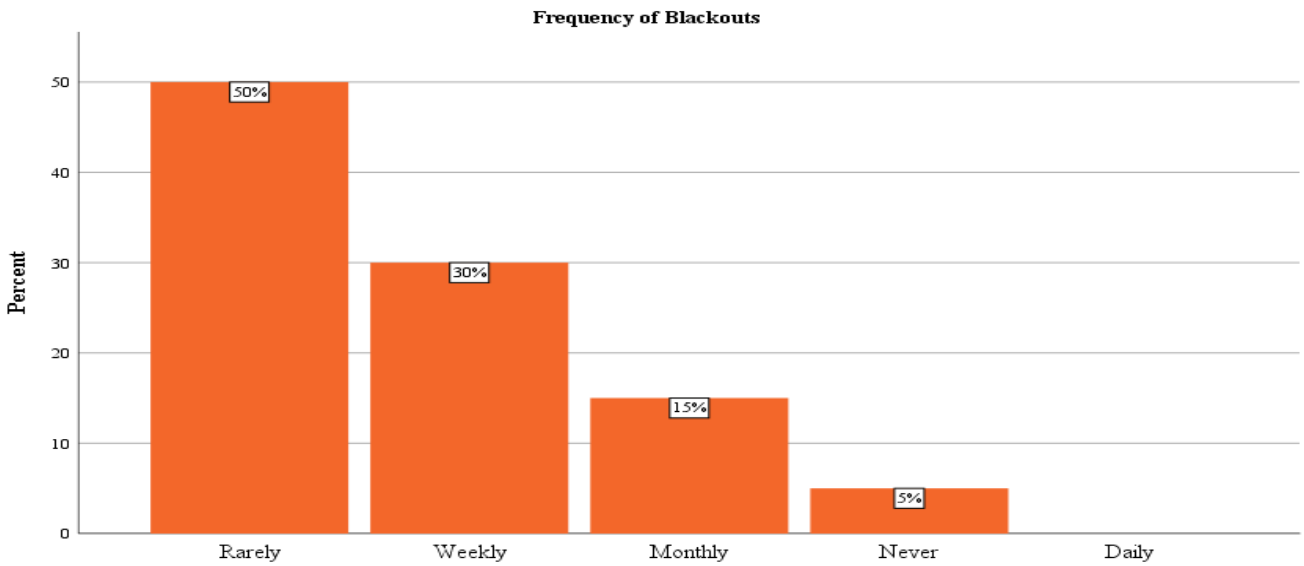
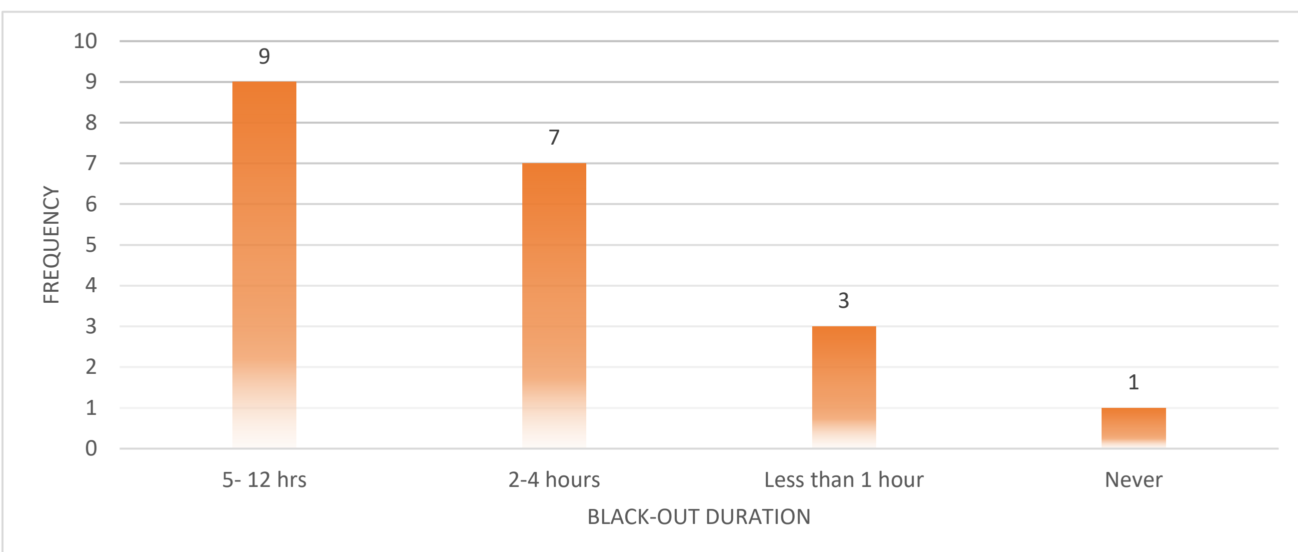


