Project Title: Kitchen Energy Audit for e-Cooking

E-Cooking Demo During Baseline Data Collection Exercise (source SCODE 2023)

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Last but not least, we like to express our gratitude to the two enumerators who worked tirelessly and provided crucial feedback to ensure the field piloting of the tools was successful.

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 ensuing document captures all the steps undertaken by SCODE's project team in developing, piloting, and deploying kitchen energy auditing and wiring assessment data collection and analysis tools.

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

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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

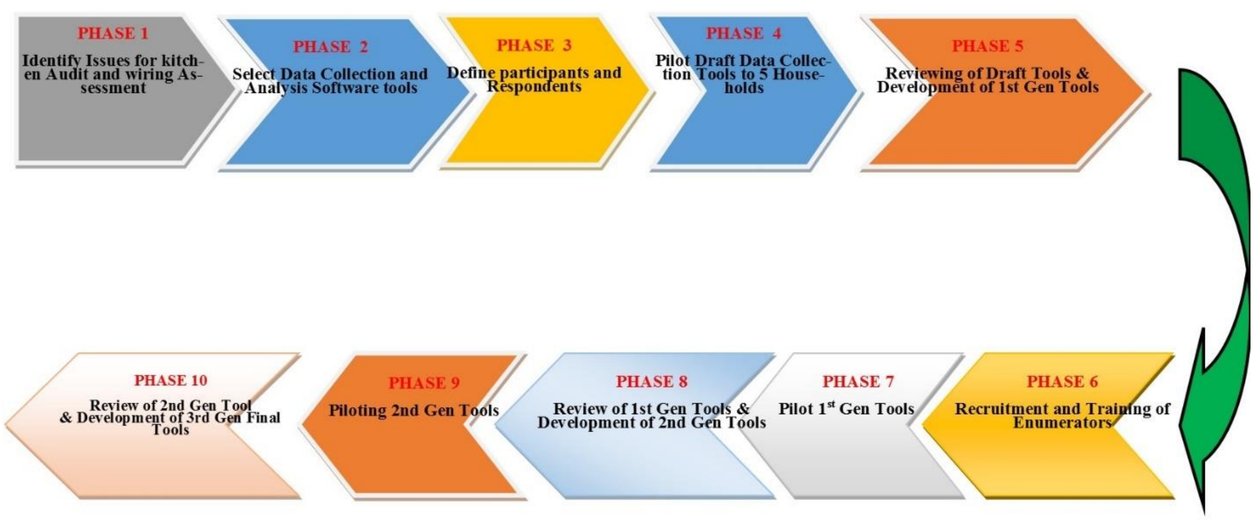
c) Kitchen Energy Audit Baseline data collection tools

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: Identification of 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 first identify and understand the issues pertinent to the process by examining the existing pool of knowledge available in the public domain.

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 understating 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 2 enumerators (1 man, 1 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 rescruitment. Gender was also considered with the two enumerators being from both genders.

Participating households were selected based on Convenience Sampling dictated by the project parameters. The project parameters that were considered for households to participate were grid connectivity (participating households had to be already connected to electricity through the national grid system), willingness to participate, household heads of participating households had to have basic education, and household size of 4 persons and above.

Geographically, households and participating enumerators were also selected through convenience sampling with reference to their proximity to SCODE's main offices within Bahati sub-county.

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.

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 intended to visit 10 households from each strata. Secondly convenience sampling was used based on the aforementioned project parameters in phase 3 (grid connectivity, willingness to participate, households with basic education, and household size of 4 persons and above). Thirdly, simple random sampling was done in the selected locations with the help of field guides who were familiar with the areas selected.

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. Simple random sampling was used to select individual households among the qualified households.

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.
- 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.

Analysis of the Results

Kitchen Energy Audit

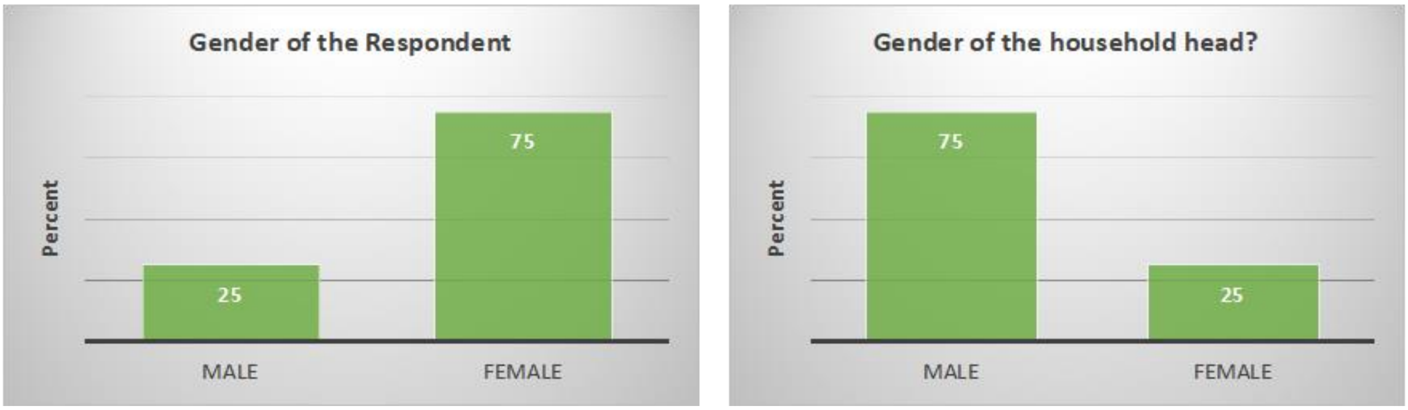
While the actionable data collected using the developed kitchen energy audit and wiring assessment tools was limited in the scope of households covered, it highlights the effectiveness of the tool in gathering critical information necessary for energy auditing and wiring assessment.

