Examining the Experience of Using Electric Pressure Cookers in Urban Households in Kigali, Rwanda

NEXLEAF ANALYTICS

MECS Modern Energy Cooking Services

ELECTROCOOK

A2E

SUSTAINABLE ENERGY FOR ALL

CLIMATE SOLUTIONS CONSULTING

Acknowledgement

This report was developed by Sustainable Energy for All (SEforALL). The SEforALL team led by Mikael Melin included Annette Aharonian, Caroline Ochieng, Grace Busingye and Tom Rwahama. The Lead Consultant for the report was Nexleaf Analytics and contractors, consisting of Iwona Bisaga, Megan Bomba, Jost Uwase, Eric L. Wright and Martin Lukac. Other contributors to the report included Nigel Scott and Will Clements (MECS), Paul Snijders,Sandrine Nibyobyiza, Xandra Wihogora and Christelle Ininahazwe (Electrocook Ltd), Elliot Avila (A2EI) and Olivier Lefebvre (Climate Solutions Consulting).

We also acknowledge the following SEforALL staff for their support in the review and publication of the report: Cristina Dominguez, Michael Abrokwaa, Stephen Kent. Editing of the report was done by Jenny Nasser and design and typesetting by Neil Claydon and Adetola Adedapo whose contributions are also acknowledged.

SEforALL acknowledges with gratitude the financial support from Swedish Postcode Foundation that made this report possible.

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CHAPTER ONE

Introduction

The world remains off track to achieve Sustainable Development Goal 7 (SDG7) – universal access to affordable, reliable, sustainable and modern energy for all. Progress has been particularly slow on increasing access to clean and modern cooking fuels and technologies. The global population lacking access to clean cooking fell from 2.9 billion in 2010 to 2.3 billion in 2021, but the goal of universal access by 2030 remains elusive: unless prompt action is taken to increase the access rate by more than 3 percent per year, some 1.9 billion people will still be without access to clean cooking in 2030 (ESMAP & MECS 2020). If current trends continue, almost six out of ten people in Sub-Saharan Africa (SSA) will remain without access to clean cooking in 2030 (IEA 2023). Increased access to clean cooking in SSA and globally, including the reduction of the reliance on biomass, will not only improve indoor air quality, but also reduce time spent gathering fuel, and help curb deforestation and greenhouse gas emissions from the incomplete combustion of biomass. It will also help address forest degradation and, in some countries, deforestation, a result of the unsustainable harvesting of fuelwood, primarily charcoal for urban consumption (ibid.).

According to the Population and Housing Census of Rwanda (2022), 93 percent of Rwandan households use biomass for cooking in the form of firewood (76 percent) and charcoal (17 percent). Just 5 percent of households have access to clean fuels, predominantly LPG. Rwanda ranks among the top 20 countries worldwide with the lowest percentage of the population with access to clean fuels and technologies (IEA 2022). Firewood has negative impacts both on peoples' health and on the environment. To address this, the government launched a campaign in 2020 to reduce the use of firewood for cooking and promote other fuels and technologies such as LPG and improved cookstoves.

Up until recently, cooking with electricity was not viewed as a viable clean cooking alternative in Rwanda and other low-middle income countries (LMICs) due to the relatively high cost and inefficiency of electric cooking appliances, low levels of electricity access, and high cost of electricity where connections are available. However, with the emergence of energy-efficient appliances such as electric pressure cookers (EPCs) and the increasing availability and improved reliability of electricity, particularly in urban centres, electric cooking has become an option for greater numbers of people.

Unlike hotplates and electric coils, EPCs are highly cost competitive over the long term compared to charcoal and LPG (ESMAP & MECS 2020). The appliances are insulated airtight pots that seal in steam during cooking. This increases the temperature of the contents and subsequently the pressure within the pot. The insulation minimizes heat losses by convection through the pot's surface while the airtight cover prevents any heat losses, meaning that the pressurized steam cannot escape. High temperatures and pressurized steam allow for much faster cooking than is possible with other pots. Household staples can be cooked faster, more cleanly and conveniently and at a cost that is competitive to other fuels. High-quality EPCs could represent an attractive cooking alternative for LMICs, particularly in urban settings with reliable grid connections (Efficiency for Access 2021).

The benefits of using electricity for cooking are twofold: a cleaner more convenient cooking experience and reduced expenditure for users in the long term (albeit with a higher initial investment) and faster recovery from the cost of investment in electrification for utility and mini-grid providers (Lee, Miguel and Wolfram 2019). Some estimates (e.g., Kweka et al. 2021) suggest that mini-grid providers could benefit from

an average of 20 percent higher energy consumption as a result of EPC use among their customers.

Rwanda's access to electricity has been rapidly growing in recent years, thanks to targeted government intervention. The government aims to ensure universal electricity access to all households by 2024 (REG 2018). However, even if most households are connected, studies have shown that simply providing access to electricity does not automatically result in a meaningful uptick in energy consumption; the majority of connected end users consume very little electricity due to limited ownership and/or access to electric appliances and variable reliability of the connection (e.g., AfDB 2022).

1.1 Study motivations and objectives

Among the key challenges for clean cooking in LMICs is the cost associated with cooking solutions: the cost of the appliance and the cost of the fuel, unless the fuel is collected. In many countries in SSA and Asia, charcoal and biomass stoves and fuels are predominantly used due to their relatively low cost and/or their availability; not often considered is the underlying health-related costs to households due to toxic emissions as well as the negative environmental impacts in terms of emissions and deforestation (Chakravorty et al. 2023). In urban areas in Rwanda, most households rely on the use of charcoal which, combined with basic, often inefficient stoves, is among the main contributors to household (as well as ambient) air pollution. During the COVID-19 pandemic, some households were pushed to switch to firewood even in urban areas due to cost increases of both charcoal and LPG (Woolley et al. 2022). Traditional culture dictates that women cook for their families; hence they bear the brunt of the negative health impacts associated with exposure to cooking-induced pollutant emissions.

Urbanization is projected to double in the next 25 years in SSA countries (CSIS 2018) and Rwanda is expected to reach 70 percent urbanization by 2050 (MINECOFIN 2020). If urban and peri-urban areas continue to rely on charcoal for cooking at the current rate, it will have catastrophic outcomes for air quality and forest resources. With recent instability in the price of LPG, more options are urgently needed for a transition from charcoal to be feasible. As electrical grids become more widespread and robust, electric cooking should be considered as part of a cleaner fuel mix for urban and peri-urban households alongside LPG and other cleaner fuels.

Enterprises such as Electrocook Ltd. are entering the market and aim to make eCooking technologies, and primarily EPCs, available and increasingly affordable to Rwandan households and, in the long term, also businesses and institutions. A study of cooking with electricity (EPCs and induction stoves) in Rwanda conducted by Energy4Impact in 2021-2022 already demonstrated advantages of EPCs, including cultural fit and reductions in cooking expenditure. It found that eCooking cost per capita was USD0.047 per meal while charcoal was USD0.068 per meal and LPG was USD0.073 per meal. However, the potential of efficient electric appliances, such as EPCs, to offset charcoal use must be better understood as Rwanda plans for a transition away from charcoal, especially in urban Kigali where a charcoal ban has been proposed. This study aimed to fill this knowledge gap.

The overall objective of the study was to examine the experience of urban households in Kigali of using EPCs. The study was conducted to help understand: (1) the possible levels of reductions in the use of charcoal after the purchase of an EPC; (2) the costs to households when using an EPC, and whether and how any cost savings could be achieved by replacing cooking with charcoal and/or LPG with cooking with electricity; (3) the preferred payment models that could address the challenge of the relatively high up-front cost of an EPC (e.g. daily, weekly or monthly payments); and (4) any possible time savings that could result from including electricity in the cooking energy mix. The study also examined the participants' general experience of using an EPC, including what they liked and disliked about cooking with electricity as compared to charcoal and LPG, any changes in cooking habits and foods/dishes prepared, and any major barriers or challenges they encountered that would have to be addressed by electric cooking solutions providers going forward.

CHAPTER TWO

Methodology

2.1 Target population and sample selection

The study recruited 100 participants from three Kigali city districts who, by signing up, also became customers of Electrocook, the manufacturer of the electric pressure cookers (EPCs) used in the study. All participating households were connected to the grid and were using charcoal or a mix of charcoal and LPG as their primary cooking fuels at the time of recruitment. Households from different socioeconomic backgrounds (Ubudehe categories 2 and 3[1]) were included (for details on the participating households see Section 3.1). The main reason for selecting households from these two groups was to assess the ability to pay and the willingness to transition to cleaner fuels among different segments of the urban population, and among those who are more reliant on charcoal yet have potentially sufficient capacity to pay for alternative fuels (in particular Ubudehe category 3). Including a sample from Ubudehe 2 allowed for an assessment as to whether eCooking is currently at all feasible for those with relatively low income levels and more limited ability to pay. In total, there were 43 Ubudehe 2 households and 57 Ubudehe 3 households who participated in this study. It should be noted that the sampling method was purposeful,[2] and involved direct community outreach, including door-to-door recruitment in each district. Each participant (and effectively each new customer for Electrocook) was offered an incentive to participate in the study: RWF 30,000 (USD 26) to be received upon the completion of the study (disbursed only if the household had submitted all data required). Only those customers willing to fulfil these requirements were included and recruitment continued even after the initial sample of 100 was reached to account for people dropping out.

The selected sample size of 100 included enough households to enable insights from a diverse group in terms of location, current fuel usage and income category. The study was not meant to be representative of the whole population of Rwanda therefore no sampling calculations were included. Instead, the goal was to build evidence for a preliminary assessment of the feasibility of cooking with electricity in selected areas of urban Kigali.

Geographically, the households were spread across the city's districts as per Table 1. Households were distributed equally in the administrative entities of either cell or sector to ease data collection. The distribution can be seen in the Figure 1 showing the GPS coordinates of the participating households.

[1] To learn about Rwanda's Ubudehe categories that helps determine poverty levels, please refer to this website: https://www.loda.gov.rw/ubudehe.

[2] Market storming activities included EPC demonstrations in public spaces, such as shopping malls, community halls and local markets; community outreach events; door-to-door visits; and customers recommending other customers

FIGURE 1 GPS coordinates of participating households

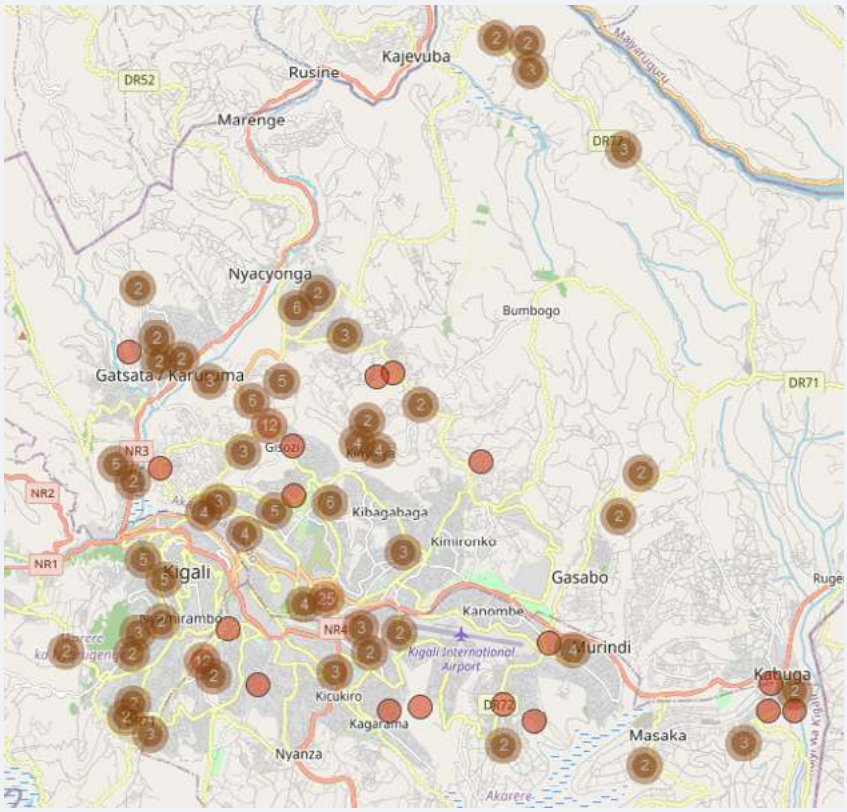


TABLE 1 District-level distribution of the study participants

PROVINCE	DISTRICTS	# HOUSEHOLDS
Kigali City	Nyarugenge	9
	Kicukiro	26
	Gasabo	65
TOTAL		**100**

2.1.1 EPC pricing and payment plan options

Initially, Electrocook priced its EPC at RWF 85,000 (USD 75), which was comparable to the price of other EPCs on the market. However, potential participants, and thus Electrocook's customers, approached for this study were unenthusiastic. Their reluctance stemmed both from the high cost of the appliance and the requirement to disclose personal information. Consequently, a low sign-up rate for the study was observed.

To address this issue, Electrocook and the study team reduced the price of the EPC from RWF 85,000 (USD 74) to RWF 40,000 (USD 35). This was to make the product more affordable and attractive to the target audience, and to encourage more participation in the study. The reduced price was well received, and the response rate for the study sign-up increased significantly.

Participants could choose from several payment options for the EPC: weekly, bi-weekly, monthly or a lump-sum payment after a month. Regardless of their chosen payment method, all participants were required to make a down payment of RWF 2,500 (USD 2.20) before receiving the EPC as confirmation of their willingness to participate in the study.

The payment details for each method were as follows:

- **Down payment:** At the time of sign-up every participant made a down payment of RWF 2,500 (USD 2.20).
- **Periodic payments:** Participants had three options: i) Weekly payments of RWF 2,500 (USD 2.20) for 15 weeks; ii) Bi-weekly payments of RWF 5,000 (USD 4.40) for eight weeks, followed by a final payment of RWF 2,500; or iii) Monthly payments of RWF 10,000 (USD 8.80) for four months, followed by a final payment of RWF 7,500 (USD 6.60) in the last month.
- **Lump-sum payment:** Individuals choosing to pay the full amount after one month paid RWF 37,500 (USD 32.80).

Notably, no interest was charged on the balance of RWF 40,000 (USD 35) for participants choosing to pay in installments. This effectively provided households with an interest-free loan from Electrocook.

FIGURE 2 Specifications and image of the EPC deployed in the pilot

- T1.5mm two side painting Aluminum inner pot
- Pressure indicator showing the pressure status
- Mechanical control with max 60/90min timer
- Multi-function
- 8 safety GUARDS
- Working pressure 70KPa
- Stainless steel housing
- 6 L

TYPE	
Model Series	MY-CJ6002W
Voltage/Power	220-240V/1000W
Certification	CB
FCL 20GP	712
FOL 40HQ	1596

2.2 Research methods

The study utilized a mixed-method approach whereby both quantitative and qualitative research tools were used to collect data. Quantitative data were collected through stove use monitors (SUMs), which monitored daily activity on charcoal and LPG stoves (by measuring changes in stove temperatures, thus demonstrating when cooking events were taking place) and fuel scales, installed in each household to measure the weight of charcoal sacks and LPG cylinders, thus demonstrating how much fuel was used for cooking on a daily basis. Smart meters were installed in each household when the EPCs arrived to measure the power consumption of the new appliances on a one-minute resolution. Additional quantitative data, as well as qualitative data, were collected through cooking diaries (see Appendix 1), a methodology developed by the Modern Energy Cooking Services (MECS) programme (2019) to measure, on a daily basis, the use of different stoves and fuels, and capture all the various dishes cooked for each meal. The Registration Survey (see Appendix 2) was used at the start of the study to collect general information about participating households, as well as their perceptions of different cooking fuels and stoves, including cooking with electricity. The Exit Survey (see Appendix 3) at the end of the study period was used to collect data on the experiences of cooking with electricity among the participating households and to identify any changes in their cooking habits following the purchase of EPCs. Additionally, each of the 10 enumerators was asked to write down their observations during data collection to provide further qualitative insights into the experiences of the study participants and help identify any challenges that could not be captured using the other research tools.

Kobo Toolbox, an online, open-access platform, was used for all survey-based data collection. SUM and logging-scale data were collected periodically in the households using a Unified Launcher during enumerators' visits. The data were then uploaded to the cloud for processing. Beside the sensor data, Kobo Collect questionnaires were also used to collect metadata and to control the quality of the deployment. EPC usage data collected through smart meters were uploaded on A2EI's platform (the provider of the smart meters used in this study) and subsequently analyzed in conjunction with data from the cooking diaries, SUMs and fuel scales.

FIGURE 3 Data-logging scales for charcoal, LPG and SUMs for charcoal and LPG.

2.3 Study timelines

Data collection took place over three and a half months starting in February 2023 and ending in May 2023, detailed as follows:

- **February 2023:** Registration Survey with 100 participating households.
- **February – March 2023:** Baseline data collection of charcoal and LPG use (or the use of any other cooking fuels, where applicable) using the baseline cooking diaries questionnaire (EPCs were not used in this period).
- **March – May 2023:** Data collection of EPC and other cooking fuel(s) using the pilot cooking diaries questionnaire (with an adapted last open-ended question to collect feedback specifically on cooking with electricity rather than other fuels)
- **May 2023:** Exit Survey.
- **February – May 2023:** ongoing collection of qualitative feedback from the study enumerators and the Electrocook team based on interactions with, and observations of, members of the participating households.

It should be noted that there was an EPC 'transition' period between the end of March and the start of April, when households were receiving their EPCs but did not yet have the smart meters installed in their homes and hence power consumption of the appliances was not being captured. In the following sections the distinction to clearly indicate which datasets the insights are based on is the following: baseline phase (no EPC usage); transition phase (staggered start of EPC usage among the participating households, no smart meters deployed); pilot phase (EPC usage with smart meters deployed and power consumption measured).

TABLE 2 Study Timeline

ACTIVITY	FEB 2023	MAR 2023	APR 2023	MAY 2023
Registration Survey with 100 participating households.				
Baseline data collection of charcoal and LPG use (or the use of any other cooking fuels, where applicable) using the baseline cooking diaries questionnaire EPCs were not used in this period).				
Data collection of EPC and other cooking fuel(s) using the pilot cooking diaries questionnaire (with an adapted last open-ended question to collect feedback specifically on cooking with electricity rather than other fuels)				
Exit Survey.				
Ongoing collection of qualitative feedback from the study enumerators and the Electrocook team based on interactions with, and observations of, members of the participating households.				

2.4 Recruitment and training of enumerators

For the purposes of this study, Electrocook hired 10 enumerators with experience in field data collection as well as additional skills in marketing. The enumerators were responsible for both the recruitment of participants (who would automatically become Electrocook's customers) with support from the Electrocook team, and the collection of all field data. A series of training sessions were conducted over a four-day period to introduce the enumerators to the selected research methods used for this study and to highlight best practices in data collection. As part of the training, Electrocook staff and the enumerators conducted some mock data collection and the enumerators were introduced to the use of SUMs and fuel scales, how to install them in households and how to download the data during household visits. They were also trained on the use of EPCs so they could be familiar with the different functionalities and able to answer any questions the participants may have had. In total, there was one supervising member of staff and 10 enumerators who were trained and who conducted the data collection activities.

FIGURE 4 Training of enumerators on the research tools and equipment, and the use of EPCs.

2.5 Data analysis

Quantitative data collected through surveys/questionnaires were analyzed in Excel and Stata version 17. Qualitative data collected through surveys/questionnaires and through written accounts of the enumerators' observations were analyzed using thematic analysis whereby all text-based data were reviewed, coded and summarized in a descriptive manner to present the findings.

Calculated results are presented as descriptive statistics, primarily in the form of base rates. Primary outcomes of interest (expressed as group means/proportions) were: average usage trends of charcoal and LPG prior to EPC purchase; household perceptions of EPC usability and affordability; the percentage of participants in each payment group who expressed satisfaction or dissatisfaction with the appliance and the available payment options; payment plans selected by the participating households; cost savings (if any) between the baseline and the pilot phases, based on the cost of use of the EPC (and/or the EPC in combination with other fuels); average cost per meal when cooking with the EPC versus other fuels; total cost of ownership of the EPC and time to pay it off; impact on charcoal use per day and per meal, including average charcoal use pre- and post-EPC purchase; stove and fuel stacking among households in different income segments; overall use of the EPC in comparison to other forms of cooking during the pilot phase; foods cooked on different stoves (including including comparison of before and after the purchase of an EPC); and the average (overall) time spent

cooking before and after the purchase of an EPC to demonstrate any potential time savings.

The cooking diaries were analyzed using a combination of Excel and SPSS[3]. The data were cleaned by locating errors in data recording, such as reversed start and end times, and correcting where possible. SPSS was then used to analyze and understand how the participants cooked in each phase in terms of foods, fuels, devices, energy consumption and cooking durations. As explained further in Section 3.3 (Cooking energy consumption using different fuels), the datasets obtained from the cooking diaries, smart meters and SUMs were combined to align energy consumption of cooking events with corresponding cooking diary events, in order to understand energy consumption at the meal and dish level, where possible.

EPC usage was analyzed by processing raw smart meter data into events in Python. The events were then analyzed in pivot tables in Excel and Python.