Figure 12: Duration of Black Outs

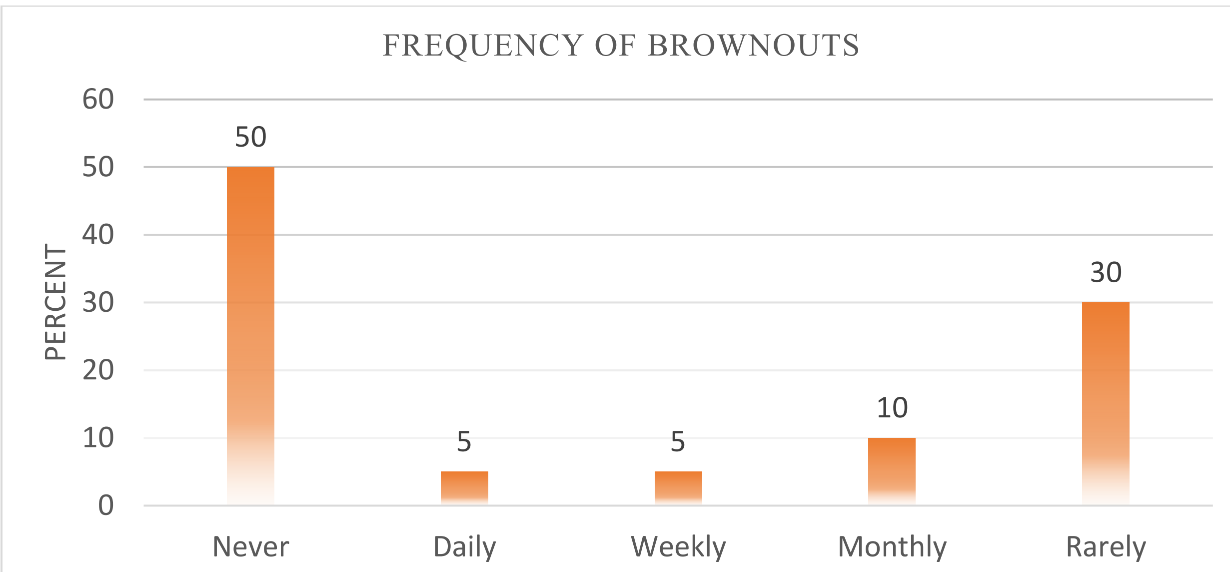


According to Figure 11, 50% of the households reported that they experienced blackouts rarely, 30% experienced blackouts weekly, 15% experienced blackouts monthly and 5% never experience blackouts. No household experienced blackouts on a daily basis. Figure 12 indicates that for 45% of the households (9HHs), the duration of the black outs lasted between 5 and 12 hours, for 35%

of the households (7HHs), the blackouts lasted between 2 and 4 hours, and for 15% of the households (3HHs) they lasted for less than 1 hour. Five percent of the households (1HH) never experienced blackouts.

Brownouts

Figure 13:: Occurrence of Brown Outs



According to Figure 13, 50% of the households (10HHs)never experienced brown outs, while 30% (6HHs) experienced them rarely. 5% of the households (1HH) each experienced brown outs daily and weekly respectively while 10% (2HHs) experienceed them monthly. No data was collected on the duration of the brownouts.

Quality of HH Wiring installations

Electrical tools used in Wiring Assessment

1. **Automatic Socket Tester**

It is a portable electrical gadget that one can use to test live sockets to make sure they are reliable, safe, and compliant with regulations. It is available in the Kenya market at a retail price of approximately Ksh 2000.

Figure 14:Image of the Socket Tester

Figure 15:Data Specification Sheet on Automatic Socket Tester

SPECIFICATIONS	PM6860ER
Voltage Range	220-250V 50-60Hz
GFCI/RCD Test	√
Tripping Current	> 30mA
LED Indicate Condition Of The Socket's Wiring	Correct
	Missing Earth
	Live –Earth Reverse
	Live –Neutral Reverse
	Missing Neutral
GENERAL	
Product Size	66mm x 61mm x 57mm
Product Weight	Approx. 60g
Safety Standard/ Rating	EN61010-1,EN61326,CAT.III 600V

Table 7: Results on Automatic Socket Tester

	Frequency	Percent
Correct	20	100.0

All the 20 households were found to have correct wiring when the socket tester was plugged into their sockets.

2. **Energy Meter**

Figure 16:Image of Energy Meter

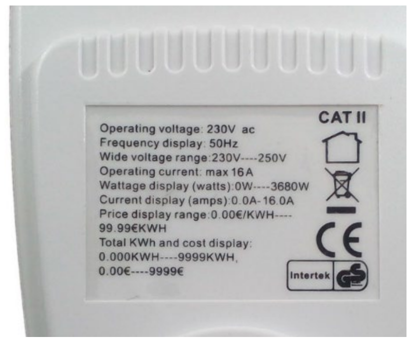
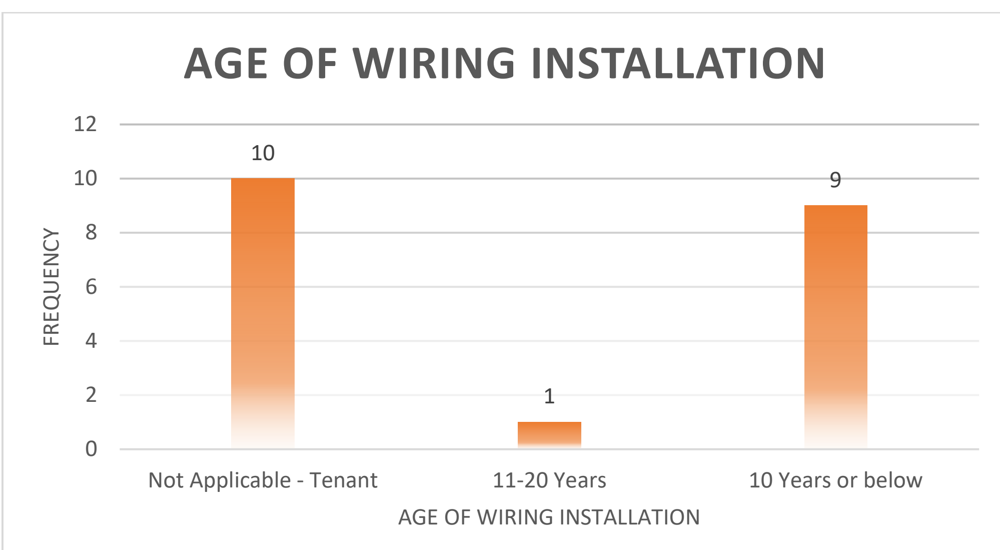


