MECS-TRIID Project Report (public version)

Developing and Testing Innovative User-friendly LPG financing models to accelerate uptake among rural poor through mobile pay

Sustainable Community Development Services (Scode)

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Executive Summary

The aim of the project was to increase access and use of LPG as a cooking fuel among internally displaced low income rural households in Mbaruk and Mogotio areas of Nakuru County.

A baseline survey was conducted in the area to bring about a more detailed understanding of the supply and demand situation of cooking fuels in the project target areas. The survey found out that the households were heavily dependent on traditional biomass fuels and that majority were already purchasing their cooking fuels. An indication that the biomass fuel stocks were on the decline in the study area and that the households were in need of an alternative cooking fuel.

Building on the results from the baseline survey, the project team developed and tested a suitable financing model which was expected to ease the burden of the cost of purchasing of LPG cooking kit and refills among the target households. The a priori argument in this project was that poverty is a major constraint to adoption and use of clean cooking fuel such as LPG.

This model was tested against the following criteria: ease of payment in small and affordable amounts, effectiveness in supply of LPG and discipline instituted among user households for payment of energy consumed.

The model enables registered customers to acquire complete LPG cooking kit on loan and pay for their LPG cylinder refills promptly, in amounts equivalent to or lower than the daily spend on fuels currently purchased by each of the households. Implementation of this project has resulted in increased savings among users initially purchasing biomass fuels and kerosene and who have adopted LPG; other additional benefits are expected to include improved health and wellbeing of end-users, increased environmental conservation, and increased last-mile distribution points / improved access to LPG among the rural poor in the target area.

The results from this project show that majority of target households have been able to make regular payments for their LPG refills, the payments are made promptly, the LPG supply hubs have maintained regular and adequate stocks.

Thus, the initial stages in the implementation of the model indicate great potential for supporting communities in the study area to start transitioning from solid biomass fuel to LPG for cooking. In spite of the seeming transitioning, it may be too early to project what is likely to happen to traditional biomass stocks.

The study will contribute data and lessons on rural households cooking fuels, spending on cooking fuels and financing options available. This can be used by stakeholders in enhancing adoption of LPG for cooking in the study areas. In addition, the findings of the study provide useful insights into how stakeholders can improve access and adoption of LPG as primary or complementary fuel for cooking in rural households.

In summary, it is important to note that this project focused on a small sample size of rural residents (the internally displaced persons) who may have unique socio-economic characteristics that impact on their cooking energy requirements. A more realistic picture of the energy supply demand situation requires a larger and more inclusive sample that takes care of other rural residents besides IDPs. Broadly, the project opens a number of opportunities for further R&D that would firmly ground LPG as fuel of choice alongside other modern cooking fuels in the project area.

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1. Introduction

In Kenya, 70% of households use traditional biomass fuels (charcoal and firewood) for cooking and heating. Moreover, approximately 77% of the total population lack access to electricity. As of 2018, 14% of Kenyans were using kerosene for cooking. In comparison 28% of urban residents used LPG and only 2% having adopted it as primary fuel in rural areas (Republic of Kenya, 2018). Traditional biomass fuels (and kerosene) are often more expensive than LPG; they contribute significantly to household air pollution (HAP), they contribute to deforestation and forest degradation, and negatively impact climate change. In 2016, about 14,000 premature deaths in Kenya were attributed to indoor air pollution (Ngeno G, Otieno N, Troncoso K, Edwards R., (2018). In addition, traditional biomass appliances have low thermal efficiency, place disproportionate burden on women and adolescent girls in rural areas, denying them time and resources to engage in more economically productive assignments and education.

By 2018 only 15% of Kenyans had access to clean cooking energy with projections of a rise to 46% by 2030 (IEA, 2020). Transitioning to clean cooking energy is deemed crucial in reducing health burden, reducing women's drudgery and increasing their productive options. The attainment of this target will, however, depend on practical steps taken to help rural low income families to transition to clean fuels for their cooking (Eric Hsu et al, 2019).

In 2018, the Ministry of Petroleum & Mining through National Oil Corporation rolled out a National LPG enhancement project dubbed *Mwananchi Gas Project* with the objective of enhancing LPG penetration from approximately 10% then to 70% within 3 years. Despite efforts to promote LPG use for cooking in Kenya, there is low adoption and provision of LPG in rural areas to date where only 2% of the population has adopted it as a primary fuel. In contrast, 28% urban residents have adopted LPG for their cooking needs (Republic of Kenya, 2018).

In line with this, SCODE has been engaged in a drive to support rural communities in Mogotio and Mbaruk locations of Nakuru County to transition from the use of traditional solid biomass fuels for cooking and heating, to clean fuels with emphasis on LPG and solar electric cooking. Scode expects uptake of LPG to complement electric cooking among households in the study area who have hitherto depended mainly on purchasing biomass fuels and kerosene for their cooking and heating needs.

The project has demonstrated accelerated uptake of LPG and significant reduction in cost of cooking energy among the households that have adopted and are using LPG in the study area.

Aim of the project

The aim of the project was to increase access and use of LPG as a cooking fuel among low income rural households in Mbaruk and Mogotio areas of Nakuru County

The Objectives of the project were:

1. To conduct a baseline market survey to assess the consumers' awareness, perceptions, knowledge of LPG as a cooking fuel, as well as costs of different fuels, to design the best financial and delivery model for target communities.

2. To develop and test suitable LPG consumer financing models for LPG start-up equipment and refills, through mobile payments and a mobile Phone App for rural households
3. To evaluate the effectiveness/suitability of the developed financing model to be replicated in other communities and across the national territories over time.

Methodology

To achieve its aim of developing and testing innovative financial models for LPG start-up equipment and subsequent refills among the disadvantaged segments of the populace through the use of mobile phone payments and mobile Application, the project has been conducted through a series of phases.

i) A baseline survey was carried out in the two target communities settled in Mbaruk and Mogotio locations in Nakuru County. The two communities were sampled purposively because they comprised of vulnerable households that had been introduced to the e-cook project that aimed at providing Solar Electric Pressure Cooker (SEPC) as affordable and clean convenient source of cooking energy. The LPG project was introduced to complement the SEPC by ensuring that the selected communities do not resort to their conventional cooking on dishes that cannot be prepared with the SEPC. The baseline survey helped the research team to understand the fuels used for cooking in the communities, the communities' perception towards LPG, their willingness to adopt LPG, possible barriers that could hinder adoption of LPG and drivers that could enhance adoption of LPG. Primary data was collected through mobile-based questionnaires in Survey CTO collect administered by 10 trained enumerators.

To effectively carry out data collection, ten enumerators were recruited with priority given to the locals who were qualified. Training of the recruited enumerators was conducted for two days. This was done by giving the enumerators a preview of the project, its design, and what the survey aimed to achieve. Then the trainers proceeded to familiarize the enumerators with the tool (the paper questionnaire). Through this process, enumerators were trained on how to handle the questions and different situations while in the field. On the second day, the enumerators were taken through the softcopy questionnaire (mobile-based) designed in Survey CTO, the process of downloading, installing, and configuring the application in their phones. The training proceeded in a similar manner to the paper questionnaire with keen attention to the flow of questions, restrictions, and skip functions designed in the tool.

After training, the enumerators were paired in groups of two and did role play (respondent vs. enumerator), then shared experiences based on the responses given by "respondents" and how "enumerators" filled them. Issues in the softcopy tool were then noted, where skip functions or restrictions were needed, changes were incorporated then the updated and finalized version uploaded to the Survey CTO server and enumerators asked to install updates in their tools.

The survey team then pre-tested the tools in the communities within the Sustainable Community Development Services (SCODE vicinity. Through this process, the enumerators experienced a challenge in getting the required accuracy for the GPS

readings, but the trainers gave an alternative solution. Otherwise, everything was successful.

The actual field survey was conducted for three days. Since the households existed in organized residential blocks, systematic random sampling technique was employed and data collected from 168 households (n= 94 from Mbaruk and n= 74 from Mogotio). In total, 64.88% of the respondents were female while 35.12% were male.

Data from the Survey CTO server was then downloaded both in .csv and .dta formats. Statistical Package for Social Sciences (SPSS) version 20.0, Stata (v.15) and MS excel were used in cleaning and analysing the data. Data cleaning process and preliminary analysis took 7 days, after which data was analysed. The first stage involved understanding the situation on the ground, the types of fuels that were being used, the cost of those fuels and the time it took the target participants to collect or get respective fuels used and their perceptions on the same fuels and whether they were aware of other available types of fuel like LPG that are cleaner.

To obtain deeper understanding of these issues and cross-check the information obtained from through the questionnaire interviews, the survey team organised focus group discussions and key informant interviews.

ii) Three financing models; pay to use (PAYGO), Cash payment, and access to LPG through microfinance lending platform were identified, discussed and evaluated using a participatory approach involving target local communities. The PAYGO model was considered most appropriate and therefore selected because of the following advantages: ease of payment in small and affordable amounts, convenience of accessing LPG through a mobile communication money platform (telephony), and time savings.

This model was tested against the following criteria: ease of payment in small and affordable amounts, effectiveness in supply of LPG and discipline instituted among user households for payment of energy consumed.

In terms of ease of payment, the results show that over 95% of beneficiary households made regular payments of kes1,000/month. This suggests that a significant number of registered users are able to meet their PAYGO commitments on time.

Effectiveness in supply of LPG – the 2 LPG hubs have adequate stock of LPG cylinders, facilitate timely and reliable delivery of refills whenever required by registered users.

Discipline instituted among user households for payment of energy consumed - The project instituted a peer pressure payment framework that has ensured that each participating registered user makes prompt payment for LPG used. This is useful for ensuring commercial viability and sustainability of the use and promotion of LPG

iii) To evaluate the effectiveness/suitability of the developed financing model to be replicated in other communities and across the national territories over time, the research team sought to answer three questions likely to influence replicability of the model to other regions of the country.

a) How representative are the communities in which this project was implemented, to the wider communities in the rest of the country?

This project was implemented in two communities comprising of internally displaced persons from the 1992 – 2007 post-election violence and the 1988 - 2009 eviction of squatters from the government forests. All these post-election victims and forest evictees are now settled in Mogotio and Mbaruk locations of Nakuru. They earn their living from small scale agriculture, petty trade and remittances from relatives. When all the socio-economic attributes of the community in which the project was conducted are considered, it is clear that this community is largely unique. This suggests that any attempt to replicate this financing model to wider communities in Kenya may have to be refined in view of the different and unique socio-economic background of those communities.

b) How possible is it to use the key features of the model in other communities in Kenya?

