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The True Cost of Kerosene in Rural Africa




Report Authorship and Research Design

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The primary author of this article is Jennifer Tracy, who completed the work under a consultancy to the IFC of the World Bank Group. Ms. Tracy, who was based at the IFC's office in Nairobi, also led the field team that conducted the field research over six months in 2010 and 2011.
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Executive Summary

This study reveals a substantial disparity between the per liter price of kerosene at fuel pumps in urban centers compared to the price for small volume purchases from kerosene vendors in rural villages. In the rural villages in five African countries, Senegal, Mali, Ghana, Tanzania and Kenya, the median price per liter of kerosene for small volume purchases was 35% higher than prices found in nearby urban centers. This means that estimates of the economic payback period for people who replace fuel based lighting with modern off-grid lighting, which often involve the use of urban kerosene prices to estimate baseline lighting fuel costs, tend to understate the benefits of making the switch. The true cost of kerosene to rural consumers, as revealed by this study, indicates that the typical payback period for a switch to modern off-grid lighting is on the order of 26% shorter than would be indicated by an analysis that uses urban kerosene prices.

Over the past decade, oil prices have fluctuated dramatically with a generally upward trend. Kerosene prices tend to track world oil prices, which subjects those who rely on kerosene for lighting to prices that are both volatile and increasing. Given the price premium that many rural people pay for small volume purchases from rural kerosene sellers, the savings in avoided kerosene purchases for those who switch to modern off-grid lighting will be even greater for rural households than for their urban counterparts.

Finally, this study also highlights a scarcity of kerosene in West Africa, where it was observed that households now more commonly light their homes with candles or low-cost dry cell battery powered lamps than with kerosene.

Introduction

In rural communities throughout Africa daily earnings are meager, and many families buy daily necessities in small quantities that suffice only until the following day. Kerosene, used as a lighting source, is one such necessity. Previous off-grid lighting field observations in Kenya has indicated that in rural villages people tend to purchase kerosene in small quantities that are well under one-liter. These observations also suggest that the cost per liter of kerosene for rural villagers buying in small quantities is generally higher than the pump price for larger purchases from petrol stations.

Economic analyses that compare the cost of modern off-grid lights, including many that are solar powered, have frequently been based on national kerosene prices per liter found in industry statistics or pump prices at petrol stations.[1] However, to our knowledge there has been no systematic documentation of the true cost of kerosene in rural areas when purchases are made in small quantities.

This study documents the rural price of kerosene in five African countries: Senegal, Mali, Ghana, Tanzania and Kenya. The goal is to document the cost of kerosene for those who buy in small quantities in order to better inform cost benefit analyses for the transition from kerosene lighting to modern off-grid lighting systems.

The timing of this study comes after a decade of kerosene price volatility that includes a generally increasing trend (Figure 1). This trend is closely linked to world oil prices, thereby subjecting kerosene users to the price fluctuations of the global oil market.

In this time of volatility and increasing cost, the economic benefits of switching from a kerosene-based lighting source to good quality, modern off-grid lamps are significant.[2] As this study will demonstrate, the benefits are even larger for rural kerosene users who currently buy in small quantities.

