REPUBLIC OF KENYA
MINISTRY OF ENERGY

CCAK
CLEAN COOKING ASSOCIATION OF KENYA

Abridged Report

Kenya Cooking Sector Study:
Assessment of the Supply and Demand of Cooking Solutions at the Household level

August 2019

Netherlands Enterprise Agency

german cooperation
DEUTSCHE ZUSAMMENARBEIT

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

SNV

Practical ACTION

Acknowledgements

This study was commissioned by the Clean Cooking Association of Kenya (CCAK) and the Ministry of Energy with support from the Netherlands Enterprise Agency (RVO), Deutsche Gesellschaft für Internationale Zusammenarbeit – Energizing Development, Kenya Country Programme (GIZ – EnDev-K), the Netherlands Development Organization (SNV) and Practical Action. EED Advisory recognizes the invaluable support and contribution of the Study Steering Committee whose members were drawn from various institutions including: CCAK, the Ministry of Energy, GIZ – EnDev-K, SNV, Practical Action and the Clean Cooking Alliance (formerly Global Alliance for Clean Cookstoves). We also acknowledge the inputs and expertise provided by: the Policy and Advocacy working group under CCAK, Clean Cooking Inter-Ministerial Committee; Ministry of Health; Center of Research in Environmental Geography, National Autonomous University of Mexico (UNAM); participants of the pre-validation and validation workshops; all the respondents interviewed in the national survey; the Stockholm Environment Institute (SEI) Project Team and the EED Advisory Project Team.

Disclaimer

While this document has been prepared in good faith and based on international best practices in research and consulting, EED Advisory does not accept responsibility whatsoever for any consequences of its use. Readers are responsible for assessing the relevance and accuracy of the content of this publication. EED Advisory will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on information in this publication.

EED Advisory Limited
Shelter Court, 140 Manyani West Road, off Waiyaki Way, Nairobi – Kenya
P.O. Box 66053-00800, Nairobi | T: +254 (20) 2574927
E: contact@eedadvisory.com | W: www.eedadvisory.com

Table of contents

List of figures

List of tables

Terminology

Although there are no universally accepted definitions of the terms “improved cookstoves”, “improved cooking solutions” and “clean cooking solutions”,v this study adopts the definitions used by a World Bank (ESMAP) report on the state of the global clean and improved cooking sector[1]. These definitions, given below, were guided by the ISO IWA tiers of performance.

- **Cooking solution:** Any combination of technology and fuel used for cooking.

- **Traditional cooking solutions:** Baseline cooking technologies that employ no functional considerations for fuel and/or thermal efficiency. Examples include the three stone fire, open U-shaped clay or mud stoves, metallic charcoal stoves, and unvented coal stoves.

- **Improved cooking solutions:** Cooking solutions that improve, however minimally, the adverse health, environmental, or economic outcomes from cooking with traditional solid fuel technologies. This definition encompasses clean cooking solutions and the entire range of improved biomass cookstoves.

- **Improved biomass cookstoves:** Biomass stoves that improve on traditional baseline biomass technologies in terms of fuel savings via improved fuel efficiency. Some improved cookstoves also lower particulate emissions through improved efficiency of combustion, but the critical distinction from “clean” cooking solutions is that “improved” stoves may not reach sufficiently low emissions levels to generate meaningful health benefits. Examples include basic chimney improved cookstoves (ICS), basic portable ICS (e.g. Kenya Ceramic Jiko), and intermediate ICS (e.g. rocket cookstoves).

- **Clean cooking solutions:** Cooking solutions with low particulate and carbon monoxide emissions levels (IWA ISO Tier 3-4 for the indoor emissions indicator, within the Global Alliance’s Monitoring and Evaluation framework). These include stoves based on petro-chemical fuels (Liquified Petroleum Gas (LPG), natural gas, kerosene), electric stoves and electromagnetic induction cookstoves. Biofuel cookstoves powered by ethanol and other plant-based liquids, oils or gels, and biogas cookstoves are included in this category. Solar cookers and retained-heat cooking devices are also considered clean cooking solutions.

The terms of reference for this study requires an evaluation of both cooking technologies and cooking fuels. While the structure of this report discusses the approaches and findings largely based on these two components of cooking, the distinction is less obvious in cooking solutions that are not packaged as such. For example, cooking solutions like the 3kg and 6kg complete LPG cylinders (with grill and regulator) and biogas systems which are sold as consolidated units combine technology and fuel. On the other hand, some cooking solutions are designed for specific fuels (e.g. some gasifiers only work with pellets and/or briquettes) and therefore any meaningful discussion will have to be done within that context.

Further, the following terms and phrases are also frequently used in this report:

- **Primary cooking solution:** the cooking solution that is most used (frequency of use).

- **Secondary cooking solution:** the second most commonly used cooking solution for households (frequency of use).

- **Use rate:** Percentage number of households in possession of and using a technology or fuel.

- **Used and owned solutions:** This study distinguished between cooking solutions that are owned and those that are used and two should not be used interchangeably. A household may own but not use a cooking solution.

- **Branded stoves:** Cookstoves manufactured or imported by formally registered entities that have a distinct product name. These stoves are standardized and typically have a warranty.
- **6 kg complete cylinder:** This is a 6 kg gas cylinder complete with a burner and grill.
- **Technology and fuel stacking:** This phrase describes the use of multiple devices and fuels to satisfy household energy needs
- **Woodfuel:** A compound word that includes all types of solid biomass cooking fuels including firewood, charcoal, agricultural residues and others.
- **Fuelwood:** Solid biomass fuel from wood sources. The word is used synonymously with firewood.

The following stove definitions are also adopted:

Cookstove	Description
Traditional cooking solutions	
Three stone open fire	Most basic form of cooking solution that uses stones as the stove (to support cooking appliance) and firewood.
Artisanal metallic charcoal stove	These are traditional metallic charcoal stoves that do not include a clay/ceramic liner or any other component to help with fuel and thermal efficiency.
Improved cooking solutions	
Fixed biomass stove	Unmovable firewood stove designed with improvements, however minimal, to the thermal efficiency of the three stone open fire. This may range from stone and concrete cooking areas to units incorporating a clay/ceramic liner and chimney. Examples include Rocket stoves, Jiko Kisasa and Maendeleo stoves.
Improved artisanal Portable firewood stove	Improved artisanal portable firewood stoves that have incorporated a clay/ceramic liner for improved thermal efficiency. The most dominant stove was the Kuni Mbili stove.
Branded firewood stove (manufactured)	Improved and branded portable firewood stoves whose production is standardized and factory based. Examples include BURN's Kuni Okoa, EcoZoom's Dura and Envirofit's supersaver wood stoves.
Improved artisanal portable charcoal stoves	Charcoal stoves that have incorporated a ceramic liner for improved thermal efficiency. The Kenya Ceramic Jiko (KCJ) is the most common stove of this category.
Branded charcoal stoves	Improved and branded portable charcoal stoves whose production is standardized and factory based.
Other Non-Improved Cooking Solution	
Kerosene wick stove	Stoves that use wicks to draw kerosene from a tank to the burner through capillary action. A common design incorporates a series of wicks, usually made of loosely twisted or woven cotton placed in a holder such that they can be moved up and down by a control lever or knob.

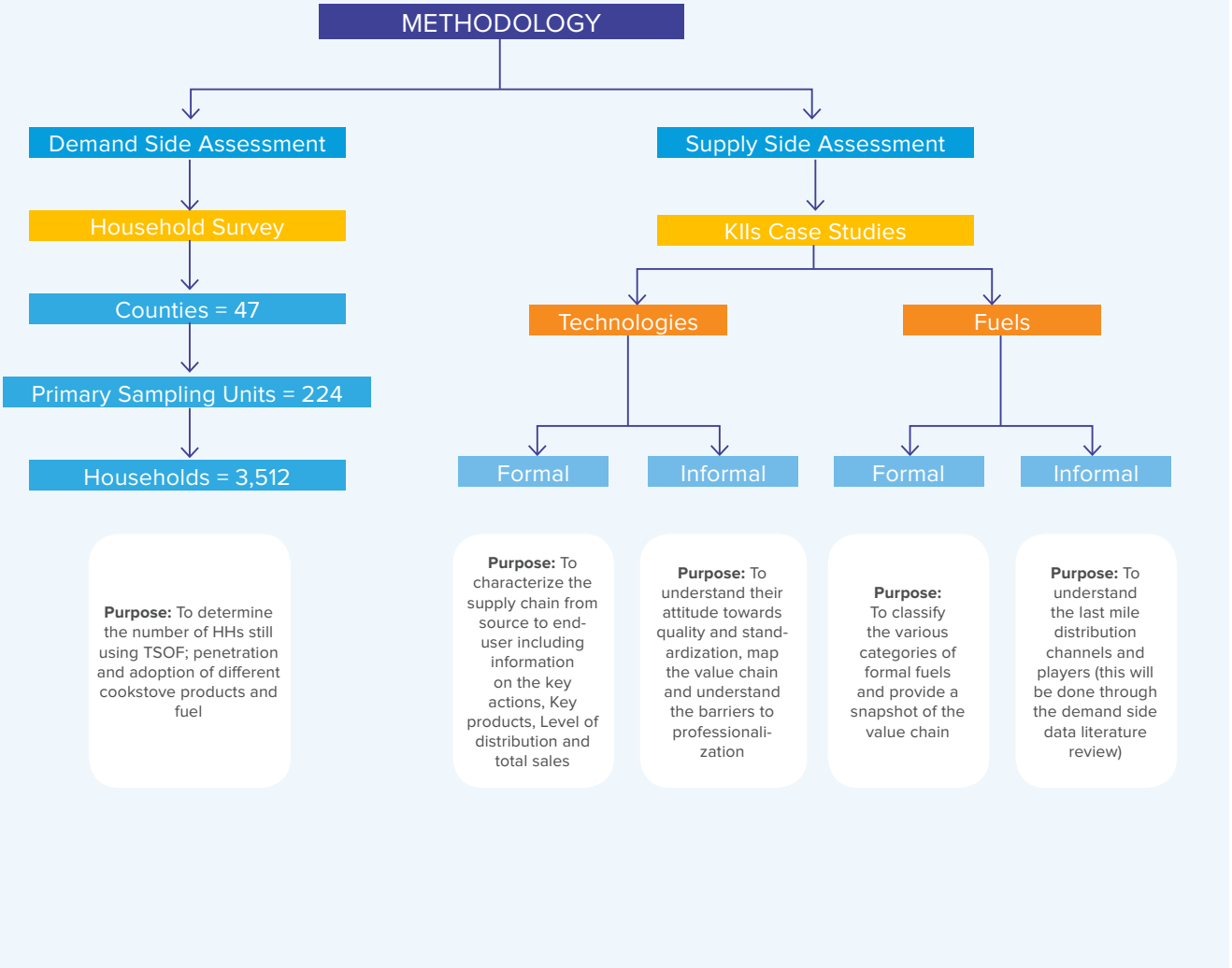
Exchange rate at the time of reporting, 1 USD = KES 100

Executive Summary

This report is an abridged version of the *Kenya Cooking Sector Study: Assessment of the supply and demand of cooking solutions at the household level.* The study was commissioned by Clean Cooking Association of Kenya (CCAK) in collaboration with Ministry of Energy, SNV (Netherlands Development Organisation), RVO (Netherlands Enterprise Agency), Practical Action and GIZ – EnDev-K ("Deutsche Gesellschaft für Internationale Zusammenarbeit – Energizing Development, Kenya Country Programme"). Building on a body of research spread over the last three decades, the main objective of this study was to determine the state of cooking in Kenya at the household level. The purpose of this study is to establish baseline indicators for the cooking sector, raise the conceptual understanding of the cooking sector among stakeholders, attract strategic private and public investments and guide the process of policy formulation.

Multiple data collection approaches including literature and data review, household surveys, real-time remote monitoring, geo-spatial analysis and key informant interviews have been applied. The household survey, which is the main component of this study, covered 3,512 household interviews carried out by over 250 data collection assistants across all 47 counties between 1st October and 14th November 2018. Interviews were done using CAPI (Computer Aided Personal Interviews) and household selection guided by SW Maps which is a geospatial tracking application. Statistical extrapolations are based on 2018 demographic projections done by UNICEF, estimating the number of rural and urban households to be 7,419,542 and 5,157,150 respectively. Interviews were also conducted with supply side actors including technology and fuel suppliers. In addition, six case studies were conducted to provide specific and in-depth insights to various aspects of cooking – two of these case studies are highlighted in this abridged report while the rest may be found in the detailed report. Figure 1 is a summary of the approach adopted for this study.