Figure 17:Data Specification Sheet/Nameplate

The energy meter covertly monitors the power consumption of all standby or working electronic devices. To this effect, the energy meter has a wide range of monitoring capabilities including readings on power (watt), energy (kWh), voltage, amplifier, hertz, power factor, minimum and maximum power, time, and electricity cost. When an appliance is removed from the meter or the meter removed from the socket, the energy meter will save the latest data. The energy meter retails in the Kenyan market at a price of approximately Ksh 2000.

Age of Wiring Installation

Figure 18: Age of Wiring Installation



The duration a wiring installation has been in existence is a major factor in determining its soundness. The IEEE regulations advises home owners to check on their wiring to ensure it is still working correctly after every 10 years. Another good practice is carrying out a simple, voluntary annual household energy audit to examine for current leakages and address any electrical issues immediately. Respondents with wiring older than 10 years were not asked if they had checked their wiring but were advised to do so as a matter of priority.

Electrical Issues; Bottleneck to Ecooking

Missing Meter box – The standard practice in electrical installation is the mounting of a meter box. This is a major component in electrical wiring installation. If it is missing, this is a major red flag on the state of the HH wiring. The meter box houses the KPLC 'electric Consumer Meter', the Cutoff fuse and a few other protective devices installed by KPLC for the safety of the consumer. The meter box protects the KPLC devices from harsh weather elements and tampering.

Table 8: Results on Meter Box Availability

	Frequency	Percent
No	1	5
Yes	19	95
Total	20	100

Missing CCU - The standard practice in electrical installation is the mounting of a Consumer Control Unit (CCU). The electrical consumer Control unit is a housing made up of a mains switch, several residual current devices (RCDs). It is responsible for powering and separating all the circuits in a household. The purpose of the electrical consumer unit is to protect electrical appliances, buildings from electrical fires, and shield humans from electrical shock.

Table 9: Results on CCU Availability

	Frequency	Percent
No	1	5
Yes	19	95

Total	20	100

Out of the20 households, 19 households were found to have installed CCUs as part of their electrical wiring installation while 1 did not.

Outdated Circuit Breakers – Currently the emphasis is on RCD circuit breakers hence any wiring installation using the old circuit breakers needs to be changed

Table 10: Results on Type of Circuit Breakers

	Frequency	Percent
Traditional/old generation	3	15
Residual Current Device (RCD)	17	85
Total	20	100

Residual Current Device (RCD) is a sensitive safety device that cuts off electricity within 10 to 50 milliseconds before an electric shock can occur. Installing RCD helps to prevent electrical damage to Ecooking appliances and also protect Ecooking users from electrocution and fire caused by earth faults. The project recommends replacing other types of circuit breakers with RCDs. 17 households out of the 20 households were found to have the recommended RCD circuit breakers while 3 had the old generation circuit breakers. Those with the old generation circuit breakers were advised to install the recommended RCD circuit breakers at a cost of Ksh 300 for each RCD exclusive of labor costs.

Table 11: Results on Circuit Breakers

	Frequency	Percent
No	1	5
Yes	19	95
Total	20	100

According to Table 11, 19 households were found to have circuit breakers and only one household did not have a circuit breaker as part of their electrical wiring installation. The project advised households with no circuit breakers to install circuit breakers as a matter of urgency.

Shared Meter boxes – For ecooking one needs to install at a sub meter so as to ensure they are in control of their electricity bill to eliminate the illusion that cooking with electricity is expensive. Also, if a sub-meter is not a viable option, then the HH should disclose the need for ecooking with the person they share the meter with.

