

The Rise of Solar

Market Evolution of Off-Grid Lighting in Three Kenyan Towns



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TABLE OF CONTENTS

<u>EXECUTIVE SUMMARY</u>	<u>3</u>
MARKET PRESENCE STUDY APPROACH	3
KEY FINDINGS	4
<u>AN EVOLVING MARKET</u>	<u>5</u>
THE DOMINANCE OF SOLAR LIGHTING PRODUCTS	7
THE CONSOLIDATION OF BRAND	9
MARKET SIZE	11
AVAILABILITY AND DIVERSITY OF LIGHTING PRODUCTS	12
PRICES OF AVAILABLE OFF-GRID LIGHTING PRODUCTS	17
THE RETAILERS	17
PRODUCT PROCUREMENT	18
WARRANTIES AND FINANCING	19
INFORMATION AND COMMUNICATION TECHNOLOGIES	20
<u>GEOGRAPHIC BACKGROUND</u>	<u>22</u>
KERICHO	22
BROOKE	25
TALEK	26
<u>STUDY METHODOLOGY</u>	<u>28</u>
<u>LOOKING FORWARD</u>	<u>29</u>
<u>ANNEX A: A NOTE ABOUT MEASURING MARKET GROWTH</u>	<u>32</u>
<u>ANNEX B: PRICES OF AVAILABLE OFF-GRID LIGHTING PRODUCTS</u>	<u>33</u>
<u>ANNEX C: RETAILER DEMOGRAPHIC INFORMATION</u>	<u>39</u>
<u>ANNEX D: MARKET PRESENCE SURVEY FOR 2014</u>	<u>42</u>

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Cover photo: A street scene from Kericho, Kenya, at the retail end of the off-grid lighting supply chain during a field research interview of a shop (photo: P.Alstone)

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Executive Summary

For the past six years researchers affiliated with Lighting Africa have been visiting Kericho, Brooke, and Talek in Kenya to observe trends in the off-grid lighting market. Starting in 2009, the initial market survey provided a baseline for the types of off-grid lighting products that were available in an urban, a peri-urban, and an off-grid market. We returned in 2012 and 2014 to survey all three towns again and observe shifts in lighting technologies and power sources, product sales and revenues, and retailer demographics. This longitudinal dataset has provided key insights into an African off-grid lighting market undergoing rapid transitions: from incandescent to LED lighting, from dry-cell batteries and grid-charging to solar power, and from cheap, plastic torches to quality-verified lighting systems with warranties. In the short span of six years, these three markets have undergone dramatic changes, with potential lessons to be learned for other maturing markets and future opportunities as the Kenya market continues to develop. This effort has also provided evidence that can be used to evaluate the efficacy of programs like Lighting Africa and Lighting Global that seek to combat market spoilage and improve consumer access to affordable and sustainable off-grid lighting products.

Market Presence Study Approach

Both fuel-based and electric off-grid lighting products are widely available in sub-Saharan Africa. This report focuses on characterizing the availability, price, and market penetration of *electric* off-grid lighting products in Kenya based on a survey of retail vendors in three towns. We first designed and deployed a survey and field observation study in June 2009 in the Kenyan towns of Kericho, Kapkugerwet (also known as Brooke), and Talek.¹ In June 2012 and June 2014 we conducted updated surveys in these same towns to compare to the baseline information from 2009. Only products that have electric light sources and do not require a continuous connection to grid electricity are included. These include incandescent torches powered by dry-cell batteries (i.e., flashlights), grid-charged products, solar lanterns, and preconfigured mini-solar home systems. Component-based, customized solar home systems were not included in the study. Data were collected about the diversity of products available, estimated prices, and weekly sales volumes of each product. Additionally, we compiled information about each retailer surveyed, including the use of credit in their business. We also tracked the emergence of high quality solar lighting products and their rapidly expanding market share.

The three towns included in this study are located in the Rift Valley region of Kenya. Kericho is a large town (~102,000 pop.) in the prosperous tea-growing region in the highlands of southwest Kenya. Brooke is a small town (~14,000 pop.) that is close to Kericho (~5 km away). Both Kericho and Brooke are electrified, but many residents and people who live in outlying areas do not have access to electricity. Talek is a small market center (~5,000 pop.) that is far from any large towns and is off the grid (population estimates are from the 2009 Kenya Population and Housing Census).

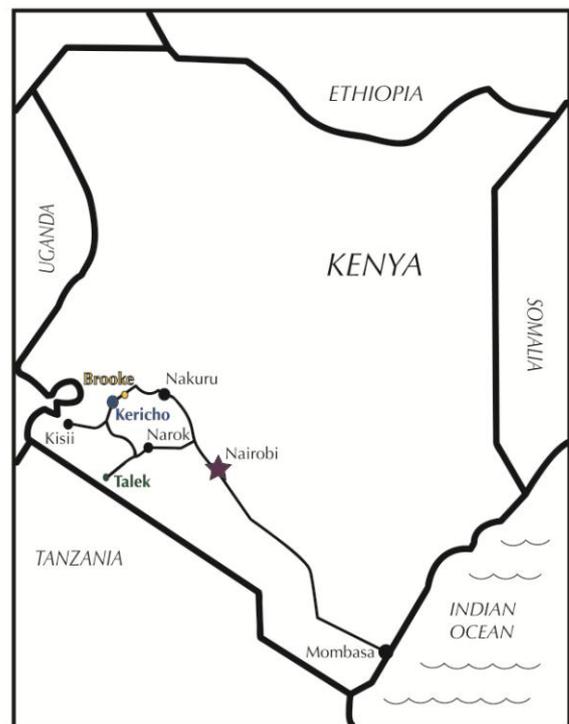


Figure 1: Map of Kenya showing the approximate location and relative size of the three towns included in the study. Cities and towns where retailers source their products are included as well.

¹ The 2009 and 2012 reports can be found at <https://www.lightingafrica.org/resources/market-research/market-intelligence/>.

Key Findings

There has been massive growth in off-grid lighting sector. From 2012 to 2014, the number of off-grid lighting products sold in the three towns almost doubled (77% increase from 2012 to 2014), and the estimated monthly revenue from off-grid lighting products more than quadrupled (from US\$32,000 in 2012 to over US\$180,000 in 2014). All three towns saw growth in product revenue, and Kericho accounted for the vast majority of product sales and revenue growth from 2012 to 2014. This perhaps indicates a key shift in consumer (and re-seller) purchasing preferences toward urban and peri-urban centers where there are established markets for other high-value electronic goods.

Solar has become the predominant power source. Solar lighting products were the main drivers of growth in the off-grid lighting sector over the study period. In 2009 less than 2% of available products² were solar in a retail market dominated by very inexpensive (and low quality) torches³, and sales were sparse. By 2012, solar products represented ~1% of all products sold with 31% of the revenue in the market. In the most recent survey, solar products captured 24% of product sales and 85% of product revenue.

Quality-verified product sales and revenue grew. Quality-verified products represented 1% of products sold and 18% of product revenue in 2012; this jumped to 15% of products sold and 30% of product revenue by 2014. Of all the available solar products available in 2014, 56% were quality-verified. Although quality-verified products captured 63% of solar product sales, that only represented 36% of solar product revenue. There was significant revenue from prepackaged solar home systems that were not quality-verified but were larger in peak generation capacity than was tested by Lighting Global in 2014. Quality-verification measures for higher power solar lighting products are now included in the program.⁴

More mobile-charging devices: Devices that were able to charge mobile phones – typically with a USB port or an adaptor compatible with a variety of mobile phone sockets – represented about 10% of the products available in the market, 15% of all product sales, and 53% of all product revenue. While only 52% of the mobile-charging products we observed were solar home systems, the vast majority of sales and revenue from mobile-charging devices were captured by solar home systems (88% of sales and 83% of revenue), indicating a small market share for mobile-charging devices that were not solar home systems.

Consolidation of brand in off-grid lighting: Over two thirds of product revenues were garnered by the top five brands in 2014, compared to just 20% of product revenue in 2012. In addition, much of the market growth was captured by a few solar brands that did not figure prominently in the 2012 market survey.

Growth of a look-alike market: With the consolidation of brand has followed a growth in solar product look-alikes, perhaps indicating a need to penetrate further down the supply chain with information about product quality and performance for manufacturers and end-users. Although one of the look-alike products was among the top ten selling brands, the overall market for look-alike products remained small compared to much higher selling market leaders in the top five. Although look-alike products may pose a threat to future quality assurance efforts in off-grid markets, their reported market share as of June 2014 was relatively small in the towns included in the study (2% of available products, 1% of products sold, and 2% of product sales revenue).

² In each town we analyzed how many distinct products and total products were available. For example, if Acme Model X was sold in three shops in Kericho it only represented one distinct product but three total products. We did not collect total inventories of products (i.e. we did not distinguish between a shop which carried one Acme Model X and a shop that carried 20).

³ Also known as “flashlights”.

⁴ In 2012 and 2014, the Lighting Global testing methods covered all pico-solar products (products that are generally less than 10 Watts), but testing for larger solar home system kits was not available.

LED lighting technology ascendant: LEDs have almost completely replaced incandescent and fluorescent lighting products, with 99% of products being lit by LEDs. Incandescent lights represented 4% and 9% of all products surveyed in 2012 and 2009, respectively. Fluorescent lights represented 3% and 2% of all products in 2012 and 2009, respectively.

Diversification of product form factor: The torch form factor, which was ubiquitous in 2009 and 2012, was edged out by ambient lights, task lamps, and solar home systems in 2014. Ambient room lighting form factors represented 3% of available products in 2009, but that increased to 35% of available products by 2014. At the same time, the percentage of products that were torches decreased significantly from 95% in 2009 to 52% in 2014. Task lights represented 14% of all the products observed in the market, 15% of all product sales, and 22% of all product revenue. Similarly, solar home systems represented 5% of all the products observed in the market, 4% of all product sales, but 45% of all product revenue. Given the trend toward greater expense in solar products, there will be even greater needs for quality assurance and verification for higher value solar products.

Significant increase in product warranties and retail financing: The number of retailers offering warranties for their products increased from 3% in 2009 to 37% in 2014. Similarly, the number of retailers offering financing for customers increased from 2% in 2009 to 29% in 2014.

Widespread use of mobile phones and services: One hundred percent of off-grid lighting retail vendors had mobile phones in 2014, with a third using more than one mobile phone. Smart phones were used by 43% of retailers, followed by basic phones at 41% and internet phones at 21%. In addition, retailers reported using a variety of mobile services like mobile money (87%), texting (79%), Facebook (50%), internet (48%), email (35%), and WhatsApp (21%), indicating a great degree of digital literacy among off-grid retailers.

An Evolving Market

According to recent estimates from the Ministry of Energy and Petroleum, only 32% of the Kenyan population had access to electricity as of June, 2014.^{5,6} With an estimated 76% of the population living in rural areas and 43% living below the poverty line,⁷ a great majority of Kenyan households depend on fuel-based or electric lighting products for after hours illumination. While kerosene has been the dominant source of lighting for off-grid households in Kenya, that reality is rapidly changing as solar lanterns and solar home systems that are less harmful and less polluting than kerosene become more accessible and affordable.⁸

The market for solar products in Kenya dates back to the 1980s, when solar home systems began to be sold on a commercial basis. While early sales were based primarily on crystalline silicon PV modules, the market grew in the 1990s based largely on sales of small (12 to 15 Watt-rated) amorphous silicon modules. By the early 2000s, an estimated 200,000 household solar systems had been sold in Kenya.⁹ Market sales of pico-solar products that utilize LED lighting technology began to emerge in 2008.

⁵ Ministry of Energy and Petroleum (2015) "Draft National Energy and Petroleum Policy." Ministry of Energy and Petroleum website: <http://www.energy.go.ke/>.

⁶ However, some estimates of electrification in Kenya are much lower due to the cost associated with connecting to the grid. See Lee, Kenneth, et al. (2014) "Barriers to Electrification for 'Under Grid' Households in Rural Kenya." National Bureau of Economic Research Working Paper Series.

⁷ Central Intelligence Agency. (2009) *World Fact Book*.
<https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html>

⁸ Jacobson, Arne, et al. (2013) "Black Carbon and Kerosene Lighting: An Opportunity for Rapid Action on Climate Change and Clean Energy for Development." *Global Economy and Development at Brookings*.

⁹ Jacobson, Arne. (2004) "Connective Power: Solar Electrification and Social Change in Kenya." PhD Dissertation, University of California, Berkeley.

The growth of this market was facilitated by the World Bank Group's Lighting Africa program, which launched operations in Kenya beginning in 2009. The initiative involved a quality assurance (QA) testing and verification program, business support services for companies with quality assured products, and consumer awareness activities. Quality assurance product testing began in 2009 when the first seven products met the newly announced Lighting Africa quality standards.¹⁰ The QA program has since expanded beyond Africa to cover market activities in Asia and other parts of the world, and it is now called the Lighting Global Quality Assurance Program. Consumer awareness activities began in Kenya in 2010. Key activities have included road shows, print, radio and television advertising, and even inclusion of themes related to off-grid solar products in a prominent Kenyan TV comedy series.

While the efficacy of such efforts can be difficult to quantify, the market for affordable and sustainable lighting products has grown tremendously over the period of Lighting Africa's involvement in Kenya. Sales of quality assured pico-solar products have grown from approximately twenty thousand units in 2009 to nearly one million units in 2014. As of June 2015, a cumulative total of 2.3 million quality-verified pico-solar products had been sold in the Kenya market since 2009.¹¹ As one of the leading markets for solar lighting products, Kenya stands as an important case study for other off-grid lighting markets worldwide.

In addition to Lighting Africa's efforts to promote affordable and effective lighting products in Kenya, there have been other forces driving market growth that have been observed over the course of this study. Perhaps most significantly, there have been rapid innovations in LED and battery technologies that have enabled superior lighting service for a fraction of the former energy consumption. Similarly, global innovation and investment in photovoltaic technology has led to an unprecedented reduction in costs for photovoltaic cells and modules. Improvements in product efficiency and cheaper solar power have been coupled with innovative distribution strategies and large scale investments in sustainable energy access solutions, enabling the rapid development and expansion of off-grid lighting markets like the ones observed in this study.^{12,13}

This report provides the most recent snapshot of these three off-grid lighting markets in Kenya. In our 2012 report we documented the ascendance of LEDs over incandescent and fluorescent technologies and a marked increase in off-grid lighting sales. In our most recent survey in 2014, we witnessed remarkable growth in the availability and sales of solar and quality-verified products. In addition, we observed a consolidation of branding among off-grid lighting products that could portend greater consumer awareness among end-users and greater overall quality within the off-grid lighting market. We also recorded information related to product characteristics, pricing, and weekly sales volumes in each town, and key demographic data related to the retail vendors. Finally, we observed supply chain characteristics (where retailers sourced products, how they learned about new products, how and whether they provide financing and warranties, etc.) and documented the types of information and communication technologies that are commonly used at the end of the off-grid solar and lighting supply chain.

¹⁰ Lighting Africa Annual Report. (2010) Lighting Africa Website.

¹¹ Lighting Global sales data through June 2015. Note that quality-verified pico-solar sales declined in Kenya relative to the prior six months for the period from January to June 2015. This indicates a slowdown in sales growth, although it is too soon to say whether this represents a temporary decline or the beginning of a longer-term trend.

¹² Phadke, Amol. et al. (2015) "Powering a Home with Just 25 Watts of Solar PV: Super-Efficient Appliances Can Enable Expanded Off-Grid Energy Service Using Small Solar Power Systems." Clean Energy Ministerial Website.

¹³ Alstone, Peter, et al. (2015) "Off-grid Power and Connectivity: Pay-as-you-go financing and digital supply chains for pico-solar." Lighting Global Website.

The Dominance of Solar Lighting Products

As seen in Figure 2, solar products grew from less than 10% in 2009 to over 85% of product revenue in 2014. Although solar products only represented 35% of the products that we observed in the market and 24% of product sales, the higher value of solar products contributed to the greater market share for solar products.¹⁴ Moreover, it appears that solar products accounted for the vast majority of the massive growth in off-grid lighting revenue from 2012 to 2014, as solar products represented only 11% of products observed, 1% of product sold, and 31% of product revenue in 2012.