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

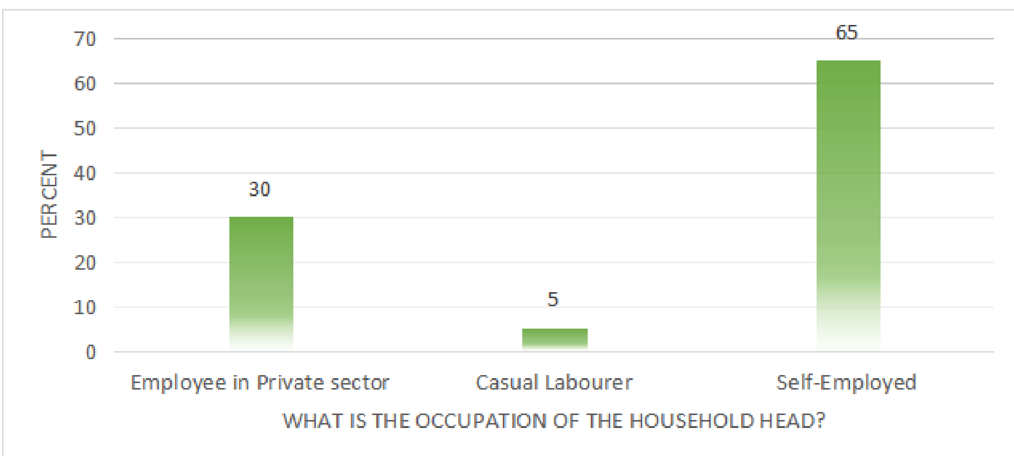


Figure 3: Occupation of Household Head

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

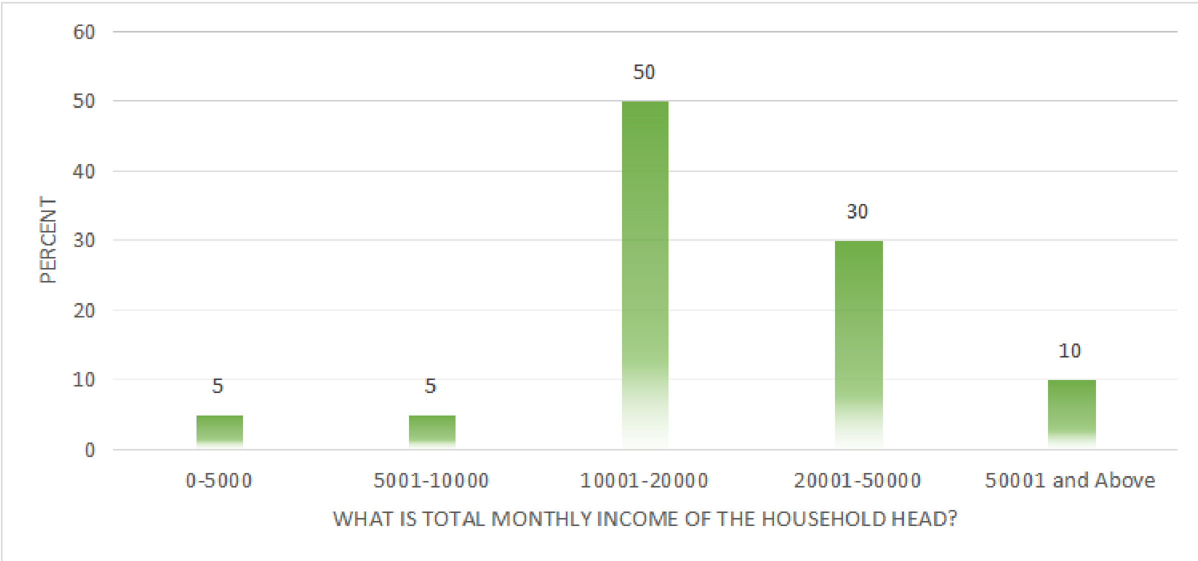


Figure 4: Income of Household Head

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.

Literacy Levels

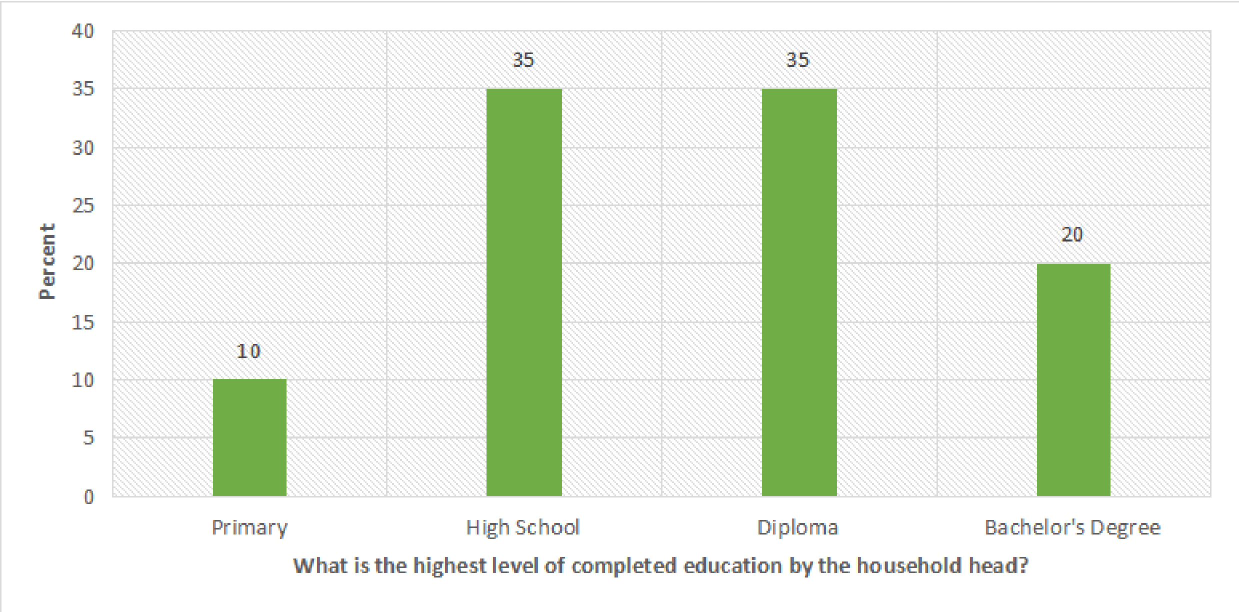


Figure 5: Highest Level of Completed Education of Household Head

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.

Correlation Analysis

Household information is critical in determination of relationships with other variables that eventually inform on how energy consumption and use in the kitchen is impacted by variables outside the kitchen such as literacy levels, gender, income, and occupation.

Table 1: Sample Linear Regression Analysis Between House Hold Head Education Level and Charcoal Use

Model Summary									
				Std. Error	Change Statistics				
		R	Adjusted	of the	R Square	F			Sig. F
Model	R	Square	R Square	Estimate	Change	Change	df1	df2	Change

1	.262[a]	.069	.017	1.136	.069	1.327	1	18	.264

a. Predictors: (Constant), What is the highest level of completed education by the household head?

Table 2: Sample Linear Regression Analysis Between House Hold Head Education Level and Charcoal Use

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.713	1	1.713	1.327	.264[b]
	Residual	23.237	18	1.291		
	Total	24.950	19			

a. Dependent Variable: Charcoal Preference Rank

b. Predictors: (Constant), What is the highest level of completed education by the household head?