Figure 1: Summary of study methodology



This study finds that the concept of stacking, which is the practice of using multiple cooking devices and fuels, is common among households. In interpreting the findings of this study, it is important for the readers to distinguish between the terms "main/primary cooking solution", "used stove/cooking solution" and "owned stove/cooking solution" (see preceding terminology section for the working definitions). The term "woodfuel" is an umbrella word that includes "any energy source that comes from woody biomass including charcoal, pellets, briquettes, agro-waste, wood and others" while "fuelwood" is simply firewood. The study focussed on household cooking solutions and excludes institutional and commercial applications.

A summary of the key statistics and findings is provided below.

1. **59%** of households in Kenya use the TSOF compared to **76% twenty years ago** and although the proportion of household users has dropped, the aggregate number has increased from **4.7 million households to about 7.3 million households;**

2. **64.7%** **(8.1 million)** of households in Kenya still use wood as their primary cooking fuel, followed by LPG at 19% (2.4 million) and charcoal at 10% (1.3 million);

3. **4.3 million** households depend solely on fuelwood for cooking;

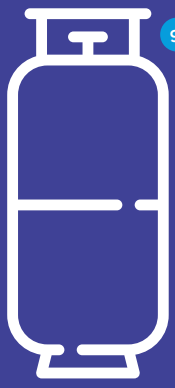
4. **80%** of the estimated **6.2 million households** that use only one cooking option rely solely on either charcoal or fuelwood;

5. **71%** of households in Kenya still use a type of woodstove as either their primary or secondary cookstove, with a greater prevalence of **92% in rural areas;**

6. **5.5 million** households own at least one charcoal stove with **1.3 million (10.3%)** reporting using a type of charcoal stove as their primary cooking solution. KCJ is still the most prominent charcoal stove in Kenya with an estimated **4.2 million households (33.8%)** reporting using at least one;

7. This study estimates that the annual market value of charcoal consumed at the domestic level alone is **KES 68 billion;**

8. This study finds that **1.7 million household**s in Kenya (14% of the total population) **use kerosene for cooking with 27.7%** and **3.2% of urban and rural populations respectively reporting use;**



9. Over the last two decades (1999-2018), the number of households using LPG has increased about six times from approximately **0.6 million to 3.7 million** (54% urban and 18% rural households respectively now use LPG);

10. 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;

11. Only **3%** of households own an electric cooking appliance such as mixed LPG-electricity stove, electric coil stove and microwave;

12. **17,900** biogas systems had been installed at the household level at the time of this study;

13 Households using LPG must travel nearly twice as far (5.3 km) on average than kerosene users (2.9 km) even though twice as many households nationwide cook with LPG than with kerosene. This willingness to travel longer distances could be due to the convenience of use but also due to the frequency of purchase. While kerosene may need to be purchased weekly or even daily, LPG refills would almost always require less frequent travel to purchase;

14 Annual greenhouse gas (GHG) emissions from combustion of residential cooking fuels are 13.6 MtCO2e per year split 2:1 between rural and urban populations (estimates from the demand side);

15 **99% and 97%** of urban and rural households respectively acquired their cooking appliance through an upfront cash payment demonstrating the limited access to financial services;

16 71% of households are willing to pay for a 6kg complete LPG cylinder if priced at KES 1,125 compared to 69% who are willing to pay for a Burn stove at KES 973;

Average weekly fuel consumption per household per week is shown in the table below.

Fuel	Urban		Rural		National	
	Mean	Median	Mean	Median	Mean	Median
Fuelwood (kg)	23.7	15.0	26.2	20.0	25.9	20.0
Charcoal (kg)	7.0	4.0	7.9	5.0	7.6	4.0
LPG (kg)	1.3	1.5	0.9	0.8	1.1	0.8
Kerosene (l)	2.5	2.0	1.5	1.0	2.2	2.0
Crop Residues (kg)	5.2	3.0	8.1	5.0	7.7	5.0

1. Cooking Sector – An overview

1,.1 Overview of general access rates

A wide range of cooking technologies are available in Kenya today. The household survey identified 22 distinct categories of cooking technologies grouped under 5 main aggregate categories (woodstoves, charcoal stoves, LPG stoves, kerosene stoves, electrical appliances) and an 'other' category that includes biogas, ethanol and solar based cooking solutions. Table 1 shows the cooking technologies *used* as aggregated (6 classes) and constituent categories (22 classes; mixed LPG-electricity solutions are placed in both the LPG and electricity aggregate groups). This analysis offers a detailed overview into the various categories of cookstoves used in Kenyan households. The table shows appliances used (use rate) regardless of whether it is a primary or secondary solution. Also, the totals add up to more than 100% as some households own more than one type of cooking option.

Table 1: Categories of cooking technologies identified in the national HH survey – Usage

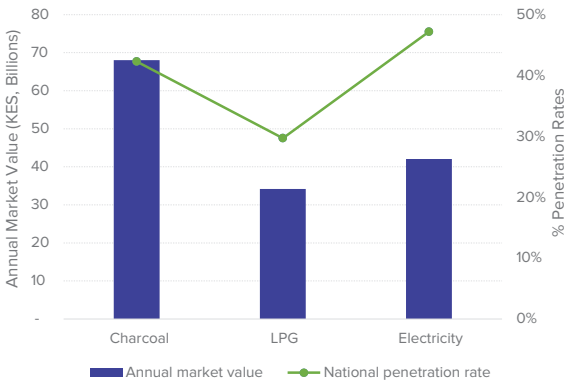
Aggregate Category	% of HHs currently using			Specific category	% of HHs currently using		
	Urban	Rural	Total		Urban	Rural	Total
Woodstoves	26%	90%	70%	Three stone open fire	21.8%	75.4%	58.1%
				Fixed biomass stove	3.9%	14.2%	10.9%
				Improved artisanal portable firewood stove	0.4%	2.4%	1.8%
				Branded firewood stove	0.2%	0.6%	0.4%
				Gasifier stoves	0.0%	0.0%	0.0%
Charcoal stoves	47%	40%	42%	Improved artisanal portable charcoal stoves	39.9%	30.8%	33.8%
				Branded charcoal stove	3.6%	2.8%	3.1%
				Artisanal metallic charcoal stove	4.6%	8.6%	7.3%
				Nyama choma grill	0.3%	0.0%	0.1%
LPG stoves	54%	18%	30%	6kg complete cylinder	39.1%	15.0%	22.8%
				LPG stove (multiple burner)	13.6%	2.0%	5.8%
				Mixed LPG-Electricity stove	4.9%	0.3%	1.8%
Kerosene stoves	28%	3%	11%	Kerosene wick stove	27.7%	3.2%	11.1%
				Pressurized kerosene stove	0.0%	0.0%	0.0%
Electrical appliances	7%	1%	3%	Mixed LPG-Electricity stove	4.9%	0.3%	1.8%
				Microwave	2.2%	0.2%	0.8%
				Electric coil stove	0.8%	0.0%	0.3%
				Electric induction stove	0.0%	0.0%	0.0%
Other	0%	1%	0%	Biogas stove	0.1%	0.2%	0.1%
				Gel biofuel stove	0.0%	0.1%	0.1%
				Liquid biofuel stove	0.0%	0.0%	0.0%
				Solar cooker	0.0%	0.0%	0.0%
				Retained heat cookers	0.0%	0.3%	0.2%

The Three Stone Open Fire (TSOF) has historically been and remains the most commonly used fuelwood-based cooking technology in Kenya. About 58.1% of households in Kenya use the TSOF compared to 76% twenty years ago. Although the proportion of household users has dropped, the aggregate number has increased from 4.7 million households to about 7.3 million households. 70% of households in Kenya still use a type of woodstove as either their *primary* or *secondary* cookstove, with a greater prevalence of 92% in rural areas.

This study divides the charcoal stoves into three main groups: improved artisanal charcoal stoves (including the Kenyan Ceramic Jiko or KCJ), artisanal metallic charcoal stove, and the branded charcoal stoves (including Jikokoa, Jiko Bora, Jiko Fresh, SuperSaver Charcoal, SmartSaver Charcoal and others). Approximately 5.5 million households own at least a one charcoal stove with 1.3 million (10.3%) reporting using a type of charcoal stove as their primary cooking solution. The KCJ is still the most prominent charcoal stove in Kenya with an estimated 4.2 million households (33.8%) reporting using at least one. 0.9 million households (7.3%) report using a metallic charcoal stove and about 386,000 households (3.1%) use a type of branded charcoal stove. Mean charcoal consumption among households that use charcoal is roughly 395kg per year. Data on weekly charcoal expenditure collected from responding households indicates that the annual market value of charcoal consumed by the *residential sector alone* is KES 68 billion: twice the amount spent on LPG (as reported by the respondents) and almost 40% more than what all domestic customers paid to Kenya Power in 2018 for their electricity consumption (according to Kenya Power's 2018 annual report) (see Figure 2).

Over the last two decades (1999-2018), the number of households using LPG has increased about six times from approximately 0.6 million to 3.7 million. Nyang (1999) estimated that the LPG household use rate was 9% (20% urban and 4% rural) in 1999. The Kamfor study estimated this to be 8% (23% urban and 1.8% rural) about two years later. Data from this study indicates that nearly 3.7 million households, about 30% of the population (54% urban and 18% rural), use LPG and 2.4 million households, 19% of households nationwide, consider it their primary fuel. Only 3% of households own an electric cooking appliance such as mixed LPG-electricity stove, electric coil stove and microwave. This is largely attributed to the high cost of the stoves (the survey reported an average

Figure 2: Market of charcoal used by households relative to LPG and electricity



retail price for the mixed-LPG stove at KES 28,920 and KES 39,250 for urban and rural users respectively) and the cost of electricity. Kerosene use for cooking is still prevalent in urban low-income areas. This study finds that 1.7 million households in Kenya (14% of the total population) cook with kerosene (27.7% and 3.2% of urban and rural households respectively). Alternative cooking technologies like ethanol stoves, biogas, briquettes, pellets and solar cookers remain very rare, and are collectively used by less than 1% of Kenyan households.

1.2 Primary and secondary cooking solutions

The primary cooking solution is a common indicator of energy access in census data and demographic and health surveys (DHS). The working definition of primary cooking solution in this report is "the cooking solution that is mostly used (frequency of use)." With data on primary and secondary cooking options, the survey provides information on the most common household stoves and fuel mixes. This analysis is related to but different from the discussion in the section above which was an overview on general usage of cooking solutions; here we zoom in on primary and secondary cooking solutions.

About one in every two (49%) households in Kenya use only one type of stove option (specific category of stoves) while 36% use two types of stoves. The remaining 15% have three or more options. The use of multiple solutions to satisfy a household's energy needs is commonly known as stacking. There is no significant difference in stacking behaviour between urban and rural households as seen in Figure 3.