In most rural households, meals are cooked in more than one pot concurrently. The LPG cooking kit (consisting of two burners, a regulator, a 6-KG cylinder and a 1.5M hosepipe) allows households which adopt LPG to continue sticking to their cooking schedules without any adjustments on time or type of meal. The model provides for LPG user training on safe and efficient use of LPG which gives the first-time users the knowledge and confidence they need to effectively use LPG for their cooking.

The mobile application enables households to order, pay and receive their LPG supplies in the convenience of their homes. The establishment of LPG hubs within target households has allowed for quick turn- around time for LPG supply to households.

These key features of the model (cooking kit, mobile application and LPG hubs) can be replicated and effectively work in most sedentary rural communities in Kenya

c) Is there good value for money for households adopting and using LPG through this model?

The model evaluated through monitoring LPG supply and payments among the participating households. A kitchen performance test lasting10 days was conducted among those who had received the LPG cooking kit. This was done to help the project establish the cost incurred on use of LPG in comparison to that incurred from use of other fuels per day. The KPT field validation tests were conducted in Lomolo B, Echeriria, Heshima and Solai locations in Nakuru County. KPT used the paired-sample study approach

From the KPT results it can be concluded that cooking with LPG costs less compared to cooking with traditional biomass fuels. On average the 95 households that participated in the KPT reduced their energy cost from Kes.525.50 to Kes.258.29. This reduction in energy cost is largely attributable to high cooking efficiency associated with of LPG cooking kit. The results therefore challenge the perception that cooking with LPG is more expensive compared to using traditional biomass fuels for cooking. Moreover, the use of LPG has added advantages including having less emissions and convenience of use.

Outline of the concept *(including scientific basis) on how the technology is going to help to solve a modern energy cooking problem*

Liquefied petroleum gas (LPG) has been recognised as an efficient and safe cooking fuel with the potential to deliver benefits for health, climate, environment and development (Bruce et al., 2017). In addition, LPG is known to be widely available across geographical regions of sub-Saharan Africa, albeit with limited use in many countries within the region. Evidence from India corroborates this view (Kumar, et al., 2017). It is in view of this that, a number of sub-Saharan governments including Kenya have made it a priority to provide a majority of their populations with LPG (Van Leeuwen et al., 2017; Bruce et al., 2017). In order to facilitate widespread transition from traditional biomass fuels to LPG for cooking, it is important however, to understand how best to encourage and support households to both adopt LPG and use it exclusively in a sustained way (Pope, et al., 2018). Understanding the key drivers of adoption and sustained use of clean fuels such as LPG among the poor is similarly critical (Kumar, et al., 2017). Recent research work on LPG access intervention in Ghana has also brought to the fore the importance of the 'last mile' – the last 30 km of LPG delivery/accessibility (Carrión et al., 2018 cited in Carrion, D., Dwommoh, R., Tawiah, T. et al 2018).

It is clear from the scientific literature that LPG is a suitable technology for solving the cooking problem in rural households given its manifold benefits. However, increased use and adoption of LPG for cooking is constrained by a number of barriers including poverty, which is rampant across rural areas. Using evidence from the baseline survey, the project team was persuaded that if rural communities were supported financially, they would be willing and able to adopt and sustainably use LPG for their cooking needs in replacement of traditional biomass fuels. In pursuance of this, an innovative financing model considered suitable in view of the rural communities' low and erratic incomes, was developed and tested.

The model allows the end users to pay for the cost of the initial equipment (LPG cylinder, burner, regulator, gas pipe) (Kes 8,000) spread over a period of 12 months and 5 refills, each at Kes 800 (cost as at 2019), a total of Kes 4,000. The project finances were restricted to 6 months for LPG refilling.

In addition to the financing component, the project established two other elements, the LPG hub and the mobile app. One hub each is located in the two project areas (Mbaruk, Mogotio) within a distance of 4.5 km from the furthest end user. This is considered appropriate for timely and efficient delivery of LPG to the end users. Each hub holds a stock of 10-20 LPG cylinders at any one given time and is managed by a fulltime hub manager who demonstrates the use of LPG cooking kit and recruits new customers.

To facilitate end-users' access to LPG hub, a mobile application was designed and tested for performance. This works at three levels; end user, project team and hub management. The mobile app allows end-users to order, pay and receive LPG refills whenever required. The project staff use it to monitor/track payment by individual end-users, monitor stock as well as keep proper books of account. The hub manager uses the mobile app to monitor stock, release refills to end-users or transporters for delivery, receive and respond to issues raised by customers.

The model that has been developed integrates several benefits to rural communities: access to finance, ease of reach to LPG hubs and convenience of delivery to end-users.

How the idea was generated (e.g. is it an Application from another industry?)

This study builds on a concept espoused by the Kenya Government which has over the last 5 years been concerned with the negative impacts arising from heavy dependence on traditional biomass energy resources especially at the household level. The government's concept dubbed the 'Mwananchi Gas Project' was rolled out in 2018 and aimed at increasing LPG penetration through provision of one-off subsidised LPG cooking kits.

In addition to this, the project has developed a financing and distribution model that makes LPG kits and refills affordable and available within reach of clusters of low income rural households. The design and integration of an easy to use mobile application platform has significantly contributed to the ease of ordering, payment and delivery of the LPG kits and refills.

Interim results from this project show wide acceptance and use of LPG among the target communities and significant reduction in cost of energy for cooking as well as reduction in reliance upon traditional biomass fuels.

Intellectual Property Rights

The mobile application that has been developed and used in this project does not require any registration or patenting. The app is based on existing mobile technology but involved extensive software design and customising for the project's use. It is expected that the software will undergo refinement and any necessary adjustments to accommodate increased customer numbers as well as improve its effectiveness in the years to come as Scode seeks to replicate the success of this project to the wider rural areas in Kenya.

Assumptions made

-The LPG will be safe and promote health among the users

-Participating members will take care of the LPG kits and protect them from theft

-All participating members of the community will continue residing in the project area for the duration of the project – 1 year.

-The project will not lead to any business conflict between the LPG hubs and other retailers or actors in the LPG sector in the study areas

-The project will work in conformity with government regulations on use of LPG

-Mobile phone service providers will remain in business/operation

2. Implementation

The work conducted (including technologies/approaches/equipment used)

Technology

The project adopted an LPG cooking kit comprising of a 6 kg LPG cylinder, a double burner, regulator and gas pipe. The cooking kit promoted by the project allows users' flexibility to cook using up to two pots at any given time, the burner is more efficient and the regulator reduces risks of gas leakage. The Ramton burner brand was selected from among three other double burner brands in the market and with advice of the Global LPG Partnership. In comparison to other burners, the Ramton brand has low LPG consumption, is durable, widely available in the market and is backed by strong after sale service.

The Proto Energy type of LPG cylinder was selected because of the distributor's robust marketing support and efficient delivery of refills to retailers; and the IGT brand of regulators was selected because of their high quality of their valves.

In the Kitchen Performance Test, the following tools were use:

- Digital weighing scale
- Digital moisture metres
- Smart phones

Approaches

1. The baseline survey.

A baseline survey was conducted in Mbaruk and Mogotio in Nakuru County to understand the energy supply and demand situation on the ground. A survey instrument (questionnaire) was designed and used to elicit information on the following: primary fuels used by the rural communities, perception of rural communities towards LPG as a cooking fuel, willingness of rural communities to adopt LPG for cooking purposes, and factors that may hinder their willingness to adopt this technology.

Communities from the two areas were sampled purposively because they comprise of vulnerable residents who were settled in these areas after losing their original settlements on account of eviction from forests and post-election violence.

Primary data was collected through mobile-based questionnaires in Survey CTO collect administered by trained enumerators.

2. Training

Project staff – all 8 members of project staff were trained for half a day by GLPGP trainer on safety and efficient use of LPG

Hub managers – 2 hub managers were trained on safety and efficient use of LPG, and use of mobile application in managing stocks and delivery operations

LPG end users – trained on safety and efficient use of LPG, ordering and payment of LPG, as well as communication with the hub manager.

Enumerators – trained on correct procedures to collect data from respondents.

3. Kitchen Performance Test

The Kitchen Performance Test (KPT) is the principal field–based procedure used to measure consumption of all types of fuels used by households. Kitchen Performance Test Version 4.0 protocol developed by Global Alliance for Clean Cook stoves was used in this study (see Appendix 1). KPT method that was used was the paired-sample study. This was implemented by conducting daily measurements as households use the traditional biomass fuels for a period of five days, followed by daily measurements of the same households using the LPG energy for the same period of time. This method of test made a comparison of the households' fuel use between traditional biomass and LPG energy sources. The number of households that were randomly selected to participate in testing was 100 distributed within the four locations. This activity was done by well-trained enumerators.

The project findings (*How the findings advance the solution)*

- Evidence emerging from the short (10 days) period of KPT based data collection shows that the cost of energy for cooking among the participating households is coming down significantly. If this trend is sustained, we can expect to see a steady increase in adoption, and use of LPG, and at the same time, a steady reduction of rural residents relying on traditional biomass energy for cooking. This would engender a transition towards exclusive reliance on LPG and other clean energies, thus maximising the health, environment and development benefits for the households and the community in general

Evidence from the project shows that the participating households find the established schedule of payment for the LPG refills affordable and convenient. Majority of participating households have elected to pay for their LPG requirement in small amounts but there also a few who prefer to make lump sum payments. The mobile application has been used effectively by end-users to order, pay and receive LPG refills whenever required. In addition, the app has been used by project staff in monitoring and tracking payment by individual end-users, monitoring stock levels as well as keeping proper books of accounts. Hub managers have also used the mobile app to monitor stock, release refills to end-users or transporters for delivery. They also receive and respond to issues raised by customers using the app.

- The group/cluster peer influence mechanism has so far worked well in ensuring prompt payment by participating households for the LPG energy consumed.

- The mechanism has also enabled households that would otherwise have been left due to lack of loan security to be included and benefit from using the LPG cooking kit upfront.

Limitations of the innovation/approach/design/system

- It is clear from the results that an important demographic component of the rural residents- women – was not directly captured in the objectives of this project. It is however noted that majority of the project participants (over 70%) across the range of activities are women. This presents a dilemma in a patriarchal society where men

exercise predominance in income expenditure, including purchase of LPG cooking kit, with the expectation that women would use it for cooking. This is an assumption that needs to be verified empirically in the sense that women may have their own preferences in choosing the energy technologies for their cooking.