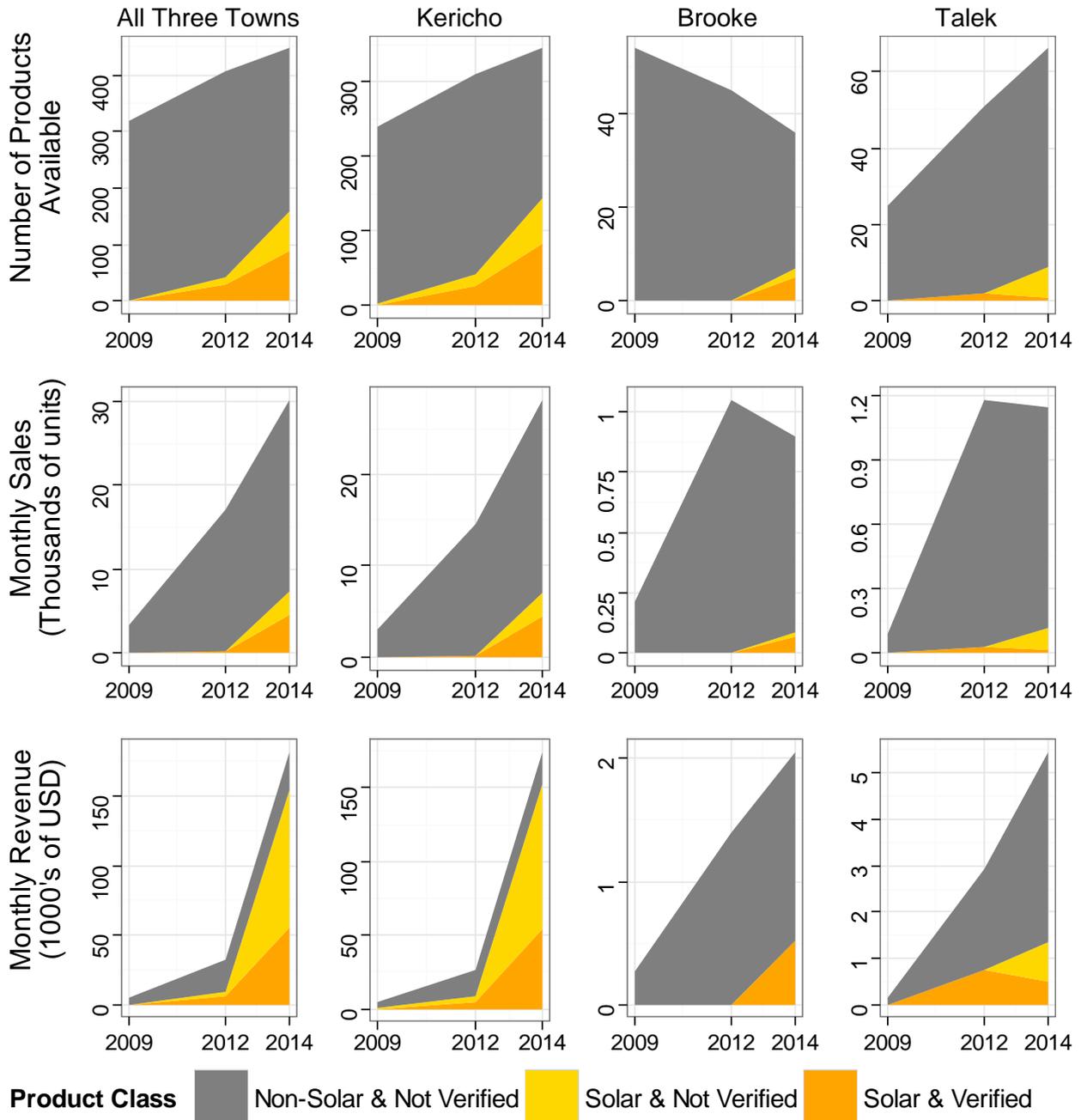


Figure 2: Product availability, monthly sales, and monthly revenue for 2009, 2012, and 2014 for all three towns. Solar products that are quality-verified (satisfy the Lighting Global Minimum Quality Standards) are represented in orange. Solar products that are not quality verified are represented in yellow, and non-solar products that are not quality-verified are represented in grey. Note that the scales on the y-axes for the various graphs in a given row are not identical.

¹⁴ Solar products had a median price of KSH 1500 compared to a median price of KSH 575 for non-solar products in 2014.

Also seen in Figure 2, much of the growth in off-grid lighting revenues was captured by the Kericho market. With over 87% of revenues coming from solar products, Kericho was the only market that saw an increase in the total number of products available and the number of products sold between 2012 and 2014. In contrast, retailers in Brooke in Talek reported an overall reduction in product sales from 2012 to 2014 (14% less for Brooke and 3% for Talek). Brooke also saw a 20% reduction in the number of available products, perhaps indicating that its off-grid lighting market had shifted to the nearby and larger commercial center in Kericho. This shift would support a hypothesis that retail customers prefer urban and peri-urban markets for higher value purchases like solar lanterns due to the greater number of products available and the opportunities for comparison-shopping.¹⁵

Quality-Verified Products

From 2012 to 2014, quality-verified products also experienced substantial growth in the three towns, with the total number of quality-verified products available in the market tripling from 29 products in 2012 to 89 products in 2014.¹⁶ Monthly sales also increased substantially, from 170 quality-verified products in 2012 to 4500 in 2014. This resulted in an almost ten-fold increase in monthly revenue for quality-verified product sales, from US\$6,000 in 2012 to US\$55,000 in 2014. Quality-verified products represented 56% of all available solar products, 63% of solar product sales, and 36% of solar revenue. The fact that the revenue share for quality-verified off-grid solar products is smaller than the unit sales share may indicate a need for quality-verification measures for higher value solar lighting products.¹⁷

It is also interesting to note the reduced product availability, sales, and revenue for quality-verified products in Talek. A remote off-grid market, Talek had a higher fraction of revenue from solar in 2012 than Kericho or Brooke (albeit with a small sample size of only two solar products, both quality-verified). In 2014 the quality-verified solar product availability and revenue dropped, and was surpassed by growth in the availability, sales, and revenue for non-verified solar products. This underscores the challenges associated with disseminating information about product quality and performance to remote markets and reaching them with distribution supply chains.

Despite the large number of solar products that were not quality verified (16% of available products, 22% of total sales, 56% of total revenue), retailers seemed to believe that solar products in general were higher quality than grid-charged lanterns or dry-cell torches (see Figure 3). When asked the expected lifespan for different products, solar products had an average expected lifespan of 23 months, compared to 6.2 and 4.5 months for grid-charged and dry-cell products, respectively.

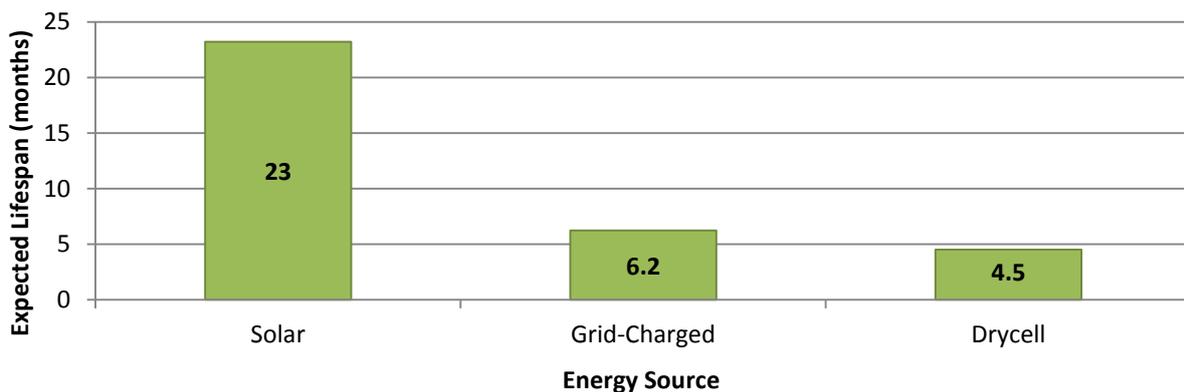


Figure 3: Expected lifespan for lighting products by energy source (N=447).

¹⁵ Neuwirth, Benjamin. (2011) "Marketing Channel Strategies in Rural Emerging Markets." Kellogg School of Management.

¹⁶ The number of distinct quality-verified products available in the market also increased from 15 distinct models in 2012 to 23 distinct models in 2014.

¹⁷ The Lighting Global Quality Assurance program only covered products with solar modules up to 10 watts at the time of the survey in 2014.

Mobile Charging Products

Devices that were able to charge mobile phones, typically with a USB port or an adaptor compatible with a variety of mobile phone sockets, represented about 10% of the products available in the market, 15% of all product sales, and 53% of all product revenue. While only 52% of the mobile-charging products we observed were solar home systems, the vast majority of sales and revenue from mobile-charging devices was captured by solar home systems (88% of sales and 83% of revenue), indicating a small market share for mobile-charging devices that weren't solar home systems. Given the recharging costs (~US\$0.25 per charge) and prevalence of mobile phones in Kenya, mobile charging could be a key driver of solar sales in off-grid markets.



Figure 4: An example of a solar lantern that also charges a mobile phone.

The Consolidation of Brand

In 2009 and 2012, the off-grid lighting markets in all three towns were flooded with inexpensive torches. The poor quality of these products resulted in considerable consumer disappointment. The brands and product models for these torches changed frequently, perhaps because manufacturers sought to rebrand their products once customers began to avoid them due to negative prior experience. As a result, in 2009 and 2012 market stalls and hawkers tables were frequently filled with an assortment of plastic torches with generic brands or models (see Figure 5A). When we visited again in 2014, there were still a large number of brands and manufacturers represented in the market (169 unique brands in 2014, compared to 119 in 2012 and 181 in 2009), but there was a dramatic decrease in the number of unique brands for torches (52 unique torch brands, compared to 91 in 2012 and 158 in 2009). The market stalls and hawker's tables also reflected a shift toward brand awareness, as tables were often neatly arranged by product type with the product brand more prominently on display (see Figure 5c). There was also a contrast between the limited examples in 2012 of on-street displays for similarly branded off-grid pico-solar (Figure 5b vs. 5c and 5d).

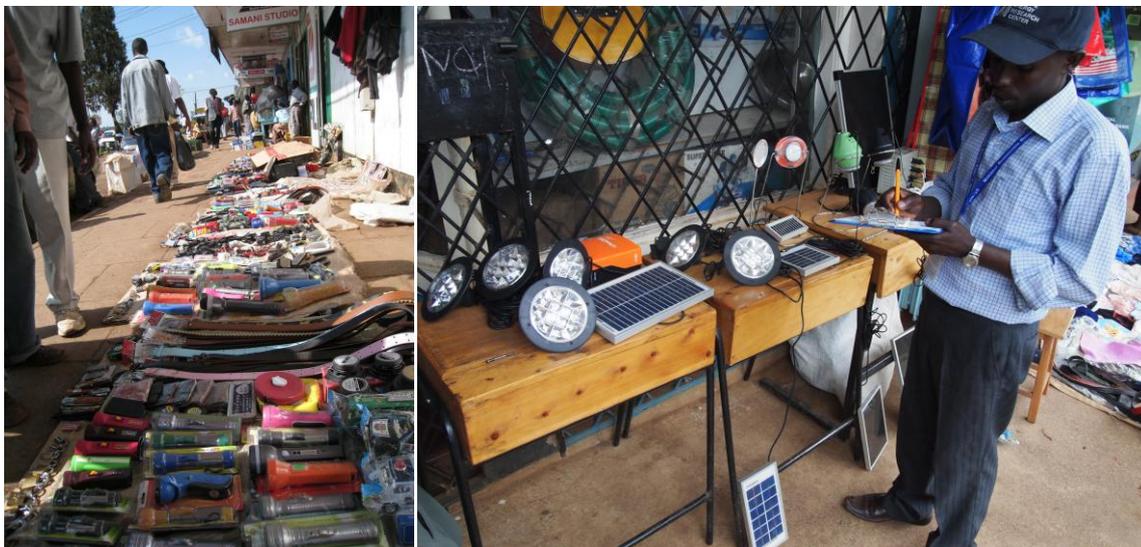


Figure 5 a/b: Left: An arrangement of transiently branded torches for sale in 2009. Right: A sales table with off-grid solar products in 2012. Both pictures are from Kericho.

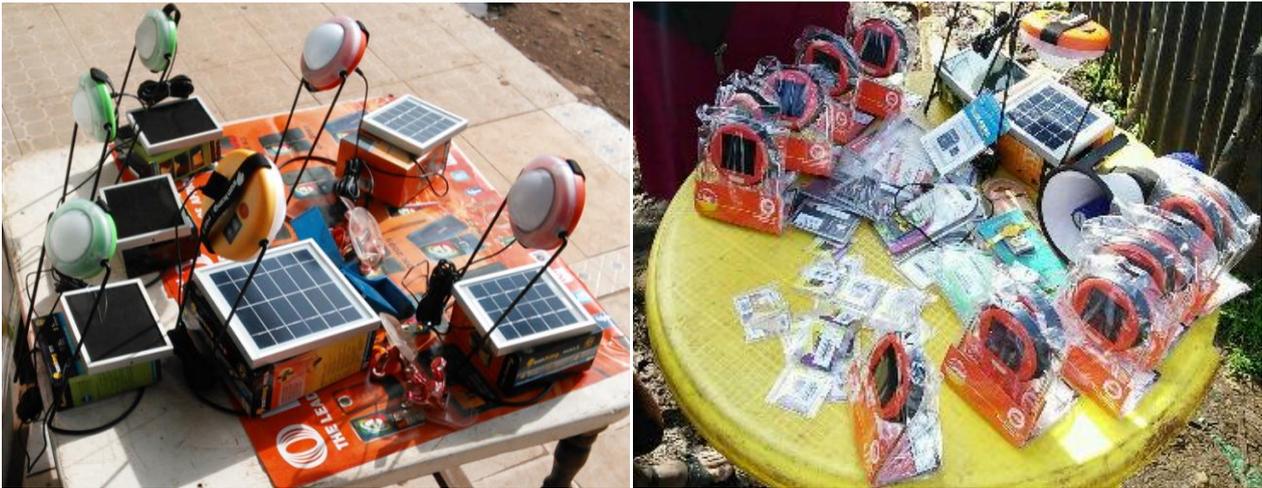


Figure 5c/d: Left: A table display of solar products outside a retailer's shop in Kericho. Right: A table display of products at an open air market in Chepsion.

Much of the market growth in 2014 was captured by five new solar brands, including three companies selling products that met the Lighting Global Minimum Quality Standards. None of these brands figured prominently in the 2012 or 2009 market surveys. Over two-thirds of product revenues were garnered by the top five brands in 2014, compared to just 20% of product revenue in 2012. As seen in Figure 6, six of the top ten brands in 2012 were dry-cell torch manufacturers. In 2014, the top earners were dominated by emerging solar brands that had relatively large average weekly revenues. Revenue estimates from 2009 for individual brands are not included in this comparison because sales and revenue were estimated differently in the 2009 survey.

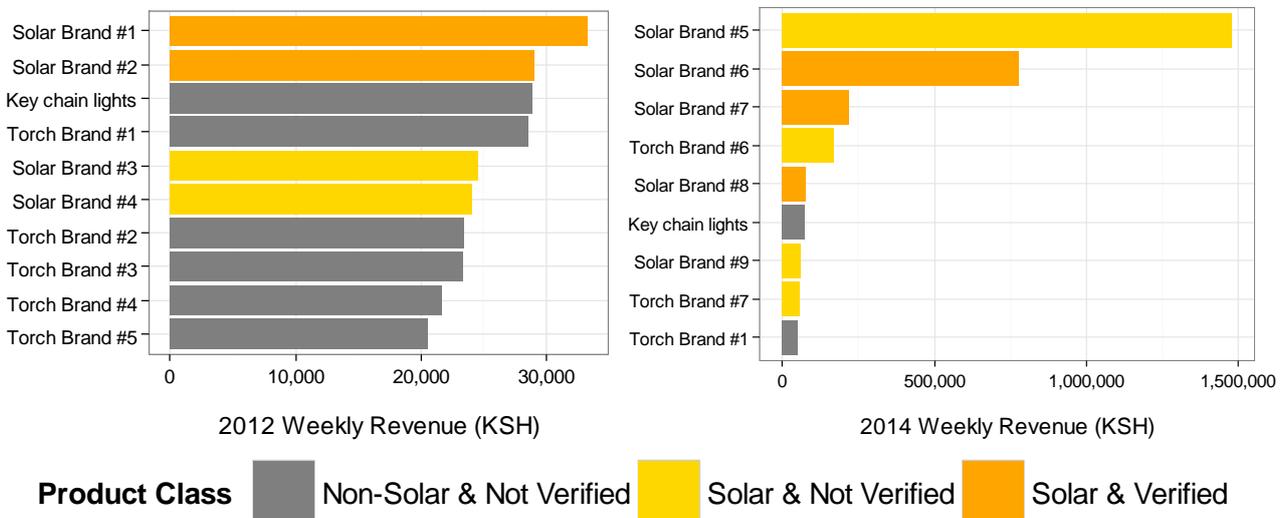


Figure 6: Left: Reported weekly sales estimates for all three towns by brand for 2012 market. Only the top brands are displayed (greater than KSH 20,000 per week). Right: Reported weekly sales estimates for all three towns by brand for 2014 market. Only the top brands are displayed (greater than KSH 50,000 per week). Solar products that were quality-verified are represented in orange, solar products that were not quality-verified are represented in yellow, and non-solar products that were not quality-verified are represented in grey. Note that Torch Brand #1 appears in 2012 and 2014.