The sensor data from the EXACT (SUM) and FUEL (data-logging scale) were processed using Python and Excel while the associated questionnaires were processed using Excel. Before the analysis the meta data and deployment picture were checked to ensure that the sensors were deployed correctly and to understand when data were collected in each household. For sensors that were deployed correctly, the following analyses were performed:

- **EXACT:** cooking events were identified using an algorithm derived from the Firefinder algorithm (Wilson et al. 2020) with tuned absolute and slope threshold for cooking event start and stop times, and to merge events close to each other.
- **FUEL:** the signal was first processed using a running median with a window of 35 measurements. For biomass, fuel consumption was then identified when a sudden weight drop greater than 25g was observed. Each fuel-use event was then combined to derive a daily consumption. For LPG, this method could not be used because of weight change unrelated to fuel consumption (many households disconnect the regulator from the cylinder after cooking; the smallest LPG stoves have the burner directly on top of the cylinder). The weight of the cylinder at 3am was used instead to quantify daily LPG consumption.

This study was not intended to produce results generalizable to the population of Rwanda. Instead, it was intended to serve as an exploration of the potential for future EPC adoption in urban Rwanda by examining the different aspects of the experience of the 100 participating households (in terms of reduction of charcoal use/charcoal displacement; cooking expenditure; preferred payment models for the appliance; cooking habits; and time savings) from specific population segments and with specific characteristics. The results presented in this report are therefore representative of the study's participants, rather than of Kigali or Rwanda. No modelled error structures or sample weights were incorporated into the data analysis.

[3] SPSS (Statistical Package for the Social Sciences), also known as IBM SPSS Statistics, is a software package used for the analysis of statistical data.

CHAPTER THREE

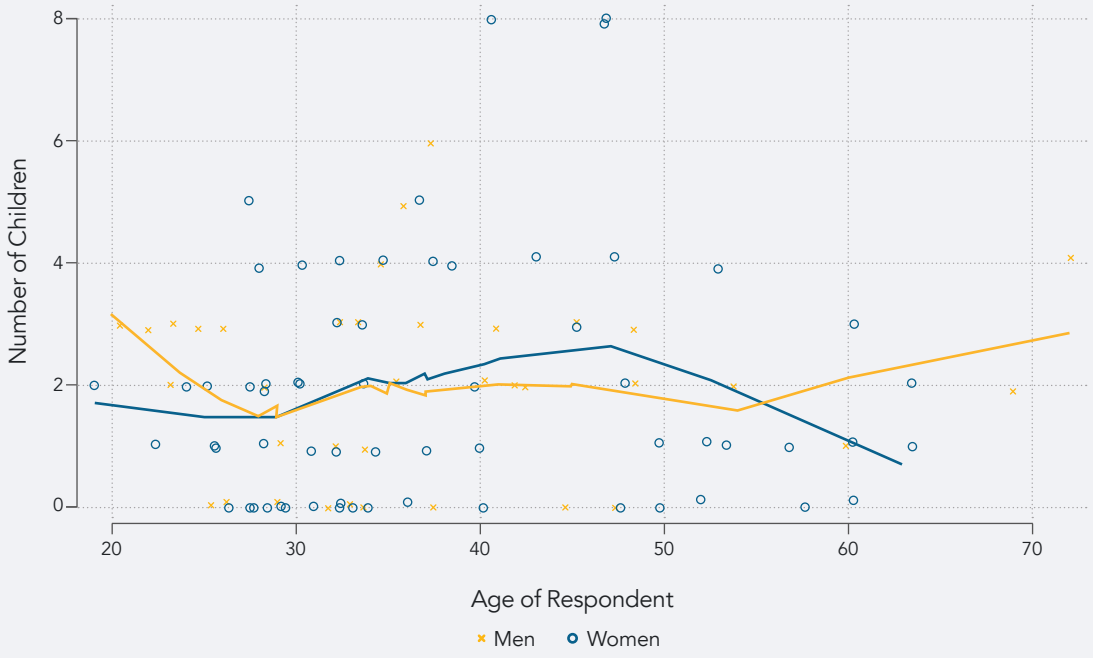
Findings

3.1 Socioeconomic profile of participating households

3.1.1 Household size and composition

The average household size was fairly consistent across the age of participants (averaging two children per household), with few differences in the overall distribution based on whether the person participating in the study was male or female (Figure 5). Overall household size followed a similar pattern, with an average household size of four to five people, with no substantial variation according to the gender of the head of the household.

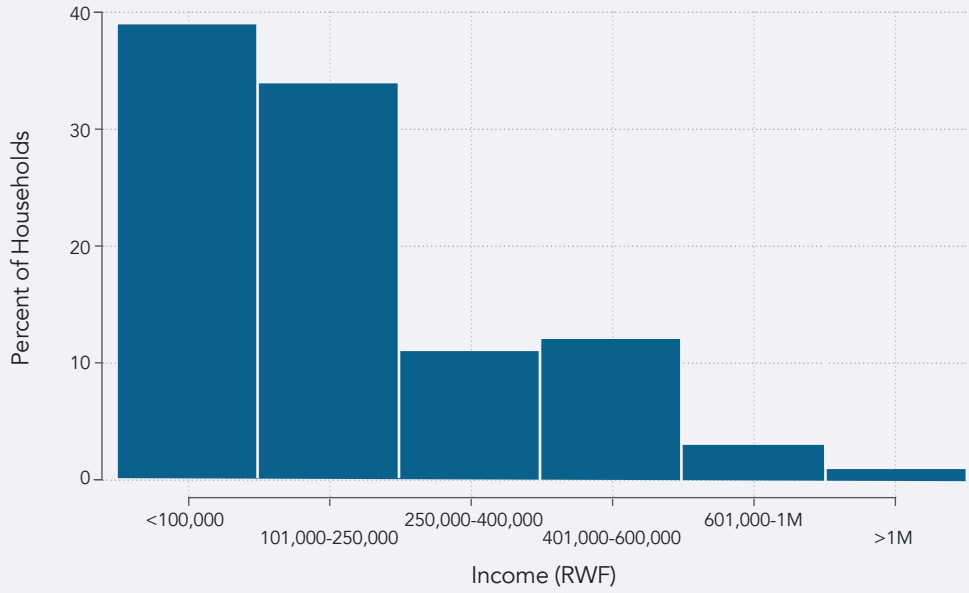
FIGURE 5 Number of children by age and gender in participating households



3.1.2 Income and education

Roughly 70 percent of households in the study earned less than RWF 250,000 (USD 220) per month, with more than half of that group earning less than RWF 100,000 (USD 87), as shown in Figure 6. For those households, the initial proposed cost of Electrocook's electric pressure cooker (EPC) would have constituted as much as 80-100 percent of a month's income. Of the remainder, 11 percent earned between RWF 250,000 (USD 220) and RWF 400,000 (USD 350), 12 percent earned between RWF 400,000 (USD 350) and RWF 600,000 (USD 520), and 4 percent earned several times the median income of the study's participants.

FIGURE 6 Monthly household income in participating households



While participants' income distribution curved downwards, their education curved upwards; 67 percent had at least a secondary education and 28 percent had studied beyond secondary schooling. The full breakdown is shown in Figure 7 below.

The association between education and income was positive overall (Figure 8), with households with higher education more likely than those with lower education to have higher incomes (Note: A positive relationship between the two does not constitute causality as higher income levels could also be the enabler for households to access higher levels of education).

FIGURE 7 Education level of study participants

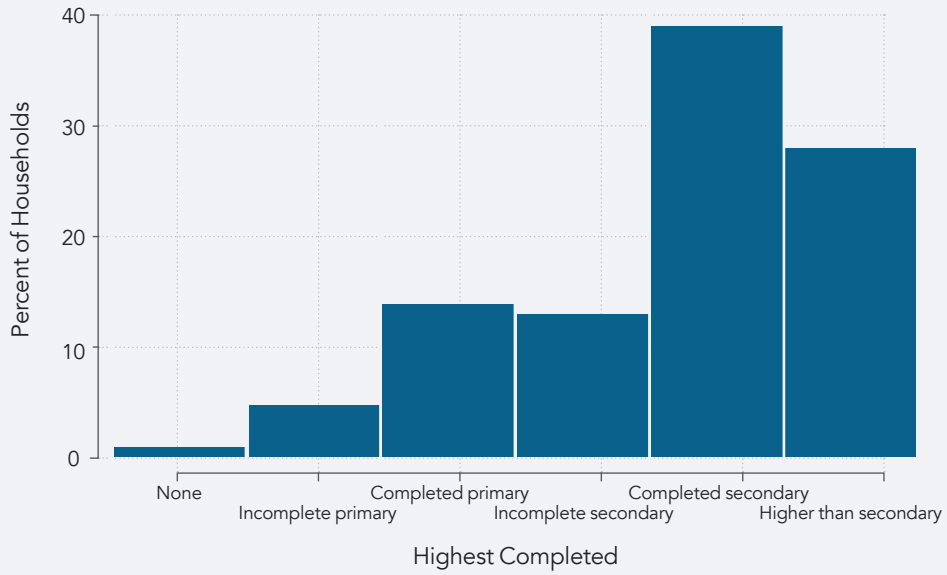
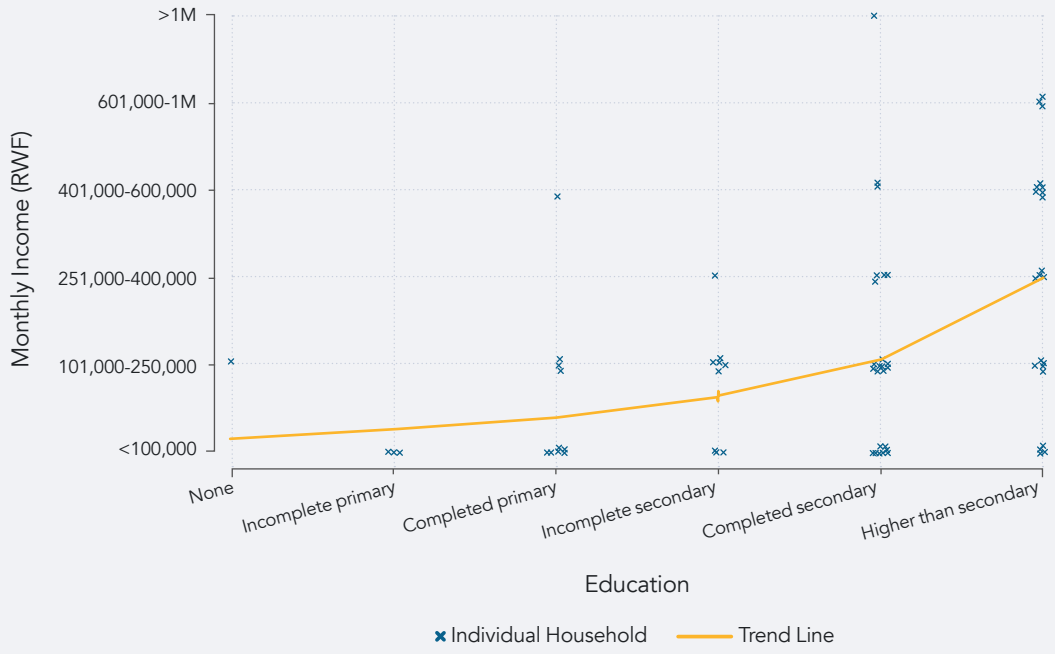


FIGURE 8 Relationship between level of education and income



3.1.3 Access to financial services

In addition to education and income, the Registration Survey investigated participants' access to various forms of financial services, including banks, saccos (credit unions)/tontines, microfinance institutions, microfinance NGOs, mobile digital finance services and pawn shops. Of these, banks and saccos/tontines were the most common, with 61 percent and 60 percent of households saying they had access to them, respectively. 24 percent of respondents said they had access to mobile banking, and 18 percent said they had access to microfinancing.

TABLE 3 Available financial services

VARIABLE	NO	YES	TOTAL
Bank	39	61	100
Sacco_Tontine	40	60	100
Microfinance	82	18	100
Microfinance_NGO	100	0	100
Mobile_finance	76	24	100
Pawn	100	0	100
TOTAL	**437**	**163**	**600**

The availability of these different financial services was not equally distributed across respondents, however. While all of them said they knew of at least one of them (with 56 percent saying they knew one), only 29 percent said they were able to access two, 11 percent three, and 4 percent four.

For those respondents who were aware of the availability of one financial service, banks, saccos/tontines and mobile banking were the most common. Notably, while banks and saccos/tontines were widely available to most respondents who had access to multiple forms of financial services, the availability of mobile banking was concentrated among respondents who had no other access to other financial services.

Knowledge of a financial service's existence, though, is not the same as actual utilization. Fewer than half of respondents had actually utilized any of these financial services. There was also variation in utilization of these services by gender of the household head. While 46 percent of male-headed households had made use of one or more of these services, only 32 percent of female-headed ones had.

Among respondents who reported having access to some form of financial services, banks and saccos/tontines remained the most common, as shown in Table 4. Table 5 shows the types of payment modes for clean cooking solutions that respondents had used before, with monthly installments (without a deposit) being recorded among 16 households. The majority (77 households) reported paying up front. Table 5 shows payment modes that respondents reported as being available to them, with cash and mobile money being the most common. Prepaid and credit and debit cards were reported as being available to one respondent each.

TABLE 4 Available financial services by numbers and access

FINANCIAL SERVICES	NO			YES			
	Number of Financial Services Available			Number of Financial Services Available			
	1	2	3	1	2	3	4
	41	19	3	15	10	8	4
Bank	12	17	3	11	6	8	4
Sacco_Tontine	15	18	3	3	9	8	4
Microfinance	1	2	3	0	1	7	4
Microfinance_NGO	0	0	0	0	0	0	0
Mobile_finance	13	1	0	1	4	1	4
Pawn	0	0	0	0	0	0	0

TABLE 5 Financing for clean cooking solutions used previously

APPLIANCE OWNED	MONTLY INSTALMENTS (WITH DEPOSIT)	MONTLY INSTALMENTS (NO DEPOSIT)	UP FRONT	TOTAL
3SF only	11	11	10	1
LPG only	34	34	22	11
Charcoal only	3	3	3	34
3SF/Charcoal	4	4	3	3
Charcoal/Electric	5	5	2	4
LPG/Electric	2	2	5	5
Charcoal/LPG	3	3	33	38
Charcoal/LPG/Electric	4	4	1	2
TOTAL	**5**	**5**	**77**	**98**

TABLE 6 Availability of payment schemes for clean cooking solutions

CLEAN COOKING ENERGY PAYMENT SCHEMES AVAILABLE	% OF PARTICIPANTS REPORTING ITS AVAILABILITY
Credit/Debit	1%
Bank Transfers	3%
Cash	82%
Mobile Money	75%
Prepaid Cards	1%
Crypto	0%

3.1.4 Household roles and responsibilities regarding cooking

At the start of the project, participants were asked to provide the names of people in their households who helped in preparing food, along with an estimate of the percentage of cooking duties they contributed. Figure 9 is a heat plot showing the number of cooks in each household on the x axis and the percentage of cooking duties undertaken by the person reported to do the most cooking. In 42 percent of households, all cooking was done by a single person (represented by the yellow hex at the top left of the figure).

In the bulk of the remaining households (58 percent), cooking tasks are performed by two or three people. About two thirds of households relied upon a main cook who did at least 80 percent of the cooking.

FIGURE 9 Distribution of cooking duties in participating households

3.1.5 Cooking stoves and appliances in use and fuel expenditure

Prior to the introduction of EPCs, the majority of households in the study cooked using charcoal-burning biomass stoves (83 percent in total; two of the households had "improved stoves"). 61 percent of households owned LPG cooking appliances as well, and 55 percent of households owned both LPG and biomass cooking stoves. 35 percent of households had only biomass cooking stoves, and 7 percent had only LPG stoves (see Tables 7 and 8, and Figure 10 for reference).

Among the 57 Ubudehe 3 category households, the most common fuel mixes were the following:

- 59 percent charcoal and LPG
- 28 percent charcoal only
- 5 percent LPG only

Among the 43 Ubudehe 2 category households, the most common fuel mixes were the following:

- 46 percent charcoal and LPG
- 40 percent charcoal only
- 9 percent LPG only

While the share of exclusive users of charcoal was higher in the Ubudehe 2 category households, the overall percentage of households using charcoal in both Ubudehe categories was similar (87 percent in Ubudehe 3 and 86 percent in Ubudehe 2). The overall percentage of households using LPG was 10 percent higher in the Ubudehe 3 category (64 percent) than in the Ubudehe 2 category (54 percent).

FIGURE 10 Different stoves used in the participating households before the introduction of the EPC (top two and middle - charcoal; bottom left and right - LPG).

TABLE 7 Use of different stoves and appliances prior to EPC purchase in percentage (%)

STOVE (OR APPLIANCE) TYPE OWNED	% OF PARTICIPANTS
Three-Stone Fire	4%
LPG	57%
Charcoal	83%
Kerosene	0%
Electric	11%

The 11 percent of participants who reported using electricity for cooking prior to the study were using an electric hotplate (7 percent) and an EPC (4 percent).

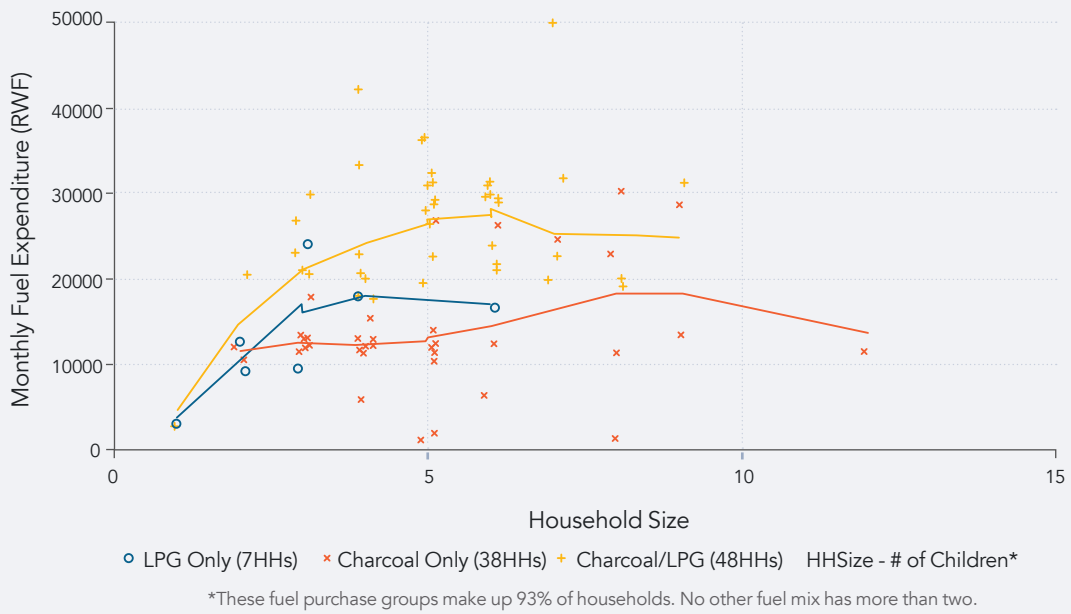
In addition to stoves or electric cooking appliances, eight participants reported owning a kettle (Note: The kettles were not verified as electric kettles; however, the response "kettle" was provided to the question on any other cooking appliances, including electric appliances).

TABLE 8 Use of different electric cooking appliances prior to EPC purchase (as part of the study) in percentage (%)

TYPE OF APPLIANCE OWNED	% OF PARTICIPANTS
Kettle	8%
Rice Cooker	0%
EPC	4%
Microwave	0%
Hotplate	7%

As household size increased, there were corresponding increases in household fuel expenditure (see Figure 11). Households cooking some or all their meals using LPG stoves had slightly higher average monthly fuel expenditure than charcoal-only households. Across all fuel mixes, though, an increase in average monthly fuel expenditure as household size increased was observed, before the costs levelled out at around households of five or more.

FIGURE 11 Household size and fuel expenditure according to the fuel mix in use



*These fuel purchase groups make up 93% of households. No other fuel mix has more than two.

TABLE 9 Mean price per kilogram of fuel and mean amount of fuel purchased per month among the participants.