- Exclusive reliance on LPG is desirable but may have limitations in rural households. Cooking as an end use is not pursued for a singular purpose. In cold environments, the cooking fire also produces heat to warm the space in the house and may also serve a hub for a range of family social interactions including cooking training girl child by the mother. In poor households, cooking fire may serve as a point to illuminate the house. This would suggest that transition to exclusive LPG use may need to be informed by more incisive research that brings on board socio-cultural, economic and environmental factors likely to influence adoption of LPG especially among low income rural households.

- Empirical data informing this project is based on data that was collected over a period of only 10 days. This period is not adequate to allow us to be certain as to the sustainability of the uptake and use of LPG. Recent studies on LPG adoption suggest that more time for data collection. In addition, more work needs to be done to understand the conditions under which households adopt and sustain LPG adoption and use.

- In Kenya, sale of LPG is a heavily regulated by Energy & Petroleum Regulatory Authority (EPRA). The project did not provide for acquisition of requirements for licensing of LPG retailers by EPRA.

3. Practical applications of the concept to the national cooking energy system (including costs)

The project's concept was to develop and test a financing model that would enable low income rural households to access and use LPG (clean energy) as primary or secondary fuel for cooking. In this way, more and more households would transition to the use of LPG and thus reduce reliance on traditional biomass fuels.

In line with SGD 7, Kenya has an ambitious target of achieving universal access to modern cooking solutions by 2030. These solutions include LPG, electricity, biogas, bioethanol and improved solid fuel cook stoves.

Kenya's national cooking energy system comprises of the following components: solid biomass fuels, kerosene, bio-energy (ethanol, biodiesel, biogas), LPG, solar (PV, thermal) and grid electricity. The Kenya government has prioritised provision of LPG to majority of citizens and has a goal of having 35% of Kenyans using LPG by 2030. However, a survey conducted in 2019 indicates that households using LPG as the primary fuel still use, on average, 42% of the amount of charcoal used by households that depend on charcoal as the primary fuel (GoK, 2019). The realisation of the goal will necessitate concerted and deliberate actions by relevant stakeholders – MoE&P, private sector (manufacturing, distribution, financing) to support the required transition, particularly from reliance of traditional solid biomass fuels to LPG among other clean energies.

Promotion of LPG to be a strategic source of energy for cooking at the national level will require the following:

Awareness creation and behaviour change campaigns among rural communities in Kenya where LPG uptake is lowest. The campaigns should focus on changing communities' perceptions regarding cost, safety and availability of LPG. In the initial stages, the campaign would focus on counties where the reliance on purchased traditional biomass fuels is highest. Each selected county would be represented by 4 purposively selected clusters that would form the focus of the campaigns. Estimated cost of GBP 250,000 per county for 3 months to cover transport, personnel, advertisement, community mobilisation, stationery, demonstration kits

Capacity building – skills' training for manufacturers of LPG appliances especially SMEs in conformity to national and international standards, distributors and retailers on safe handling of LPG (storage and transportation) and entrepreneurial skills; end users on safety handling and efficient use of LPG. Cost estimated at GBP 300,000

LPG value chain gaps' assessment survey - This will involve assessing gaps in the LPG cooking appliances chain. Customisation and standardisation of LPG cooking appliances in the market and their fit/suitability for local communities' cooking needs. Cost estimated at GBP 250,000 for a six months study.

Next steps (e.g. beta or field testing and implementation; more development etc)

Data collection on LPG use – the time budgeted for data collection for the ending project was inadequate to inform the dynamics related to accessibility and use of LPG

for cooking in the study areas. As a way forward, Scode is requesting for a 9 months' period within which more detailed and informative data will have been collected, analysed and synthesised into actionable work packages. To realise this objective, Scode is requesting for GBP 40,000.

Scale up of the project sample size - The project that is ending has given indications of the potential of LPG to penetrate rural areas as a cooking fuel of choice. These indications need to be verified by a scaled up study based on a larger sample size. Moreover, the study upon which this report is based, was focused on a specific clientele (internally displaced persons). As a way forward, Scode is proposing to undertake a wider study that would include other households in the rural communities where the study was conducted and beyond. This would provide a more accurate and representative picture of the wider rural communities' cooking fuels mix. Time frame: 15 months; Budget: GBP 275,000

LPG value chain analysis – In an effort to maintain the momentum created by the project now ending for LPG as a cooking fuel, Scode wishes to undertake a value chain analysis to examine constraints (including policy and commercial) that may hinder adoption and sustained use of LPG among low income rural households. This will help to formulate pragmatic interventions that would encourage increased uptake and use of LPG as a cooking fuel. The cost is estimated at GBP 200,000.

Dissemination of results: It is the plan of the project team to disseminate project findings to stakeholders including the Ministry of Energy, Petroleum and Mining, relevant county institutions in which the study was conducted (Mbaruk and Mogotio locations). Findings of this study will also be uploaded on Scode's website to enable wider dissemination. Finally, we intend to publish 1-2 papers in reputable and peer reviewed journal(s).

Scode is requesting for a supplementary budget in the amount of GBP 20,000 upon approving the final report. Time frame: 3 months

Dissemination Plan

Discuss the dissemination measure done already – provide link for where on the internet the report is published by you, what journals you have plans to publish, conferences attending to publicise the research etc

The project planned to collect data for a period of 3-4 months followed by data analysis and report writing. However, the data collection period was reduced to 10 days. This constrained the time that would have been used to complete the analysis and compile the results (data collection was completed at end of February 2020). In view of these circumstances, dissemination could not have been done any earlier. It is the plan of the project team to disseminate project findings to stakeholders including the Ministry of Energy, Petroleum and Mining, relevant county institutions in which the study was conducted (Mbaruk and Mogotio locations). Findings of this study will also be uploaded on Scode's website to enable wider dissemination. Finally, we intend to publish 1-2 papers in reputable and peer reviewed journal(s).

Scode is requesting for a supplementary budget in the amount of GBP 20,000 upon approving the final report.

Conclusion

This study sought to develop and test a user-friendly financing model that would enable low income rural households in Mbaruk and Mogotio areas to access and use LPG as a cooking fuel. The project team conducted a baseline survey to understand the supply and demand situation of cooking fuels in the study areas.

Building on the results from the baseline survey, the project team developed and tested a suitable financing model to deliver LPG fuel for cooking to target households.

Evidence from the project shows that the participating households find the established schedule of payment for the LPG refills affordable and convenient. Majority of them have elected to pay for their LPG requirements in small amounts but there also a few who prefer to make lump sum payments. Thus, the initial stages in the implementation of the model indicate great potential for supporting communities in the study area to start transitioning from solid biomass fuel to LPG for cooking.

This focused on a small sample size of rural residents (the internally displaced persons) who may have unique and special energy requirements. A more realistic picture of the energy supply demand situation requires a larger and more inclusive sample. The project opens a number of opportunities for further R&D that would firmly ground LPG as fuel of choice.

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5. Appendices

Appendix A: Baseline Survey Report

SCODE/MECS LIQUEFIED PETROLEUM GAS (LPG) RESEARCH & DEVELOPMENT PROJECT BASELINE SURVEY REPORT

Background Information

The SCODE-MECS LPG baseline survey was carried out in two communities, Mbaruk and Mogotio in Nakuru County. The two communities were sampled purposively because they comprised of vulnerable communities that had been introduced to the e-cook project that aimed at providing affordable and clean convenient source of cooking energy, specifically the Solar Electric Pressure Cooker (SEPC). The LPG project has been introduced to complement the SEPC by ensuring that the selected communities do not resort to their conventional cooking on dishes that cannot be prepared with the SEPC. To effectively achieve this, a baseline survey was conducted to understand the prevailing situation on the ground, primary fuels in the communities, their perception towards LPG, their willingness to adopt LPG, and possible barriers that could hinder adoption. Primary data was collected through mobile-based questionnaires in *Survey CTO collect* administered by trained enumerators.

To effectively carry out the process, ten enumerators were recruited with priority given to the locals who were qualified. Training of the recruited enumerators went on for two days (on 10th and 11th September 2019). This by giving the enumerators a preview of the project, its design, and what we aim to achieve. We then proceeded to familiarize them with the tool (the paper questionnaire). Through this process, we trained them on how to handle the questions and different situations while in the field. On the second day, we went through the softcopy questionnaire (mobile-based) designed in Survey CTO, took them through the process of downloading, installing, and configuring the application in their phones. We proceeded with the training in a similar manner to the paper questionnaire with keen attention to the flow of questions, restrictions, and skip functions designed in the tool.

After training, the enumerators were paired in groups of two and did role play (respondent vs. enumerator), then shared experiences based on the responses given by "respondents" and how "enumerators" filled them. Issues in the softcopy tool were then noted, where skip functions or restrictions were needed, changes were incorporated then the updated and finalized version uploaded to the *Survey CTO* server and enumerators asked to install updates in their tools.

After lunch, we then left for pre-testing in the communities within the Sustainable Community Development Services (SCODE vicinity. Through this process, the enumerators experienced a challenge in getting the required accuracy for the GPS readings, but we gave an alternative solution. Otherwise, everything was successful.

The actual field survey began on 12/09/2019 to 14/09/2019. Since the households existed in organized residential blocks, systematic random sampling technique was employed and data collected from 168 households (n= 94 from Mbaruk and n= 74 from Mogotio). In total, 64.88% of the respondents were female while 35.12% were male.

Data from the Survey CTO server was then downloaded both in *.csv* and *.dta* formats. Statistical Package for Social Sciences (SPSS) version 20.0, Stata (v.15) and MS excel were used in cleaning and analysing the data. Data cleaning process and preliminary analysis took 7 days, after which data was analysed.

Findings

This section presents and discusses the findings of the survey and is divided into two major sections. The first section presents the descriptive statistics for the socio-economic and institutional characteristics of consumers based on their willingness to pay for the LPG unit while the second section presents results of the Probit model on factors influencing consumers' willingness to adopt the LPG.

Descriptive Statistics

Table 1: Consumer's household and institutional characteristics

Location	**Variable**						
	Age (years)	Gender		Schooling years	Group membership	Monthly income (KES)	Nature of income (seasonality)
		Male	Female				
Mbaruk	46.97	52.13%	47.87%	9.36	53.20%	6391	80.85%
Mogotio	44.59	60.53%	37.84%	7.76	32.43%	5151	86.49%

The average age of the household heads in Mbaruk was approximately 47 Years while that of Mogotio was 44 years. As presented in Table 1, majority of the households in the study areas were male-headed with 52.13% and 60.53% of the households headed by males in Mbaruk and Mogotio respectively. This represents a typical African society. However, Mbaruk had more households (52.13%) headed by females as compared to Mogotio with only 37.84%. Regarding the number of schooling years attained by household heads, Mbaruk had an average of 9.36 schooling years while Mogotio had 7.78. However, majority of the heads in the study areas (52.38%) had attained primary level of education followed secondary (29.17%) while only 13.22% had attained tertiary level as presented in Figure 1.