Figure 3: Number of cooking technologies per household

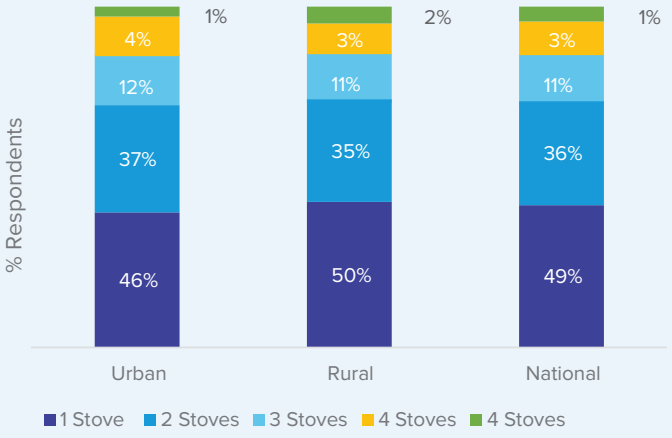


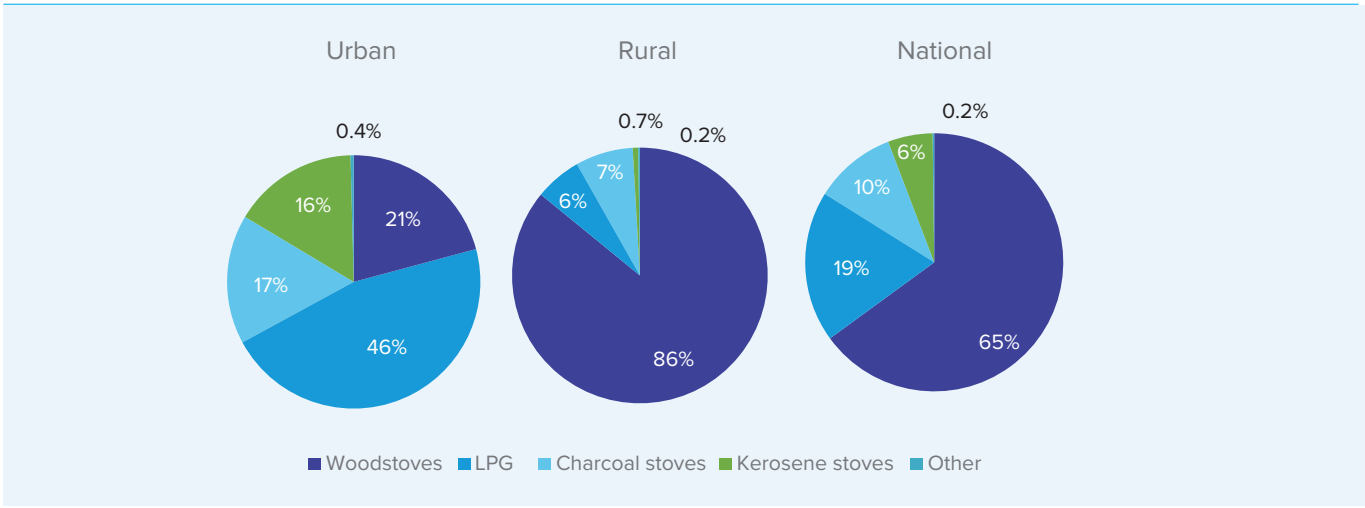
Table 2 is a matrix of primary and secondary cooking options as reported during the survey. The table is read starting with the information on the rows followed by the information on the columns. For example, 6.6% of all households in Kenya have LPG as a primary stove and no other appliance as a secondary stove (cell A1). 22.9% of households use a wood and charcoal as their primary and secondary cooking solution respectively (cell E5). The largest proportion of households (34.5%) of households use wood stoves as the only cooking solution (cell A5) closely followed by those that combine wood and charcoal. This (cell A5) translates to 4.3 million households depending solely on fuelwood for cooking. 80% of the estimated 6.2 million households that use only one cooking option rely solely on either charcoal or fuelwood.

Table 2: Percentages of primary and secondary pairings of cooking options nationwide

		A	B	C	D	E	F	G	H
	Secondary stove / Primary stove	**No 2nd stove**	**LPG**	**Electric**	**Kerosene**	**Charcoal**	**Wood**	**Other**	**Total**
1	LPG	6.6%	1.3%	0.3%	2.2%	6.5%	2.0%	0.1%	19.00%
2	Electric	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.20%
3	Kerosene	3.3%	0.2%	0.0%	0.0%	1.9%	0.2%	0.0%	5.60%
4	Charcoal	4.9%	2.0%	0.0%	1.1%	0.3%	2.0%	0.0%	10.30%
5	Wood	34.5%	5.4%	0.0%	0.8%	22.9%	1.1%	0.0%	64.70%
6	Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.10%
	Total	**49.40%**	**9.00%**	**0.30%**	**4.10%**	**31.60%**	**5.40%**	**0.10%**	**99.90%**

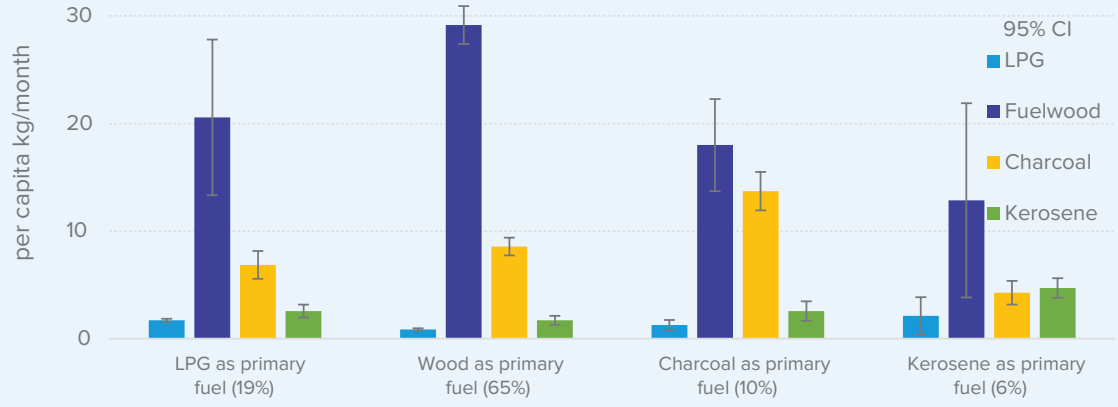
Expounding on this further, this study finds that about 64.7% (8.1 million) of households in Kenya still use wood as their primary cooking fuel, followed by LPG at 19% (2.4 million) and charcoal at 10% (1.3 million). Woodfuel (charcoal and firewood) is the most commonly used primary cooking fuel with 75% of Kenyan households report using it. 93.2% of rural households use woodfuel (fuelwood or charcoal) as their primary fuel. As seen in Figure 4, the challenge of polluting fuels is predominantly a rural one with 86% of rural households relying on woodstoves as their primary stoves. Kerosene on the hand is predominantly used in urban areas.

Figure 4: Primary cooking stoves in Kenya (urban areas, rural areas, national average)



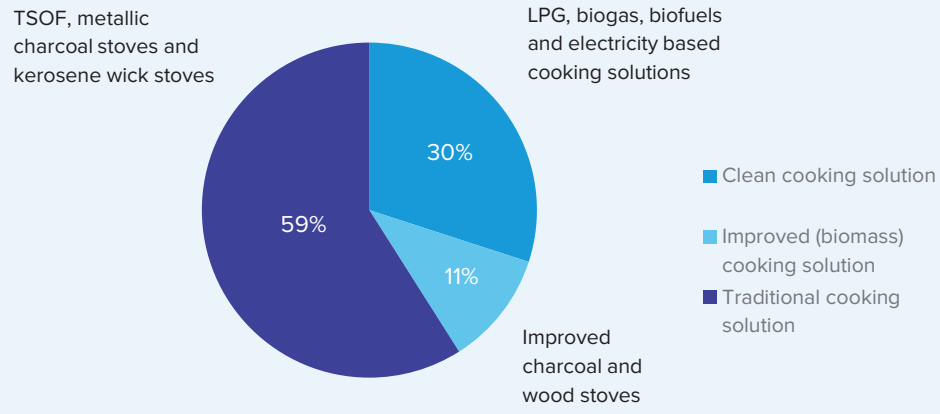
Energy researchers have over time observed that when new cooking solutions are introduced in a household, existing options are rarely displaced. Rather, it is more common to see new options incorporated into the mix of cooking solutions. This study finds that households using LPG as the primary fuel still use, on average, 42% of the amount of charcoal used by households that depend on charcoal as the primary fuel. Among households that have LPG as their primary fuel, those who also use fuelwood, charcoal or kerosene as their second option consume 144 ± 51 kg, 48 ± 9 kg and 14 ± 3 kg per household per month of the secondary fuel respectively as seen in Figure 5. The message here is clear: although uptake of clean fuels typically results in the reduction of use of traditional fuels, it does not necessarily translate into complete displacement of those fuels. This has implications for programs that aim to reduce or displace the use of traditional forms of cooking with cleaner fuels like LPG, especially with a target on health impacts. Researchers have demonstrated that even minimal use of polluting fuels in combination with clean fuels can confound efforts to improve health. To achieve World Health Organization standards for $PM_{2.5}$[2], traditional wood or charcoal burning must be limited to just 1–3 hr/week.[3]

Figure 5: Monthly consumption of polluting fuels by HHs



Recognizing the stacking phenomenon, it is important to understand the incidence of clean cooking solutions and improved biomass solutions at the household level. It is especially key in tracking SEforALL commitments where Kenya targets to have 100% of the population having access to modern cooking solutions by 2030. These include LPG, electricity, biogas, bioethanol-based solutions and improved solid fuel cookstoves. Figure 6 shows the percentage of households using the different classes of the cooking solutions.

Figure 6: Proportion of households with access to clean cooking solutions, ICS and traditional cooking solutions



1.3 Types of cooking technologies

From the supply side, this study analyses cooking technologies in two categories: branded (formal) and artisanal (informal). Formal sector players are registered companies or non-profits operating under an officially recognized name with a physical address in the form of an office or manufacturing/assembly/distribution facility. They offer standardized and branded products, provide warranties and after-sales support. They are also registered with the Kenya Revenue Authority and remit the mandated taxes, levies and fees. These include organizations such as Biogas International, Envirofit, Scode, EcoZoom, Ramtons, Wisdom Stoves, Consumer's Choice, Koko Networks, BURN Manufacturers and LPG suppliers among others. The three leading firms in the distribution of solid biomass stoves are BURN (which manufactures locally), Biolite (which imports fully assembled stoves) and Envirofit (which assembles stoves locally from imported prefabricated components). Wisdom Energy Hub and SCODE are also prominent formal players in solid biomass stoves. The market has a choice of at least 25 different brands of biomass cookstoves from these five main companies. Table 3 provides examples of products and manufacturers in the country along with the reported numbers of branded cookstoves at the household level based on the survey.

25

The approximate number of different brands of biomass cookstoves in the market from five main companies

Table 3: Reported numbers of branded cookstoves at the household level

#	Aggregate category	Specific category	Examples of products	Examples of manufacturer/ distributors	Est. no. of Households using these Stoves
1	Woodstoves	Manufactured wood stove Biomass gasifier	Kuni Okoa, Jiko Dura "24 cm", Jiko Dura "28 cm", Model 2-M2, SmartSaver Wood, SuperSaver wood, Kuni mbili	Burn, Ecozoom, Envirofit, Wisdom, SCODE	54,000
2	Charcoal stoves	Manufactured charcoal stoves	Jikokoa, Jiko Bora, Jiko Fresh, SuperSaver Charcoal, SmartSaver Charcoal	Burn, Ecozoom, Envirofit, Wisdom	390,000
3	LPG stoves	6kg complete LPG cylinder (single burner) LPG stove (multiple burner)	Total, Kobil, Pro-gas, K-gas, Hashi, Afrigas, Oil Libya, Lake Gas, Mid Gas e.t.c	Total, Kobil, Oil Libya, Pro-gas	3.7 million
4	Kerosene stoves	Kerosene wick stove Pressurized kerosene stove	Parameko, Fire Wheel Brand Kerosene Wick Stove, Generic Handy Portable 8 Wicks Kerosene Stove	Gundua Engineering Services	1.4 million
5	Electrical appliances	Electric coil stove Electric induction stove Microwave Mixed LPG-Electricity stove	LG, Samsung, Ramtons, Hotpoint, Beko, Ariston, Mika Bruhms, Armco	Ramtons, Ariston, Hotpoint,	350,000
6	Other	Biogas stove Gel biofuel stove Liquid biofuel stove Retained heat cookers Solar cooker	Ethanol stove, Moto safi	Consumer Choice, Koko networks, Flexi Biogas International	50,000

Informal sector players are an important source of cooking technologies but unlike the formal organizations, they neither label their products nor offer them in standardized versions. Informal manufacturers and entrepreneurs use tried and tested business models with little or no external financial support; the enterprises interviewed have been operating for an average of 17 years. There are opportunities to further improve the quality and methods of product delivery including semi-automation of some of the production processes; research and development on stoves designs (particularly the wood stoves); market development; standardization and branding of products; appropriate business skills training; and supporting product testing. Table 4 summarizes the number of households observed to be using non-branded stoves from the demand survey.

