

## Household Lighting Fuel Costs in Kenya

This Market Intelligence Note presents empirical data from the 2005/06 Kenya Integrated Household Budget Survey on the expenditure for lighting fuels and the adoption of solar home systems among Kenyan households. A key finding is that median expenditure on kerosene by Kenyan households that used this fuel for lighting was 2% of total income.

### Introduction<sup>1</sup>

The Kenya Integrated Household Budget Survey (KIHBS) carried out by the Kenya National Bureau of Statistics (KNBS) in 2005/06 offers unique insights into the lighting fuel choices of a representative sample of Kenyan households. Moreover, by collecting data on a wide range of topics, it provides a solid quantitative basis for the analysis of many socio-economic questions. Specifically, the KIHBS dataset contains a wealth of data related to the consumption of energy sources in relation to lighting and cooking. It has been used by a number of researchers to address questions related to grid extension as opposed to off-grid electrification (Zeyringer et al., 2011), the demand for rural grid connections (Abdullah and Jeanty, 2009), and lighting fuel choice and the determinants of solar home system (SHS) adoption (Lay et al., 2012), among others.

This Lighting Global Market Intelligence Note is specifically aimed at practitioners, policy-makers, and academics interested in the potential for and use of alternative lighting technologies (e.g., solar energy technologies) to displace the currently-prevailing lighting fuels (e.g., kerosene and firewood), which are commonly associated with substantial social, environmental, and economic costs (Ekholm et al., 2010). The Note builds upon a previous study by three of the authors, which contains additional information on the KIHBS methodology and dataset, as well as research results on lighting fuel choice in general and the determinants of SHS adoption in particular (Lay et al., 2012).

According to the KIHBS, kerosene (in the survey also referred to as paraffin) was the dominant lighting fuel among Kenyan households (Table 1). Nearly three quarters of all Kenyan households stated that their main lighting fuel was kerosene, followed by electricity and collected firewood (Table 1). Solar and dry cells (torches) were less common, but still used by a number of households as the main lighting fuel. The most common combination of lighting fuels for households that used more than one fuel was a combination of kerosene and dry cells. In cases where kerosene was not the primary fuel, it was typically the secondary fuel (Lay et al., 2012).

**Table 1. Main sources of lighting, in percent (source: authors' calculations based on KNBS, 2005/06)**

Fuel Type	Main Lighting Fuel (%)	Secondary Lighting Fuel (%)
Collected firewood	6.4	12.3
Purchased firewood	0.2	1.1
Grass	0.2	0.2
Kerosene	73.5	20.8
Electricity	16.4	2.0
Solar panels	1.4	1.4
Gas	0.2	0.9
Dry cell (torch)	1.4	48.3
Candles	0.2	12.6
Biogas	0.2	0.1
Other	0.0	0.5
<b>Number of observations</b>	<b>12,990</b>	<b>4,479</b>
Note: Table shows national data.		

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### Kerosene Consumption

Almost all households surveyed stated that they used kerosene in one way or another. Of those respondents who used kerosene, the vast majority (81.2%) used it primarily as a lighting fuel (Table A.1). Cooking was the second most important primary use of kerosene (15.9%).

Table A.1 suggests that the majority of kerosene consumed was used for lighting, implying that most of the stated kerosene expenditure must have been for meeting lighting needs. Because households reported monthly expenditures on kerosene and other fuels in the KIHBS, absolute and relative expenditure levels on kerosene can be derived by combining this information with stated annual household incomes and dividing the survey sample into income quartiles.<sup>2</sup> Assuming that most (if not all) kerosene was used for lighting, the data suggest that the median Kenyan household spent 156 KSh/month on kerosene for lighting, with absolute monthly expenditure increasing by quartile.<sup>3</sup> The annual expenditure on kerosene decreased from almost 3% in the 1<sup>st</sup> quartile to a little over 1% in the 3<sup>rd</sup> quartile, with the median being slightly above 2% (Table A.2).

