Consumer Preferences for Cooking and Lighting Fuels and Domestic Energy Transition: A Nyeri Town, Kenya, Perspective

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ABSTRACT

Improving access to modern fuels in developing countries is crucial in mitigating unfavorable environmental and health impacts caused by the continued use of traditional fuels. Use of modern fuels lead to improved standards of living and gender equity of women and children. This paper estimates preferences for domestic fuels and reasons thereof by households in urban areas in Nyeri town, Kenya. The study uses Nyeri town micro-data to perform correlation analysis to

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determine the relationship between fuel preference and domestic energy transition. Transition is considered along three categories of domestic fuels: traditional -firewood and charcoal; transitional fuels- kerosene; modern fuels – Liquefied Petroleum Gas (LPG), biogas, solar and grid electricity. The result findings show that urban residents use traditional, transitional and modern fuels through energy stacking theory with the transition to modern fuels following a consistent pattern. The major reasons for fuel preference were established as fuel convenience, affordability, ease of accessibility and cultural beliefs by 46.5%, 37.2%, 10.5% and 5.8% of the respondents respectively.

ABBREVIATIONS

LPG   : Liquified Petroleum Gas
WHO   : World Health Organization
KNBS   : Kenya National Bureau of Statistics
SID   : Society for International Development
PV   : Photovoltaic

1. INTRODUCTION

Energy is key to almost every opportunity and challenge faced by the world today [1]. It is of utmost importance to improve access to clean fuel and technology and progress towards integrating renewable energy into end-use applications in buildings, transport and industry. Further, there is need for an increased focus on regulatory frameworks and new business models to change the world's energy systems. According to the World Health Organization [2], the use of unprocessed coal and kerosene for cooking and heating, is detrimental to human health, since such fuel sources produce high levels of smoke and toxic fumes and are dangerous to burn. Nearly 3 billion people, majorly in low- and middle-income countries, depend on solid fuels (wood, animal dung, charcoal and crop waste)which are combusted inefficient during cooking and heating resulting in production of pollutants [3].The change from using traditional fuels; firewood and charcoal, to using modern fuels; LPG, solar and electricity, is key to curb environmental pollution, climate change and enhance crucial health improvements [2].Due to varying challenges that limit people to dependency on solid fuels, there is no 'one size fits all' strategy to effective clean household energy initiatives. A collection of options targeted to discrete socio-cultural environments is plausible to have wider acceptance. In Kenya, a shift to clean fuels will demand such work in some areas. In urban and peri urban areas, the cost of clean household energy is competitive with that of solid fuels and kerosene hence, a direct transition to clean technologies is feasible. Media campaigns to eliminate misconception about clean fuels are effective means for reforming the national dialogue and establishing rewarding markets for clean cooking fuels. Cultural impression (including illusion about the flavour of food cooked on traditional stoves and the relative low safety and high cost of clean alternatives) remain a persistent barrier to wider uptake of clean cooking fuels. Information to disprove such beliefs is accessible locally, but it is not widely circulated [4].

If the desire to achieve a high-energy future while conserving the natural world for the future generation is paramount, it requires the examination of the environmental consequences of energy production and use at all stages of the decision-making processes. Energy solutions that ignore economic costs are not practical, especially in a profoundly unequal world where billions of people presently can't manage access to essential energy services [5].Climate change poses serious threats to socio- economic development in Kenya, through lengthened droughts, uncertain weather patterns, and the development of new pests and diseases. Enlightened dialogue and debate among decision-makers and the public is fundamental to understand the significance of differences in resource access, including how rising costs would contrast with the projected economic gains that might be gained from a transition to low-carbon energy systems [6].In an attempt to address this global issue the WHO gives recommendations to governments and practitioners to discourage the use of traditional fuel source and further emphasize the adoption of clean energy use in the households [2].