Table 4: Main categories of non-branded stoves - used (informal)

#	Aggregate category	Specific category	% of HH using artisanal stoves	Est. no. of Households using these Stoves
1	Woodstoves	Fixed biomass stoves	11%	1.4 million
		Artisanal firewood stoves (e.g. Kuni Mbili stoves)	2%	270,000
2	Charcoal stoves	Artisanal charcoal stoves (KCJ)	34%	4.2 million
		Metallic charcoal stove	7%	1.2 million

1.4 Availability and last mile distribution of cooking fuels

As seen in Figure 7, last mile fuel distribution points vary with fuels. Kiosks for instance, play a significant role in the access of kerosene both at the urban and rural setting (73% and 68% respectively). Firewood is mostly purchased from open markets. Only 40% of LPG is purchased from specialty stores (e.g. petrol stations) in urban areas with the largest distribution points being kiosks at 42%. The stocking of LPG cylinders at local kiosks is seen to significantly improve access to LPG both at the urban and rural areas. The sale of LPG has evolved from restricted purchase by tank brand in speciality store (e.g. petrol stations) to purchase across any speciality store to a diversified suite of options including kiosks and home delivery. This provides valuable lessons on the last mile landscape to promoters of other fuels aiming to increase penetration and use.

Figure 7: Last mile fuel distribution points

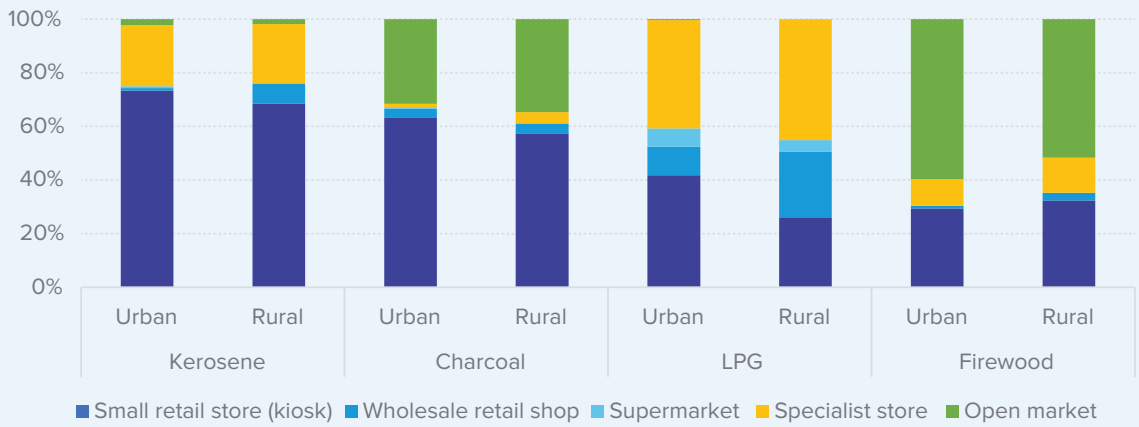
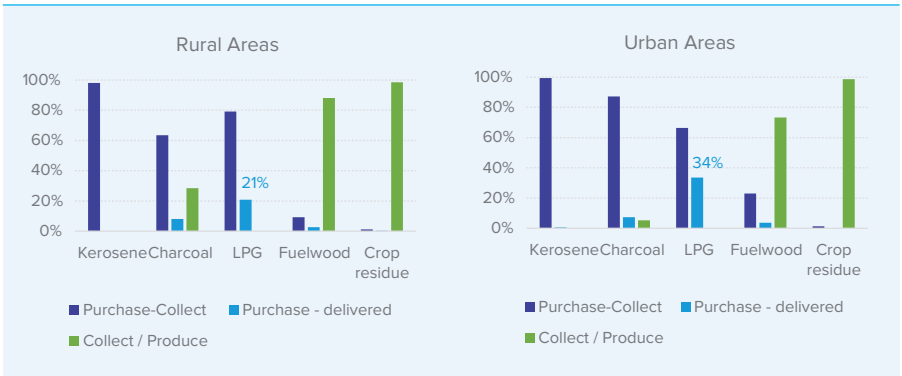


Figure 8 summarizes the observations on perceptions on availability of the various fuels used. At an average of 86% and 81% in urban and rural areas respectively, LPG users were more likely to note that they have not had concerns on availability of LPG in the quantities desired over the last 12 months compared to any other fuel. Charcoal users, on the other hand, had the highest incidence of people indicating that the fuel was either often or sometimes not available in quantities desired. While kerosene has relatively well-developed last mile distribution networks with regard to distance and purchase points, there are concerns over reliability of supply in rural areas with 37% of users noting that they often or sometimes can't access the fuel in quantities desired. Disaggregating the information by gender doesn't highlight significant variances in opinion between female and male respondent.

Figure 8: Unavailability of fuel in quantities desired disaggregated by gender and locality (often – more than once a month; rarely – 4-12 times a year)

This study provides information on the prevalence of fuel transporters improving the last mile access for LPG (Figure 9). More than one in three urban households and one in five rural households now have their LPG refills transported to their houses. This is largely made possible by the ease of availability of boda-bodas (motorcycle riding services) that can deliver gas cylinders from the various retail points presented above.

Figure 9: Modes of acquisition of the most commonly observed fuels for rural and urban household use

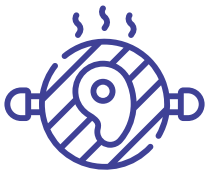


1.5 Fuel prices and consumption

Most fuels, except for LPG, are purchased in small quantities and used within a few days. For these, the survey asked respondents about their expenditure and quantity consumed in the immediate week before the survey. These quantities were divided to obtain a unit cost as either KES per kg of fuel sold by mass or KES per litre of kerosene. For LPG, respondents were asked about the size of the cylinder that they typically purchase (3 kg, 6kg, 13kg and others), its cost and how long, on average, the cylinder lasts. These quantities were computed to estimate the equivalent household weekly consumption of fuels (in kgs or ltrs) as summarized in Table 5.

Table 5: Weekly fuel consumption per household (kgs or ltrs per week)

Fuel	Urban		Rural		National	
	Mean	Median	Mean	Median	Mean	Median
Fuelwood (kg)	23.7	15.0	26.2	20.0	25.9	20.0
Charcoal (kg)	7.0	4.0	7.9	5.0	7.6	4.0
LPG (kg)	1.3	1.5	0.9	0.8	1.1	0.8
Kerosene (l)	2.5	2.0	1.5	1.0	2.2	2.0
Crop Residues (kg)	5.2	3.0	8.1	5.0	7.7	5.0



Charcoal, which has traditionally been considered an urban fuel, is used by nearly the same proportion of urban and rural households.

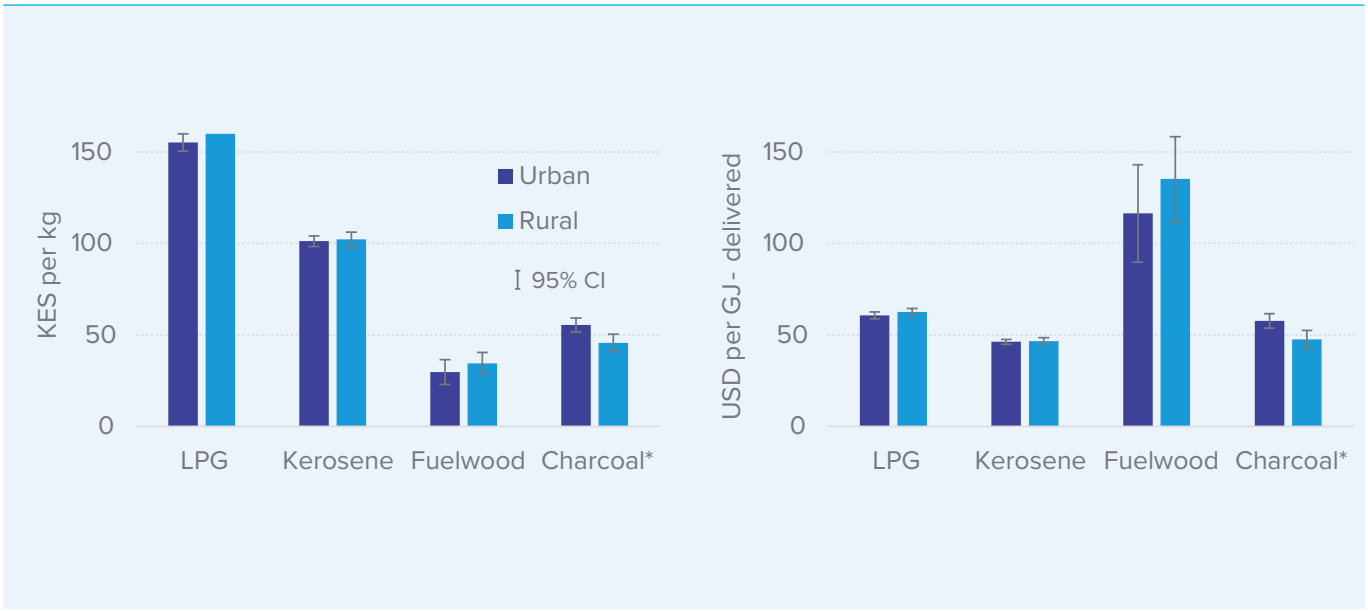
The data in Table 5 was used to estimate annual consumption by simply multiplying weekly or monthly consumption by 52 or 12. Table 6 shows average annual consumption per household with 95% confidence intervals for each fuel and the proportion of the Kenyan population using that fuel. Observations from these two tables reinforce some of the long-understood differences between energy demands in urban and rural households, but challenges others. Fuelwood and crop residues, typically rural fuels, are used by far more households and have a higher median consumption in rural areas. The same holds for LPG and kerosene in urban households. However, charcoal, which has traditionally been considered an urban fuel, is used by nearly the same proportion of urban and rural households. Moreover, consumption per household is higher in rural areas (though per capita consumption is similar in the two regions) with a plausible reason being rural families are larger than urban families.

Table 6: Average annual consumption for common cooking fuels by households

Fuel	Urban			Rural			Total		
	% HHs using	Average (kg/yr)	95% CI (kg/yr)	% HHs using	Average (kg/yr)	95% CI (kg/yr)	% HHs using	Average (kg/yr)	95% CI (kg/yr)
Fuelwood	24%	1,232	224	86%	1,362	60	66%	1,347	59
Charcoal	46%	364	44	42%	411	29	44%	395	24
LPG	51%	68	3	15%	47	3	27%	57	2
Kerosene	29%	163	12	7%	78	10	14%	114	9
Crop Residues	3%	270	155	11%	421	61	9%	400	57

Costs per unit mass of fuels and per energy delivered (to the cooking pot) were also estimated and are shown in Figure 10. Fuels have different energy content values and stoves have different thermal efficiencies. A more balanced comparison of fuel prices accounts for these factors by considering the cost of energy delivered to the cooking pot. Prices reported for firewood only constitute purchased firewood and are not an average from purchased and collected firewood. Prices vary by fuel and differ slightly between urban and rural markets. Commercial fuels like LPG and kerosene are more expensive per unit mass. However, when converted to useful energy by accounting for the energy content of the fuel and efficiency of the stove, the pattern differs considerably. Due to its low energy content and poor energy conversion efficiency, purchased fuelwood, the cheapest fuel per kilo, is the most expensive in terms of energy delivered. LPG, the costliest fuel on a mass basis, is marginally more expensive than the remaining options. Kerosene is the cheapest fuel in terms of energy delivered. Despite this, kerosene is not a popular fuel among Kenyans using purchased fuels; far more people use charcoal or LPG either as primary or secondary cooking options. Thus, factors other than ease of access and energy cost must be considered in household decisions.

