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Research Note #5

Use Patterns of LED Flashlights in Kenya and a One-Year Cost Analysis of Flashlight Ownership

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The Lumina Project includes an Off-Grid Lighting Technology Assessment activity to provide manufacturers, re-sellers, program managers, and policymakers with information to help ensure the delivery of products that maximize consumer acceptance and the market success of off-grid lighting solutions for the developing world. Periodic *Research Notes* present new results in a timely fashion between the issuance of more formal and lengthy reports. Our results should not be construed as product endorsements by the authors. For a full archive of *Research Notes* and *Technical Reports* see: http://light.lbl.gov/technology-assessment.html

Background

Flashlight usage is widespread across much of sub-Saharan Africa.[1] In Kenya in particular, over half of all households report owning a flashlight (Kamfor, 2002). Aside from household use, flashlights are also widely used to perform income-earning jobs in Kenya. Lumina Research Note #4, the first report in this series documenting flashlight use in Kenya, highlights flashlight use patterns of night watchmen and bicycle taxi drivers. Both of these are occupations that rely on the use of flashlights on a nightly basis (Tracy et al., 2009).

Also highlighted by Research Note #4, flashlight users in Kenya have reported being highly dissatisfied with the quality of the low-cost LED flashlights that are available, and they identify several reoccurring problems they have faced as flashlight end-users (Tracy et al., 2009). The fact that there exists a substantial dependency upon flashlights in Kenya and that users are disgruntled with the available products suggests reasons for concern about flashlight quality.

This concern is present despite two recent technological transitions in the flashlight market. First, LED technology has quickly emerged as the dominant source of portable lighting in Kenya, outpacing incandescent flashlights (Johnstone et al., 2009). LED technology has the potential to provide efficiency and performance benefits relative to incandescent bulbs, and low-cost LEDs have achieved price levels that make them cost competitive with conventional lighting sources for a number of applications (Mills, 2005). Second, rechargeable sealed-lead acid (SLA) batteries are also becoming more prevalent alternatives to disposable dry cell batteries. Flashlights using rechargeable SLA batteries tend to have a lower total cost of ownership over a two-year period than a flashlight using dry cell batteries (Radecsky, 2009); however, as this current report highlights, this may vary depending on the intensity of use patterns. To avoid a potential market spoiling effect for off-grid lighting products based on LED technology (Mills and Jacobson, 2008; Lighting Africa, 2007) a better understanding of flashlight use-patterns is crucial (Tracy et al., 2009).

In addition, the economic implications faced by rural flashlight end-users provide further incentive for a move toward higher quality low-cost flashlights. In this report, our team uses interviews with 46 end users of flashlights to collect information about their use patterns and costs associated with owning and operating flashlight products.

While flashlights used in their portable mode typically do not represent a substitute for kerosene or other forms of fuel-based lighting, at times they are used in stationary applications in place of a fuel-based lamp. In either case, these products often represent end users' first exposure to LED technology and rechargeable dry cell batteries, and thus stand to either provide a positive or negative impression of these technologies for a diversity of lighting applications.

Field Methods

We interviewed three distinct groups of flashlight users: night watchmen, bicycle taxi drivers, and households. These groups were selected because they are frequent and – in some cases – intensive – users of flashlights. A total of 46 individuals (15 watchmen, 15 bicycle taxi drivers,

[1] Flashlights are also commonly referred to as "torches".

and 16 household members) participated in a short survey about flashlight use patterns. In the context of the survey interviews, they shared their experiences with the flashlights that they use. Our colleague Maina Mumbi and one of the authors (Jenny Tracy) conducted the surveys over a three-week period during June and July 2009. See Appendix A for a copy of the survey forms.

Night Watchmen: Towns that serve as an overnight stopping point for lorry truck drivers generally have crews of night watchmen that provide security while drivers sleep. The night watchmen that we interviewed reported that they direct and monitor lorry trucks in work shifts that last from 7pm to 7am, seven days per week. Each watchman that we surveyed owned at least one flashlight that was used on a nightly basis. The watchmen surveys took place in a small truck stop town, Maai Mahiu (population ~30,000), located in Kenya's Rift Valley Province, approximately 46 miles northwest of Nairobi. All of the watchmen participants were male and had an average monthly income between 3,500 and 4,000 Ksh (approximately $46-52).

Bicycle Taxi Driver: In some of Kenya's towns, bicycle taxis provide transportation services to the general public within town limits. Those that we surveyed indicated that they operate primarily between the hours of 5am and 2am. We focused on surveying drivers that worked during the evening hours (anytime between 6pm and 2am). They use flashlights mounted on the frames of their bicycles seven nights per week. The Bicycle Taxi Driver surveys took place in Nakuru, a larger town of 300,000 people 86 miles north-west of Nairobi where bicycle taxis are common. All of the Bicycle Taxi Drivers participants were male and had an average monthly income of 9,800 Ksh (approximately $130).

Households: The surveys of households took place in Maai Mahiu with members of off-grid households. Specific monthly earnings were not ascertained for the household participants, but prior research in the area suggests that the average income for households in the area is around 5,000 Ksh (approximately $65). Although the households reported using flashlights for shorter periods of time than the watchmen and bicycle taxi drivers, they did nonetheless use them on a regular basis (Appendix B., Photo 1).