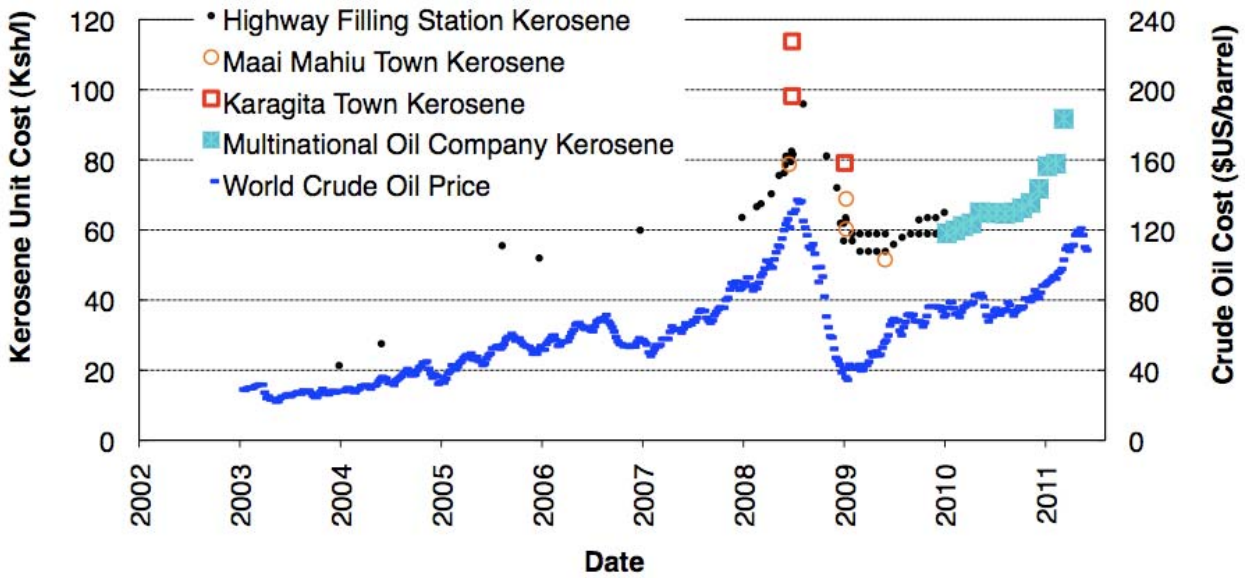

Figure 1: Historical unit prices of Kenyan kerosene and world crude oil from 2003 to 2011. Kenyan kerosene prices are from petrol stations in the Rift Valley region and price data from a leading multinational petroleum company. The monthly world average crude oil prices are from EIA, 2011.

[1] e.g., Mills, E. and A. Jacobson (2007) "The Off-Grid Lighting Market in Western Kenya: LED Alternatives and Consumer Preferences in a Millennium Development Village," Lumina Project Technical Report #2.

[2] Radecsky, K., P., Johnstone, A., Jacobson, E., Mills. 2007. Solid-State Lighting on a Shoestring Budget: The Economics of Off-Grid Lighting for Small Businesses in Kenya. Lumina Project. Technical Report #3.

Methodology

The data collection for this study was carried out in parallel with another study focused on consumer preferences in relation to aspects of the Lighting Africa quality assurance program. The data collection points in each of the five countries therefore mirrored the general sites selected for the other study. In each area specified, an urban center was identified around which a circumference could be drawn capturing the nearby rural villages that relied upon that center (Table 1). The data for this study were collected within that radiating boundary with an initial focus on the villages targeted by the primary study. In regions where kerosene vendors were scarce, the collection points extended beyond the villages involved in the primary study to other nearby villages.

In each region two sets of data were collected:
1) kerosene prices from pumps located in the urban centers selling by the liter, and
2) kerosene prices for small quantities of kerosene purchased from village vendors; the amounts purchased were typical of the quantities commonly purchased by the local villagers.

The price per liter for kerosene in the urban centers was either recorded from petrol station signs displaying the cost or, when unavailable or when the displayed price appeared dubious, from an employee operating the pump. To assess the price of kerosene available to rural villagers who buy in small quantities, kerosene samples were purchased by one of the in-country assistants.[3]

Table 1: List of the urban centers surveyed in this study and the approximate distance between the urban center and the rural villages where kerosene was purchased.

Country	Urban Center	Distance (km) [Urban Center to villages]
Senegal	Fatick	13
	Tambacounda	25
	Richard Toll	30
	Dakar	6
Mali	Siribala	3-7
	Djoliba	3-9
	Garalo	1-12
	Bamako	10
Ghana	Sunyani	10-14
	Ho	20-76
Tanzania	Arusha	7
	Morogoro	3-10
	Mwanza	10-13
Kenya	Kisumu	8
	Eldoret	10
	Meru	16-46
	Kilifi	10-25

For the rural kerosene samples the research team sought to identify five kerosene vendors in the rural areas near the urban center. In a few regions five vendors could not be identified despite many hours of searching and inquiring with local villagers. In such cases kerosene was purchased from the available vendors. Two samples of kerosene were purchased from each vendor. The two small quantities varied from site to site, but they represented typical amounts purchased by local villagers. The two amounts purchased were neither consistent among all the shops visited, nor within each country or between countries.