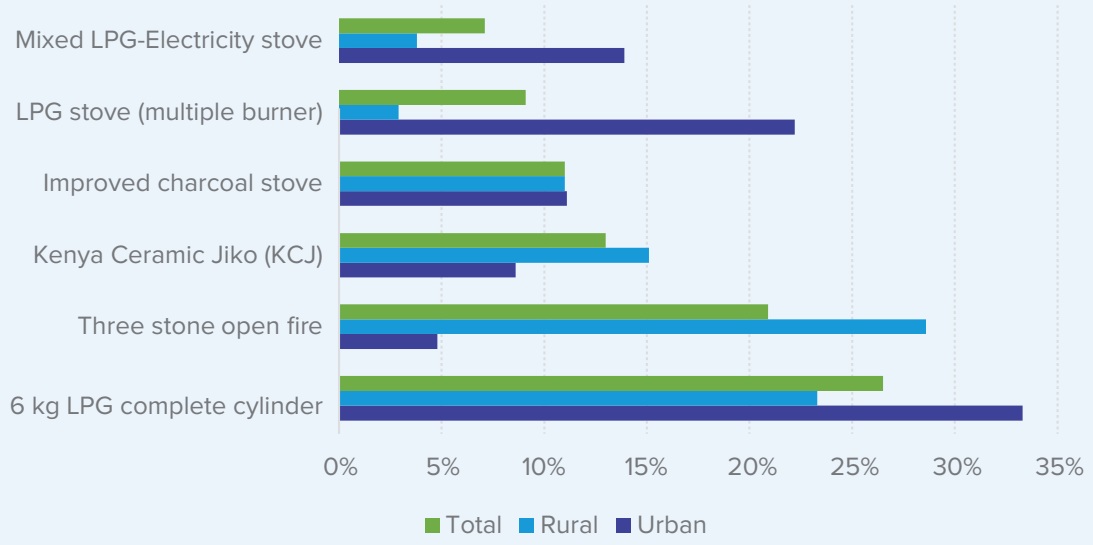
Figure 10: Fuel price per unit mass (left) and energy delivered (right) for major commercial fuels (star denotes statistically significant differences between rural and urban areas with 95% confidence interval)



1.6 Preference and willingness to pay for stoves

When the respondents were asked to select their most preferred stove, 26.5% and 20.9% of the respondents selected the LPG 6kg complete cylinder and the TSOF respectively. These are the top two most preferred cooking technologies – see Figure 11 below. The TSOF's popularity was significantly higher in rural households, of which 28.6% preferred it compared to only 4.8% in urban areas. The KCJ is the third most preferred stove nationally at 13% but with a lower preference among urban households (8.6%) relative to rural households (15.1%). Respondents were further asked if they owned their most preferred stoves, and if not, what the main limiting factor for ownership was. Almost all the respondents whose most preferred stove was the TSOF were already using TSOF. For the 4% who preferred the TSOF but weren't using it, the main limiting factors were unavailability of firewood (45%) and safety concerns (30%). The main limiting factor for all other stoves was the cost of the stove itself.

Figure 11: Top 6 most preferred stoves



As an additional exercise, participants were asked about their willingness to pay (WTP) for various cooking technologies. Respondents were assigned a stove at random from among 6 options: Burn - Jikokoa, KCJ, Kerosene wick stove, 6kg complete LPG cylinder-single burner, Electric single coil, and a Wisdom gasifier stove. They were asked if they would be willing to purchase the randomly selected stove for one of four randomly assigned prices: 100%, 75%, 50% or 25% of the full retail price. This resulted in a hypothetical demand curve for each stove as shown in Figure 12. Note, the horizontal axis, which shows the stove prices, is on a logarithmic scale. This makes it easier to compare the angles of each curve. Steep curves indicate that willingness to pay decreases sharply moving from lower to higher prices (left to right along the x-axis). Of note is the low willingness to pay for KCJ at higher price points – 64% WTP for a KCJ at KES 250 compared to WTP of 24% at KES 750. This may be contrasted with the 6kg complete LPG cylinder which has a 71% WTP at KES 1,125. It may therefore be inferred that KCJ producers, who sell their stoves at a price range of KES 250 – 500, tend to respond to market demand in making and pricing their stoves. While the quality of stove may be improved by using high-quality liners and cladding, this would make the stoves more expensive, yet the market does not respond to a more expensive KCJ. Also, worth noting is the low WTP for improved charcoal stoves at current market prices – the WTP for a BURN stove at the market price (KES3,890) was 6%. It could be inferred that with the current ownership rates of branded cookstoves at 3%, which is half the WTP rate for the stoves, the pricing of these stoves or their revenue models needs reviewing if mass adoption is to be realized.

If respondents declined to purchase the stove at the initial asking price, they were asked if they'd be willing to purchase the same stove under 6, 12 or 24-month payment schemes. Figure 13 shows the effect of adding a 6-month payment plan to respondent's willingness to pay for the KCJ, the Jikokoa by Burn and the 6kg complete LPG cylinder stoves. The boost in demand is larger for the Jikokoa (2-12%) than the other two stoves: KCJ increases from 5-13% and the 6kg complete LPG cylinder at 0-7%. Except for one scenario, the increase in WTP decreases with increasing price. The exception is the observation that, at the current market prices for the 6kg complete cylinder, provision of a financing mechanisms has no impact on the willingness to pay.

Figure 12: Respondents willing to purchase a stove at 25%, 50%, 75% and 100% of the price

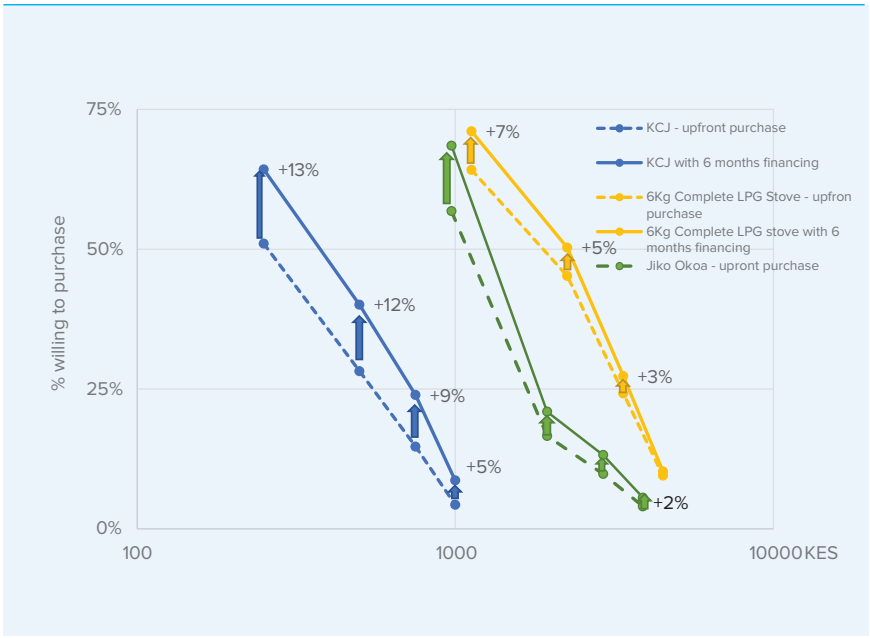
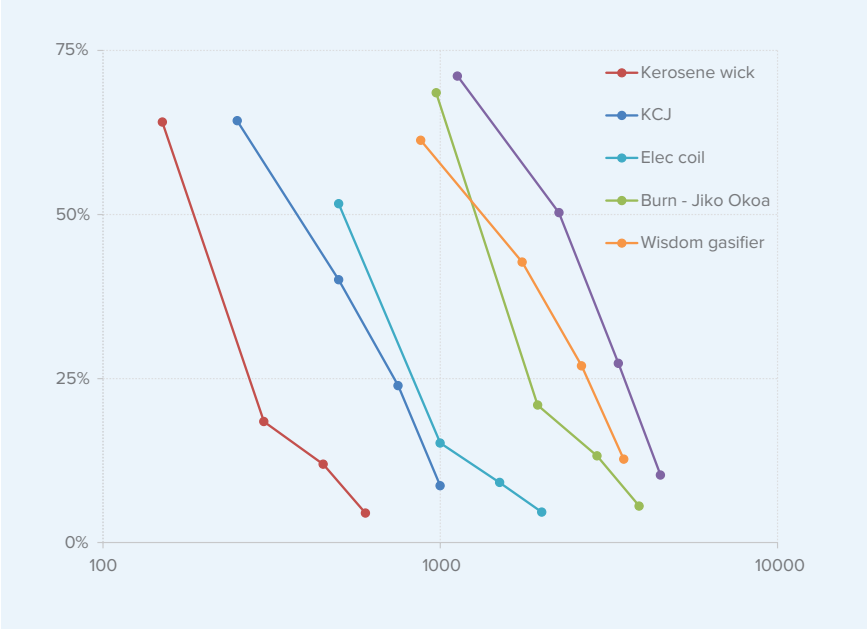


Figure 13: Change in willingness to purchase KCJ and 6kg complete LPG cylinder stoves at different price points between one-time cash payment and 6-months staged payment



These observations have obvious implications on the business models adopted for sale of stoves in Kenya. At 99% and 97% in urban and rural areas respectively, almost all the purchased stoves were acquired on an upfront cash payment basis. This is unsurprising given that at 82%, retail stores (kiosks, supermarkets, wholesale retail shops and open markets) represent the largest proportion of last mile distribution channels for stoves.

The TSOF also known as the open-hearth, open-fire or three-stone hearth, has remained the most common form of cooking technology for decades and continues to defy efforts to displace it as the centre of cooking especially in rural areas. Although the proportion of household users has dropped, the aggregate number has increased from 4.7 million households to 7.4 million households due to the overall population growth. While acknowledging that the process of stove selection is a complex multi-dimensional decision-making process, this study proposes four reasons why the TSOF remains as common.

Perceptions and attitudes towards the problem:

Cooking using the TSOF is considered traditional and promoters of alternatives expect households to see it as such and therefore be inclined to readily adopt other forms of cooking. It is also considered an inferior technology associated with very low efficiency rates. Since it is considered inferior, efforts to displace the TSOF do not ask how the alternatives can mimic the existing setting. Drivers of choice favoring the TSOF go beyond the technology itself and include the type of housing and availability of appropriate fuels within reasonable distances. Like other past research, this study also finds that most of the TSOF users are rural households (76% use rate) with considerably greater access to fuelwood than the urban households and have cooking spaces that can accommodate this type of cooking. Therefore, while many initiatives seek to replace the technology, it is the rural setting that is a greater determinant of this choice.

Appropriate technology:

The TSOF is a widespread technology that has been refined over thousands of years. Its advantages are often misunderstood or overlooked. In addition to being durable and sturdy, the ability to adjust according to the size of the cooking utensil distinguishes this option. Besides the stones themselves, there are no moving parts, bearings, rollers or springs reducing the risk of breakages or malfunction. No parts require replacement even after sustainable use. Users can use it for dual or triple purposes including roasting, drying and space heating while cooking. Multiple solid fuel sources are compatible including firewood, maize cobs, maize stalks, animal dung among others. In some instances, the smoke produced repels insects.

Inaccurate assumptions:

In promoting alternatives to the TSOF, the headline messages are those around fuel cost savings. Although this is an important consideration, it will be most attractive in areas that are fuelwood constrained. When respondents were asked how often they could not acquire firewood in the desired quantities, 45% and 56% of urban and rural firewood users respectively said “never”. The attractiveness of this proposition is reduced in cases where fuelwood is available in sufficient quantities. Another inaccurate assumption is that most households do not appreciate using the TSOF but resort to using due to a complete lack of alternatives.

LPG based cooking. The other inaccurate assumption is that the users of TSOF are not aware of the negative impacts of IAP. Only 6% of TSOF users do the cooking in the main living area, an indication that the inconvenience of cooking outside is overridden by the exposure to smoke. This demonstrates an understanding and awareness of the pollution attributed to TSOF. Attributing deforestation to non-commercial fuelwood use is also inaccurate. Contrary to common perception, non-commercial traditional biomass energy use does not drive deforestation but in some instances may contribute to degradation, which is an emerging consensus across several studies.

Cost and distribution:

It only takes three similar sized, typically spherical stones to build a TSOF. Such stones are widely available and therefore there are no upfront costs of purchase or installation. There are no distributors or need for after-sales-support. No training is required on the use of the solution. This makes the TSOF very competitive relative to any other form of cooking technology in rural areas.

2 Policies and Regulations

There are several international, regional, national and sub-national level policy, regulations and standards that influence the cooking sector. The SDG, UNFCCC Paris declaration and the SEforALL initiative are examples of international interventions and are summarized in Figure 14.

Figure 14: Summary of global energy policies and initiatives

SDG 7

- SDG 7 aims to ensure access to affordable, reliable, sustainable and modern energy for all by 2030. Targets relevant to the cooking sector include: Ensure universal access to affordable, reliable and modern energy services;Double the global rate of improvement in energy efficiency; Enhance international cooperation to facilitate access to clean energy research and technology, [...] and promote investment in energy infrastructure and clean energy technology; Expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries.