Look-alike Products

The growth of brand awareness has also prompted the growth of look-alike products. As an example, we observed at least four look-alike lamps that were being sold interchangeably alongside the highest selling pico-solar lamp on the market, the d.light S2 (see Figure 7).¹⁸ Although look-

¹⁸ Due to its promotion through local school campaigns, its low price point, and company marketing efforts, the d.light S2 was one of the most sought-after products we observed on the market. Many retailers referred to all solar products as "d.lights," and most people referred to the S2 as "d.light" (i.e., there was little

alike products may pose a threat to future quality assurance efforts in off-grid markets, their reported market share as of June 2014 was relatively small in the towns included in the study (2% of available products, 1% of products sold, and 2% of product sales revenue). During June of 2014, the d.light S2 was also in short supply due to an inventory shortage in Kenya, which several retailers described as a reason for low or sold-out stocks. As a result, it is not clear whether or not the market for look-alike S2 lamps was temporarily bolstered by the inventory shortfall or whether retailers really considered the S2 and the S2 look-alike lamps equivalent.



Figure 7: From left to right: a d.light S2, a look-alike of the S2, and the Winning Star look-alike of the S2.

Market Size

Overall market growth for the three towns since 2012 has been dramatic, with estimated annual sales increasing from 200,000 to 360,000 units sold and annual revenue jumping from US\$400,000 to US\$2.2 million. This indicates a substantial increase in demand for higher value off-grid lighting products. As mentioned above, much of the market growth was captured by Kericho, with total product sales decreasing in Brooke and Talek even while total product revenue increased (see Table 1). This disproportionate market growth may include factors of urban population growth as well as the sale of products in Kericho to individuals or businesses from outside the city.

According to the largest distributor of pico-solar products in Kenya, Kericho represented about 17% of their national sales revenue in 2014. Assuming that this percentage holds across all brands, the gross sales of pico-solar products in Kenya is estimated at US\$10.7 million. This matches well with sales data from Lighting Africa, which estimated the total revenue for quality-verified solar products in Kenya at approximately US\$10 million for 2014. Assuming that Kericho represents approximately 17% of the off-grid lighting market in Kenya (not just solar lighting products), annual revenues for off-grid lighting in Kenya would be estimated at \$12.2 million. Please see Annex A: A Note About Measuring Market Growth for a discussion of our survey methodology and uncertainty in the data.

differentiation between different d.light products: S2, S20, or S300). As a result, and despite a clear lack of branding on the packaging, S2 look-alikes were often sold interchangeably with S2 lamps all under the category of "d.light."

Table 1: Estimated monthly sales volume of off-grid electric lighting products in the surveyed towns. Note that the estimation methods in 2009 vs. 2012 and 2014 are different.¹⁹

	Estimation method	Kericho	Brooke	Talek
Monthly Sales 2014 (units)	Individual product sales estimates	28,100	899	1,140
Monthly Sales 2012 (units)	Individual product sales estimates	14,600	1,050	1,178
Monthly Sales 2009 (units)	Total sales estimates	3,100	210	90
Monthly Sales 2014 (KSH,USD) ²⁰	Product level pricing and sales	KSH 15,000,000 USD 173,000	KSH 177,000 USD 2,040	KSH 469,000 USD 5,410
Monthly Sales 2012 (KSH,USD) ²¹	Product level pricing and sales	KSH 2,313,000 USD 27,500	KSH 120,000 USD 1,500	KSH 252,700 USD 3,000
Monthly Sales 2009 (KSH,USD) ²²	Median price & total sales estimates	KSH 403,000 USD 5,400	KSH 23,200 USD 310	KSH 13,500 USD 180

Availability and Diversity of Lighting Products

As seen in Figure 8, the total number of distinct products has been steadily increasing from 2009 to 2014. While the number of distinct torches has decreased over the same period, the number of distinct solar products has increased greatly from 2 in 2009 to 27 in 2012 to 84 in 2014. Notably, Brooke is the only town that has experienced a downward trend in distinct products available, probably due to its market share shifting to Kericho from 2009 to 2014. While the number of distinct products in Kericho increased by 45% from 2012 to 2014, the number in Talek more than doubled with a 122% increase.

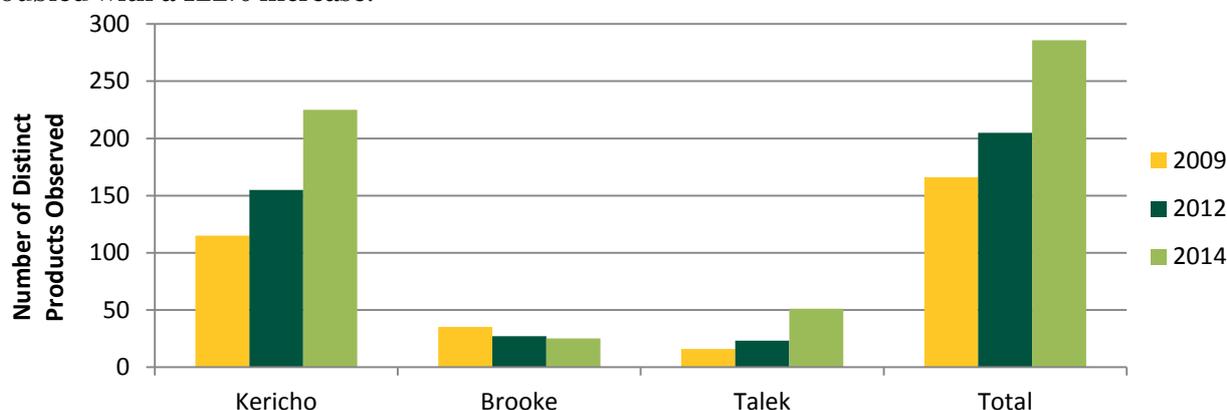


Figure 8. Comparison of the number of distinct products available in each town in 2009, 2012, and 2014.

¹⁹ In 2009, retailers were asked to estimate their total monthly sales volume and at times reported the monthly sales volume for their best selling product, while at other times reported the monthly sales volume for all products. Additionally, differences may arise from being asked to estimate on a weekly basis, rather than a monthly basis.

²⁰ Based on the price and weekly sales volume of each product, the assumption of 4.3 weeks/month and an exchange rate of KSH 86.8 per USD for June 2014.

²¹ Based on the price and weekly sales volume of each product, the assumption of 4.3 weeks/month and an exchange rate of KSH 84 per USD for June 2012.

²² Based on the median price of products in each market, as reported in Table 1, and an exchange rate of KSH 75 per USD for 2009.

Although the torch was still the dominant form factor in 2014, Figure 9 displays how the percentage of torches has decreased significantly from 95% of available products in 2009 to 52% in 2014. It is also interesting to note that while torch sales increased from 2009 to 2014, the revenue from torches decreased in Kericho and Brooke (see Figure 10).

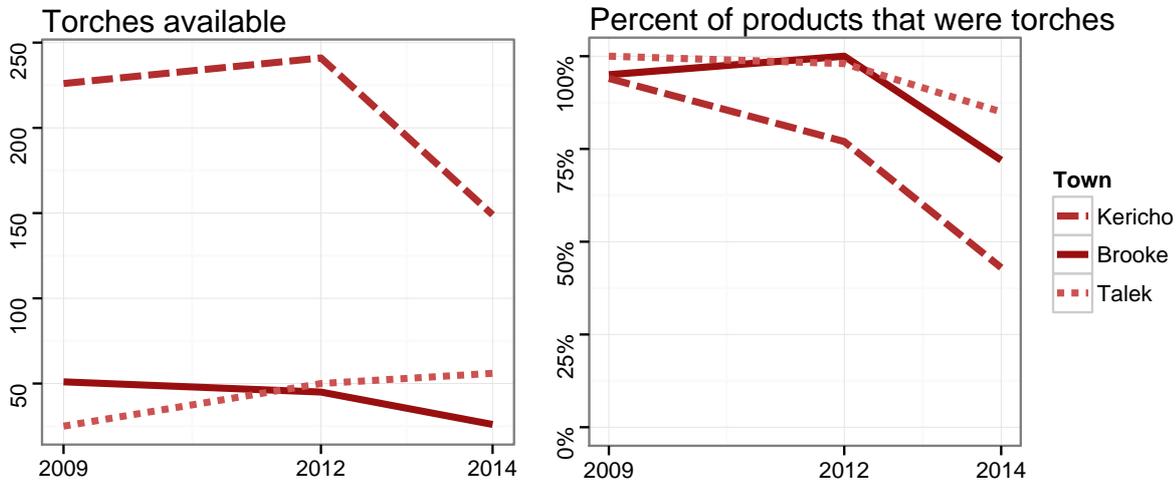


Figure 9: Number of products that were torches and the percentage of total products that were torches for 2009, 2012, and 2014.

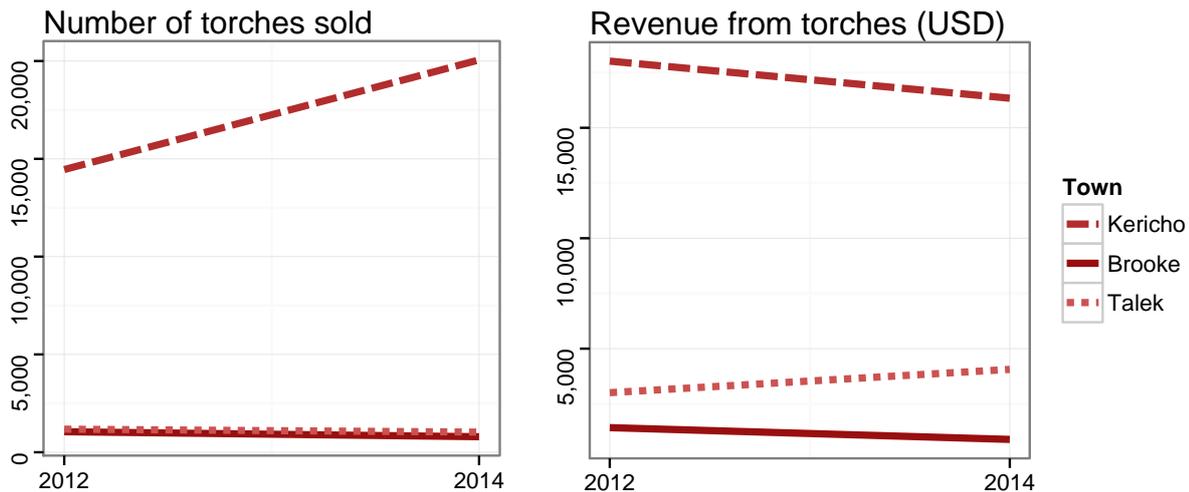


Figure 10: Monthly sales and revenue from torches in Kericho, Brooke, and Talek for 2012 and 2014.

Figure 11 provides a summary of the physical design characteristics of all the observed products in each town 2014. Figure 12 and Figure 13 present the previous results from 2012 and 2009 for comparison. From 2012 to 2014 the percentage of available products with ambient room lighting form factors increased from 20% to 35%, while task lights almost tripled from 4.9% to 14% over the same period. Despite their small share of available products, task lights (also called study lamps) represented 15% of all product sales and 22% of all product revenue. Similarly, solar home systems represented 5% of all the products observed in the market and 4% of all product sales but 45% of all product revenue. The growing revenue share for solar products in the off-grid sector indicates significant growth in sales of larger systems. This supports the idea that the Lighting Global Quality Assurance program should be expanded to cover larger off-grid solar products.

Regarding light source, by 2014 LEDs had completely replaced incandescent and fluorescent lighting products, with 99% of products being lit by LEDs. By comparison, incandescent lights represented 4% and 9% of all products surveyed in 2012 and 2009, and fluorescent lights represented 3% and 2% of all products in 2012 and 2009, respectively.

2014 Product Availability

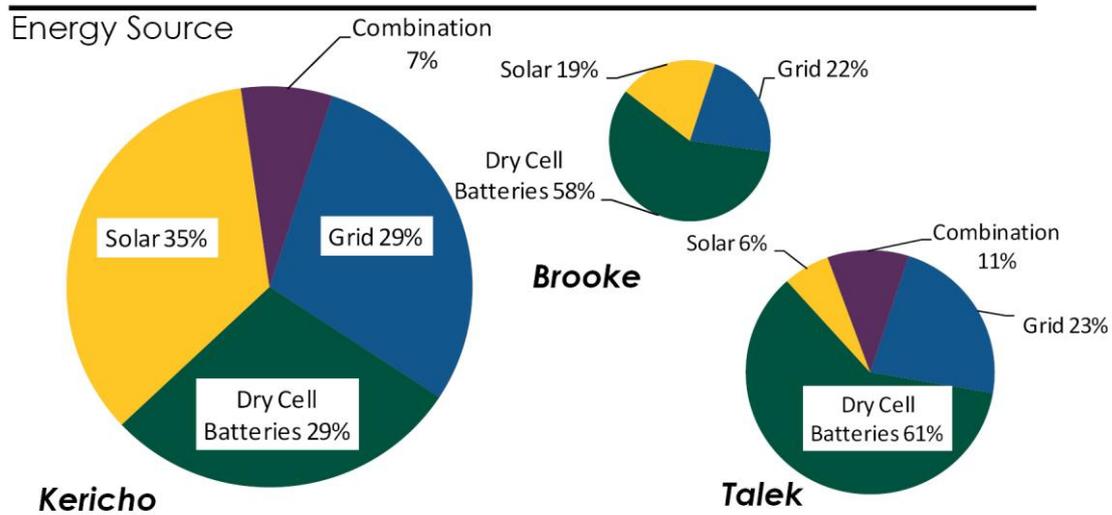
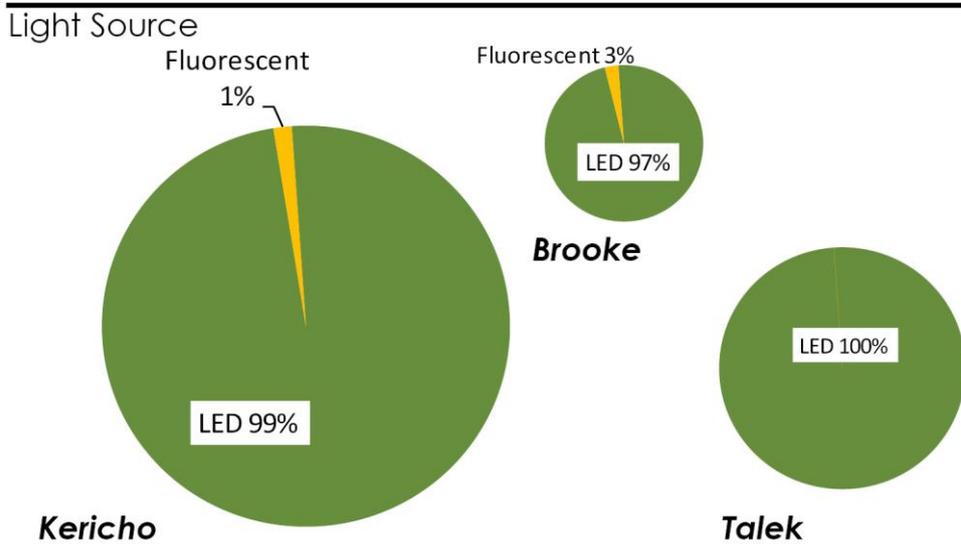
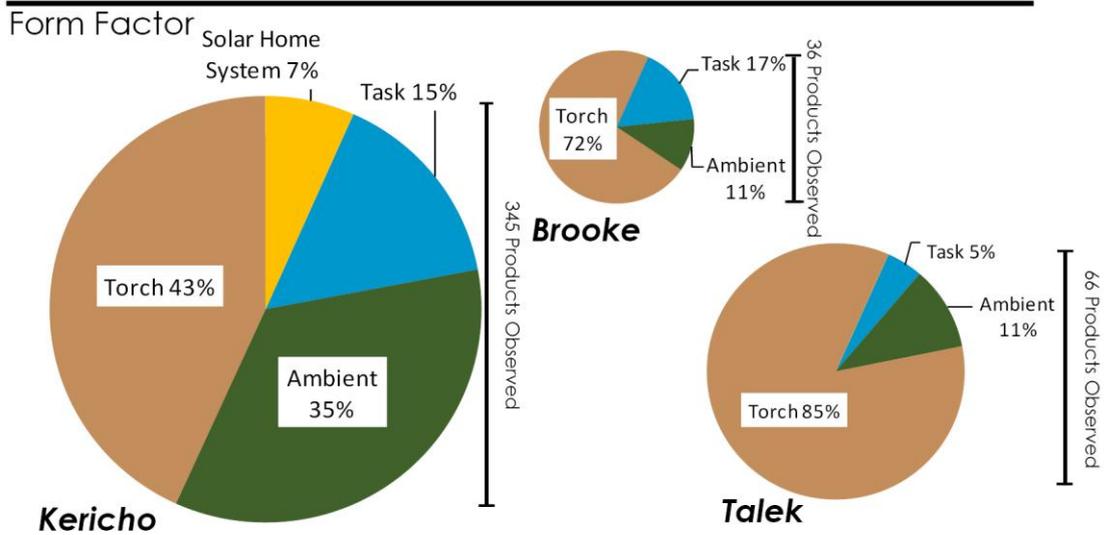
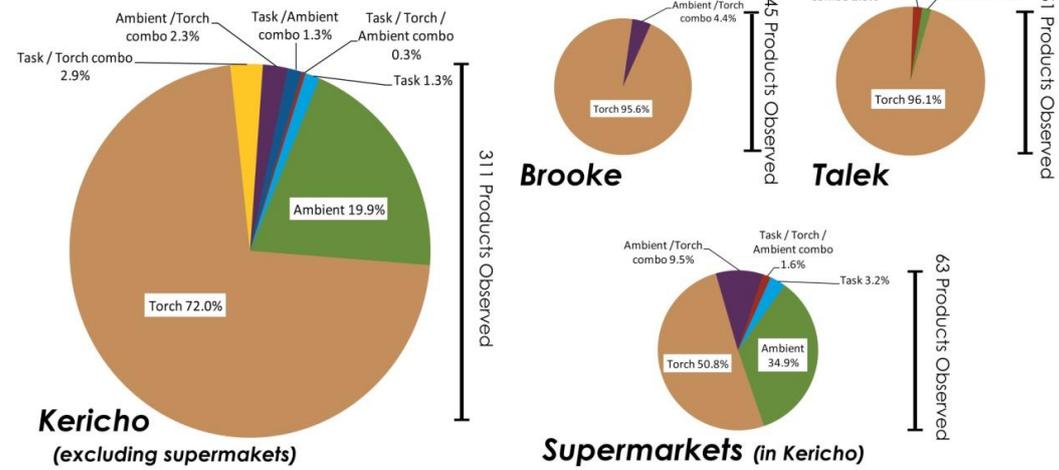