FUEL	MEAN PRICE/KILO (RWF)	MEAN AMOUNT PURCHASED/MONTH (KG)
Charcoal	295	47
LPG	1460	10

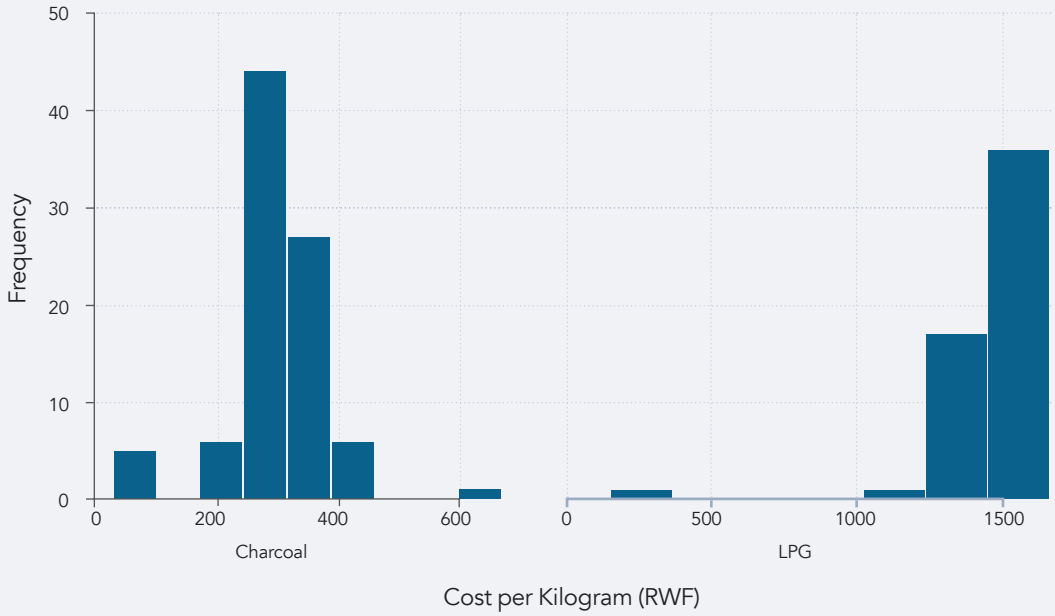
From reported fuel purchase data, relative cost estimates for each fuel type were generated. At baseline, participants reported purchasing charcoal and LPG to fuel their stoves (and some additional households reported collecting firewood). On average[4], participants reported paying about RWF 300 (USD 0.25) per kilogram for charcoal. In households where charcoal was the only reported cooking fuel, users reported purchasing about 45 kilograms of charcoal per month, on average, resulting in an average monthly charcoal expenditure of about RWF 13,500 (USD 12). Average monthly costs of LPG in LPG-only households were nearly identical, with an average monthly expenditure of about RWF 13,500 (USD 12) as well. While participants reported spending substantially more per kilogram for LPG (RWF 1,500 (USD 1.30) on average), LPG's increased fuel efficiency by mass means that those users only purchased an average of nine kilos per month.

Monthly charcoal expenditure in households that purchased both charcoal and LPG were slightly lower than those in charcoal-only households (RWF 11,000 (USD 9.70) vs RWF 13,500 (USD 12)). This relative decline in overall charcoal costs was met by a slight increase in LPG costs in dual-fuel households. Participants reporting a charcoal/LPG stack estimated their monthly LPG cost to be about RWF 14,500 (USD 12.70), a 7 percent increase in monthly LPG expenditure relative to those households who relied only upon LPG.

[4]Please note: There is a difference between prices stated in the text and those presented in Table 9 as the former shows averages whereas the latter shows the mean.

On average, households cooking with both charcoal and LPG had nearly double the average monthly fuel expenditure of single-fuel households, averaging RWF 25,000 (USD 22) per month in cooking fuel expenditure, with the important caveat that these households were, on average, twice the size of LPG-only households.

FIGURE 12 Reported fuel cost per kilogram (in RWF)

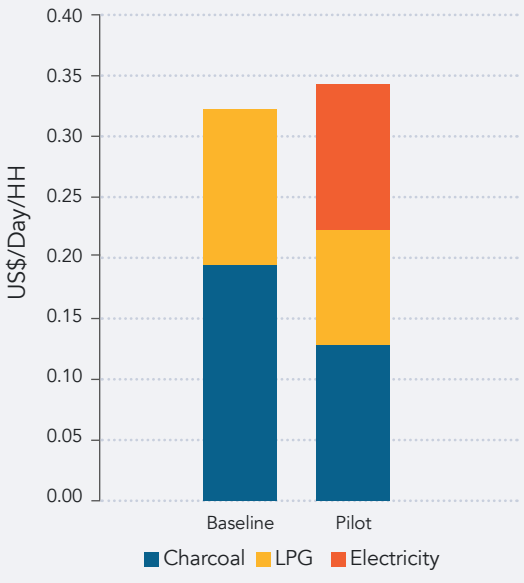


Using the fuel consumption measured by the data-logging scales and the EPC and the fuel unit cost reported above, we derived the daily cost of cooking per household before and after the introduction of the EPC (Figure 13).

The overall cost of cooking remained similar between the two phases (around USD 0.34/day/HH or RWF 388/day/HH).

More insights from the comparative analysis of the baseline and the pilot phases can be found in Section 3.2.

FIGURE 13 Cost of cooking comparison (baseline vs pilot phases) (in USD)



3.1.6 Challenges and advantages of cooking with charcoal and LPG

The dominant fuels used for cooking before the start of the study (and during the baseline phase) were charcoal and LPG. The households participating in the study highlighted a number of challenges of cooking with these fuels as well as their perceived advantages. A summary of the most common challenges and advantages is presented in Table 10 below.

TABLE 10 Challenges and advantages of cooking with charcoal and LPG

FUEL	MAIN CHALLENGE(S)	OTHER CHALLENGE(S)	ADVANTAGES/LIKES
Charcoal (N=92)	▪ Dirty ▪ Preparation is time-consuming ▪ Takes long time to cook/slow ▪ Expensive	▪ Difficult to prepare/cook with ▪ Difficult to get charcoal (limited availability) ▪ Cooking equipment gets dirty ▪ Cook gets dirty	▪ Food tastes good ▪ Familiar/easy
LPG (N=55)	▪ Unsafe ▪ Fear of explosion ▪ Fear of burning/fire accident	▪ Expensive	▪ Food is cooked fast ▪ Clean ▪ Simple/easy to use ▪ Saves time

The above challenges and advantages were reported prior to the start of the baseline study as well as during the study (across the baseline, the transition and the EPC pilot phases). While most charcoal users found cooking with charcoal to be difficult because of the preparation needed, the dirtiness of the fuel and the difficulties in igniting it, there were some users who said it was easy to cook with. This perception of charcoal's ease of use appears to be due to the level of familiarity of households with it – even if it has its disadvantages, they find it easy to use because they have been using it for a long time (most or all of their lives). As a result, both accounts of difficult to use and easy to use have been recorded in the feedback from the participants.

Households using LPG noted its speed and cleanliness. Those using charcoal said they found it to be better suited than alternative fuels to cooking cassava leaves, kawunga (cornmeal) and beans and easily available on the market. Approximately 30 percent of participants reported that there was nothing they liked about cooking with charcoal.

3.1.7 Household motivations to purchase an EPC

At the start of the baseline period, all participants were asked about their motivation in taking part in the study and purchasing an EPC, and things they were looking forward to the most regarding cooking with an EPC, as well as things they were most concerned about. Table 11 below shows the most common motivations, expectations and concerns as expressed by the study participants.

Interestingly, while most participants were aware that EPCs consume less power than other electric cooking appliances, they were still concerned about how much power they would consume and therefore by how much their electricity bills would go up. Similarly, while safety improvement while cooking with EPCs as compared to cooking with LPG or charcoal was an important motivation for them to participate and purchase one, they were also concerned about any potential accidents while using the EPC, e.g., burning. The speed of cooking and the associated time savings were among the top reasons households chose to purchase an EPC and the things they were looking forward to the most during the study, as well as the ability to learn and see how an EPC works and how it could improve their overall cooking experience.

TABLE 11 Study participants' motivations for purchasing an EPC, expectations and concerns regarding cooking with an EPC

MOTIVATIONS FOR PURCHASING EPC	EXPECTATIONS/THINGS TO LOOK FORWARD TO	CONCERNS
▪ Learn how it works ▪ Save (cooking) time ▪ Low power consumption ▪ Cleanliness ▪ Heard it works well ▪ Payment mode on offer ▪ Affordable price ▪ Improve cooking experience ▪ Avoid food burning	▪ Fast cooking of meals ▪ Improved safety while cooking ▪ Cleanliness ▪ Low power consumption	▪ Actual power consumption (and increase in the electricity bill) ▪ Size too small/not enough pots ▪ Fear of burning/accident ▪ Level of difficulty of use ▪ Longevity of the product

3.1.8 Selection of EPC payment plans

As one of the study objectives was to understand how households preferred to pay for their cooking appliances, and how much they were willing to pay, Electrocook chose to offer several payment plans. These included weekly, bi-weekly or monthly plans, or paying the entire cost at once after the first month of usage. Regardless of the chosen payment method, participants were required to make a down payment of RWF 2,500 (USD 2.20) before receiving the EPC.

86 participants chose to pay for the EPC on a monthly basis, eight chose to pay weekly, five chose to pay the full amount after a month, and one chose to pay bi-weekly.

Overwhelmingly, when asked about the preferred payment plan before the start of the study, households expressed preference for the monthly option, as is seen in the actual selection of payment plans shown above. Only 13 households preferred to pay for their EPC up front (ultimately five chose to pay in full after one month) and 10 opted for weekly installments (ultimately eight chose weekly and one chose bi-weekly installments). This preference for monthly payment was consistent, regardless of the types of cooking solutions or appliances participants owned prior to the start of the study. Paying up front was associated with slightly higher income, on average, than choosing either of the payment plans, but that difference was small.

More on how the households paid for their EPCs throughout the duration of the study can be found in Section 3.6.

TABLE 12 Payment plan preference (as expressed prior to the start of the study)

APPLIANCES OWNED	UPFRONT	WEEKLY	MONTHLY	TOTAL
3SF only			1	1
LPG only			11	11
Charcoal only	4	5	26	35
3SF/Charcoal			3	3
Charcoal/Electric		1	3	4
LPG/Electric	1	2	2	5
Charcoal/LPG	8	1	30	39
Charcoal/LPG/Electric		1	1	2
TOTAL	**13**	**10**	**77**	**100**

3.2 Cooking fuels and practices - baseline, transition and pilot phases

3.2.1 Use of stoves and fuels

The number of meals recorded in each phase of the cooking diaries is shown in Table 12. This confirms that fuel stacking was more common after participants had acquired their EPCs, as would be expected.

EPCs were used quite intensively in the pilot phase, in 41 percent of cooking events. They were most commonly used in place of charcoal. The proportion of meals cooked using charcoal dropped from 67 percent to 45 percent of meals in the baseline and pilot phases respectively; see Table 13 (Note: Percentages sum to more than 100 percent because some events covered the preparation of multiple meals).

TABLE 13 Number of meal events recorded in each study phase

NUMBER OF FUELS	BASELINE		TRANSITION		PILOT	
	N	%	N	%	N	%
0	2	0.3%	1	0.1%	24	1.4%
1	700	94.6%	1598	90.2%	1442	83.1%
2	37	5.0%	168	9.5%	259	14.9%
3	1	0.1%	5	0.3%	10	0.6%
TOTAL	**740**	**100.0%**	**1772**	**100.0%**	**1735**	**100.0%**
WITH OF EVENT	1.05		1.10		1.15	

TABLE 14 Fuels used in each phase

FUEL	BASELINE		TRANSITION		PILOT	
	N	%	N	%	N	%
Firewood	19	2.6%	19	1.1%	16	0.9%
Charcoal	495	66.9%	1018	57.4%	772	44.5%
LPG	259	35.0%	550	31.0%	493	28.4%
Electricity	4	0.5%	362	20.4%	709	40.9%

3.2.2 Fuels used for different meal types

Dinners were the most commonly cooked meals, closely followed by lunches. This was consistent across all three phases of the study; see Table 15 (Note: Percentages sum to more than 100 percent because multiple fuels can be used in cooking a single meal).

The following charts illustrate the breakdown of fuels used to cook different meal types. Note that these figures include only those cooking events that covered a single meal. Comparing Figure 14 with Figure 15 shows that the proportion of dinners cooked with charcoal dropped from 65 percent to 44 percent between the baseline and the pilot phases; lunches showed a similar drop. EPCs appear to have been most commonly used for preparing lunches and dinners in the pilot phase; 45 percent of lunches and 40 percent of dinners involved the use of EPCs. However, the greatest transition away from charcoal was observed for cooking breakfasts, which dropped from 54 percent to 20 percent cooked using charcoal.

EPCs were also used in place of LPG to cook both lunches and dinners. The proportion of lunches cooked using LPG fell from 36 percent to 25 percent, and for dinners, from 34 percent to 29 percent. However, part of the reduction in charcoal use for breakfasts was due to the increased use of LPG, from 45 percent to 54 percent. The remainder is due to the introduction of EPCs, which were used to cook 29 percent of breakfasts. There is no obvious reason why this increase in LPG use should be linked to the use of EPCs, other than perhaps over the course of the study participants became sensitized to the time needed to use charcoal.

TABLE 15 Distribution of meal types recorded under each phase

NUMBER OF FUELS	BASELINE		TRANSITION		PILOT	
	N	%	N	%	N	%
Breakfast	92	12.4%	195	11.0%	173	10.0%
Lunch	351	47.4%	843	47.6%	836	48.2%
Dinner	387	52.3%	907	51.2%	922	53.1%
Snack	7	0.9%	13	0.7%	2	0.1%
Water heating	21	2.8%	43	2.4%	4	0.2%
Other	3	0.4%	0	0.0%	8	0.5%

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FIGURE 14 Fuels used to prepare different meal types – baseline phase (single meals only)

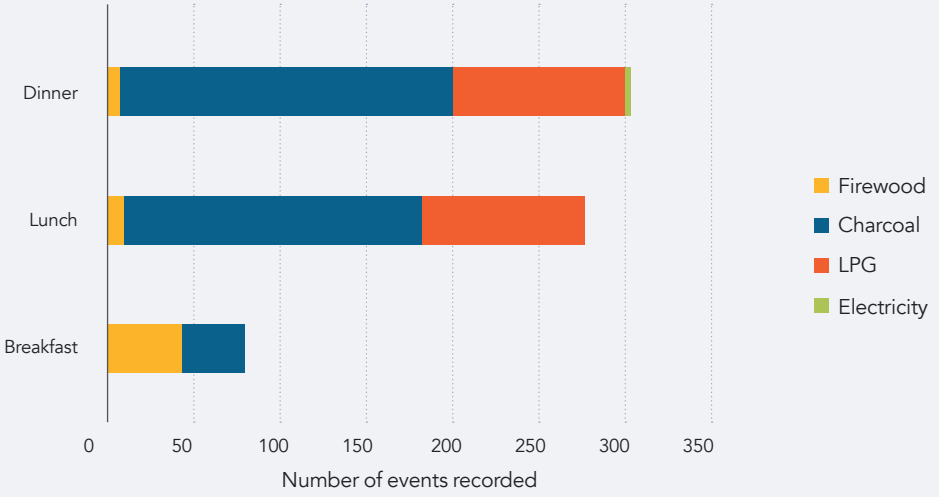
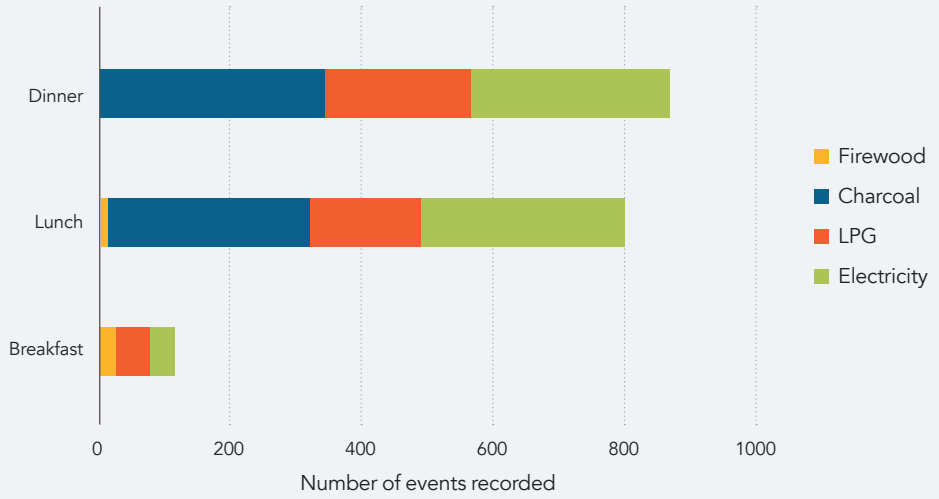


FIGURE 15 Fuels used to prepare different meal types – pilot phase (single meals only)



3.2.3 Fuels used to cook different dishes

Popular Rwandan cuisine is dominated by vegetables and beans along with carbohydrate-rich foods such as rice, cassava and corn breads, and porridge. Meat and fish are cooked relatively infrequently. Each of these dishes is freshly prepared (i.e., from scratch) on over 90 percent of occasions, with the exception of cassava leaves. Hot water (for unspecified purposes) is often reheated. Table 16 shows the type and number of foods that were prepared in the course of the study, and whether they were freshly cooked or reheated.

Table 17 suggests that participants were more likely to cook fresh dishes after they had started using the EPC. This could be due to the shorter cooking times of dishes needed in an EPC (as compared to the previously used stoves and fuels), making it more convenient to cook from scratch. The size of the EPCs also means they cook smaller amounts, making them less suited to cooking food in bulk for reheating later. The analysis in this section considers the mix of both fresh and reheated meals.

TABLE 16 Commonly cooked dishes (N > 100) by fresh or reheated - all phases

DISH	FRESH		REHEATED		TOTAL
	N	%	N	%	N
Vegetables	1,506	91.5%	140	8.5%	1646
Rice	1,393	95.1%	72	4.9%	1465
Beans	1,003	95.8%	44	4.2%	1047
Porridge	891	94.5%	52	5.5%	943
Bread	844	93.8%	56	6.2%	900
Tea	778	93.7%	52	6.3%	830
Irish (white) potatoes	736	94.1%	46	5.9%	782
Water	474	71.9%	185	28.1%	659
Matoke (green bananas)	477	93.5%	33	6.5%	510
Soup	375	91.0%	37	9.0%	412
Meat	252	90.6%	26	9.4%	278
Milk	252	95.5%	12	4.5%	264
Cassava leaves	182	82.7%	38	17.3%	220
Spaghetti	171	89.1%	21	10.9%	192
Chips	179	96.8%	6	3.2%	185
Sweet potatoes	160	93.6%	11	6.4%	171

TABLE 17 Fresh and reheated dishes (by phase)

	BASELINE		TRANSITION		PILOT	
	N	%	N	%	N	%
Fresh	1,832	88.7%	4,268	91.6%	4080	93.9%
Reheated	234	11.3%	390	8.4%	265	6.1%
TOTAL	**2,066**		**4,658**		**4345**	

Table 18 shows the number of occasions on which dishes were cooked and expresses the number as a proportion of the total number of dishes recorded in each phase of the study (see Table 18).

Table 19 shows that the foods prepared were broadly similar under all phases of the study, with a few notable exceptions:

- Water was heated less often in the pilot phase.
- Beans and soups were prepared more often in the pilot phase.

TABLE 18 Number of dishes recorded in each phase of the study

PHASE	FREQUENCY	PERCENT
Baseline	2,072	18.6
Transition	4,681	42.1
Pilot	4,356	39.2
Total	11,109	100.0
Missing	2	0
TOTAL	**11,111**	**100.0**

TABLE 19 Types of foods cooked in each phase (top 16 dishes)

DISH	BASELINE		TRANSITION		PILOT		TOTAL
	N	%	N	%	N	%	N
Vegetables	323	15.6%	729	15.6%	604	13.9%	1656
Rice	254	12.3%	611	13.1%	609	14.0%	1474
Porridge	167	8.1%	420	9.0%	359	8.2%	946
Water	166	8.0%	322	6.9%	176	4.0%	664
Tea	156	7.5%	365	7.8%	313	7.2%	834
Beans	155	7.5%	430	9.2%	466	10.7%	1051
Irish (white) potatoes	155	7.5%	337	7.2%	294	6.7%	786
Bread	136	6.6%	397	8.5%	370	8.5%	903
Matoke (green bananas)	96	4.6%	201	4.3%	217	5.0%	514
Milk	63	3.0%	95	2.0%	107	2.5%	265
Meat	42	2.0%	108	2.3%	128	2.9%	278
Sweet potatoes	41	2.0%	63	1.3%	68	1.6%	172
Soup	38	1.8%	163	3.5%	212	4.9%	413
Chips	30	1.4%	74	1.6%	81	1.9%	185
Spaghetti	30	1.4%	77	1.6%	86	2.0%	193
Cassava leaves	28	1.4%	82	1.8%	112	2.6%	222

The appliances used to prepare dishes were noted in almost all of the records (only 61 records had missing data). Of the valid records, 99.3 percent listed only a single appliance. The breakdown by phase presented in Table 20 shows that EPCs were mostly used in place of charcoal. During the pilot phase, 32 percent of dishes were prepared using the EPC. This corresponds to a reduction in the proportion of dishes prepared using charcoal from 68 percent in the baseline phase to 44 percent during the pilot phase, and a modest reduction in use of LPG from 29 percent to 23 percent.

During the baseline phase, fried potato chips were the only dish cooked mostly using LPG. Other dishes that participants liked to cook with LPG included sweet potatoes and matoke (green bananas) (see Figure 16). When EPCs were introduced to kitchens in the pilot phase, participants found them particularly well suited to cooking Irish (white) potatoes, beans and cassava leaves, but also rice, bread, matoke (green bananas) and sweet potatoes (see Figure 17). EPCs were least likely to be used for heating water, for which charcoal continued to be the preferred method. EPCs were seldom used for frying potatoes, and although LPG remained popular, the use of charcoal was unchanged, implying that participants used the EPC in place of LPG.