Feedback from villagers and kerosene vendors about amounts typically bought or sold, respectively, guided the amounts of kerosene that were purchased. However, in general, the two quantities purchased from each vendor differed from each other by approximately 50%. The purchased samples were then measured in a graduated cylinder, the price paid for the quantity was recorded, and the cost per liter was calculated.

[3] In each country the in-country assistance reassured our team that regardless of who purchases the kerosene the same quantity will be given the same price as paid by the local villagers. There kerosene was typically measures with a device such as a coke bottle, medicine jar, tin cup or dipper. One set quantity (e.g. one full tin cup) had a set price and this was not negotiable.

The underlying data for Figure 1, which shows the relationship between world oil prices and kerosene prices, were collected from several sources. World oil prices were collect from the EIA website,[4] a division of the U.S. Department of Energy. The kerosene prices in the figure are from four sources, including three petrol stations located in rural towns in the lower Rift Valley of Kenya (Maai Mahiu, Karagita and Naivasha)[5] and a dataset provided by a leading multinational petroleum company that sells kerosene from retail petrol stations in Kenya.[6]

Results and Discussion

Across all five countries, the median price per liter of kerosene sold in small quantities in the rural villages was 35% higher than the median price recorded in the urban centers, $US 1.30 versus $US 0.96, respectively. This indicates a distinct difference between the cost per liter of kerosene sold at pumps in urban centers and the cost of kerosene when purchased in small quantities in nearby villages. The greatest difference was in Ghana, which had a 170% median price increase; the smallest difference was in Tanzania at 23% (Figure 2).