Flashlights Used by Survey Respondents

Four types of flashlights were reported to be in use by the survey participants: LED flashlights powered by a rechargeable sealed lead-acid (SLA) battery, LED flashlights powered by dry cell batteries, incandescent flashlights powered by a rechargeable SLA battery, and incandescent flashlights powered by dry cell batteries (see Tracy et al. 2009 for further detail and photos of the flashlight types used by survey respondents). All of these products were available in the local market at the time of the survey and purchased voluntarily by the users independently of this project.

The majority of survey participants reported using rechargeable LED flashlights followed by LED flashlights powered by dry cell batteries. Incandescent bulb flashlights that used either rechargeable or dry cell batteries were the least common type of flashlight. Of the three groups, households use flashlights with dry cell batteries to a greater extent than flashlights with rechargeable batteries, whereas the night watchmen and bicycle taxi drivers used rechargeable flashlights as their primary lighting device.

Results and Discussion

The following results depict flashlight use patterns as reported by the three groups, including a description of typical uses, frequency of use, time of use and frequency of charging or replacing of batteries. Based upon these results the total cost of ownership was assessed, including initial cost and the cost to charge or replace batteries, followed by a one-year cost analysis.

Use Patterns

Specific Uses: Both the night watchmen and the bicycle taxi drivers use flashlights for their jobs; flashlight uses outside of their employment were not ascertained. Household flashlight users reported using flashlights under four circumstances: going outside at night, in the bedroom at night, in the kitchen at night, and when searching for something inside the house. The primary use by households was for going outside at night, which was cited by 15 out of the 16 participants. Going outside at night includes walking between town and home, using the outside toilet, opening gates for animals, and other tasks which require going outside in the dark. Seven households reported using their flashlight in the bedroom at night; this includes getting ready for bed and assisting the children to prepare themselves for school in the early morning. Five households reported using the flashlight to search for items inside the house, during the day or at night, whenever lighting levels were too dim to locate the item of interest. Two out of the sixteen households reported using the flashlight while cooking at night (Figure 1).

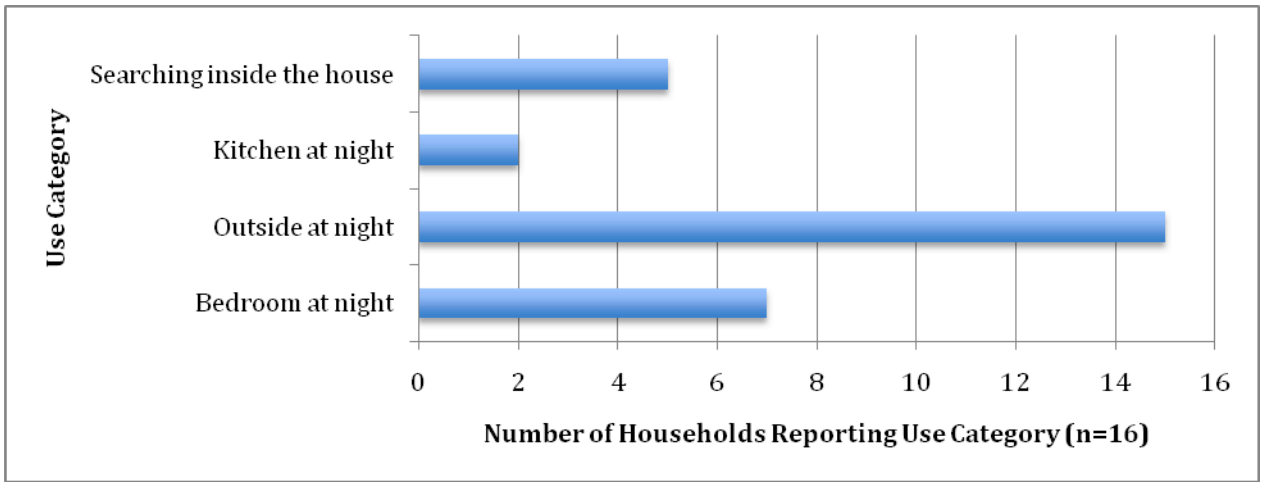

Figure 1. Common reported uses of flashlights in homes.

Frequency of Use: Both night watchmen and the bicycle taxi drivers use their flashlights on a daily basis during the night hours and regularly work seven days a week. On average households used flashlights less frequently than the night watchmen or the bicycle taxi drivers. Among the sixteen households, the median reported value indicates household participants had last used their flashlight within two days, while 46 % of households reported using their flashlight the previous evening.

Time of Use: The flashlight is a critical device for both night watchmen and the bicycle taxi drivers. It enables them to safely and effectively work through the night. Because both groups use the flashlight on a daily basis while on the job, the amount of time they have the light turned

on is substantially greater than in the case of households. Night watchmen and bicycle taxi drivers reported using their flashlights on a nightly basis for roughly the same amount of time, 3.5[2] hours and 3.75 hours respectively. Households, in contrast, reported using their flashlight on average for only 18 minutes per day (Figure 2).