Energy efficiency (EE) is the most economical way to harmonize energy needs and resources.Optimization of EE measures are effective means of decreasing energy costs and boosting the gross national domestic product by improving the country's competitiveness in the

global market. In Kenya, the Ministry of Energy and Petroleum has enacted regulations to bolster the use of efficient appliances in all subsectors. Social migration and large electrification programs offer opportunities to advocate EE improvement and the adoption of efficient equipment in the residential subsector, especially in the urban areas [7]. Implementation of new well-designed regulations for clean domestic fuels can lead to significant advancement in the health and social prosperity of the nation. Both governments and researchers have developed interest in understanding the factors that affect domestic energy consumption so as to design and implement practical policies that reduce utilization of traditional energy sources [8]. Households diversify their energy consumption in accordance with the energy stacking theory. Social, economic and cultural factors play a critical role in determining the fuel used by households [9,10]. Ensuring access to affordable, reliable, sustainable and modern energy is advocated by United Nations' Sustainable Development Goal 7. With growing world's population, the demand for cheap energy to light homes and streets, use phones and computers and run their everyday business surges proportionally. Fossil fuels and greenhouse gas emissions have a negative impact on every continent. An investment to more energy- efficient clean energy sources such as solar and wind can positively contribute towards meeting electricity needs and protect the environment [11]. Policies that do not address the actual needs and preferences limit the efficacy of interventions to promote the use of modern fuels. Programs and interventions should be based on a deep understanding of how people really use energy in their homes .Looking at the current available energy options to most households, electricity is one of the cleanest fuels in terms of exposure to health-damaging pollutants [12]. LPG stoves produce very low levels of emissions from particulate by-products of incomplete combustion. Solar cookers are also clean for human health. Biogas burns cleanly with no negative climate impacts. It can be used for cooking, lighting and to power electric generators [1].

Most developed nations and members to Organization for Economic Co-operation and Development (OECD) have virtually universal access and dependence on modern energy sources [13]. Conversely, the energy consumption pattens in Sub-Saharan Africa (SSA) overshadow the world totals with approximately 80% dependency on biomass. It is estimated that only 43% of the population in Sub-Saharan Africa have access to electricity [14]. The East Africa region is one of the rapidly developing regions in Africa but still exhibits a high reliance (80%) on non-clean energy sources. This trend certainly illustrates the degree to which clean energy potential benefits and opportunities are lost [15].

In Kenya, wood fuel and other biomass resources are predominantly consumed, accounting for about 68% of the total primary energy consumption, followed by petroleum sources at 22% and electricity at 9%. Nearly three-quarter of Kenya's population rely on biomass sources in meeting their cooking, heating, and lighting needs. In urban domestic set-up, petroleum products and electricity are the dominant forms of energy consumed by the households [16,17]. Modern solar energy technologies continue to improve ways of using solar energy. Biogas energy is an effective complementary source of energy for cooking and lighting [18].

Considerable efforts have been made to transform the energy sector in Kenya through government regulations and policies. Nonetheless, utilization of clean energy sources remains comparatively low at the household level [19]. For most households practicing multiple fuel use, consumption intensity for clean energy sources is considerably low. This greatly contributes to indoor air pollution due to exposure to biomass smoke which leads to adverse impacts on human health. Close to 15,000 lives are lost annually in Kenya and implications are severe among women and girls, whose household energy use revolves around biomass [15]. This trend ought to be reversed to fast track domestic energy transition towards clean energy consumption. A fuel stacking model gives a realistic picture of how people use energy in their homes. Members of a household might continue to cook or heat their home with charcoal, even after gaining access to LPG. A family might continue to use kerosene lamps as back up for electric light. This phenomenon is referred to as fuel stacking and is one of the major reasons why the transition to modern, clean, domestic fuels is a complex challenge. Fuel stacking is more intense in urban communities compared to rural communities such that the impact of modern fuels to reduce indoor air pollution is expected to be higher in urban areas than in rural areas [18].

While conducting a comprehensive assessment of residential fuel choice and consumption in urban areas in developing world, Barnes et al. [20] established that urban energy transitions are quite varied, in terms of the timing of the transition period, and the transition fuels consumed. The intermediate stage of the transition follows one of several definite directions. Further, the income threshold at which households transition to modern fuels vary broadly in various societies, depending on specific household characteristics, household income, and policy regimes. Consumers react to energy price signals and constraints in urban fuel markets. Government influence energy prices and access, thereby playing a crucial role in urban market transformations. Biomass supply around cities is another factor that shapes the conditions found in urban energy markets, and diversifies the expression of the urban energy transition in different cities and nations [20]. Complex interrelatedness between preferences, habits, cultural norms, technology and behaviour influence domestic energy transition [21]. Local cuisine contains a wide range of foods and hence dictates the use of various cooking devices for specific tasks. There is need for better insights into why people use different household energy sources, and how access to clean energy can benefit all members of the household. A 'portfolio' approach to substitute clean modern fuels for polluting traditional fuels will provide customized options that meet users' needs and preferences in specific geographical, cultural and economic contexts [22].