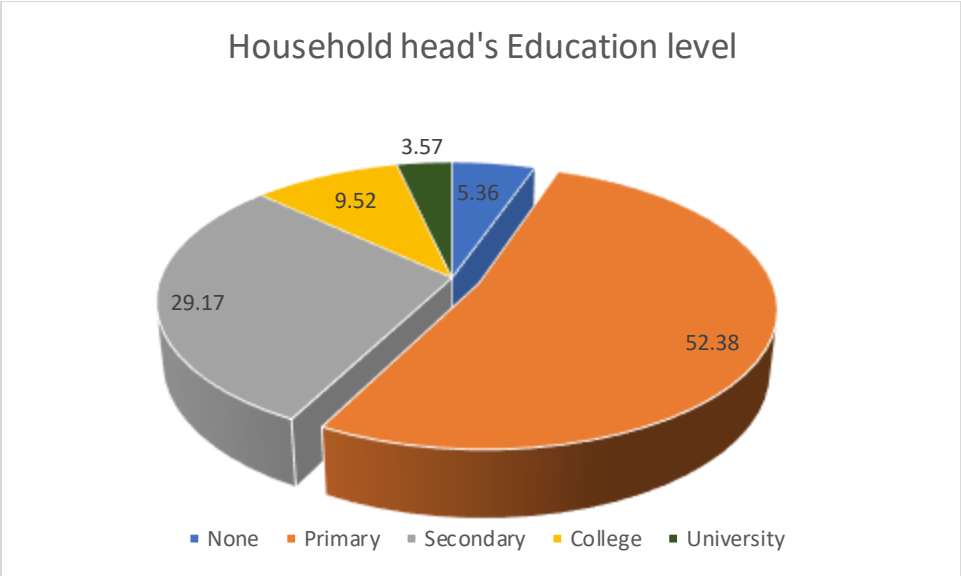


Figure 1: Household head's Education level

The average monthly income of households in Mbaruk was KES 6391 and KES 5151 in Mogotio. Despite the low income by households in the study areas, majority of their incomes 80.85% in Mbaruk and 86.49% n Mogotio were affected by seasonality. This could be attributed to the overdependence on rain fed agriculture and casual employment. The gap in the incomes between the two areas could be attributed to similarity in households' main activities with farming the dominant income generating activity.

On group membership, more households in Mbaruk (53.20%) reported to have at least one member in the household affiliated to a social group as compared to their counterparts in Mogotio at 32.43%. As agued by Ndunda and Mungatana (2013), social groups act as vital channels through which cardinal information on new innovations or improved techniques could be transferred to communities besides being an enabling factor in accessing financial services.

Primary Fuel

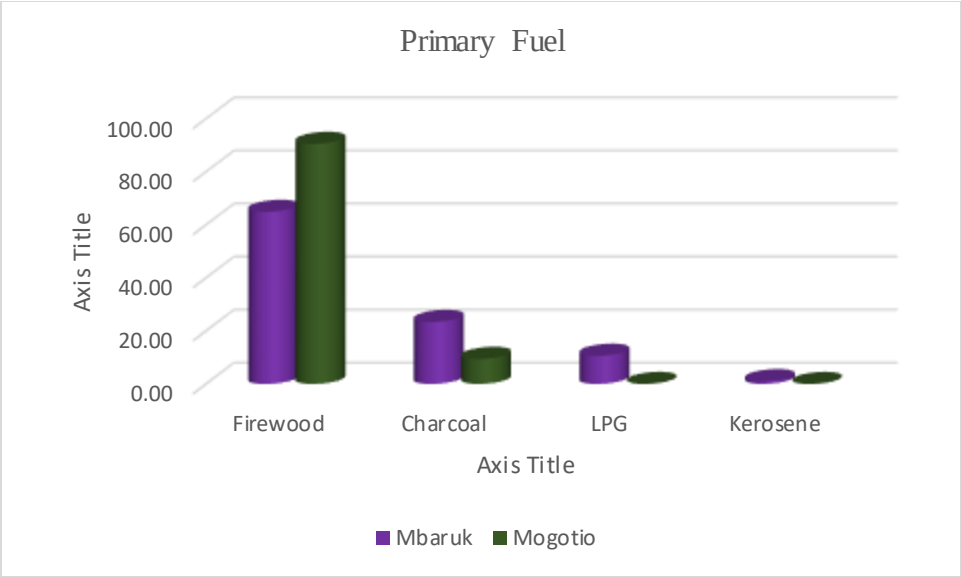


Figure 2: Primary fuel

Majority of the households in the study areas (90.54% in Mogotio, 64.89% in Mbaruk) rely on firewood as their primary cooking fuel followed by charcoal (23.40% in Mbaruk and 9.46% in Mogotio). Only 10.64% of the households (all in Mbaruk) reported to rely on LPG as their primary cooking fuel. However, no household was found to use LPG as a primary fuel in Mogotio.

Around 46% (n= 43) of the respondents in Mbaruk owned LPG while none of the interviewed households in Mogotio owned LPG. Of the households with LPG in Mbaruk, only 29.79% (n= 28) were currently using LPG for cooking. Of this, only 10.64%(n=10) reported LPG as their primary source of fuel. Households that owned LPG but were not using them at the time of the survey, 15.96% (n=15) in Mbaruk cited Affordability of the refills, unreliable distributors, and distance to the refill centres as the major reasons of resorting to other sources of cooking fuels.

Decision-maker on the type of fuel

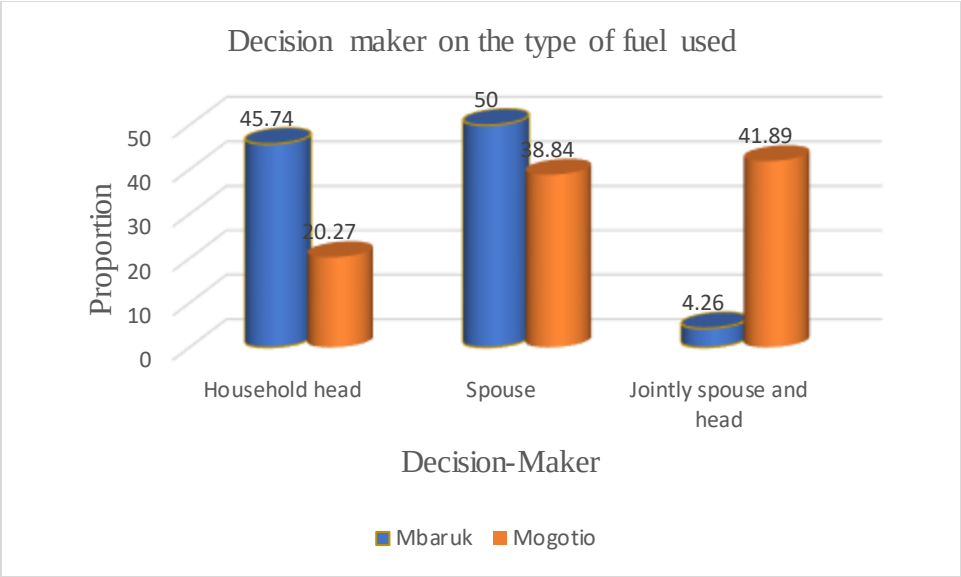


Figure 3: Decision maker on the type of fuel used

In Mbaruk, decision on the type of fuel to be used within a household were mostly made by spouse (50%), followed by 45.74% relying on the household head while only 4.26% were jointly made by the head and the spouse. In Mogotio, the decision on the type of fuel to be used within a household was jointly determined by the head and spouse at 41.89% followed by the spouse at 38.84% as presented in Figure 3.

Access to Cooking Fuel

Majority of household in Mogotio (64.9%) obtained their fuel for free as compared to their counterparts in Mbaruk (22.3%). This could be attributed to the type of primary fuel used. As presented in Figure 3, majority of the households in Mogotio (90.54%) relied on firewood with only a few using charcoal and kerosene. This was contrary to their counterparts in Mbaruk as they also used LPG and a higher proportion on charcoal as compared to their counterparts. Besides, majority of the households in Mogotio (59.56%) relied on fetching their firewood while those in Mbaruk (67.21%) sourced their firewood from timber yards which implies purchasing as presented in Figure 4.