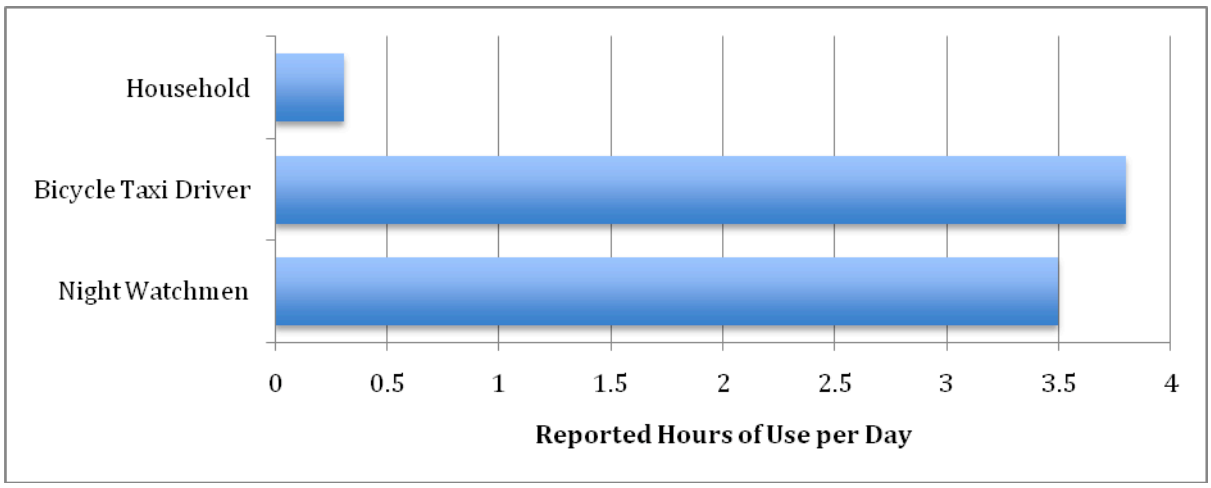

Figure 2. Number of hours per day flashlights are used as reported by the three groups.

Frequency of Charging/Replacing Batteries: Fourteen of the 15 night watchmen who used rechargeable flashlights reported recharging their flashlights on a daily basis on average, whereas the bicycle taxi drivers, all of whom reported using rechargeable flashlights, reported recharging every three days on average. The four households using rechargeable flashlights reported recharging their flashlights every seven days on average, though responses ranged from four to fourteen days.

Fourteen of the households and three of the night watchmen reported using flashlights with disposable dry cell batteries; however, the night watchmen used the dry cell flashlights only as an emergency backup flashlight. None of the bicycle taxi drivers used dry cell battery powered flashlights. The most frequently reported number of days between dry cell battery replacement was 14 days for the households and around 24 days for the night watchmen.[3] Note, however, that the since households reported using flashlights for less than 20 minutes per day the dry cell batteries lasted considerably longer than they would in the case of the night watchmen and bicycle taxi drivers. Because the night watchmen and bicycle taxi drivers report using their flashlights for roughly ten times longer than households, they would potentially need to replace batteries in a dry cell LED flashlight every 1.5 days if they used this type of flashlight. The responses from the household respondents indicated that the dry cell batteries in LED flashlights lasted longer (average replacement interval was 30 days) than the dry cell batteries in

[2] The night watchmen reported an estimated time of 3.5 hours of use per night; however, preliminary results from digital data logging of night watchmen flashlight use patterns indicates that nightly time of use is closer to 1.5 hours on average. Use patterns are logged using a data-logging devices designed by Schatz Energy Research Center engineers; the loggers record when the lamp is turned on and when it is being charged, providing detailed data on consumer use patterns.

[3] Only twelve of the seventeen participants using dry cell flashlights were able to report on the frequency with which they replaced their batteries (nine households and three night watchmen).

incandescent flashlights (14 days). This is consistent with the fact that incandescent lights are less efficient and therefore draw greater amount of power than LED lights.

Cost Analysis

Initial Cost: The initial cost for the flashlights currently in use by the participants ranged from 80 to 480 Ksh, $1.05-$6.30. On average the night watchmen tended to pay more for their flashlights than the bicycle taxi drivers. The households tended to pay the least of the three groups. The night watchmen paid a median price of 175 Ksh ($2.30), the bicycle taxi drivers paid a median price of 150 Ksh ($1.97), while the households paid a median price of 120 Ksh ($1.58). For both the night watchmen and the bicycle taxi drivers, the most common initial cost reported was 150 Ksh ($2.00) whereas the households reported 100 Ksh ($1.30).

The initial cost broken down by flashlight type shows that the most expensive flashlights are the rechargeable LED flashlights and the least expensive are the rechargeable incandescent flashlights (Table 1).

The initial cost of a rechargeable LED flashlight ranged from 130-280 Ksh ($1.70-$3.70) with a median price of 150 Ksh ($2.00). The initial cost of a disposable dry cell LED flashlights ranged from 80-480 Ksh ($1.05-$6.30) with a median price of 110 Ksh ($1.45). The initial cost of a rechargeable incandescent flashlight ranged from 100-120 Ksh ($1.30-$1.60) though only two of these flashlight types were reported (n=2). Only one participant reported using an incandescent dry cell flashlight, with an initial cost of 120 Ksh ($1.60). The reported prices closely reflect prices documented in a recent off-grid lighting market presence pilot study conducted through the Lighting Africa program (Johnstone et al., 2009) (Table 1). In that report, three towns of varying population sizes reported the median price of rechargeable LED flashlights at 150 Ksh ($1.97) (n=141), dry cell LED flashlights at 100 Ksh ($1.32) (n=100), and incandescent dry cell flashlights at 50 Ksh ($0.66) (n=30). Rechargeable incandescent flashlights, however, were not represented in any of the stores surveyed.