The Paris Agreement

- The Agreement entered into force on 4th November 2016 and is currently ratified by 184 Parties of the 197 Parties to the Convention. Kenya is among the ratifying countries.
- Central to the Agreement is the goal to limit the global temperature rise to below 2oC of the pre-industrial temperatures while strengthening countries to deal with the adverse effects of climate change;
- Participating countries detail their commitments under the Nationally Determined Contributions and are required to regularly report on their performance.

Clean Cooking Alliance

- The CCA works with a global network of partners working to create a thriving global market for clean and efficient household cooking solutions;
- It's work is built around three key pillars: behaviour change and awareness-raising interventions, mobilizing investments, and fostering an enabling environment for industry growth.

SEforALL

- The SEforALL is an initiative that is working with varied stakeholders to drive further, faster action toward achievement of [SDG 7] ... and Paris Climate Agreement by 2030;
- This initiative has three main objectives: Ensure universal access to modern energy services; Double the global rate of improvement in energy efficiency; and Double the share of renewable energy in the global energy mix; Kenya was among the first countries to sign a commitment to the SEforALL Initiative.

Policies are also set at the regional (East African Community) and at the national and sub-national levels. Figure 15, Figure 16 and Figure 17 summarize some of the key policies set at the three levels respectively

Figure 15: The East African Community Integration pillars

The Customs Union Integration establishes free trade on goods and services within the bloc, and imposition of a common external tariff (CET) on imports from non-EAC countries when sold to EAC partner States. New CET tariffs came into effect from 1 July 2018 and affected the Kenyan cooking sector through:

- The zero-rating (0% import duty) of inputs and raw materials for use in the manufacture of energy saving stoves;
- Imposing a 35% import duty on complete sets of non-electric cooking appliances under the one-year country specific CET duty rates. This revised a 2016 decision that reduced the tax from 25% to 10%.

The Common Markets Integration

provides freedoms and rights that foster economic growth and development within the EAC. On Energy, the EAC seeks to adopt "policies and mechanisms to promote the efficient exploitation, development, joint research and utilization of various energy resources available within the region". It has, among other things:

- Developed the Regional Strategy on Scaling Up Access to Modern Energy Services (November 2006) to promote adoption of high impact, low cost scalable approaches;
- Launched the East African Centre for Renewable Energy and Energy Efficiency.

Figure 16: Summary of key regulations

The Energy Sessional Paper No. 4 of 2004

- Recognizes biomass as most important primary source of energy;
- Projects significant deficit esp. in wood fuel demand (33 million metric tons by 2020);
- Includes commitments to license charcoal production, increase adoption of efficient charcoal and fuelwood stoves, pass policy that promotes use of cleaner fuels.

2004 → 2005 → 2006 → 2007 → 2008 → 2009

The Energy Act No. 12 of 2006

- Restructured the energy sector including establishment of the ERC which was mandated with, among other things, licensing charcoal producers.
- Highlights the role of the minister to formulate activities and programs that enhance energy efficiency and conservation.

The Energy (Liquified Petroleum Gas) regulations of 2009

- Subsidiary regulations anchored on the Energy Act, 2006;
- Outline the licensing requirements for those involved in the LPG business including the importation, bulk storage, filling, transportation, wholesale and retail trade of LPG;
- Standardized the capacities of LPG cylinders (at 1kg, 3kg, 6kg and 13kg) and valves used;
- Established an LPG cylinder exchange pool regulating the exchange of LPG cylinders among marketing companies.

2010

The Kenya Constitution of 2010

- Devolved the roles of county planning and development in electricity and gas reticulation and energy regulation

2012

The Forest (Charcoal) Rules of 2012

- The rules, first gazette in 2009 and revised in 2012, actionized provisions of the Energy Act 2006 specifically regulating the sustainable production, transportation and marketing of charcoal;
- Charcoal producers and transporters must be licensed by the Kenya Forest Service (KFS); commercial charcoal producers must organize themselves in Charcoal Producers Associations (CPAs); charcoal wholesalers or retailers should not trade with unlicensed producers.

2013

The Energy (Improved Biomass Cookstoves) Regulations of 2013

- Intended for manufacturers, importers, distributors, technicians, and contractors of Improved Biomass Cookstoves, and institutions using biomass fuels for cooking and heating purposes;
- Sets out the classes and requirements for licensing for installation, maintenance, manufacture, importation and distribution of cookstoves.

2014

2015

2016

The Forest Conservation and Management Act of 2016

- Retains the licensing role of Kenya Forest Service noting that they are to "receive and consider applications for licenses or permits in relation to forest resources" and to "implement and enforce rules and regulations governing importation, exportation and trade in forest produce"
- Consequently, among the Regulations provided for by the Act concern production, transportation and marketing of charcoal.

2017

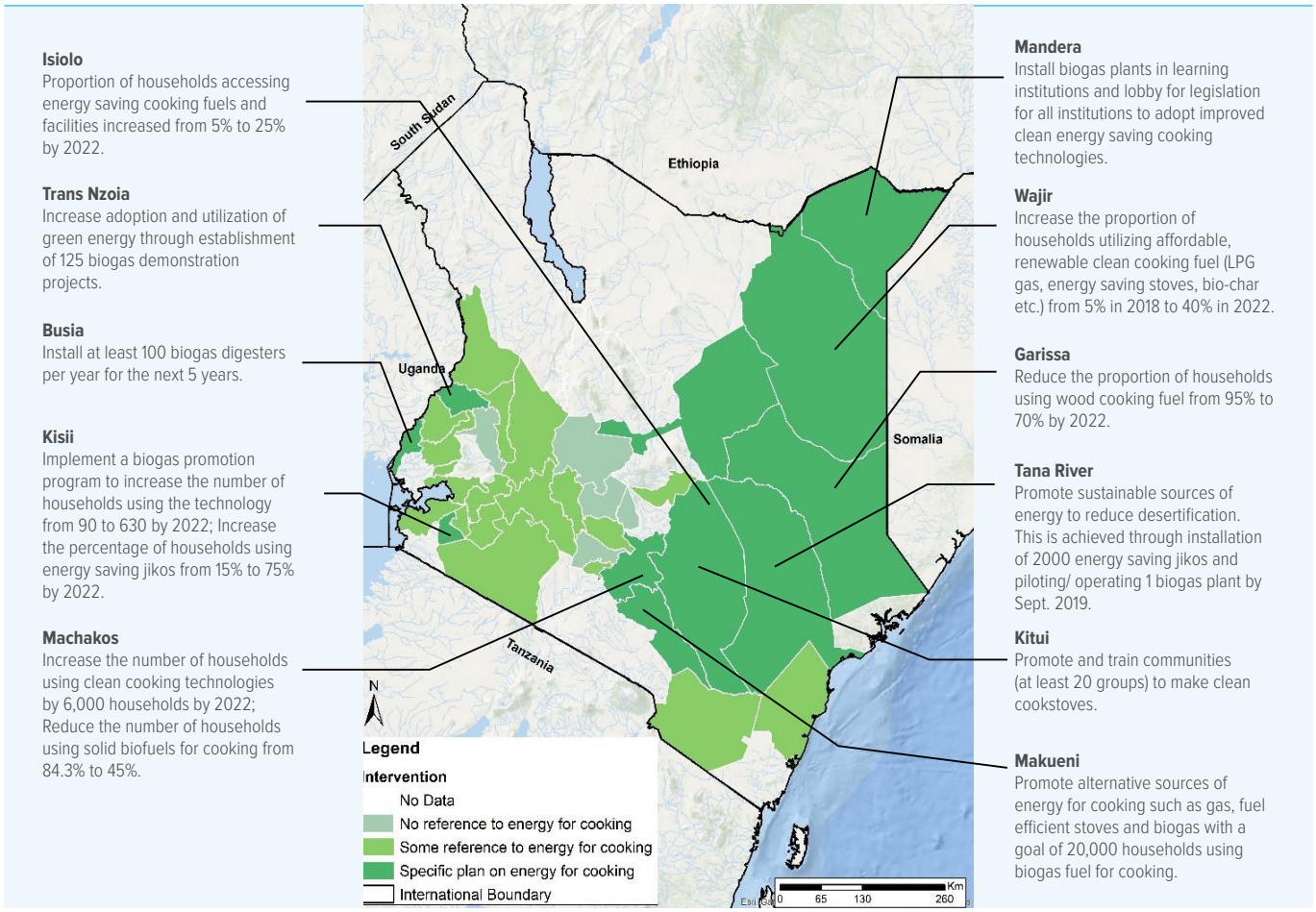
2018

2019

Energy Act of 2019

- County governments are mandated with regulating and licensing of: i) biomass production, transport and distribution; ii) biogas systems; and iii) charcoal production, transportation and distribution;
- Cabinet Secretary to make regulations for the licensing and management of renewable energy sources including biogas and biomass among others;
- Cabinet Secretary also required to "develop and publish the Integrated National Energy Plan.

Figure 17: County specific cooking sector plans per the 2018-22 CIDPs



Various standards have been put forward in guiding manufacturers of cookstoves both internationally and nationally. Internationally, the current guiding standards are The International Organization for Standardization (ISO) Harmonized Laboratory Test Protocols guided by ISO 19867-3: Voluntary performance targets for cookstoves based on laboratory testing, and ISO 19867-1: Standard test sequence for emissions and performance, safety and durability. The voluntary performance targets result in 6 tiers under each of the following categories: thermal efficiency (%), CO emissions (g/MJ delivered), Fine Particulate Matter Emissions (mg/MJ delivered), safety (score) and durability (score).

The Kenya Bureau of Standards (KEBS) has developed specific standards for improved cookstoves. Among these standards are: KS 1814-2018 Biomass stoves – Performance Requirements and KS 2759 – 2018 Ethanol fuelled cooking appliances; KS 2520 – 2014 Domestic biogas stoves – Specification; ISO 17225-3: 2014 Solid biofuels – Fuel specifications and classes Part 3: Graded wood briquettes; and ISO 17225-7:2014 Solid biofuels – Fuel specifications and classes Part 7: Graded non-woody briquettes, among others.

3 Social, health and environmental costs

3.1 Greenhouse gas emissions

From reported consumption numbers, this study estimates the annual emissions from combustion of residential cooking fuels as 13.6 $MtCO_2e$ per year split 2:1 between rural and urban populations (Table 7). Adding Carbon Monoxide (CO), Black Carbon (BC), Organic Carbon (OC) and Nitrogen Oxide (NOx) increases the total impact to 20.5 $MtCO_2e$, with a similar ratio between rural and urban households (Table 8). In July of 2015, the Ministry of Environment and Natural Resources submitted to the UNFCCC Kenya's Nationally Determined Contribution (NDC). This document sets the 2010 baseline total greenhouse gas emissions at 73 $MtCO_2e$ including LULUCF (Land use, land-use change, and forestry). The Second National Communication to the UNFCCC (2015) has this at 69.5 MtCO2e for the same year (2010). Household level cooking is therefore a prominent contributor to total national emissions. The National Climate Change Action Plan (2018-22) notes that uptake of improved cookstoves with higher conversion efficiency has the largest potential for GHG emission reductions highlighting the importance of the cooking sector in Kenya's quest to meet her NDC.