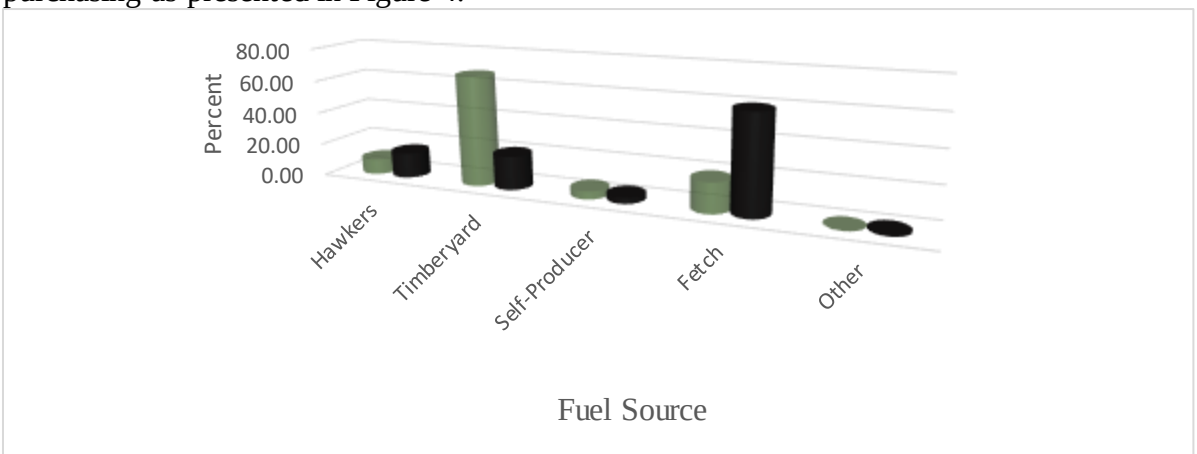


Figure 4: Source of cooking fuel

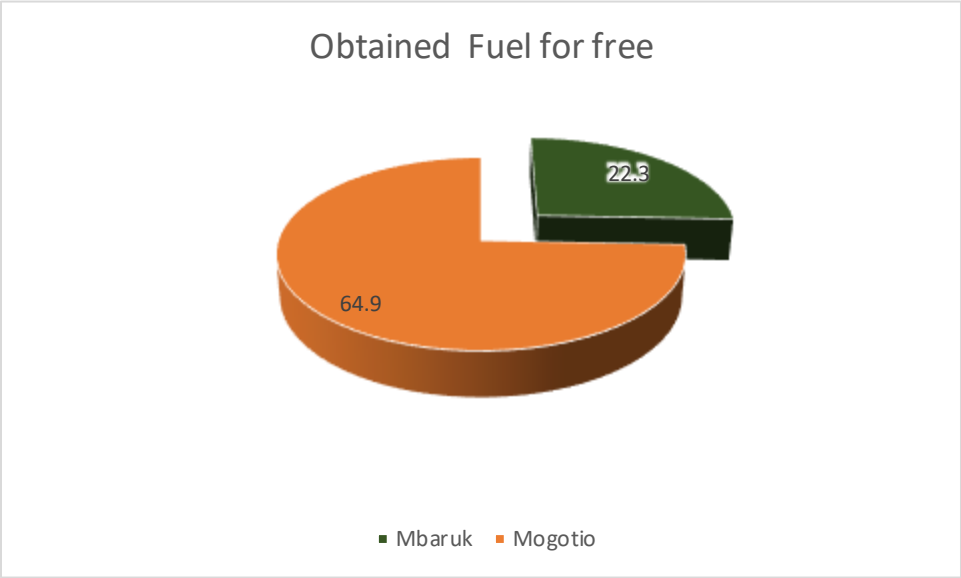


Figure 5: Free fuel

Cooking place

Table 2: Cooking place

Location	Main house	Separate room within Main house	Open air Outside Main house	Separate room outside Main house
Mbaruk	10.64%	26.60%	18.09%	44.68%
Mogotio	14.86%	16.22%	2.70%	66.22%

Majority of the households (44.68% in Mbaruk and 66.22% in Mogotio) cooked in a separate room outside the main house while on 10.64% in Mbaruk and 14.86% in Mogotio cooked in the main house. This could plausibly be attributed to the smoke emitted by the conventional cooking ways of the two communities. This could be a challenge to many households in during the rainy seasons. As a result, there is an urgent need for cleaner and convenient cooking for majority of the households in the study area.

Table 3: Light source

Location	Electricity	Solar-powered lanterns	Rechargeable flashlights	Battery-powered	Kerosene lamp
Mbaruk	42.55%	36.17%	0%	3.19%	15.96%
Mogotio	43.24%	32.43%	12.16%	5.41%	1.35%

on the safety of LPG. Furthermore, since majority of the cooking in the two communities is done by the females, they are likely to have the final say if they would use LPG or not. Majority of the

households (42.55% in Mbaruk and 43.24% in Mogotio) were found to rely on electricity as their main source of light followed by solar-powered lanterns (36.17% in Mbaruk and 32.43% in Mogotio as presented in Table 3. This could be attributed to the current rural electrification programme by the government of Kenya and other development partners like Safricom through their M-Kopa programme. These programmes have ensured that households in the rural set-up are connected to the national grid and those unconnected are supplied with smaller solar panels units that comes with special electric bulbs and charging systems, and even Television sets.

Decision to own LPG

Households that had no LPG indicated that if they were to adopt the use of LPG, the decision would majorly be made jointly by the household head and the spouse in both areas (55.41% in Mogotio and 43.13% in Mbaruk followed by Spouse (31.37% in Mbaruk and 22.97% in Mogotio). Joint decision making could be attributed to households' perceptions that LPG is expensive in addition to many families' reservations

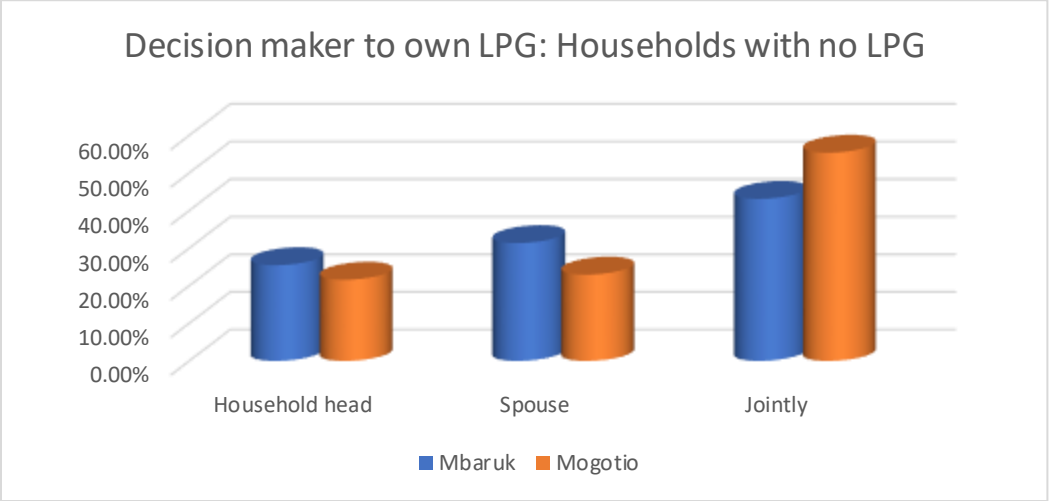


Figure 6:Decision maker to own LPG

Households' perception on LPG attributes

During the survey, the respondents were asked to give their opinion by rating how they agreed or disagreed with a number of aspects on LPG. The perceptions were categorized into the opinions of those households that were using LPG and those that did not have. A summary of their perceptions is as presented in Table 4. Majority of the households with LPG agreed that LPG is convenient, cooks faster, is safe to use, clean, and easy to use while those without LPG agreed that LPG is clean and cooks faster. Diametrically, majority with LPG disagreed that LPG refills were easily available with and 34.88% of them disagreed that refills were affordable attributes that were equally disagreed by those without LPG at 66.40% and 67.20% respectively. Furthermore, households without LPG believed that LPG could not cook most dishes.

Table 4: Households perception on LPG attributes

Attribute	Without LPG		With LPG	
	Agree	*Disagree*	*Agree*	*Disagree*
LPG is Convenient	67.38%	1.60%	97.67%	2.33%
LPG cooks faster	80.80%	0.80%	100%	0%
LPG is safe to use	22.11	60.8	97.67	2.33%
Refills are affordable	24.80%	67.20%	65.12%	34.88%
Refills are easily available	25.60%	66.40%	20.93%	79.07%
LPG is clean	87.20%	12.80%	100%	0.00%
LPG is easy to use	74.40%	25.60%	100%	0.00%
LPG can cook most dishes	29.60%	64.80%	83.72%	16.28%

LPG Attributes

Cylinder size: Majority of the households with LPG, 97.67% (n= 42) used 6kg cylinders while only 2.33% (n=1) had 13-Kg cylinder.

Number of Cylinders: Majority of the households with LPG, 97.67% (n= 42) had one cylinder while only 2.33% (n=1) had two cylinders

Burner type: Majority of the households with LPG, 97.67% (n= 42) used one burner fixed on top of the cylinder while only 2.33% (n=1) used two burners connected with a regulator

LPG Start date: The majority of the households with LPG, 39.53% started using LPG more than 2 years but less than 5 years ago, followed by 20.93%, who had started using it between 5 and 10 years ago while only 6.98% had started using LPG more than 10 years ago.

Frequency of cooking with LPG: the majority of households with LPG, 72.09% reported to have cooked with LPG for every day of the last seven days before the survey while 20.93% had not cooked with it at all during the same period.

Burner problems: of those owning LPG, 23.25% reported to have encountered problems with their burner. This was majorly in terms of leaking and loose burners either wasting the gas or making cooking difficult.

LPG Refilling

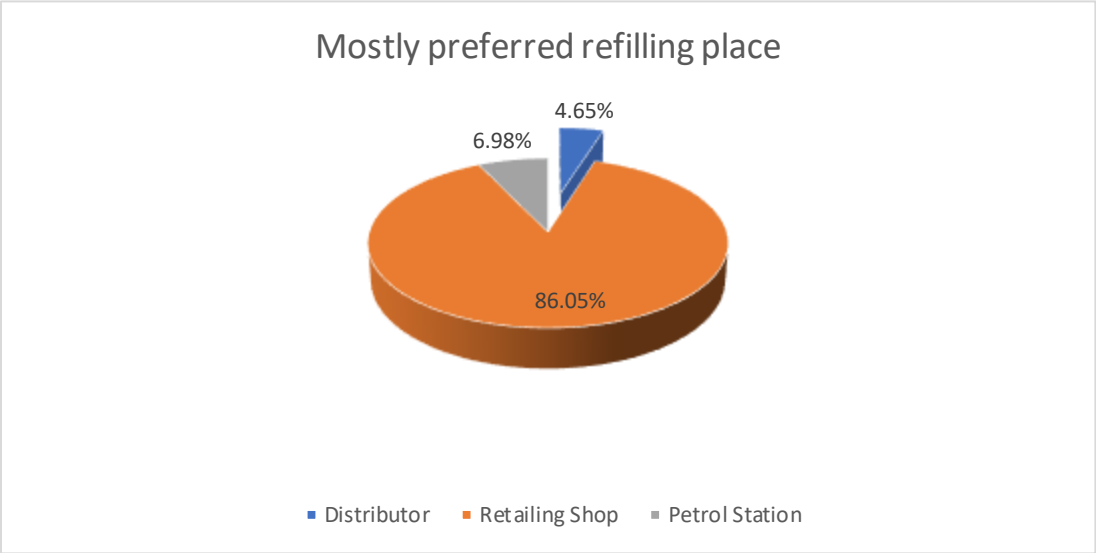


Figure 7: Mostly preferred refilling place

Mostly households (86.05%), refilled their LPGs at retailing shops while only 4.65% refilled with distributors in the area. Majority of the households cited proximity to where they live (44.19%) and good customer services (23.26%) as the main reasons for refilling at their preferred joints. Majority of the households, 37.21% reported that their refills lasted for about one month and 30.23% for two months while 4.65% reported that the refills only lasted for two to three weeks.