Table 12: Results on Shared Meter

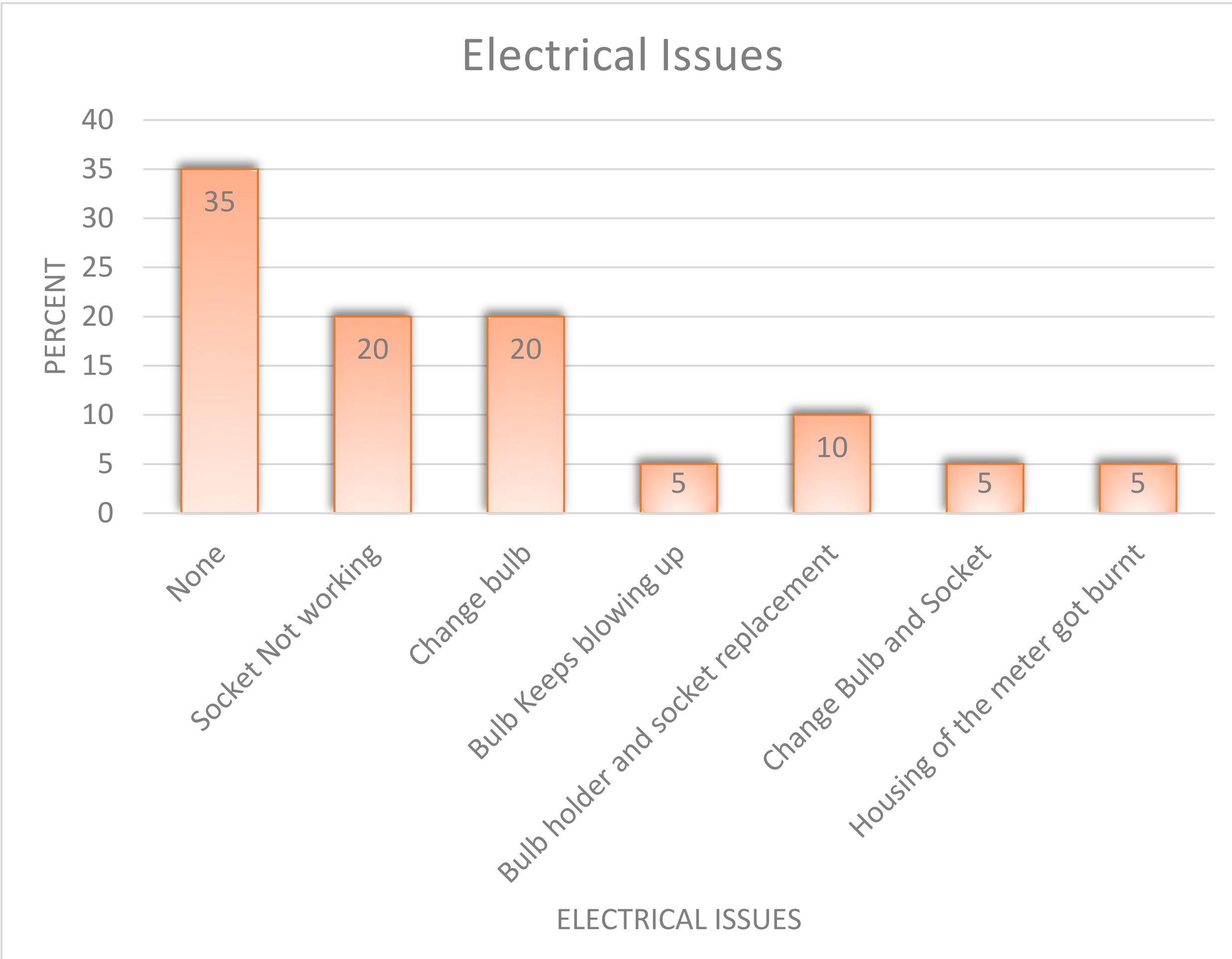
	Frequency	Percent
No	17	85
Yes	3	15
Total	20	100

According to table 12, out of the 20 households, 17 had a dedicated meter box while 3 had shared meter boxes. Those with shared meter boxes were advised to install submeters or get dedicated meters from KPLC.

Electrical Issues Experienced by Households

Even though no data was collected on size of socket cable, circuit breakers sizing and quality of cables used by households, it is known that poor socket cable size will keep melting, overloaded circuit breakers will keep on tripping and poor-quality cable can result in electrical fires. The figure below shows the common electrical issues encountered by the 20 households.

Figure 19:Other Electrical Issues Experienced by HHs



Average HH Daily Energy Consumption

A daily Energy Consumption Chart enables assessment of power leaks by comparing it to the analyzed average monthly electric bill. If the calculated cost from the daily Energy Consumption Chart is lower than the analyzed average monthly electric bill by a big margin this means that the household probably has power leakages through faulty wiring.

Table 13: Load Chart

SNO	Appliance	Load (W)	Units	Total Watts	Hours	WH/day
1	Lights	5	5	25	5	125.00
2	TV	36	1	36	5	180.00
3	Radio	13	1	13	5	65.00
4	Phone charging	5	2	10	2	20.00
5	Shower heaters	4500	1	4500	0.17	750.00
6	Iron box	1500	1	1500	0.17	250.00
	TOTAL			**6084**		**1,390.00**

Table 13 above shows that on average households used electricity of about 1.390kwh daily.

Table 14 below shows calculations of cost of daily, monthly, and annual energy consumption.

Table 14: Energy Consumption Cost

	units(kwh)	unit cost (ksh)	Avg elec. cost	analyzed cost
Daily kwh	1.39	26.1	36.28	36.23
Monthly kwh	41.7	26.1	1,088.37	1,087
Annual kwh	500.4	26.1	13060.44	13,044

Sample data from Table 14 indicates that the average daily energy consumption of electric appliances in the household was 1.39kwhs. If the calculated cost from the Energy Consumption Chart is lower than the analyzed cost (actual electricity bill paid) this means that the household probably has power leakages through wiring or other variables that makes the household pay more on electricity compared to their consumption. In this case as indicated by Table 11, the discrepancy is negligible indicating that there are probably no power leakages. None of the 20 households indicated any power leakages

ECooking Readiness

One of the most important aspects of Ecooking is power availability where Ecooking appliances can be plugged in for cooking. As such, having sockets in the kitchen is critical in assessing readiness for Ecooking and potential to adopt Ecooking practices. Figure 20 presents data on socket availability in households visited.