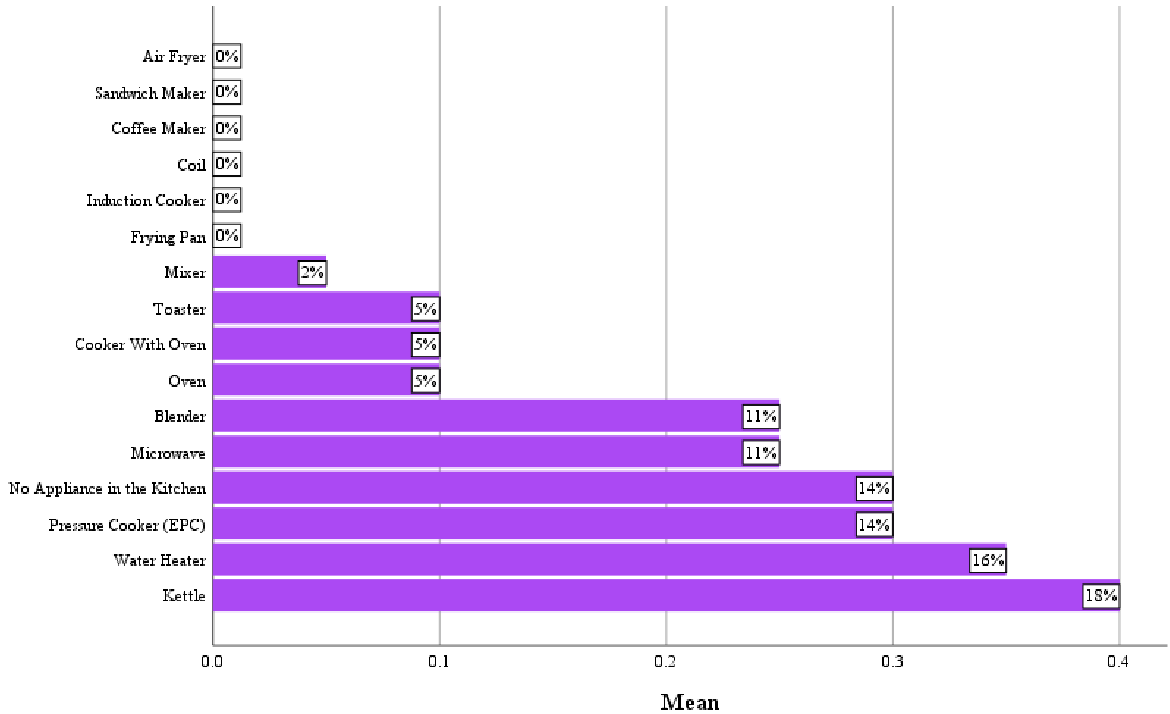
According to the regression results in Table 1 the simple linear regression model indicates that the house hold head level of education accounts for 6.9% (0.262) of charcoal use. Therefore, 93.1% of the variance in charcoal preference was explained by other factors not in the model.

The F-statistic value was found to be insignificant ($F(1,19) = 1.327$, $p = 0.264$), indicating that the level of education of the house hold head is not a significant predictor of charcoal preference rank. Consequently, the null hypothesis that there is no statistically significant relationship between education level of household head and charcoal preference was accepted at 0.05 level of significance.

Drawing from Tables 1 and 2, other relationships can be extrapolated as needed from data collected by the kitchen energy auditing tool.

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 energy consumption of the e-cooking appliances can further be calculated from data collated by the kitchen energy auditing tool as demonstrated in Table 3

Table 3:: Sample Load Chart Calculated using Collected Data

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 4:Calculated cost vs Analyzed cost of Electricity Consumption

	units(kwh)	unit cost (ksh)	Calculated Cost	Analyzed cost
Daily kwh	1.39	26.1	36.28	36.23
Monthly kwh	41.7	26.1	1,088.37	1,087.00
Annual kwh	500.4	26.1	13060.44	13,044.00

Sample data from Table 3 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 4, the discrepancy is negligible indicating that there are probably no power leakages.

Foods Cooked

Figure 7: Foods Commonly Cooked in Household Kitchens

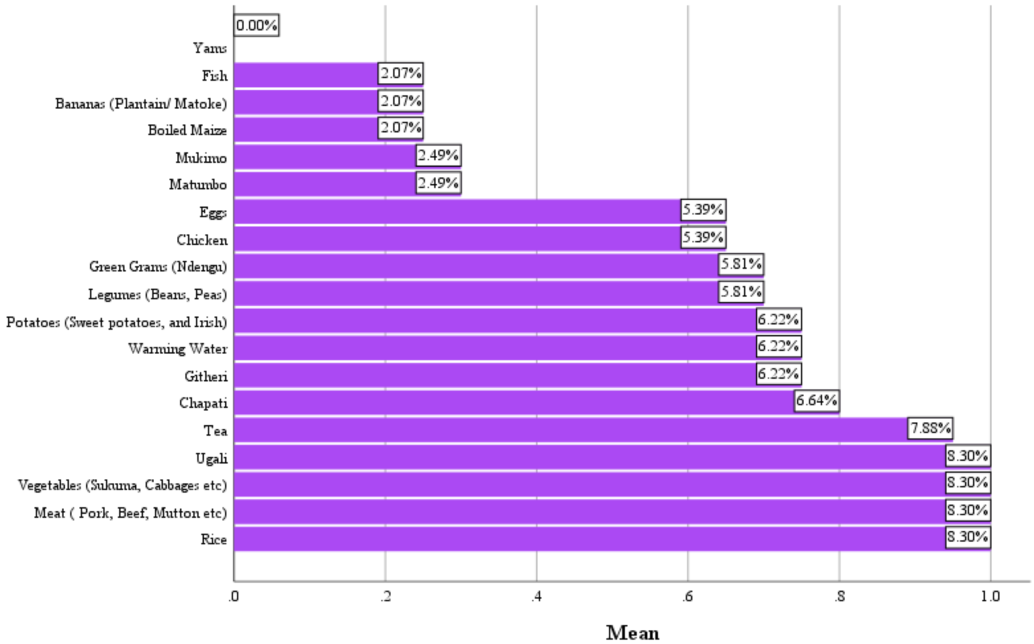


Figure 7 depicts what foods are commonly cooked in household kitchens. The data can then be analysed in a number of ways including the time taken to cook each food using different fuels as indicated in Figure 8 below.