### Electricity Use and Consumption

Electricity was the second most important main lighting fuel (Table 1), but its use was mostly limited to households connected to the grid. Of course, electricity as a modern lighting fuel is not associated with some of the negative socio-economic and environmental side-effects mentioned in the introduction; therefore, data on electricity consumption should help to assess households' willingness and ability to pay for modern

<sup>2</sup> In line with the survey methodology, annual household expenditure is used as a proxy for household income. Annual median income for the four quartiles was 38,901 KSh (1<sup>st</sup> quartile), 74,610 KSh (2<sup>nd</sup> quartile), 118,511 KSh (3<sup>rd</sup> quartile), and 236,639 KSh (4<sup>th</sup> quartile).

<sup>3</sup> The USD-KSh exchange rate in 2005/06 stood at 1:74 (i.e., KSh 156 corresponds to 2.11 current 2005/06 USD).

lighting services. It should be stressed that when interpreting the following data, one must assume that not all electricity consumed was used for lighting purposes (especially in the case of higher income households). However, the survey shows that the primary use of electricity in the vast majority (95%) of households is for lighting, suggesting that a major share of electricity is consumed for this purpose (Table A.3).

Regarding absolute and relative expenditure on electricity, the same pattern emerges as in the case of kerosene. While absolute monthly expenditure increased by quartile (quartiles being defined over the whole population), readers should note the steep increase between the 3<sup>rd</sup> quartile (200 KSh/month) and 4<sup>th</sup> quartile (500 KSh/month). This observation is even more important as the largest number of electricity users are in the 4<sup>th</sup> income quartile (1,153, or 72% of all electricity users). Median monthly expenditure on electricity amounted to 332 KSh, or slightly less than 2% of the median household's annual income. As seen before for kerosene, the share of income spent on electricity decreases from almost 3% to below 2% from the 1<sup>st</sup> quartile to the 4<sup>th</sup> quartile, but the overall reduction is less dramatic than in the case of kerosene (Table A.4).

Regarding electricity sources, the vast majority of households (88.7%) who use electricity reported receiving power mainly from the Kenya Power & Lighting Company (KPLC), Kenya's national electricity distribution company.<sup>4</sup> Solar panels are the second most important source (9.2%) among those who use electricity at home, with the remaining 2.1% of households indicating they receive power mainly from

<sup>4</sup> Households were asked, "What is household main source of electricity?" if they reported using electricity (independent of source) or solar as their main or secondary lighting fuel. The range of possible sources they could then identify were KPLC, community or personal generator, solar panels, car or motorcycle battery, or "other."

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diesel generators and car batteries.<sup>5</sup> The median KPLC customer spent 352 KSh/month on his or her electricity bill (slightly, but not significantly, higher than the median presented in Table A.4). As discussed above, it is not possible to determine what fraction of this cost is devoted to lighting services (KNBS, 2005/06).

## Expenditure on Wood Fuel

Collected firewood was reported to be the third most important *primary* lighting fuel source and the fourth most important *secondary* lighting fuel source (Table 1). Firewood, both collected and purchased, was predominantly used for cooking (96.9% and 95%, respectively). Very few households reported using wood primarily for lighting (Table A.5). This is not surprising, as much of the lighting from firewood (as seen in Table 1) was derived as a by-product of cooking with firewood.

No cost or expenditure data were reported for collected firewood; therefore, this section presents some analysis based on purchased firewood, assuming that findings in terms of absolute and relative spending on purchased firewood can be used as approximations of households' effort to collect firewood. This is an imperfect assumption, but it does reflect the fact that firewood collection involves opportunity costs associated with the time spent on collection. Nonetheless, when interpreting the results presented in Table A.6, it is important to bear in mind that the vast proportion of household firewood expenditure was for cooking purposes, not lighting.

## Dry Cell Battery Consumption

According to the data presented in Table 1, dry cell batteries were the most frequently named secondary lighting fuel source (48.3%), with most households

<sup>5</sup> The limited importance of car batteries reported by households contrasts with earlier research that found a large number of households using such batteries for their off-grid electricity needs (e.g., Jacobson, 2007).

using a combination of kerosene as their main lighting fuel and dry cells for torch lights (i.e., flashlights) as their secondary lighting source (Lay et al., 2012). According to the survey data, more than half of all households reported using dry cell batteries in the month prior to being interviewed, and nearly all households replied to the respective question (Table A.7).