Sockets in the Kitchen

Figure 20: Socket Availability in the Kitchen

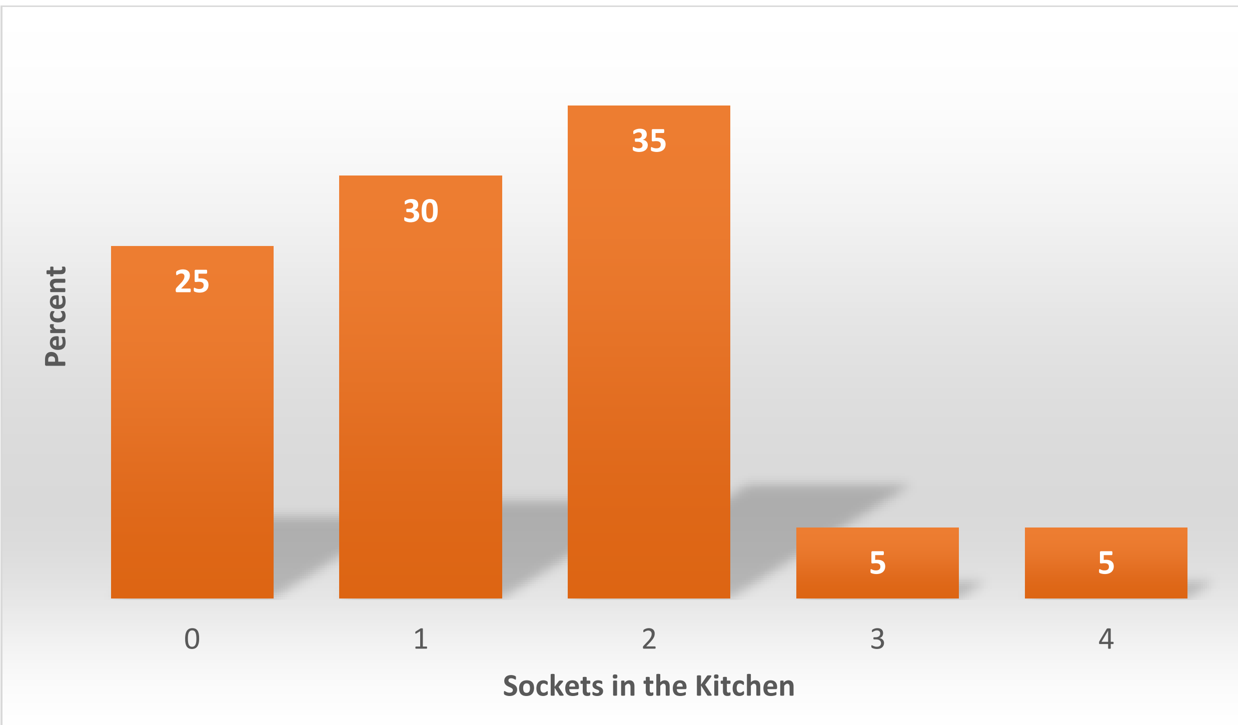
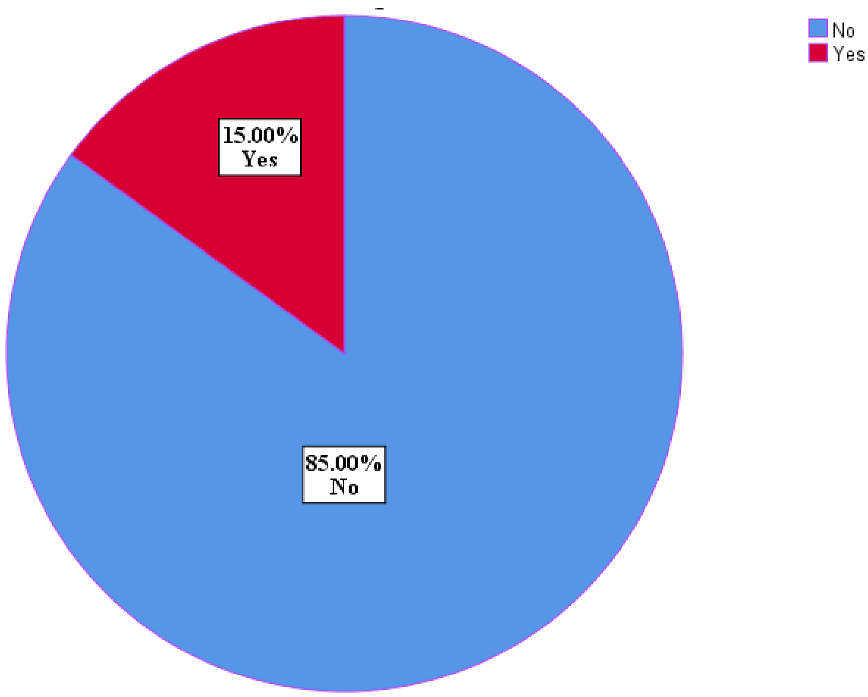


Figure 20 above shows that 35% of HH had 2 sockets, 30% had 1 socket, 25% had zero socket, 5% had 3 sockets in the kitchen and 5% had 4 sockets in the kitchen. All those with zero sockets were willing to have a socket installed and were advised on the cost implications.

Protective devices in Households

Figure 21: Households Using Electrical Protective Devices



As shown in Figure 21, 15% of households were using protective devices while 85% were not using any form of protective devices. Households were using fridge guards or TV guards. The AVS is the ideal protective device because it protects all your electrical and electronic gadgets from damage when installed at the CCU or meter box. However, because the analysis indicates that blackouts and brownouts are a rare occurrence in the region, households were advised accordingly on the purchase and installation of protective devices. While it is not necessary, it is a good cautionary measure to protect devices in case of irregularities in their power supply.