TABLE 20 Appliances used to prepare individual dishes – by phase (single appliances only)

APPLIANCE	BASELINE		TRANSITION		PILOT	
	N	%	N	%	N	%
Firewood stove	25	1.2%	29	0.6%	51	1.2%
Charcoal stove	1,396	67.9%	2,517	54.0%	1,887	43.6%
Gas stove	589	28.6%	1,233	26.4%	972	22.5%
Gas oven	4	0.2%	2	0.0%	1	0.0%
Electric Pressure Cooker	13	0.6%	833	17.9%	1,385	32.0%
Other electric	6	0.3%	20	0.4%	6	0.1%
TOTAL	**2,033**	**98.8%**	**4,634**	**99.4%**	**4,302**	**99.4%**

FIGURE 16 Breakdown of charcoal vs LPG (main fuels) used to prepare top 16 dishes – baseline phase (single appliance only)

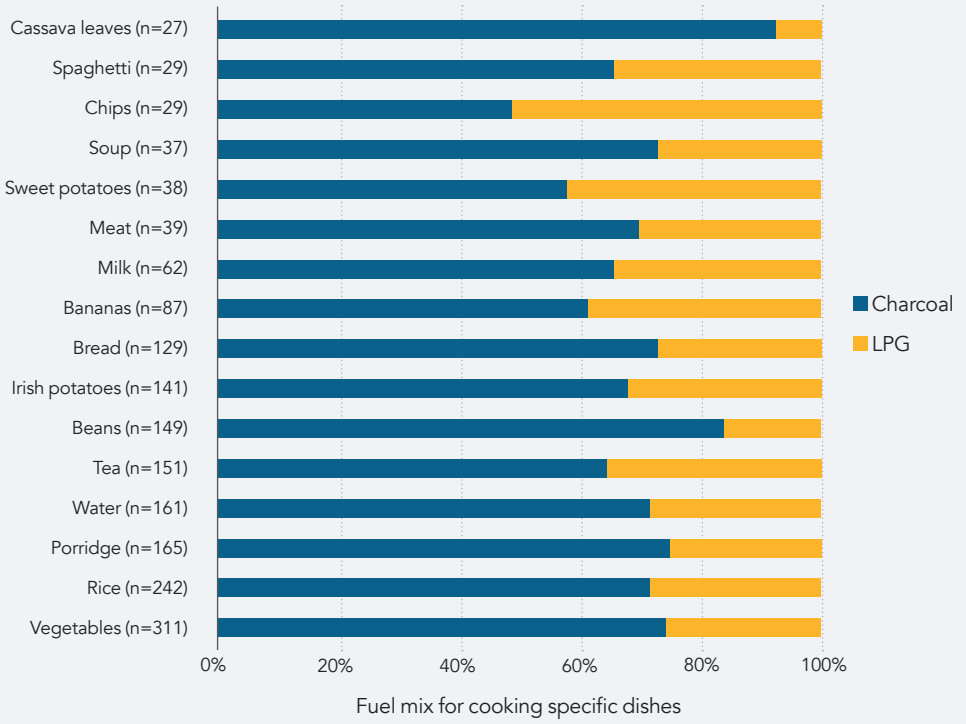
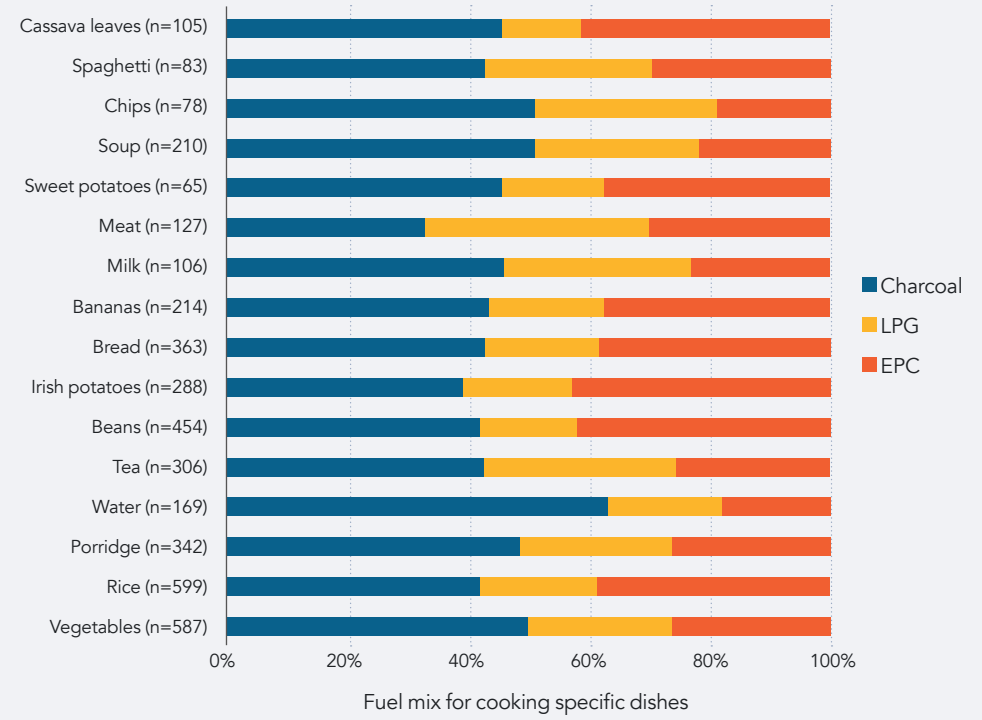


FIGURE 17 Breakdown of charcoal vs LPG vs EPC used to prepare top 16 dishes – pilot phase (single appliance only)



3.3 Cooking energy consumption using different fuels

3.3.1 Analysis at the cooking event level

To evaluate the energy consumption of cooking events recorded in the cooking diaries, the smart meter (EPC) and fuel sensor (charcoal stove) datasets were integrated into the cooking diaries dataset. Taking the smart meter dataset first, for illustration, the procedure for dataset integration went as follows: for each smart meter event, the cooking diary dataset was scanned to find events that occurred in the same household and on the same date. Smart meter events that occurred within the cooking diary event start and end times (plus and minus ten minutes) were matched to the diary events. The ten-minute period added either side of the diary event boundaries was specified to capture cooking that was imprecisely recorded in the diaries or by the smart meter.

A similar procedure was followed for the fuel sensor events, except that the focus was on matching the start time of the fuel sensor event to the start time of the diary event. This was due to the likelihood that fuel sensor events would extend beyond the conclusion of charcoal stove cooking as the temperature, which was used to identify events, would take time to fall. The average fuel sensor event duration was 214 minutes (three hours and 34 minutes), while the average cooking diary event duration for events containing charcoal stove usage was 162 minutes (two hours and 42 minutes). Therefore, the start time of the fuel sensor event was considered more reliable than its end time.

Thus, fuel sensor events for which the start time occurred up to ten minutes before the diary event start time, and up to one hour after the diary event start time, were matched to the diary event. As charcoal dishes could be cooked later within the timeframe of a meal, the one-hour period within which the fuel sensor event could begin was specified. Sensitivity analyses were performed when selecting the before and after periods for both smart meter and fuel sensor events, until extending the period further failed to match many more events while maintaining realistic approximations to cooking practices.

Once the process was complete, matched events that were recorded to have included different cooking fuels were filtered out, e.g., smart meter events for which the recorded cooking fuels did not include electricity. Tables 21 and 22 show how many matched events were obtained during the integration of the datasets.

TABLE 21 Summary statistics for matched smart meter and diary events

RESULTS FOR EPC USAGE	BASELINE	TRANSITION	PILOT
Diary events containing EPC usage	7	431	790
Matched smart meter events	0	43	130
Mean electrical energy consumption (kWh)	-	0.46	0.38
Mean electrical energy consumption (MJ)	-	1.66	1.36
Mean electrical energy consumption per capita (kWh)	-	0.09	0.11
Mean electrical energy consumption per capita (MJ)	-	0.34	0.41

TABLE 22 Summary statistics for matched fuel sensor and diary events

RESULTS FOR CHARCOAL USAGE:	BASELINE	TRANSITION	PILOT
Diary events containing charcoal usage	491	1005	780
Matched fuel sensor events	54	53	36
Mean charcoal consumption (kg)	0.64	0.58	0.39
Mean charcoal consumption (MJ)	17.30	15.48	10.42
Mean charcoal consumption per capita (kg)	0.15	0.13	0.11
Mean charcoal consumption per capita (MJ)	3.90	3.42	2.91

As the table shows, relatively few events were matched (around 10 percent). This is due to low data coverage in the cooking diaries for many households, and likely imprecision and inaccuracy in the cooking diary data due to recording errors. While the cooking diary event start and end times are subject to inaccuracy, the cooking fuels may also have been specified incorrectly. Imprecision and inaccuracy in the smart meter and fuel sensor datasets may also have contributed to the difficulty in matching events.

The matched events were analyzed to assess the energy consumption of events and dishes in each phase, as far as possible. Tables 23 and 24 show the mean energy consumptions and per capita energy consumptions for EPC and charcoal stove cooking in each phase, for all events in which the respective appliances were used, not excluding events in which more than one fuel was used. As expected, cooking with charcoal consumed approximately 10 times the energy of cooking with an EPC. It was also expected that the average charcoal consumption per event would decrease across the phases as the EPC was used to cook more dishes in the pilot phase, as is evident in Table 22.

Event-level energy consumption was explored further by breaking down consumption into breakfast, lunch and dinner. Table 23 below, in which all averages are means, shows that dinners consumed slightly more electrical energy and required slightly more charcoal than lunches, on average. Very few breakfasts had matched events, especially for charcoal.

TABLE 23 Energy consumption of EPC and charcoal stove, split by event purpose

EVENT PURPOSE	EVENTS USING EPC	ELECTRICAL ENERGY, KWH (MJ)	ELECTRICAL ENERGY PER CAPITA, KWH (MJ)	EVENTS USING CHARCOAL	CHARCOAL ENERGY, KG (MJ)	CHARCOAL ENERGY PER CAPITA, KG (MJ)
Breakfast	9	0.45 (1.62)	0.12 (0.43)	2	-	-
Lunch	84	0.37 (1.33)	0.10 (0.36)	62	0.46 (12.50)	0.12 (3.28)
Dinner	64	0.43 (1.54)	0.12 (0.43)	60	0.64 (17.15)	0.14 (3.83)
OVERALL	**157**	**0.40 (1.43)**	**0.11 (0.39)**	**124**	**0.52 (13.99)**	**0.13 (3.55)**

TABLE 24 Energy consumption of EPC and charcoal stove (baseline phase)

EVENT PURPOSE	EVENTS USING EPC	ELECTRICAL ENERGY, KWH (MJ)	ELECTRICAL ENERGY PER CAPITA, KWH (MJ)	EVENTS USING CHARCOAL	CHARCOAL ENERGY, KG (MJ)	CHARCOAL ENERGY PER CAPITA, KG (MJ)
Breakfast	-	-	-	2	-	-
Lunch	-	-	-	17	0.63 (16.81)	0.16 (4.22)
Dinner	-	-	-	23	0.64 (19.93)	0.17 (4.45)
OVERALL	**-**	**-**	**-**	**42**	**0.67 (18.01)**	**0.16 (4.21)**

Tables 25, 26 and 27 break down the energy consumption further, across the three phases, showing the variation in the average amount of electrical energy and charcoal consumption per event.

The tables provide insights on electrical and charcoal energy requirements for cooking in Rwanda, despite the low numbers of data points. Importantly, the mean charcoal consumption per capita per event decreased from 0.16 kg (4.21 MJ) in the baseline phase to 0.11 kg (2.94 MJ) in the pilot phase, a reduction of 30.2 percent, due to participants substituting charcoal stove usage with EPC cooking. The mean EPC energy consumption per capita per event increased slightly between the transition and pilot phases, while the most energy-intensive meal purpose varied across the phases for each fuel, between lunch and dinner.

The data were explored further to approximate the energy requirements at a dish level. Events were identified where only one of the dishes was cooked with an EPC, and the same for a charcoal stove. Table 25 below shows that the electrical energy consumption of events where only one dish was cooked with an EPC was slightly lower than that of all matched EPC events, decreasing from 0.11 kWh (0.39 MJ) per capita to 0.08 kWh (0.35 MJ), implying that the EPC was sometimes used for more than one dish within a meal, and providing useful data on EPC cooking requirements. It is also clear that charcoal was rarely used for only one dish.

TABLE 25 Energy consumption of EPC and charcoal stove (transition phase)

EVENT PURPOSE	EVENTS USING EPC	ELECTRICAL ENERGY, KWH (MJ)	ELECTRICAL ENERGY PER CAPITA, KWH (MJ)	EVENTS USING CHARCOAL	CHARCOAL ENERGY, KG (MJ)	CHARCOAL ENERGY PER CAPITA, KG (MJ)
Breakfast	3	0.64 (2.29)	0.12 (0.43)	0	-	-
Lunch	22	0.41 (1.48)	0.08 (0.29)	25	0.40 (10.72)	0.09 (2.52)
Dinner	17	0.50 (1.81)	0.11 (0.39)	22	0.71 (19.16)	0.16 (4.22)
OVERALL	**42**	**0.46 (1.67)**	**0.10 (0.34)**	**47**	**0.55 (14.67)**	**0.12 (3.32)**

TABLE 26 Energy consumption of EPC and charcoal stove (pilot phase)

EVENT PURPOSE	EVENTS USING EPC	ELECTRICAL ENERGY, KWH (MJ)	ELECTRICAL ENERGY PER CAPITA, KWH (MJ)	EVENTS USING CHARCOAL	CHARCOAL ENERGY, KG (MJ)	CHARCOAL ENERGY PER CAPITA, KG (MJ)
Breakfast	6	0.36 (1.29)	0.12 (0.44)	0	-	-
Lunch	62	0.35 (1.28)	0.11 (0.38)	20	0.41 (11.05)	0.13 (3.42)
Dinner	47	0.40 (1.44)	0.12 (0.45)	15	0.36 (9.77)	0.09 (2.30)
OVERALL	**115**	**0.37 (1.34)**	**0.11 (0.41)**	**35**	**0.39 (10.50)**	**0.12 (3.32)**

TABLE 27 Energy consumption of events with one dish cooked using an EPC or charcoal

EVENT PURPOSE	EVENTS USING EPC	ELECTRICAL ENERGY, KWH (MJ)	ELECTRICAL ENERGY PER CAPITA, KWH (MJ)	EVENTS USING CHARCOAL	CHARCOAL ENERGY, KG (MJ)	CHARCOAL ENERGY PER CAPITA, KG (MJ)
Breakfast	4	0.36 (1.30)	0.08 (0.29)	0	-	-
Lunch	49	0.33 (1.19)	0.10 (0.37)	11	0.61 (16.42)	0.25 (6.60)
Dinner	27	0.40 (1.44)	0.09 (0.34)	6	0.66 (17.62)	0.17 (4.58)
OVERALL	**80**	**0.36 (1.28)**	**0.08 (0.35)**	**17**	**0.63 (16.84)**	**0.22 (5.89)**

The number of dishes per event cooked using EPCs and charcoal stoves was explored and is presented in Table 28 below. While it was more common to cook more than one dish with charcoal, cooking two dishes with the EPC was surprisingly common, only slightly less prevalent than cooking one dish with the EPC.

Table 29 breaks down the energy consumption for events in which two or more dishes were cooked using EPCs and charcoal, showing that the electrical energy consumption increased, as expected. Charcoal consumption actually decreased, although this is likely due to the small number of data points available for single charcoal dish events and the foods cooked within those events.

TABLE 28 Energy consumption of events with one dish cooked using EPCs or charcoal

DISHES PER EVENT	EPC	EPC %	CHARCOAL	CHARCOAL %
0	3,016	71%	1,967	46%
1	543	13%	439	10%
2	464	11%	782	18%
3	149	4%	632	15%
4	54	1%	269	6%
5	11	0%	93	2%
6	7	0%	62	1%
TOTAL	**4,244**		**4,244**	

TABLE 29 Energy consumption of events with two or more dishes cooked using EPCs or charcoal

EVENT PURPOSE	EVENTS USING EPC	ELECTRICAL ENERGY, KWH (MJ)	ELECTRICAL ENERGY PER CAPITA, KWH (MJ)	EVENTS USING CHARCOAL	CHARCOAL ENERGY, KG (MJ)	CHARCOAL ENERGY PER CAPITA, KG (MJ)
Breakfast	5	0.52 (1.88)	0.15 (0.55)	2	-	-
Lunch	35	0.42 (1.53)	0.10 (0.35)	51	0.43 (17.62)	0.10 (4.58)
Dinner	37	0.45 (1.60)	0.14 (0.50)	54	0.64 (16.42)	0.14 (6.60)
OVERALL	**77**	**0.44 (1.59)**	**0.12 (0.44)**	**107**	**0.54 (16.84)**	**0.12 (5.89)**

Finally, an analysis of what could be considered a typical transition in stove usage was conducted. The energy consumption of baseline-phase events using only charcoal was compared to that of pilot-phase events that included charcoal and/or EPC usage, to understand the average consumption of electrical energy and charcoal for households in which an EPC was introduced, and enabling comparison to the energy consumption before the transition. Tables 30 and 31 below present the results (Note: There were insufficient data on the preparation of breakfast to provide any meaningful analysis on that meal).

The tables show a clear reduction in charcoal usage, from 0.17 kg (4.47 MJ) per capita to 0.12 kg (3.22 MJ) per capita, a reduction of 28.0 percent, while also providing data on the corresponding average EPC energy requirement in the pilot phase, enabling a direct comparison between household energy requirements before and after introducing EPCs.

TABLE 30 Energy consumption of charcoal-only events in the baseline phase

EVENT PURPOSE	EVENTS USING EPC	ELECTRICAL ENERGY, KWH (MJ)	ELECTRICAL ENERGY PER CAPITA, KWH (MJ)	EVENTS USING CHARCOAL	CHARCOAL ENERGY, KG (MJ)	CHARCOAL ENERGY PER CAPITA, KG (MJ)
Breakfast	-	-	-	1	-	-
Lunch	-	-	-	14	0.60 (16.26)	0.17 (4.51)
Dinner	-	-	-	23	0.74 (19.93)	0.17 (4.45)
OVERALL	**-**	**-**	**-**	**38**	**0.69 (18.58)**	**0.17 (4.47)**

TABLE 31 Energy consumption of charcoal and/or EPC events in the pilot phase

EVENT PURPOSE	EVENTS USING EPC	ELECTRICAL ENERGY, KWH (MJ)	ELECTRICAL ENERGY PER CAPITA, KWH (MJ)	EVENTS USING CHARCOAL	CHARCOAL ENERGY, KG (MJ)	CHARCOAL ENERGY PER CAPITA, KG (MJ)
Breakfast	7	0.38 (1.38)	0.18 (0.65)	0	-	-
Lunch	64	0.36 (1.28)	0.11 (0.38)	16	0.45 (12.10)	0.15 (4.06)
Dinner	55	0.36 (1.30)	0.11 (0.41)	13	0.33 (8.83)	0.08 (2.19)
OVERALL	**126**	**0.36 (1.30)**	**0.11 (0.41)**	**29**	**0.40 (10.63)**	**0.12 (3.22)**

3.3.2 Analysis of energy consumption on a daily basis

The FUEL data logging scales recorded the consumption of charcoal and LPG throughout the study while the electricity meter recorded the energy used by the EPC during the pilot phase. Using the net calorific value (NCV) of charcoal and LPG and the typical thermal efficiency of the charcoal stoves, LPG stoves and EPCs, we can calculate the useful energy (delivered to the cooking pot) before and after the introduction of the EPC (the transition phase is excluded because no electricity meter was measuring the energy used).

We used the following value to calculate the energy delivered to the pot:

TABLE 32 NCV and thermal efficiency used to calculate energy delivered to the pot

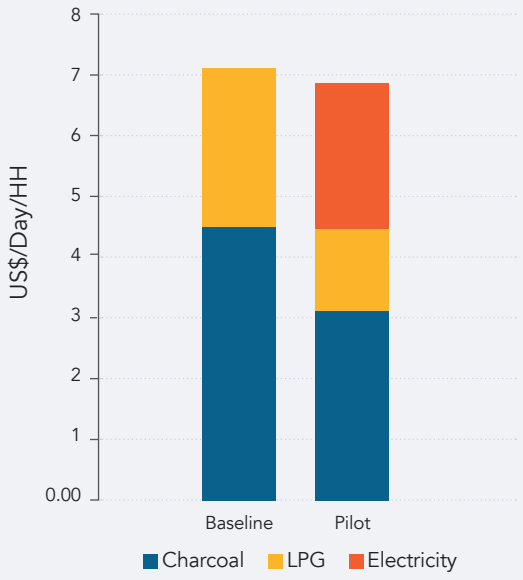
	CHARCOAL	LPG	EPC
NCV (MJ/kg)	25.6	45.5	
Thermal Efficiency (%)	25%	55%	90%

In the baseline phase, about 7.04 MJ/day/HH of useful energy was consumed for cooking.

In the pilot phase, the useful energy from LPG and charcoal decreased to 4.86 MJ/day/HH (31 percent less than during the baseline phase) and the EPC delivered 1.91 MJ/day/HH of useful energy for a total of 6.77 MJ/day/HH. Please see Figure 18.