Fuels Used to Cook Foods vs Time Taken

Figure 8:Fuels Used to cook Foods vs Time Taken

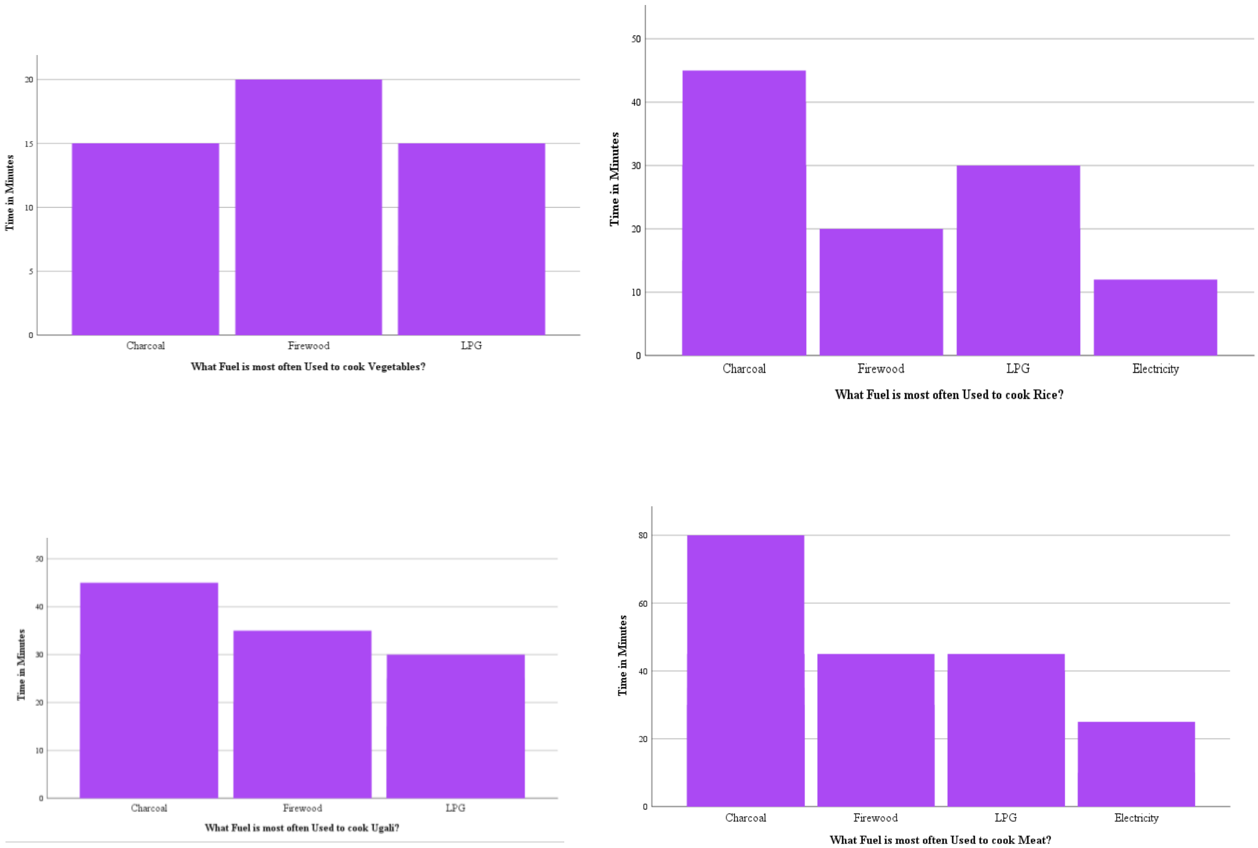


Figure 8 above depicts sample data on the types of foods cooked versus the time taken when using different fuels. When compared against CCT's of individual foods and fuels, cost benefit ratio can thus be calculated. Additionally, the kitchen energy data collection tool also avails data on methods of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

Fuels Used, Cost, and Fuel Stacking

Figure 9:Primary, Secondary, and Tertiary Fuels

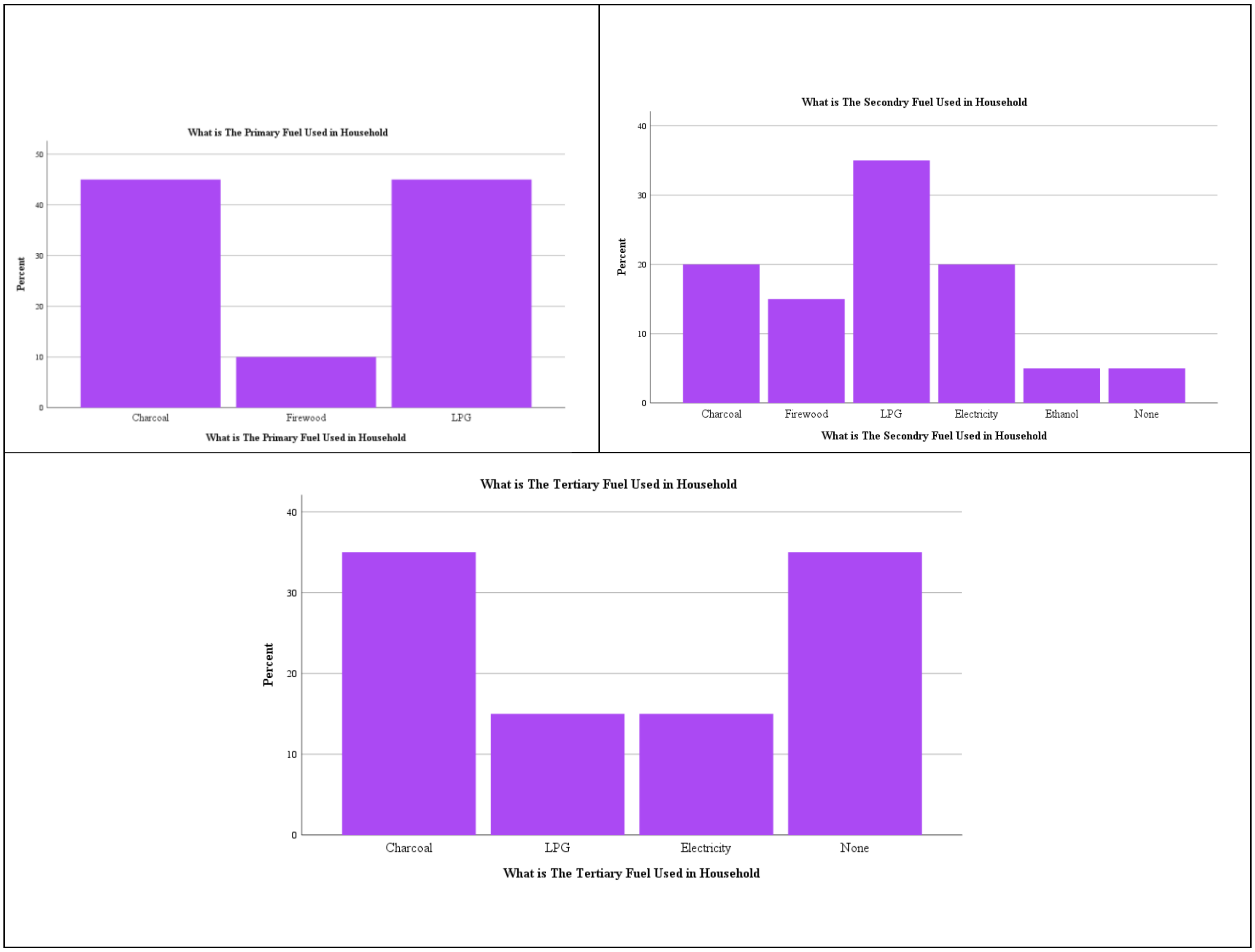


Figure 9 displays sample data on fuel usage in household kitchens depicting the most common fuels used as energy sources for cooking. When used with Figure 10 below, average costs of fuels can be computed and cost benefits of switching between fuels demonstrated.