According to research conducted by Treiber et al.[23], on reducing energy through increasing choice of fuels and stoves from three regions in Kenya; Western, Central and Transmara, over 90% of the households acknowledged using biomass fuels. About 96.3% of the interviewees used kerosene mainly for lighting and rarely for cooking due to high market prices. The use of LPG was not as common as that of charcoal but their consumption distribution showed patterns of income-related fuel choice. Only 34% of the households cooked with LPG. Every household in the sample applied a mix of fuels to satisfy its needs with a range between two and ten fuel types. This implied that households make a choice to consume a given type of fuel from the available alternatives [23]. While carrying out research in rural Mexico, Masera et al. [24] observed that households did not ascend the 'energy ladder' with an increase in net earnings. Instead, they 'stacked' fuels, where traditional energy sources were not completely discarded but used together with modern fuels due to cultural preferences. Households make their preference for fuel based on the available sources at various stages of the transition [24,25].

For a swift transition towards clean domestic fuels, it is key to grasp: the fuel mix found in the households and their changing use patterns; and the relationship between the household requirements, conducts and culture that influence the continued utilization of traditional fuels [22]. There is limited study on the above issues from previous research and thus, this research was geared to filling in important information gaps necessary in the formulation of effective policies to promote the transition of domestic fuel use from traditional to modern fuels. The main objective of this research was to investigate;

1. The relationship between domestic fuel preferences and transition towards modern domestic energy.
2. The motivations underlying domestic energy transition in Nyeri town households.

This study was accomplished by examining fuel preferences of Nyeri town residents to understand how their choices shape the domestic energy transition process. Through establishing the patterns of energy use by the target population, the study formed an understanding of both the diversity underlying the energy transition and the fundamental principles that apply in Nyeri town.

2. MATERIALS AND METHODS

2.1 Description of the Study Area and Data Acquisition

The study was carried out in Nyeri town, Kenya. Nyeri town is the largest town by population in County government of Nyeri. Nyeri town comprise of 3 urban areas; Majengo, Kamakwa and Ruring'u. Based on the research gap identified, the study utilized household dataset that was acquired through a survey that was carried out by the lead researcher. The study used both primary and secondary data for the analysis. Primary data was obtained from a survey in Nyeri town – our area of study. Secondary data was obtained from an expansive review of literature from official statistical publications such as Economic Survey, Kenya National Bureau of Statistics, KNBS, report. The scope of the study was to provide a summary

assessment of domestic fuels preferences and domestic energy transition in Nyeri town. Nyeri town was selected as it is the largest by urban population in Nyeri County. It is a cosmopolitan town with an estimated population of over 100,000 residents. It serves as the administrative center for the county and regional center for the national government, and other organizations. Further, Nyeri town has established distribution networks for traditional, transitional and modern fuels [26,27].

A descriptive research design was adopted to manage the research. Walter and Bichanga [28] propose that a descriptive research design needs to define the target population, questions, survey and the analysis method before the start of data collection [28]. According to [26] urban population projections, there were 20,000 households in Nyeri town in the year 2018 [26]. Population projections are illustrated in appendix A and B. Study sample size was determined as follows [29]:

$$n = \frac{z^2 r(1-r)fk}{p n_h e^2} \tag{1}$$

Where ;

n	is the sample size in terms of the number of households to be adopted;
z	is the statistic that characterize the desired level of confidence;
r	is an impression of a critical indicator to be assessed by the survey;
f	is the sample design effect;
k	is a scale-factor to account for the expected rate of non-response;
p	is the percentage of the total population explained by the target population and whereupon the parameter, *r*, is based;
n_h	is the mean household size;
e	is the margin of error to be attained;

In this study;

z	= 1.96 for the 95% level of confidence according to [29];
r	= 26%, percentage of the Nyeri County population using modern sources of fuel according to [27];
f	= 2.0, according to [29];
k	= 10% according to [29];
p	= 71.15% according to [26];
n_h	= 4 according to [26];
e	= 0.10r according to [29];

Using equation (1);   n≈78

A stratified random sampling method was used in this research, to identify sample households. Stratified random sampling method ensures the inclusion of existing subgroups from the population in the final sample [29]. Table 1 shows the distribution of the research sample in the three major urban areas that form Nyeri town. A stratified sampling technique was undertaken by dividing the population in stratum representing Majengo, Kamakwa and Ruring'u urban areas. Sample size proportions were arrived at by determining the proportion of the target population from each of the urban areas.