An overall decrease in energy use was expected since the higher cooking temperature and pressure characteristic of the EPC reduces energy requirements.

FIGURE 18 Useful energy used before and after the introduction of the EPC



3.4 Time Savings

3.4.1 Meal preparation times across phases

There was a long list of events with long preparation times, which may represent foods that took longer to cook, or the preparation of multiple meals (40 percent of events longer than six hours represent the preparation of two or more meals), or they may reflect inaccuracies in participants' recording of events. Events longer than six hours made up only 3 percent of valid records, so these have been omitted from this part of the analysis.

The median time taken to prepare a meal dropped from one hour 44 minutes in the baseline phase to one hour 30 minutes in the pilot phase, a saving of 14 minutes (or 13 percent) – see Table 33. (Note: These figures include a small number of records (10 percent) covering multiple meals. When these records are omitted, times can then be calculated for each type of meal prepared; see Table 34. This shows that time savings were greatest when households prepared lunches (40 minutes, comparing the pilot phase with the baseline phase). The median time taken to prepare both breakfasts and lunches was reduced by one third, while EPCs reduced the median time taken to prepare dinners by 25 percent.

TABLE 33 Average event duration by phase (< 6 hours)

PHASE OF STUDY	MEAN	MEDIAN	N	STD. DEVIATION
Baseline	1:52	1:44	702	1:07
Transition	1:44	1:30	1,700	1:07
Pilot	1:36	1:18	1,699	1:06
TOTAL	**1:42**	**1:30**	**4,101**	**1:07**

TABLE 34 Average duration of time spent preparing meal types by phase (single meal types; < 6 hours)

		BASELINE	TRANSITION	PILOT
Breakfast	Mean	01:14	00:49	00:39
	Median	00:45	00:37	00:30
	N	80	161	104
Lunch	Mean	02:21	01:51	01:41
	Median	02:00	01:31	01:20
	N	260	667	685
Dinner	Mean	02:01	02:04	01:42
	Median	01:45	01:44	01:19
	N	295	746	761

3.4.2 Cooking times with different fuels

The time taken to prepare a meal using EPCs was similar to that taken when cooking with LPG, but approximately half of the time taken to cook with charcoal (Table 35). These figures do not take account of the different types of dishes prepared using the different fuels, although these differences have been shown to be modest (Table 19). These figures were confirmed by the amount of time saved when households cooked specific dishes (Figure 19). The average amount of time saved across the six dishes in the figure was 36 percent. The figures in Table 35 show that charcoal tends to be used to prepare larger meals, where large refers to both the number of dishes in the meal and the number of people eating the meal.

In principle, the time taken to cook a meal using a given fuel should be independent of the phase of the study, but only if the same foods are cooked in each phase. However, the durations given in Table 35 for meal preparation times for both charcoal and LPG imply a trend of decreasing cooking time with increasing use of EPCs. Note that EPCs tended to be used for foods that take longer to cook such as beans, breads, Irish (white) and sweet potatoes (Table 14), which left a higher proportion of foods that take less time to cook with traditional fuels in the pilot phase.

TABLE 35 Meal preparation times by fuel (single fuels; < 6 hours)

		EVENT DURATION (HH:MM)		NUMBER OF DISHES	NUMBER OF PEOPLE COOKED FOR
	N	Mean	Median	Mean	Mean
Firewood	49	01:56	01:25	2.0	3.5
Charcoal	1,861	02:04	01:56	2.8	4.8
LPG	996	01:17	01:00	2.4	4.1
Electricity	712	01:11	00:58	2.1	3.8

FIGURE 19 Cooking times (median) using different fuels for common dishes (n>=5)

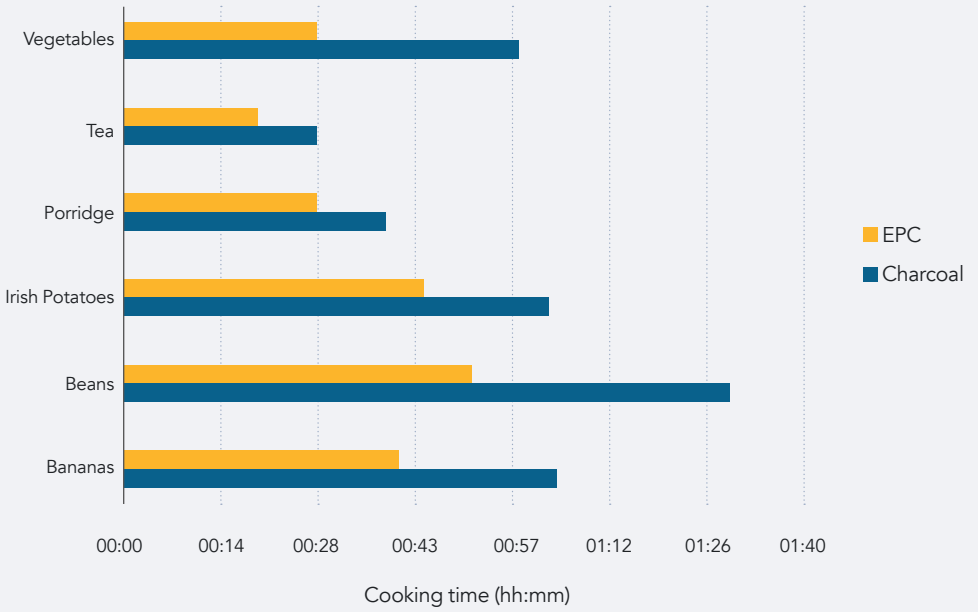


TABLE 36 Meal preparation times by fuel and phase (single fuels; < 6 hours)

		BASELINE	TRANSITION	PILOT
Firewood	Mean	01:23	01:28	03:21
	Median	00:55	00:50	03:30
	N	19	17	13
Charcoal	Mean	02:09	02:02	02:02
	Median	02:00	01:52	01:50
	N	430	848	583
LPG	Mean	01:23	01:19	01:10
	Median	01:10	01:04	00:55
	N	215	439	342
Electricity	Mean		01:17	01:08
	Median		01:00	00:56
	N		234	477

Event duration times refer to the time that elapsed between turning the stove on and turning it off at the end of the meal preparation. The cooking diaries included an additional question that asked how much time was taken to prepare the fuel before putting the pot on the stove. These figures indicate that both LPG and electricity are available more or less instantaneously, but charcoal takes approximately seven minutes to prepare (Table 37). This represents an additional time saving potential of EPCs on top of the hour shown in Table 36.

For cooking events where only, a single dish was prepared and only a single appliance was used, the entire duration of the cooking event can be attributed to the dish prepared. Most of the events recorded comprised more than one dish, so the figures in Table 38 are based on a relatively small subset of the data. Note that these times were for cooking fresh dishes only; reheating would be expected to take less time. The table shows a consistent trend that times for cooking most dishes are similar when using EPCs and LPG, but represent a considerable time saving over cooking with charcoal. Time savings over around 30 minutes can be achieved when cooking certain foods such as vegetables and matoke (green bananas), and savings for cooking beans are even greater. An EPC is still quicker than charcoal for food or drinks that can be made quickly, such as porridge and tea, although time savings are more modest at around ten minutes.

TABLE 37 Time taken to prepare fuel (single fuels)

FUEL	MEAN (MINUTES)	MEDIAN (MINUTES)	N	STD. DEVIATION
Firewood	13.56	15.00	16	3.521
Charcoal	8.29	7.00	779	5.776
LPG	.86	.00	416	2.706
Electricity	1.61	.00	621	4.733
TOTAL	**4.38**	**1.00**	**1,832**	**6.015**

TABLE 38 Duration of cooking event for single foods freshly cooked on single appliances (n>=5)

DISH	CHARCOAL			LPG			ELECTRIC PRESSURE COOKER		
	Mean (hh:mm)	Median (hh:mm)	N	Mean (hh:mm)	Median (hh:mm)	N	Mean (hh:mm)	Median (hh:mm)	N
Matoke (green bananas)	01:25	01:04	39	00:58	00:58	18	00:49	00:41	30
Beans	02:04	01:30	31				00:57	00:52	40
Irish (white) potatoes	01:07	01:03	51	00:51	00:49	32	00:52	00:45	51
Milk	00:32	00:31	5	00:18	00:15	7			
Porridge	00:47	00:39	35	00:27	00:29	52	00:25	00:29	29
Rice							00:28	00:27	22
Spaghetti				00:28	00:29	6	00:44	00:30	5
Tea	00:41	00:29	15	00:25	00:25	42	00:20	00:20	21
Vegetables	01:03	00:59	9	00:48	00:50	5	00:37	00:29	11

3.5 Energy consumption of eCooking

EPC usage data were recorded by smart meters connected to the appliances. Three different metrics were used to assess EPC usage in households: events, energy and time. These metrics were reported over different time bases to provide deeper insight into energy consumption following the arrival of the EPC and minimize bias that can result from the smart meters being disconnected from the EPCs, which results in gaps in the data and an underreporting of the actual appliance usage. The time bases were as follows:

- **Day of ownership:** the number of days between the first and last recorded events in each household.
- **Day of ownership (net maximum gap):** the number of days between the first and last recorded events minus the number of days from the largest unreported period in each household.
- **Day of usage:** the number of days on which EPC usage events were recorded in each household.

The day of ownership metrics provide conservative estimates of usage since some participants cooked with their EPCs disconnected from the smart meter, which was noted and corrected in follow-up visits by enumerators. The day of usage metrics are aggressive estimates of usage since many households did not actually use their EPC every day. The day of ownership net maximum gap metrics account for these realities and are thus our best estimates for the actual usage.

On average, most EPC cooking events were 40 minutes long and consumed 0.45kWh of energy (Table 39). Since cooking events were determined by instances of sustained energy usage, it is possible that actual cooking events were longer as a result of food continuing to cook in the EPC without additional energy input. This is commonly seen in pressure cookers when using a natural release method, in which power is cut but the food is kept sealed in the cooking chamber until the pressure is gradually reduced.

EPCs were used on average 1.4 times per day after the study participants had purchased them, which corresponded to 0.59 kWh and 56 minutes of usage per day (see Table 40 below). Daily usage of the EPC suggests that the appliances were integrated seamlessly into household cooking behaviour. However, the rate of usage also suggests that the EPC was stacked with other fuels.

TABLE 39 EPC usage data from smart meters (n=92

	PER DAY OF OWNERSHIP	PER DAY OF OWNERSHIP (NET MAXIMUM GAP)	PER DAY OF USE
Average Events	1.1 events/day	1.4 events/day	1.9 events/day
Average Energy	0.45 kWh/day	0.59 kWh/day	0.80 kWh/day
Average Time	43 minutes/day	56 minutes/day	76 minutes/day
Average Events	1.1 events/day	1.4 events/day	1.9 events/day

TABLE 40 EPC usage data from smart meters (n=92)

	TOTAL	PER HOUSEHOLD	PER HOUSEHOLD PER DAY
Events	2,431	26.1	1.4
Energy	1007 kWh	10.94 kWh	0.59 kWh
Cooking Time	1,603 hours	17.24 hours	56 minutes
Average Time	43 minutes/day	56 minutes/day	76 minutes/day
Average Events	1.1 events/day	1.4 events/day	1.9 events/day

3.6 EPC payment

The participants had the opportunity to pay for the EPCs in installments. The payment scheme was categorized as follows:

- Those who paid on a weekly basis: 8
- Those who paid on a bi-weekly basis: 1
- Those who paid monthly: 86
- Those who paid once (the total amount) after one month: 5

The analysis shows that the average payment duration was two days per payment which means that on average, it took approximately two days for payment to be processed and completed. This metric indicates the typical timeframe between the date a household was supposed to pay and when the payment was received.

In general, the default rate was 18 percent. This figure included customers who were late in paying the installments after paying the down payment. These customers needed reminding several times before they paid. At the time of writing this report, no participant had refused to continue paying.

EPC payment explained by category:

1. Those who paid on a weekly basis: seven out of eight households paid on time; one household was late in paying. This represents an 87.5 percent rate of timely payment and a 12.5 percent rate of untimely payment.
2. Those who paid bi-weekly: one household chose to pay bi-weekly and paid on time, representing 100 percent timely payment.
3. Those who paid on a monthly basis: 76 of 86 households (88.37 percent) paid on time while 10 households (11.63 percent) fell behind with their payments.
4. Those who paid the total amount after one month: five households all paid in full after the first month, representing 100 percent timely payment.

3.7 Experience of using EPCs

3.7.1 Advantages of eCooking

The majority of households in the study found cooking with an EPC easy. Food did not burn, and tasted good. This ease of use combined with the speed of cooking and associated time saved were among the most common observations shared by the participants; more than 90 percent of households highlighted their ability to do other activities while cooking with an EPC. Most strongly agreed that it was easy to find recipes for an EPC, the appliance was easy to clean, there was enough space for it in their kitchens, and that it looked good in their kitchens. Cleanliness (including the absence of smoke) and safety while cooking were also appreciated; 95 percent of participants found cooking with an EPC to be safer than cooking with other fuels, especially charcoal. 10 percent of participants perceived EPCs as being affordable or saving them money.

3.7.2 Challenges and limitations of eCooking

The most common challenge when cooking with an EPC reported by the study participants was the availability of only one pot, which made preparation of meals difficult as there is usually more than one food prepared at each meal.

Participants were neutral about the size of the cooking pot; however, it was clear that while the size was mostly sufficient, the number of cooking pots was not. This is also supported by the finding that for households using stoves with hobs (N=92), they use, on average, 2.4 hobs when cooking. Additionally, approximately 20 percent of households reported using additional appliances other than pots used on the stoves with hobs. These were typically pots used on charcoal or a kettle.

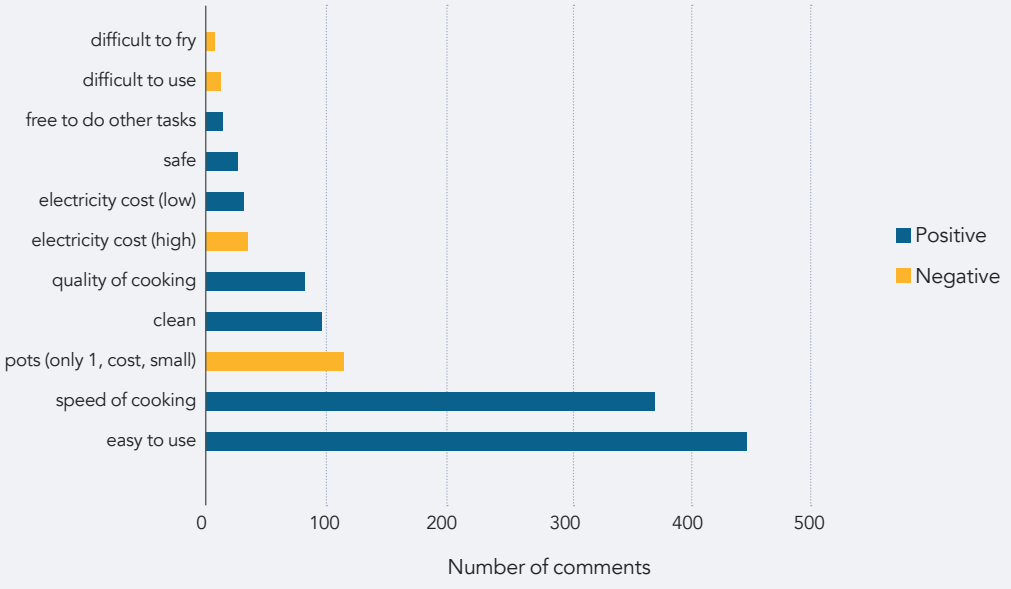
There was also no particular preference for boiling water in an electric kettle rather than the EPC.

There were a few recorded instances (less than 10 percent) where the EPC was not used much because the young people employed to cook were not the ones who attended the training provided by the enumerators and the Electrocook team and therefore did not know how to use it.

10 percent of participants described the electricity consumption of the EPC as the thing they disliked most, meaning they thought it consumed a lot of electricity. A similar number identified the fear of a short circuit in the house as an issue during the EPC pilot phase. Approximately 20 percent found the unreliability of power and the fact that the EPC does not work when the power is off to be what they disliked the most about cooking with it. In instances where the electricity was off (i.e., during a power cut) at the time of cooking, households typically resorted to using other fuels they already had (LPG and/or charcoal).

It is interesting to see in Figure 20, which compiles the overall positive and negative aspects of cooking with an EPC and quantifies them according to the number of comments made in the cooking diaries, that opinions on the cost of using an EPC were split almost equally between those who found it expensive (it used a lot of electricity) and those who didn't. Study participants found the most pressing drawback of the EPC to be the pot. Most of their comments related to only having one pot, meaning it was not possible to cook more than one type of food at any given time. However, the data indicate that most people were successfully able to cook meals consisting of multiple foods in the EPC; the mean number of dishes cooked was 2.1 (Table 18). Other issues raised were the size of the pot, which they found to be too small, and the cost of buying additional pots.

FIGURE 20 Observations on the experience of cooking with EPCs



3.7.3 Compatibility of cooking dishes in EPC and using other fuels

On average, the most common Rwandan dishes were reported to be easy to cook in an EPC. The easiest ones to cook were:

- rice
- Irish (white) or sweet potatoes
- boilo (meat soup)
- leafy vegetables
- meat stews
- fried meat
- pasta (or noodles)

The dishes that were the most challenging were isombe (stew made from cassava leaves) and chapatti.

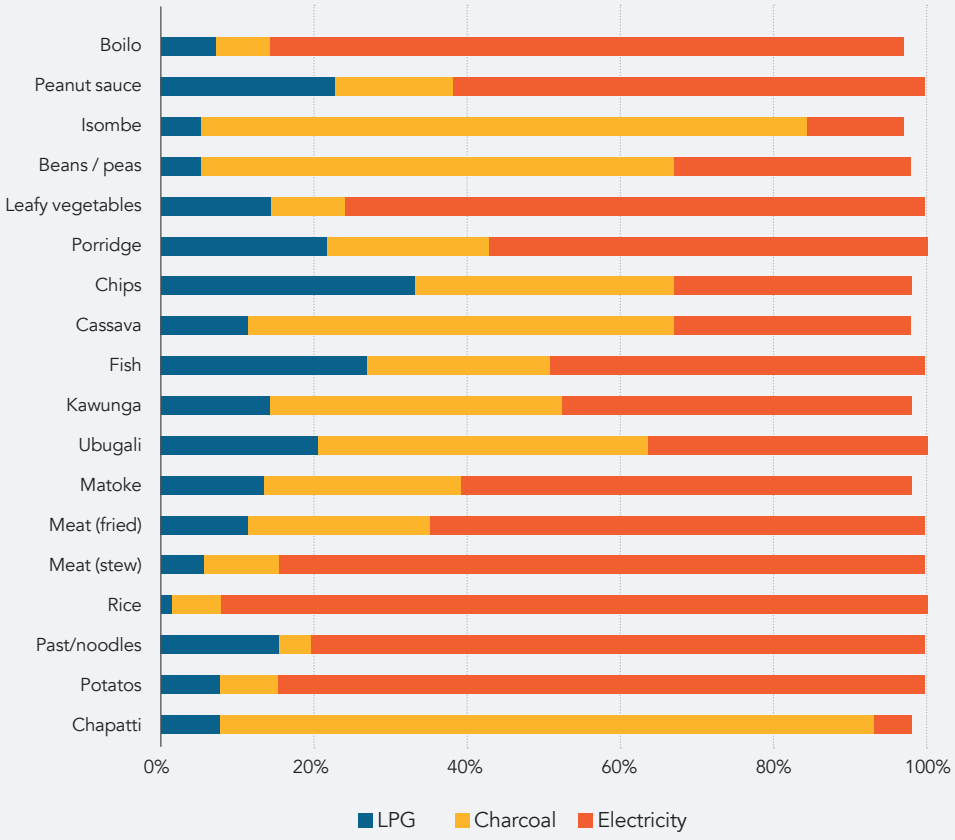
Figure 21 below shows which fuel (LPG, charcoal or electricity) the study participants preferred to use to cook different typical Rwandan dishes.

Electricity was preferred for rice, meat stews, potatoes, pasta/noodles, boilo and leafy vegetables (more than75 percent of respondents). LPG was preferred for making chapatti and frying chips (although that was only 35 percent of respondents). Charcoal was the preferred fuel for the cooking of isombe, beans/peas, and making chapatti (80 percent, 63 percent and 57 percent of respondents, respectively).

13 percent of respondents reported using the EPC for only one dish while preparing a meal, whereas 87 percent said they use it for more than one dish, meaning that the same pot is used multiple times while preparing a meal.

FIGURE 21 Fuel preference for selected dishes

Note: The number of respondents for each of the dishes varied between 93 and 99



3.7.4 Impact of eCooking on flavour

Only 15 percent of all participants missed the smoky flavour of food cooked on charcoal, and the foods that they missed that flavour in were potatoes, stewed meat, beans or peas, and boilo.

3.7.5 Adaptation of in-house infrastructure

Only 4 percent of participating households required modifications to their electrical installation inside the house (plugs/sockets) but these were not found to cause any inconvenience.