Based on the information presented above, it can be assumed that many of the dry cell batteries used by households served the purpose of powering a torch light. However, when interpreting the cost data for dry cell batteries, readers need to once again consider that it is unclear whether dry cell expenditure actually went towards lighting services or whether the cells were used for powering other electric devices, such as radios. With this caveat in mind, the data suggest that the median Kenyan household spent 35 KSh/month on dry cells for all purposes, with absolute monthly expenditure increasing from the 1<sup>st</sup> quartile to the 3<sup>rd</sup> quartile and then leveling off. Most striking, in the 1<sup>st</sup> income quartile the reported median expenditure on dry cells was 0 KSh. Relative to annual income, the expenditure on dry cells initially increased from 0% in the 1<sup>st</sup> quartile to nearly 0.6% in the 2<sup>nd</sup> quartile, and then decreased to just 0.24% in the 4<sup>th</sup> quartile, with the overall median expenditure being 0.29% (Table A.8).

## Lighting Costs

In a different section of the KIHBS survey, households were asked to report their monthly cost of lighting, *excluding* the cost of electricity (which includes electricity from solar panels). As can be seen from Table A.9, these data allow for the presentation of households' median overall expenditure on lighting for both their stated main and secondary lighting fuel.<sup>6</sup>

<sup>6</sup> It should be noted that the expenditure reported here is for all lighting fuels and the table therefore does not allow one to disaggregate expenditure by main, secondary, and other lighting fuels.

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Table A.9 suggests that households using kerosene as their main lighting fuel had a median expenditure of 150 KSh/month for lighting (most of which was probably spent on kerosene), whereas electricity users spent an additional 50 KSh on other lighting fuels. Households using collected firewood as the main lighting fuel spent a median 100 KSh/month on lighting (with a high probability of this being kerosene). Interestingly, owners of solar home systems (SHS) seemed to need substantial amounts of additional lighting fuels to meet their overall lighting demand, as they reported spending a median 120 KSh/month on other lighting fuels.

Households using dry cells as their secondary lighting fuel reported a median monthly expenditure of 161 KSh for all lighting fuels (Table A.9). Based on the evidence presented before, this expenditure was likely to be split primarily between kerosene (as the most common main fuel source) and dry cells (as the most common secondary fuel source). However, it is unfortunately not possible to determine from the data which fuel source accounted for which proportion. Readers should note the close match between the expenditure levels reported in Table A.9 and the expenditure levels presented in earlier tables.

The low reported median monthly cost for households using kerosene as their secondary lighting fuel (60 KSh/month) may stem from these households using collected firewood as their main source. Households using collected firewood as their main source of lighting spent little on other lighting fuels, and in many cases these expenditures were for kerosene as their “backup” fuel. On the other hand, households using candles as their secondary fuel (median expenditure on lighting of 69 KSh/month) predominantly relied on electricity (59.2%) and kerosene (39.6%) as their main fuels, of which only the latter should be represented in the stated total cost of lighting.

The total monthly cost of lighting (excluding electricity) for the median household using kerosene as its main lighting fuel increased from 100 KSh/month for the 1<sup>st</sup> quartile to 250 KSh/month for the 4<sup>th</sup> quartile. Conversely, for households with kerosene as their secondary lighting fuel, no such increase could be observed (Table A.10). This suggests that households using kerosene only as their secondary lighting fuel (and hence some other fuel as their main lighting fuel) generally spent less on lighting overall (excluding electricity). Likewise, households using dry cells as their secondary lighting fuel reported median total costs as rising from 110 KSh/month for the 1<sup>st</sup> quartile to 250 KSh/month for the 4<sup>th</sup> quartile (Table A.11).<sup>7</sup>

The same pattern of absolute spending on lighting (excluding electricity) increasing by quartile can also be observed in the case of collected firewood as the secondary lighting fuel, where the median monthly expenditure steadily increased from 80 KSh/month for the 1<sup>st</sup> quartile to 180 KSh/month for the 4<sup>th</sup> quartile (2<sup>nd</sup> quartile: 118 KSh/month, 3<sup>rd</sup> quartile: 174 KSh/month). Interestingly, median expenditure if candles are used as the secondary fuel remained fairly stable between 50 KSh/month and 100 KSh/month across quartiles (1<sup>st</sup> and 4<sup>th</sup> quartiles: 50 KSh/month; 2<sup>nd</sup> and 3<sup>rd</sup> quartiles: 100 KSh/month). The overall number of observations is relatively small (N = 428), however, and most of these observations correspond to the 3<sup>rd</sup> and 4<sup>th</sup> quartiles.