Table 1. Median initial costs for flashlights as reported by Johnstone et al. and by the three groups participating in the current study.

Flashlight Type	Median Initial Cost (Johnstone et al., 2009)		Median Initial Cost (This Study's Participants)	
	Ksh	USD	Ksh	USD
LED Rechargeable	150	$1.97	150	$1.97
LED Dry Cell	100	$1.32	110	$1.45
Incandescent Dry Cell	50	$0.66	120[4]	$1.60[4]
LED Dry Cell	NA	NA	110[5]	$1.45[5]

Cost to Charge/Replace Batteries: Thirty-four participants reported the cost to recharge their rechargeable flashlights. Nineteen of the 34 were able to charge for free either at their work place or at home, while the other 15 respondents took their flashlights to a charge-shop to be charged

[4] Only one person reported a cost for buying an incandescent dry cell flashlight

[5] Only two people reported a cost for buying a LED dry cell flashlight, so the average value was used (not the median).

(Figure 3). Those taking their flashlights to a charge shop paid a median price of 20 Ksh per charge ($0.25); the price ranged from 10-30 Ksh ($0.13-$0.40). There was no substantial difference between the price charge-shops charged between the two towns, Maai Mahiu and Nakuru, and thus all three groups who paid for a charge all paid roughly the same. The bicycle taxi drivers, however, tended to charge their flashlights for free more often than did the night watchmen and households (Figure 3). This is likely a result of grid-electricity being more accessible to households in the larger city than in the small town. However, of the 15 night watchmen, six reported being able to charge for free at their workplace. Eight of the 15 bicycle taxi drivers charged "for free" at their homes,[6] and, of the four households who reported using rechargeable flashlights, only one was able to recharge for free at her workplace.

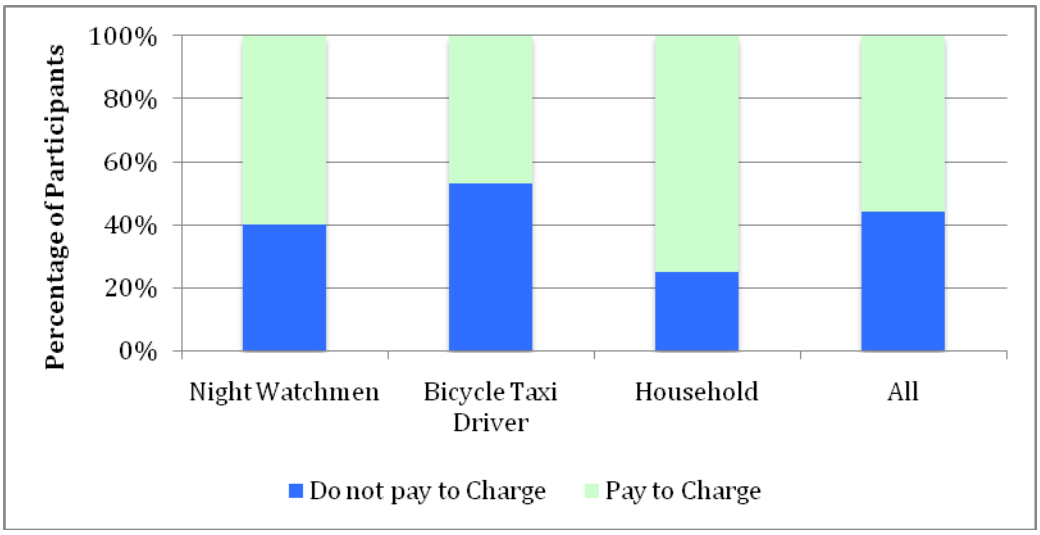

Figure 3. Percentage of participants, broken down by group, who pay and who do not pay to charge their flashlight. The bicycle taxi drivers tend to recharge their flashlights for free more often than the night watchmen or households.

Ten of the participants using flashlights powered by dry cell batteries (two night watchman and eight households) were able to report how much they paid for the batteries, with a median price per battery of 30 Ksh ($0.40). Of those ten, eight used flashlights that required two batteries and the other two participants owned flashlights using just one battery (Appendix A. Photos 2-3). Taking into account the number of batteries the flashlight requires, the median price to replace the flashlight batteries is 60 Ksh ($0.79). It is interesting to note that the two participants who owned the single battery flashlights reported paying 20 Ksh ($0.26) for the one battery, but those who had to purchase two batteries reported paying either 60 or 70 Ksh ($0.80, $0.92) for the two batteries. This likely reflects the different quality of batteries purchased, with the price ranging from cheaper to more expensive depending upon the ampere-hour capacity of the battery.

One-Year Cost Analysis

This section includes one-year cost assessments for two scenarios. The first scenario involves a high-intensity flashlight use pattern while the second involves a low-intensity flashlight use pattern.

[6] The amount of metered electricity required to charge these products is extremely small.