A sample size of 78 households was considered an adequate representation of the entire population of the study. The lead author engaged sample members from the target population for a period of 6 days in December 2018. Within this time household energy data was collected which formed the base for this study. The study used structured copies of questionnaires as the primary data collection tools. Questionnaires were used because they generate uncomplicated data and allows expeditious analysis [29]. Prior to data collection, the researcher visited the sampled households for introduction, familiarization and getting consent from the household to participate in the study. A pilot survey was conducted from areas outside the target population to ascertain reliability of the data collection instrument. The respondents were evaluated on the type of domestic fuel preferred for cooking and lighting, reasons for fuel preference and fuel use patterns between the year 2014 and 2018.The study considered seven types of domestic fuels which are mainly consumed by Nyeri town households and classified them into three categories: Traditional fuels (firewood, charcoal), transitional fuel (kerosene) and modern fuels (LPG, biogas, solar photovoltaic (PV) cell and grid electricity).Four reasons for fuel preference were considered (fuel convenience, fuel affordability, cultural value associated with the fuel for example certain food taste better when prepared with a particular fuel, and ease of accessibility to a particular fuel). Further, the study sought to understand consumption pattern of the seven types of fuel by the sampled population for a period of five years (2014-2018). This formed a picture of the transition pattern over a period of 5 years. A correlation analysis was performed on the data to establish the relationship between fuel preferences and domestic fuel use patterns, signifying the transition process.

3. RESULTS AND DISCUSSION

3.1 Descriptive Analysis of Preferences for Cooking and Lighting Fuels

Table 2 shows the preferences for traditional, transitional and modern fuels from the sampled population. Table 4 shows the domestic fuel use between the year 2014 and 2018. The findings indicate that: 35.9% of the respondents strongly disagreed that they prefer using firewood in their households;51.3% of the respondents agreed that they prefer using charcoal in their households; 35.9% of the respondents strongly disagreed that they prefer using kerosene in their households; 59% of the respondents strongly agreed that they prefer using LPG in their household; 35.9% of the respondents disagree that they prefer using LPG in their households; 42.3% of the respondents disagree that they prefer using solar PV cell in their households; 48.7% of the respondents agreed they prefer using electricity in their households. Charcoal (69.2%), LPG (78.2) and electricity (92.3%) are dominant energy sources for Nyeri town urban households (Table 4). This may signify a desire for households to adopt modern forms of domestic energy. Firewood and kerosene are least preferred. Many of urban poor are recent migrants from the country side and remain dependant on traditional fuels. Subsidies on kerosene encourage kerosene use [20]. Contrast to this expectation, a majority of the respondents do not prefer using kerosene. Charcoal has a high preference and is among the dominant fuels. This seems to concern with findings by Karekezi et al. [18] which concluded that due to the already established distribution networks, charcoal remains the most affordable source of

fuel to the urban poor [18]. The use of charcoal decreased by 14.1% between the year 2014 and 2018.

3.2 Respondents' Reasons for Fuel Preference

The researcher sought to establish the reason behind the preferred type of fuel by the respondents. The findings are presented in Table 3. The study observed that 46.5% and 37.2% of the respondents respectively considered fuel convenience and affordability when deciding the fuel to use. Fuel convenience relate to cooking speed, cleanliness (does not produce smoke) and availability to the target population. This supports observations made by Masera et al; preferences for fuel switching are influenced by but are not limited to; fuel costs, convenience in sourcing, storing, and using modern fuels [24]. Cultural values have a negative influence on the transition to modern fuels, particularly where the use of traditional fuels is so deeply established such that modern fuels have little or no attractiveness even when potential savings are evident [30]. This imply people seek to utilize modern fuels since they are the most convenient. However, the cost of acquiring the modern fuel may be limiting, thus slowing their swift adoption.