Table 7: Net annual GHG emissions from residential cooking fuels accounting for CO2, CH4, and N2O

TOTAL EMISSIONS (CO2, CH4, N2O)	Urban			Rural			Total		
	% sample	Millions of HHs	Total (MtCO2e)	% sample	Millions of HHs	Total (MtCO2e)	% sample	Millions of HHs	Total (MtCO2e)
Fuelwood	24%	1.0	1.1	85%	6.06	5.2	65%	7.48	6.2
Charcoal	43%	1.9	2.3	39%	2.77	3.8	40%	4.61	6.1
Crop residues	3%	0.1	-	8%	0.54	-	6%	0.69	-
Kerosene	28%	1.2	0.5	6%	0.44	0.1	13%	1.51	0.6
LPG	51%	2.2	0.5	15%	1.07	0.1	27%	3.07	0.6
TOTAL			**4.3**			**9.2**			**13.6**

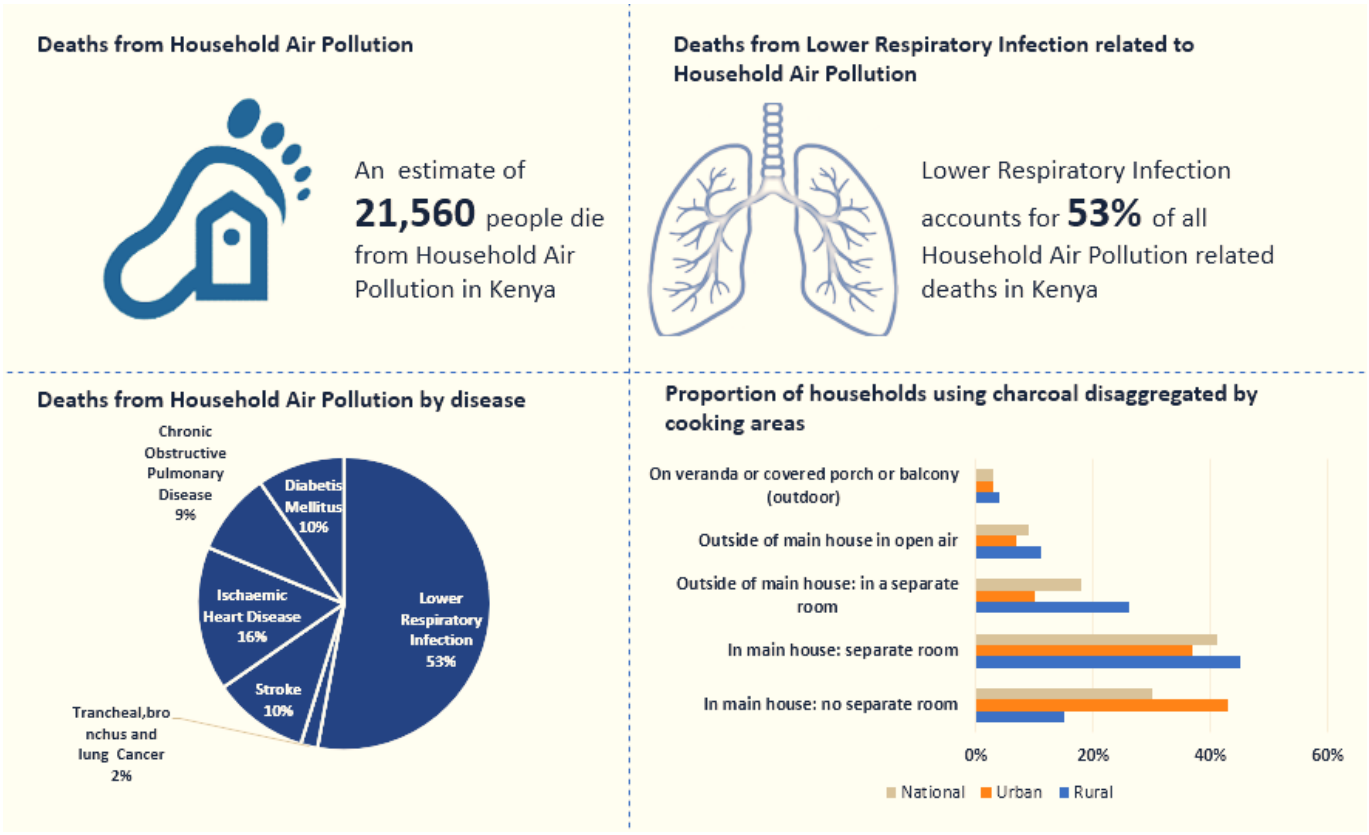
Table 8: Net annual GHG emissions from residential cooking fuels accounting for CO2, CH4, N2O, CO, BC, OC, and NOx

TOTAL EMISSIONS (CO2, CH4, N2O), CO, BC, OC, NOx)	Urban			Rural			Total		
	% sample	Millions of HHs	Total (MtCO2e)	% sample	Millions of HHs	Total (MtCO2e)	% sample	Millions of HHs	Total (MtCO2e)
Fuelwood	24%	1.0	1.6	85%	6.1	8.3	65%	7.5	9.9
Charcoal	43%	1.9	3.3	39%	2.8	5.5	40%	4.6	8.8
Crop residues	3%	0.1	0.1	8%	0.5	0.4	6%	0.7	0.5
Kerosene	28%	1.2	0.5	6%	0.4	0.1	13%	1.5	0.6
LPG	51%	2.2	0.5	15%	1.1	0.1	27%	3.1	0.6
TOTAL			**5.9**			**14.5**			**20.5**

3.2 Household air pollution

Household Air Pollution (HAP) continues to be a global risk with annual deaths of 1.6 million revised down from 3.8 million. One of the leading sources of HAP is the use of solid fuels and kerosene in traditional and inefficient/simple stoves such as open fires, which leads to emission of large amounts of pollutants such as particulate matter (PM), carbon monoxide (CO), hydrocarbons, and oxygenated and chlorinated organic compounds. The Ministry of Health estimates that HAP in Kenya claims 21,560 lives annually. Other estimates are between 14,000 and 17,000 lives annually, more than five times the number of lives lost to traffic accidents yearly. Lower Respiratory infections such as pneumonia and acute bronchitis have been the greatest contributor to the HAP related deaths in Kenya. Overall, acute lower respiratory infections are considered the second largest cause of death and are linked to 26% of all deaths reported in hospitals in Kenya. Other diseases include ischemic heart disease (IHD), chronic obstructive pulmonary diseases (COPD) and stroke.

Figure 18: Household Indoor Air Pollution Impacts in Kenya



4 Barriers and M&E Metrics

4.1 Barriers

The choice of cooking technologies and fuels is a composite process with several secondary and tertiary contributing factors. At the heart of the cooking problem is the use of traditional cooking technologies and fuels. Drivers of the prevalent choice of traditional cooking solutions include high cost, limited or non-existent distribution channels, lack of awareness, and inappropriate technological designs of alternatives. The impact of the prevalent use of traditional forms of cooking is negative health consequences, sustained GHG emissions and environmental degradation. As demonstrated by the information collected in this study, other attributes including physical location (rural vs urban), size of household, access to fuels, socio-cultural practices, cost of technologies and fuels, choice of meals, past dependency, and size and location of cooking areas all contribute to various technologies and fuels used. Figure 19 summarizes core barriers by type in the adoption of clean cooking technologies in Kenya.

Figure 19: Matrix of core barriers by type

Class of Barrier	Specific Barrier	Metallic & KCJ charcoal stoves	Branded charcoal stoves	Improved woodfuel stoves	LPG stoves	Biogas stoves	Pressurized kerosene stoves	Ethanol stoves	Electric stoves	Solar cookers
Cost and Acquisition	High cost of technology		■		■	■	■	■	■	■
	High cost of fuel				■				■	
	Limited market intelligence					■	■	■	■	■
	Lack of suitable business models					■				■
Appropriateness	High emissions / smoke	■	■	■						
	Size limitation						■	■		
	Lack of systematic fuel regulation	■	■	■						■
	Restricted to day-time use									■
Availability	Limited supply options					■	■	■		■
	Limited distribution options		■	■	■	■	■	■	■	■
	Limited or lack of awareness					■	■	■		■
Policy and Standards	Low quality products (spoilage)	■		■		■				
	Restrictive policy / standards		■				■			
	Unclear policy / standards					■				
	Non-existent policy / standards	■		■			■			■
	Applicable Barrier									

Fuel specific barriers are summarized in Table 9 using the RAG (Red, Amber and Green) rating meaning critical, moderate and mild barrier types respectively. For example, charcoal is constrained at the upstream stage but has very few barriers elsewhere. Briquettes on the other hand face several barriers along the value chain, most of which are critical.

Table 9: RAG Rating on Fuels

	Fuel	Policy/ Regulations	Upstream	Midstream	Downstream
SOLID	Charcoal	Charcoal regulations (2009)	Significant unsustainable production; low technology pyrolysis	Well established distribution channels	High adoption of improved stoves
	Woodfuel	Forest Act (2009)	Unsustainable production; informal production systems	Well established distribution channels	Low adoption of improved stoves;
	Briquettes	Unclear policy and regulations	Limited feedstock sources; charcoal is a leading source of feedstock	Incomplete distribution channels	Low adoption of improved stoves;
GAS	LPG	Zero-rated LPG (Finance Act 2016 +)	Well established distribution channels	Well established distribution channels	Incomplete distribution channels
	Biogas	Domestic biogas stoves standards	Nascent ecosystem of manufacturers	Incomplete distribution channels	Incomplete distribution channels; low technology adoption
LIQUID	Kerosene	Restrictive policy and regulations	Well established distribution channels	Well established distribution channels	Low adoption of improved stoves;
	Ethanol	Ethanol standards	Nascent ecosystem of manufacturers	Incomplete distribution channels	Incomplete distribution channels; low technology adoption
	Biodiesel	Unclear policy and regulations	Limited sources of fuels	Incomplete distribution channels	Incomplete distribution channels; low technology adoption

Mild Barriers Moderate Barriers Critical Barriers

4.2 Monitoring and Evaluation metrics

There are various documents that set targets on adoption of clean and improved cooking solutions in Kenya among them being the Kenya National Climate Change Action Plan 2018-2022, the Sustainable Energy for All: Kenya Action Agenda, and the Kenya Country Action Plan (amended in 2016). To improve on the framing and monitoring of these targets and to strengthen the target setting processes, there is need to define the key terms (working definition), select the unit of observation (e.g. persons, households, communities), establish the baseline, and provide details on how the progress and results will be monitored and evaluated. The common terms used in these documents include improved stoves, clean cookstoves, clean cookstoves and fuels, modern cooking solutions and clean cooking solutions. The unit of observation is also mentioned as households, institutions, populations, schools and public facilities. Most of the targets are to be achieved by 2020, apart from the Kenya Climate Change Action Plan, which sets the targets at 2022 and the Kenya SEforALL Action Agenda which sets its target at 2030. This study finds that some of these targets have already been met and therefore need to be revised or reported as having been achieved. An attempt to compare the results of this study with the SEforALL Action Agenda targets is made and represented in Table 10. Highlighted in yellow are the outcomes of this study; numbers on both primary cooking solutions and ownership of cooking solution are presented for comparison as the SEforALL Action Agenda is unclear on its measuring unit.

Table 10: Comparison of the study data with SEforALL targets

Year	2013	2017	2018 (Primary Use)	2020	2022	2027	2030
LPG (%)	8.6	13.6	18.9	15	18.6	25.6	35.3
Biogas (%)	0.1	0.2	0	0.3	0.4	0.6	0.8
Bioethanol (%)	0	0	0	1	1.5	3	4.5
Electricity (%)	0.6	1	0.1	1.2	1.5	2	2.3
HHs access to clean fuels non-solid (%)	9.3	14.8	19.0	17.5	22	31.2	42.9
Improved cookstoves-solid fuels (%)	37.2	42.9	20.2	47.7	52.7	57.6	57.7
Total access to modern cooking services (%)	46.5	57.7	39.2	65.2	74.7	88.8	100
Access to unclean cooking services (%)	53.5	42.3	60.4	34.8	25.3	11.2	0
Total access to cooking (%)	100	100	100	100	100	100	100

From the comparison in Table 10 the following definitional issues are noted:

- The definition of 'Access' under the SEforALL document is unclear. For instance, does it refer to ownership or usage? If usage, is it as primary or secondary use? It is critical that definitions are specified in setting targets.

- Assuming the SEforALL projections are for primary usage, this study finds the total number of households using unclean cooking services as their primary cooking solution is at 60.4% which is higher than the baseline (2013) value of 53.5%.

- Assuming that the targets were on ownership, this study finds that national LPG ownership rates are at 29.8% which has surpassed the 2027 SEforALL targets.

- Further, what does access to unclean cooking services mean? If a household had a TSOF as their primary cookstove and an improved charcoal stove as their secondary stove, under which category would it fall?

For draft documents such as the Kenya Country Action Plan and the Ministry of Energy and Petroleum (Kenya SEforALL Secretariat) tracking framework, new targets need to be set guided by these new findings. This study finds that at least 3.7 million households (30.2%) use clean cooking solutions (LPG, electricity, biogas or biofuels) – much higher than the Kenya National Climate Change Action Plan projections, which sets a target of 2 million households by 2022. Of these 3.7 million households, 1.3 million (10% of all households) use clean cooking solutions exclusively. The SEforALL Prospectus (2016) cites the Kenya Country Action Plan (2013) as marking a baseline of 3.2 million households using improved cooking solution although the Country Action Plan does not explicitly mention this figure. Factoring in improved cooking solutions (KCJ, branded charcoal stoves and branded wood stoves) in addition to the clean cooking solutions, this study finds that at least 5.2 million households (41%) use either clean or improved cooking solutions.