Refill delivery

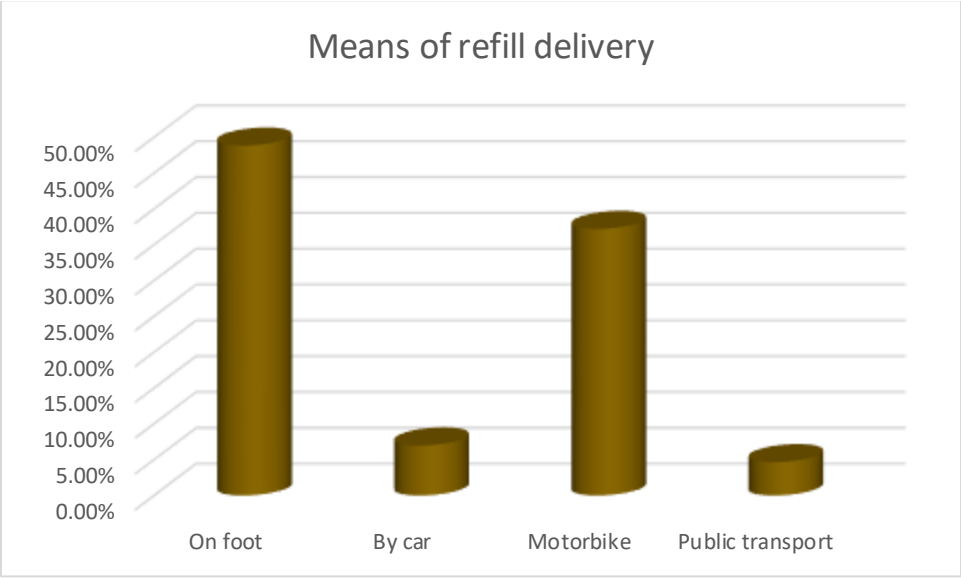


Figure 8: Means of refill delivery

Majority of the households (48.84%) went to get the LPG refills on foot. This was followed by motorbike (37.21%) and only 4.65% delivered their refills by public means as presented in Figure 8.

On average, the amount for refilling a 6-Kg cylinder gas was KES 889 while for a 13-Kg cylinder was KES 2500. On distance to the mostly preferred refill stations, households with LPG took approximately 25 walking minutes to get to the refill stations. Approximately 42% (n=18) of the households with LPG incurred around KES 64 to deliver refills to their homesteads.

Mobile-Technology

Table 5: Mobile-Technology

	Phone	Phone type		Money account
		Smart phone	*Button-type*	
Mbaruk	91.49%	30.85%	66.28%	91.49%
Mogotio	95.95%	16.90%	83.10%	97.30%

Majority of the household heads (91.49% in Mbaruk and 95.95% in Mogotio) had phones. Majority of the household heads (66.28% in Mbaruk and 83.10% in Mogotio) had button-type phone while only 30.85% and 16.90 respectively had smart phones. Of those with phones, (91.49% in Mbaruk and 97.30% in Mogotio) had mobile money accounts.

Mobile money accounts

Majority of the households (90.43% in Mbaruk and 100% in Mogotio) had activated Mpesa accounts in their phone followed by 20.93% in Mbaruk with Equitel money account and 2.78% in Mogotio with Airtel money accounts.

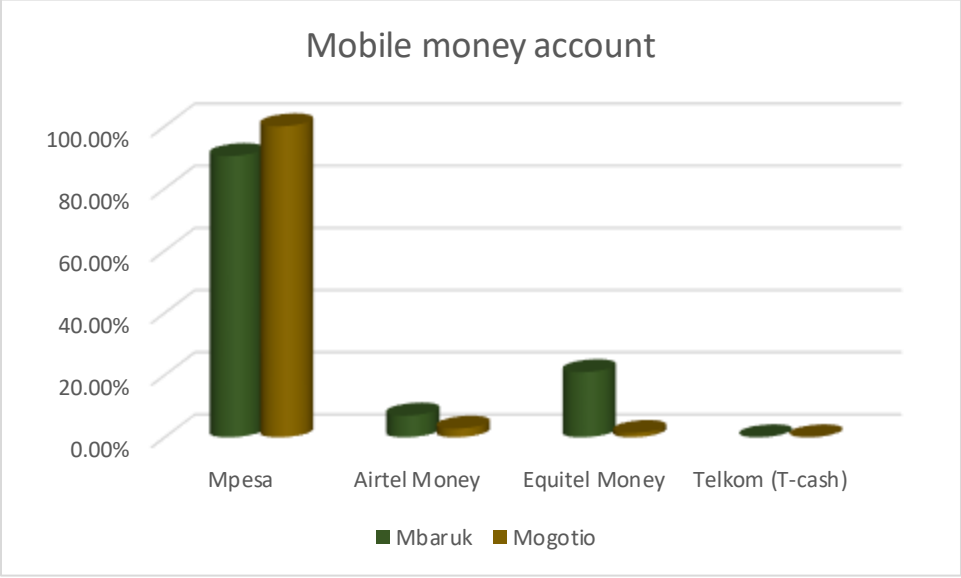


Figure 9: Mobile money account

Use of mobile applications

Table 6: Use of mobile Apps

Location	Mobile application service (%)	Service cost (KES)
Mbaruk	38.3	197.75
Mogotio	28.38	23.19

Around 39% and 29% of the households in Mbaruk and Mogotio respectively reported to have used mobile applications in conducting market transactions with average service cost of KES 197.75 and KES 23.19 per transaction as presented in Table 6.

Asset Ownership

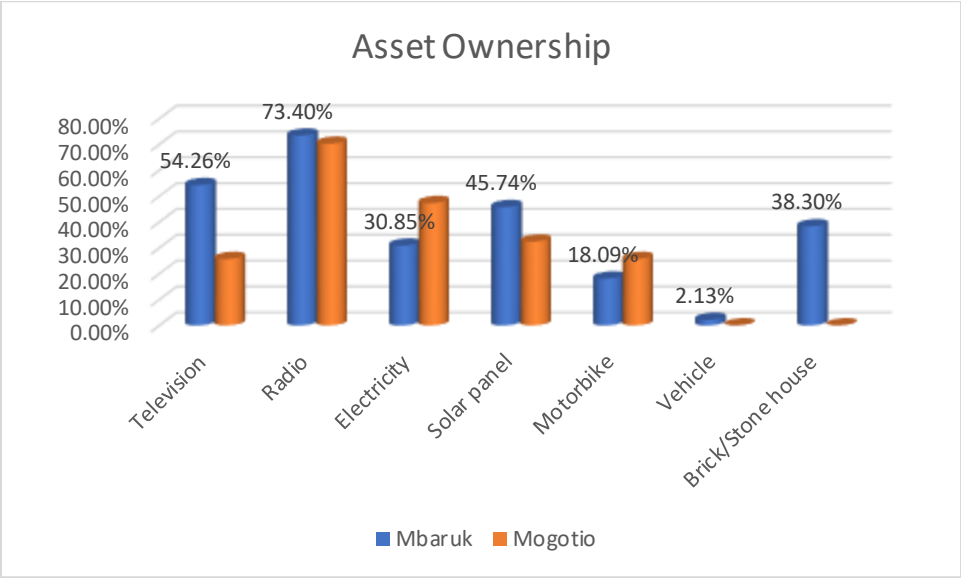


Figure 10: Asset Ownership

Majority of the households in the study areas owned a radio, TV, and electricity as presented in Figure 10. Around 39% of the households in Mbaruk had brick or stone walled houses while households in Mogotio were majorly mud-walled.

Access to financial services

With regard to access to financial services, majority of the households had access to credit services while only a few had access to insurance (life and property) services as presented in Figure 11

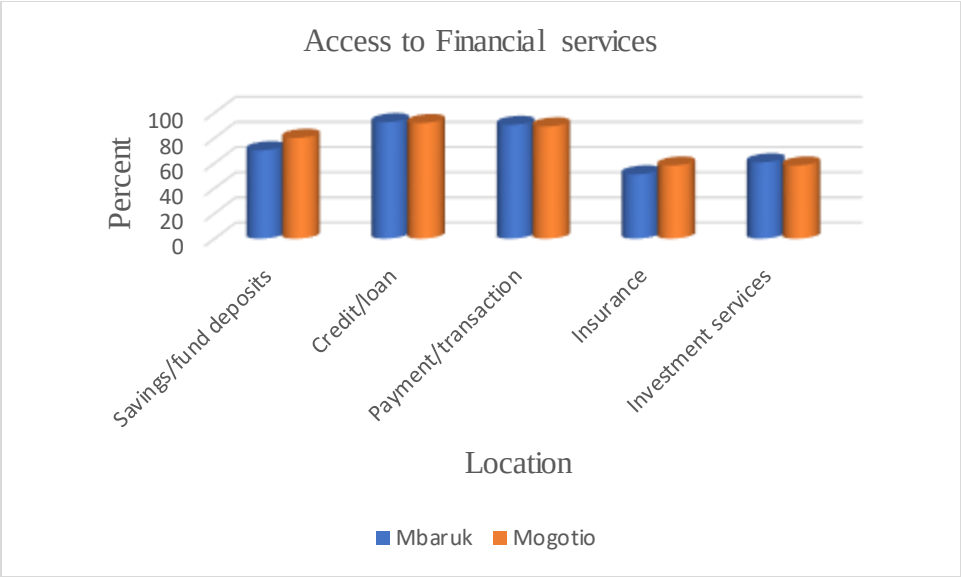
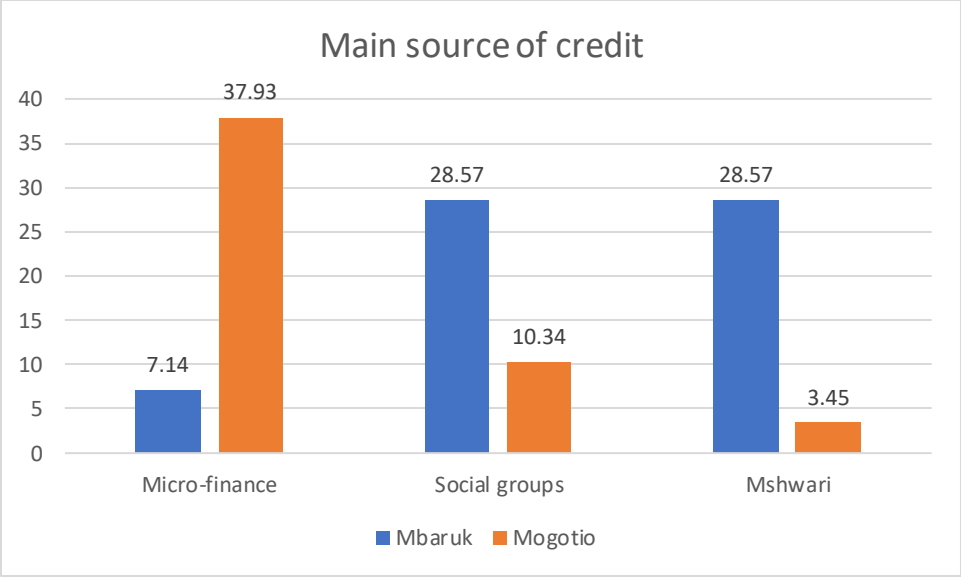


Figure 11: Access to Financial services

Only 29.78% (n= 28) and 39.19% (n=29) of the households that had frequently access financial services in Mbaruk and Mogotio respectively had accessed credit in the last 12 months before the survey. Majority of those who accessed credit in Mbaruk relied on mobile money, that is Mshwari at 28.57% and social groups (*chamas*) at 28.57% while majority in Mogotio (37.93%) accessed their credit through Micro-finance institutions followed by social groups (*chamas*) at 10.34%.