3.3 Domestic Energy Transition between the Year 2014 and 2018

During the research, data of household fuel use from the year 2014 to 2018 was also collected in an effort to understand the domestic energy transition. The findings are presented in Table 4 while the energy consumption trends during the period are presented in Fig. 1. The findings

Table 1. Distribution of the research sample in the three major urban areas

Major urban area	Target population (households)	Percentage (%)	Sample size
Majengo	8488	45.8	36
Kamakwa	5077	27.4	21
Ruring'u	4973	26.8	21
Total	18538	100	78

Source: Department of Finance and Economic Planning Nyeri County (2016)

Table 2. Respondents' Preferences for fuel during the year 2018

Fuel preference	Strongly agree	Agree	Neither	Disagree	Strongly disagree
Firewood (%)	10.3	17.9	2.6	33.3	35.9
Charcoal (%)	15.4	51.3	6.4	15.4	11.5
Kerosene (%)	3.9	33.3	1.3	25.6	35.9
LPG (%)	59.0	28.2	0	12.8	0
Biogas (%)	15.4	21.8	12.8	35.9	14.1
Solar PV cell (%)	16.7	23.1	11.5	42.3	6.4
Electricity (%)	44.9	48.7	3.8	0	2.6

Source: Filled structured questionnaire

Table 3. Respondents' reason for fuel preferences

Reason for fuel preference	Responses	
	N	Percent
Convenience	40	46.5
Affordability	32	37.2
Cultural	5	5.8
Ease of accessibility	9	10.5
Total	86	100%

Source: Filled structured questionnaire

indicate that electricity use by the respondents between the year 2014 and 2018 increased from 88.5% to 97.4%. There has been a steady increase in LPG adoption by the respondents, from 64.1% to 89.7%, between the year 2014 and 2018. This may imply a rising adoption of modern domestic energy by Nyeri urban households. A majority of the households, 69.2%, used charcoal between the year 2014 and 2018. However, trends indicate a declining charcoal utilization. This may imply a cultural reason to prepare certain meals with charcoal. Kerosene use by the respondents steadily declined, from 51.3% to 33.3%, between the year 2014 and 2018. Biogas and solar energy adoption remained very low in comparison to LPG and electricity at 2.6% and 3.8% respectively between the year 2014 and 2018.

Mwangi [31] in her study on household energy consumption in Mukaro location - Nyeri County, observed that about 63% of the households used kerosene either for cooking or lighting [31]. This study observed that only 37.2% of the respondents prefer using kerosene in their households. The use of kerosene decreased by 18.0% between the year 2014 and 2018 in Nyeri town. Hazards associated with household use of kerosene due to its toxicity and flammability make kerosene less desirable [32]. This study observed utilization of tradition, transition and modern fuels by the sample population. All sample households were utilizing more than one type of fuel. This may imply the urban households are at different stages of domestic fuel transition. Households made the choice to consume a given type of fuel from available alternatives. Schlag and Zuzarte [30] made observations that fuel substitution is not perfect and households often use multiple fuels alongside one another [30]. Domestic energy consumption pattern in Nyeri urban area portrayed more of fuel stacking than fuel switching as households used multiple fuels. The well-established distribution network of domestic fuel imply that traditional, transitional and modern fuels are available to the households of Nyeri

town. Preferences of fuels by households influence their ultimate choice.

3.4 Correlation Matrix between Fuel Preferences and Domestic Energy Transition

A Pearson correlation test was performed to establish the relationship between fuel preference and the mean fuel use between the year 2014 and 2018, Domestic Energy Transition. The findings are presented in Table 5. The findings indicate positive correlation between preference for modern fuels (LPG, biogas, solar PV cell and electricity) and domestic energy transition between the year 2014 and 2018. Electricity is mainly preferred for lighting and powering small domestic appliances as opposed to cooking. LPG is preferred due to its convenience of speed and cleanliness (does not produce smoke during combustion). Solar energy is readily available in Nyeri town through the year; the cost of solar PV cell serves as the limiting factor. Further, the high cost of grid electricity drive people to prefer less costly sources of energy.

There exists a negative correlation between preference for firewood, kerosene and domestic energy transition during the period of year 2014 and 2018. Based on respondents' reason for fuel preference, firewood and kerosene are 'dirty' (they produce a lot of smoke due to incomplete combustion). Further, due to urban domestic setting, their use is not sustainable as it exposes the members of the household to health risk, in addition to risk of fire. Charcoal, a traditional fuel has a positive correlation to domestic energy transition between the year 2014 and 2018. This may be explained by cultural beliefs that preparing certain meals is best done using charcoal. Charcoal emits fewer pollutants and has a higher energy content and is simpler to transport [18]. Also, charcoal use in urban areas varies according to factors such as differences in price and availability of an alternative.