3.7.6 Change in cooking habits

At the end of the EPC pilot phase, the participants were asked about any changes in cooking habits resulting from the pilot and the use of an EPC (e.g., cooking more of certain foods/dishes, or cooking different dishes, shifting cooking times, etc.). 26 percent reported changes to their cooking habits while 76 percent reported no changes. For the former, the changes were predominantly around saving time and being able to do other activities while cooking, as well as making more tea.

3.7.7 Confidence, usability and affordability perceptions of eCooking

89 percent of respondents said they were very confident using an EPC after they had had it for a few weeks. The remaining 11 percent were either somewhat confident or not confident. However, 100 percent stated that they would be confident explaining how to use an EPC if they were asked to do so, and 98 percent said it was either easy or somewhat easy to learn how to cook with an EPC because training and guidance were provided, as well as a user's manual, which was found to be helpful. Generally, the participants felt learning how to use an EPC is not difficult but that for new users training would be necessary (77 percent said so, while 23 percent believed new users could learn by themselves). The suggested focus of any future training was: knowing how to measure the amount of water to use for cooking different foods; how to regulate the heat/operate the EPC; how to cook different staple foods; setting the timer; how to open and close the EPC; and the advantages of cooking with electricity and why clean cooking is important.

Of the 89 percent of respondents who said there could be some improvements made to the design of the EPC for greater usability, more than 80 percent suggested increasing its size and/or the number of cooking pots. One respondent suggested that it would be better to have a transparent lid to be able to see the food inside, while another said that frying should be removed as a function as it consumes more electricity (compared to boiling).

Regarding the perceptions around the affordability of cooking with electricity, 59 percent of respondents found it very affordable, 30 percent found it somewhat affordable, and only 5 percent found it somewhat unaffordable. 6 percent could not tell.

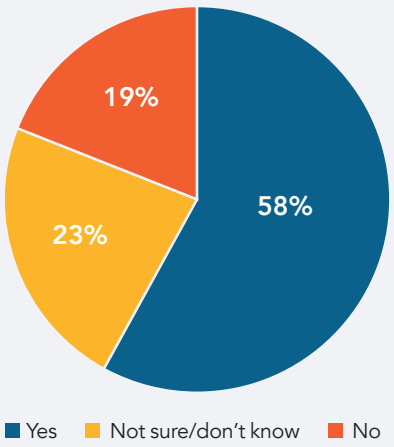
75 percent of participants found cooking with electricity to be cheaper than cooking with other fuels. 18 percent reported seeing it as comparative in cost to the use of other fuels, and 3 percent found it was more expensive. The remaining 4 percent either did not respond or could not tell.

3.7.8 Interest in EPCs and suitability of payment mode

Figure 22 below shows how many participants would choose to purchase an EPC if they had not purchased one as part of this study.

Only 8 percent of participants did not find their chosen payment mode (selected at the time of signing up to the study and the purchase of the EPC) unsuitable. For all but one of those the chosen mode was a monthly payment (as was the choice for the majority of participants). It was unclear specifically why the chosen payment mode did not suit those participants other than the lack of money to pay when it was time, which suggests it may have been an issue of ability to pay rather than an unsuitable payment mode. Paying monthly was appreciated by those who selected it as it offered the ability to pay in installments and to plan for the payment every month. Participants also appreciated having options from which to choose.

FIGURE 22 Willingness to purchase an EPC among the study participants if they had not purchased one as part of the study



3.7.9 Future cooking choices

57 percent of participants stated that they would consider using only electricity for cooking in the future because it is safe, fast and economical. The common reasons for not being willing to consider switching to eCooking only (43 percent of respondents) were: the unreliable power; a preference for other fuels; and that cooking with only one EPC might not be sufficient, especially for larger families.

All the participants said they would continue using their EPC following the completion of the study, with 25 percent stating specifically that they would continue using their EPC alongside all the stoves they had previously owned. The motivation to continue stove stacking was to cook certain foods on other stoves.

All participants reported that they were very or somewhat likely to cook with electricity more if the electricity tariffs were lower.

3.7.10 Satisfaction with EPC – Net Promoter Score

81 percent of participants reported that the EPC met their expectations. For the remaining 19 percent, they either could not tell or did not think the EPC had met their expectations. The main reason for that was the size of the EPC that was seen as too small for a big family to use.

The calculated Net Promoter Score (NPS), which asks how likely a customer is to recommend a product or a service to others, which in turn reflects their satisfaction, was 4.9 (on a scale 1-5, where 5 is very likely to recommend and 1 not at all likely). This shows a high level of satisfaction with the EPC and a high likelihood of participants promoting the appliance in their networks.

CHAPTER FOUR

Challenges and limitations

4.1 Challenges and limitations during the baseline and transition phases

During the baseline and transition phases, Electrocook faced several challenges with data collection and with the installation of stove use monitors (SUMs) and fuel scales.

One of the first steps that had to be completed for households to participate in the study was the Registration Survey. The enumerators reported that numerous participants were not available for the survey. Some participants were hard to reach during regular working hours and had to be visited or contacted over the weekend. Others were only available for a limited amount of time and had to be visited several times for enumerators to complete the necessary data collection. Similarly, there were challenges associated with the daily completion of cooking diaries; in some instances, the house staff responsible for cooking were not literate and required a significant amount of assistance to fill out the forms, while in other cases there was negligence in that the forms were not filled out every time meals were cooked and the enumerators had to follow up with the cooks or the responsible house staff or household members on the cooking events that were then added to the forms retrospectively. This meant that some recalled cooking events might contain some inaccurate data or might have some data missing. As soon as this challenge was identified, the study team decided that each enumerator should regularly follow up with the households they were responsible for (10 households per enumerator) to ensure that the cooking diary forms were indeed being filled out in a timely fashion.

As the study was conducted during the long rainy season (March–May), there were instances where data collection was interrupted by rainy weather as enumerators were unable to reach households located in hard-to-reach parts of Kigali, where roads were difficult to drive on.

Challenges with the installation of the equipment used for data collection on stove usage and fuel consumption were mostly associated with the misplacement of the SUMs or fuel scales during the installation process, or inaccurate installation (e.g., fuel scales not placed on a flat surface). The wrongly installed sensors had to be re-installed by the designated enumerators and supervising staff, a process that took approximately two weeks due to the limited availability of household members and therefore limited access to the equipment. This challenge resulted in delays in the collection of data on stove and fuel usage in 19 households for which no charcoal or LPG consumption data were collected during the baseline phase, which has been acknowledged in the presented results.

It was also noted that a few of the households found it difficult to weigh charcoal with the fuel scales provided at the start of the study. The process was found to be tedious and the challenges associated with the use of the scales might have affected the accuracy of measurements of the charcoal used for cooking. As a result, there are 13 and 21 households in the transition and pilot phase respectively that have no LPG and charcoal consumption data.

4.2 Challenges and limitations of the pilot phase

Once the study reached the phase where electric pressure cookers (EPCs) were being distributed, there were a number of participants who were hesitant to use the appliances without tracking the energy consumption from the energy meters as they were skeptical about their energy efficiency. Despite participants' reservations, there were no instances where they did not use the EPC before receiving the energy meter.

After receiving the energy meters, some participants complained that more electricity was being used, which led them to believe that the energy meters themselves were consuming electricity.[5] Households that perceived a difference in energy consumption avoided using their smart meters, creating gaps in the data.

To address this challenge, Electrocook provided further information to the participants on how to use the energy meters correctly and how to understand the readings. Additionally, Electrocook conducted follow-up visits to the participants to ensure that they were using the smart meters correctly and to address any issues they were facing. During the analysis, additional steps were taken to account for issues related to data gaps or passive energy consumption of the smart meters. Overall, these efforts helped to ensure that the study was collecting accurate data on the energy consumption of the EPCs.

Another challenge that impacted participants' experience and the robustness of data collection was the fact that 17 of the 100 participating households shared their electricity meters with their landlords or neighbours, which made them hesitant to use the EPCs for fear that they would be exceeding their usual electricity consumption. This could raise suspicion of the landlords or neighbours, and lead to potential conflict.

Finally, there were also instances where the power plugs and/or sockets had to be repaired or changed due to malfunctions or breaking. That was the case in eight households. These issues were addressed by the Electrocook team as soon as they were reported and took, on average, one to two days to resolve.

A comprehensive log of issues recorded in the participating households can be found in Appendix 5.

However, despite all the challenges experienced during the three phases, all participants said they would be interested in participating in another study of this kind should one be conducted in the future.

[5] Although the meters typically consume 0.5W of power, a review of data showed that a subset of meters were experiencing passive power draws ranging up to 23W while in the field. The power consumption was not observed when the meters were connected in a controlled setting, suggesting that the issue was related to a leakage current in the connection of the EPCs to the smart meters. The effect of this passive consumption was minimal on the overall energy analysis (1 percent difference), but was noticeable to some households.

CHAPTER FIVE

Summary of findings and recommendations

5.1 Key insights

This report presents the findings of a study on the experience of urban households in Kigali using electric pressure cookers (EPCs) and the impact of those on stove(s) and fuel(s) usage, fuel stacking, cooking expenditure, time savings and cooking habits, including any changes in the types of dishes cooked. The results show that the overall experience of cooking with an EPC, which was a new cooking appliance to nearly all participating households, was positive. This chapter summarizes the key insights that came out of the study.

USAGE PATTERNS AND FUEL STACKING

After acquiring their EPCs, participants commonly resorted to fuel stacking, indicating the challenge of cooking multiple dishes in an EPC, especially given that only one pot was provided with the appliance. This finding emphasizes the need for a cooking appliance that can accommodate multiple dishes simultaneously and include multiple pots (whether as an extra item paid for upfront or in installments, or as part of a set).

FUEL DISPLACEMENT

The use of EPCs led to the displacement of commonly used cooking fuels, such as charcoal and LPG, which were the main fuels used for cooking prior to the study. The proportion of meals cooked using charcoal decreased from 67 percent to 45 percent, with the most substantial shift observed in breakfasts, where its use dropped from 54 percent to 20 percent. Similarly, the proportion of meals cooked using LPG decreased from 35 percent to 28 percent, with a decline in dishes prepared using LPG from 29 percent to 23 percent. This fuel displacement indicates the potential of EPCs to reduce reliance on traditional cooking methods and the compatibility of EPCs with several common Rwandan dishes.

REDUCTION IN CHARCOAL CONSUMPTION

The mean charcoal consumption per capita per event decreased by 30 percent, from 0.16 kg (4.21 MJ) in the baseline phase to 0.11 kg (2.94 MJ) in the pilot phase. This reduction can be attributed to participants substituting charcoal stove usage with EPC cooking. Consequently, useful energy consumption from charcoal and LPG was reduced by 31 percent after the introduction of EPCs.

COST OF COOKING

As stated above, there was a significant displacement of charcoal following the arrival of an EPC. Displacement of LPG was also seen but to a lesser extent. Consequently, there was a reduction in expenditure on the two fuels during the pilot phase when households were using their EPCs as part of the cooking mix. With the introduction of eCooking (or more eCooking for the few households who had used some form of it prior to the study) expenditure on electricity for cooking increased. However, the overall cost of cooking remained similar: during both the baseline and the pilot phases the average cost of cooking fuels (various combinations of electricity and LPG and/or charcoal) stood at around RWF 388 (USD 0.34) per household per day. This demonstrates that transitioning to a cleaner cooking mix can be achieved at no additional on-going cost to households.

PAYMENT PREFERENCES

The majority of participating households expressed preference for the monthly EPC payment plan option, with 86 households choosing it. Eight households chose weekly payments, five chose to pay in full after one month, and one chose bi-weekly payments.

The preference for monthly payments was the top choice regardless of the types of cooking solutions or appliances participants owned prior to the start of the study.

EPC USAGE INTENSITY

EPCs were used extensively during the pilot phase, accounting for 41percent of cooking events. Participants mainly cooked lunch and dinner in them, with approximately 45 percent of lunch dishes and 40 percent of dinner dishes involving their use. This underscores the popularity of EPCs for these meal types and indicates that most gains can be made with an EPC when preparing those meals (e.g., time saving, ability to perform other activities while cooking).

TIME SAVINGS

The median time taken to prepare a meal decreased from one hour 44 minutes in the baseline phase to one hour 30 minutes in the pilot phase, resulting in a time saving of nearly 15 minutes. Meals cooked using EPCs and LPG took half the time of meals cooked using charcoal, but meals cooked using charcoal comprised a larger number of dishes (mean of 2.8 dishes per meal, compared with 2.1 for EPCs). This indicates that cooking with an EPC as part of the cooking stack (rather than charcoal) can reduce cooking time. However, there is a need to address the ability to cook more dishes in an EPC for it to compete with other stoves/fuels.

Time savings were greater when cooking certain foods, notably beans, matoke (green bananas) and vegetables.

USAGE WITHIN EVENTS

Within cooking events, EPCs were primarily used to cook a single dish, while charcoal stoves were more commonly used for preparing two or more dishes. Surprisingly, it was not uncommon for participants to cook two dishes simultaneously in the EPC, only slightly less prevalent than cooking a single dish. This demonstrates the versatility of EPCs in accommodating multiple dishes.

ENERGY CONSUMPTION

EPC cooking consumed an average of 0.11 kWh (0.39 MJ) per capita per event, as determined by matching the smart meter and cooking diary datasets. This information provides insight into the energy consumption associated with EPC usage and an opportunity to conduct a cost analysis of cooking with different fuels.

CHANGES IN FOODS COOKED

While the introduction of EPCs did not significantly alter the type of foods cooked, an increase in the preparation of beans and soups was observed during the pilot phase. This change indicates the versatility of EPCs in cooking a variety of dishes.

SUITABILITY OF EPCs

EPCs were found to be particularly well suited for cooking Irish (white) potatoes, beans, cassava leaves, rice, bread, matoke (green bananas) and sweet potatoes. However, they were less suitable for making chips and soup, and heating water. This insight helps identify the optimal-use cases for EPCs.

THE HABIT OF REHEATING FOOD

The majority of dishes prepared in the EPCS (typically 90 percent) were freshly cooked (i.e., from scratch with new ingredients). Participants said they were slightly more inclined to cook fresh dishes once they had started using the EPC. This finding suggests that EPCs are less suited to cooking in bulk and may encourage people to cook more fresh dishes. (as opposed to people cooking in bulk and reheating leftovers)

EXPERIENCE OF USING EPCS

The majority of study participants found the EPC easy to use and enjoyed using it. Participants described the best aspect as being able to cook quickly with it. Most concerns with the EPC focused on only having one pot and a feeling that the pot was too small. However, all of the participants said they would continue using their EPC following the completion of the study, with 25 percent stating specifically that they would continue using their EPC alongside all the stoves they had owned before.

The EPC met the expectations of 81 percent of participants. The Net Promoter Score was high at 4.9, meaning that the study participants were very likely to recommend an EPC to others. At the end of the study, 58 percent said they would buy an EPC if they had not already bought one as part of the study.

5.2 Emerging opportunities

As evident in this study and supported by previous studies focusing on cooking with electricity in Rwanda (Energy4Impact 2022), transitioning to eCooking offers numerous advantages both within households and on a wider scale. With the pressing risks associated with climate change and deforestation, reducing reliance on biomass has become one of the top challenges the Government of Rwanda is looking to address over the coming decade. By highlighting the benefits of cooking with electricity, and the compatibility of cooking with energy-efficient cooking appliances, this study has aimed to inform the possible pathways for clean cooking transitions in Rwanda.

One of the key advantages is to create a cleaner cooking experience for end users. Study participants appreciated the cleaner and more convenient cooking experience offered by the EPC compared to cooking with charcoal (both in terms of the fuel preparation and the cooking process itself Cooking with electricity generates significantly fewer harmful emissions and has been shown to be among the cleanest sources of energy (Floess et al. 2023). This shift reduces indoor air pollution, mitigating health risks in the home. Moreover, cooking with electricity eliminates the release of CO2 and other greenhouse gases, contributing to the fight against climate change.

In addition to the environmental benefits, transitioning to eCooking offers a range of other benefits that position it as a competitive alternative to charcoal and LPG. A wide variety of foods can be prepared in EPCs, allowing households to maintain their culinary preferences while also reducing the time needed to cook the most common dishes such as rice and beans. Although there was a concern about an insufficient number of cooking pots provided with the EPC, it was the appliance can handle a diverse range of recipes, providing a seamless transition from traditional cooking methods.

Another advantage lies in the time savings eCooking offers. With the faster heating capabilities of EPCs, cooking becomes more efficient and convenient. This allows individuals to spend less time in the kitchen and more time on other activities. This was among the most frequently highlighted advantages of cooking with an EPC reported by the study participants.

Furthermore, transitioning households to a cleaner cooking stack aligns with the broader government agenda. Continued use of charcoal contributes to deforestation and loss of natural habitats, issues that are high on the government's priorities regarding energy access and natural resource management. A transition to cleaner cooking plays an important role particularly in urban centres, where a robust electrical infrastructure already exists. It can also contribute to reduced pressure on local rural communities who rely on biomass as an energy source, by alleviating the large amounts of biomass that are used to produce charcoal for urban areas, and thus making the often-sole fuel households in rural areas are able to afford more available. This, in turn, can create a more sustainable and equitable energy landscape.

While there are concerns related to people's ability and willingness to pay for energy-efficient cooking appliances such as EPCs, the study participants did well in paying off their EPCs, with a default rate of 18 percent and no participants dropping out or refusing to make payments going forward. It is important to note that the participants were offered an incentive of RWF 30,000 (USD 26) upon the completion of the study that no doubt had an impact on their willingness to participate and continue making payments as they would have forfeited the incentive had they defaulted/stopped paying and ceased their participation.

While the total price the participants had to pay for the EPC was lower than the current price of EPCs offered on the Rwandan market, it is consistent with the price reductions offered to Ubudehe 2 and 3 households by the Clean Cooking RBF, a subsidy designed to address the affordability of clean cooking technologies (IBRD 2022). These reductions, along with a credit system that enables households to spread out their payments, are opportunities to address low demand and upfront affordability barriers and therefore speed up uptake of eCooking appliances such as EPCs. At the end of the study, 58 percent of the participants said they would purchase an EPC if they did not already have one,

demonstrating that the participants attached value to the appliance.

Additionally, as the overall cost of cooking with a mix of fuels (predominantly charcoal and LPG in the baseline phase and charcoal and/or LPG and electricity in the pilot phase) remained the same after the introduction of the EPCs to the households, at approx. RWF 388 (USD 0.34) per household per day, there is a strong indication that a cleaner cooking mix can be achieved at no additional on-going cost to the households. This is an important finding that can inform awareness-raising campaigns on electric cooking.

In summary, the urgency of reducing reliance on biomass and embracing electric cooking is evident in the face of climate change and deforestation risks. The advantages of transitioning to electricity for cooking, or at the very least adding it into the cooking mix, are multifold, ranging from a cleaner and more convenient cooking experience to time savings, and no additional ongoing costs. By highlighting these benefits, implementing schemes that can offer price reductions for lower-income groups, and by offering financing solutions for eCooking appliances, households across different socioeconomic segments can be encouraged to make the switch.

5.3 Key recommendations

To facilitate transitions to cooking with electricity in Rwanda, it is crucial to overcome potential barriers to people buying and using appliances. These include the cost, the current lack of training and familiarity with how to use eCooking appliances, user-centric design considerations, shared household electricity meters, and lack of awareness on cost competitiveness of cooking with electricity as part of a cooking mix. By addressing these factors, households can be encouraged to move away from biomass and transition towards cleaner and more sustainable fuel alternatives. The following sub-section offers recommendations for policymakers and regulators, and the emerging sector of eCooking solution providers, as well as the research community.

5.3.1 Recommendations for policymakers and regulators

1. Demonstrate energy conservation, cost comparisons and compatibility: to effectively promote cooking with electricity, it is crucial to highlight its efficiency and cost competitiveness compared to traditional alternatives like charcoal and LPG. Conducting demonstrations that showcase these outcomes, as well as the suitability of EPCs for cooking most Rwandan dishes will provide users with tangible evidence of the advantages of cooking with electricity, and encourage uptake.
2. Support the nascent market of eCooking appliances: to improve the affordability of and accessibility to eCooking solutions, there is a need for more technology providers to access the market. This will require targeted policies, such as VAT exemptions for eCooking appliances and electricity tariffs favourable for end users, as well as the demonstration of the market opportunity for such solutions in Rwanda. This could attract more and diverse private sector companies, not just for the provision of EPCs but also other appliances and solutions (such as rice cookers, induction stoves and air fryers).
3. Promote clean cooking practices: a key objective should be to promote clean cooking practices and a cleaner energy stack, particularly in urban centres. This involves replacing charcoal with electricity and advocating for an LPG-electricity stack. By emphasizing the benefits of clean cooking, such as reduced indoor air pollution, and improved health outcomes, users can be incentivized to switch to eCooking, or add appliances such as EPCs to their cooking stack. Dedicated awareness-raising campaigns led by government stakeholders could help to achieve this.
4. Overcome infrastructure barriers: ensuring that household electrical infrastructure is robust will alleviate the need for households to make special electrical adaptations when considering a switch to eCooking or an adoption of eCooking solutions into their cooking mix. The presence of shared meters can be a significant barrier to the uptake of eCooking and other electricity-based services. Users might be reluctant to switch to eCooking if they are held accountable for their neighbours' power consumption. To address this challenge, it is necessary to develop strategies to overcome the shared meter issue.