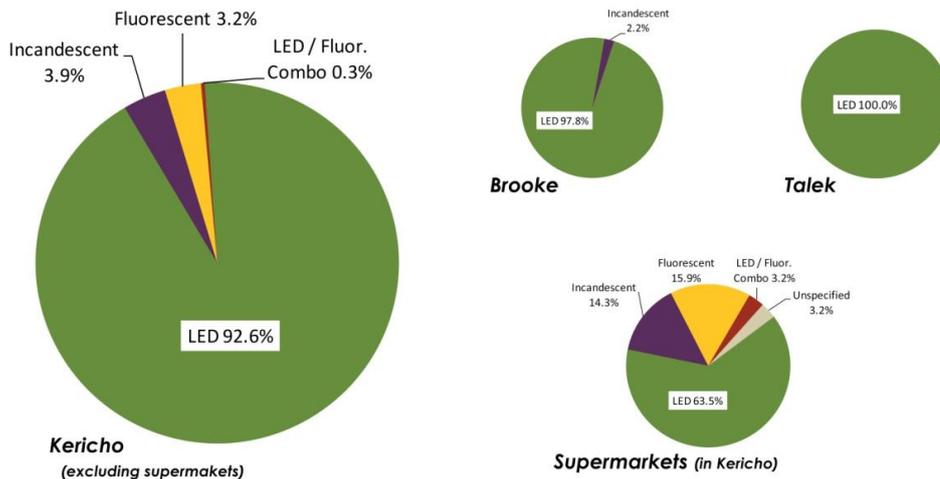
Figure 11: Characteristics of observed off-grid lighting products in 2014. All percentages represent portions of the total products available for sale in each specified town.

2012 Product Availability

Form Factor



Light Source



Energy Source

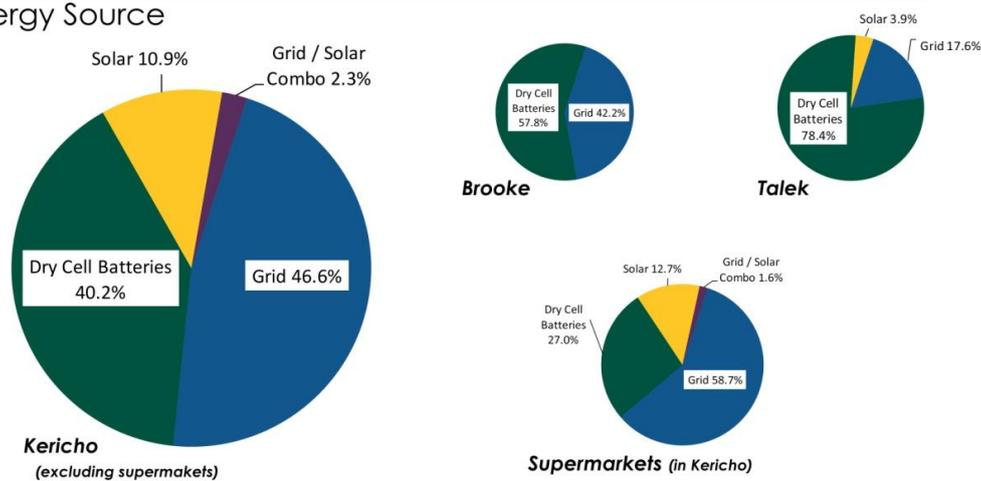
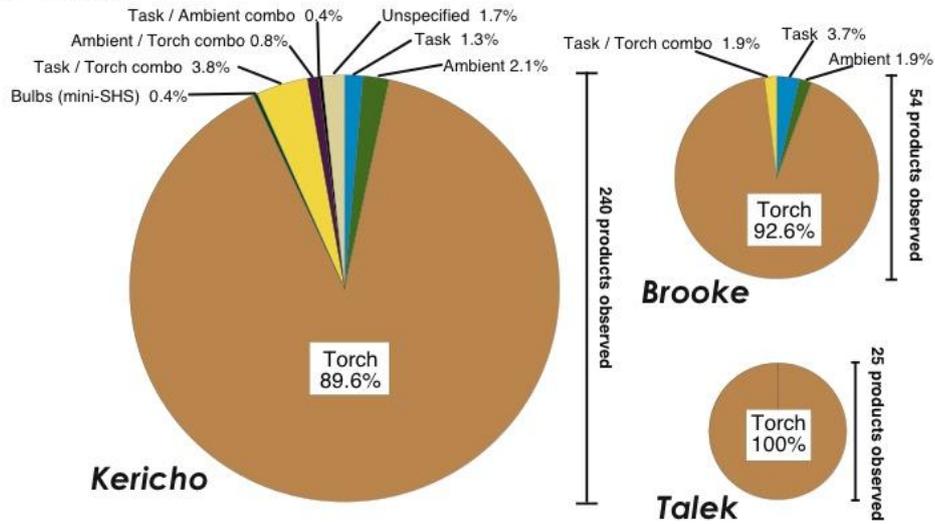


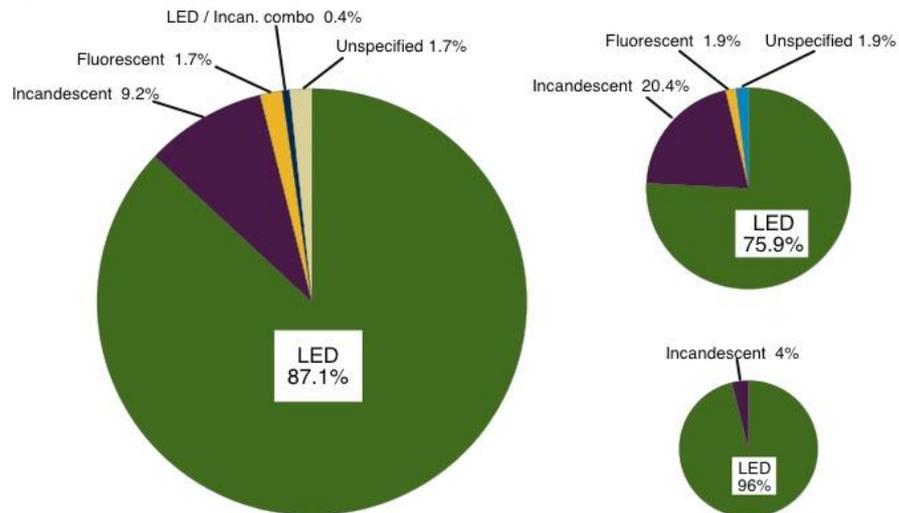
Figure 12: Characteristics of observed off-grid lighting products in 2012. All percentages represent portions of the total products available for sale in each specified town.

2009 Product Availability

Form Factor



Light Source



Energy Source

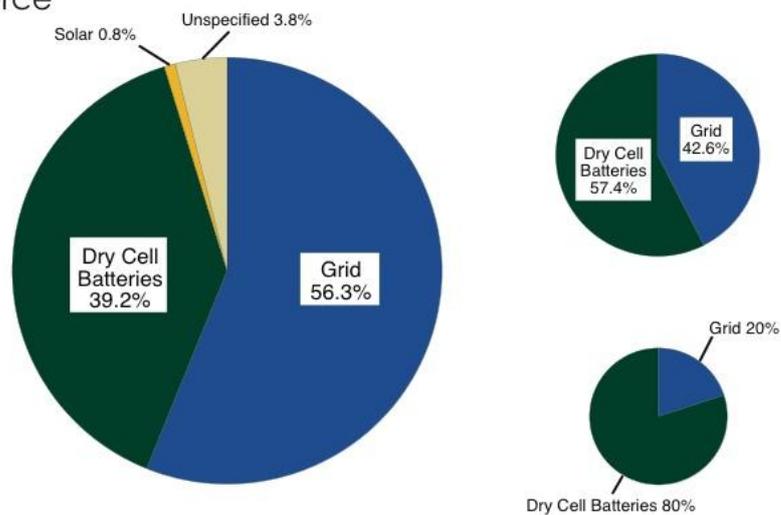


Figure 13: Characteristics of observed off-grid lighting products in 2009. All percentages represent portions of the total products available for sale in each specified town.

Prices of Available Off-Grid Lighting Products

Although the average price for off-grid lighting products increased steadily from 201 KSH in 2009 to 1,356 KSH in 2014, the average price of solar products decreased dramatically over the same period. As seen in Figure 14, prices for solar products dropped from 8,530 KSH in 2009 when there were just two solar products observed in the market to 2,668 KSH in 2014 when there were 159 solar products (also see Table B.1 in Annex B for a summary of the prices observed in each town). The trends are similar when the median price values are considered. The distribution of prices also reflected this shift, with non-solar products staying concentrated below 400 KSH and a marked increase in solar products priced between 1,000 and 1,600 KSH in 2014 (see Figure B.1 and Figure B.2 in Annex B).

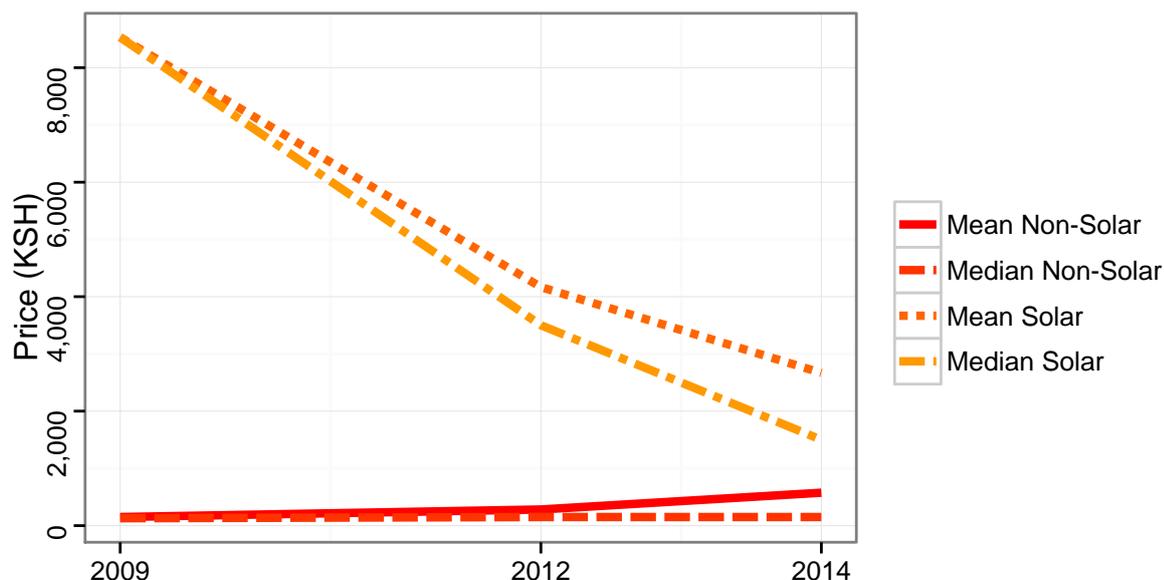


Figure 14: Mean and median prices for non-solar and solar products for 2009, 2012, and 2014 for all three towns.

The "most commonly available" products that were identified in 2009 and 2012 were nonexistent in 2014 (see Table B.2 in Annex B). In their stead, small solar task lights captured the greatest availability and sales, followed by key chain and larger dry-cell battery torches (see Table B.3 in Annex B).

The Retailers

In 2014 we surveyed a total of 63 shops in Kericho, 11 in Brooke and 20 in Talek. Although the number of shops remained about the same in Brooke and Talek from 2012 to 2014, the number of shops increased significantly in Kericho. This is due in part to a widening of the survey area to include the *matatu* stage²³ where many wholesale lighting products were sold (see the Geographic Background section for more information).

As in 2012, the shops in Kericho generally carried a greater selection of products (5.5 products per shop average) compared to Brooke and Talek (3.3 products per shop for both). Table C.1 in Annex C summarizes the key results of the survey we administered to shopkeepers. Results from 2012 and 2009 are included for reference in Table C.2 and Table C.3, along with a paper version of the digital survey that was used in Annex D. The highlights from Table C.1 are:

- The proportion of female shopkeepers increased since 2012 in Kericho and Talek. Talek is still the only town with a higher proportion of women than men working as shopkeepers in shops that sell off-grid solar and lighting products.

²³ *Matatus* are privately owned minibuses used for transporting people and goods in Kenya. The stage is the area where *matatus* arrive and depart from Kericho.

- In Kericho there was a wide range of shop types that offered off-grid lighting products. Electronics and solar specialty shops (43%) were the most common shop type. In Brooke and Talek, general shops were the most common vendor of off-grid lighting products (73% and 85%, respectively).
- As in 2012, the shops that sold lighting products in each town were predominantly small operations, with a majority having 1-2 employees. Kericho also had several larger shops (i.e., > 3 employees).
- Fifty-seven percent of sellers in Kericho were strictly retail shops; the others did some or all of their business on a wholesale basis.
- In terms of the demographics of the customers of each shop, there were no clear trends in customer age. Similarly, most retailers in Kericho and Brooke indicated that customers were equally divided between men and women. In contrast, almost all of the retailers in Talek indicated that their customers were mostly men.