### Conclusions

Kerosene is the single most important lighting fuel used in Kenya, as evidenced by a median monthly expenditure on kerosene of 165 KSh according to the 2005/06 KIHBS survey. The second most important

<sup>7</sup> Readers should note that Table A.10 and Table A.11 present the total cost of lighting, whereas the corresponding Table A.2 and Table A.8 **Error! Reference source not found.** show the stated expenditure on kerosene and dry cells, respectively. Therefore, the tables cannot be compared directly.

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lighting fuel, electricity, is a modern fuel and households using it spent a median 332 KSh/month to use it. However, households in the lower income quartiles were typically not connected to the grid. Lighting from wood is usually a by-product of cooking with firewood. Therefore, expenditure on wood specifically for lighting was likely negligible. Dry cells were the fourth most important secondary lighting fuel, but median expenditure on dry cells was relatively low (35 KSh/month). In contrast, owners of solar home systems (SHS) reported spending a median 120 KSh/month on alternative lighting fuels—primarily kerosene—to meet their overall lighting needs, compared to only 50 KSh/month spent on alternative lighting fuels by other electricity users. This suggests that the SHS in place did not enable households to meet their total lighting needs without additional lighting fuels.

## References

1. Abdullah, S., Jeanty, P.W. (2009), Demand for Electricity Connection in Rural Areas: The Case of Kenya, Working Paper 26/09, Department of Economics, University of Bath.
2. Ekholm, T., Krey, V., Pachauri, S., Riahi, K. (2010), Determinants of household energy consumption in India, *Energy Policy* 38, 5696-5707.
3. Jacobson, A. (2007), "Connective Power: Solar Electrification and Social Change in Kenya," *World Development*, v35, n1, pp. 144-162.
4. KNBS (2005/06), Kenya Integrated Household Budget Survey 2005-2006, Version 1.0 of the KNBS dataset, Kenya National Bureau of Statistics, Nairobi.
5. Lay, J., Ondraczek, J., Stöver, J. (2012), Renewables in the Energy Transition: Evidence on Solar Home Systems and Lighting-Fuel Choice in Kenya, GIGA Working Paper No 198, July 2012, Hamburg.
6. Zeyringer, M., Morawetz, U., Pachauri, S., Schmid, E., Schmidt, J., (2011), Stand-alone vs. grid extension for electrification in Kenya - Development of a spatial explicit energy system model, Proceedings of the 34th IAEE International Conference, Stockholm.

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## Appendix A.

**Table A.1. Primary use of kerosene (source: authors' calculations based on KNBS, 2005/06)**

Purpose of use	Frequency	Percent
Boiling	206	1.9
Heating	83	0.8
Cooking	1,747	15.9
Lighting	8,947	81.2
Other	42	0.4
<b>Number of observations</b>	<b>11,025</b>	<b>100.0</b>
Note: Table shows national data.		

**Table A.2. Median expenditure on kerosene by quartile, absolute, and as a percentage of annual income (source: author's calculations based on KNBS, 2005/06)**

Income Quartile	Absolute Monthly Expenditure (KSh)*	Percent of Annual Income Spent on Fuel
1	100	2.91
2	150	2.30
3	200	1.96
4	250	1.26
<b>Total</b>	<b>156</b>	<b>2.01</b>
Note: Table shows national data.		
* Blank data entries for kerosene expenditure data for households that reported they were not using kerosene was set to 0 KSh. This reduces median monthly expenditure on kerosene from 160 KSh to the 156 KSh presented here (a reduction of 2.5%).		

**Table A.3. Primary use of electricity (source: authors' calculations based on KNBS, 2005/06)**

Purpose of use	Frequency	Percent
Boiling	36	1.8
Cooking	49	2.4
Lighting	1,927	95.0
Other	17	0.8
<b>Number of observations</b>	<b>2,029</b>	<b>100.0</b>
Note: Table show national data.		