Scenario one depicts high-intensity flashlight use, following the typical use patterns reported by both the night watchmen and the bicycle taxi drivers (Table 2). The high intensity use one-year cost analysis assumes the following:

1. Initial costs: rechargeable LED flashlight, 150 Ksh: dry cell LED flashlight, 100 Ksh: rechargeable incandescent flashlight, 100 Ksh: dry cell incandescent flashlight, 50 Ksh
2. One flashlight lasts two months (Tracy et al., 2009)[7]
3. The cost per grid charge for rechargeable flashlights is 20 Ksh
4. Rechargeable flashlights are charged every 3 days
5. Dry cell powered flashlights use 2 batteries
6. The cost to replace two dry cell batteries is 60 Ksh
7. Dry cell batteries are replaced every 1.5 days in LED flashlights and every 0.75 days in incandescent flashlights.[8]

The second scenario depicts a lower-intensity of flashlight use, following the use patterns reported by households (Table 3). This scenario uses the same assumptions as in the high intensity use scenario except as follows,

1. Rechargeable flashlights are charged every 7 days, and
2. Dry cell batteries are replaced every 14 days in incandescent flashlights and every 30 days in LED flashlights.

For two reasons, no one-year cost analysis has been included for the incandescent rechargeable flashlight. First, incandescent rechargeable flashlights are not commonly available within the market (as indicated by the lack of representation of these flashlights in the Johnstone et al., 2009 study). The one incandescent rechargeable light reported in this study initially used LEDs, but when the LEDs no longer functioned the owner replaced them with an incandescent bulb. Secondly, the single participant owning this type of flashlight reported insufficient use-pattern data.

Table 2. One-year cost of ownership of the four different types of lighting products for a high intensity scenario. One analysis shows the cost if the owner must pay 20 Ksh (Kenya Shillings) to charge their rechargeable flashlight, while the other is for the case where they can charge for free.

Flashlight Type	Annual Cost of Ownership (w/charging fee of 20 Ksh)		Annual Cost of Ownership (w/out charging fee)	
LED Rechargeable	Ksh 3,333	$43.86	Ksh 900	$11.84
LED Dry Cell	Ksh 15,200	$200.00	Ksh 15,200	$200.00
Incandescent Dry Cell	Ksh 29,500	$388.16	Ksh 29,500	$388.16

[7] Rechargeable flashlights were reported and documented in Lumina Research Note #4 (Tracy et al., 2009) to last approximately two months before failing. Dry cell flashlights also have a reported lifespan of two months.

[8] There is no data on time between replacing dry cell batteries in incandescent flashlights under high-use situations (i.e. with the night watchmen), therefore the same ratio was used as indicated by the households for time between replacing batteries in LED flashlight vs. and incandescent flashlight, approximately 1:2.

For high-intensity users, the one-year cost of ownership for a dry cell powered flashlight is significantly greater than that of owning a rechargeable flashlight. For those who own rechargeable flashlights, recharging for free saves roughly 70 to 80% over a one-year period as compared to paying a recharging fee. Under the high-intensity use assumptions, the incandescent dry cell flashlight has a much higher cost of ownership than the LED dry cell flashlight (48% more costly).

For low-intensity flashlight users, over a one-year period the cost of owning a LED rechargeable flashlight is somewhat higher than owning a dry cell LED flashlight if the user must pay a charging fee. LED rechargeable flashlights and dry cell incandescent flashlights, however have roughly the same cost of ownership if the user pays a charging fee. If no fee is paid then the LED rechargeable is about half the cost of the incandescent dry cell flashlight.

Cases where the annual cost to operate a rechargeable flashlight is higher than a dry cell flashlight arise from a combination of a higher initial cost to purchase the flashlight and the necessity of paying the charging fee. For those who own rechargeable flashlights, recharging for free saves roughly 55 to 65% over a one-year period compared to paying a recharging fee. If a fee for charging is required, then under the low-intensity use assumptions the cheapest flashlight to own is the LED dry cell flashlight.

Table 3. One-year cost of ownership of the four different types of lighting products for a low-intensity use scenario. One analysis shows the cost if the owner must pay 20 Ksh (Kenya Shillings) to charge their rechargeable flashlight, while the other is for the case where they can charge for free.

Flashlight Type	Annual Cost of Ownership (w/charging fee of 20 Ksh)		Annual Cost of Ownership (w/out charging fee)	
LED Rechargeable	Ksh 1,943	$25.56	Ksh 900	$11.84
LED Dry Cell	Ksh 1,330	$17.50	Ksh 1,330	$17.50
Incandescent Dry Cell	Ksh 1,864	$24.53	Ksh 1,864	$24.53

Participants owning a rechargeable flashlight, those who are able to recharge for free either at their home or at their workplace pay roughly half as much over a one-year period. High-intensity flashlight users are better off owning a rechargeable flashlight versus a dry cell powered flashlight to save on cost. For low-intensity flashlight users, the cost difference between the various scenarios is small except in cases where rechargeable flashlights can be charged for free.