Product Procurement

Each shopkeeper provided us with information regarding where he or she procured products, giving insight into the distribution of products through the off-grid lighting supply chain. Most products passed through Nairobi, but retailers listed seven different towns as sources for their products. Each of these towns, with the exception of Dubai, UAE, is included on the map displayed in Figure 1.

Sixty of 63 shopkeepers in Kericho shared information about where they procured their stock. As seen in Figure 15, the number of retailers that sourced products from Nairobi decreased from 78% in 2012 to 48% in 2014. Accordingly, 37% of retailers in Kericho reported sourcing stock from within Kericho, up from 22% in 2012. There were slight shifts in product sourcing in Brooke, with fewer retailers sourcing from Kericho in 2014 compared to 2012. It is also interesting to note that six of the twenty retailers in Talek sourced their products from within the small town. These findings indicate development of local and regional wholesale markets in Kenyan towns.

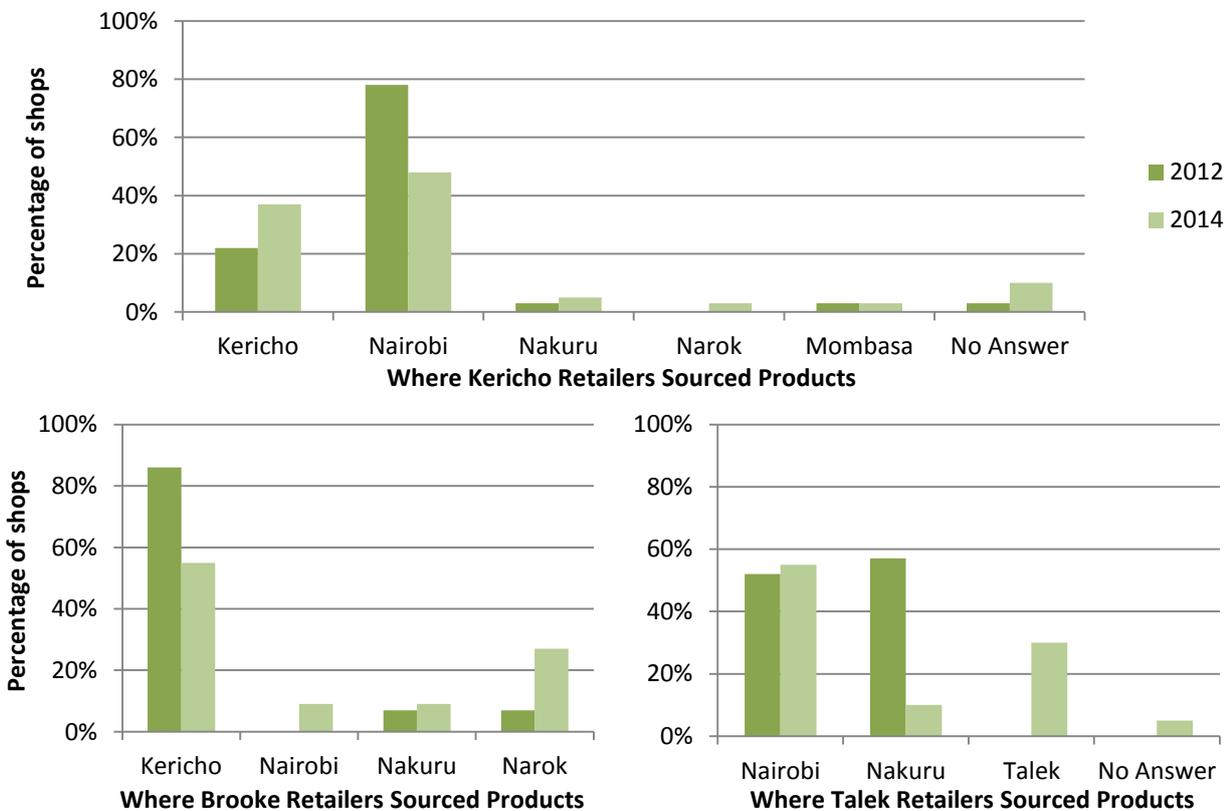


Figure 15: The location of retail suppliers for shops in Kericho, Brooke, and Talek in 2012 and 2014. Responses from 2012 are represented in dark green while 2014 responses are represented in light green. Retailers were able to indicate more than one source for products.

In 2014, we were also interested in learning about the flow of information through the off-grid lighting supply chain. Figure 16 displays the different ways that retailers reported learning about new lighting products. Notably, wholesale sellers play a significant role in informing retailers about new products, but customers were also a significant source of new product information, perhaps indicating greater information access and off-grid lighting product awareness among end-users.

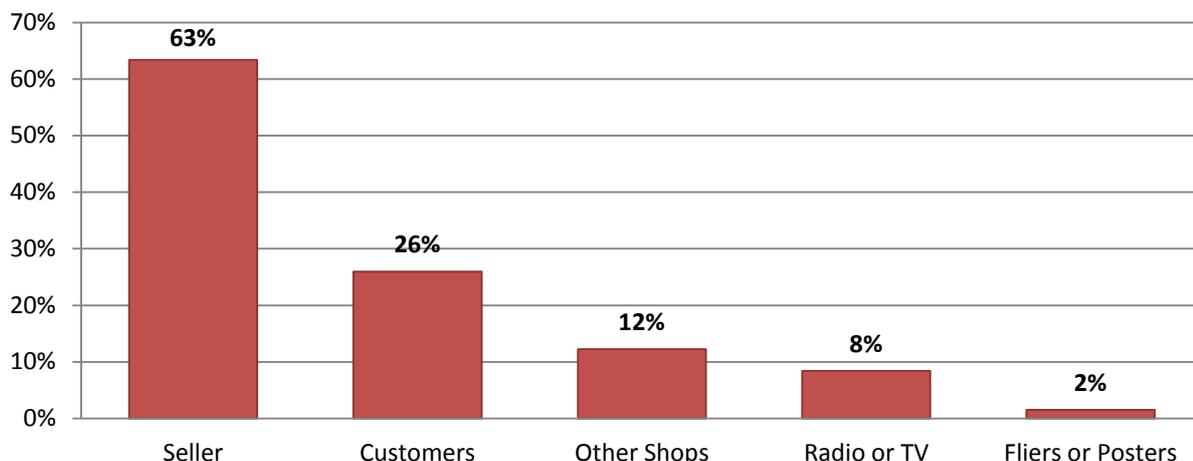


Figure 16: How retailers learn about new lighting products. Retailers could cite more than one source.

Warranties and Financing

Since its inception in 2009, the Lighting Global Quality Standards have required that manufacturers provide a consumer-facing warranty for quality-verified products.²⁴ Given the preponderance of inexpensive torches in the market and relative novelty of LED lighting and solar-charging technologies in off-grid lighting markets, the warranty requirement was aimed at protecting consumers from product defects and reducing the risk associated with purchasing a new and potentially more expensive technology. In theory, the warranty holds manufacturers accountable for faulty products and also protects consumers from cheap products being dumped in the market. In practice, it is not always easy for customers to obtain after-sales service because not all retailers honor warranties, there is often an ill-defined process for assessing manufacturing defects versus customer misuse, and determining the exact warranty period is also difficult.²⁵

When we visited retailers in 2009, only 3% were offering warranties for any of their products. In 2014, the number of retailers offering warranties increased more than ten-fold to 37%, with 6% offering warranties on all products and 31% offering warranties on products with manufacturer warranties (see Figure 17). However, given that only 20% of the products that we encountered in the market had known manufacturer warranties, it was encouraging to hear that, for 78% of products with manufacturer warranties, the retailer claimed that their business would honor the warranty.²⁶

²⁴ The initial quality standards for Lighting Africa required a manufacturer warranty for six months from the time of purchase. When the standards were updated in 2014 after soliciting customer and market stakeholder feedback, the warranty duration was increased from six months to one year.

²⁵ Please see Harper, Meg, et al. (2013) "Warranty Practices in Tanzania Retail Markets: Market Intelligence Note 4" for more information on warranties and servicing in Kenya and Tanzania.

²⁶ There were sixteen of 130 retailers that indicated that they did not honor any warranties, even though they sold products with manufacturer warranties; those un-serviced products represented 22% of the products with manufacturer warranties that we saw in the market.

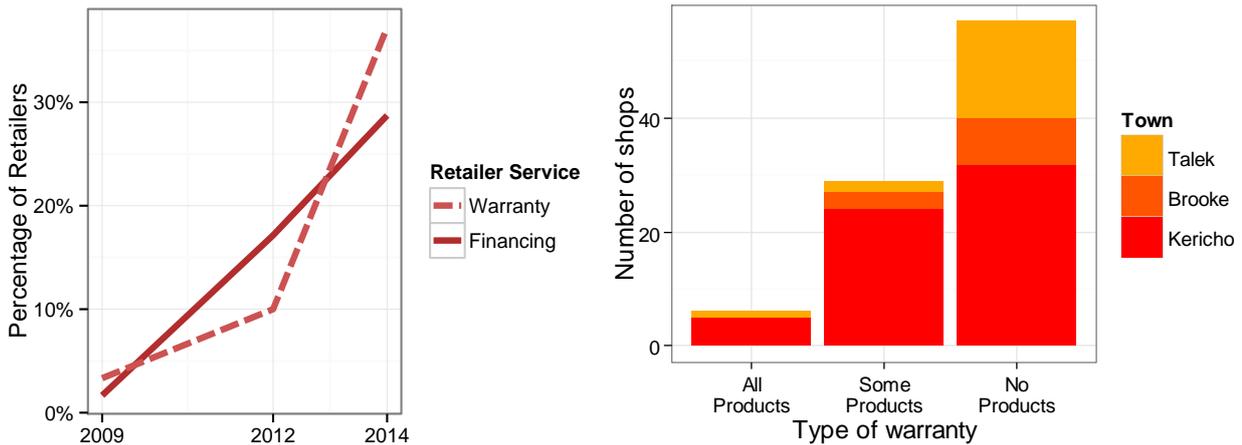


Figure 17: Left: Percentage of retailers offering warranties or financing from 2009 to 2014 for Kericho, Brooke, and Talek. Right: Types of warranties offered by retailers in Kericho, Brooke, and Talek in 2014. "All Products" indicates that retailers serviced warranties on all products sold in the store, whereas "Some Products" indicates that retailers only offered warranties on products with a manufacturer warranty.

Similarly, only 2% of retailers reported offering financing in 2009, compared to 29% in 2014. This marked increase could be due to a variety of factors, including the greater adoption of mobile money services like PayBill that make tracking and collecting installment payments easier for retailers and the development of pay-as-you-go (PAYG) financing for off-grid lighting products that enforce customer payment by turning off the product until payment is made.²⁷ It is also possible that more retailers are able to provide financing for customers because they have greater access to financing themselves through micro-financing institutions (MFIs), savings and credit cooperatives (SACCOs), or distributors. In 2014, 45% of retailers were accessing credit, compared to just 26% in 2012. As seen in Figure 18, 69% of retailers that accessed finance in 2014 did so from a bank, 29% from a distributor, 7% from a SACCO, and 5% from family or friends. Similarly, 67% of retailers that accessed finance in 2012 did so from a bank, 11% from a distributor, and 11% from a SACCO.

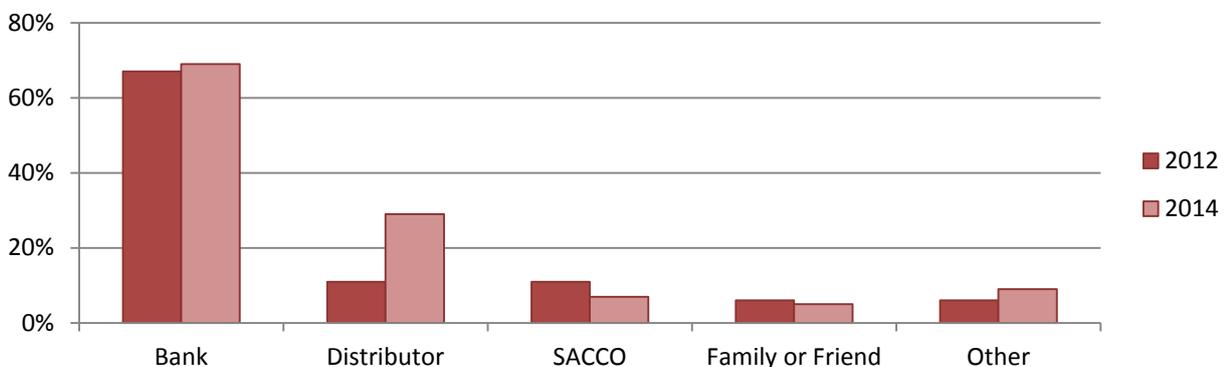


Figure 18: Financing sources for retailers in all three towns in 2012 and 2014.

Information and Communication Technologies

In the 2014 survey, we asked retailers to characterize their use of different information and communication technologies like mobile phones, mobile services, and the internet. We found that all of the off-grid lighting retailers had mobile phones, with a third using more than one mobile phone. As seen in Figure 19, smart phones were used by 43% of retailers, followed by basic phones at 41% and internet phones at 21%.²⁸ In addition, retailers reported using a variety of mobile

²⁷ Please see Alstone, Peter, et al. (2015) "Off-grid Power and Connectivity: Pay-as-you-go financing and digital supply chains for pico-solar" for more information on PAYG financing.

²⁸ For the purposes of this investigation, smart phones were defined as mobile phones with touch screens or QWERTY keyboards and the ability to download and manage different applications; feature or internet phones were defined as mobile phones with access to the internet and fixed applications like Facebook,

services like mobile money (87%), texting (79%), Facebook (50%), internet (48%), email (35%), and WhatsApp (21%), indicating a great degree of digital literacy among off-grid retailers.

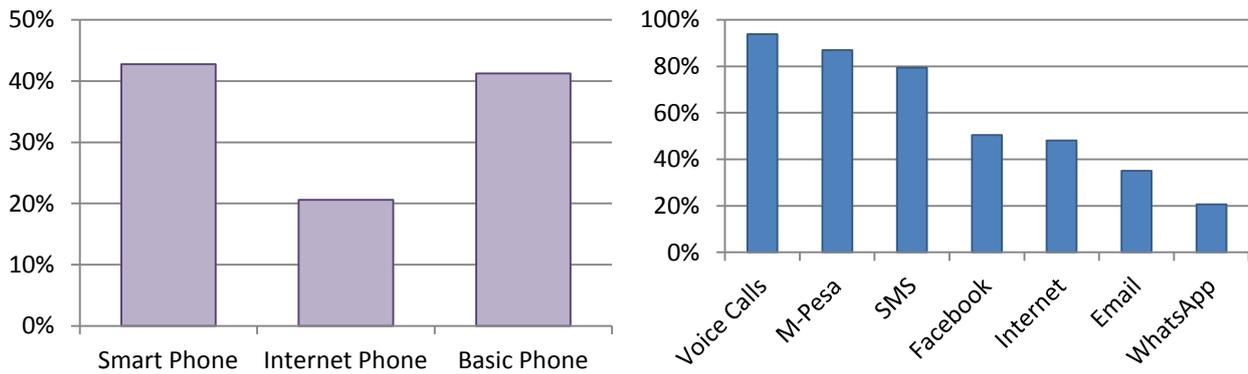


Figure 19: Left: Types of phones used by off-grid lighting retailers (N=107). Right: Mobile services frequently used by off-grid lighting retailers (N=94).

There have also been significant developments in mobile money capabilities that we have observed over the course of this longitudinal study. As seen in Figure 21, the number of mobile money subscribers in Kenya has grown exponentially since M-Pesa's inception in 2007. Although our team did not ask retailers about their use of mobile money in 2009, there was a substantial uptake between 2012 and 2014 from 54% to 80%. The increased use of mobile money was spread fairly evenly between accepting customer purchases and making business purchases, but there were also new mobile money capabilities that we observed in the market. Most notably, many retailers were using *Lipa Na M-Pesa* to allow customers to purchase goods without paying a money transfer fee.²⁹



Figure 20: Lipa Na M-Pesa sign prominently displayed at a general shop in Brooke.

Twitter, or WhatsApp; basic phones referred to the least expensive phones with no internet access or applications.

²⁹ *Lipa Na M-Pesa* means "Pay with M-Pesa." Retailers using *Lipa Na M-Pesa* are assigned a unique till number. When customers make a purchase they can send the money to that account without being charged for the transaction. Retailers however are charged for using the *Lipa Na M-Pesa* account, much like retailers are charged when customers make purchases using credit or debit cards.