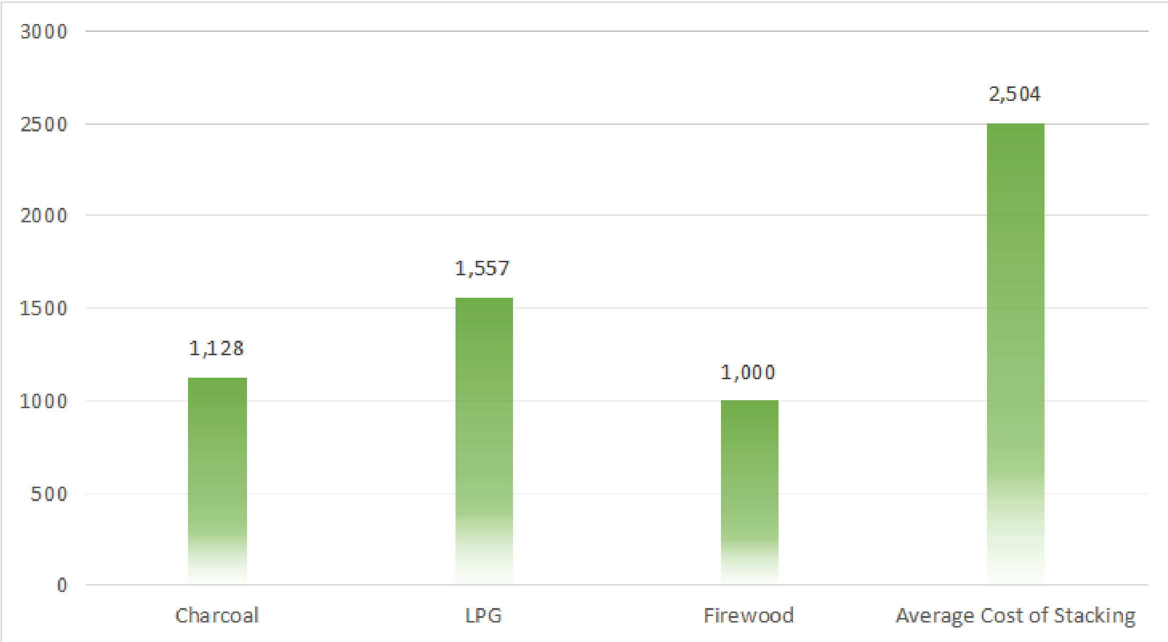


Figure 10: Average Fuel Expenditure per Month for Household Kitchens

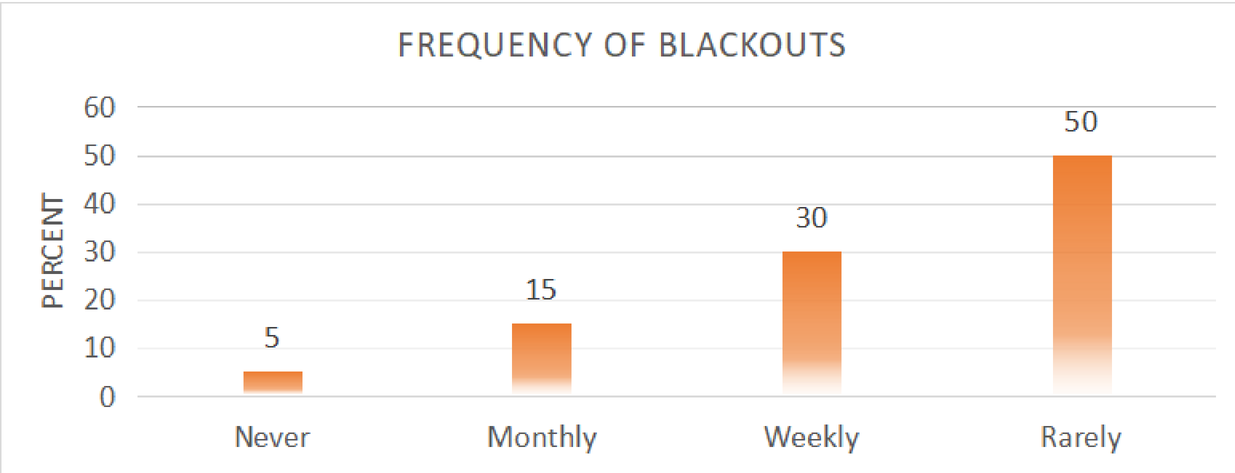
Wiring Assessment

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.

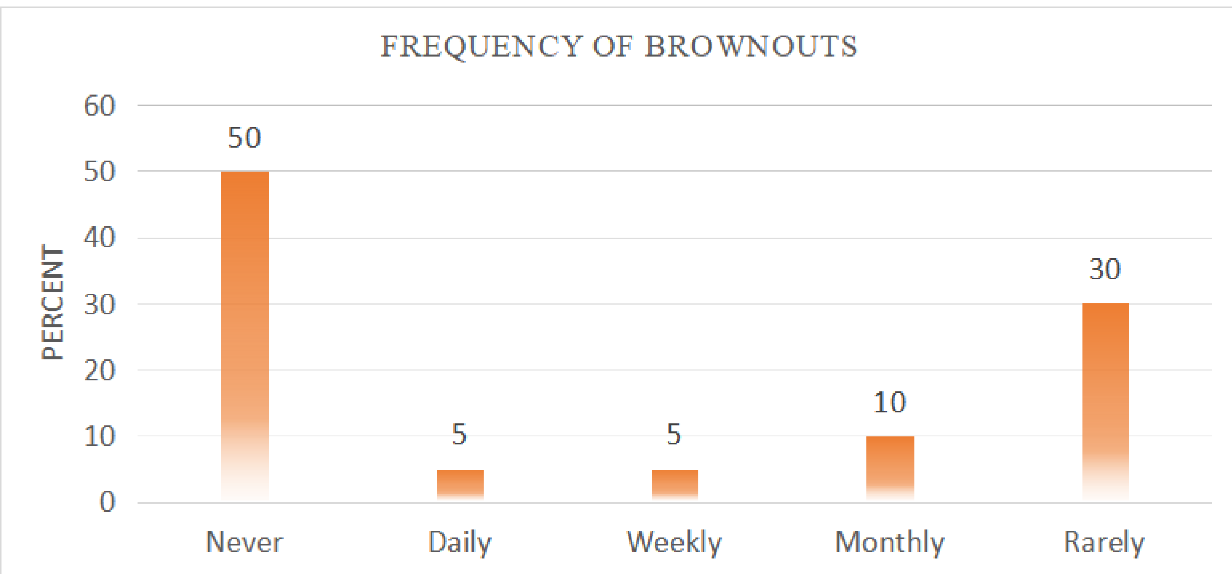
Blackouts

Figure 11: Occurrence of Electricity Blackouts



Brownouts

Figure 12:: Occurrence of Brown Outs



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.

Figure 13:Image of the Socket Tester

Figure 14: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 5: Results on Automatic Socket Tester

	Frequency	Percent
Correct	20	100.0

2. Plug Energy Meter

It is a versatile electricity monitoring device with a variety of applications as far as energy monitoring is concerned.