Figure 22: Image of AVS

Low power (under-voltage) will not damage Ecooking appliances but the appliance will not operate. High Power (Over voltage) will damage Ecooking appliances and it is therefore recommended for user to install an AVS to protect against over voltage, power-back surges and spikes/surge protection which would otherwise damage any Ecooking appliance.

Overall, the wiring assessment revealed that 75% of households that participated in study had the requisite wiring installations and critical components necessary to support Ecooking including correct wiring, a meter box, CCU, RCD, at least one kitchen socket, and submeters where applicable. However, there were still instances where some non-critical components were missing meaning that although such households could use Ecooking appliances, their safety or efficiency could not be guaranteed. For example, while a missing meter box generally exposes consumers to the risk of tampering and electric shock, it does not necessarily mean that wiring inside the household is faulty and cannot support Ecooking especially when all other components are present. Therefore, households whose wiring installation could not support Ecooking (25% of Households) would have to incur the cost of installing a kitchen socket and an RCD (≈ Ksh 1, 400) to adopt Ecooking as opposed to installing all the components in a worst-case scenario (≈ Ksh 10, 200).

E-Waste Management

E-waste management is an important aspect of electrical and electronic use. It is especially important in this era of climate change and environmental pollution mitigation. Since ecooking is a fairly new phenomenon in Kenya, the waste it is expected to produce should be discussed now. As such, the wiring assessment tool sought to understand the current practice of disposing of eWaste

Figure 23 below shows the disposal methods of households when it comes to electronic and electrical waste.

Figure 23: E-Waste Management

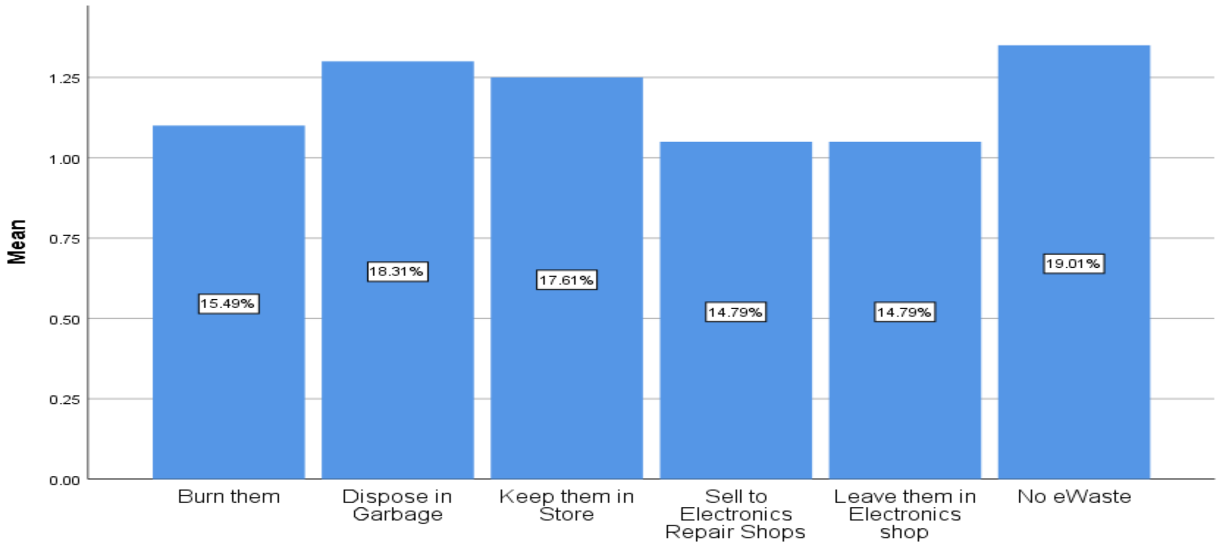


Figure 23 shows that most people did not have eWaste at 19.01%, followed by 18.31% that disposed of their eWaste in the garbage. 17.61% indicated that they kept their eWaste in storage while 15.49% said they burnt their eWaste. 14.79% of households indicated that they sold their eWaste to electronic repair shops and another 14.79% left their eWaste in electronic repair shops. The above data shows that there is need to keep on improving the eWaste management by coming up with a system that would be environment friendly and also great for the household's economics.

Final Kitchen Energy Audit Tools

Data Collection Tools

To Access the Data Collection Tools on KoboCollect Web Platform, Click on the Links Below

Alternatively, if using an android device, follow the KoboCollect Manual from **STEP 10**

Kitchen Energy Baseline Data Collection Tool: https://ee.kobotoolbox.org/x/6sHQKeg3

Household Wiring Assessment Data Collection Tool: https://ee.kobotoolbox.org/x/EpUhUScC

Kobo Collect Manual: KoboCollect Manual.pdf

Data Analysis Tools

To access the data analysis tools install the latest version of IBM SPSS (not older than version 25) and open the respective code-book files

Kitchen Energy Baseline Data Analysis Tool: 

Household Wiring Assessment Data Analysis Tool: 

Feed in the collected data into the analysis tools (code books) and analyze per variable of interest.