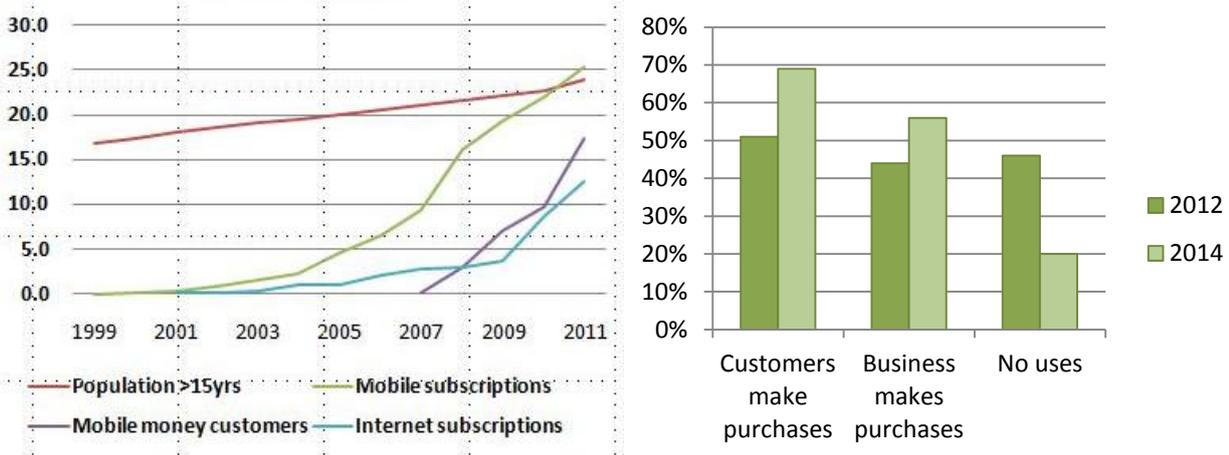


Figure 21: Left: Information and communication technology penetration in Kenya.³⁰ Right: Percentage of retailers that reported using mobile money for all three towns in 2012 and 2014.

Our team also asked retailers questions about their mobile phone use. As seen in Figure 22, retailers reported spending an average of 130 KSH each day. They also estimated an average use of 20 megabytes per day and an average of seven mobile money transactions per day. The average years of adoption for mobile phone and mobile money were 2005 and 2008, respectively. Finally, 27% of retailers reported using the internet to research new lighting products.

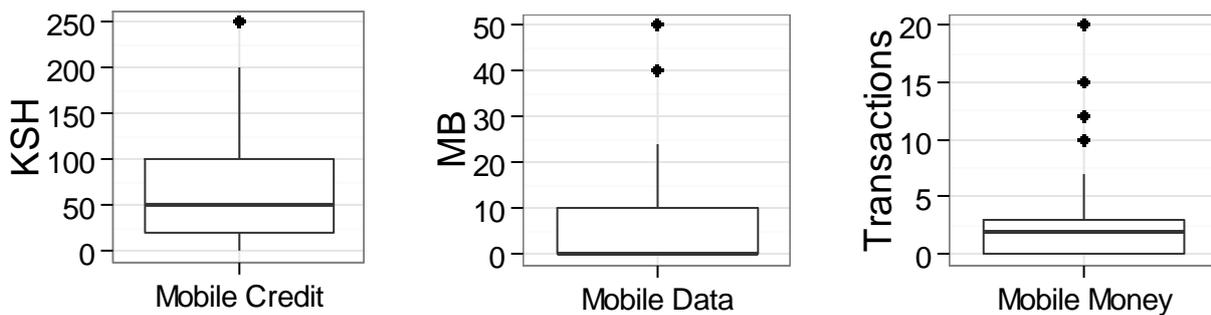


Figure 22: Estimated daily use of mobile credit (KSH), mobile data (megabytes), and mobile money (number of transactions) for retailers in all three towns in 2014. The mobile credit and mobile box plots have five outliers that were removed, while the mobile money box plot has seven outliers that were removed.

Geographic Background

This section provides a brief description of the three towns that have been surveyed since 2009.

Kericho

Kericho is a large town in a tea-growing region, with approximately 100,000 residents. Multinational corporations—notably Unilever Tea Kenya Limited and James Finlay Kenya Limited—and small-holder farmers grow and process tea in the surrounding area. The town center is the commercial hub of the area. The center of Kericho town and the surrounding tea areas are shown in Figure 23. Our initial survey covered an area near the town center where electronic goods stores were concentrated, but the boundary was expanded in 2014. As seen in Figure 23, we opted to include retailers located in the *matatu* stage coach where many off-grid lighting wholesalers had relocated since 2012. Information on product availability and pricing was also collected from two supermarkets and a petrol station outside of the boundary. However, we encountered unexpected difficulty obtaining sales estimates from supermarket staff in 2014, and the supermarket data are not included in this report. Figure 24 shows a typical scene on the street in central Kericho.

³⁰ Fengler, Wolfgang. (2012) "How Kenya became a world leader for mobile money." *Africa Can End Poverty: A blog about the economic challenges and opportunities facing Africa*.



Figure 23: Aerial image of central Kericho (retrieved from Google Earth in 2015; imagery from 2015), with the boundary of the baseline market study indicated by a yellow dashed line and the *matatu* stagecoach area indicated by a red dashed line. Global positioning system coordinates: S 0.369 E 35.284.



Figure 24a/b: Street scenes in Kericho from 2014.

Brooke

Kapkugerwet (colloquially, and throughout this paper, referred to as Brooke), is a small market center outside of Kericho town with a population of approximately 14,000. It is adjacent to the main offices of Unilever Tea Kenya Limited (previously the Brooke Bond Tea Company—the source of the Anglicized version of the town's name). There is electricity access for those who can afford a grid connection, though many in the surrounding villages do not have grid electricity. Our survey covered the commercial area, staying within the same boundaries as the 2009 and 2012 surveys, as noted in Figure 25. Figure 26 shows a typical street scene from Brooke in 2014.

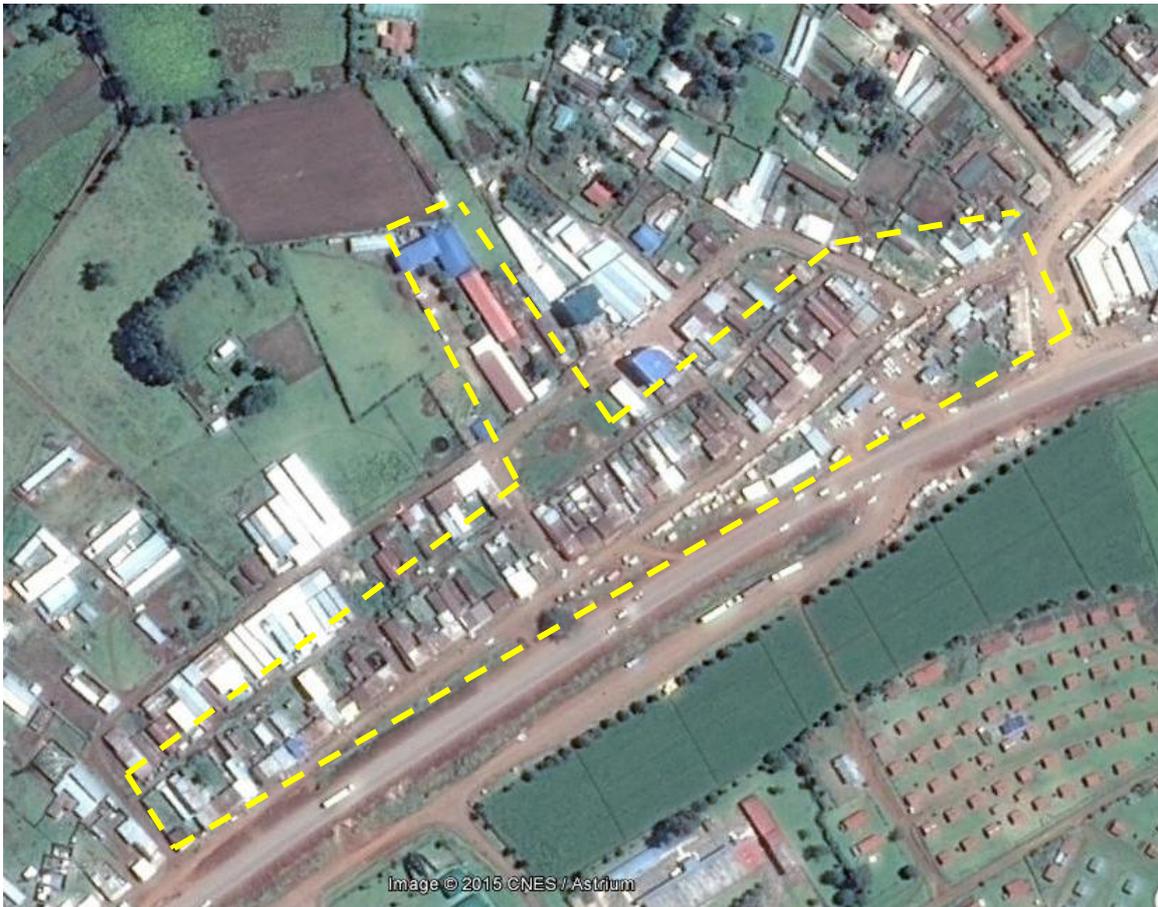


Figure 25: Aerial image of Brooke (retrieved from Google Earth in 2015; imagery from 2015), with the boundary of the baseline study indicated by the yellow dashed line. Global positioning system coordinates: S 0.336 E 35.323.



Figure 26a/b: Street scenes in Brooke (Kapkugerwet) from 2014 (it was raining the day we surveyed Brooke).

Talek

Talek is a small town in southern Rift Valley Province, located near one of the entrances to Maasai Mara National Park. There are several lodges and hotels in the area for tourists who are visiting the park, and support of tourism is a large part of Talek's economic base. Additionally, people raise livestock and grow farm crops in the area. The electric grid does not extend to Talek, although

mobile telecommunications are now available there. Our survey covered the commercial area. Talek grew substantially between the 2009 study and 2012; the commercial area had expanded greatly, and the number of shops carrying lighting products tripled. To capture the larger market, the survey area was expanded in 2012, as noted in Figure 27. Figure 28 shows a street scene in Talek in 2014.



Figure 27: Aerial image of Talek (retrieved from Bing Maps in 2015), with the boundary of the 2009 market study indicated by a yellow dashed line and the 2012 and 2014 market studies indicated by the red dashed line. The extents noted on the map are for the survey boundaries, which roughly correspond to the main commercial areas for each year. There was significant growth in Talek between 2009 and 2012. Global positioning system coordinates: S 1.442 E 35.215.





Figure 28a/b: Street scenes in Talek from 2014.

Study Methodology

We used the same set of sampling, survey, and observation methods to achieve the data collection goals for this study as were used in the 2009 and 2012 studies. With the goal of accurately capturing the presence of off-grid lighting products in the market, we used the following definition for “off-grid electric lighting products” in the context of the study:

- Has energy storage incorporated into the product (or uses dry-cell batteries).
- Has an LED, fluorescent, incandescent, and/or other electric lighting source.

The definition was intentionally broad to ensure that we captured the full range of products, including “traditional” incandescent torches with dry-cell batteries.

In each town, we included and sometimes expanded upon the geographic sampling area that was used in the 2009 study. The 2009 areas were determined using the following methods:

1. Select a study area that achieves the highest density of commercial off-grid lighting product sales in the town.
2. Create a study boundary that is sensible (based on blocks and streets) and is a relatively normal polygon (we sought to avoid irregular shapes). Limit the size of the study area based on the available time for surveying.

In practice in 2009, surveys were started without a fixed boundary and the team established the boundary as they identified the extent of the main commercial areas with off-grid lighting sales and learned how quickly they could cover areas. In Talek, the team surveyed the entire commercial area of the town in 2009, which included only seven shops that sold lighting products. When we returned in 2012, the commercial area had more than doubled in size. Rather than limiting our survey to shops within the original geographic boundary, we decided to again survey the entire commercial area, which now included 21 shops with lighting products. In 2014, the commercial

area in Talek had not changed much in size relative to 2012, and 20 shops were found within the town. Similarly, when we returned in 2014 to Kericho we found that many of the wholesalers of off-grid lighting products had moved from the central commercial area to the *matatu* staging area. As a result, information was also collected from 26 retailers located in the *matatu* stage located northeast of the central commercial area in Kericho.

The general practice during a surveying day was to systematically administer the survey on a shop-by-shop basis, working street-by-street and block-by-block during business hours to identify and survey shops and other outlets where off-grid lighting products were available for purchase. An example of the 2014 survey is included in Annex D. Native speakers of Swahili (and other locally spoken languages) who live and work in the region conducted most of the interviews, with support and guidance from our California-based research team. There were a few exceptions where the interviews were conducted by the California-based researchers in cases where the interviewee was a very good English speaker.

The survey included questions about the interviewee, the shop, the off-grid lighting products sold in the shop, and the shop's customers. Data collected about lighting products included the form factor, light source, energy source, price, and estimated weekly sales of each available product. Note that weekly sales data were only collected in 2012 and 2014 (i.e., these data were not collected in 2009). We did not record the full inventory of each shop (i.e., how many of each product the shop had in stock). We also collected information about the shops, including the type of shop (ranging from market hawkers to solar specialty shops), the number of employees, the type of sales (retail or wholesale), the basic demographics of their customers, and the use of credit in their business. The key additions to the 2014 survey were questions related to quality assurance outreach efforts³¹ and mobile telephone and services use among retailers. Retailer and distributor surveys were conducted using Open Data Kit (ODK) software on tablet computers. Surveys were processed using the formhub online platform for ODK data. Information was then cleaned and analyzed using Microsoft Excel, OpenRefine, and the R statistical programming platform.

Looking Forward

Since 2009, the off-grid lighting market in Kenya has undergone several significant transformations: from incandescent to LED lighting, from dry-cell batteries and grid-charging to solar power, and from cheap, plastic torches to quality-verified off-grid solar systems with warranties. Over the same period, the rapid rise of mobile coverage and the use of mobile phones and services in rural areas have facilitated greater connectivity, financing, and information access throughout the off-grid lighting supply chain. This and a variety of other technology drivers have contributed to the evolution and growth that we have observed in the market, including innovations in lighting and energy storage technologies, plummeting photovoltaic prices, and greater investment in clean energy services for off-grid households. There are also significant institutional and organizational efforts supporting growth, with programs like Lighting Africa and Lighting Global and other market stakeholders and participants throughout the off-grid lighting supply chain.

Looking forward, there are several core insights we can glean from these unique longitudinal datasets. First, as the off-grid lighting market shifts from cheap, disposable torches to higher value solar lanterns and home systems, commercial activity is likely to increase in larger urban and peri-urban markets where competition is greater and there are more opportunities for comparison shopping. We saw that market growth was greatest for the largest of the three towns in our survey, Kericho, and that the off-grid lighting market in the satellite town of Brooke actually declined in its availability and sale of off-grid lighting products. Also, while there was significant growth in the market for all solar products in Talek, it was notable that there is slight decline in the availability,

³¹ See Turman-Bryant, Nick, et al. (2015) "Quality Communication: Quality assurance in Kenya's off-grid lighting market" for more information about the quality assurance data collection effort.

sale, and revenue of quality-verified products, perhaps indicating a lag in market development or a lack of access to information about product quality or performance for remote markets (or due to sampling error).

Second, the need for quality-verification among solar home systems is already present in the market and will undoubtedly grow with the demand for more affordable and reliable energy services. Although solar home systems represented only 4% of available products and 5% of total product sales, they captured an estimated 45% of total market revenue. Fifty-six percent of total market revenue was captured by solar products that were not quality-verified, and solar home systems represented three-quarters of that revenue. With a growing number and diversity of products entering markets like Kenya, solar home system testing and quality assurance could play a critical role in the next phase of growth for the off-grid lighting market in Kenya. At the time of writing, Lighting Global had just included information for the first set of quality-verified solar home system kits on the program's website.

Third, the consolidation of brands could lead to a previously unprecedented awareness and loyalty to particular companies in Kenya's off-grid lighting market. While this brand awareness could boost the overall level of and expectation for quality among off-grid lighting products, there are also potential pitfalls associated with brand success. In the 2014 survey, we witnessed a proliferation of look-alike products taking advantage of the success of the d.light S2. Without institutional protections of trademarks and intellectual property, it may be more difficult for companies to combat look-alike products in remote, off-grid markets and build long-term, valuable brands.