Figure 15:Image of Plug Energy Meter

Figure 16:Data Specification Sheet/Nameplate

The plug energy meter has inbuilt energy monitoring features:

a) POWER USAGE MONITORING: You can covertly monitor the power consumption of all your standby or working electronic devices. With SET, VALUE, DISPLAY to set the power rate; you can also set the nightly rate individually, you can determine how much your standby devices are costing and what the power factor is. Help you reduce power consumption and save money.

b) WIDE RANGE OF USE: power (watt), energy (kWh), voltage, amplifier, hertz, power factor, and minimum and maximum power, 7 modes for your choice. Kilowatt hour, time, and electricity cost. The total time can be displayed on the LCD screen, and you can easily get the power consumption. When you remove the appliance from the meter or remove the meter from the socket, the meter output will save the latest data

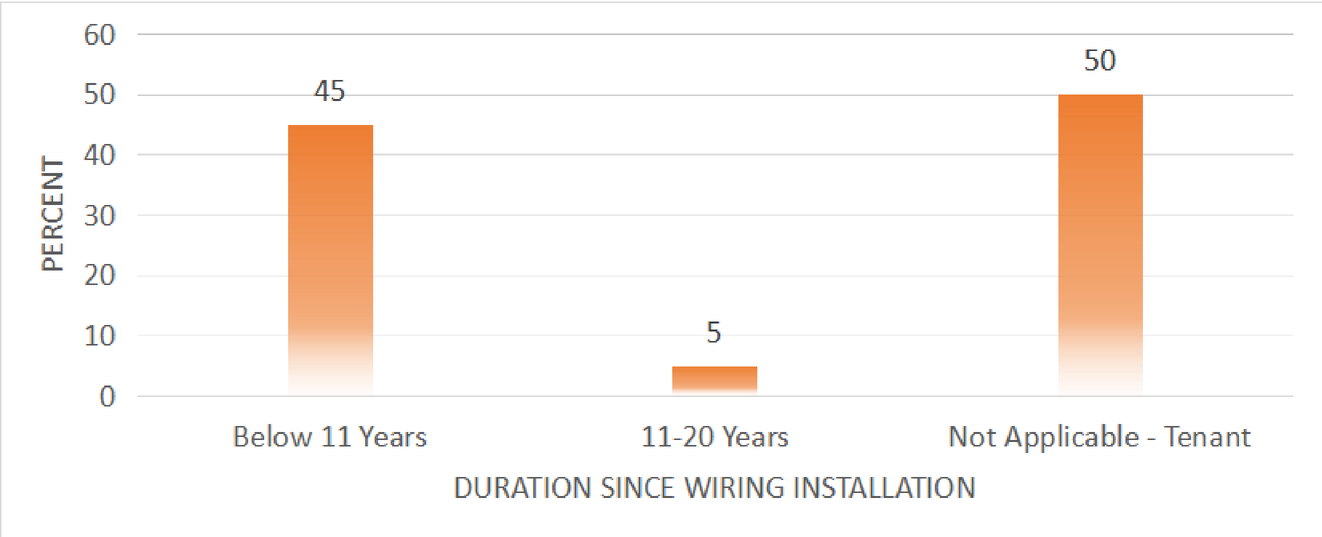
c) DATA MEMORY FUNCTIONALITY: When you take it off the socket or remove the appliance from the power monitor, the wattmeter will record your electricity consumption data. The next time you use it, you can see the last data directly. This function also saves the data automatically when there is a sudden power failure.

d) OVERLOAD PROTECTION: LCD display overload warning, easy and safe to use. When the whole power exceeds the 1650W rated power of the monitor, LCD will display "overload" with a roaring sound to warn the user and disconnect the power automatically. It is the ideal energy consumption monitor.

e) DIGITAL LCD: The power consumption display uses a large, clear backlit LCD with an open, clear view, making it easy to read and record data, especially in the dark. Note: Please look at the numbers from the front, not from the side.

Duration of Wiring since Installation

Figure 17: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.

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.

Table 6:Results on Meter Box Availability

	Frequency	Percent
No	1	5.0
Yes	19	95.0
Total	20	100.0

- **Missing CCU** - The standard practice in electrical installation is the mounting of a Consumer Control Unit (CCU). 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

Table 7:Results on CCU Availability

	Frequency	Percent
No	1	5.0
Yes	19	95.0
Total	20	100.0

- **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 8:Results on Circuit Breakers

	Frequency	Percent
Traditional/old generation	3	15.0
Residual Current Device (RCD)	17	85.0
Total	20	100.0

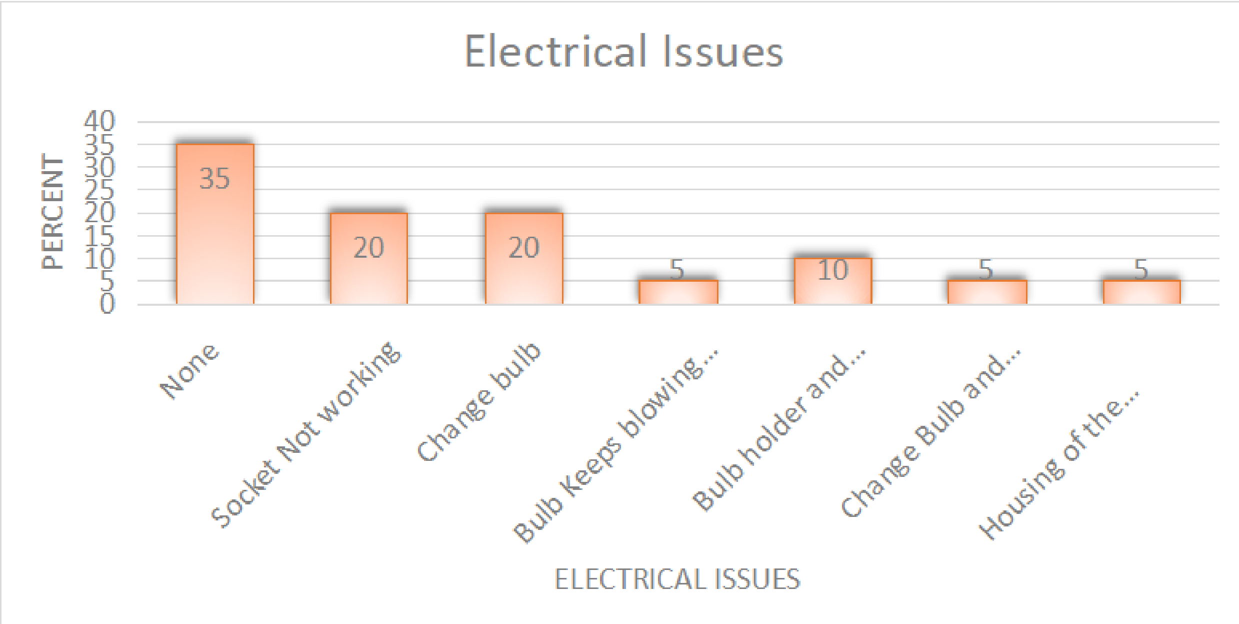
- **Shared Meter boxes** – For ecooking one needs to install at a sub meter so as to ensure they are in control of their electricity bill to eliminate the illusion that cooking with electricity is expensive. Also, if a sub-meter is not a viable option, then the HH should disclose the need for ecooking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

Table 9:Results on Shared Meter Boxes

	Frequency	Percent
No	17	85.0
Yes	3	15.0
Total	20	100.0

- **Poor Socket Cable size**: The cables will keep on melting if they are undersized.
- **Undersized Circuit Breaker**: The circuit breaker will keep on tripping if it is undersized.
- **Fake cable Brands**: If the cable is fake is might have issues of under sizing.