Recommendations

1. A kitchen energy audit should be administered annually in households to enable HH to evaluate energy use and inspect ways on how to save energy or improve a HH's kitchen energy mix.
2. Household Electrical Wiring Assessment should be carried out annually to avoid abnormal bills, safety hazards, and improve household confidence in use of HH electricity.
3. ECooking organizations should advocate for 'meter separation' or sub meter installation whenever they come across shared metering.
4. Always inform the KPLC office formally via writing whenever you find an area has severe or frequent brownouts or blackouts that might be significant enough to hinder ecooking adoption.
5. Advice potential clients to install extra-sockets in the kitchen when using an EPC instead of using an extension
6. Find a way to confirm cable sizes in any household that reports regular or persistent electrical issues or abnormal bills

S/N.	Household Electrical Wiring Circuits	Recommended Cable Size
1	LIGHTING	1.5mm2
2	SOCKETS	2.5mm2
3	COOKER SOCKET	10mm2
4	SHOWER	6.00mm2

100% of the households (20HHs) had 2.5mm^2 cabling to their sockets in the kitchen. A cooker socket is for the big four plate cookers with integrated ovens as opposed to normal sockets that could support smaller plug-in cooking devices.

7. Instead of buying protective devices for each electrical appliances e.g. fridge guards, better to install an AVS at the CCU point so as to protect all your electrical devices While fridge guards and power guards are priced between Ksh 1, 000 on the lower end and up to Ksh 4, 000 on the higher end, they only protect one electrical device at a time compared to an AVS that is priced between Ksh 4, 000 up to Ksh 8, 500 and protects the entire household's electrical appliances.
8. Generally, a design goal of a resistance-to-ground of less than 5 ohms for most installations is recommended. For sites with sensitive electronics, IEEE recommends a design goal of a resistance-to-ground of less than 1 ohm. If after measurement it is above the 5ohms then the earthing needs to be treated by a qualified technician. Using the socket testing device, it was determined that all of the 20 households met this specification
9. Cables should be checked for proper color coding. However, none of the 20 HHs had colour coding issues.

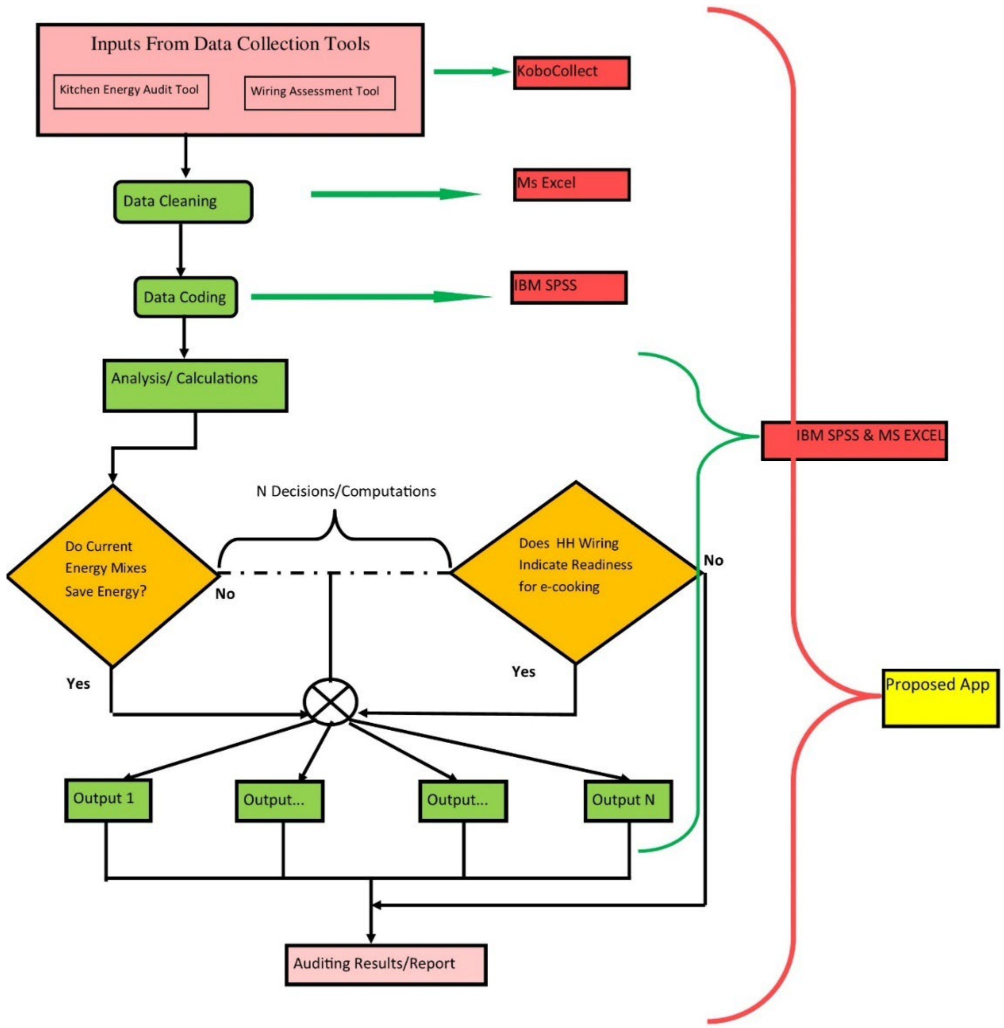
S/N.	Cable Description	Coded Colour
1	Live Cable	Red/Brown
2	Neutral Cable	Black/ Blue
3	Earthing Cable	Yellow with a green strip/ Green

The Future: Going Forward

The tools developed require technical know-how in order to carry out the energy audits. The Project recommends developing an application to automate the process for ordinary people's use. The App will be used to collect data, analyze it and post the results automatically without much human intervention. As shown in Figure 23, the auditing process requires different software tools (KoboCollect, IBM SPSS, MS EXCEL, MS WORD) from point of data collection, cleaning, coding, computation, and ultimate production of auditing and assessment results, all with different levels of technicality.