For the last 3 years, only 15.96% of the households in Mbaruk and 22.97% in Mogotio had taken items/products on credit and paid in installments. The average total cost of the product/item (s) was KES 33614 in Mbaruk and KES 13789 in Mogotio. The average installment amount paid by the beneficiaries/borrowers was KES 627 and KES 453 per week in Mbaruk and Mogotio respectively.

Saving

In terms of income generating activities, 80 households relied on farming, 14 on salaried employment and 42 on business. Approximately 60% of the households involved in farming save around 20% of their proceeds while only 40% in Mogotio save 17% of the farm produce. The largest proportions of savings were undertaken by households that relied on employment at 100% in Mbaruk and 80% in Mogotio saving more than a fifth of their total monthly earnings as presented in Table 7.

Table 7: Monthly savings

Income activity	Location	Households	Percentage saved
Farm income	*Mbaruk*	60	19.79
	Mogotio	40	17.19
Salary	*Mbaruk*	100	22.81
	Mogotio	80	21.25
Business	*Mbaruk*	85.71	20.96
	Mogotio	57.14	11.75

Unforeseen events

In the event of unforeseen emergencies, majority of the households (56.4% in Mbaruk and 51.4% in Mogotio) pointed out that they relied on friends and relatives followed by loans from mobile money (*Mshwari*) at 41.5% in Mbaruk and 40.5% in Mogotio as presented in Figure 12.

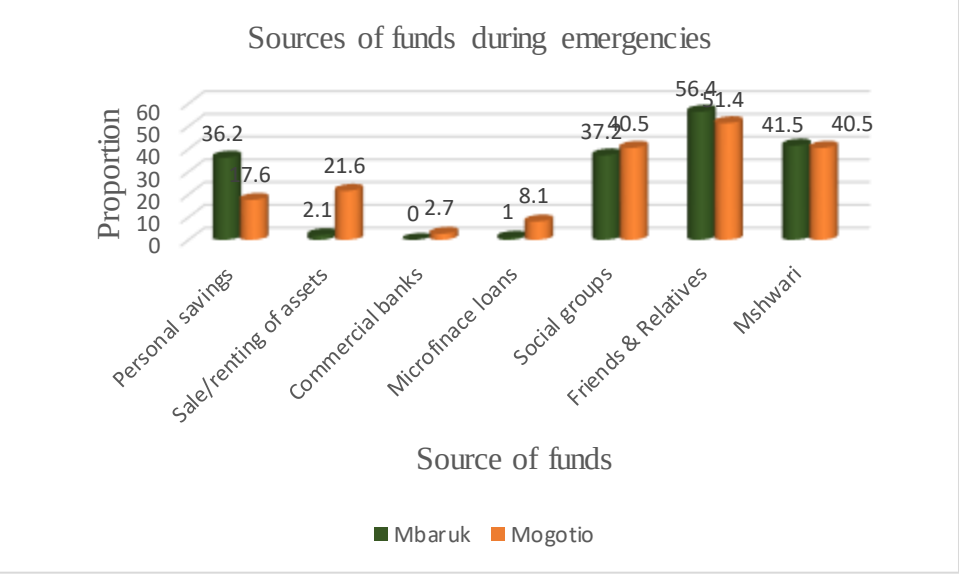


Figure 12: Sources of funds during emergencies

Appendix B: Kitchen Performance Test Report

KITCHEN PERFOMANCE TEST ON INTRODUCTION OF LIQUIFIED PETROLEUM GAS – CASE STUDY NAKURU COUNTY

Introduction

The Kitchen Performance Test (KPT) is the principal field–based procedure to measure household fuel consumption. The primary objective of the KPT was to quantify fuel consumption under typical household and stove usage conditions. KPTs are often combined with household surveys, which help to contextualize fuel consumption practices. Because it occurs in the homes of stove users, this type of testing, when conducted carefully, was the best way to understand the stove's impact on fuel use and, when complemented with the appropriate surveys, on general household characteristics and behaviours (Lillywhite, 1984; VITA, 1985), in this context, Liquefied Petroleum Gas (LPG) was the stove under KPT test. However, the KPT is also a particularly difficult way to test stoves because it intrudes on people's daily activities. In addition, the measurements taken during the KPT are more uncertain because potential sources of error are harder to control in comparison to laboratory-based tests. For this reason, the protocol for the KPT is quite different from the protocols for the Water Boiling Test (WBT) and the Controlled Cooking Test (CCT). Kitchen Performance Test Version 4.0 protocol developed by Global Alliance for Clean Cook stoves was used in this study. KPT is both qualitative and quantitative surveys.

Quantitative surveys are used to gauge how people feel about the stove. The goal being to identify basic social, economic and cooking information of the community families. This survey provides important information and it should occur before stoves are sold or distributed. The survey may also include households that do not adopt the stove. In addition to providing information about families that are potential stove users, the survey will also identify households that are willing to participate in more in-depth fuel consumption tests as well as households that are willing to participate in the second stage which is quantitative survey.

MATERIALS AND METHODS

The quantitative KPT field validation test was conducted in Lomollo B, Echereria, Heshima and Solai locaions in Nakuru County. The choice of the locations was in the proposal based on low income, post-election violence victims and gender issues. KPT method that was used was the paired-sample study. This was achieved by conducting daily measurements as families use the traditional stoves for a period of five days followed by daily measurements of the same families

using the improved stove (LPG) for the same period of time. This method of test made a comparison of the family's fuel use with the old and improved stove. The number of households that were randomly selected to participate in testing was 100 distributed within the four locations. Enumerators were selected and trained on data collection and Kobbocollect application that was used for two days. Day 0 was on a Monday where the enumerators were deployed in their respective field and supervisors. On this day, the enumerators explained to family members the purpose of the test and arranged to measure their fuel consumption at a roughly the same time each day. It was stressed to household members that their cooking practices should remain as close to normal as possible for the duration of the test. The enumerators recorded the weight using a spring balance and moisture content using moisture meter of the initial stock of solid fuels on Kobbocollect. If liquid and/or gaseous fuels were used, the initial stock of fuel was also recorded. The family was asked to keep newly acquired fuel separate from the fuel that had already been measured. The family was further asked to define an inventory area to store the fuel during the test. If the family was to collect or purchase solid fuel during the days of the test, they were asked to keep newly collected or purchased solid fuel separate from fuel that has already been tested for moisture and weighed. Enumerators visited each household at roughly the same time each day, without being intrusive. With each daily visit, the number of people that ate their meals in the household since your last visit was recorded. Since this number could vary from one day to the next, an average value was avoided. Gender and age of each person was also recoded calculate the number of standard adult persons served as shown in Table 1. Fuel consumption was recorded by weighing the remaining fuel. In cases where the family was providing their own fuel, the weight and moisture content of newly collected fuel was recorded before it was added to the family's stock.

Table: Standard adult equivalence factors defined in terms of sex and age

Gender and Age	Fraction of standard adult
Child 0 – 14 years	0.5
Female Over 15 years	0.8
Male 15 - 59	1
Male Over 59 years	0.8

The fuel was not provided to any of the families hence there was no frequent checks to see that they have adequate supplies and add to their stock. The data was then cleaned at the end of the test period and analysis done.

RESULT AND DISCUSSION

The data of impact of Liquefied Petroleum Gas on energy used per adult equivalent in 95 households is shown in Table 2. The households were given special identification numbers. Total energy used in mega joules before intervention was calculated from traditionally used fuels that include; firewood, charcoal, other biomass (maize residue), electricity and fixed grilled LPG using their respective calorific values from literature. The total energy used after intervention was obtained from mainly LPG with double burner and other supplement fuels that include; firewood and charcoal. The means of total energy used per adult equivalents before are high as compared to after intervention from the visual observation. It was however necessary to conduct a t-test on the two data sets. According to hypothesis, energy used per adult equivalent was expected to decrease on the introduction of LPG cooker unit. Therefore, a one tailed t test was conducted with repeated measured design. The value obtained was 0.00015 which is less than the critical value of 0.05. This confirms that there was significant difference in the energy used before intervention and after intervention.

Table 2: Impact of LPG use on energy per adult equivalent in 95 households

	BEFORE INTERVENTION			**AFTER INTERVENTION**		
HHID	**No. of adult equiv**	**Total energy Used**	**Energy used per adult equiv**	**No. of adult equiv**	**Total Energy Used**	**Energy used per adult equiv**
1	3.9	76.032	20.05265	4.1	57.684	14.06927
2	6.88	141.3	20.52969	6.4	99.838	15.59969
3	7.4	118.674	16.10371	7.3	105.013	14.38534
4	3.8	69.696	18.99043	3.6	18.06	5.016667
5	4.1	113.22	27.61463	4.1	62.17	15.16341
6	2.92	139.824	54.20474	2.84	14.504	5.982199
7	5.9	130.0725	22.04619	6.3	90.088	14.32712
	BEFORE INTERVENTION			**AFTER INTERVENTION**		
HHID	**No. of adult equiv**	**Total energy Used**	**Energy used per adult equiv**	**No. of adult equiv**	**Total Energy Used**	**Energy used per adult equiv**
8	3.8	107.676	28.33579	3.4	30.2616	8.776338
9	2.65	88.73013	33.43569	1.8	51.456	28.58667
10	5.825	78.3225	13.85853	6.7	110.945	16.55896
11	4.72	211.428	46.00572	4.333333	659.6217	229.0601
12	3.54	39.024	11.16	3.8	16.17	4.058586
13	1.72	223.652	129.28	1.6	367.108	229.4425
15	5.45	118.53	24.18185	2.94	211.68	99.28642
16	3.16	87.35	27.51667	3	15.974	5.324667