5.3.2 Recommendations for eCooking appliance providers

1. Train and familiarize: to ensure the successful adoption and continued use of EPCs, it is essential to provide comprehensive training to cooks (including domestic staff) when households invest in an EPC. Insufficient knowledge of how to operate an EPC may hinder its long-term use and push users back to more familiar fuel options, even when these are dirtier and less convenient. Training should focus on familiarizing household cooks with the operation of the EPC, associated processes, and the benefits of using the product, including time savings and cleanliness.
2. Practice user-centric design and adaptation: to meet user needs effectively, it is crucial to incorporate user-centric design principles into the product. One particular consideration is the provision of multiple pots for the EPC, along with financing options. This approach will cater to the diverse needs and preferences of users, increasing accessibility and affordability.
3. Offer appliance payment plans: to overcome the up-front cost barrier of eCooking appliances, it will be critical to explore financing opportunities and payment plans. Monthly payment plans seem to be preferred by urban households in Kigali. However, more testing of different payment plans could be beneficial so that they are tailored to different segments of the population.

5.3.3 Recommendations for further research

Given the scope of this study and its timeline (six months), there are outstanding areas of research and inquiry that were not covered. Below are recommendations for further research that would be the most useful and informative to support efforts towards clean cooking transitions, and eCooking transitions in particular in Rwanda:

1. Research to explore the potential impact of a favourable electricity tariff (e.g., an eCooking tariff similar to that introduced in Uganda (ERA 2021) for domestic cooking to encourage uptake of electric cooking. This could potentially have a significant impact as Rwanda's household electricity tariff is currently among the highest in East Africa, which also contributes to the common perception that cooking with electricity is expensive.
2. Linked to the above, an examination of the impact of increased uptake of eCooking for the electric utility should be investigated.
3. Further research on gender-differentiated experience and impact of using EPCs is needed. Data collected during this study or additional data collected in both male- and female-headed households could be used to conduct a more gender-disaggregated analysis on how women's experiences and perceptions differ from those of men, and inform how product developers respond to those differentiated needs.
4. Research on the impact of eCooking adoption on household air pollution (HAP) and health relative to charcoal and LPG. Such studies should help highlight the health benefits of eCooking and cement it as primary in, or at least part of the clean cooking energy stack.
5. Further research on what awareness-raising and marketing strategies can be used by providers of electric cooking solutions (whether EPCs or other eCooking appliances) to encourage uptake of electric cooking. Visual and written testimonials from this study's participants as well as other testimonials from households and consumers already using EPCs and other eCooking appliances could be used to encourage prospective customers.

Appendix 1: Cooking Diaries protocol

1. Date
2. Household ID
3. Who's cooking? Select one:
   - ○ Houseboy
   - ○ Housegirl
   - ○ Household Head
   - ○ Wife/Husband of household head
   - ○ Daughter/Son of household head
   - ○ Parent (Father/Mother) of household head

   Others:
4. Gender of cook:
   - ○ Male
   - ○ Female
5. How many people are being cooked for?
6. How many adults are being cooked for?
7. How many children (<18yrs) are being cooked for?
8. Which meal is being cooked?
   Select all that apply:
   - ○ Breakfast
   - ○ Lunch
   - ○ Dinner
   - ○ Snack
   - ○ Others
9. Is any food that does not require cooking being served? (e.g., Bread, fruit, chapati, cold milk, etc.)
   - ○ Yes
   - ○ No
10. (If Yes to Q9) What foods that do not require cooking are being served?
11. How many dishes are being cooked
    - ○ 1
    - ○ 2
    - ○ 3
    - ○ 4
    - ○ 5
    - ○ 6+
12. How long did it take you to get the cooking fuel ready before putting the pots on the stove? (in minutes)
13. Cooking start time (time stove is turned on to cook food; 24hr format):
14. Cooking fuel used for cooking (select all that apply):
    - ○ Firewood
    - ○ Charcoal
    - ○ LPG (gas)
    - ○ Kerosene
    - ○ Pellets
    - ○ Electricity (if electric appliances used)

    Others

REPEAT FOR EACH DISH COOKED (tea/drink should be considered a dish)

Day	15.Dish Cooked fresh or reheated?	16.What cooking appliances are being used to cook this dish?	17.What cooking processes are involved in the preparation of this dish?
Dish 1	○ Fresh ○ Reheated	○ Rice cooker ○ Microwave ○ Electric kettle ○ Electric Pressure Cooker ○ Gas stove ○ Electric stove (induction) ○ Electric stove (coil or hot plate) ○ Charcoal stove ○ Firewood stove ○ Kerosene stove ○ Gas oven ○ Electric oven Others:	○ Boiling ○ Dry frying ○ Wet frying ○ Deep frying ○ Grilling ○ Steaming ○ Baking ○ Microwaving Others:
Dish 2	○ Fresh ○ Reheated	○ Rice cooker ○ Microwave ○ Electric kettle ○ Electric Pressure Cooker ○ Gas stove ○ Electric stove (induction) ○ Electric stove (coil or hot plate) ○ Charcoal stove ○ Firewood stove ○ Kerosene stove ○ Gas oven ○ Electric oven Others:	○ Boiling ○ Dry frying ○ Wet frying ○ Deep frying ○ Grilling ○ Steaming ○ Baking ○ Microwaving Others:
Dish 3	○ Fresh ○ Reheated	○ Rice cooker ○ Microwave ○ Electric kettle ○ Electric Pressure Cooker ○ Gas stove ○ Electric stove (induction) ○ Electric stove (coil or hot plate) ○ Charcoal stove ○ Firewood stove ○ Kerosene stove ○ Gas oven ○ Electric oven Others:	○ Boiling ○ Dry frying ○ Wet frying ○ Deep frying ○ Grilling ○ Steaming ○ Baking ○ Microwaving Others:

Dish 4	○ Fresh ○ Reheated	○ Rice cooker ○ Microwave ○ Electric kettle ○ Electric Pressure Cooker ○ Gas stove ○ Electric stove (induction) ○ Electric stove (coil or hot plate) ○ Charcoal stove ○ Firewood stove ○ Kerosene stove ○ Gas oven ○ Electric oven Others:	○ Boiling ○ Dry frying ○ Wet frying ○ Deep frying ○ Grilling ○ Steaming ○ Baking ○ Microwaving Others:
Dish 5	○ Fresh ○ Reheated	○ Rice cooker ○ Microwave ○ Electric kettle ○ Electric Pressure Cooker ○ Gas stove ○ Electric stove (induction) ○ Electric stove (coil or hot plate) ○ Charcoal stove ○ Firewood stove ○ Kerosene stove ○ Gas oven ○ Electric oven Others:	○ Boiling ○ Dry frying ○ Wet frying ○ Deep frying ○ Grilling ○ Steaming ○ Baking ○ Microwaving Others:
Dish 6	○ Fresh ○ Reheated	○ Rice cooker ○ Microwave ○ Electric kettle ○ Electric Pressure Cooker ○ Gas stove ○ Electric stove (induction) ○ Electric stove (coil or hot plate) ○ Charcoal stove ○ Firewood stove ○ Kerosene stove ○ Gas oven ○ Electric oven Others:	○ Boiling ○ Dry frying ○ Wet frying ○ Deep frying ○ Grilling ○ Steaming ○ Baking ○ Microwaving Others:

18. Cooking end time (time stove is turned off; please use 24hr format):

19. Any cooking fuel purchased today?
    - Yes
    - No

20. If Yes to Q20, please state type of fuel and quantity:

21. Please share any comments about the experience of preparing this meal (e.g., ease or difficulty of using stove(s), cooking fuel(s), pots etc.)

Appendix 2: Registration Survey protocol

Hello, my name is **[enumerator's name]**. We are doing a study on the cooking habits of people in Kigali City. After a couple of short questionnaires, we will leave some sensors on the stove and a scale to measure your fuel consumption. We will also ask you to fill out a short form every time you cook. Everyone who completes this study will receive RWF30,000 as an appreciation token. There is no foreseeable risk associated with this study but there is an expectation that you will pay for the Electric Pressure Cooker- a total of RWF40,000 which you can pay upfront, weekly or monthly. All the information you provide during this study will remain confidential and will only be used for the purpose of this study. You may refuse to participate in this study with no consequences for you. Do you wish to participate in this study?

○ Yes ○ No

Survey Data

1. Date

2. Name of enumerator

3. Household ID

4. Information about the participant

a. Name

b. Gender

c. Age

d. Phone number:

e. What is the highest level of school you have attended?

f. Occupation

5. Information about the household

a. Location (district, sector, cell)

b. Type of area

c. How many people live in the household? (please state the number of household members living here permanently)

d. How many are aged between 5-9 years old?

e. How many are aged between 10-17 years old?

f. How many people cook in your household?

g. What is the average monthly household income? (in RWF) This should be the collective income among all permanent household members earning an income.

6. Cook details

a. Name

b. Relationship to head of household (e.g., wife, daughter, son etc.; or if houseboy or housegirl then state 'houseboy' or 'housegirl')

c. What proportion of cooking do they do? (%)

d. When do they cook? (All, lunchtime only, dinner only, Sunday/weekend only, special occasions)

e. Information about the dwelling

f. How many rooms in the household?

g. Type of dwelling

i. Construction: Walls

ii. Construction: Roof

iii. Construction: Floor

8. Information about cooking and kitchen

a. In the past 12 months, have you purchased any beef meat? ○ Yes ○ No

b. In the past 12 months, have you purchased any pineapples? ○ Yes ○ No

c. Where is the kitchen?

d. Where do you usually cook?

e. Who in the household makes decision about purchases of cooking appliances?

f. Who in the households makes decisions about purchases of electrical appliances?

g. Does the household own a radio? (with or without a CD player) ○ Yes ○ No

h. Is your electricity meter individual or shared? ○ Yes ○ No

i. What rules do you use to share the cost?

j. Do any of those rules impact your appliance use? ○ Yes ○ No

k. How much, on average, do you pay for electricity per month? (total in RWF)

l. What cooking appliances do you have in your house? Check all that apply.
○ Firewood ○ Charcoal
○ LPG (gas) ○ Kerosene
○ Pellets ○ Electricity

m. What fuels are you using for cooking now?

n. Do you buy or collect firewood? ○ Buy ○ Collect

9. Buying Firewood

j. How often do you buy firewood?

k. What quantity do you buy?

l. How much does that quantity cost? (RWF)

10. Collecting firewood

a. How often do you collect firewood?

b. Where do you go to collect firewood?

c. How long does each trip to collect take?

d. How difficult is it to collect firewood? (1-Easy, 5 is Hard)
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

e. What is your experience of cooking with firewood? Please share any feedback

11. Buying charcoal

a. How often do you buy charcoal?

b. What quantity do you buy?

c. How much does that quantity cost? (RWF)

d. How hard is it to access charcoal?

e. What is your experience of cooking with charcoal? Please share any feedback

12. Buying gas

a. When did you start using the gas cooker stove?

b. How much did you pay for the gas cooker stove?

c. What size gas tank do you use?

d. How often do you refill the gas tank?

e. How much does it cost to refill the gas tank? (in RWF)

f. How hard is it to refill the gas tank? (1-Easy, 5-Hard)
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

g. What is your experience of cooking with gas? Please share any feedback

13. Buying kerosene

a. How often do you buy kerosene?

b. How much does that quantity cost you? (in RWF)

c. What quantity do you buy?

d. How hard is it to access kerosene? (1-Easy, 5-Hard)
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

e. What is your experience of cooking with kerosene? Please share any feedback

14. Electricity

a. How long have you been cooking with electricity?

b. What do you spend on cooking with electricity per month? (in RWF)

c. What is your experience of cooking with electricity? Please share any feedback

15. Perceived difficulty of using fuels

a. How difficult is it to cook with firewood? (1-Easy, 5-Hard)
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

b. How difficult is it to cook with charcoal? (1-Easy, 5-Hard)
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

c. How difficult is it to cook with LPG? (1-Easy, 5-Hard)
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

d. How difficult is it to cook with kerosene? (1-Easy, 5-Hard)
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

e. How difficult is it to cook with electricity? (1-Easy, 5-Hard)
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

16. Payment options and financial services

a. Which of the following end-user financing for clean cooking systems is available in your area?

b. Please specify 'Other'

c. How did you purchase your current clean cooking energy systems?

d. Please specify 'Other'

e. Which of the following end-user payment schemes is available in your location for payment of clean cooking energy?

f. Which of the following financial institutions is available in your location?

g. Have you yourself been able to access any of financial products/ services they offer?
○ Yes ○ No

h. If yes, for what purposes do you intend/ have used these financial products for?

i. In your opinion, are the financial products / services easy to access, if available?
○ Yes ○ No

j. Which of the following payment structures do you find the most comfortable/most preferable?

k. Which of the following mode of payment do you find comfortable/convenient?

18. Motivations and pay plan

a. Pay plan selected for the purchase of the EPC

b. What are you most excited about regarding the use of the EPC? Why?

c. What are your main reasons/motivations for purchasing the EPC?

d. What are you most worried about regarding the use of the EPC? Why?

Appendix 3: Exit Survey protocol

Name of the respondent

Date

Location (sector, village)

Household ID

Which fuel(s) did you cook with before the study started (i.e., before February 2023)?

Which electric cookers or pressure cookers did you already own (before the start of this study)?

As we come to the end of the survey, we take this opportunity to thank you for your endurance throughout the period. We are glad that all went well from our side, however we wish to hear from you with a few questions below.

1. How did the EPC suit the way you cook in your home? (please score using 1-5 scale where: 1 = strongly agree; 2 = agree; 3 = no opinion; 4 = disagree; 5 = strongly disagree)

		1	2	3	4	5
1	It was easy to control heat					
2	I was able to multitask while the EPC was cooking					
3	The EPC could cook fast enough					
4	It was easy to find recipes for cooking with EPC					
5	Long cooking dishes were cooked much faster					
6	The eCooker often burnt the food					
7	The pot it came with was big enough					
8	Food cooked using the eCooker tasted better than usual					
9	The EPC itself was easy to clean					
10	The EPC looked good in my kitchen					
11	There is enough space for the EPC in my kitchen					
12	Operating the EPC was easy					
13	The EPC was safe to use					
14	I prefer to use an electric kettle for water boiling					

2. How easy is it to cook each food in the EPC? (please respond using the scale 1-5 where: 1 = very easy; 2 = easy; 3 = neither easy, nor difficult; 4 = difficult; 5 = very difficult)

		1	2	3	4	5
1	Chapatti					
2	Irish or sweet potato					
3	Pasta/noodles					
4	Rice					
5	Meat (stewed)					
6	Meat (fried)					
7	Matoke					
8	Ubugali					
9	Kawunga					
10	Fish					
11	Cassava					
12	Porridge					
13	Leafy vegetables					
14	Beans / peas					
15	Isombe					
16	Peanut sauce					
17	Boilo					
18	Cassava leaves					
19	Chips					

3. Did you miss the 'smoky flavour' of food (that may result from cooking on charcoal or firewood)?
   - ○ Yes ○ No

a. For which dishes in particular did you miss the smoky flavour?

4. Which fuel is your preferred one to cook with for the below dishes?
   - ○ Chapatti
   - ○ Irish or sweet potato
   - ○ Pasta/noodles
   - ○ Rice
   - ○ Meat (stewed)
   - ○ Meat (fried)
   - ○ Matoke
   - ○ Ubugali
   - ○ Kawunga
   - ○ Fish
   - ○ Cassava
   - ○ Chips
   - ○ Porridge
   - ○ Leafy vegetables
   - ○ Beans / peas
   - ○ Isombe
   - ○ Peanut sauce
   - ○ Boilo

5. Do you feel confident about how to use the EPC now that you have had it for a few weeks?
   ○ Yes ○ No
a. Would you feel confident enough to explain to your family/friends how to use an EPC?
   ○ Yes ○ No
6. Did cooking with electricity require modifying the electrical installation inside your house?
   ○ Yes ○ No
a. If it did, was it inconvenient for you or has it cause any issues (e.g. with the quality of electricity you get or the aesthetics of the wiring in and around the house)?
7. On a typical day when cooking, how many hobs (rings) on a stove do you need?
8. In addition to the pots used on a stove, do you typically use other cooking appliances for the preparation of daily meals?
a. What kind of appliances do you use?
9. What were the best things about cooking with electricity (cooking with the EPC)?
10. And what were the worst things about cooking with electricity (cooking with the EPC)?
11. What do you like most about cooking with charcoal/firewood?
12. What do you like most about cooking with LPG?
13. What do you like least about cooking with charcoal/ firewood?
14. What do you like least about cooking with LPG?
15. Did you change your cooking behaviour during the last couple of months? (e.g. have you started cooking one or selected dishes more often than you used to? Have you started cooking some dishes in an EPC exclusively? Have you changed the way you prepare dishes, or the order in which you cook different dishes as a result of having the EPC? Have you started making more tea?
    ○ Yes ○ No
a. Please explain how you changed your cooking behaviour.
16. What is your typical usage of the EPC? (i.e., what do you typically use it for?)
17. What foods/dishes do you typically need more than just the EPC to prepare? (i.e. the EPC is not sufficient to prepare those foods)
18. Do you typically use the EPC to cook one dish? Or more than one dish? (when cooking a single meal, for example when cooking lunch or dinner)
    ○ Yes ○ No
19. Do you think electric cooking is affordable?
    ○ Yes ○ No
20. Do you think cooking with electricity is cheaper or more expensive than cooking with the fuels you normally use/used regularly before February?
    ○ Yes ○ No
21. How much did you pay for your monthly electricity bill in this last month when using the EPC (in RWF)?
22. Were there times when the electricity was off and you wanted to cook something or heat water? ○ Yes ○ No
a. What did you do when the power was off and you wanted to cook / boil water?
23. Do you feel that cooking with the EPC is safer or more dangerous than cooking with your normal stove? ○ Yes ○ No
a. Please explain your answer: why do you think it is safer, the same or more dangerous?
24. Did you feel that cooking meals using the EPC saved you time (i.e., took shorter than cooking on a charcoal or LPG stove)?
    ○ Yes ○ No
a. Please elaborate on your answer – why do you believe it does or does not save time?

b. How do you use the time that you save on cooking? (e.g., for leisure, for work, for other chores, for rest etc.)

25. How easy is it to learn to cook with an EPC?

a. Please elaborate on your answer – why is it easy or difficult?

26. Do you think people would need training on how to use an EPC, or would they be able to learn by themselves?

a. What should the training focus on?

27. Would you ever cook using only electricity and no other fuels? Can you explain why (why yes or why not)?

28. If you could change one thing about the design of the EPC, what would you change?

29. Will you continue using the EPC now that your participation in this project is over or will you switch back to your cooking stoves and fuels you were using before this pilot?

○ Yes ○ No

a. If yes (or yes to both), what will you continue to use the EPC for?

30. How likely would you be to cook with electricity more if the electricity tariffs were lower?

31. If you didn't already have the EPC you got under this pilot, would you buy this EPC if you saw one in a shop now?

a. How much would you be prepared to pay for this EPC (in RWF)?

32. What do you think about the payment mode you have selected (either up front cash or instalments)?

a. Please explain why it did or did not suit you well.

33. How likely are you to recommend this EPC to your family or friends?

a. Did the EPC meet your expectations? (any expectations you had at the start of this pilot?)

○ Yes ○ No

b. Why did it or did it not meet your expectations? Please elaborate.

We have tried our best to learn as much as we can about how you cook, but we appreciate that the tools we are using are limited. Please help us to understand what we may have missed.

34. Are there any meals that were cooked or water that was heated in your household since the beginning of the study that were not recorded on the forms you have given to us?

a. Why? (why were there unrecorded cooking events)

35. Is there anything else that you think is important about the way you cook that we have not yet captured?

Finally, we would like to ask you a couple of last questions which concern the surveys we have conducted with you.

36. What do you think we could have done better in the different surveys we conducted with you?

37. Were the enumerator's visits helpful or did you feel it was too much or too little? (you can choose more than one answer)

38. If we were to do another similar survey in the future would you be willing to be part of it?

Thank you very much for your participation!