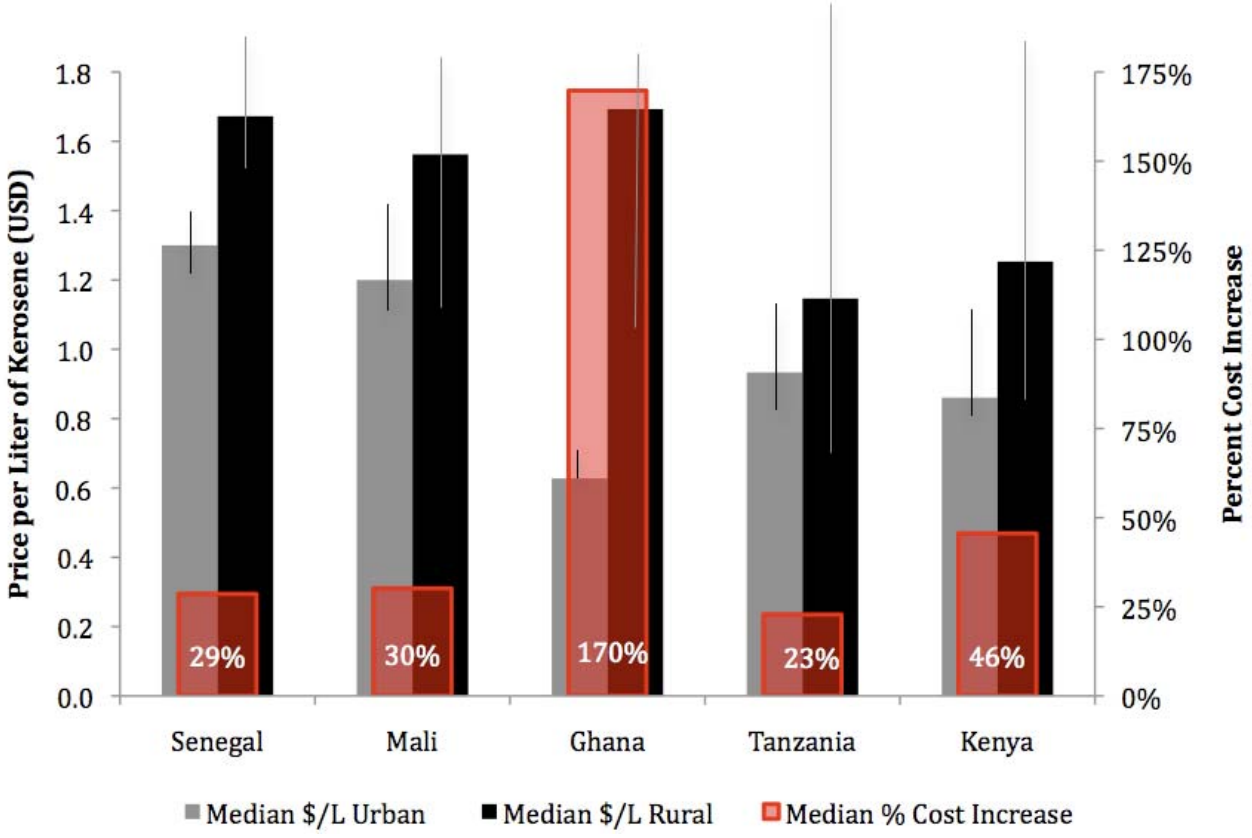

Figure 2: Median price per liter of kerosene recorded at pumps in urban centers versus the cost when purchased in small quantities from rural village vendors within each country; the median cost increase between the two prices is also shown. Error bars indicate the range in prices found.

It is also very important to point out that in some regions the availability of kerosene was limited or even non-existent. Table 2 shows the number of regions in each country included in the study and the prevalence of kerosene selling points in both the urban centers and their respective rural areas.

[4] http://www.eia.doe.gov/dnav/pet/pet_pri_wco_k_w.htm
[5] This dataset spans from December 2003 to January 2010 and from March 2011 until May 2011. There is a 13 month gap in the data from February 2010 to March 2011.
[6] Data received in June, 2011 courtesy of a leading multinational petroleum company.

Table 2: Availability of kerosene in urban and rural areas in five African countries.[7,8]

	Senegal	Mali	Ghana	Tanzania	Kenya
# Of Regions in Study	4	4	2	3	4
Availability in Urban Area[7]	Very Scarce	Scarce	Moderately Available	Readily Available	Readily Available
Availability in Rural Area[8]	Very Scarce	Moderately Available	Scarce	Readily Available	Readily Available

Kerosene was much more widely available in the East Africa countries than in the West Africa countries in the study. Kerosene vendors were easily found in both urban and rural areas in Kenya and Tanzania. In Senegal, in contrast, the research team was not able to find any kerosene vendors in three of the four rural areas surveyed. In the urban centers surveyed in Senegal only one kerosene pump was located within each town. In the one region where kerosene was more prevalent, Fatick, only two pumps were located in the urban center and only four village vendors were located.

The cause of the scarcity of kerosene in Senegal was not determined during the study, but some people indicated that imports had been reduced due to high world oil prices. A 2010 World Bank Group study on the supply chain of petroleum products in multiple Sub-Saharan African countries also noted the practically nonexistence of kerosene in Senegal.[9]

In Mali, village kerosene vendors were reasonably common in three of the four regions, but in the corresponding urban center the number of kerosene pumps was more limited. The one region in Mali where village kerosene vendors were sparse was Garalo, with only two village vendors located and only one pump in town selling. In Ghana, only two regions were surveyed. In the Sunyani region of Ghana four pumps in town were located, but no village kerosene vendor was found.[10] In Ho, three town pumps were located along with four village kerosene vendors.[11]

[7] Definitions for *Availability* for urban locations. *Unavailable*: no kerosene retail locations were identified within the city boundaries despite an extensive search. *Very Scarce*: within the city boundaries, only one or two out of 10 petrol stations identified as potential kerosene sellers sold kerosene at the time of the visit. *Scarce*: three to five out of 10 petrol stations sold kerosene. *Moderately Available*: six to eight out of ten petrol stations sold kerosene. *Readily Available*: nine to ten of the ten petrol stations visited in the city sold kerosene.

[8] Definitions for *Availability* for rural locations. *Unavailable*: no kerosene retail locations were identified after spending several hours surveying within a radius of 50+ kilometers from the urban center, which in all circumstances included multiple rural villages. *Very Scarce*: only one kerosene retail location was identified after spending multiple hours surveying within a radius of 50+ kilometers from the urban center. *Scarce*: two kerosene retail locations were identified after spending multiple hours surveying within a radius of 50+ kilometers from the urban center. *Moderately Available*: three or four kerosene retail locations were identified after spending multiple hours surveying within a radius of 50+ kilometers from the urban center. *Readily Available*: at least five kerosene retail locations were easily identified near the center of the rural village (which was typically 20 kilometers or less from the urban location sampled).

[9] Kojima, Masami, W. Mathews, F. Sexsmith (2010) "Petroleum Markets in Sub-Saharan Africa: Analysis & assessment of 12 countries." World Bank Group & ESMAP Report, March 2010.