Table 4. Domestic fuel use between the year 2014- 2018

Transition stage	Year 2014	%	Year 2015	%	Year 2016	%	Year 2017	%	Year 2018	%	Mean for year 2014-2018	%
Firewood	23	29.5	20	25.6	18	23.1	19	24.4	18	23.1	20	25.6
Charcoal	60	76.9	56	71.8	53	67.9	53	67.9	49	62.8	54	69.2
Kerosene	40	51.3	38	48.7	34	43.6	33	42.3	26	33.3	34	43.6
LPG	50	64.1	55	70.5	65	83.3	66	84.6	70	89.7	61	78.2
Biogas	1	1.3	2	2.6	3	3.8	3	3.8	2	2.6	2	2.6
Solar PV cell	3	3.8	4	5.1	2	2.6	2	2.6	2	2.6	3	3.8
Electricity	69	88.5	68	87.2	73	93.6	74	94.9	76	97.4	72	92.3

Source: Filled structured questionnaire

Table 5. Correlation matrix between fuel preferences and domestic energy transition

	Firewood	Charcoal	Kerosene	LPG	Biogas	Solar PV cell	Electricity	Energy transition
Firewood	1	.625**	.610**	-.452**	.179	.350**	-.225*	-.560**
Charcoal	.625**	1	.535**	-.260*	-.025	.230*	-.223*	.421**
Kerosene	.610**	.535**	1	-.273*	.181	.257*	-.256*	-.579**
LPG	-.452**	-.260*	-.273*	1	.289*	.031	.087	.060
Biogas	.179	-.025	.181	.289*	1	.566**	-.240*	.286*
Solar PV cell	.350**	.230*	.257*	.031	.566**	1	-.275*	.451**
Electricity	-.225*	-.223*	-.256*	.087	-.240*	-.275*	1	.340**
Energy transition	-.560**	.421**	-.579**	.060	.286*	.451**	.340**	1

**. Correlation is significant at the 0.01 level (2-tailed).
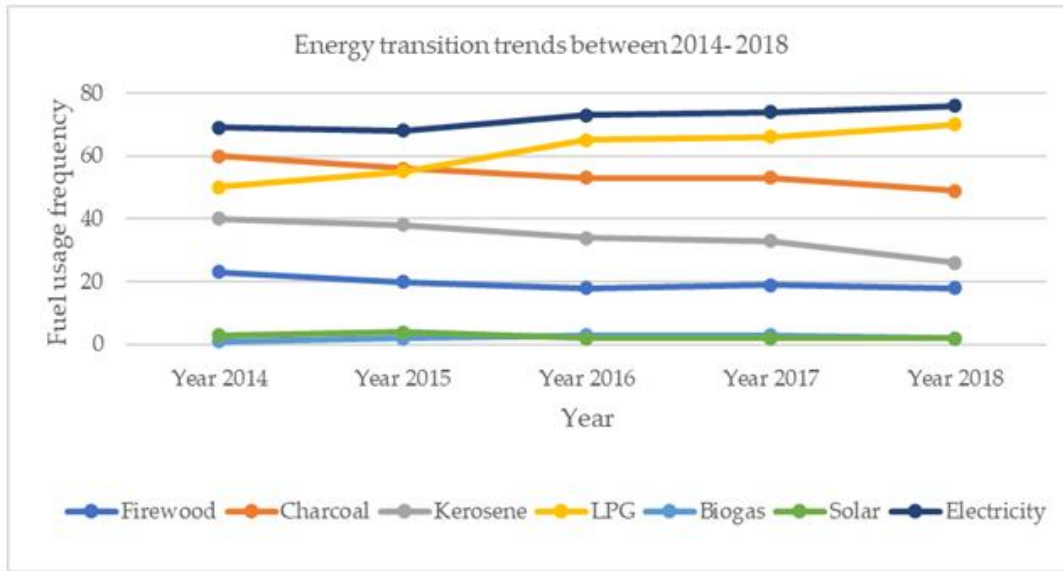**. Correlation is significant at the 0.05 level (2-tailed).*