Taking average monthly earnings into account, we have calculated an approximation for the percentage of annual income flashlight ownership consumes. The outcome is dependent upon the flashlight type and to the amount paid to charge. The assessment follows the assumptions made for high-intensity use pattern for night watchmen and bicycle taxi drivers and assumptions for a low-intensity use pattern for households. Overall, night watchmen spent more of their annual income on flashlights than either of the other two groups, with bicycle taxi drivers spending the least amount of their annual income. Households used between 1.5 to 3.2% of their annual income, bicycle taxi drivers used between 0.8 to 2.8%, and the night watchmen used between 2.0 to 7.4% typically. However, if night watchmen were to use dry cell powered LED flashlights regularly, they would use one-third of their annual income on owning and operating a flashlight. This may explain why they do not use this type of flashlight (Table 4).

Table 4. Percentages of annual income spent on owning and operating flashlights over one-year broken down by group and the cost to charge. The blackened cells indicate that the group did not use that type of flashlight, so no assessment was possible.

	% of Annual Income		
	w/ charging fee of 20 Ksh		
	LED Rechargeable	LED Dry Cell	Incandescent Dry Cell
Night watchmen	7.4%	33.8%	
Bicycle taxi drivers	2.8%		
Households	3.2%	2.2%	3.1%
	w/out charging fee		
	LED Rechargeable	LED Dry Cell	Incandescent Dry Cell
Night watchmen	2.0%	33.8%	
Bicycle taxi drivers	0.8%		
Households	1.5%	2.2%	3.1%

Summary and Conclusions

In Kenya, flashlights have a variety of uses within and outside of the home. Household respondents use flashlights with less frequency than do the night watchmen and bicycle taxi drivers, whose job requires them to use a flashlight on a nightly basis for extended periods of time. However, many of the households use the flashlight on a daily basis but only for a matter of minutes rather than hours. Because night watchmen and bicycle taxi drivers use their flashlights for longer time periods than households, their frequency of recharging batteries for rechargeable flashlights was more than double that of households. Households, however, utilized dry cell powered flashlights more often than rechargeable flashlights and tended to replace their batteries every two weeks.

Taking into account reported use patterns and initial and ongoing ownership costs for the four different types of flashlights, calculations for the annual costs associated with the different types were estimated for two scenarios. The first scenario involved high-intensity use, which was representative of night watchmen and bicycle taxi driver use patterns. The second scenario involved low-intensity use, which was representative of reported household use patterns. For the high-intensity scenario rechargeable flashlights are by far the least expensive option in comparison to dry cell powered flashlights. Dry cell powered LED flashlights, in contrast, appear to have a lower cost than rechargeable LED flashlights for many low-intensity users. However, if it is possible to recharge batteries for free, rechargeable flashlights are substantially cheaper. Bicycle taxi drivers tend to only have to devote a small percentage of their income to owning and operating flashlights (<3%), whereas night watchmen may use more than 7% of their income to own and operate flashlights. At 1.5% to 3.2% of annual income devoted to flashlight use, households tend to fall in the middle.

Understanding use patterns and estimating the cost of owning and operating low-cost flashlights that are currently available in the off-grid lighting market is essential to address quality assurance concerns. An understanding of the annual costs to which flashlight users are subject can assist

decision makers to identify improved quality flashlights of slightly higher cost that would still be affordable to users on an annual basis. While higher quality flashlights may have a higher initial cost, they are likely to have a comparable, if not lower, overall annual cost of ownership. Kenyan flashlight owners have expressed serious dissatisfaction with the flashlights that are currently available to them (Tracy et al., 2009), and some have indicated a strong interest to purchase higher quality flashlights provided that the associated cost increase is modest. With this in mind, a company that could deliver a rugged, good quality, moderately priced (e.g., $10-13; 750-1,000 KSh) rechargeable LED flashlight to the Kenya market could be in a position to deliver superior portable lighting services to low income Kenyans. Demand for such products may be especially strong among high intensity users such as the night watchmen and bicycle taxi drivers interviewed in this study. However, the delivery of such a flashlight would need to be accompanied by a successful marketing campaign aimed at differentiating the product from the very low quality products that are currently available in the market.

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Appendix A. Survey Forms

I. Night Watchmen Survey

Survey Form
Portable Lamps in Kenya
June, 2009

Askari SURVEY

Survey by: Arne Jacobson
Humboldt State University
Arcata, CA 95521, USA

Section 1: General Information (filled in prior to starting interview):

1.1 Name of person(s) administering survey: _____

1.2 Date & time of interview: _____

1.3 Town: _____

1.4 Participant ID # _____ **1.5 Torch ID # _____**

##

1.6 What is the **name** of the person being interviewed?

Name: _____

1.7 **Gender:** ☐ Female (1) ☐ Male (2)

1.8 Who do you work for? **Employer**: _____

1.9 Where in town are you stationed? **Location**: _____

1.10 How long have you **worked** as an Askari?

1.11 Note their monthly income: _____

Section 2: Torch Use

2.1 What **brand** of torch do you **currently** use? (Describe the torch if no name, i.e. number of LEDs, rechargeable/dry cell, number of light settings).

2.1.1 How long ago did you **start using** the torch you use now? **# Months** _____

2.2 What **brand** of torch did you use **previous** to the one you currently use? (Describe the torch if cannot remember the name, i.e. number of LEDs, rechargeable/dry cell, number of light settings).