Figure 18: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 10: 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**

The table above shows that on average households used electricity of about 1.390kwh daily.

Table 11 below shows calculations of cost of daily energy consumption.

Table 11: Daily 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	1,087.00
Annual kwh	500.4	26.1	13060.44	13,044.00

ECooking Readiness

Sockets in the Kitchen

Figure 19:Socket Availability in the Kitchen

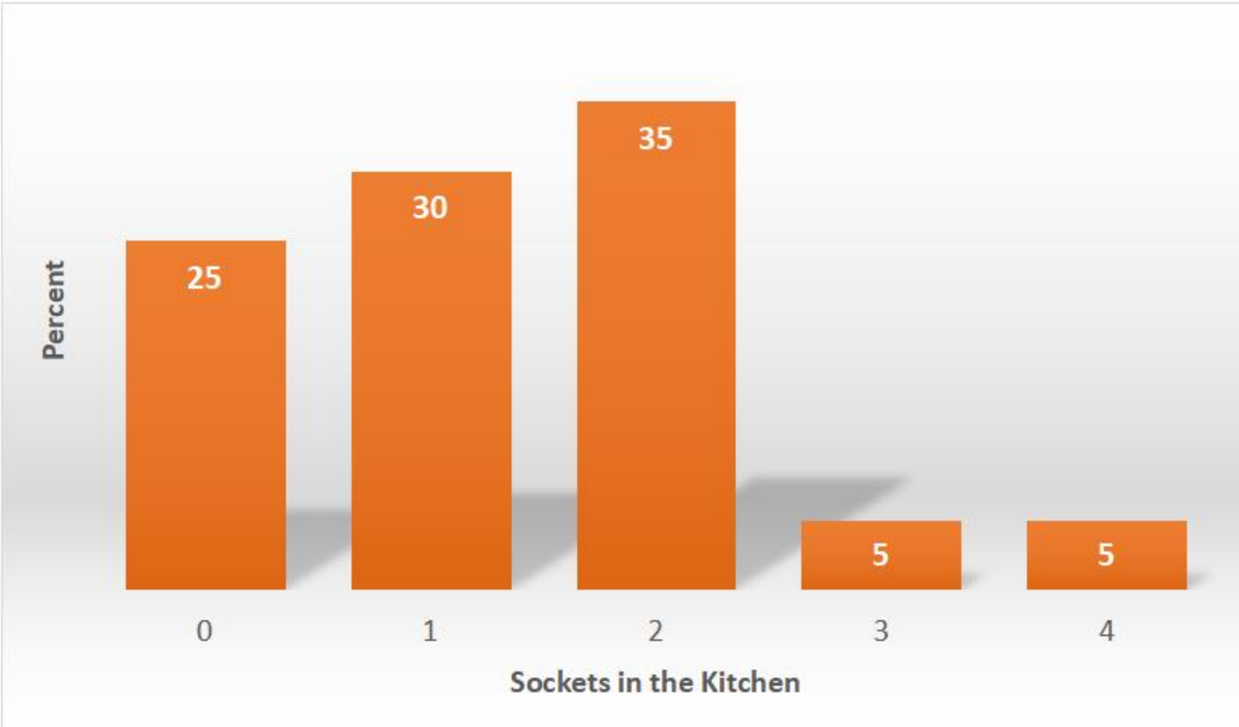
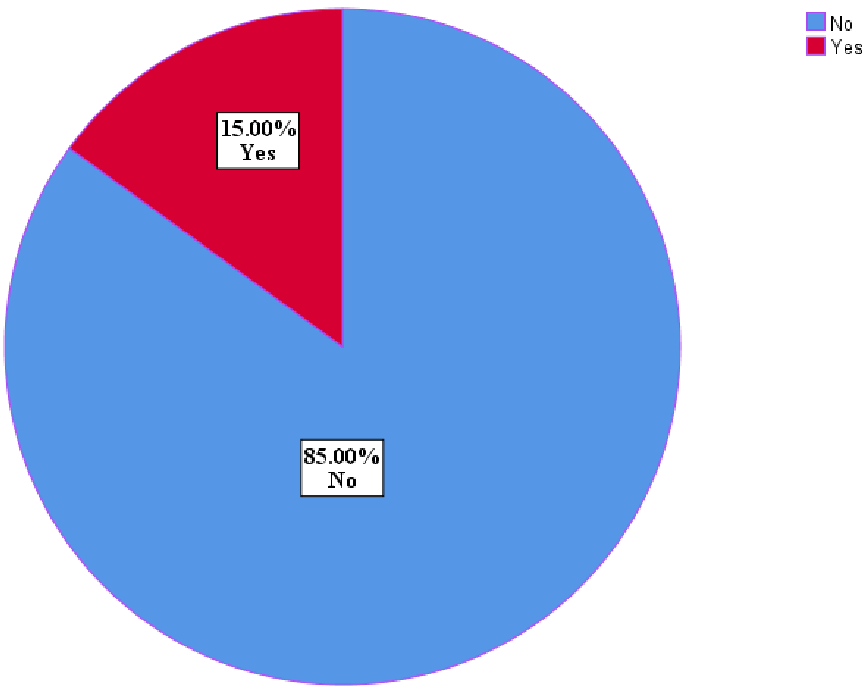


Figure 19 above shows that 35% of HH had 2 sockets, 30% had 1 socket, 25% had zero socket, 5% had 3 sockets in the kitchen and 5% had 4 sockets in the kitchen.

All those with zero sockets were willing to have a socket installed.

Protective devices in Households

Figure 20:Households Using Electrical Protective Devices



As shown in Figure 20, 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.

Figure 21: Image of AVS

Description of AVS

Low power (under-voltage) will damage any refrigeration appliance's compressor and High Power (Over voltage) will damage any electrical or electronic equipment. The AVS30 is the most complete power protection device combining over-voltage, under-voltage, power-back surges and spikes/surge protection. Additionally, there is a delay when power returns to normal. This will ensure that the appliance is not switched on-off repeatedly during fluctuations nor is it subjected to a massive surge normally experienced when power returns after power cuts. Also accommodating a start-up/inrush current of 110Amps.