17	1	10.5	10.5	1	9.506	9.506
18	2.6	104.175	40.06731	2.6	16.562	6.37
19	1.98	128	63.69251	2.94	18.382	7.004454
20	8.05	305.82	43.23528	9.3	99.656	10.90643
21	1.8	209.916	116.62	2.483333	13.55667	6.593896
22	5.1	151.2	29.64706	5.1	24.5	4.803922
23	8.1	155.916	19.24889	8.3	28.028	3.355214
24	4.95	87.645	17.40989	4.6	19.306	4.231176
25	5.46	107.64	22.59117	3.133333	20.00833	8.048356
26	3.8	196.2	51.63158	3.3	15.3125	4.685855
27	8.8	324	36.81818	3.05	24.8675	7.957865
27	4.7	77.7412	17.37966	2.8	17.64	5.673544
27	3.96	237.024	59.82096	3.64	37.3184	9.894905
28	2.88	56.08732	20.38357	3.5	196.49	62.7197
29	2.3	75.2608	38.06978			
30	5.22	71.2408	12.78089	4.7	18.816	4.080788
31	2.3	92.025	40.01087	2.3	8.166667	3.550725
31				1.6	28.9375	18.08594
33	3.3	12.5	3.787879	3.3	30.19625	9.150379
34	5.8	164.4023	29.29277	4.75	77.692	17.01806
35	2.98	40.9135	17.5821	5.8	24.99	4.27239

	BEFORE INTERVENTION			**AFTER INTERVENTION**		
HHID	**No. of adult equiv**	**Total energy Used**	**Energy used per adult equiv**	**No. of adult equiv**	**Total Energy Used**	**Energy used per adult equiv**
37	3.2	165.1353	51.60477	2.8	29.825	11.65547
38	4.22	248.7212	58.7164	4.15	57.0775	13.73439
39	1.92	103.1659	63.79519	1.8	14.7	14.53411
40	5.983333	121.74	21.78319	4.5	15.68	3.327046
41	5.4	136.0605	25.19639	5.65	59.01	10.69333
42	2.4	96.804	40.33	2.4	23.422	10.18348
43	5.1	141.702	27.78	5.1	36.456	7.038838
44	0	50.9565	31.84	1.6	24.696	15.435
45			8.1	8.54	39.788	4.845258
46	0	284.9132	24	2.54	21.952	9.68477
47	4.1	95.04	23.18049	4.1	48.412	11.8078
48	7	181.78	25.96857	5.9	68.2625	11.52886
49	3.35	30.875	11.76008	2.6	19.9675	7.679808
50	2.46	149.77	70.78454	2.94	38.678	14.46707

51	5.1	103.458	24.74903	4.55	27.76667	7.851743
60	0.8	26.875	33.59375	0.8	15.615	19.51875
61	1.6	10.2	6.375	1.6	10.29	6.43125
62	0.64	2.1888	1.8	0.8	1.96	2.45
65	1.625	52.8	41.47857	1.2	14.7	13.132
66	49.85	249.6645	5.010232	49.44	195.974	3.964315
67	1.8	11.52	6.4	1.8	10.682	5.934444
68	2.05	207.24	114.8435	2.3	6.664	2.897391
69	2.6	7.36	2.830769	2.6	16.856	6.483077
70	2.64	27	10.227	3.3	8.33	2.524242
71	2	28.35	15.37393	1.8	10.976	6.097778
77	4.3	135	31.39535	4.3	143.374	33.34279
78	2.8	270	96.42857	2.3	180.81	78.61304
79	1.94	108	56.7033	2.42	160.132	69.4046
80	3.76	295.76	78.76914	4.44	158.564	37.83428
BEFORE INTERVENTION				**AFTER INTERVENTION**		
HHID	**No. of adult equiv**	**Total energy Used**	**Energy used per adult equiv**	**No. of adult equiv**	**Total Energy Used**	**Energy used per adult equiv**
81	5.66	147.6	27.44006	6.1	127.204	20.85311
82	2.8	510.048	182.16	2.7	139.356	51.53522
83	3.72	176.8	52.37937	3.6	94.815	26.3375
84	2.171429	79.55714	45.25893	2.6	51.94	22.9621
85	0.8	96.6	120.75	1.25	39.8125	45.94928
86	4.6	155.64	35.51353	4.4	47.8975	11.68526
87	5.44	298.8	59.03946	5.42	93.644	19.82345
88	2.316667	112.2	50.89376	2.775	43.904	15.50468
89	2.266667	113.5	49.52036	2.3	56.4725	24.55326
91	4.6	64.8	14.08696	2.6	28.3225	10.89327
92	2.76	28	11.37255	3.4	7.9625	2.341912
93	7	82.8	13.93333	3.36	23.254	7.267786
94	2.8	284	101.4286	2.8	17.64	6.3
95	4.46	111.1	25.11491	4.3	19.9528	4.640186
MEAN	**4.29711813**	**129.2891 3**	**38.25123359**	**4.18314101 3**	**62.7346485**	**20.86268564**
STDV	**5.59820435**	**91.38722 2**	**32.82886969**	**5.48437065 9**	**92.3729521**	**38.27900595**
T-test = 0.000154352 < 0.05						

In order to compare the differences in cost of energy used before and after intervention, the Kenya Power Rate of Ksh. 15 per 1 kWh was used. This translated to Ksh. 4.17 per Mega Joules. Therefore, when the t-test was conducted using one tailed with repeated measure design, the value was 0.00000036 which far mush less than 0.05 hence there was significant difference in the cost of energy before and after intervention of the LPG cooking unit. Table 3 indicates the cost impact of LPG cooking unit on the introduction in 95 households.

Table 3: Cost impact of LPG cooking unit introduction in 95 households

BEFORE INTERVENTION			AFTER INTERVENTION	
HHID	**Total energy Used**	**Cost of energy**	**Total Energy Used**	**Cost of energy**
1	76.032	317.05344	57.684	240.54228
2	141.3	589.221	99.838	416.32446
3	118.674	494.87058	105.013	437.90421
4	69.696	290.63232	18.06	75.3102
5	113.22	472.1274	62.17	259.2489
6	139.824	583.06608	14.504	60.48168
7	130.0725	542.402325	90.088	375.66696
8	107.676	449.00892	30.2616	126.190872
9	88.73013	370.0046421	51.456	214.57152
10	78.3225	326.604825	110.945	462.64065
11	211.428	881.65476	659.6217	2750.622489
12	39.024	162.73008	16.17	67.4289
13	223.652	932.62884	367.108	1530.84036
15	118.53	494.2701	211.68	882.7056
16	87.35	364.2495	15.974	66.61158
17	10.5	43.785	9.506	39.64002
18	104.175	434.40975	16.562	69.06354
19	128	533.76	18.382	76.65294
20	305.82	1275.2694	99.656	415.56552
21	209.916	875.34972	13.55667	56.5313139

22	151.2	630.504	24.5	102.165
23	155.916	650.16972	28.028	116.87676
24	87.645	365.47965	19.306	80.50602
25	107.64	448.8588	20.00833	83.4347361
26	196.2	818.154	15.3125	63.853125
27	324	1351.08	24.8675	103.697475
27	77.7412	324.180804	17.64	73.5588

BEFORE INTERVENTION			**AFTER INTERVENTION**	
HHID	**Total energy Used**	**Cost of energy**	**Total Energy Used**	**Cost of energy**
27	237.024	988.39008	37.3184	155.617728
28	56.08732	233.8841244	196.49	819.3633
29	75.2608	313.837536		0
30	71.2408	297.074136	18.816	78.46272
31	92.025	383.74425	8.166667	34.05500139
31		0	28.9375	120.669375
33	12.5	52.125	30.19625	125.9183625
34	164.4023	685.557591	77.692	323.97564
35	40.9135	170.609295	24.99	104.2083
37	165.1353	688.614201	29.825	124.37025
38	248.7212	1037.167404	57.0775	238.013175
39	103.1659	430.201803	14.7	61.299
40	121.74	507.6558	15.68	65.3856
41	136.0605	567.372285	59.01	246.0717
42	96.804	403.67268	23.422	97.66974
43	141.702	590.89734	36.456	152.02152
44	50.9565	212.488605	24.696	102.98232
45		0	39.788	165.91596
46	284.9132	1188.088044	21.952	91.53984
47	95.04	396.3168	48.412	201.87804
48	181.78	758.0226	68.2625	284.654625
49	30.875	128.74875	19.9675	83.264475
50	149.77	624.5409	38.678	161.28726
51	103.458	431.41986	27.76667	115.7870139
60	26.875	112.06875	15.615	65.11455
61	10.2	42.534	10.29	42.9093
62	2.1888	9.127296	1.96	8.1732

65	52.8	220.176	14.7	61.299
66	249.6645	1041.100965	195.974	817.21158

BEFORE INTERVENTION			**AFTER INTERVENTION**	
HHID	**Total energy Used**	**Cost of energy**	**Total Energy Used**	**Cost of energy**
67	11.52	48.0384	10.682	44.54394
68	207.24	864.1908	6.664	27.78888
69	7.36	30.6912	16.856	70.28952
70	27	112.59	8.33	34.7361
71	28.35	118.2195	10.976	45.76992
77	135	562.95	143.374	597.86958
78	270	1125.9	180.81	753.9777
79	108	450.36	160.132	667.75044
80	295.76	1233.3192	158.564	661.21188
81	147.6	615.492	127.204	530.44068
82	510.048	2126.90016	139.356	581.11452
83	176.8	737.256	94.815	395.37855
84	79.55714	331.7532738	51.94	216.5898
85	96.6	402.822	39.8125	166.018125
86	155.64	649.0188	47.8975	199.732575
87	298.8	1245.996	93.644	390.49548
88	112.2	467.874	43.904	183.07968
89	113.5	473.295	56.4725	235.490325
91	64.8	270.216	28.3225	118.104825
92	28	116.76	7.9625	33.203625
93	82.8	345.276	23.254	96.96918
94	284	1184.28	17.64	73.5588
95	111.1	463.287	19.9528	83.203176
Average	**129.289131**	**525.486672**	**62.73464855**	**258.2920479**
STDV	**91.38722251**	**385.7021561**	**92.37295211**	**383.8481279**
		T-test = 0.00000036 < 0.05		

The saving in terms of the cost of the energy could be as a result of improved efficiency of LPG cooking unit.

CONCLUSIONS AND RECOMMENDATIONS

From the results it can be concluded that LPG cooking unit uses less amount of fuel as compared to the traditional energy cooking devices. This translates to cheaper cost of energy probably due to high efficiency of LPG cooking unit. Therefore, these results challenge the perception that LPG cooking units are expensive on daily use. The contrary is actually true, since apart from daily use being cheaper, they have less emissions.