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Table A.4. Median expenditure on electricity by quartile, absolute, and as a percentage of annual income (source: author's calculations based on KNBS, 2005/06)

Income Quartile	Absolute Monthly Expenditure (KSh)*	Percent of Annual Income Spent on Fuel
1	100	2.74
2	150	2.15
3	200	1.95
4	500	1.82
<b>Total</b>	<b>332</b>	<b>1.93</b>

Note: Table shows national data.  
\* Blank data entries for electricity expenditure data for households that reported they were not using electricity was set to 0 KSh. This reduces the median monthly expenditure from 350 KSh to the 332 KSh presented here (a reduction of 5.1%).

Table A.5. Primary use of collected and purchased firewood (source: authors' calculations based on KNBS, 2005/06)

Purpose of use	Collected Firewood		Purchased Firewood	
	Frequency	Percent	Frequency	Percent
Boiling	109	1.5	64	3.4
Cooking	61	0.8	18	0.9
Lighting	7,280	96.9	1,817	95.0
Other	63	0.8	10	0.5
<b>Number of observations</b>	<b>7,516</b>	<b>100.0</b>	<b>1,912</b>	<b>100.0</b>

Note: Table shows national data.

Table A.6. Median expenditure on purchased firewood by quartile, absolute, and as a percentage of annual income (source: author's calculations based on KNBS, 2005/06)

Income Quartile	Absolute Monthly Expenditure (KSh)*	Percent of Annual Income Spent on Fuel
1	50	1.53
2	100	1.40
3	150	1.55
4	250	1.21
<b>Total</b>	<b>120</b>	<b>1.38</b>

Note: Table shows national data.  
\* Blank data entries for firewood expenditure data for households that reported they were not using purchased firewood was set to 0 KSh. This reduces the median monthly expenditure from 200 KSh to the 120 KSh presented here (a reduction of 40%).

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Table A.7. Use of torch batteries (dry cells) (source: authors' calculations based on KNBS, 2005/06)

Batteries used	Frequency	Percent
Yes	7,187	55.3
No	5,802	44.7
<b>Number of observations</b>	<b>12,989</b>	<b>100.0</b>
Note: Table shows national data.		

Table A.8. Median expenditure on dry cells by quartile, absolute, and as a percentage of annual income (source: author's calculations based on KNBS, 2005/06)

Income Quartile	Absolute Monthly Expenditure (KSh)*	Percent of Annual Income Spent on Fuel
1	0	0.00
2	35	0.57
3	50	0.51
4	50	0.24
<b>Total</b>	<b>35</b>	<b>0.29</b>
Note: Table shows national data.		
* Blank data entries for dry cell expenditure data for households that reported they were not using dry cells was set to 0 KSh. This reduces the median monthly expenditure from 80 KSh to the 35 KSh presented here (a reduction of 56%).		

Table A.9. Median total cost of lighting (excluding electricity) by fuel source (source: authors' calculations based on KNBS, 2005/06)

Fuel Type	Main Lighting Fuel		Secondary Lighting Fuel	
	Cost (KSh/month)	Number of Responses	Cost (KSh/month)	Number of Responses
Collected firewood	100	258	104	532
Purchased firewood	135	24	135	46
Grass	150	19	150	7
Kerosene	150	9,437	60	736
Electricity	50	1,024	150	49
Solar panels	120	121	200	59
Gas	175	26	180	33
Dry cell (torch)	100	70	161	2,086
Candles	100	27	69	428
Biogas	n.a.	n.a.	104	1
Other	240	7	230	18
<b>Total</b>	<b>150</b>	<b>11,013</b>	<b>140</b>	<b>3,995</b>
Note: Table shows national data				



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Table A.10. Median total cost of lighting (excluding electricity) if kerosene is used as the main or secondary fuel, by quartile (source: author's calculations based on KNBS, 2005/06)

Income Quartile	Main Lighting Fuel (KSh/month)	Secondary Lighting Fuel (KSh/month)
1	100	69
2	150	50
3	200	60
4	250	80
<b>Total</b>	<b>150</b>	<b>60</b>
<b>Number of Observations</b>	<b>9,434</b>	<b>735</b>
Note: Table shows national data		

Table A.11. Median total cost of lighting (excluding electricity) if dry cells are used as the secondary fuel, by quartile (source: author's calculations based on KNBS, 2005/06)

Income Quartile	Cost of Lighting (KSh/month)	Number of Responses
1	110	359
2	150	567
3	200	644
4	250	515
<b>Total</b>	<b>161</b>	<b>2,085</b>
Note: Table shows national data.		