Fig. 1. Energy transition trends between year 2014- 2018

4. CONCLUSION

In view of rising demand for clean domestic fuels, the transition to modern fuels is paramount to ensuring a sustainable future for the growing urban population. However, limited understanding of factors influencing household energy transition limits the expeditious realization of sustainable development goal 7 of the UN. In this paper, a study was made of the factors influencing domestic energy transition through the analysis of respondents' preference for domestic fuels and the reasons thereof. It was concluded that fuel preference greatly influences the use of the particular fuel. Charcoal, LPG and electricity are most preferred by 51.3%, 59.0% and 48.7% of the urban households. Charcoal (69.2%), LPG (78.2) and electricity (92.3%) are dominant energy sources for Nyeri town urban households. There exists a positive correlation between preference for charcoal (0.421), LPG (0.06), and electricity (0.34) and domestic energy transition between the year 2014 and 2018. Firewood (35.9%), kerosene (35.9%), biogas (35.9%) and solar PV cells (42.3%) are the least preferred by the urban households. Consequently, firewood, kerosene, biogas and solar PV cells contribute 25.6%, 43.6%, 2.6% and 3.8% respectively to the urban energy sources. Adoption of biogas and solar PV cells as clean energy sources has remained relatively low (less than 4%) over the period of 5 years. Charcoal, despite being a traditional fuel, has remained dominant, being used by more than 60% of the urban households between the year 2014 and 2018. About 46.5% and 37.2% of the households considered fuel convenience and affordability respectively when deciding the fuel to use. The study established there exists a positive correlation between utilization of modern fuels; LPG, biogas, solar PV cell, electricity at 0.06, 0.286, 0.451 0.34 respectively and domestic energy transition. Improving modern fuel affordability through favourable policies is key to fast track transition towards clean domestic fuels. As a follow-up of this study, an analysis of government input as the main stakeholder of the energy market should be performed. Through regulations, the government can establish 'friendly' policies that seek to reduce the cost of acquiring and maintaining modern sources of domestic energy.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Appendix A. Population projections by urban centre in Nyeri County

Urban Centre	2009 (Census)			2013 (Projections)			2015 (Projections)			2017 (Projections)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Nyeri Town	31885	31741	63626	32503	32356	64859	32817	32668	65485	33133	32984	66117
Karatina	3594	4634	8228	3664	4724	8388	3699	4769	8468	3735	4815	8550
Naromoru	2965	2840	5805	3022	2895	5917	3052	2923	5975	3081	2951	6032
Othaya	2385	2752	5137	2431	2805	5236	2455	2832	5287	2478	2860	5338
Mweiga	1698	1885	3583	1731	1922	3653	1748	1940	3688	1764	1959	3723
Endarasha	1429	1620	3049	1457	1651	3108	1471	1667	3138	1485	1683	3168
Total	43956	45472	89428	44808	46353	91161	45242	46799	92041	45676	47252	92928

Source: Kenya national bureau of statistics, 2013

Appendix B. Population of sub-locations within municipality division

Sub-Location	Male	Female	Total	Households	Area In Sq Kms	Density (Per Sq Km)
Majengo	13353	11665	25018	8168	6.5	3848
Kihuyo	1073	1079	2152	558	4.8	449
Karia	1586	1678	3264	912	3.5	927
Thuguma	4360	4515	8875	2852	17.9	496
Githiru	1141	1211	2352	640	5	468
Muthuaini	1765	1776	3541	939	6.2	576
Kihatha	876	911	1787	483	3.3	549
Riamukurwe	1715	1782	3497	894	6.9	505
Gatitu	1046	1083	2129	650	5.1	420
Kamakwa	6843	7281	14124	4886	5.9	2388
Marua	1077	1194	2271	610	4.7	487
Mathari	4080	3943	8023	2094	38.7	207
Ruringu	6295	7087	13382	4785	3.3	4092
Chorongi	2670	2844	5514	1446	8.1	677
Kinunga	640	657	1297	370	2.2	585
Munungaini	1377	1644	3021	776	4.5	670
Muruguru	1282	1398	2680	725	5.7	470
Gitathini	1326	1323	2649	706	2.8	957
Total (Mukaro Location)	52505	53071	105576	32494	135	782
Kiganjo	2196	1251	3447	924	5.4	636
Gachika	1270	1364	2634	680	7	375
Kirichu	2187	2301	4488	1329	9.7	464
Nyaribo	1595	1533	3128	985	10.6	294
Total (Kiganjo Location)	7248	6449	13697	3918	32.7	418

Source: KNBS (2010)