2.2.1 How long did that torch **last**? **# Months** _____

2.2.2 Why did you **replace** it?

2.3 In the last 6 months, how many torches have you **used**? # _____

2.3.1 In **your opinion**, of the torches you have used in the past, which one was the **best**? **Why** was it better?

Best torch: _____

Why better: _____

_____

2.4 How do you **get** your torches?

☐ I buy (1) ☐ Employer gives (2) ☐ Other _____ (3)

2.5 How much do the torches **initially cost**? **Cost:** _____

2.6 If the torch is rechargeable, how do you **charge** it AND how often do you charge? If it uses dry cell batteries, what type of batteries AND how often do you **replace** them?

☐ Rechargeable (1) Charging Method: _____

How often recharge: _____

☐ Dry Cell (2) Brand Name: _____

How often replace: _____

2.6.1 **Who pays** for the charge/batteries?

2.6.2 What is the **cost** to charge or to buy replacement batteries? **Cost:** _____

2.7 Approximately how many **hours per night** is the torch turned on? **# Hours:** _____

Section 3: What would be an ideal torch?

3.1 How much would you **pay** for a better quality torch that lasted for at least 2 years?

☐ More than1000 [1] ☐ 800-1000 [2] ☐ 600-800 [3]

☐ 400-600 [4] ☐ 200-400 [5] ☐ Less than 200 [6]

3.2 Would you prefer a **rechargeable** torch or one that used **dry cell** batteries?

☐ Rechargeable [1] ☐ Dry Cell Batteries [2]

3.2.1 If you prefer rechargeable, would you prefer to **charge** a torch by

☐ Grid [1] ☐ Solar [2] ☐ Both Grid & Solar [3] ☐ Crank [4]

3.2.2 How **often** would you be able and willing to **charge** the torch?

☐ Everyday [1] ☐ Every 2 days [2] ☐ Every 4 days [3]

☐ Once per week [4] ☐ Once every two weeks [5]

3.2.3 What factors may **limit** you from charging?

☐ Security of Solar [1] ☐ Access to the Grid [2] ☐ Grid Charge Cost [3]

Other Limiting Factors: _____

3.3 What **features** would you like the torch to have?

II. Bicycle Taxi Driver Survey

Survey Form
Portable Lamps in Kenya
June, 2009

Torch Use: Boda Boda SURVEY

Survey by: **Error! Reference source not found.**
Humboldt State University
Arcata, CA 95521, USA

Section 1: General Information (filled in prior to starting interview):

1.1 Name of person(s) administering survey: _____

1.2 Date & time of interview: _____

1.3 Town: _____ **1.4 GPS point** _____

1.5 Participant ID # _____

##

1.12What is the **name** of the person being interviewed?

Name: _____

1.13**Gender:** ☐ Female (1) ☐ Male (2)

1.14Who do you work for? **Employer**: _____

1.15Where in town are you stationed? **Location**: _____

1.16 How long have you **worked** as a Boda Boda driver?

1.17 Note their monthly income: _____

Section 2: Torch Use

2.8 What **brand** of torch do you **currently** use? (Describe the torch if no name, i.e. number of LEDs, rechargeable/dry cell, number of light settings).

2.8.1 How long ago did you **start using** the torch you use now? **# Months** _____

2.9 What **brand** of torch did you use **previous** to the one you currently use? (Describe the torch if cannot remember the name, i.e. number of LEDs, rechargeable/dry cell, number of light settings).

2.9.1 How long did that torch **last**? **# Months** _____

2.9.2 Why did you **replace** it?

2.10 In the last 6 months, how many torches have you **used**? # _____

2.10.1 In **your opinion**, of the torches you have used in the past, which one was the **best**? **Why** was it better?

Best torch: _____

Why better: _____

_____

2.11 How do you **get** your torches?

☐ I buy (1) ☐ Employer gives (2) ☐ Other _____ (3)

2.12 How much did you current torch **initially cost**? **Cost:** _____

2.13 If the torch is rechargeable, how do you **charge** it AND how often do you charge? If it uses dry cell batteries, what type of batteries AND how often do you **replace** them?

☐ Rechargeable (1) Charging Method: _____

How often recharge: _____

☐ Dry Cell (2) Brand Name: _____

How often replace: _____

2.13.1 **Who pays** for the charge/batteries?

2.13.2 What is the **cost** to charge or to buy replacement batteries? **Cost: _____**

2.14Approximately how many **hours per night** is the torch turned on? **# Hours: _____**

Section 3: What would be an ideal torch?

3.4 How much would you **pay** for a better quality torch that lasted for at least 2 years?

☐ More than1000 [1] ☐ 800-1000 [2] ☐ 600-800 [3]

☐ 400-600 [4] ☐ 200-400 [5] ☐ Less than 200 [6]

3.5 Would you prefer a **rechargeable** torch or one that used **dry cell** batteries?

☐ Rechargeable [1] ☐ Dry Cell Batteries [2]

3.5.1 If you prefer rechargeable, would you prefer to **charge** a torch by

☐ Grid [1] ☐ Solar [2] ☐ Both Grid & Solar [3] ☐ Crank/Dynamo [4]

3.5.2 How **often** would you be able and willing to **charge** the torch?

☐ Everyday [1] ☐ Every 2 days [2] ☐ Every 4 days [3]

☐ Once per week [4] ☐ Once every two weeks [5]