Finally, the widespread adoption of mobile phones and services could simultaneously drive and help facilitate off-grid lighting market growth by enabling mobile money transactions and facilitating financing through pay-as-you-go (PAYG) platforms and micro-lending. As of 2014, mobile network coverage provided wireless access to 96% of the population of Kenya, with 70% SIM penetration³² and 11% of the population connected to the internet over 3G.³³ At the same time, digital literacy is increasing rapidly as customers use mobile phones and services for calls, texts, social media, email, internet, and mobile money transactions. As mobile phones become increasingly indispensable for connectivity, productivity, and banking, demand for devices that provide affordable and reliable mobile charging will continue to increase.

From 2009 to 2014 there has been a quiet revolution in Kenya's off-grid lighting market, with overall market revenue quintupling each time we return. The pace of technological innovation and deployment, and the resultant transformation of the off-grid lighting market in Kenya, has provided three high-resolution snapshots of an off-grid lighting market undergoing rapid transitions and mirrored in sales data across Kenya and globally. As photovoltaic prices continue to drop and even greater efficiencies are achieved for lighting, battery storage, and mobile charging technologies, we anticipate continued growth in the next stage of Kenya's off-grid lighting market development.

³² SIM penetration is a measure of the total SIM connections divided by the total population. Since some subscribers may have more than one SIM connection, it is not necessarily an accurate representation of unique mobile connections.

³³ GSMA Intelligence. (2014) "Data > Markets > Africa > Kenya." GSMA Intelligence Website.

About Lighting Global

Lighting Global is the World Bank Group's platform to support development of commercial markets for modern energy services for the [more than 1.2 billion](#) people in the world without access to electricity. Through Lighting Global, IFC and the World Bank collaborate with the Global Off-Grid Lighting Association (GOGLA), the solar energy services industry and development partners to spur growth of markets for clean, affordable, modern energy services.

The Lighting Global product quality assurance program sets the global standard for quality off-grid solar devices and kits. Under the program, Lighting Global presently lists over fifty quality verified solar products from more than 20 manufacturers. The Lighting Global platform provides support to a broad portfolio of country-based regional market development programs - Lighting Africa, Lighting Asia and Lighting Pacific, which work along the supply chain to reduce market entry barriers and first mover risks in key off-grid solar markets.

Lighting Global is a key element of the Global Lighting and Energy Access Partnership (Global LEAP), an initiative of the Clean Energy Ministerial (CEM). The World Bank Group implements Lighting Global in partnership with the Africa Renewable Energy and Access (AFREA) grants program, Denmark, the Energy Sector Management Assistance Program (ESMAP), the Global Environment Facility (GEF), Italy, The Netherlands, and the United States of America. For more information, visit www.lightingglobal.org.

About IFC

IFC, a member of the World Bank Group, is the largest global development institution focused exclusively on the private sector. Working with private enterprises in about 100 countries, we use our capital, expertise, and influence to help eliminate extreme poverty and boost shared prosperity. In FY14, we provided more than \$22 billion in financing to improve lives in developing countries and tackle the most urgent challenges of development. For more information, visit www.ifc.org.

About World Bank

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Annex A: A Note About Measuring Market Growth

Ideally, market growth is documented through the regular collection of product sales data over a specific measurement period. In this study, we have tried to capture market growth by documenting product availability, product sales, and product revenue in 2009, 2012, and 2014. As singular snapshots, this information has limitations (e.g., inability to extrapolate to broader markets, uncertainty regarding seasonality, greater susceptibility to outlier influence, etc.), but several snapshots of the same market taken at regular intervals (and at a similar time of year) can still yield valuable insights into market trends over a period of time. As with most studies, our methods of measurement have improved during the five years that we've been conducting this research.

To measure product availability we recorded every off-grid lighting product that we observed in the market during the period of the survey. This included product form factor, light source, energy source, and price. In 2014, we were able to record wholesale and retail prices for retailers that sold on a wholesale and retail basis; however, wholesale and retail pricing was not included in the 2012 and 2009 surveys.

To measure product sales we asked the retailer how many products were sold in the last week *for each product*. In 2014, we also asked retailers how many of those sales were retail sales and how many were wholesale sales. Given the potential for inaccuracy in self-reporting, there is a degree of uncertainty associated with these sales figures (in addition, we used a different method for reporting sales in 2009, which leads to greater uncertainty in the comparison).³⁴ Also, since we asked shopkeepers to estimate how many of each product they had sold but did not look at their books for accurate numbers, reported sales should be taken as estimates with some degree of uncertainty. To measure product revenue we multiplied the product price by the product sales for that week and divided it by the exchange rate at that time. Given the variability of pricing for different customers, there is additional uncertainty associated with revenue estimates for each product.

Three other sources of uncertainty affect these estimates of market growth for 2014. The first source arises from the fact that approximately 34 retailers sourced products from within the same town. Fourteen of those retailers sourced products from retailers that were included in our survey, but the other twenty sourced products from unspecified or unknown sources within the same town. In order to prevent double-counting, we subtracted the retail sales of the retailers that sourced from within the same city but retained the wholesale sales of the retailers that were named as the product source. The second source of uncertainty is that no sales figures were provided by supermarkets, which may represent a considerable portion of sales in Kericho. Finally, the wholesale sales figures for Kericho Industrial Supply (KIS) were excluded from our market estimates because KIS is a sub-distributor for four other towns in western Kenya, because no other retailer in Kericho reported sourcing products from KIS, and because their reported sales data were an order of magnitude greater than any other shop in town. Each of these sources of uncertainty and the way that the data were treated would suggest that we have underestimated total sales.

Accordingly, the metric that most interests us for measuring market growth, product revenue, is also the measurement with the greatest uncertainty. As a result, we present all three metrics whenever possible to provide indications of how product availability, diversity, and sales have changed over time. In addition, we checked these estimates against any other sales data that we were able to obtain to corroborate our results.

³⁴ In 2009, retailers were asked to estimate their total monthly sales volume and at times reported the monthly sales volume for their best selling product, while at other times reported the monthly sales volume for all products. Additionally, differences may arise from being asked to estimate on a weekly basis, rather than a monthly basis.

Annex B: Prices of Available Off-Grid Lighting Products

Figure B.1 and Figure B.2 display the histograms of price distributions for products observed in 2014 and 2012, respectively. Table B.1 provides a summary of off-grid lighting product prices in Kericho, Brooke, and Talek for 2009, 2012, and 2014. Table B.2 provides a summary of the most common products in 2009 and their incidences in 2012 and 2014, and Table B.3 and B.4 display the most common products from 2014 and 2012, respectively.

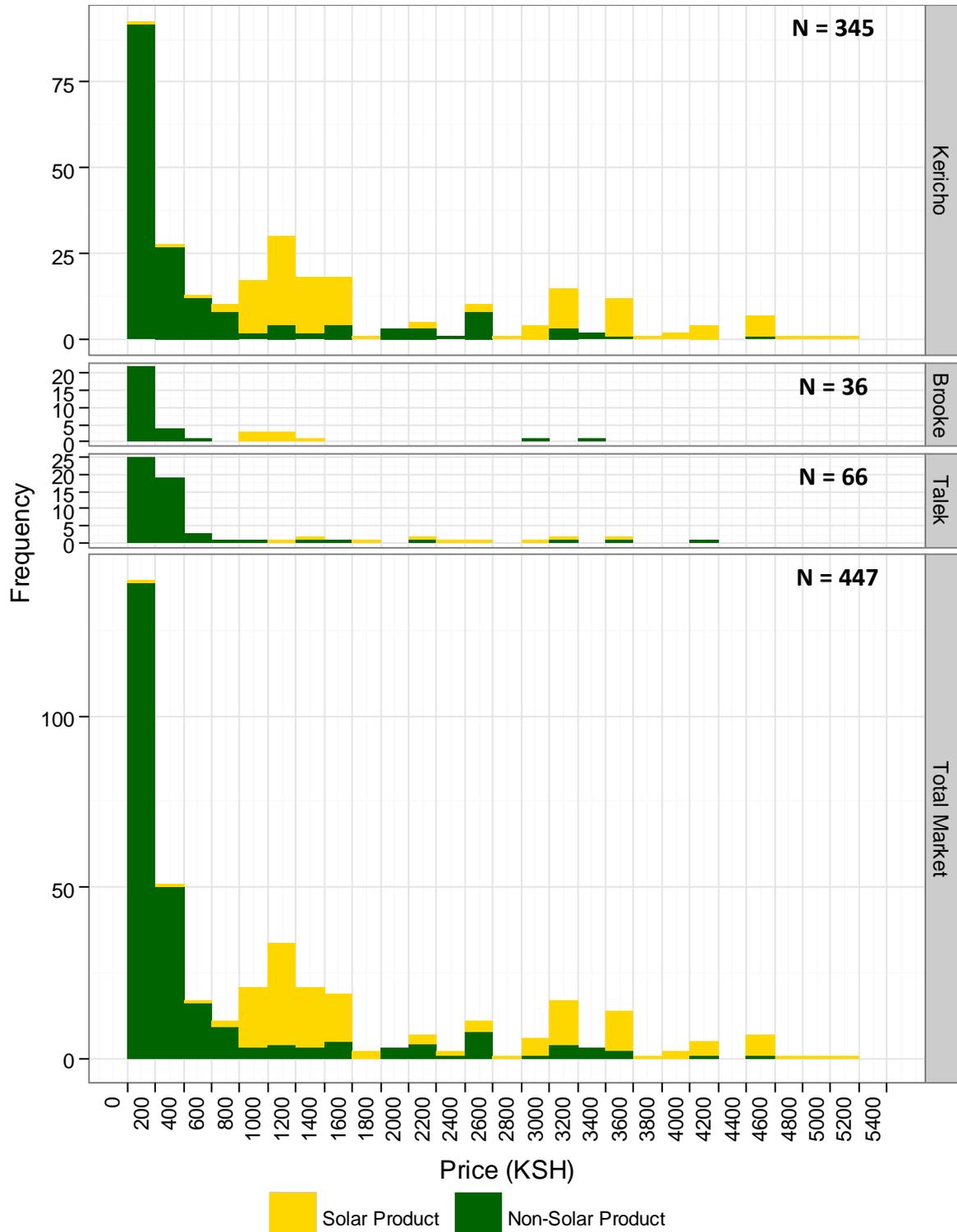


Figure B.1: Histograms showing the distribution of product price in 2014. Solar products in Kericho, Brooke, and Talek are highlighted in gold. Note that the frequency is scaled differently for each market. In Kericho, outliers greater than KSH 10,000 and having a maximum value of KSH 18,000 are not shown here. These outliers comprise 10 small solar home systems that constituted 4% of the available solar products observed in Kericho.

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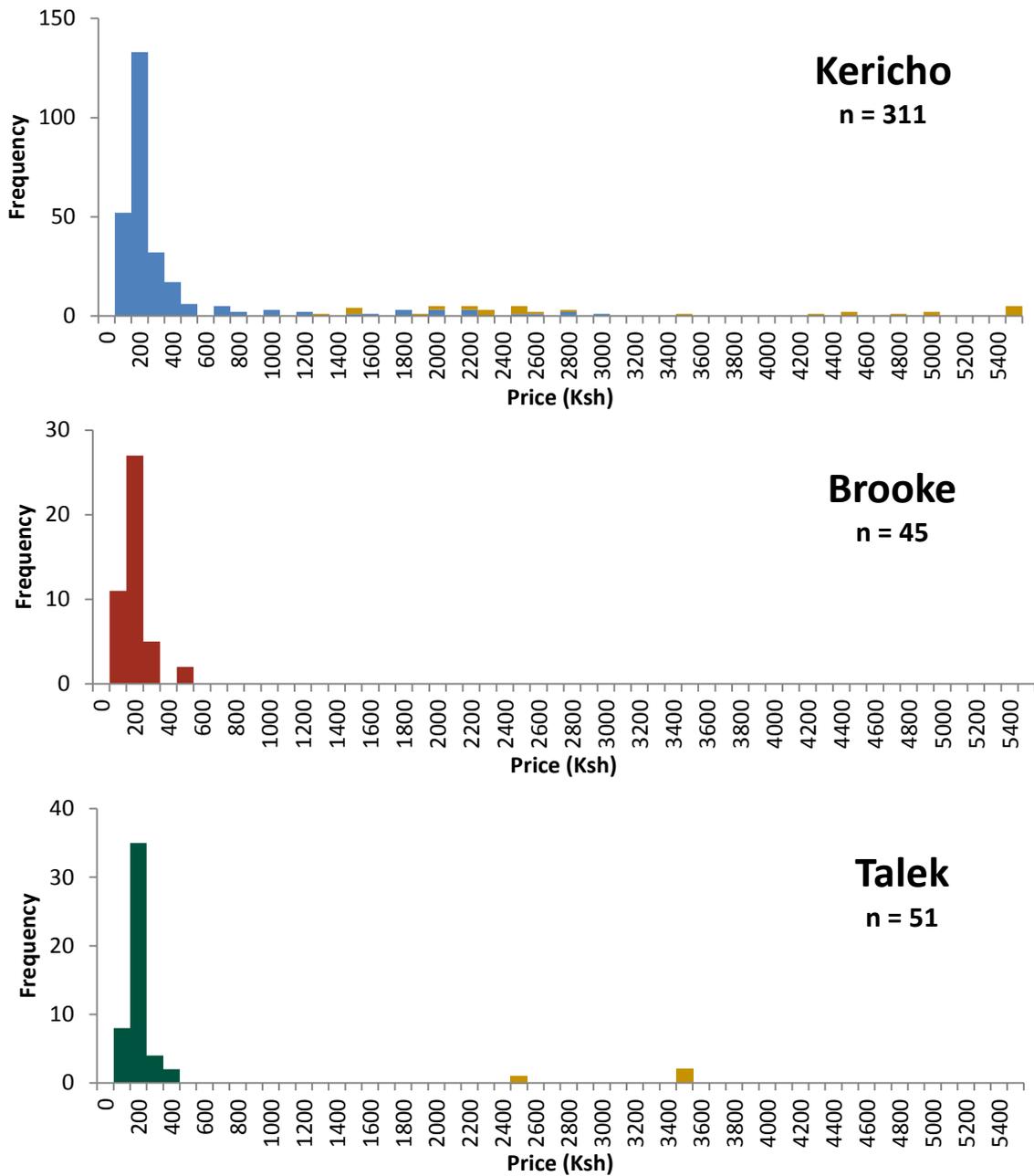


Figure B.2: Histograms showing the distribution of product price in 2012. Solar products in Kericho, Talek and the supermarkets are highlighted in gold. Note the frequency is scaled differently for each market. In Kericho, outliers greater than Ksh 5,500 and having a maximum value of Ksh 11,500 are not shown here. These outliers comprise 10 solar products which constitute 25% of the available solar products observed in Kericho.

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Table B.1 Summary of off-grid lighting product prices in Kericho, Brooke, and Talek.

		Mean Price (KSH)	Median Price (KSH)	Std. Deviation of Price (KSH)
Kericho	All Products 2014 (n=345)	1577	900	2328
	All Products 2012 (n=311)	846	180	1675
	Non-solar Products 2014 (n=202)	621	170	1010
	Non-solar Products 2012 (n=270)	326	150	505
	Solar Products 2014 (n=143)	2783	1500	2896
	Solar Products 2012 (n=41)	4334	4400	2451
Brooke	All Products 2014 (n=36)	462	150	732
	All Products 2012 (n=45)	137	140	87
	All Products 2009 (n=54)	121	110	87
	Non-solar Products 2014 (n=29)	332	130	759
	Solar Products 2012 (n=7)	1000	1000	144
Talek	All Products 2014 (n=66)	787	250	1166
	All Products 2012 (n=51)	282	170	568
	All Products 2009 (n=25)	153	150	66
	Non-solar Products 2014 (n=57)	559	200	1052
	Non-solar Products 2012 (n=49)	171	150	71
	Solar Products 2014 (n=9)	2200	2200	804
	Solar Products 2012 (n=2)	3000	3000	707
All Three Towns	All Products 2014 (n=447)	1356	500	2123
	All Products 2012 (n=409)	704	170	1503
	All Products 2009 (n=319)	201	130	847
	Non-solar Products 2014 (n=288)	575	150	995
	Non-solar Products 2012 (n=364)	282	150	443
	Non-solar Products 2009 (n=317)	150	130	140
	Solar Products 2014 (n=159)	2668	1500	2774
	Solar Products 2012 (n=45)	4167	3500	2411
	Solar Products 2009 (n=2)	8530	8530	9404

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Table B.2: Comparison of commonly available products in Kericho 2009 to 2014. All of the products below are torches with dry-cell batteries.