However, the project has developed a simple methodology that could provide advice to households considering cooking with electricity, so that they could understand what they would need to do to get their kitchen ready for eCooking and what the likely benefits (cost, time savings etc.) would be if they made the switch. All this has been done using a simple checklist with the right questions and well researched relevant advice depending upon the answers given. This process could certainly be streamlined with an app to allow everyday cooks to assess their own kitchens.

Figure 24: Process and Software Tools Requirements for Energy Auditing and Wiring Assessment



The proposed App as indicated in Figure 24 above will negate the need for technical know-how and multiple software tools to produce reliable results as far as wiring assessment and energy auditing is concerned. Additionally, it will make self-auditing much simpler and confidential without reliance on third parties for data analysis. The App developed can be made available in the public domain for wider use by actors in the energy sector.

KPLC meter readers could help customers fill in the data into the checklist and the KoboCollect data collection tools for analysis once a year.

Conclusion

The main aim of the project was to develop and test kitchen energy auditing and wiring assessment data collection and analysis tools. The final deliverables comprised of wiring assessment data collection tool, wiring assessment data analysis tool, kitchen energy audit baseline data collection tool, and kitchen energy audit baseline data analysis tool.

Development, piloting and ultimate deployment of the data collection tools was noted to be without many hurdles throughout the project life. However, it was noted that energy auditing was still an unfamiliar concept in most households who perceived the data collected for auditing as intrusive to their privacy. This made administering the questionnaires a bit challenging as a lot of attention had to be given in clearly explaining how the data collected would ultimately help households in monitoring their energy consumption in the kitchen and benefit from other energy efficient practices as far as cooking was concerned. Nevertheless, the data collection tools developed were successful in capturing pertinent information key to the success of household energy auditing and by extension success of the project.

In developing the required analysis tools, it was noted that the technical element of the whole process in converting collected data to actionable results was still out of reach for ordinary persons and stakeholders. In particular, the process requires multiple proprietary software tools, and a professional background in data analysis. To this end, while SCODE's project team was able to deliver tools that can be used for analyzing collected data as far as kitchen energy auditing and wiring assessment is concerned, users still require professional and technical interventions to accentuate meaningful results. Additionally, it was noted that data from CCTs was required as an input in computing the potential cost, time, and energy savings of using various kitchen energy mixes. Therefore, data from your previous MECS projects, was utilized to give people an indication of the savings they would likely make if they adopted eCooking.

As such, to eliminate the technical element that might curtail the use of the analysis tools by ordinary people for self-auditing and other stakeholders in the energy sector, the project team recommends development of a mobile application. The mobile Application will compound all the technical stages of auditing (data cleaning, data coding, data analysis/calculation) into a background process so that users only have to interact with the data collection, results presentation, and recommendation stages of the auditing process. To develop the mobile Application, SCODE appeals to MECS for financial support in building on the already existing wealth of knowledge and experience gained during the project lifeline to actualize a working kitchen energy audit mobile Application.

Nevertheless, the project team was able to deliver on its mandate as far as the project objectives were concerned. The original objective from the ToR was do develop "a streamlined version of the energy audit methodology that could be applied to kitchens to enable cooks understand the potential costs and benefits of changing the way they cook." The project developed a template for a checklist indicating what advice would be offered to each of the respondents in terms of the costs and benefits to them of transitioning to eCooking.

The checklist helps the user to calculate how much money they would typically save each month on cooking fuel by adopting eCooking taking into account increases in their electricity bill. The cost of the Ecooking appliance (Ksh 12, 091 for Pawapot EPC) and the cost of upgrading kitchen wiring to include a kitchen socket, and an independent RCD (Ksh 1,400) total to Ksh 13, 491. Therefore, considering the cost savings (Ksh 1,482) as shown in the Kitchen Energy Audit Baseline Data Checklist, the typical payback period would therefore be ≈9 months.

References

Energy audit guide: How to conduct a business energy audit. (2018, June 19). SEFE Energy. https://www.sefe-energy.co.uk/energy-guides/how-to-conduct-an-energy-audit-of-your-business/

Home | energy sparks. (n.d.). Retrieved July 19, 2023, from https://energysparks.uk/

Household Air Pollution. (2022). https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health

Sustainable development goals | united nations development programme. (2023). UNDP. https://www.undp.org/sustainable-development-goals/affordable-and-clean-energy

Appendix

Appendix 1: Kobo Collect Manual

KoboCollect Manual.docx

Appendix 2: Raw Data Files

Energy_Wiring_Assessment_Tool Raw

Kitchen_Energy_AuEdit_Tool_Raw Data.x

Appendix 3: Kitchen Energy Audit Baseline Data Checklist

Kitchen Energy Audit Checklist.xlsx

Appendix 4: Kitchen Energy Audit Wiring Data Checklist

Wiring Assessment Checklist.xlsx

Appendix 5: Kitchen Energy Audit Baseline Data Collection Tool

Kitchen Energy Audit Tool F.V.pdf

Appendix 6: Kitchen Energy Audit Wiring Data Collection Tool

Energy Wiring Assessment Tool F.V

Appendix 7: SCODE Controlled Cooking Test Data

Baseline Data Rice & Meat.xlsx

BASELINE Ugali & Sukuma.xlsx

Baseline Data (2) Githeri Final.xlsx