5 Conclusion and call to action

5.1 Conclusion

Sustained efforts to transform the cooking sector from one that is highly dependent on traditional cooking solutions to one where the majority have access to clean solutions has yielded mixed results. While the use of TSOF remains prevalent, the uptake of LPG is one positive outcome associated with policy and legislative interventions as well as market-based innovations such as last mile transportation. Fuels and technologies such as electricity, briquettes, pellets, liquid ethanol, gel ethanol, biogas, solar cookers and fireless cookers have been promoted over several decades. Their prevalence and use at the household level remain marginal. This study finds that access to cleaner technologies does not mean displacement of traditional forms of cooking or the elimination of health and environmental costs. As demonstrated above, households that use clean cooking solutions often supplement their cooking mix with traditional sources. Emphasis should therefore be placed on access but also on use. Incentives should be two-prong in nature – promoting access and use simultaneously. Although cost is the most important determinant of access and use, other critical factors such as ease of use, availability of fuels, distances to fuel sources, last mile distribution options, availability of longer-term payment plans, nature and structure of cooking area, types of food and number of household members all contribute to the hypercomplex matrix of choice. "Ease of use" is a compound factor that includes the following capabilities: direct ignition, systematic heat regulation, systematic fuel use, allowance for partial fuel refill, non-smoking clear flame/heat, and fuel level detection. This for example, beyond cost, explains why a low-income urban household will use a kerosene stove to prepare two cups of tea rather than a charcoal stove. The kerosene stove offers direct injection and systematic fuel use features which a charcoal stove would not. There are also major gaps in understanding the social, health and environmental costs of various cooking solutions.

5.2 Call to action

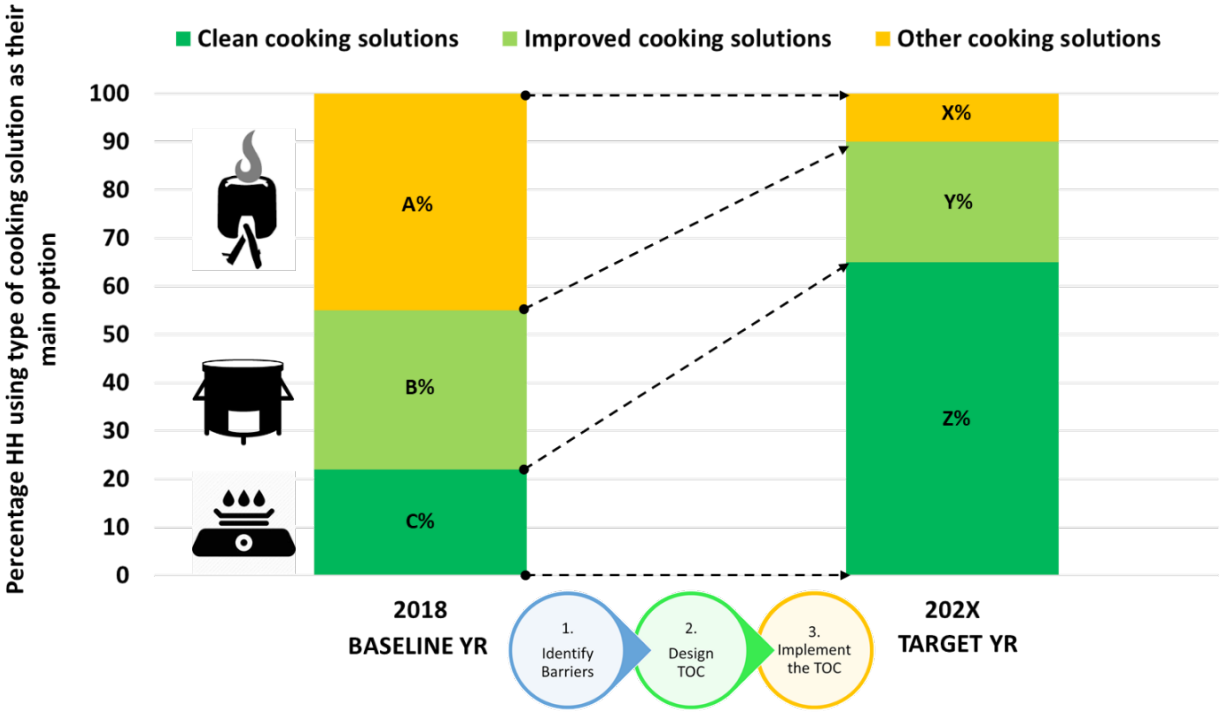
The key recommendation from this study is a call for the development and implementation of a cooking sector market transformation program. The purpose of this program would be to fundamentally change the cooking sector – beyond the aim of increasing the number of stoves sold – into a clean, sustainable and profitable enterprise. This study establishes a baseline elaborating the status of access to fuels and cooking appliances but also provides information that begins to explain the reasons informing the current situation. Moving the sector from this baseline to a desired end within a stated period and through clearly defined strategic interventions as shown in Figure 20 should be the aim of the program. Identification of specific barriers should be followed by the design of a theory of change (TOC) and implementation of the TOC.

Market transformation programs aim to address barriers to entry and growth through essential and lasting changes to the characteristics of targeted markets. Although there is no universally acceptable definition of market transformation, common elements include targeted and strategic policy or regulatory interventions, introduction or actions to increase the number of goods or service providers, emergence of new and innovative business models, reduction in market barriers, technical and business capacity development and increased awareness of desired product or types of products. As opposed to interventions that seek to increase the availability or spread of products or services through direct promotion, market transformation programs aim to affect the fundamental structure and characteristics of the market. Some of the proposed efforts to market transformation from the outcomes of this study include:

- **Sustain market intelligence efforts** - The Ministry of Energy, together with CCAK should institutionalize regular cooking sector surveys to track progress systematically and periodically. Key sector performance metrics can then be tracked, and outcomes linked or associated with actions taken.

- **Design of problem driven approaches** - The core problem within the cooking sector is the use of traditional technologies and fuels. Since the prevalence of clean technologies is not synonymous with a reduction in use of traditional fuels, the focus of adopted approaches should be reducing the prevalent use of traditional fuels.

Figure 20: Illustration on a path to market transformation



- **Prioritizing solutions and interventions** - The uptake of LPG demonstrates how government policy when matched with private sector interests can result in positive market transformation. These efforts should be accelerated and expanded to rural and remote areas.

- **Support for technology advancement and business development** - The KCJ has been fabricated in largely the same way over the last three decades. Although the stove has been widely distributed and is one of the most popular cooking device, very little innovation and changes have been incorporated since. Collaboration between universities, research institutions, and the Jua Kali artisans needs to be further strengthened to yield more efficient, locally made solutions.

- **Strengthening of sectoral coordination -** CCAK, being the cooking sector coordinating body, needs to be further strengthened in its role of "facilitating the scaling up of clean cookstoves and clean fuels market in Kenya through convening and coordinating the sector, advocating for enabling government policies, creating public awareness and capacity building". There is also a need to expand the CCAK membership base to include the players in oil and gas, particularly those in LPG.

- **Facilitation of access to finance and fiscal incentives, especially for informal sector artisans** - With clear financing gaps along the cooking sector value chain, it is expected that facilitating access to finance will address a critical barrier to promoting improved and clean cooking solutions. Formal and informal financial institutions that are ecosystem enablers should also be provided with suitable funding sources that they can channel to this sector.

The LPG market in Kenya has had tremendous growth over the past 2 decades with the number of households using LPG increasing six times from about 0.6 million to 3.7 million. An estimated 2.8 million households currently use LPG stoves as their primary stove. Beyond the overall national use rate, this study finds that more than half (53.4%) of the households using LPG started using it within the last five years - translating to an estimated 2 million households. The most impressive growth has however been realized in the last three years, with 42.4% urban users and 26.1% of rural users having started using LPG-based solutions during this period. Figure 21 highlights five key reasons that have contributed this impressive rise in the uptake of LPG as lessons to inform other market transformation initiatives.

Standardization of the capacities of LPG cylinders (at 1kg, 3kg, 6kg and 13kg) and the valves used. Before the standardization of the cylinder design, consumers would be restricted to using separate regulators and cylinders from individual dealers. Cylinders are now compatible across brands.

Introduction of smaller tanks (6kg complete gas cylinders) made LPG more accessible to lower income households. However, just a reduction in size does not translate to more uptake as the introduction of the 3 kg complete cylinder in 2011 did not experience the same reception.

The Finance Act of 2016 zero-rated LPG sending a strong signal to the markets on the Government's intention to promote the uptake of LPG. This has contributed greatly to the increase in use of this fuel option with data showing a surge in the use of LPG around this time

Institution of the LPG cylinder exchange pool which, among other things, allowed LPG users to exchange their LPG cylinders with any dealers regardless of the brand turning LPG outlets to exchange points accessible to all users regardless of cylinder type. Gazette notice No. 4124 published on May 4th, 2018 proposed to amend this arrangement by changing the mandatory requirement to exchange with one that is done under agreement between dealers.

The Finance Act 2018 introduced an anti-adulteration levy on kerosene. The tax of KES 18/litre is intended to deter use of kerosene to adulterate vehicle fuels. It is expected that some of the users of kerosene will now shift to LPG and other alternatives.

ANNEX 1: IMAGES OF THE DIFFERENT COOKSTOVES

Clean Fuels Stoves | Improved stoves | Traditional Stoves | TSOF

TSOF

Metallic Charcoal Stove

Fixed Biomass Stove

KCJ

Kuni Mbili

Gasifier

Branded Charcoal Stove

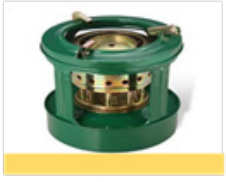
Branded Charcoal Stove

Mixed LPG and Electricity

Fireless Cooker

Fixed Dome Biogas Plant

Tubular Biogas System



Kerosene Wick Stove

Multiple Burner LPG Cooker

Ethanol Liquid Stove

Pressurized Kerosene Stove

6 Kg LPG Cooker

Ethanol Gel Stove

Electric Induction Cooker

Electric Coil Cooker

Endnotes

1. Putti, V., Tsan, M., Mehta, S. & Kammila, S. (2015). The State of the Global Clean and Improved Cooking Sector. Retrieved from http://prdrse4all.spc.int/system/files/state_of_global_clean_improved_cooking_sector_0.pdf
2. UNICEF. (2018). UNICEF Data: Monitoring the situation of children and women: Kenya population projections. Retrieved from https://data.unicef.org/resources/resource-type/datasets/
3. According to the WHO Air quality guidelines, 2006, the mean levels of PM2.5 should be 10microgram/m3. This is the lowest levels at which total cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence interval and response to long term exposure to PM2.5.
4. Johnson, M.A. and Chiang, R.A. (2015). Quantitative guidance for stove usage and performance to achieve health and environmental targets. Environ Health Perspect 123:820–826. http://dx.doi.org/10.1289/ehp.1408681
5. World Health Organization. (2018). Household Air Pollution and Health. Retrieved from http://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health
6. Interview with Ministry of Health official done on the 28th January 2019
7. Estimated based on data from Institute of Health Metrics and Evaluation, Global Burden of Disease Compare Seattle, WA: Institute for Health Metrics and Evaluation; 2018 [cited August 2018]. Available from: http://vizhub.healthdata.org/gbd-compare/.
8. National Transport and Safety Authority. Accident Statistics as of 21st November 2018, 2750 people had lost their lives from road accidents. Retrieved from http://www.ntsa.go.ke/index.php?option=com_content&view=article&id=213&Itemid=706

Publication information

Publication date:	August 2019
Consulting Team:	EED Advisory –Ida Githu, Beryl Ajwang', Brian Kinuthia, Michael Mwangi (GIS Expert), Ruth Gichuhi (Project Manager) and Murefu Barasa (Team Leader) Stockholm Environment Institute – Rocio A. Diaz-Chavez (PhD), Robert Bailis (PhD) and Hannah Wanjiru
Graphic Design:	Michael Lusaba

REPUBLIC OF KENYA
MINISTRY OF ENERGY