Product	Form Factor	Charge Source	Incidence in Kericho (2009)	Incidence in Kericho (2012)	Incidence in Kericho (2014)	Kericho Median Price (KSH) (2009)	Kericho Median Price (KSH) (2012)	Kericho Median Price (KSH) (2014)	Total Sold in All Towns (2012)	Total Sold in All Towns (2014)
Casibao CA199	Torch	Dry-cell battery	19	1	0	130	120	--	5	--
Jinge JG6170	Torch	Dry-cell battery	14	1	0	135	150	--	4	--
Keychain LED	Torch	Dry-cell battery	12	13	17	20	30	25	1275	
Lion Head LED	Torch	Dry-cell battery	9	2	0	80	110	--	12	--
Diamond	Torch	Dry-cell battery	8	3	0	110	150	--	16	--
Jinge JG6162	Torch	Dry-cell battery	8	1	0	163	200	--	0	--

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Table B.3: Summary of commonly available products in all three towns in 2014.

Product Brand	Form Factor	Charge Source	Product Model	Incidence in Kericho	Incidence in All Towns	Kericho Median Price (KSH)	Total Sold in Kericho
d.light	Task	Solar	S2	28	33	1000	814
	Ambient	Solar	S20	10	11	1200	87
	SHS	Solar	D20g	8	8	3000 ³⁵	11
	Ambient	Solar	S300	5	5	3500	14
Keychain LED	Torch	Dry-cell battery	--	17	27	25	1081
Tigerhead	Torch	Dry-cell battery	Ft2de2f	3	16	110	87
H	Torch	Dry-cell battery	TH-5098	7	15	90	442
Greenlight Planet	Task	Solar	SunKing Eco	5	5	1100	26
	Task	Solar	SunKing Mobile	5	5	3000	56
	Ambient	Solar	SunKing Pro2	4	4	3950	11

³⁵ The D20g was the d.light product sold by M-KOPA before it was replaced by the M-KOPA III. The KSH 3000 median price was the down payment required from customers. The remainder of the product cost was paid electronically through mobile money payments in a pay-as-you-go contract. Under the contract for the D20g, customers paid KSH 50 per day for one year. Alternatively, customers were able to purchase the D20g off the shelf for KSH 18,000. However, in July, 2014 d.light began to sell an almost identical version of the D20g for KSH 9,000 without the ability to pay-as-you-go.

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Table B.4: Summary of commonly available products in Kericho in 2012.

Product Brand(s)	Form Factor	Charge Source	Product Model	Incidence in Kericho	Incidence in All Towns	Kericho Median Price (KSH)	Total Sold in Kericho
Keychain LED	Torch	Dry-cell battery	--	13	25	30	1275
Liger Head, Horse Brand, Horse Yu	Torch	Dry-cell battery	FTJ991E1	11	13	150	158
LZ	Torch	Dry-cell battery	LZ7588	9	10	180	137
AQIN	Torch	Dry-cell battery	AH3141	8	11	150	97
San Feng, Xian Feng, Xiang Feng, Eagle Head	Torch	Dry-cell battery	9772B	7	8	150	66
San Feng, Xian Feng, Xiang Feng, Wen Bang	Torch	Dry-cell battery	9771B	7	7	150	52
Eagle Head, MJM Power, Tiger Haida, Tiger Head, Two Tiger	Torch	Dry-cell battery	FTJ2DE1	6	7	100	75

Annex C: Retailer Demographic information

Table C.1, Table C.2, and Table C.3 present demographic information from the shops that were surveyed in 2014, 2012, and 2009, respectively.

Table C.1: Shop survey summary results for 2014.

Information	Kericho (n=63)	Brooke (n=11)	Talek (n=20)
Gender of Interviewee			
Male	68%	82%	40%
Female	32%	18%	60%
Shop Type			
Electrical and Electronics	43%	9%	15%
General Shop	32%	73%	85%
Super Market	3%	9%	0%
Hardware	5%	0%	5%
Solar Specialty Shop	43%	27%	10%
Kiosk	0%	0%	0%
Market Stall	1%	0%	0%
Table / Street Hawker	21%	9%	0%
M-KOPA	13%	0%	5%
Sunny Money	8%	0%	0%
Total Petrol Station	3%	0%	0%
Other	13%	0%	5%
Number of Employees			
1-2	70%	91%	80%
3-5	17%	0%	20%
6-10	3%	0%	0%
11+	6%	9%	0%
Unspecified	4%	0%	0%
Sales Type			
Retail	57%	91%	95%
Wholesale	2%	0%	0%
Retail + Wholesale	41%	9%	5%
Demographics of Customers			
Mostly Men	24%	9%	80%
Mostly Women	8%	0%	0%
Men and Women Equally	67%	91%	20%
Mostly Under 40 yrs. old	24%	18%	35%
Mostly Over 40 yrs. old	40%	9%	15%
All Ages Equally	33%	73%	50%

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Table C.2: Shop survey summary results for 2012.

Information	Kericho (n=32)	Brooke (n=14)	Talek (n=21)
Gender of Interviewee			
Male	88%	71%	43%
Female	13%	29%	57%
Shop Type			
Electrical and Electronics	34%	7%	0%
General Shop	28%	79%	81%
Super Market	0%	0%	0%
Hardware	0%	7%	5%
Solar Specialty Shop	3%	0%	0%
Kiosk	0%	0%	5%
Market Stall	0%	7%	0%
Blanket / Street Hawker	34%	0%	0%
Other	0%	0%	10%
Number of Employees			
1-2	59%	86%	100%
3-5	28%	0%	0%
6-10	6%	7%	0%
11+	0%	0%	0%
Unspecified	6%	7%	0%
Sales Type			
Retail	59%	93%	100%
Wholesale	3%	0%	0%
Retail + Wholesale	38%	7%	0%
Length of time they have offered LED lighting products			
0-3 mo.	13%	0%	24%
3-6 mo.	3%	0%	14%
6 mo.-1 yr.	6%	36%	5%
1 - 1.5 yr.	0%	0%	0%
1.5 - 2 yr.	9%	0%	10%
2 - 3 yr.	16%	7%	10%
3 - 6 yr.	34%	36%	14%
6+ yr.	16%	21%	24%
Not yet ³⁶	3%	0%	0%
Demographics of Customers			
Mostly Men	25%	57%	52%
Mostly Women	3%	0%	0%
Men and Women Equally	59%	43%	48%
Mostly Under 40 yrs. old	22%	36%	5%
Mostly Over 40 yrs. old	19%	21%	5%
All Ages Equally	56%	43%	90%

³⁶ Shop owner stated that they have products in stock, but have not yet made any sales.

The Rise of Solar | Lighting Global Market Research Report

Table C.3: Shop survey summary results for 2009.

Information	Kericho (n=37)	Brooke (n=16)	Talek (n=7)
Gender of Interviewee			
Male	73%	63%	29%
Female	27%	31%	71%
Unspecified	0%	6%	0%
Shop Type			
Electrical and Electronics	41%	13%	14%
General Shop	27%	63%	86%
Super Market	3%	6%	0%
Hardware	3%	0%	0%
Solar Specialty Shop	0%	0%	0%
Kiosk	0%	0%	0%
Market Stall	0%	13%	0%
Blanket / Street Hawker	24%	0%	0%
Unspecified	3%	6%	0%
Number of Employees			
1-2	68%	88%	100%
3-5	22%	0%	0%
6-10	0%	6%	0%
11+	8%	0%	0%
Unspecified	3%	6%	0%
Sales Type			
Retail	58%	100%	86%
Wholesale	12%	0%	0%
Retail + Wholesale	27%	0%	0%
Unspecified	3%	0%	14%
Length of time they have offered LED or fluorescent lighting products			
3 mo.	14%	13%	14%
6 mo.	22%	0%	14%
1 yr.	22%	6%	29%
1.5 yr.	3%	6%	14%
2 yr.	22%	6%	14%
3 yr.	3%	6%	0%
3+ yr.	8%	0%	0%
Not yet	0%	6%	0%
Unspecified	6%	56% ³⁷	14%

³⁷ The reason so many Brooke shopkeepers did not answer this question in 2009 is unknown.

Annex D: Market Presence Survey for 2014

The following survey is a PDF version of a survey that was administered using the Open Data Kit software on three tablet computers.

offgrid-RETAIL-5-29-2014

Hello. We are talking to all the local retailers to gather information related to OFF-GRID LIGHTING PRODUCTS. We are using TABLET COMPUTERS today like this one to make it easier to collect the data.

Preparation

This interview is completely voluntary but if you have the time we very much appreciate you talking to us. Do you have ten minutes free?

- Yes
- No

Person conducting the interview:

- Maina
- Peter
- Dimitry
- Nick
- Mumbi
- Daniel
- Other

Specify other.

Shop Info

Town:

- Kericho
- Wote
- Nairobi
- Machakos
- Brooke
- Talek
- Other

Specify other.

Type of shop:

- Electrical / Electronics
- General Shop
- Super Market
- Hardware
- Solar goods
- Kiosk
- Market Stall
- Table
- Hawker
- M-KOPA
- Sunny Money
- Total
- Other

Specify other.

What is the name of the shop?

How many employees work here?

Do you sell retail, wholesale, or both?

Select all that apply

Retail

Wholesale

Demographics

What is your name?

The person being interviewed

Gender:

Male

Female

What is your role at the shop?

Owner

Worker

Other

Specify other.

What is your phone number?

Product types

What type of off-grid power / lighting products are available at the shop?

Read options and check all that apply

- Torches
- Array-type lighting (many LED's, not solar)
- Pico solar products
- Keychains
- Solar Home System Kits
- Solar Home System Components
- Battery backup powered lighting

Customer types

Are the typical customers for this product mostly men, mostly women, or about equal?

- Mostly Men
- Mostly Women
- Equal

Are the typical customers for this product mostly under 40, mostly over 40, or about equal?

- Mostly under 40
- Mostly over 40
- Equal

Information Priorities: Customers

What information have customers asked for or used to make purchase decisions in the last week?

DO NOT READ THIS LIST TO THE RESPONDENT. If they mention some of them, check off. If others, use other.

- Price
- Warranty terms / guarantee
- Quality label / mark
- Brightness
- The run time
- Mobile phone charging
- Durability
- Brand name
- Trust in the seller
- Powers a television
- Lighting Africa certification
- Other certification
- Not applicable / did not understand

Other things mentioned:

Information Tools: Information Source

Do you sell solar lanterns?

- Yes
- No

When customers purchase a solar product, do they come in looking for a specific product?

- Yes
- No

There are some new tools for selling solar products that are currently being developed. Which of the following things would be useful for you or your salespeople to learn about solar or choosing new products to sell?

Information Tools: Communication Tools

Specification Sheet

Show an example of a spec sheet to shopkeeper

- 1: Best
- 2
- 3
- 4: Worst
- Not useful

Quality Seal

Show an example of a quality seal

- 1: Best
- 2
- 3
- 4: Worst
- Not useful

Flip Book

Show an example of a flip book

- 1: Best
- 2
- 3
- 4: Worst
- Not useful

Educational video about solar lighting

Show an example of a video

- 1: Best
- 2
- 3
- 4: Worst
- Not useful

Are there any other materials that would be helpful for you or your salespeople to learn about solar?

Leave blank if they have no suggestions.

Which of these things would be most useful to show to your customers in order to sell more solar products?

Information Tools: Communication Tools

Specification Sheet

Show an example of a spec sheet to shopkeeper

- 1: Best
- 2
- 3
- 4: Worst
- Not useful

Quality Seal

Show an example of a quality seal

- 1: Best
- 2
- 3
- 4: Worst
- Not useful

Flip Book

Show an example of a flip book

- 1: Best
- 2
- 3
- 4: Worst
- Not useful

Educational video about solar lighting

Show an example of a video

- 1: Best
- 2
- 3
- 4: Worst
- Not useful

Are there any other materials that would make it easier for you to sell solar products?

Leave blank if they have no suggestions.

Information Tools: Advertising Information

Which of the below options would be MOST USEFUL in getting more customers to purchase solar products?

Pick one

- Television Ads
- Radio Ads
- Road Show
- Fliers

Other things mentioned:

Supply chain information. The following questions refer to the supply chain for off-grid lighting products only.

Supply Chain

Do you buy from the same person / vendor or different ones?

- Usually the same sellers
- Usually different or multiple sellers
- I don't know / Can't say

What is the name of your primary distributor?

Where is your primary distributor located?

What town or city?

- Nairobi
- Nakuru
- Kericho
- Mombasa
- Abu Dhabi
- Other

Specify other.

How do you buy the products from the distributor?

Read options and check all that apply

- Go to buy
- They are delivered
- Other

Specify other.

How do you find out about new lighting products to sell?

Do not read options out loud

- The people I buy from
- I see other shops in town
- Customers ask for them
- Advertising on radio or television
- Local advertising / flyers / posters
- Other

Specify other.

ICT

» Introduction

Do you use a mobile phone?

- Yes
- No

What kinds of things do you use the phone for?

Read options and check all that apply

- Voice calls
- Text messages / SMS
- Emails
- Internet
- Mobile Money (M-Pesa, etc.)
- Social Media (Twitter, Facebook, etc.)
- Other

Specify other.

» Mobile Stats

» » Mobile Information

How many mobile phones do you use?

What types of mobile phones do you use?

Read options and check all that apply

- Normal Phone
- Internet Phone
- Smart Phone

» » Mobile Credit

How much did you spend on phone credit yesterday?

Voice, data, and/or texting; Ksh per day

Is that a typical amount?

Phone Credit

- Yes
- No

What would be a typical amount?

Phone Credit

» » Mobile Data

How many MB of mobile data did you use yesterday?

Number of MB

Is that a typical amount?

MB

Yes

No

What would be a typical amount?

MB

» » Mobile Money

How many mobile money transactions did you make yesterday?

Like M-Pesa or other platforms

Is that a typical amount?

M-Pesa transactions

Yes

No

What would be a typical amount?

M-Pesa transactions

» Adoption

In what year did you get your first mobile phone?

In what year did you first start using mobile money (like M-Pesa)?

» **Internet**

Do you ever use the internet to research lighting products?

- Yes
 No

Finance and Warranty

Do you offer guarantees or service warranties for customers?

- Yes, for all products
 Only for those manufacturers that support it
 No, not for any

Do you offer credit or financing to customers?

- Yes
 No

Do you access credit to run your business?

- Yes
 No

Where do you access credit for your business?

Check all that apply

- Bank
 Distributor
 Family or Friend
 SACCO
 Informal Loan (local loan agent)
 Other

Specify other.

How do you use M-Pesa for your business (or other mobile money)?

Read options and check all that apply

- Customers can buy
 Pay a distributor / buy wholesale products
 I do not use it for buying or selling products.
 Other

Specify other.

Datasheet

Has product information already been entered on a paper datasheet?

- Yes
- No

Product Information Section: Take a picture of the top three selling off-grid products by adding a new product information group for each one.

Top product first, second product second, etc.

Product Information Section: Ask the shop keeper to show you the off-grid lighting products they have available and "Add a new Product Information Group" for each one.

Product Information

Form Factor

- Torch
- Study Lamp
- Ambient Lamp
- Solar Home System

Energy Source

- Dry cell battery
- Solar PV
- Grid-charging
- Dynamo

If it uses dry cell batteries, how many dry cell batteries does it use?

Light Source

- LED
- Incandescent
- CFL

Quality marks / certifications on the package:

- KEBS
- CE
- ISO xxxxx
- UL
- TuV
- XX,000 hours lifetime
- none

Manufacturer Name

Model Name

Retail Price for one unit (Ksh)

Put the total price for all the units.

Wholesale Price for multiple units (Ksh/x#)

How many units for the wholesale price? (x#)

Write how many units are included for the given wholesale price.

Does the sales person remember the split between retail and wholesale?

If no, do not need to enter detailed split below

- Yes
- No

How many of these did you sell last week? (# sold total)

How many of those sales were retail sales?

How long do you think this product will last?

Enter it in number of months.

If possible, please take a picture of the product

This is optional, of course

Please enter any notes about your observation

Please enter any comments here about TABLET surveys that were offered by the shop keeper.

GPS

Please record the location

GPS coordinates can only be collected when outside.

latitude (x.y °)

longitude (x.y °)

altitude (m)

accuracy (m)

If not using internal GPS, enter location data here