3.5.3 What factors may **limit** you from charging?

☐ Security of Solar [1] ☐ Access to the Grid [2] ☐ Grid Charge Cost [3]

Other Limiting Factors: _____

3.6 What **features** would you like the torch to have?

III. Household Survey

Survey Form
Portable Lamps in Kenya
June, 2009

Torch Use: Household SURVEY

Survey by: **Error! Reference source not found.**
Humboldt State University
Arcata, CA 95521, USA

Section 1: General Information (filled in prior to starting interview):

1.1 Name of person(s) administering survey: _____

1.2 Date & time of interview: _____

1.3 Town: _____ **1.4 GPS point**: _____

1.5 **Household ID # _____**

##########

1.6 What is the **name** of the person being interviewed?

Name: _____

1.7 **Gender:** ☐ Female [1] ☐ Male [2]

Section 2: Demographic Information

2.1 What are the major sources of income for your household (check all that apply and indicate the greatest source with a **#1**)?

☐ Business (kiosk / shop / selling goods / etc.) > *type:* _____ [1]
☐ Jua Kali (mechanic / carpenter / dress making / etc.) [2]
☐ Salary / Professional work (ex: teacher) > *source*: _____ [3]
☐ Farming [4]
☐ Remittance [5]
☐ Other _____ [6]

2.2 How many **people** are in your household? #_____

2.3 Do you have **grid** electricity at home? ☐ Yes [1] ☐ No [2]

2.4 Do you have grid electricity at your business?

☐ Yes [1] ☐ No [2] ☐ Not Applicable (does not have business) [3]

Section 3: Torch Use

3.1 In the last 6 months, how many torches have you **bought**? **# Torches: _____**
3.2 How long did the torch you used previous to your current torch last? **# Months: _____**

3.3 What are the **main problems** that you have experienced with torches?

Failure of: ☐ LEDs/Bulb [1] ☐ Battery [2] ☐ Switch [3] ☐ Drops & breaks [4]

Other Problems experienced: _____

_____

3.4 Of the torches you have used in the **past**, which one was the **best**? Why was it **better**? (Describe it if cannot remember: # of LEDs, rechargeable/dry cell, # of light settings).

Best torch: _____

Why better: _____

Section 4: What would be an ideal torch?

3.7 How much would you **pay** for a better quality torch that lasted for at least 2 years?

☐ More than1000 [1] ☐ 800-1000 [2] ☐ 600-800 [3]

☐ 400-600 [4] ☐ 200-400 [5] ☐ Less than 200 [6]

3.8 Would you prefer a **rechargeable** torch or one that used **dry cell** batteries?

☐ Rechargeable [1] ☐ Dry Cell Batteries [2]

3.8.1 If you prefer rechargeable, would you prefer to **charge** a torch by

☐ Grid [1] ☐ Solar [2] ☐ Both Grid & Solar [3] ☐ Crank [4]

3.8.2 How **often** would you be able and willing to **charge** the torch?

☐ Everyday [1] ☐ Every 2 days [2] ☐ Every 4 days [3]

☐ Once per week [4] ☐ Once every two weeks [5]

3.8.3 What factors may **limit** you from charging?

☐ Security of Solar [1] ☐ Access to the Grid [2] ☐ Grid Charge Cost [3]

Other Limiting Factors: _____

3.9 What **features** would you like the torch to have?

THE LUMINA PROJECT

http://light.lbl.gov

Component	Type	Code
Bulb	LED	LED
	Incandescent	INC
Battery	Rechargeable	R
	Dry Cell (mawe)	D
Ex: LED-D		

Section 3: Current Torch Use

3.1 Regarding each torch you and your family currently uses

3.1.1 What **brands** of torches do you own and how many of each?
3.1.2 What **type** of torch is it (use codes from table-→)?
3.1.3 How much did each torch **initially cost** you?
3.1.4 How long did the charge/batteries last before you recharged/replaced the batteries most recently?
3.1.5 How much did it **cost** you to charge/replace batteries last time?
3.1.6 How many **days ago** did the torch last get **used**?
3.1.6.1 List all the ways the torch was **used** the last time you used the torch and for how many **minutes**.

Torch #	*3.1.1*	*3.1.2*	*3.1.3*	*3.1.4*	*3.1.5*	*3.1.6*	*3.1.6.1*				
	Brand	**Type**	**Initial Cost (Ksh)**	**Time Between Charge/ Replace**	**Cost Recharge/Replace (Ksh)**	**# Days Ago Last Used**	***List Ways Used and # Minutes Used for***				
1							# mins. ____	# mins. ____	# mins. ____	# mins. ____	# mins. ____
2							# mins. ____	# mins. ____	# mins. ____	# mins. ____	# mins. ____
3							# mins. ____	# mins. ____	# mins. ____	# mins. ____	# mins. ____
4							# mins. ____	# mins. ____	# mins. ____	# mins. ____	# mins. ____

Note 1: _____ Note 2: _____

Note 3: _____ Note 4: _____

Appendix B. Photo Gallery of flashlights and their users in Kenya

Photo 1. One of the households participating in the flashlight survey.

Photo 2. LED flashlights used by a household that requires two dry cell D batteries.

Photo 3. LED flashlights used by a household that requires only one dry cell D battery.

DISCLAIMER