Appendix 4: Sensor registration protocol

Sensor DEPLOYMENT

1. Household ID / Nomero y'urugo
2. Name of cook / Izina ry'uteka
3. Phone Number 1: / Numero ya Telepone ya
4. Surveyor Name / Izina ry'ukusanya amakuru
   Suveyor phone number/ telefoni y'Ukusanya amakuru
5. Date/Italiki

FUEL Deployment/Gutegura umunzani w'ibicanwa

Please place up to two FUEL sensors in the kitchen. Make sure you pick a location that will convenient for the cook and that the attachment is sturdy and will be able to hold the weight of the fuel. Do NOT put the fuel in the fuel holder quite yet! / Shyira umunzani n'umufuka w'ibicanwa mu gikoni. Urebe ko wahisemo aho ubishyira kuburyo bitabangamira uteka kandi mu buryo bworohereza upima ibicanwa. Ube uretse gushyira ibicanwa mu mufukaPlease remind the cook to remove fuel for cooking but not replace unused fuel after it has been in the holder. Refill the holder with new fuel when nearly empty" / Wibutse uteka gufata ibicanwa mu mufuka. Ibisigaye mu bicanwa byakuwe mu mufuka ntibisubizwamo. Ongera ibicanwa bishya mu mufuka igihe ibicanwa birimo byenda gushiramo.Please remind the cook to keep the newly acquired fuel in the "Fuel Holder" for at least 1 minutes before removal? / Ese wibukije uteka nyuma yo gushyira ibicanwa mu mufuka agomba gutegereza byibura umunota 1 mbere yo kubikuramo ngo bicanwe?Record the serial Number of the tensile FUEL that weight charcoal. / Andika numero iranga umunzani upima amakaraRecord the Serial Number of the compressive FUEL that weight LPG/ Andika numero iranga umunzani upima gaze

EXACT Deployment / Gushyira akuma gapima ubushyuhe ku mashyiga/ku maziko

How many EXACT sensors are you deploying (put one sensor per stove, up to three sensors per household)? / Ni utwuma dupima ubushyuhe tungahe washyize ku mashyiga / amaziko muri urwo rugo (shyira akuma kamwe gapima ubushyuhe kuri buri ziko, nturenze utwuma 3 kuri buri rugo)

EXACT Serial Number/Numero iranga akuma gapima ubushyuhe

Serial Number of the EXACT on firewood stove (put zero if no sensor were put on this stove) / Numero y'akuma gapima ubushyuhe ku ziko ry'inkwi (shyira hano 0 niba nta kuma gapima ubushyuhe washyize kuri iri ziko)

Serial Number of the EXACT on the LPG stove (put zero if no sensor were put on this stove) / Numero y'akuma gapima ubushyuhe ku ziko rya gaze ya LPG (shyira hano 0 niba nta kuma gapima ubushyuhe washyize kuri iri ziko)

Serial Number of the EXACT on the Electric stove (put zero if no sensor were put on this stove) / Numero y'akuma gapima ubushyuhe ku iziko rikoresha amashanyarazi (shyira hano 0 niba nta kuma gapima ubushyuhe washyize kuri iri ziko)

Serial Number of the EXACT on the charcoal stove (put 0 if no sensors were put on the stove). / Numero y'akuma gapima ubushyuhe ku iziko rikoresha amakara (shyira hano 0 niba nta kuma gapima ubushyuhe washyize kuri iri ziko)

Please take a picture of the first EXACT on the stove / Fata ifoto ya mbere y'akuma gapima ubushyuhe

uhagaze imbere y'iziko(igaragaza uburyo ako kuma gafashe ku ishyiga kandi igaragaza numero ikaranga.

You can now START all the sensor deployed in the household. For the FUEL, please choose a log rate of 4s (FAST) and the "LONG BAT" option. For the EXACT please choose "TEMP" option and a log rate of 8 minute. Once the FUEL sensor is started, you can place the charcoal and LPG in the fuel holder. If some sensors are not started, please make sure they are not too far from you. Ushbora gutangiza gupima utwuma dupima ubushyuhe n'iminzani mu rugo rw'umuturage wasuwe. Ku minzani ipima ibicanwa yiregere ku kigero cya 4s (faster) n'uburyo bwa LONG BAT. Ku twuma dupima ubushyuhe hitamo uburyo bwa USAGE na log rate y'iminota 8. Igihe umunzani watangijwe kubara, ushobora gushyira ibicanwa (inkwi n'ibisigazwa by'umusaruro) mu mufuka umanitse ku munzani. Niba hari tumwe mu twuma dupima ubushyuhe cyangwa iminzani biri kugorana gutangizwa kubara, genzura niba niba utwegereye cyane.

Time at which equipment is STARTED/Isaha igikoresho gitangiriye

Were you able to start all the equipment successfully?Ese waba wabashije gutangiza ibikoresho byose ku buryo bukwiriye?

○ Yes ○ No

Please take a picture of the compresive FUEL for LPG/ Fata ifoto y'umunzani upima gaze

Please take a picture of the tensile FUEL for charcoal/ Fata ifoto y'umunzani upima amakara

Please take a picture of kitchen as a whole, showing the stoves and sensors/Fata ifoto igaragaza igikoni cyose, inerekana amashyiga n'utwuma dupima ubushyuhe

Before you leave the house, please demonstrate to the main cook the correct way to use the fuel from the holder. And let her repeat the process herself to check that she has well understood. Please leave them your phone number so that they can call you / Mbere y'uko uva mu rugo, ereka uteka ko bakoresha neza ibicanwa bizaba byashyizwe mu mufuka. Muhe umwanya asubiremo uko bakoresha ibyo bicanwa. Umusigire numero ya telefone yawe kugirango muge muvugana mukurikirana icyo gikorwa.

GPS coordinate of the household location/ Fata ibipimo bya GPS by'aho uherereye

End of day 1. Please save the questionnaire with the household number. /Aho umunsi wa 1 usoreza. Funda ibibazo unabibike ukoresheje numero y'urugo! Ubundi ushimire uwabajijwe 11- Comments from surveyor / Icyo Umukozi ukusanya amakuru yongeraho

Sensor CHECK

1. 0.1 - Household ID / Nomero y'urugo
2. 0.2 - Name of cook / Izina ry'uteka
3. Phone Number 1: / Numero ya Telepone ya 1:
4. Surveyor Name / Izina ry'ukusanya amakuru
5. Suveyor phone number/ telefoni y'Ukusanya amakuru Date/Italiki
6. 4.1 - Date / Itariki

EXACT Quality Control / Igenzura ry'utwuma dupima ubushyuhe

How Many EXACT sensors are not in place anymore? / Ni utwuma tungahe dupima ubushyuhe tutari mu mwanya watwo ?

How many EXACT sensor are missing? / Harabura utwuma dupima ubushyuhe tungahe?

FUEL Quality Control / Igenzura ry'ibicanwa

FUEL scale control/Kugenzura umunzani upima ibicanwa

Are the fuel holder containing the right type of fuel (charcoal in the charcoal holder and LPG on the compressive FUEL)? / Ese ibicanwa biri mu mufuka byagenewe kubamo (amakara mu mufuka wazo, gaze iteretse ku munzani bayipimiraho)?)

○ Yes / yego ○ No / oya

Are the FUEL sensor and holder still attached correctly? / Ese Umunzani n'umufuka w'ibicanwa

biracyafatanye neza?

○ Yes / Yego ○ No / Oya

Fuel Compliance/Iminzani y'ibicanwa

Please ask the respondant to demonstrate herself how she/he proceeds to use the fuel from the holder. And then show he/her the right way. Please do not actually take fuel from the holder. / / Saba ko utanga amakuru we ubwe akwereka uko akoresha ibicanwa nkuko bikwiriye muri iki gikorwa. Umwereke cg umukosore aho bikenewe ariko ntugomba gukoresha ibicanwa byashyizwe mu mufuka igihe uri kumwereka uko agomba kubigenza.

During the last 24h, did you put back on the holder leftover fuel that was previously used for cooking? / Mu masaha 24 ashize, waba warasubije ku mugozi uziritseho umufuka ibisigazwa by'ibicanwa byakoreshejwe mbere?

○ Yes / Yego ○ No / Oya

During the last 24h, did you use some fuel for cooking that you did not place on the fuel holder first? / Mu masaha 24 waba waratekesheje ibicanwa utigeze ubanza gushyira mu mufuka w'ibicanwa?

○ Yes / Yego ○ No /Oya

Data download/Kumanura/gupakurura amakuru

Please download the data from this household using the launcher. Please press on DOWNLOAD ONLY. / Ubu wapakurura/wamanura amakuru yafashwe n'utwuma dukurura amakuru twashyizwe muri uru rugo

Did the launcher detect all the sensors present in the household? / Ese akuma gakurura amakuru kabonye utundi twuma twashyizwe mu gikoni?

○ Yes / Yego ○ No (please try again closer to the sensors. If they are still not detected, please contact your supervisor). / Niba igisubizo ari Oya, gerageza kwegera utwuma dukurura amakuru. Niba bikomeje kwanga kubona ayo makuru, wahamagara ugukuriye akakuyobora uko byakemuka.

Was the data downloaded sucessfully? / Ese amakuru wapakuruye yaje uko bikwiye?

○ Yes / Yego ○ No (please contact your supervisor) / Oya (Baza umugenzuzi w'igikorwa)

End of the questionnaire for the second visit. Don't forget to give the household the per diem. Please save the questionnaire and leave the household./ Iherezo ry'umunsi wa kabiri; Emeza ibyo wanditse hanyuma uve muri urwo rugo.

11- Comments from surveyor / Icyo Umukozi ukusanya amakuru yongeraho

Sensor COLLECTION

1. Household ID / Nomero y'urugo
2. Name of cook / Izina ry'uteka
3. Surveyor Name / Izina ry'ukusanya amakuru
4. Suveyor phone number/ telefoni y'Ukusanya amakuru Date/Italiki

EXACT Quality Control / Kugenzura imikorere y'akuma gapima ubushyuhe

How many EXACT sensors are not in place anymore? Ni utwuma tungahe dupima ubushuhe tutari mu mwanya watwo?

How many EXACT sensors are missing? / Ni utwuma tungahe dupima ubushyuhe tubura?

FUEL Quality Control / Kugenzura ibicanwa

FUEL scale control

Are the fuel holders containing the right type of fuel (charcoal in the charcoal holder and LPG on the compressive FUEL? / Ese umufuka w'ibicanwa urimo ibicanwa byateganyirijwe kuwubamo?(inkwi aho zateganyirijwe n'ibisigazwa by'umusaruro aho byateganyirijwe)

○ Yes / Yego ○ No /Oya

If the type of fuel in each holder is incorrect, please provide details here but do not change the fuel/ Niba ibicanwa bitari mu mufuka byagenewe kubamo, andika hano uko ubisanze n'ibisobanuro

Are the FUEL sensor and holder still attached correctly? / Ese iminzani n'imifuka y'ibicanwa biracyamanitse neza?

○ Yes / Yego ○ No / Oya

FUEL scale compliance

Yesterday, did you put back on the holder leftover fuel that was previously used for cooking? / Ejo hashize, waba warasubije ku mufuka ibicanwa byasagute uteka?

○ Yes / Yego ○ No /Oya

Yesterday, did you use some fuel for cooking that you did not place on the fuel holder first? / Ejo hashize waba waratekesheje ibicanwa utigeze ubanza gushyira mu mufuka w'ibicanwa?

○ Yes ○ No

Data download/Kumanura/gupakurura amakuru

You can now download the data from this household.

Please press "STOP and DOWNLOAD". / Hagarika kandi ukure amakuru mu kuma gapima ubushyuhe ku ziko.

Were you able to download the data successfully? / Wabashije gupakurura amakuru yuzuye ku twuma twose?

○ Yes / Yego ○ No/ oya (Vugana n'umugenzuzi) (please talk to your supervisor)

If this is the final visit (end of study), please remove the EXACT from the stoves. Otherwise, please leave the EXACT in place. In both cases, please remove the FUEL sensors. /Kuraho akuma gapima ubushyuhe, umunzani, n'imifuka.

Influence of equipment on cooking practices/impinduka mu buryo bwo guteka busanzwe zatewe n'igikoresho

Did you change your cooking habit in any way because of the equipment? / Ese waba warahinduye uburyo bw'imitekere bitewe n'utu twuma?

○ Yes / Yego ○ No / Oya

Did you have any issue with the equipement? / Haba hari ikibazo watewe n'utu twuma?

○ Yes ○ No

11- Comments from surveyor / Icyo Umukozi ukusanya amakuru

Appendix 5: Registration Survey protocol

HHS NO.	LOCATION	COOKING DIARIES FILLING	EPC TRAINED USER AVAILABILITY	EPC POWER CONSUMPTION	CHANGING ENERGY METER PLUG/ REPAIR	ENERGY METER POWER CONSUMPTION	LANDLORD/ SHARED CASHPOWER	SIZE OF EPC	NEED EPC EXTRA INNER POT	CHANGING ELECTRICITY INSTALLATION
1001	Rugando	Well	1	0	0	0	1	0	0	1
1002	Kimironko	Well	1	0	1	0	1	0	0	0
1003	Kicukiro	Well	0	0	0	0	1	0	1	0
1004	Kinyinya	Well	0	0	0	0	0	1	1	0
1005	Kanombe Busanza	No time due availability	0	0	0	0	0	0	0	0
1006	Kanombe Busanza	No time due availability	1	0	0	1	0	0	1	0
1007	Kagugu	Well	0	0	0	0	0	0	0	0
1008	Kinyinya	No time due availability	0	0	0	0	0	0	0	0
1009	Kagugu	Well	0	0	0	0	0	0	0	0
1010	Nyarutarama	Well	0	0	0	0	0	0	1	0
1011	Kinyinya	Well	0	0	0	0	0	1	1	0
1012	Kinyinya Birembo	No time due availability	0	0	0	0	1	0	1	0
1013	Gahanga	Well	0	0	0	0	1	0	1	0
1014	Gatsata	Well	0	0	0	0	1	0	1	0
1015	Nyarutarama	Well	0	0	0	0	0	1	1	0
1016	Jabana	Well	0	0	0	0	0	0	1	0

HHS NO.	LOCATION	COOKING DIARIES FILLING	EPC TRAINED USER AVAILABILITY	EPC POWER CONSUMPTION	CHANGING ENERGY METER PLUG/ REPAIR	ENERGY METER POWER CONSUMPTION	LANDLORD/ SHARED CASHPOWER	SIZE OF EPC	NEED EPC EXTRA INNER POT	CHANGING ELECTRICITY INSTALLATION
1017	Gatsata	Well	0	0	0	0	0	0	1	0
1018	Rutunga	Well	0	0	0	0	0	0	1	0
1019	Kimisagara	No time due availability	1	0	0	0	1	0	1	0
1020	Rutunga	Well	0	0	0	0	0	1	1	0
1021	Rutunga	Well	0	0	0	0	0	1	1	0
1022	Kagugu	Well	0	0	1	0	1	0	0	0
1023	Ndera	Well	0	0	0	0	0	1	1	0
1024	Masaka	Well	0	0	0	0	0	1	1	0
1025	Masaka	Illiterate user	1	0	0	0	0	0	1	0
1026	Ndera	No time due availability	1	0	0	0	0	0	1	0
1027	kabuga	Negligence	0	0	0	0	0	0	0	0
1028	Kinyinya	No time due availability	1	0	1	0	1	0	1	0
1029	Kinyinya	Well	1	0	0	0	0	0	1	0
1030	Gikondo	No time due availability	1	0	0	0	0	0	0	0
1031	Nyamirambo	Well	0	0	0	0	0	0	1	0
1032	Nyamirambo	Well	0	0	0	0	0	1	1	1
1033	Kagugu	Well	0	0	0	0	0	0	1	1
1034	Kicukiro centre	Well	1	0	0	0	1	0	1	0
1035	Batsinda	Well	0	0	0	0	0	0	1	0
1036	Kinyinya	Well	0	0	0	0	0	0	0	0
1037	Batsinda	Well	1	0	0	0	0	0	0	0
1038	Kacyiru	Well	1	0	0	0	0	0	0	0

HHS NO.	LOCATION	COOKING DIARIES FILLING	EPC TRAINED USER AVAILABILITY	EPC POWER CONSUMPTION	CHANGING ENERGY METER PLUG/ REPAIR	ENERGY METER POWER CONSUMPTION	LANDLORD/ SHARED CASHPOWER	SIZE OF EPC	NEED EPC EXTRA INNER POT	CHANGING ELECTRICITY INSTALLATION
1039	Kacyiru	No time due availability	1	0	0	0	0	0	0	0
1040	Remera	Well	0	0	0	0	0	0	1	0
1041	Jali	Well	0	0	0	0	0	0	1	0
1042	Rugando	Well	0	0	0	0	0	1	1	0
1043	Zindiro	Well	0	0	0	0	0	0	1	0
1044	Gitega	No time due availability	0	0	0	0	0	1	1	1
1045	Nyamirambo Norvege	Well	0	0	0	0	0	1	0	0
1046	Gasanze-Batsinda	Negligence	0	0	0	0	0	0	1	0
1047	Gikondo	No time due availability	0	0	0	0	1	1	1	0
1048	Kagugu	Well	0	0	0	0	0	0	0	0
1049	Rugando	Well	0	0	0	0	0	1	1	0
1050	Rugando	Well	0	0	0	0	0	0	1	0
1051	Kimihurura	Well	0	0	0	1	0	1	1	0
1052	Gikondo	No time due availability	1	0	0	0	0	0	1	0
1053	Gikondo	Illiterate user	1	0	0	0	1	0	0	0
1054	Kanombe	Well	0	0	0	0	0	0	0	0
1055	Kicukiro Centre	No time due availability	1	0	0	0	1	0	0	0
1056	Kinyinya	Well	0	0	0	0	0	0	0	0
1057	Batsinda	Well	0	0	0	0	0	0	0	0
1058	Kanombe 12	Well	1	0	0	0	0	0	0	0

HHS NO.	LOCATION	COOKING DIARIES FILLING	EPC TRAINED USER AVAILABILITY	EPC POWER CONSUMPTION	CHANGING ENERGY METER PLUG/ REPAIR	ENERGY METER POWER CONSUMPTION	LANDLORD/ SHARED CASHPOWER	SIZE OF EPC	NEED EPC EXTRA INNER POT	CHANGING ELECTRICITY INSTALLATION
1059	Masaka	No time due availability	0	0	0	0	0	0	0	0
1060	Jali	Well	0	0	0	0	0	1	1	0
1061	Gatsata	Well	0	0	1	0	0	0	0	0
1062	Kagugu	Well	0	0	0	0	0	0	0	0
1063	Gasanze	Well	0	0	0	0	0	0	1	0
1064	Gasanze	Illiterate user	1	0	0	0	0	0	0	0
1065	Gasanze	Well	0	0	0	0	0	1	1	0
1066	Gatsata	Well	0	0	0	0	0	0	0	0
1067	Cyahafi Mosque	Well	0	0	0	0	0	0	1	0
1068	Kanombe Hos-pital	Well	0	1	0	0	1	0	0	0
1069	Miduha Nyami-rambo	Well	0	0	0	0	1	1	0	0
1070	Kacyiru police	Well	0	0	0	0	0	0	1	0
1071	Kanombe	Well	0	0	0	0	0	0	1	0
1072	Kagugu	Well	0	0	0	1	0	0	0	0
1073	Kagugu	Well	0	0	0	1	1	0	1	0
1074	Jabana	Well	0	0	0	0	0	0	0	0
1075	Kanombe Busanza	Well	0	1	0	0	0	0	0	0
1076	Kacyiru Mosque	No time due availability	0	0	0	0	0	0	0	0
1077	Nyarutarama	Well	0	0	0	0	0	0	0	0
1078	Kabuga	Well	1	1	0	0	0	0	1	0
1079	Rugando	Well	0	1	1	0	0	0	1	0

HHS NO.	LOCATION	COOKING DIARIES FILLING	EPC TRAINED USER AVAILABILITY	EPC POWER CONSUMPTION	CHANGING ENERGY METER PLUG/ REPAIR	ENERGY METER POWER CONSUMPTION	LANDLORD/ SHARED CASHPOWER	SIZE OF EPC	NEED EPC EXTRA INNER POT	CHANGING ELECTRICITY INSTALLATION
1080	Kinyinya Kami	Well	0	0	0	0	0	0	1	0
1081	Rugando	No time due availability	0	0	0	0	0	0	1	0
1082	Rugando	Well	0	0	0	0	0	1	1	0
1083	Rugando	Well	0	0	0	0	1	0	0	0
1084	Rugando	Illiterate user	0	0	0	0	0	1	1	0
1085	Kanombe Busanza	No time due availability	0	0	0	0	0	1	1	0
1086	Rugando	Negligence	0	0	0	0	0	0	0	0
1087	Kimisagara	Well	0	0	0	0	0	0	0	1
1088	Kacyiru	Well	0	0	0	0	0	0	0	0
1089	Rugando	Negligence	0	0	0	0	0	0	0	1
1090	Gikondo	Well	0	0	0	0	0	0	1	0
1091	Gikondo	Well	0	0	1	0	0	1	1	0
1092	Gikondo	Well	0	0	0	0	0	1	1	0
1093	Kimisagara	Well	1	1	0	0	0	0	1	0
1094	Kimisagara	Well	1	0	0	0	0	0	1	0
1095	Kacyiru	Illiterate user	1	0	0	0	0	0	0	0
1096	Kicukiro	Negligence	1	0	0	0	0	0	0	0
1097	Batsinda	No time due availability	0	0	0	1	0	0	0	0
1098	Kabuga	Well	0	0	1	0	0	0	0	0
1099	Kacyiru	Well	0	0	1	0	0	0	0	0
1100	Rutunga	Well	0	0	0	0	0	1	1	0

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SUSTAINABLE ENERGY FOR ALL

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Sustainable Energy for All (SEforALL) is an independent international organization that works in partnership with the United Nations and leaders in government, the private sector, financial institutions, civil society and philanthropies to drive faster action on Sustainable Development Goal 7 (SDG7) – access to affordable, reliable, sustainable and modern energy for all by 2030 – in line with the Paris Agreement on climate change.

SEforALL works to ensure a clean energy transition that leaves no one behind and brings new opportunities for everyone to fulfil their potential. Learn more about our work at www.SEforALL.org.