Furthermore, the AVS30 Micro version has enhanced features allowing the user to set the delay time and monitor the state of the voltage. The market has 2 popular sizes available, 30Amps and 100Amps to suit almost all domestic and industrial applications.

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

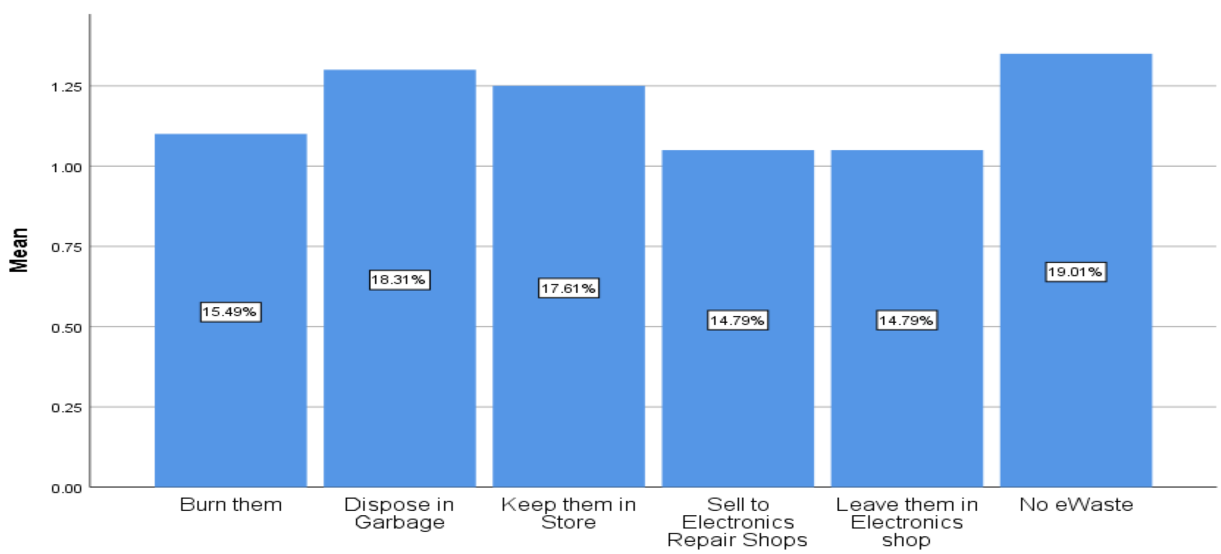


Figure 22: E-Waste Management

Figure 22 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

Use Credentials:

User Name: scodengo

Password: scodengo@2023

Alternatively, if using an android device, follow the KoboCollect Manual from **STEP 10** and enter credentials:

Server URL: `https://kc.kobotoolbox.org`

User Name: scodengo

Password: scodengo@2023

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

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

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: Kitchen Energy Audit Code Book.sa

Household Wiring Assessment Data Analysis Tool: Wiring Assessment Code Book.sav

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

Recommendations from Wiring Assessment Tools

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

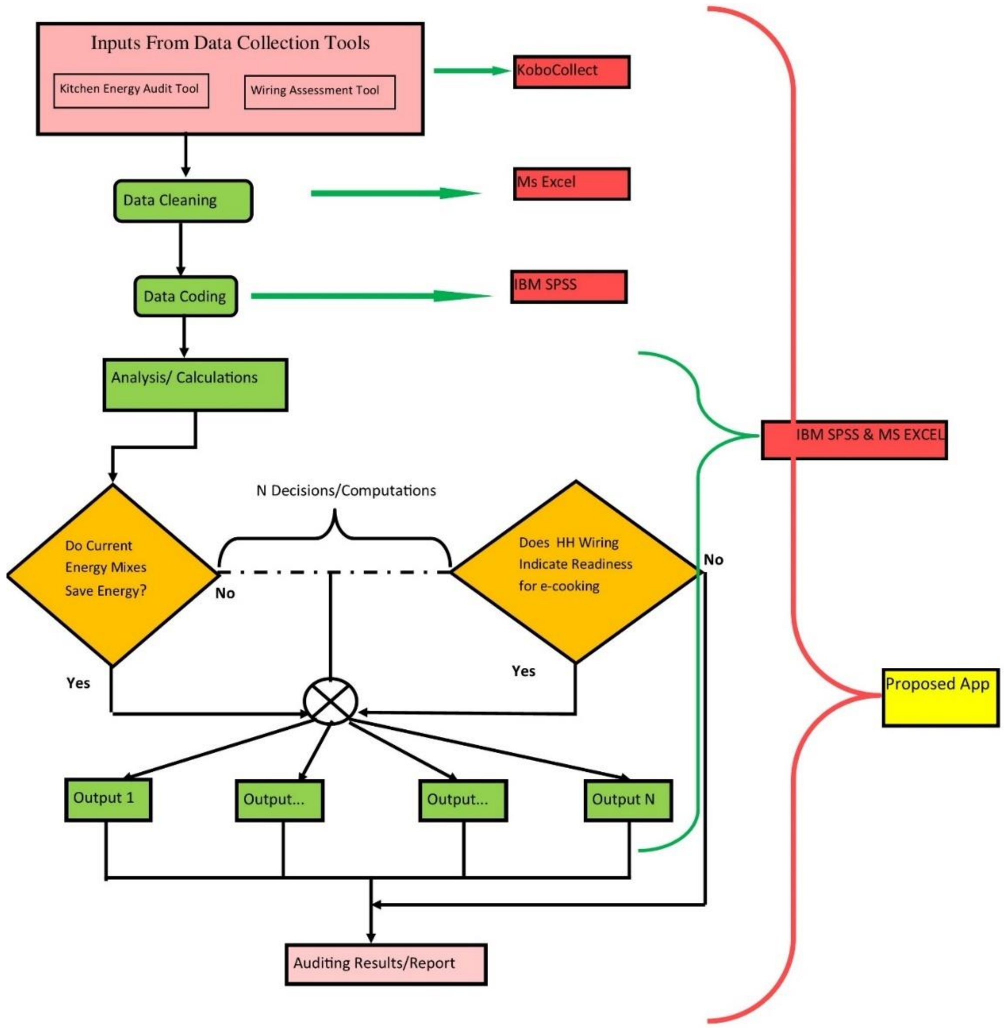
7. Instead of buying protective devices for each electrical appliances e.g. fridge guards, better to install and AVS at the CCU point so as to protect all your electrical devices
8. Generally, a design goal of a resistance-to-ground of less than 5 ohms for most installations is recommended. For sites 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.
9. Cables should be checked for proper colour coding.

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

The Future: Going Forward

1. 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 person 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.

Figure 23: Process and Software Tools Requirements for Energy Auditing and Wiring Assessment



The proposed App as indicated in Figure 23 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.

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.

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.

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Appendix

Appendix 1: Kobo Collect Manual

KoboCollect Manual.docx

Appendix 2: Raw Data Files

Energy_Wiring_Assessment_Tool Raw

Kitchen_Energy_Audit_Tool_Raw Data.x