[10] The parallel study found that in Sunyani the primary lighting source was low cost LED lamps powered by dry cell batteries; only four of the 16 study participants reported using kerosene for lighting. Therefore we can assume that people in this region do not buy much kerosene and those that do go 10-14 kilometers to town to make the purchase.

[11] In Ho 100% of the participants in the parallel study indicated using kerosene for lighting; it is therefore unsurprising that more kerosene vendors are located in the villages around Ho compared to Sunyani.

The high cost of kerosene is a significant concern for many rural families. The fact that kerosene has a higher cost when purchased in small quantities, as is frequently true in rural areas, also means that the economic benefits of a switch to modern off-grid lighting based on solar photovoltaic technology or another charging approach that has a low operating cost are larger than in cases when kerosene is purchased at national pump prices.

To illustrate the economic benefit of switching from kerosene lighting to modern off-grid lighting, Table 3 below presents simple payback estimates for three generic, good quality solar charged off-grid lighting systems. Each system has a different retail price level and represents a correspondingly larger level of lighting service provided. The analysis assumes that the more expensive lamps have higher performance levels and/or a larger number of light points that result in greater levels of kerosene displacement. The displacement amounts cited are based on prior field observations, but they are only intended to be illustrative and do not represent values that have been verified by systematic field research. The calculations for "rural pricing" in the table assume that the off-grid lighting system displaces kerosene purchases that cost $1.30 per liter, while the "urban pricing" assumes $0.96 per liter.

Under all price scenarios the payback period is reduced by 26%. For the $20 lamp the consumer starts to see the economic benefits three months earlier than previous estimates based on urban pump prices, the payback period would be four months shorter for the $40 lamp and five months shorter for the purchase of the $80 lamp.[12]

Table 3: Simple payback periods for three generic modern off-grid lighting systems under two different kerosene pricing scenarios; The analysis assumes that the quantity of kerosene displaced varies with the level of service provided by the lamp and that the level of service increases with lamp retail cost.

Lamp Retail Cost (USD)	$20	$40	$80
Kerosene Displacement Rate	60 ml/day	90 ml/day	140 ml/day
Payback Period Rural Pricing (months)[13]	8.4	11.2	14.5
Payback Period Urban Pricing (months)	11.4	15.2	19.6

The estimates presented in Table 3 assume kerosene prices associated with current world's oil pricing as of May, 2011. As noted earlier, kerosene prices are closely linked to world petroleum prices (Figure 1), and kerosene prices and associated payback periods may vary in the future due to price changes going forward.

[12] These cost savings estimates do not consider potential money savings from avoided fees associated with mobile phone charging. Many rural mobile phone owners charge their phones at shops that offer the service for a fee. Typical fees for mobile phone charging are on the order of $0.20 - $0.40 per charge, though the rate can be higher in some regions. A number of off-grid lighting products are designed to charge mobile phones, and any associated avoided charging fees can shorten the payback period.

[13] The payback period is likely to vary by country as a result of differences in kerosene cost, but these estimates are based of the median price of rural kerosene found across all five countries. The payback period also does not account for any operation and maintenance costs associated with the off-grid lamp. These are expected to be small over the lifetime of the products.

Conclusion

World oil prices appear likely to continue to be volatile and generally increasing over the coming decade, and kerosene prices will likely follow a very similar pattern. People who buy kerosene in large and small quantities are both subject to these trends, but those that buy in small quantities pay prices that are measurably higher.

Data collected in this study indicate that the median price premium for small quantity purchases in rural areas is 35% across the study areas, and in some regions the increase is much larger. Rural families lighting their homes with kerosene lamps will likely be faced with a choice; they will have to decide whether to allocate less money to other daily necessities or to have fewer hours of nightly illumination.[14]

Good quality modern off-grid lamps, including especially those that are solar powered, offer an alternative. An investment in a Lighting Africa quality assured off-grid lamp can rapidly save families money after a short payback period. This period is even shorter for rural families that light their homes with kerosene purchased in small quantities.

[14] Several people who participated in the parallel study indicated that they face this scenario from time to time, and said that when money was limited they chose to spend less on lighting fuel in order to maximize the amount of money available for purchasing food.